A MULTI-VARIATE APPROACH TO POSTURE

By

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Dedicated to my husband for being teacher, best friend, partner, eternally inspiring and dependable

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SUMMARY

What is the ideal human upright posture? Where did it come from, how did it develop, what is its significance, how is it measured? What are the cause and effect of malposture?

Much has been published on the role of posture in physical as well as mental and emotional states of the individual. This study was undertaken to investigate these issues, while at the same time aiming to find the position and role of posture in the physical and psychological context of human life.

The first aspect of posture investigated was its definition. What constitutes good posture is still a debated issue. The conclusion drawn was that good posture represents the state of balance in an individual at rest and during motion. Ideally this state should be achieved with all the body parts aligned on top of each other requiring minimal effort and energy expenditure.

The evolutionary origin of the upright posture in man was traced in order to come to a clearer understanding of the anatomical, biomechanical and physiological mechanisms involved in posture. The positions and functions of some muscles and bones have remained, and some have changed during the development of the upright human from its quadrupedal ancestors. Maintenance of balanced posture depends mainly on the coordinated action of the stabilizing mono-articulated muscles, and their place and purpose in upright man were viewed in the light of their origins. By so doing one is able to uncover their intended use and to identify misuse of these muscles.

Development throughout childhood mimics the evolutionary process. A series of postural exercises was described, which follows the childhood/evolutionary

pattern, and have proven to be successful in postural rehabilitation and body-mind integration.

In order to understand the concept of the upright standing posture, control mechanisms responsible for maintaining upright posture were reviewed. These included the sensory and the neuromusculo-skeletal systems. This was duly undertaken in accordance with existing literature, it was concluded that posture is controlled in association with all human functions.

Following the concept that posture affects the mind and emotions, the work and theories of prominent researchers in the body-mind and postural integration field such as Frederick Alexander, Raymond Dart, Moshe Feldenkrais, Alexander Lowen, Wilhelm Reich and Ida Rolf were reviewed and distilled. This led to evidence that treatment of the body has an effect on the mind, that structure influences function and that postural equilibrium has a beneficial influence on both mind and body.

According to numerous workers malposture in man is pandemic. Ensuing literature and empirical research on total body posture, and the position of each area of the body, from the head to the feet, revealed divergent causes of this problem as well as effects of malposture, including negative self-image, psychololological problems, pain, fatigue and the inability to achieve the full human potential.

Although there is no obvious cause of postural imbalance, there are many ways of preventing or rectifying the disorder. During the course of a postural rehabilitation therapy, there is a good chance of uncovering the underlying cause of the postural imbalance. This can be as deep seated as a personality disorder or as clear as the fear of an old sport injury.

The incidence and extent of postural defects were investigated in two small groups of subjects with the aim to determine the range of postural deviations,

and the body areas most commonly affected. All subjects studied, leaned forward with the gravity line anterior to the ankle joint. Postural defects were prevalent in all subjects. Most of the subjects were categorized as having severe postural defects or gross deformity. Postural asymmetry and kyphosis were the most common defects. The conclusions drawn from these studies were that most people, in any age group, suffer from some type of postural defect, supporting the general consensus that malposture is a pandemic condition.

The effects of postural rehabilitation were also investigated. Postures improved in all the subjects over a period of twelve weeks, with a more vertical body alignment the most obvious change.

Postural rehabilitation has physical and psychological consequences. This was demonstrated by improvement in posture and increased body awareness, a decrease in the tendency to become fatigued, an decrease in back and neck stiffness and improvement in mental attitudes. Postural training in general could therefore be profitable for both body and mind, and an appreciation of good posture and its resulting efficiency represents the best kind of preventative medicine. Postural training should have a place in both Education and Health.

KEY WORDS

Body awareness
Body alignment
Body use
Equilibrium
Malposture
Mind-body therapies
Muscular armouring
Poise
Posture
Postural control

SAMEVATTING

Wat is die ideale menslike regop postuur? Waar kom dit vandaan, hoe het dit ontwikkel, wat is die betekenis daarvan en hoe word dit gemeet? Wat is die oorsake en gevolge van wanpostuur?

Baie is reeds gepubliseer oor die rol van postuur in fisiese, geestelike en emosionele toestande van die individu. Hierdie studie was onderneem om hierdie aspekte te ondersoek, en terselfdertyd die posisie en rol van postuur in die fisiese en sielkundige konteks van die menslike lewe na te gaan.

Die eerste aspek van postuur wat ondersoek was, is die definisie daarvan. Waaruit goeie postuur bestaan, is steeds `n debateerbare onderwerp. Die gevolgtrekking was dat goeie postuur verteenwoordig `n toestand van balans in `n individu gedurende rus of tydens beweging. Hierdie toestand kan bereik word met al die liggaamsdele op mekaar belyn met minimale inspanning en energieverbruik.

Die evolusionêre ontstaan van die regop postuur van die mens was nagevors met die doel om `n duidelike begrip van die anatomiese, biomeganiese en fisiologiese meganismes betrokke by postuur te bekom. Die posisies en funksies van sommige spiere en dele van die skelet het onveranderd gebly, terwyl sommige verander het gedurende die ontwikkeling van die regop mens uit sy viervoetige voorvaders. Handhawing van `n gebalanseerde postuur by die mens hang hoofsaaklik af van die gekoördineerde aksie van die stabiliserende, mono-artikulerende spiere, en hulle plek en doel in die regop mens was oorweeg in die lig van hulle oorsprong. Sodoende was dit moontlik om hulle doel te ontbloot en misbruik van hierdie spiere te identifiseer.

Ontwikkeling gedurende die kinderjare volg die evolusionêre proses. `n Reeks posturale oefeninge was beskryf wat die evolusionêre patroon volg, en wat suksesvol toegepas kan word in posturale rehabilitasie en die integrasie van die liggaam en gees.

Om die konsep van die regopstaande postuur te verstaan, was die beheer meganismes wat verantwoordelik was vir die handhawing van die regop postuur nagegaan. Dit het die sensoriese en neuromuskulêre-skeletale sisteme ingesluit. Die studie was onderneem inagneming van bestaande literatuur. Die gevolgtrekking was dat postuur beheer word in assosiasie met alle menslike funksies.

Na aanleiding van die konsep dat postuur die emosies affekteer, was die werk en teoriëe van vooraanstaande navorsers, soos Frederick Alexander, Raymond Dart, Moshe Feldenkrais, Alexander Lowen, Wilhelm Reich en Ida Rolf in die veld van liggaam-gees en posturale integrasie ondersoek. Die bydraes van hierdie individue het getoon dat behandeling van die liggaam `n effek het op die gees, dat funksie beïnvloed word deur struktuur, en dat posturale balans voordelig is vir beide liggaam en gees.

Volgens verskeie navorsers is wanpostuur `n pandemiese toestand. Daaropvolgende literatuur en empiriese navorsing oor totale liggaamspostuur, en die posisie van elke area van die liggaam relatief tot die ander het uiteenlopende oorsake van die probleem ontbloot. Dit sluit in die gevolge van wanpostuur soos swak selfbeeld, sielkundige probleme, pyn, moegheid en die onvermoë om die volle menslike potensiaal te ontwikkel.

Alhoewel daar geen ooglopende rede vir posturale wanbalans is nie, is daar baie maniere om die toestand te voorkom of reg te stel. Gedurende terapie vir posturale rehabilitasie is daar `n goeie kans op ontbloting van onderliggende rede vir die posturale wanbalans. Dit kan so diepliggend wees soos `n persoonlikheidsafwyking of so duidelik soos die vrees vir `n herhaling van ‘n ou sport besering.

Die voorkoms en omvang van posturale afwykings was ondersoek in klein groepies subjekte met die doel om die omvang van posturale afwykings na te gaan sowel as die liggaamsareas wat die meeste geaffekteer word. Al die subjekte wat ondersoek was het vorentoe geleun met die gravitasielyn voor die enkelgewrig. Alle subjekte het posturale defekte getoon. Die meeste subjekte was gekategoriseer onder ernstige posturale defekte. Posturale asimmetrie en kifose was die mees algemene afwykings. Die gevolgtrekking was dat meeste mense, van enige ouderdomsgroep ly aan een of ander tipe posturale afwyking. Dit ondersteun die algemene konsensus dat wanpostuur `n pandemiese toestand is.

Die gevolge van posturale rehabilitasie was ondersoek. Die postuur van alle subjekte het verbeter oor `n tydperk van twaalf weke, met `n meer regop liggaam die opvallendste verandering.

Posturale rehabilitasie het fisiese en sielkundige gevolge. Dit was aangedui deur `n verbetering in postuur en `n toename in liggaamsbewustheid, `n afname in die neiging om moeg te word, `n afname in rug- en nek styfheid en `n verbetering in gemoedstoestand. Posturale opleiding kan in die algemeen voordelig wees vir beide liggaam en gees. `n Waardering vir goeie postuur en die gevolglike effektiwiteit daarvan verteenwoordig die beste soort voorkomende medisyne. Posturale opleiding behoort dus `n plek in te neem in beide Opvoedkunde en Gesondheid.

SLEUTELTERME

Liggaamsbewustheid
Liggaamsbelyning
Liggaamsgebruik
Balans
Wanpostuur
Liggaam-gees terapieë
Spierbewapening
Poise
Postuur
Posturale beheer

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CHAPTER 1

INTRODUCTION AND STATEMENT OF THE PROBLEM

1.1 MAN`S UPRIGHT POSTURE

1.1.1 Posture and human structure

Posture is the essence and substance of this study. It is as far as the author can ascertain, uniquely human, since it is only used in the upright human context. In animals terms such as body shape, form and outline are used to describe the "posture" of an animal.

Posture cannot be considered without reference to the element of structure. Most people think that these two words are synonymous, but according to Rolf (1977) they are not. Etymologically, the term *"posture"* contains an element of placement, since the root of the word is the Latin *positūra,* position, from *pōnere* (past participle *positus*) which means *"to place."* Applied to the human, therefore, posture implies that something has been placed into a space where it should belong (Rolf, 1977). From this it follows that posture is the consequence of structure, and that if posture is modified, from a physical point of view, it is structure that needs to be considered. For the purposes of the present study, therefore, posture will be viewed from this perspective.

In any plane, structure/body structure and therefore posture, implies a relationship. This relationship may be between structures within the individual human body or the relationship of an individual in terms of his environment. Placement of one specific body part in relation to the others may alter the total posture, function and structure of the individual, or one or more of his body parts. This placement may have a considerable effect on the individual, but on the environment the effect is small and usually restricted to the immediate environment of the individual. Posture may, for example, affect the way the individual moves or balances himself, how the clothing fits, the wear and tear on shoes, the design of furniture and how the individual is perceived by others (Barker, 1981; Lowen, 1971; Mandal, 1984; Wikler, 1980). The opposite, however, is not the case. Environmental factors such as gravity, furniture, clothing, may affect posture and the human structure to a large extent (Barlow, 1990; Mandal, 1984; Rolf, 1977). Such is the influence of environmental pressure or constraints on man, that it may in all probability have given rise to the development of the permanent upright posture in the human.

1.1.2 The attainment of human uprightness

The attainment of human uprightness has long excited the attention of those interested in this unique aspect of humanness. Man's permanent upright posture and its anatomical basis are the most striking characteristics that distinguish the human from the rest of the animal kingdom. It was also one of the earliest distinctively human features to emerge, for the hominids have, according to current scientific knowledge, been walking upright for at least 3,5 to 4 million years (Coffing, Feibel, Leakey & Walker, 1994; Tobias, 1982). Human uprightness has helped man to solve a number of problems, but contributed, on the other hand, to what Keith (1923) called the ills of uprightness. These ills include flat feet, low back pain, and malposture (Dart, 1947; Plowman, 1992; Tobias, 1982).

The upright posture has freed man`s hands from the locomotive function, and enabled them to be used for grabbing, hanging and the making of tools (Pilbeam, 1990; Tobias, 1982). The upright posture led to a smaller base of support, a greater susceptibility to fall (Dart, 1947) and costly mechanical problems such as the present nemesis of medicine - low back pain (Pope, Andersson, Frymoyer & Chaffin, 1991a).

Man's constant upright posture places him in a class of his own in the Animal

Man's constant upright posture places him in a class of his own in the Animal Kingdom. It was the first characteristic of humanness to emerge and this, according to Tobias (1982) put him on the road to full humanity.

Despite its uniqueness, the human bipedal-erect stance is not enjoying the attention it deserves from the scientific community. In physical anthropology, interest in these aspects originates mainly from the uncertainty of the date and geographical placement of the origin of the advent of man`s uprightness, which is now thought to be closely related to the origin of man (as human being) and eclipsing the big brain theory completely (Gorman, 1995; Gould, 1987; Leakey & Lewin, 1992; Lemonick, 1994; Shreeve, 1996).

Initially the scientific world placed the beginnings of mankind in Asia, and then a discovery in 1924 by Dart moved man's origins to Africa (Dart, 1925; Tobias, 1982). The discovery was that of a skull of a fossil child near Taung in the Northern Cape Province. Lately the oldest hominid fossils are being discovered in East Africa and South Africa, such as the *Australopithecus anamensis* discovered by Meave Leakey in Kenya in 1995 which was older than the *Australopithecus afarensis* found in Ethiopia 20 years earlier (Shreeve, 1996). From this famous fossil skeleton, known as Lucy, and discovered in 1974, it became clear that bipedalism came first and a large brain later, as Lucy stood upright, but had an apelike skull (Lemonick, 1994).

Bipedalism could not have taken place without influencing the rest of the physical body as well as all future development of the physical body (Dart, 1970). That significant social and intellectual changes followed bipedalism, is widely accepted and closely scrutinized (Morris, 1969), yet the nagging question remains of whether bipedalism was the cause or effect of major social changes (Leakey & Lewin, 1992). This seminal question can be applied to the whole of the posture issue up to the present state of affairs: Which was the cause and which the effect? Does structure affect function or is function the cause of structure? (Barlow, 1990).

Posture is an intensely personal feature of an individual, probably the most recognisable and stable of his characteristics (Lawson-Wood & Lawson-Wood, 1977; Lowen, 1971; Rolf, 1977). Yet this ever present attribute, attached to an ability developed more than 4 million years ago, still poses many questions, conjectures and surmises such as the optimal posture and the maintenance thereof, as well as the effect of its malfunctioning (Barker, 1985; Barlow, 1990). Because of the omnipotence of the concept of posture, a vast number of approaches and/or areas of investigation are possible, of which some are listed below:

1. A physical approach may lead to the question of whether a person's structure and the use thereof (mechanism) influences his function and his physical health (Barlow, 1990; Goldthwait, Brown, Swaim & Kuhns, 1952; Phelps, Kiphuth & Goff, 1956),

2. A psychological approach may, amongst other things, pose the question of whether a person's character lies in his posture or vice versa and can a change in one influence the other (Cailliet, 1995; Feldenkrais, 1985; Lowen, 1969; 1971; Painter, 1986; Reich, 1999)?

Due to the fact that posture is taken for granted, it is often overlooked in therapies, not noticed at all in daily life, and it does rise and fall in popularity. In the West it is mainly given attention to in activities such as ballet (Tobias, 1982) and horse riding (Albrecht, 1993; De la Guérinière, 1994). In the world of athletics its value has been realized by some (Gelb, 1981; Martin & Coe, 1991; Watson, 1995). Of particular interest is the correct posture in static Eastern practices such as Yoga (Iyengar, 1968) and in dynamic exercises, for example, Tai Chi Chuan (Pang & Hock, 1984). Posture is a subject with infinite possibilities and merits. In the present era a holistic approach is seen to be the most effective way of dealing with most types of body, mind or soul problems (Lowen, 1969; Lowen & Lowen, 1977; Painter, 1986). An overview of all aspects of posture may help to indicate the contribution of postural aspects such as muscle balance, and body alignment, in an attempt to approach total well-being from a holistic point of view. This is a way of developing the potential of the human body, and hopefully will provide an indication of the abilities and limitations of the human being.

The subject and the study of posture is regularly, but not often, dealt with in literature - scientific and otherwise. Unfortunately most of this is often done in a vague and fragmentary fashion. Publications usually highlight only individual aspects of the subject. Consequently, no integrated point of view of this subject could be found, and as a result many aspects of posture are poorly understood, and many questions are not dealt with properly.

1.2 AIMS AND PURPOSE OF THE PRESENT STUDY

The primary purpose of this study is an attempt to formulate an integrated approach to this field of study. In order to achieve this aim, posture and all its ramifications, will be approached from both a physical and a psychological perspective. With this purpose in mind the study will be subdivided into the following sections:

1.2.1 Posture from a physical perspective

In this part of the study, literature dealing with the various physical aspects of posture will be analysed. The aim of this part of the study is to gather facts in the literature relevant to posture. The premise here is, that in order to reach a full understanding of the subject, one needs to build it up from its earliest beginnings, hence the inclusion of chapters on human *phylogeny* and *ontogeny* - enabling a better comprehension of the structural and physiological adaptations to the upright posture in the human, such as neuromusculo-skeletal function, involved in upright posture and bipedalism. This will not only lead to a better appreciation of the anatomical-, physiological- and biomechanical factors pertaining to posture, but also to improvements in firstly, the approach to the treatment of defects of the fully developed posture, and secondly in the ability to recognise aberrations of, or regressions in posture, and thirdly to the improvement in physical performance (Alexander, 1932; Feldenkrais, 1985; Martin & Coe, 1991). Every step along the way of human development may have an influence on the end product; one needs to know where one has been, and to know where one is going to.

Apart from human *phylogeny* and *ontogeny,* an in-depth analysis of the physical aspects of human posture such as the "ideal" posture, postural aberrations and their consequences will be considered.

The first section will be divided into a number of chapters, each dealing with a specific issue:

- ❑ The erect, standing posture has specific characteristics and measurable qualities. These are reviewed in the second chapter. The term *"posture"* and others relevant to it will also be defined in view of these attributes,

- ❑ In Chapter 3 posture will be approached from **a paleo-anthropological point of view,** starting with a superficial overview of the course of development of a single cellular biological organism into the complex multicellular, multidimensional organism which is man today. The purpose of this is to place man in time and space in the Animal Kingdom. This will be followed by a discussion of the development of the upright bipedal posture in man. This discussion will include the following:

  The factors that may have been responsible for the change from the quadrupedal state to upright human bipedalism, The functional and structural changes associated with these changes,

An overview of the comparative anatomy of the human in relation to other primates in order to formulate an explanation of the contribution of the musculo-skeletal adaptations to the attainment of man's permanent upright posture,

The functional consequences and impact of the attainment of the upright posture to neuromusculo-skeletal control in modern man.

❑ The fourth chapter briefly touches on human anatomical development from foetal life to adulthood. Here, changes which take place in the human structure during the course of the different stages of individual development, will be highlighted. Human ontogenetic and phylogenetic development will also be compared,

❑ In the fifth chapter the problem of malposture will be investigated. Additionally the normal musculo-skeletal functions and defects in each body segment, and the effects thereof on the total body or on other segments will be investigated,

❑ The sixth chapter investigates the neural mechanisms responsible for the control of the upright position in the human and its implications for exercise science and postural rehabilitation.

1.2.2 Posture from a psychological perspective

The primary purpose of this part of the study is to examine the relationships between the physical and the psychological from a postural perspective.

❑ In the seventh chapter the work and ideas of founder members of today's body therapies are reviewed, as well as the principles of their methods. This chapter will also investigate a number of physical and psychological approaches to postural and motor rehabilitation.

1.2.3 Quantitative an qualitative studies on posture in South African subjects

The third section will address some quantitative and qualitative studies done on some selected groups of the South African population.

- In the eighth chapter postural evaluations conducted on samples of adult middle aged senior executives and primary school boys, will be presented. This will be followed by two studies conducted on small samples, in which the outcomes of postural rehabilitation will be examined.

1.2.4 Conclusion and recommendations

The final chapter attempts a perspective and evaluation of the role and meaning of posture in integrating the physical and psychological spheres of life. Reasons for recommending improved posture are listed, as well as means to achieve this goal. The chapter concludes with suggestions for further postural research.

CHAPTER 2

POSTURE

Standing is actually movement upon a stationary base, sway being inseparable from the upright stance (Hellebrandt, 1938: 473).

Standing is a complex phenomenon. Its evaluation is composed of the sum total of many diagnostic signs, changing in an infinite variety of ways (Hellebrandt, Riddle, Larsen & Fries, 1942: 148).

2.1 POSTURE AND *POISE*

Posture has long been thought of in terms of standing and sitting, and correct posture as the erect position assumed when one is under inspection, but posture should really be considered as the sum total of the positions and movements of the body throughout the day and throughout life. It should include not only the fundamental static positions in lying, sitting and standing and the variations of these positions but also the dynamic postures of the body in motion or action, for it is here that posture becomes most important and most effective. Posture has a direct relation to the comfort, mechanical efficiency and physiological functioning of the individual (Howorth, 1946: 1398).

The above is how Howorth (1946) summed up the whole issue of human posture. Dart (1947: 74) had the following to say on the same subject matter:

The human machine certainly meets more differing conditions and performs work of greater diversity than any known

> *mechanism. These functions are efficiently discharged when the body is in a state of* ***poise.*** *Visceral functions (such as those of digestion, circulation, respiration and excretion) as well as physical activities must continue with the maximum of efficiency and the minimum of interference with their rhythm whether the body is supine or prone, erect or bent, twisted or straight. Integration of these vegetative and voluntary activities of the body occurs, and their rhythm is maximal, when the body enjoys* ***poise****, because it is only when the voluntary (or striated) musculature is working in a balanced way that it is making minimal demands on the vegetative (or unstriated musculature). The striated musculature, which was elaborated for movement of the body as a whole, can only work in a really balanced way when it is responding without impediment to the vestibular organs of balance through the mechanisms elaborated for that purpose by the central nervous system - in other words, when the reflex neuromuscular apparatus of body-balance is integrated with the neuromuscular apparatus of non-reflex, purposeful or intentional movement.*

Others (Alexander, 1932; Barlow, 1990; Feldenkrais, 1985; Goldthwait *et al.*, 1952; Painter, 1986) have all echoed the opinions of Dart and Howorth, yet the condition of malposture is pandemic in urbanised and industrialised communities (Dart, 1947; Sherrington, 1946). Lawson-Wood and Lawson-Wood (1977: 13) were of the same opinion when they observed mankind in totality:

> *The erect position has NOT been attained by the overwhelming majority of mankind. It is true that human beings approximate more or less to the upright stance: it is just this more-or-lessness that conceals from people the fact that their stance and dynamic posture is still inefficient, uneconomical, and wastes a great deal of vital energy.*

Therapeutic procedures have been directed towards reducing or eliminating malposture; many of these were unfortunately based on partial understanding of the true nature of posture, its underlying principles and mechanisms, and therefore have had limited success (Barlow, 1990; Dart, 1947). In Chapter 3 (section 3.4) an attempt will be made to come to a clearer understanding of the origin and mechanics of the upright posture. The lack of understanding of the basic anatomical and biomechanical mechanisms involved in the upright human posture, and its resultant erroneous approaches in the treatment of postural problems such as low back pain will be highlighted. In this and the following chapters the question of posture and all its ramifications will be further pursued, with the eventual aim to apprehend its real nature. Once this is achieved a logical therapeusis for malposture may be elaborated.

In order to come to the essence of posture a few approaches to this issue will be investigated below.

2.1.1 Towards a definition of posture

> *Posture as a* ***state*** *of the body is defined by two relationships which we separate - that of the body to the ground and that of the parts to each other* (Martin, 1977: 25).

Alexander (1932, 1987), Barlow (1990), Feldenkrais (1972, 1985) and Howorth (1946)'s contention was that the individual should accept that posture is a twenty-four hour proposition, **and that only he can correct it, and then only if he knows how, wishes to do it and applies himself to it continuously.** Posture-consciousness, or in a broader sense, consciousness/awareness of the self, should therefore become part of the individual's life in order to form and maintain good posture and body mechanics (Alexander, 1932; Dart, 1947; Feldenkrais, 1985).

In Chapter 1 (section 1.1) it was outlined that the term posture is derived from the Latin root *positūra* which means *"to place"*. This may imply that the term posture denotes the placing of body structures in a fixed position, with the result that posture should be viewed from this point of view. Feldenkrais (1985) also linked position to posture by stating that position describes the location and configuration of the various segments of the body. Posture, on the other hand, according to Feldenkrais (1985: 53):

> *.....describes the use of the entire self in achieving and maintaining this or that change of configuration and position.* ***Posture*** *is therefore describing action, and is a dynamic term.*

Riley, Mann and Hodge (1990: 503), went further and linked the orientation of body segments to balance when they asserted that:

> *Posture, the position and orientation of body segments, and balance, the control of the center of gravity (CG) or center of force (COF) position, are coupled; most postural adjustments change the CG location.*

The control of body segment placement, that is, posture, by the central nervous system is to maintain balance (Riley *et al.*, 1990), an opinion with which Feldenkrais (1985: 53) is in agreement:

> ***Posture*** *relates to the use made of the entire neuromuscular function, or more generally, the cerebrosomatic whole; that is, the way the affect, the motivation, the direction and the execution of the act is organized while it is performed.* ***Posture*** *must, therefore, be used to describe the way the idea of an act is projected and the way the different segments of the body are correlated to achieve a change or to maintain a state.*

The link of posture to balance will be one of the central principles of this study. Balance, as far as this study is concerned, is not only about the placement of body segments, shown in Figure 2.1, but balance within the structures concerned with this the positioning of structures, and their neural control.

2.1.2 The dynamic nature of posture

Research, as well as the work done by those involved in body work, are pointing towards the dynamic and ever-changing element in human posture (Alexander, 1932; Feldenkrais, 1985; Hellebrandt, 1938; Riley *et al.*, 1990; Rolf, 1977; Valk-Fai, 1973) - in fact Howorth, already in 1946, referred to what he called "dynamic posture".

To Howorth (1946: 1401) good dynamic posture implied:

> *…the use of the body or its parts in the simplest and most effective way, using muscle contraction and relaxation, balance, coordination, rhythm and timing, as well as gravity, inertia and momentum to optimum advantage.*

Dart (1947), however, considered Howorth's (1946) dynamic posture to be nothing other than approximate poise or approximate mobile equilibrium, something which may be qualified as good, better or best. *Poise,* on the other hand, Dart (1947) felt, are either present or absent, and posture being something habitual or fixed - must with increasing fixation, ultimately become *malposture.* Alexander (1932) maintained that posture is best judged by the way in which an individual moves and carries himself.

The basic standing position has, according to Barker (1985), Dangerfield (1996), Howorth (1946), Lawson-Wood & Lawson-Wood (1977), Rolf (1977), Safrit (1986) certain ideal characteristics (Figure 2.1), characteristics which are in accordance with the principles of balance outlined in section 2.1.1. Basically the erect body should be **vertical** and essentially straight when seen from the side as well as from the back. Three dimensionally the different segments of the body should be stacked squarely on top of each other (Figure 2.1) - deviation from this ideal being viewed as a postural abnormality (Rolf, 1977). The vertical line should pass through the ear, shoulder, centre of the hip and ankle when seen from the side - the physiological thoracic and lumbar curves should be slight and the pelvis erect rather than tilted forward. The feet and knees should be directed forward, and the arches of the feet should not sag. The chest should be erect but not fully expanded or tense, the abdomen flat and relaxed, neither sagging nor pulled in. The shoulders should rest comfortably on the crest rather than be held rigidly back with the arms turned outward. The position should be held with the spine rather than with the shoulders. The body should achieve its full height in this position, with the head and chin level and not inclined backwards. There should be a feeling of tallness, with the top of the head pulling away from the feet.

All postural tests are constructed around the premise:

> ...*that the less the jointed body parts deviate from the vertical, the smaller the rotational stresses demanding equilibration by muscular contraction and the less the energy cost* (Hellebrandt & Franseen, 1943: 225).

Others, however, are of a different opinion, and feel that the above ideal biomechanical posture, in which joint centres are linearly arranged, are not to be expected in healthy populations (Woodhull, Maltrud & Mello, 1985) (Figure 2.1b). Woodhull *et al.* (1985) and others (Barker, 1985; Brunnstrom, 1954; Fox & Young, 1954; Gowitzke & Milner, 1988) stated that the vertical line falls anterior to the ankle joint, where two opposing forces - gravity and the tension of the *soleus* muscles - operate a first class lever system - the axis through the ankle joint lies between the *soleus*, acting from behind and gravity acting in front of the ankle axis (Gowitzke & Milner, 1988; Smith, 1957).

A third approach puts the vertical line behind the ankle joint (Barlow, 1990) (Figure 2.1c).

Fig. 2.1 The biomechanical " ideal" upright standing position according to various opinions (a). Standing with the gravity line (black line) going through the ankle joint (Howorth, 1946; Kendall & McCreary, 1983; Kummer, 1962; Rolf, 1977; Safrit, 1986) (b). Standing with the gravity line in front of the ankle joint (Barker, 1985; Gowitzke & Milner, 1988; Kummer, 1962), and (c) the Alexander approach, with the gravity line behind the ankle joint. The knees are also slightly bent (Barlow, 1990).

The standing position is generally the way in which posture is evaluated (Kendall & McCreary, 1983; Safrit, 1986). Although apparently static, it should, however, be realised that simple postural analysis such as this may yield abundant information about human structure, in as much as any posture - good or bad - is the outcome of neuromusculo-skeletal (tripartite) control; control which is largely the outcome of what has been learnt in the past (Alexander, 1932; Feldenkrais, 1985; Massion, 1992).

The basic tenet of this study, then, is that posture - dynamic or static:

a) Is the physical and observable consequence of the effect of the environment on the individual and of what has been learnt before,

b) Gives an indication of the arrangement of different structures in relation to each other in an individual's body, and by means of this,

c) Gives an indication of the way in which the body musculature is balanced and controlled.

The above approach is in accordance with that of Dart (1947) in that the aim of learning should be towards **the acquisition of *poise*.** This is, according to those involved in postural rehabilitation, only possible through careful study, observation and increased bodily awareness (Alexander, 1932; Dart, 1946, 1947; Feldenkrais, 1985; Hanna, 1988; Plummer, 1982; Rywerant, 1983). *Poise* - and therefore one of its visible components, posture - will then become a body state of **balance and its maintenance** (Dart, 1947). The individual, accordingly, is either balanced or not, and when this is considered, Dart's (1947: 76) definition of *poise* makes sense:

> ***Poise*** *is a character of repose or rest in the good body whether it is in the relatively static positions of lying, sitting or standing, or is actually in progressive motion during the activities of life's daily routine or of sport.*

Feldenkrais (1985: 110) brought perceptual motor learning and psychological aspects into this definition by stating that:

> *Correct posture is a matter of emotional growth and learning. It is not acquired by simple exercising or by repetition of the desired act or attitude. Learning is not a purely mental occupation, as many people believe, just as the acquisition of*

> *skill is not a purely physical process. Essentially it consists in recognizing in the total situation - environment, mind and body - a relationship in the form of a sensation that in the long run becomes so distinct that we can almost describe it in a sensible language.*

Good posture, Feldenkrais (1985: 54) also felt, is associated with a specific emotional state:

> *The common association of good posture with poise - that is, mental or emotional tranquility - is in fact an excellent criterion of good posture. Neither excessive muscular tension nor emotional intensity is compatible with good posture. Good posture means acting fast but without hurry; hurry means generally heightened activity that results not in faster action, but only in increased muscular contraction. Good posture means using all the power one possesses without enacting any parasitic movements.*

Interesting also is Howorth's (1946) basic "dynamic posture", which is characterized by a slight crouch, with the ankles, knees and hips flexed, the head and trunk inclined forward and the trunk slightly flexed, the arms relaxed and slightly flexed. With the body in this position he found that the muscles were in a midposition with increased tone, balanced and ready for instant and powerful action in any direction (Figure 2.2). In this position the muscles are able to act as springs, absorbing shock and initiating movement. The similarity between this and Alexander's (see Barlow, 1990; Drake, 1991; Jones, 1979) *position of mechanical advantage* is striking - the basic differences being Alexander's emphasis on lengthening in the spine and neck and the release of unnecessary tension in the muscles. If correctly executed, this position will produce a state of plastic tonus throughout the extensor muscle system (Jones, 1979), allowing the position to be maintained with minimal muscular effort, since all the body parts are in dynamic balance. According to Dart (1947) this is a primitive posture approximating that of the Kalahari Bushman - a position he referred to as the *humanoid orthograde posture.*

Fig. 2.2 **The human *orthograde* posture (Dart, 1947), the position of mechanical advantage (Jones, 1979) or dynamic posture (Howorth, 1946). Drawing: M. Langston.**

2.2 THE INFLUENCE OF GRAVITY ON HUMAN STRUCTURES

Even though the human body has evolved over millions of years and is structurally and functionally well adapted to the erect position, the earth's force of gravity is a constant presence that tends to unbalance this balanced structure. Hellebrandt and Braun (1939) wrote about the ever-present collapsing stresses of gravity that must be constantly equilibrated by muscular contraction. The result of this is motion even while standing perfectly still. Today this phenomenon is referred to as *body sway* or *postural sway.* Postural sway is inseparable from the upright stance (Hellebrandt & Franseen, 1943).

The significance of body sway as a diagnostic instrument for the assessment of balance has been recognized, even in the previous century (Vierordt, 1862 quoted by Hellebrandt & Franseen, 1943) and at the beginning of this century 'steadiness of standing' has been used as a criterion for both motor power and neuromuscular control (Hellebrandt & Braun, 1939). The phenomenon of postural sway still holds such a fascination that it has been scrutinized by various investigators for different reasons with a myriad array of techniques, making it difficult to apply observations from one study to the next. Andres and Anderson (1980) wondered who at that time studied postural sway, and for what reason. They observed that scientists from numerous disciplines have studied body sway including neurologists who have utilized postural sway measures in the clinical assessment of motor function as well as otoneurologists who have employed tests of postural sway to assess the vestibular system. Control engineers who study the sensory system, scientists in the field of aviation and aerospace medicine and occupational health and safety scientists all find value in pursuing postural sway studies (Andres & Anderson, 1980).

2.2.1 Definition of postural sway

Standing balance is the dynamic process of maintaining a stable upright position and postural sway has been used as a measure of standing balance (Ekdahl, Jarnlo & Andersson, 1989; Hasselkus & Shambes, 1975). Ratliffe, Alba, Halium and Jewell, (1987: 503) defined postural sway in standing as follows:

> *A dynamic equilibrium in which individual movements of different joints result in oscillations of the body. The frequency and excursion of oscillations vary according to the body's ability to maintain an upright posture against opposing forces.*

2.2.2 The features of postural sway

To fully describe postural dynamics, movements of the 5 body segments should be considered, namely: the head, torso, thigh, calf and foot. The segments in the sagittal plane rotate around 4 joint axes located at the neck, hip, knee and ankle. Postural sway occurs like an inverted pendulum with the mandible having a relatively greater displacement during sway than the hip and knee. In normal individuals the lower extremity is used for postural fixation (Ratliffe *et al.,* 1987, also refer to Chapter 3, section 3.4 for more detail).

Swaying, which normally occurs during the standing at ease position, is not sufficient to alter the relationship of the line of mass of the different segments of the body to the appropriate joints. Intermittent activity thus does not occur in the groups of muscles which resist the extending or flexing force due to gravity (Joseph, 1962). On the basis of electromyographic studies of the upright human posture in which electrical activity in leg, hip and posterior hip muscles were recorded during the standing at ease position, Joseph (1962) concluded that the concept that the erect attitude is maintained by the balance between opposing muscle groups, and that in the maintenance of this and the normal pattern the ligaments play no part, is erroneous. This is so because Joseph (1962) only found continuous variable activity in the calf muscles - mainly the *soleus* - and in the lower thoracic posterior vertebral muscles. As a rule he found no activity in the tibialis anterior, the muscles of the thigh and the hip, and the lumbar and cervical muscles. These observations emphasize the notion outlined in section 3.4.2 that standing posture depends on more than just muscle contraction, but also on other parameters such as muscle tightness, and other passive factors such as elastic tension in tissues such as ligaments, deep fascia, skin and the fibrous framework of muscles (Smith, 1957). Joseph (1962), however, in his study did not determine whether his subjects were *poised* or not - one can therefore only assume that the presence or absence of electrical activity in the muscles studied, was that which supported the habitual upright position of his subjects. In view of the pandemic nature of malposture, which includes poor mechanical alignment of body structures on top of each other (Dart, 1947; Sherrington, 1946; Woodhull *et al.,* 1985; Chapter 8 - this study), the likelihood of malposture in Joseph's (1962) subjects is more likely than not. Activity - and therefore tension - in the *soleus* muscles of Joseph's (1962) subjects is probably explained by the fact that it counteracted the downward-forward moment caused by gravity, and so prevented his subject's bodies from falling forward (Gowitzke & Milner, 1988).

Some relative motion between the body segments also exists, something which necessitates continual balance corrections (Valk-Fai, 1973). Such motion will invariably necessitate muscular contraction to some extent, something which was not observed by Joseph (1962) in his study. The least activity exists at the knee and the motion of the head and the legs is balanced by the motion of the trunk. The motion of the various body segments has a balancing effect, which can be seen in the average position of the body segments relative to each other. Their relative position is such that the centre of gravity always stays at the centre of the body in a stable position (Valk-Fai, 1973).

Upright posture in standing and gait is coordinately controlled by specialized front-back (anterior-posterior) and left-right (lateral) body-movements which govern the body's centre of gravity and, in addition, dynamically regulate movement of visual, tactual and auditory stimuli relative to the sides, base and apex of the body. Differential right-left and forward-back movements act to self-generate equilibrating motions to stabilize the eyes and head relative to the observed horizon, and to stimuli that pass laterally and vertically around the body during motion (Smith & Arndt, 1970).

Anterior-posterior sway is normally greater than lateral sway (Hellebrandt, 1938; Hellebrandt & Franseen, 1943; Yoshida, Iwakura & Inoue 1983). According to Stribley, Albers, Tourtelotte and Cockrell (1974), it is twice as large. However, body sway after disturbance of balance, is large in all age groups and is more pronounced in the lateral direction even when the disturbance is in the anterior-posterior direction (Era & Heikkinen, 1985). In addition, deviation of the direction of oscillation of the body axis seems to be contingent, although Cernacek and Jagr (1972) found deviation of the body axis to the right when the eyes are open. This they contributed to the dominance of the left eye for verticality in healthy subjects.

There is a general agreement that the upright stance is steadied when the eyes are open and focused on a fixed point, and least stable with the eyes closed. Distraction, on the other hand, reduces sway (Hellebrandt & Franseen, 1943).

2.2.3 Effect of age on postural sway

Balance gradually becomes centrally controlled during childhood and many balance behaviours become automatic as a child becomes adult (see Massion, 1992). However, this process reverses itself in late adulthood as balance gradually begins to require greater conscious effort than it had before (Payne & Isaacs, 1991).

The extent of sway changes with age. Sheldon (1963) found that children from 5 to 14 years sway more than adults. Between the ages of 15 to 60 years, the amount of sway is relatively constant. After the age of 60 years, the amount of sway increases with increasing age (Fernie, Gryfe, Holliday, Llewellyn, 1982; Murray, Seireg & Sepic, 1975; Sheldon, 1963; Stribley *et al.,* 1974).

Sheldon (1963) emphasized the difference in control amongst the age groups; the 6 to 14 years group lacks control of random movements, which leads to an increased total area of sway, while the very accurate control of stance onwards to the forties seems to be due entirely to control over these movements. The best controllers are those in their twenties, who are able to control their sway within an area of one-fiftieth of a square inch (2,54 cm) in the space of one minute. Postural equilibrium in children does however improve rapidly and reaches a plateau at 10 to 12 years (Nelson & Zike, 1971).

In elderly persons the reflexive mechanisms were found to be relatively intact. When the posture is under the control of slower, higher level sensory integrative mechanisms, however, elderly persons are at some disadvantage (Stelmach, Teasdale, Di Fabio & Phillips, 1989).

The magnitude of a person's body sway while standing, is often used to indicate balance ability (Payne & Isaacs, 1991). Hellebrandt and Braun (1939) measured postural sway in subjects ranging from 3 to 86 years, and concluded that the mean location of the centre of gravity projection near the centre of the supportive base, was consistent at all ages. However, the magnitude of the sway about the centre of the base, tended to be larger in the very young and very old.

Hellebrandt, Mueller, Summers, Houtz, Heap and Eubanik (1950) stated that the normal adult utilizes 0.66% of the functional base of support in postural sway during upright stance, while Hasselkus and Shambes (1975) put the mean maximal percentages at 0.33%, explaining that the differences were due to greater accuracy in the measuring instruments. On a practical level, Hellebrandt and Franseen (1943) observed that when the feet are together the stance is unsettled, turning the feet out to an angle of 45 degrees or separating the feet, so as to equalise the coronal and sagittal diameters of support, steadies the stance. This approach is in agreement with what was suggested by Drake (1991).

Amplitudes, as well as extent of sway, differ significantly between age groups. Era and Heikkinen (1985) found that both these variables increase about twofold when proceeding from the youngest to the oldest age groups. The differences between the age groups were more pronounced in anterior-posterior sway than in lateral sway.

Standing balance is thus proven to be influenced by age, with impaired capacity for balance in the older subjects (Ekdahl *et al.*, 1989), probably caused by physiological decline of *poise*/posture with age (Overstall, Exton-Smith, Imms & Johnson, 1977). The result of balance loss in the elderly leads to an increase in falls. The average speed of sway was significantly greater for those who were inclined to fall when compared to those who did not fall (Fernie *et al.*, 1982). Apparently many accidental falls were caused by impaired balance with the problem being that the elderly are unable to correct their balance once they have stumbled, compared to the young who regain their balance rapidly and avoid an actual fall (Overstall *et al.*, 1977).

2.2.4 Gender differences

Men and women of all ages reveal different traits in postural sway and balance. Hanock (1894, quoted by Sheldon, 1963) found that in early childhood boys swayed more than girls, thus suggesting that the two sexes mature at a different rate in their control of stance. This might also suggest that they differ in their rates of deterioration in old age. Girls in the 7 to 13 year old age group are slightly better at maintaining balance than boys of the same age - girls averaging 10% steadier. For subjects more than 15 years old, there is no difference between the sexes (Stribley *et al.,* 1974). Yet Overstall *et al.* (1977), found that at all ages women sway more than men, and attributed this to a probable function of body mass/muscle mass ratio. Without attributing it to anything, Yoshida *et al.* (1983) confirmed the finding that the grade of sway in quiet standing was greater in women than in men. However, he also mentioned that the centre of force of the male was located more anteriorly than that of the female and the mass of the female group had a greater tendency to shift backward than did that of the males. Men also utilize a greater percentage of their base of support in sway (Hellebrandt & Braun, 1939). Ekdahl *et al.* (1989), however, insisted that overall, women show better standing balance compared to men.

Swaying can be considered as a homeostatic system of the body, according to Barlow (1955). This is a system which returns to a resting state of equilibrium when it is disturbed.

> *...postural adjustment is a homoeostatic mechanism which is largely under voluntary control, provided that the right amount of information about errors finds its way back from the muscle to the cortex* (Barlow, 1955: 659).

Barlow (1955) found that there is always a slight sway around a resting mid-point, never excessive, **except in neurotics who show a much larger sway.**

Andres and Anderson (1980) warned that body sway is a psychophysical as well as a physiological response.

> *Though kaleidoscopic at first sight, when carefully made, postural sway patterns are characteristic for each person and highly reproducible* (Hellebrandt & Franseen, 1943: 227).

2.3 MEASUREMENT OF POSTURE

> *The spirit of Plato dies hard. We have been unable to escape the philosophical tradition that what we can see and measure in the world is merely the superficial and imperfect representation of an underlying reality* (Gould, 1987: 239).

With this statement Gould (1987) tried to emphasise the fact that with the correct measuring tools the researcher will, if he persists, eventually be able to come to the true nature of things. In this section the attempts by researchers to measure and understand the underlying reality of posture will be discussed, and whether we have indeed been able to put Plato's spirit to rest. This will then be contrasted to the holistic approach of those who became pioneers in the field of posture.

The erect, standing posture has specific characteristics and measurable qualities. Although the human body is always balanced on the feet when standing, and the segments follow the same sequence, that is, head, neck, shoulders, thorax, abdomen, pelvis, legs and feet, the alignment of the segments and angle of the body as a whole towards the surface, shows great discrepancies (Barlow, 1990; Burt, 1950; Hanna, 1988; Rolf, 1977; Woodhull *et al.,* 1985). For purposes of comparison on a personal, general and developmental level reliable tools and reproducible results may deliver valuable information on a scientific level. These tools will be discussed on the following pages. It must be understood, however, that the outcomes of measurement with the help of these tools are only valid in specific contexts, and that some underlying reality will not necessarily be revealed (Capra, 1983). In posture this problem may be attributed to its many facets.

Both subjective and objective observations of posture are notoriously unreliable, being influenced by various external and internal factors such as prevalent tastes in aesthetic appreciation and the level of sensitivity or awareness of the subject (Gelb, 1981). For scientific purposes of evaluation, comparison or cataloguing, it is necessary to find reliable measuring tools and methods. Accuracy alone, however, does not make assessment of postural control valid, sensitive or useful. An understanding of the biomechanical, and neurophysiological bases for postural control and dyscontrol is the most valuable measurement tool available to the therapist involved in postural evaluation and rehabilitation (Horak, 1987).

In 1943 a review paper by Hellebrandt and Franseen appeared on the physiology of the vertical stance of man and in which they also covered tests and measurements of posture dating from 1909 to the then present. During the same year Massey (1943) published a critical study of methods for measuring posture. From both these extensive works, it becomes clear that in the first part of the century, posture and the measurement thereof was very important in both the physical educational and medical fields. They were pursuing a criterion for a good and healthy posture, as practitioners in both the medical and physical educational fields became aware of the detrimental effects of the industrialised society and sedentary lifestyle on posture (Barlow, 1990; Dart, 1947; Sherrington, 1946). That bad posture had an adverse effect on the general health of an individual came to be suspected at this stage and many efforts were made to prove and rectify this. Foremost in this respect was the work done by Goldthwait *et al.* (1952).

Hellebrandt and Franseen (1943) observed that since 1900, few physiologists have interested themselves in the problems of body alignment. The validity of this statement appears to apply up to the present. They did not seem to have been impressed by either the methods or reasons for measurement, criticizing the fact that posture tests then in use were based almost exclusively on an untenable static concept of standing. Lee and Brown (1923) were of the opinion that the subjective rating of a physician who sees the body in use, may give a fairer evaluation of stance mechanics than that attainable from a single instantaneous objective observation. Alexander (1932) was a staunch supporter of this concept. This view was also held by observers in the latter part of the century (Gelb, 1981).

Problems with measuring methods do not necessarily lie with the method, but with the measurer. In the first half of the century efforts to measure posture have been made largely by lay observers (Hellebrandt & Franseen, 1943), yet posture evaluation in the hands of experts have considerable practical value and is useful for research purposes (Andres & Anderson, 1980; Massey, 1943; Winter & Hall, 1978). There is also a disparity about the nomenclature. Subjective methods could be seen as self evaluation in today's terms, whereas Massey (1943) saw them as rating by inspection, a qualitative test with no quantitative record and open to differences in interpretation. The same method of mass examinations by observation is considered to be objective, though unreliable, by Hellebrandt & Franseen (1943).

The literature contains a series of increasingly complex ways of testing and measuring posture in order to obtain a permanent record. These include the Vertical Line test and Triple Line test (1914), the schematograph (1915), the silhouetteograph (1923), Crampton's Total Ptosis test (1925) as well as the X-ray, pantograph, lithograph, centre of mass apparatus (1909) and photography. Co-ordinates were later included in the photographs to assist in evaluating the verticality of alignment (1934) and biplane stereoscopic photographs obtained a three-dimensional concept of body position with the use of mirrors. Variations in the depth of the antero-posterior curvatures of the spine have been scrutinized by the use of the lead tape, the conformature (1909), the comparagraph and by the application of light aluminium pointers to project skeletal parts which are invisible in profile view photography (1937) (Hellebrandt & Franseen, 1943). Early in the century photography gave satisfactory results but was viewed as an expensive method with the disadvantage of identifying the subject (Hellebrandt & Franseen, 1943; Massey, 1943).

Today photographs are a valuable method of documenting body alignment and spinal deformity (Barker, 1985; Winter & Hall, 1978).

2.3.1 Body sway

Body sway seems to be a phenomenon which has intrigued and drawn many investigators for many years. According to Andres and Anderson (1980) many techniques for body sway registration exist. The reason for this lies in the complexity of the control of posture (multi level reflexes, central motor programmes and psychological components) as well as methodological factors.

Romberg (1853, cited by Andres & Anderson, 1980) recognized and appreciated the diagnostic value of postural sway and subsequently attempts were made to quantify sway. At first the subject was placed in front of a grid pattern while the observer sat 10 feet away with one eye closed, writing down the maximum amplitude of observed sway. By 1887 graphic tracings were obtained by placing the subject, with a piece of smoked paper placed on the top of his head, under a stationary stylus. This ataxiagraph was used and modified for several years until the ataxiameter was developed around 1922 (Andres & Anderson, 1980).

Ataxiameters consisted of a helmet worn by the subject which had silk threads attached which were strung over pulleys, thus total movement in all directions could be measured. The disadvantages of both the ataxiagraph and ataxiameter were the mechanical loading of the subject and the fact that only head movements were measured and recorded (Andres & Anderson, 1980).

2.3.2 Unstable- and force platforms

During the 1930s unstable platforms projecting the subject's centre of gravity onto the base of support as a function of time, were constructed. At the same time the force platform, using bonded strain gauges, was being developed for studies of human locomotion. Since then and up to the present, many investigators have used different models of the force platform as tools to analyse postural sway. Andres and Anderson (1980) questioned the validity of the results of force platform measurements, citing the limitations of the assumption of an inverted pendulum body model, and the wide range of foot positions and relative body link positions that make comparisons difficult. Unstable- and force platforms mainly yield information on the control of postural steadiness and stability (Murray *et al.,* 1975), but do not give any information on the vertical alignment of the body, the shape and position of the different body segments (refer to computer and photographic techniques below).

2.3.3 Computer analysis of posture

Since the 1970s TV cameras combined with a computer analysis scheme have been in use (Dangerfield, 1996; Jones, 1979). Some of these require the use of photography as a basic tool (Dangerfield, 1996). Examples of these are Moiré photography and grating projection techniques. Moiré photography employs optical interference patterns to record the three-dimensional shape of a surface. This technique is useful in the evaluation of problems such as pelvic rotation and trunk deformity (Willner, 1979). At present it is also possible to produce three-dimensional reconstructions of the trunk by means of grating projection techniques (Dangerfield, 1996). Computer assistance also allows automatic calculation of parameters similar to those gathered by means of goniometers or flexicurves (Dangerfield, 1996).

Jones (1965, 1979) and Jones and O'Connell (1958) found multiple-image photography to be an ideal way of demonstrating posture in movement, a technique developed by the French physiologist Etienne Marey in the 1880s to enable him to analyse human and animal movement. This was the precursor of the motion picture and consists of leaving the camera shutter open and interrupting the light at fixed intervals with a perforated disc (Marey wheel) rotated in front of the camera. A movement could then be recorded as a succession of discrete images whose time relations were known. Marey called his refined method for human movement studies "geometric chronophotography". This consisted of dressing the subject in black, attaching metal reflectors at various places on the head, trunk and limbs and then taking the photograph in strong light against a dark background. The image of the subject disappeared, leaving only a black-and-white pattern showing the successive positions of the markers (Jones, 1979). Jones and O'Connell (1958) refined the method by attaching strips of reflecting tape to the subject and recording the moving image by repetitive strobe rates of 5, 10 and 20 flashes per second. The stroboscopic method is highly flexible and allows the subject a maximum of freedom to move. Patterns obtained in this way are sharp and clear-cut and contain a vast amount of information that can be quantified. Besides giving a gestalt of the movement, the method provides a large number of quantitative indices from the various trajectories. Patterns recorded in this way provide data that can be analysed graphically and statistically (Jones,1965; Jones,1979; Jones, Gray, Hanson & O'Connell, 1959).

In an attempt to evaluate the posture of public school students, grades 4 through 12, the New York State Education Department developed the New York State Posture Rating Test in 1966. The rating chart is used to assess 13 areas of the body, following the assumption that posture is the alignment of the body and its segments. This measurement method requires only a screen, rating chart and plumb line (Safrit, 1986).

Viewing the body posteriorly, 6 areas are observed and evaluated according to an illustrated rating chart provided for this purpose. The rating chart identifies the correct position, a slight deviation and a pronounced deviation from the correct position of the various body segments. A score is then allocated to each area according to the position: 5 points for the correct position, 3 points for a slight deviation and 1 point for a pronounced deviation.

Some of the identifiable defects which may be assessed by this procedure are the following (Safrit, 1986):

Head twisted or turned to one side; one shoulder higher than the other; lateral curvature of spine; one hip higher than the other; feet pointed out with ankles sagging and feet with lowered arches. Neck forward and chin out; chest depressed; shoulders forward; rounded upper back; rear inclination of the trunk; protruding abdomen and hollow lower back.

This often-used procedure is mechanistically oriented in its approach and only evaluates the arrangement and placement of different body segments, but makes no attempt to investigate aspects such as muscular use/integration.

2.3.4 Photography

Widely accepted and still the most valuable and suitable method of documenting postural information are photographs (Barlow, 1990; Safrit, 1986; Winter & Hall, 1978). Although unsuitable for quantitative analysis of certain aspects of posture such as trunk deformity and pelvic rotation, it is still a useful approach to use in the study of certain aspects of posture. These are:

> Accurate determinations of aspects such as the shape of the spine, pelvic tilt, vertical alignment of the body and its segments,or position of one body compartment relative to the other (Barlow, 1990; Rolf, 1977; Safrit, 1986; Woodhull *et al.,* 1985). Photographical records may yield similar results to that obtained with the New York State Posture Rating Test, discussed in section 2.3.3.

The basic underlying neuromuscular mechanisms involved in the maintenance of the standing position. Although qualitative, assessment of muscle tension in general and different body areas, may serve as a useful tool for future reassessment and correction (Barlow, 1990).

Photography is a valuable method of documenting body deformities and imbalances. A series of photographs of different views of the body taken at one session and compared with subsequent photographic sessions show the degree of improvement and effectiveness of the therapy or treatment. The static and visual nature of this measuring tool allows for repeated perusals of the subject matter. A series of photographs is ideal for deformities such as scoliosis or kyphosis where an ideal series consists of frontal and posterior views, posterior oblique, right and left lateral upright and lateral forward bending views (Winter & Hall, 1978). Postural alignment can be measured with relative rating scales or with goniometers and rulers from photographs by referencing anatomical landmarks to a rectangular grid or plumb line (Horak, 1987).

2.3.4.1 Photographic methods

Moire photography uses optical interference patterns to record the three-dimensional shape of a surface. It has been used to evaluate pelvic and trunk rotation and trunk deformity (Willner, 1979).

Stereophotogrammetry (Dangerfield, 1996) uses two cameras to take overlapping pairs of photographs. These can be analysed to produce a three-dimensional contour map of the subject. The technique has been adopted in the evaluation of structural deformity of the trunk and for posture measurement but has limited application in the study of scoliosis.

An extension of the above technique is stereoradiography where two x-ray images are used instead of photographs (Dangerfield, 1996). This technique is invasive and potentially hazardous due to the use of ionizing radiation. It has found only limited application.

Non-invasive methods of postural assessment employ either scanning light beams or projection of structural light patterns onto the subject. Such methods are accurate and offer the potential of fast acquisition and analysis of results, particularly with the recent advent of high speed image processing boards within computer systems (Dangerfield, 1996).

2.4 REFLECTIONS ON POSTURAL RESEARCH

A review of the literature on the subject of posture measurement tools, emphasises the uncertainties about what should be measured and the significance of the outcome of the measurements.

It is easy to conclude with Horak (1987: 1884) in that:

> *Simple, quantitative measures with stopwatches, scales, video recorders, photographs, wall grids and plumb lines can become powerful tools when they are applied with a basic understanding of what these measures indicate in terms of the central nervous system's control of posture.*

This underlines the experience of many researchers that observations and measurements by an untrained observer cannot always be relied on. A thorough understanding of the human nervous system, muscles and movement, is the most valuable asset when evaluating posture. In this respect researchers such as Barlow (1990), Dart (1947) and Jones (1979) made valuable contributions.

The trained and knowledgeable mind will discern muscle weaknesses, -over contraction and -imbalances when viewing the individual as a whole. The enlightened scientist or therapist is able to make an informed guess as to the cause of the imbalance, be its origin muscular, nervous, psychological or misuse. By asking the right questions as to the cause of the discerned problem, or by comparing relevant photographs, the trained worker is likely to come to the right conclusion concerning the course to take in rectifying the problem and to be able to suggest a relevant exercise or therapy.

A scientific investigation of posture is easier to theorise about than to implement. The main obstacle in the present study was a lack of funds. Fortunately the above-mentioned training and experience could compensate to a large extent for the shortage of equipment. The present study has made liberal use of the experience of leaders in the field of posture. These include great names such as Raymond Dart, Phillip Tobias, Frederick Matthias Alexander, Frank Pierce Jones, Wilfred Barlow, Ida Rolf, Moshe Feldenkrais, Wilhelm Reich and Alexander Lowen. These personalities were all, each in his or her own way, a mixture of a philosopher, a scientist, a psychologist and a therapist. The main categories of interest in this group were: muscles pertaining to posture, posture and the skeleton (Alexander, 1932, 1941, 1987, 1996; Barlow, 1990; Dart, 1946, 1947; Feldenkrais, 1972; 1985; Jones, 1979; Tobias, 1982), posture and psychology (Lowen, 1969, 1971, 1975, 1994; Reich, 1999), fascia and posture (Rolf, 1977).

With the exception of Alexander, all the above-mentioned names were highly regarded conventional scientists and academics, yet their most inspired and significant achievements on posture were the results of experience rather than experiment. They came from different parts of the world, yet each in his/her different and individual way reached the conclusion that improving the posture improves the person as a whole. The contribution of these individuals to the field of posture will be discussed in the chapters to follow. Special attention will be given to their contribution to the understanding of the mind-body implications of posture in Chapter 7.

CHAPTER 3

THE DEVELOPMENT OF UNIQUE HUMAN CHARACTERISTICS: A PALEO-ANTHROPOLOGICAL PERSPECTIVE

The past is the key to our future
(Louis Leakey, quoted by Leaky & Lewin, 1993: xv).

But how successfully man will use his emerging power to steer the course of the future may depend on how well he understands the steps by which nature formed him in the first place
(Leonard, 1973: 100).

.....all things move spirally and all growth is helical
(Dart, 1950: 265).

For me, the fundamental distinction between us and our closest relatives is not language, not our culture, not our technology. It is that we stand upright, with our lower limbs for support and locomotion and our upper limbs free from those functions
(Leakey & Lewin, 1993: 81).

The uniqueness of modern man is seen as the result of a technical-social life which tripled the size of the brain, reduced the face, and modified many other structures of the body
(Washburn & Howell, 1960: 52-53).

God never wrought miracles to convince atheism, because his ordinary works convince it
Sir Francis Bacon.

For You have made him a little lower than the angels,
And You have crowned him with glory and honour
Psalm 8:5 (New King James Version).

3.1 INTRODUCTION

Man is an erect terrestrial biped (Tobias, 1982). The origin of the upright posture in man is some of paleo-anthropology's most persistent mysteries (Gebo, 1996). The morphological changes associated with this development are unique and extreme, developments which clearly gave impetus to the common idea that man is indeed the crown of creation (Psalm 8:5). The upright posture is not genetically determined, but a case of imitation of the previous generation (Morton, 1926). It did, however, take millions of years of evolvement to shape him to the current stage of structure and function (Leonard, 1973), in a process which, according to Joubert (1997), was part of a Great Thought [for a full discussion of this issue see Pelikan (1960) and Schroeder (1997)].

3.2 FROM A SINGLE CELL TO AN UPRIGHT MULTICELLULAR CREATURE

It took an estimated 3,000 million years of trial and selection for the first multi-celled creatures to acquire an inside and outside, front and back and mirror imaged right and left sides and thus became invertebrates (Leonard, 1973).

The invertebrates then gave rise to the vertebrates. Most important was the establishment of the spinal column, 500 million years ago, followed by the skull, teeth and jaws. The process of evolving limbs began some 400 million years ago. Fins made way for land going limbs. Platelike bones of the pelvis and shoulder developed to provide bases for muscles as did the fulcrums between limbs and spine. The transition from an aquatic habitat to a terrestrial environment caused body mass to become a factor to be reckoned with (Leonard, 1973; Morton, 1926; Phelps *et al.*, 1956).

The earliest limbs were stubby, projected sideways and caused a waddling gait. Not being underneath the body, they could not carry weight efficiently, nor move very far with each step. The feet were complicated, with 5 sets of articulated bones forming the toes (Leonard, 1973; Moody, 1953; Phelps *et al.*, 1956; Romer, 1964).

By 225 million years ago, mammal-like reptiles had evolved and were equipped for walking and running. Their limbs were nearly underneath the body and could swivel more freely at both ends. Movement of the limbs was backwards and forwards, parallel to the body. Feet were turned to point forward (Leonard, 1973; also see Dart's double spiral arrangement of body musculature in 2.3.2.8).

The first true mammals (± 150 million years ago) eventually gave rise to the primate line (between 80 and 50 million years ago) that culminated in man (Morris, 1969).

3.3 THE DEVELOPMENT OF HUMAN CHARACTERISTICS

Man is the only primate with the ability to stand fully erect for long periods of time, with full extension at the knee joint and minimal expenditure of muscular energy. This kind of uprightness is singular to the human species among all living primates. His striding gait is his other unique feature (Tobias, 1982; Wolpoff, 1996).

Non-human primates are also capable of standing or walking on their two hind feet but the functional relations between hip-bones and thigh muscles are such that the hip joint is then subjected to stress and must be bent. The forward displacement of the centre of gravity causes instability and to compensate for this, the knees must be bent. When the ape stands or walks bipedally, it assumes a bent-hip, bent-knee stance or gait (Tobias, 1982).

Whether terrestrial or arboreal life (Leonard, 1973; Phelps *et al.*, 1956) immediately preceded evolvement in a *humanoid*[1] direction is still a debated

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[1] Humanoids are members of the Superfamily: *Hominoidia* which includes the Family *Hylobatidae* (gibbons and siamangs) and the Family *Pongidae* which includes the Subfamily

issue (Gebo, 1996). Many of the exclusively human features are legacies of agile arboreal and/or terrestrial travelling ancestors, who freed their hands from the burden of support. Thus carrying became one of the key elements in the development of efficient bipedalism (Gebo, 1996). Other developments included the coming forward of the eyes to the front of the face together with the achievement of stereoscopic vision and also amazingly dextrous hands (Leonard, 1973; Phelps *et al.*, 1956).

3.3.1 The transformation from a quadrupedal to an upright bipedal posture

How the first upright hominoids developed from the quadrupeds is still not clear. A few of the theories put forth in the twentieth century and most pertinent to the development of the upright posture will be discussed below.

The purpose of this discussion is to draw attention to the emergence of several physical characteristics, some of which the human shares with other primates, and some which became uniquely his - characteristics which should, as will later be pointed out in more detail in section 2.3.2, continuously be attended to in the growing child and adolescent as well as the adult, in order to cultivate and maintain human well-being in all age groups (see Chapters 4 & 7).

About 25 million years ago some monkey-like creatures became bigger and heavier, their tails became obsolete and instead of scampering and leaping, they became climbing and/or brachiating[2] (Gebo, 1996; Keith, 1923; Morris, 1969). According to Dart (1970: 20):

Anthropithecinae to which man, their closest relatives, the chimpanzees, as well as the gorillas belong (Wolpoff, 1996).

[2] Brachiation implies life in trees, and is a form of under branch, hand-over-hand locomotion which uses the forearms for support and power and the pendulum characteristics of the swinging body for forward momentum (Gebo, 1996; Wolpoff, 1996).

He has been clambering along and swinging by his hands from branches and rearing himself up on his hind legs during only the past 10 million years or less.

Scientists believed, with little proof, that the transformation to an upright stance probably occurred between 4 and 6 million years ago. A fossil find by Meave Leakey and her team in 1995 led them to announce that a species of hominid strode upright at least 4 million years ago (Gorman, 1995). Other finds date hominids to be older than the finds of Leakey (Shreeve, 1996). During the past century fossil finds led to different approaches in how man developed the upright posture. Some of these approaches will be discussed briefly with the aim to highlight those physical attributes which make up man, and basic reasons why they should still be considered in our daily lives. In this respect two issues are important; of which the first is the sequence and circumstances in which the present humanoid characteristics developed. The second issue is the importance of these changes to human physical activity at present, and the design of physical activity programmes, in so far as their purpose and content are concerned.

3.3.1.1 The historical precursors of hominid bipedalism and the upright posture

Keith (1923) proposed four sequential phases in human evolution: a pronograde[3] catarrhine monkey-like ancestor, a small bodied, orthograde[4], brachiating gibbon-like ancestor (the hylobatians), a large-bodied, orthograde arboreal ape-like ancestor (the troglodytians - eg chimpanzees) and a hominid[5] (human) phase of

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[3] Pronograde indicates standing and /or walking on four feet (Dart, 1947).

[4] Orthograde denotes a vertically upright posture (Dart, 1947; McDonough, 1994).

[5] Hominids are characterized by four uniquely morphological complexes (Wolpoff, 1996):

- The development of bipedal locomotion;
- Locomotor-related pelvic changes that altered the process of giving birth so as to make it more difficult;
- The development of language and culture;
- Alterations in masticatory function that combine some dental and craniofacial adaptations for very powerful grinding.

upright plantigrade[6] progression. The great anthropoid apes practised frequent brachiation, and this upright position probably preceded bipedalism in the early hominids (Keith, 1923). Morton (1926) also inferred that an arboreal (tree living), vertically suspended posture was the inevitable source of a terrestrial vertically supported posture. This was widely accepted and it seems as though the adaptations made for arboreal life, later imminently suited the varied life styles of a terrestrial biped (Jones, 1979; Lawson-Wood & Lawson-Wood, 1977; Morton, 1926; Phelps *et al.*, 1956; Tobias, 1982). The "brachiationist" theory later fell into disfavour (Gebo, 1996), even with Keith (1940) abandoning his own explanation.

The idea that dominated paleo-anthropology for a century, however, was that upright bipedalism developed in early hominids who lived in the Savanna. The upright position would then allow these early hominids to see over tall grass, escape predators, or walk more efficiently over long distances (Shreeve, 1996). Recently the discovery of new hominid fossils from Africa pointed in a new direction, in that upright bipedalism developed in a forest environment (Shreeve, 1996).

Kinematic studies have shown little similarity between human and primate bipedalism, but surprisingly a connection between human bipedalism and vertical climbing was found, despite a different arrangement of hip musculature (Prost, 1980) (also refer to 3.3.2.2). Today the vertical-climbing hypothesis is the most generally accepted explanation for the development of the upright posture (Fleagle, Stern, Jungers, Susman, Vangor & Wells, 1981) - an approach which suggests that climbing is the biomechanical link between brachiation and bipedalism (Fleagle *et al.,* 1981).

The discovery of the skeleton known as "Lucy" (*Austalopithecus afarensis)* in the Afar Triangle of Ethiopia in 1974 was a milestone in that it preserved enough

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[6] Plantigrade is locomotion with the entire sole and heel of the foot on the ground (Wolpoff, 1996).

detail to analyse early hominoid posture and locomotion (Lovejoy, 1988). "Lucy" walked upright, had a rather straight spine; a feature also observed in the later *Homo erectus* (Phelps *et al.,* 1956; Swanson, 1973). Of interest in "Lucy" was her long arms and curved fingers which hinted at tree climbing (Shreeve, 1996).

Phelps *et al.* (1956) and Gebo (1996), argued that climbing and its morphological associations only represent primitive hominoid adaptations, while Wolpoff (1996) added that these adaptations led to subsequent pongid skeletal adaptations for brachiation and arm hanging. Although primitive, these adaptations to vertical climbing and a brachiating type of body plan brought about significant changes in the thorax, shoulder girdle and upper extremity structure and function (see section 3.3.2.2). Gebo (1996) felt that this alone could not explain the mass bearing adaptations retained in the hands and feet of hominids. Quadrupedalism was a necessary element in travel, and it was here that ancestral African apes developed a foot morphology associated with heel-strike plantigrade footfalls, a mass bearing wrist and perhaps knuckle-walking fingers as functional-adaptive complexes for terrestrial quadrupedal travel (Gebo, 1996; Wolpoff, 1996). Hominid bipedalism continued the trend of terrestrial travelling, but now with freed hands for carrying articles while travelling (Gebo, 1996).

In 1924 Raymond Dart discovered the skull of a fossil child near Taung in the Northern Cape Province (Dart, 1925). His analysis of this skull forced the world of paleo-anthropology to appreciate that there had indeed been, at one time in Africa, ***small-brained*** but upright walking members of the family of man. He also compelled the realization that not all parts of the putative human ancestors' bodies had become hominized at the same rate or at the same time (Tobias, 1982).

Thus the development of the major characteristics of the human body form and stature **preceded the humanoid expansion of the cranium and brain and the ultimate refinement of facial characteristics**, observations already made early in this century by Dart (1925) and Morton (1927), observations which were later verified by subsequent research (Tobias, 1982).

Two aspects of the uprightness of man make the study of human posture important *viz*: 1) erectness of the trunk and 2) the bipedal stance or gait (see Tobias, 1982). Since the time of Darwin, most scientists in the field have tended to concentrate on bipedalism only when speaking of uprightness (Tobias 1982). Some workers concluded that this freed the hands for cultural activities and made handling of tools possible (Washburn & Howell, 1960). Vevers and Weiner (1963) suggested that the bipedal stance, although not essential for the emergence of tool-using activities, must have been crucial for the change from tool-using to tool-making. Washburn and Howell (1960) supported this idea, although they modified their own view by conjecturing that tool use is both the cause and effect of hominid bipedalism. According to the latter viewpoint, Washburn and Howell (1960) came to the conclusion that evolution of erect posture occurred simultaneously with the earliest use of tools. Tobias (1965; 1982), however, eloquently argued that a habitual upright posture and bipedal gait were not a necessary prerequisite either to effective tool-using or to rudimentary tool-making. He went further and stated that most of the implemental activities of man are carried out in the sitting position (Tobias, 1965). Sitting leads to greater trunk stability, and stability is a most important structural and functional consideration in the development of manual skills. Tobias (1965, 1982) deducted that trunk uprightness probably long preceded that of the fully *orthograde* (standing or walking erect) posture and might have been present some 50 to 60 million years ago and added that:

> *Perhaps students of human evolution have been inclined to take truncal erectness too much for granted and scarcely to include it in their thinking on the upright posture. Yet it was a fundamental and most ancient phase in the evolution of bipedalism* (Tobias, 1982: 12).

In the transition from the quadrupedal to brachiating habits, the functions of the spine changed somewhat. Whereas it acted as a bridge between the fore and hind limbs of the quadruped as well as a base for the suspension of the abdominal viscera, it then became the direct means of suspension of the pelvis and legs and the abdominal viscera within the bowl-like pelvis (Phelps *et al.*, 1956).

From the above it is clear that man has a rich structural and functional heritage, which eventually found expression in man's present physical characteristics and -abilities. These adaptations imply that man is designed and ideally equipped for a certain set of physical functions - functions which have anatomical, physiological and psychological implications. Small wonder then, that sedentary Modern Man is now becoming more and more aware of the value and importance of his heritage of movement, and the fact that his total well-being depends largely on it (Kraus & Raab, 1961; National Institutes of Health, 1997; Pate, Pratt, Blair, Haskell, Macera, Bouchard, Buchner, Ettinger, Heath, King, Kriska, Leon, Marcus, Morris, Paffenbarger, Patrick, Pollock, Rippe, Sallis & Wilmore, 1995).

The author is of the opinion that movements related to this heritage and human uniqueness are those that ought to be developed and implemented in all societies that have fallen prey to the modern sedentary lifestyle. Participation in **all** our ancestral physical patterns is not only a fundamental requirement in the development and maintenance of a number of essential items such as posture, muscular coordination, agility, balance - in short *poise*, but also may help maintain our functional ability throughout life. These exercises/activities should, as far as posture is concerned, serve to maintain the integrity and stability of the arms, shoulder and pelvic girdle, back thorax and lower limbs. The baby, for example, has to go through a number of apprenticeships such as crawling in order to master the upright bipedal position (Feldenkrais, 1985). Even in adults it makes good sense to return to our ancestral quadrupedal patterns such as crawling, climbing, hanging on branches, swinging whilst hanging (like gibbons) and walking (for example, our early ancestors and some present nomadic tribes), since movement in which fundamental and ancestral neural patterns are used, serves many purposes in growing children and adolescents, adults, and in those with neuromuscular dysfunction and common problems such as learning disabilities (Dart, 1947; Dennison, 1980; Feldenkrais, 1972, 1985; Gelb, 1981; Hannaford, 1995; Wikler, 1980). If the correct emphasis is placed on the proper use (employment) of all the body structures, the above type of exercises do not only serve to strengthen and maintain structures and functions in the human body, but also form part of all of which is required for total well-being.

The purpose and functional suitability of the exercises prescribed in gymnasia and physical education mainly cater for the improvement of so-called fitness parameters, posture and motor skills, by mainly concentrating on muscles **responsible for movement**, and subsequently do not address functions of those muscles primarily concerned with aspects such as neuromuscular coordination and the correct use/employment of various human structures (Armstrong, 1993; Baechle, 1994; Christaldi & Mueller, 1963; Fenton, 1973; Schrecker, 1971; Yessis, 1992). Armstrong (1993) blamed this on Christian thought in the Middle Ages which sought to mortify the body as a way to serve the spirit. Thinkers during the later Enlightenment ignored the body and located the source of a person's identity securely in the mind (Armstrong, 1993). René Descartes (1596-1650), the great French philosopher, wrote that there is nothing included in the concept of the body that belongs to the mind, and nothing in the mind that belongs to the body. To the mind Descartes ascribed spiritual things, while the body was merely a machine like a clock which worked according to mechanical and mathematical laws (Brom & Jaros, 1990). Armstrong (1993: 78) is strongly of the opinion that attitudes like these made intellectual *"'Mr Duffy's' of us all"*. Armstrong (1993: 78) added:

> *Intellectual activity came to be identified almost exclusively with logical-mathematical and linguistic abilities. Physical activity was assigned a lower-class status and restricted to the bedroom, the shipyard, and the playing field. Even today, with many Americans experiencing a kind of Renaissance in physical fitness, bodily culture is associated more often with Nautilus machines, weight training programs, and racquetball courts than with anything having to do with the mind. Athletes are all too*

> *often seen as "dumb jocks", and working with the hands in manual arts is assigned a second class status in comparison to the "higher" world of the humanities and sciences.*

The rapid changes mankind had to contend with since becoming "civilised" also took its toll (Alexander, 1987: 1-2):

> *The effect of these rapid changes upon a creature, who heretofore had experienced only slow and gradual changes of environment and was still subconsciously guided and controlled, could hardly fail to be harmful, inasmuch as many of his instincts, in consequence of these changes, came to survive their usefulness, whilst many of those new instincts which were developed during his* ***quick*** *attempts to meet the new demands of civilization proved to be unreliable. This degree of unreliability increased as time went on, until an observant minority became aware of a gradual but most serious deterioration, a deterioration, however, which unfortunately they recognized as a physical deterioration only, and which, at what must be considered as a psychological moment in human development, they attempted to set right by the adoption of "physical exercises."*

By regarding purposeful physical activity as an intelligence in its own right, however, this rift between body and mind may be healed (Armstrong, 1993). Recently an upsurge occurred in the use of exercises concerned with the development, integration of the nervous system, and the use of key postural muscles and the mind, exercises such as those developed by teachers of the Alexander Technique (Brennan, 1992; Drake, 1991), Dart, (Dart, 1946; 1947), Dennison (1980), Feldenkrais, (1972; 1985), Hanna, (1988), Hannaford (1995) and Pilates (Pilates & Miller, 1998; Robinson & Fisher, 1998; Robinson & Thomson, 1997; 1999). In Chapter 7 some activities/exercises, particularly designed for the improvement of *poise*, and more particularly posture will be discussed.

3.3.2 The effect of the advent of the upright bipedal posture on human structure and function

The way in which the body had to adjust its structure and biomechanics to the upright bipedal position may, according to Tobias (1982), be described as little short of ingenious, as will be seen in the discussion to follow. The acquisition of the upright position has been made possible by anatomical adjustments affecting every part of the skeleton and locomotor apparatus from the cranial base to the feet (Tobias, 1982).

Why the bipedal and upright posture developed in early hominoids is not clear at present [see Steudel (1996) and Tobias (1982)]. The human form of bipedalism was certainly not an adaptation for speed, since most mammals of similar body size can outrun a human (Wolpoff, 1996). The real advantages of the upright posture are manifold. Firstly it increases the visual range (Ravey, 1978). Secondly, the consistent use of the hind limbs alone frees the hands for carrying food and offspring, and manipulating the environment (Wolpoff, 1996). Thirdly, humans have evolved particularly low energy forms for locomotion. Striding allows them to cover long distances, without expending undue amounts of energy (Wolpoff, 1996), and without developing excessive metabolic heat (Wheeler, 1984). Whether the latter two served as an incentive to the early hominoids to develop an upright position is still a debatable issue, since it is doubtful whether the energetic efficiency found in modern man, was accrued by the early bipeds (Steudel, 1996). Increased locomotive efficiency and improved body temperature control, however, allow present day runners to compete in long distance events such as the Comrades marathon.

Some obligatory structural and functional changes had to be made before permanent upright posture was possible. These changes had serious consequences for the control and management of the human posture, and the function of some muscles. This should be taken into account in the daily functions of the body and in the prescription of exercise, especially to the aged, and those with a history of having been inactive for extended periods of time, with a proven postural abnormality and/or deficient muscle coordination.

Central to the adaptations for the upright posture were the pelvic bones and the spine, the muscles associated with these structures, and the way in which the body is propelled forward (Krogman, 1962; Lovejoy, 1988; Wolpoff, 1996). These changes preceded that of the changes towards a large cranium and brain size (Tobias, 1982) (also see 3.3.1). In order to understand these changes the basic mechanism responsible for the forward propulsion of the quadruped has to be considered (Figure 3.1), and the way in which this led to the eventual evolution of structures and function, to accommodate for the permanent upright posture.

3.3.2.1 Forward locomotion in the quadruped

As an introduction to this and the following section (3.3.2.2) it should be stated that locomotion and posture are physiological correlates (Phelps *et al.,* 1956). The structure and physiology of quadrupedalism and bipedalism, as well as their distinctive pelvic features reflect the different mechanics of two legged and four legged locomotion (Lovejoy, 1988). **Insight into locomotion is essential since it was quadrupedal locomotion that eventually gave rise to upright bipedalism** (Phelps *et al.,* 1956).

In the quadruped the centre of gravity lies well ahead of the hind legs (Bürger, 1986; Froissard, 1988; Krogman, 1962; Lovejoy, 1988). In order to propel itself forward the quadruped must apply a force in the opposite direction to the direction of travel. This is accomplished by extending all the joints of the hindquarters, structures which lie between the centre of gravity and the ground. Lengthening a leg therefore gives the propulsive thrust to move the animal forward (Figure 3.1). The required lever action is achieved by means of active

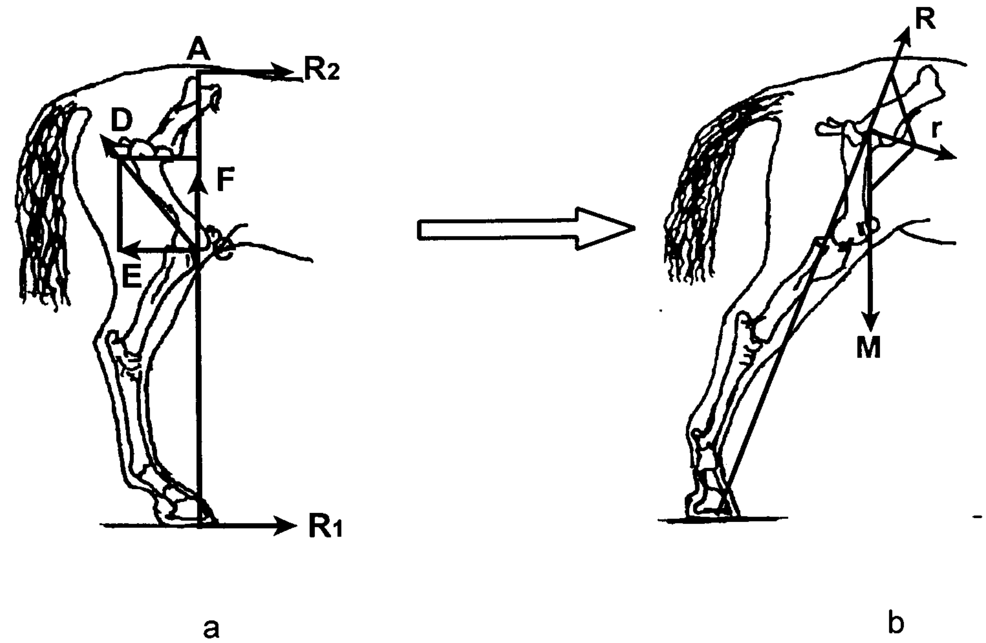

Fig. 3.1 Quadrupedal locomotion. a. The hind limb as a propulsive lever. AB = long limb axis, hip joint to toes. CD = line of action of hip extensor muscles, which resolves in force E which extends hip, and force C along the long axis, AB. R_1 = reaction of ground against backward pressure of foot. R_2 = reaction of acetabulum against backward pressure of femur. Forces E and R_2 produces a couple which extends the hip joint, forces $R_1 \cdot R_2$ and E have bending action on the limb long axis. b. The hind limb as a propulsive strut. W = mass acting through the hip joint. R = reaction from ground. r = resultant of M and R causing forward movement of the trunk (Adapted from Belasik, 1994; Krogman, 1962; Lovejoy, 1988).

extension of the hip joint by contraction of the well developed *gluteus medius* and *gluteus minimus* muscles, resulting in a backward pressure of the foot on the ground (Figure 3.1) (Krogman, 1962; Lovejoy, 1988). During this phase the knee and ankle joints are kept slightly bent, and their passive extension, which may occur due to the pressure of the foot on the supporting surface, is prevented by the action of the strong extensor muscles in the hip joint. This is where muscles that span two joints - in this case the hip- and knee joints for the hamstrings - exert their effect (Krogman, 1962). When the long axis from the hip joint centre to the ground contact slopes down - and backward, the hind limb acts as a propulsive strut. The portion of the body mass resting on the extended (retracted) limb plus the reaction from the ground gives the resultant force required to propel the body forward (Krogman, 1962; Lovejoy, 1988), hence, the hind limb is a **passive** propulsive strut. When the limb is well retracted, extension of the knee is useful in the last part of the propulsive phase, since the limb now functions as a propulsive strut. Complete extension of the knee is prevented by the action of the *hamstrings* and the *gastrocnemius* muscles.

Because the hip- and knee joints are tightly flexed at the start of each propulsion cycle their extension can be prolonged and powerful (Lovejoy, 1988).

3.3.2.2 Bipedal locomotion

The upright human posture, in contrast, places the centre of gravity almost directly over the ankle joint (Kendall & McCreary, 1983; Lovejoy, 1988). Although this arrangement allows the human to maintain the upright position with relatively little muscle effort (Krogman, 1962; McArdle, Katch & Katch, 1991), it created unique problems for the upright biped in so far as forward locomotion and maintaining of balance were concerned.

If the standing upright human mimics the action of the quadruped hind limb, and lengthens his legs by straightening the knee and rotating the ankle, the direction of the thrust will be vertical, and the individual will only manage to stand on his toes (Lovejoy, 1988).

Upright walking on two legs is at the best of times a precarious affair, something which led to Napier's (1967: 56) statement that human walking is *"a unique activity during which the body, step by step, teeters on the edge of a catastrophe."* The great teacher of physical anthropology, Hooton, referred to man as *"this tottering biped"* (Tobias, 1982: 16), or as Gorman (1981) aptly commented that human gait is a constant play between loss and recovery of equilibrium.

In order to propel the upright body *forward* the human has to reposition its centre of gravity ahead of one leg (Lovejoy, 1988). This is accomplished when the calf muscles relax and the walker's body sways forward. The sway then places the centre of gravity of the body in front of the normal pedestal formed by standing on the two feet. This necessitates one of the two legs to swing forward, to keep the trunk from falling, and when his foot makes contact with the ground, the area of the supporting pedestal is widened, and the gravity line again rests within it. The pelvis plays an important role in this action; its degree of rotation determines the distance the swinging leg can move forward, and its muscles keep the body balanced while the leg is swinging (also see 3.3.2.3.2) (Napier, 1967).

During the forward swinging of the leading leg the trailing leg is then lengthened, which allows this leg to behave as a propulsive strut (Krogman, 1962; Lovejoy, 1988) (Figure 3.2). This is accomplished by pushing against the ground first with the ball of the foot and then with the big toe (Napier, 1967).

In erect walking the action of the *gluteus maximus* acts on the hip, the *quadriceps* on the knee, and the *soleus* on the ankle in order to preserve the respective joint integrity. Since hip extension contributes very little to bipedal locomotion, active propulsive thrust is accomplished by plantar flexion of the ankle and extension of the knee (Krogman, 1962; Lovejoy, 1988). This action then lengthens the trailing limb, thus producing its forward thrust on the surface, while the other leg is swung forward to prevent the trunk from falling (Lovejoy, 1988).

3.3.2.3 Anatomical changes required for the upright position in the human

Undoubtedly, an erect squatting posture was as common among the early mammals, as it is among the modern ones. This act, however, did not, and still does not, require any change in structure, for squatting merely required a backward swing of the body and thighs upon the knees - a movement which was, and still is, well within the normal range of knee joint and ankle joint movement (Morton, 1926).

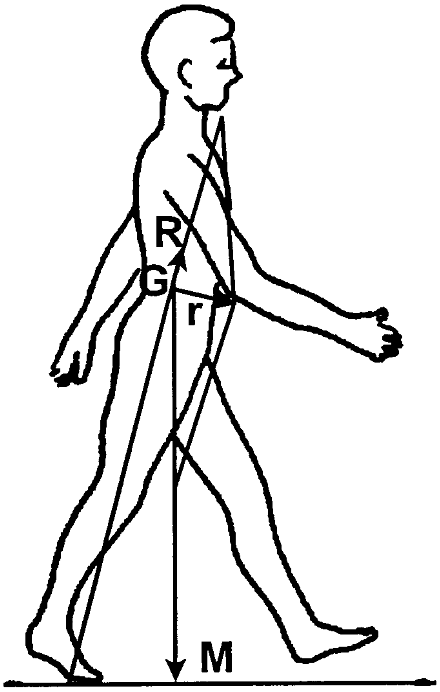

Fig. 3.2 Human locomotion (Krogman, 1962; Lovejoy, 1988; Napier, 1967) showing the lower leg as propulsive strut. M = mass acting through the centre of gravity (G), R = reaction from the ground, r = resultant of M and R. Note pelvic position in comparison to that seen in the quadruped (Figure 3.1).

Many quadrupeds are able to raise themselves into an upright position on extended legs for short periods of time. This, however can only be accomplished by an abnormal motion of the hips in non-humans, something for which they are entirely unfitted (Morton, 1926).

With the new bipedal position new roles for structures in the human body were necessary. These changes are listed below in Table 3.1, those pertaining to this study will be discussed in more detail. Probably the most important of these changes were those in the lower limb and pelvic area (Figure 3.3) (Hansson, 1945; Krogman, 1962; Lovejoy, 1988; Napier, 1967; Wolpoff, 1996). Perusal of

1945; Krogman, 1962; Lovejoy, 1988; Napier, 1967; Wolpoff, 1996). Perusal of these adaptations will reveal that all of the activities found in the vertical climbers and the brachiating primates are those that come naturally in man - activities which presently are still found in our repertoire of movement. Examples of these are tree and rock climbing, hanging from one support and then swinging from one to the other as in gymnastics.

Lewis (1972) postulated that the knuckle walking in African apes was the result of limitations of their brachiating capabilities, while Tuttle (1975) argued that these anatomical adaptations evolved together.

Table 3.1 *Anatomical features necessary for brachiation, vertical climbing and upright bipedalism. The table shows both hominid uniquenesses and characters that reflect the human climbing and arboreal ancestry (Hansson, 1945; Marzke, Wulstein & Viegas, 1992; Phelps et al., 1956; Wolpoff, 1996).*

ANATOMICAL SITES	ANATOMICAL FEATURES		
	Vertical climbing	Brachiation	Bipedalism
Upper limbs	Large primates use long and powerful arms (especially at elbow). Grip is with support held diagonally across the fingers.	Powerful grip and longer arms, much longer fingers to surround support (example branch). Grip much stronger, diagonal with fingers, but without involvement of thumb and palm. Finger bones long and curved.	Powerful grip and long arms long fingers. Grip is between thumb and fingers. Human is only primate with precision grip between finger(s) and thumb.
Shoulder girdle	Climbing does not necessarily require a flattened chest. In a flattened chest, however, the scapulae could migrate posteriorly, with the development of a long collar bone with an outward-facing shoulder joint. The shoulder joint itself is shallow - allowing wider motions.	Scapulae migrated posteriorly. Glenoid fossa cranially oriented.	Scapulae migrated posteriorly. Glenoid fossa cranially oriented.

ANATOMICAL SITES	ANATOMICAL FEATURES		
	Vertical climbing	Brachiation	Bipedalism
Spine & thorax	Thorax funnel shaped and probably flattened.	Spine and trunk short with only three lumbar vertebrae. Chest funnel shaped, short and flattened.	Trunk not shortened. Spine has 2 primary and 2 secondary curves, with 7 cervical, 12 thoracic and 5 lumbar vertebrae. The thorax is funnel shaped and flattened.
Pelvis	Sacrum and ilium long, tilted horizontally.	Sacrum and ilium long, tilted horizontally.	Sacrum and *ilia* tilted vertically. Shortening of sacrum, ischium and iliac bones. Broadening of pelvic rim. Reorganization of musculature associated with pelvis.
Lower limbs	Short legs, grasping feet and offset big toes.	Grasping feet and offset big toes.	Loss of grasping ability. Adapted for mass bearing and plantigrade locomotion.

3.3.2.3.1 Changes in the structure of the sacrum and ilium

Undoubtedly, the human upright posture has been derived from the horizontal posture of the ancient quadruped (Phelps *et al.*, 1956). In the quadruped position the iliac bones and the sacrum lie more or less in a horizontal position (Figures 3.3 & 3.4), and they do not in essence fulfil the function of supporting the mass of the upper body. When the quadruped such as a chimpanzee tries to stand upright, the situation, however, changes. Both the sacrum and iliac bones are then tilted into a vertical position and now have to support the upright trunk, with a skeletal and muscular system functioning at a biomechanical disadvantage by having the centre of gravity well above their hip joints (see 3.3.2.3.2 below). In the upright standing chimpanzee the sacrum is tilted backwards relative to the ilium (Figures. 3.3 & 3.4), and supports the upright spine when the chimpanzee leans slightly forward (Wolpoff, 1996), which pushes the centre of gravity line well in front of the ankle joint, resulting in an unstable position, requiring considerable muscle output to maintain.

Once man was on its feet, the result was that all the mass of the body had to be transmitted downwards through the pelvis and legs (Tobias, 1982).

In the upright human the function of the sacrum became one of supporting the entire mass of the upper body (Wolpoff, 1996). To keep the centre of gravity line passing through the acetabula, the knee- and ankle joints the sacrum had to be tilted forward relative to the ilium (the advantage of this arrangement will be discussed in 3.3.2.3.2 below). A second change brought the centre of gravity point of the upper body closer to the hip joints. This was accomplished by the shortening of the height of the ilium and the sacrum. The shortening of the ilium brought the articular surface of the last lumbar vertebra nearer to the hip joint, and enabled the mass of the trunk to be transmitted more directly to the lower limb, thus enhancing stability (Campbell, 1974).

The sacrum also became broad and flaring (Hansson, 1945; Kummer, 1975; Lovejoy, 1988; Pilbeam, 1990; Wolpoff, 1996). This and the backward bending of the ilium affected the posterior displacement of the sacroiliac articulation, thus equipping the human innominate bone better to carry and transmit mass (stress) between the axial skeleton and limbs, while at the same time providing an adequate birth canal (Gorman, 1981; Tobias, 1982).

The lumbar lordosis, the thoracic kyphosis and cervical lordosis of the human vertebral column were brought about by the changes in the orientation of the sacrum, in order to bring the centre of gravity of the upright body above the hip-joints, and to ensure that the body mass is more or less evenly distributed in front or back of the line of gravity (Gorman, 1981; Wolpoff, 1996).

The pelvic rim broadened in order to provide firstly an increased leverage of the balancing (abductor) muscles and secondly to produce a broader bowl-like surface in order to provide support to the viscera (in the quadruped the visceral support is the responsibility of the ribs) (Wolpoff, 1996). Bipedalism also caused the development of a prominent iliac pillar which is uniquely human.

This structure extends from the tubercle of the iliac crest down to the posterior part of the acetabulum and helps to bear the compression exerted by the *gluteus medius* muscle when it tilts the pelvis during human walking, and so draws the trunk over the stationary limb, enabling the contralateral limb to clear the ground (Tobias, 1982).

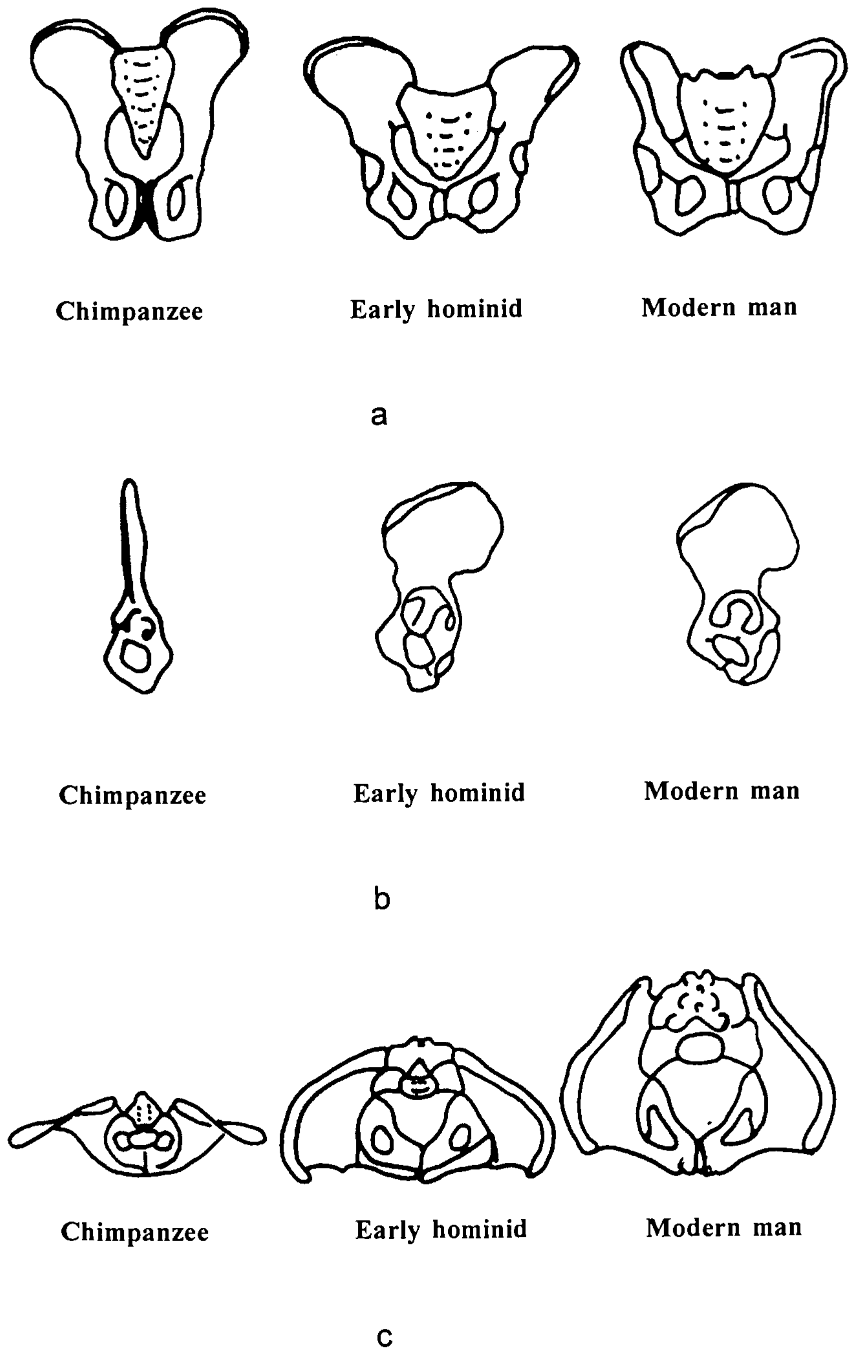

Fig. 3.3 **Front (a), side (b) and top (c) views of the pelvis of a chimpanzee, early hominoid and modern man. Note the shortening of the sacrum and iliac bones, the broadening and rotation of the pelvic rim. [a and b from Wolpoff, (1996), and c from Lovejoy, (1988)].**

3.3.2.3.2 Changes in the pelvic musculature

The need to stabilize an upright torso required a dramatic change in the body musculature. The most conspicuous change occurred in the *gluteus maximus* muscle, which is a relatively minor muscle in the quadruped (see chimpanzee in Figure 3.4), into the **largest and most powerful muscle** in the human body (Gorman, 1981; Lovejoy, 1988; Wolpoff, 1996). The *gluteus maximus* originates over much of the back of the pelvis and is attached to the back and side of the femur (Gorman, 1981; Lovejoy, 1988; Williams & Warwick, 1980; Wolpoff, 1996). As such it is classified as a hip extensor, and many classical anatomists believed that it served as the major propulsive muscle in upright walking (Lovejoy, 1988; Wolpoff, 1996). This is achieved, according to them, by the active extension of the hip, an action which results in a backward pressure of the foot on the ground similar to that seen in the quadruped (Krogman, 1962; Lovejoy, 1988). In the human, however, the hip is almost completely extended in erect walking and running, and therefore the contribution of the *gluteus maximus* to this function is limited (Lovejoy, 1988). Why then the hypertrophy of this muscle? This muscle fulfils the role of a **stabilizer of the trunk**, and when it acts from below (femur) it rotates the pelvis backwards, thus shifting the body's centre of gravity backwards. This is done in conjunction with the hamstrings (Gorman, 1981). The muscle`s role as trunk stabilizer is best seen in walking and running. When the human runs the trunk tends to flex forward at each foot strike due to its momentum; the *gluteus* then prevents the trunk from pitching forward (Lovejoy, 1988, Wolpoff, 1996). It is the author's opinion that this function is lost in many individuals during standing and even sitting, who then rely on muscles in the lower back in order to remain in the upright position. This issue will be discussed in more detail in section 3.4.

A major modification of the pelvis made the stabilizing task of the *gluteus* considerably easier (Lovejoy, 1988). In the chimpanzee and other primates the pelvic iliac bones are considerably longer than they are in humans. This lengthens the torso of these animals when they rear up - which disadvantages them by having their centre of gravity well above their hip joints. Biomechanically the animal will be at a handicap, since the trunk now forms a long lever arm, which makes it difficult to maintain the upright position for extended periods. A *gluteus maximus* working to hold such a trunk upright will fatigue rapidly (Lovejoy, 1988; Wolpoff, 1996).

In the human the problem of the upward shifting of the centre of gravity was elegantly solved by the dramatic shortening of the iliac bones and curving the innominate bone in a lordotic sense (backward rotation of the ilium) so that the sacrum and spine could be brought in a more upright position, bringing the trunk`s centre of gravity much closer to the hip joints, thus reducing the muscle`s mechanical disadvantage (Figures 3.3 & 3.4, and section 3.2.3.1) (Hansson, 1945; Kummer, 1975; Lovejoy, 1988; Pilbeam, 1990; Wolpoff, 1996).

In the quadrupedal locomotion the hamstrings serve as powerful hip joint extensors (see 3.3.2.1). In the biped, by contrast, the function of the hamstrings decreased in importance in that they do not serve to extend the lower limb any more but to **control** it (Lovejoy, 1988). In man they now serve to stabilize and flex the knee-joint, and decelerate the forward swinging leg during walking and running (Baratta, Solomonow, Zhou, Letson, Chuinard, & D`Ambrosia, 1988; Lovejoy, 1988; Wolpoff, 1996). As a consequence of the decreasing importance of the hamstrings the lower rear portion of the pelvis, where they originate, namely the ischium, became shorter (Wolpoff, 1996). In an upright positioned pelvis stiff or shortened hamstrings will, by way of its small lever action on the pelvis, have little effect on the pelvic position, but will of course reduce the range of motion during hip flexion. This leads one automatically to question the motivation of many to resort to stretching of the hamstrings in order to, amongst other things, alleviate low back pain (Cailliet, 1995).

The anterior gluteal muscles (*gluteus medius* & *gluteus minimus*), which in the quadruped play an important role in hip extension during locomotion (Sigmon, 1975, and also see 3.3.2.1), assume a new role in the human. These muscles now acquire a stabilizing function, and also take on the function of abductors. The stabilizing function is best demonstrated during standing on one leg (something which occurs naturally during walking and running). On their own the pelvis and trunk will tip toward the unsupported side, but this is prevented from happening by the action of the anterior gluteals (Lovejoy, 1988; Sigmon, 1975).

The transformation of the anterior *gluteals* from propulsive muscles to stabilizing ones necessitated major changes in their position and pelvic structure. Firstly it required the forward rotation of each ilium (see Figure 3.3), and with it the upper origin of the anterior *gluteals* (Figure 3.4). Their insertion are now on the greater trochanter of the femur (Figures 3.4 & 3.5) (Lovejoy, 1988; Napier, 1967; Sigmon, 1975), an arrangement which suits their abduction and stabilizing function perfectly.

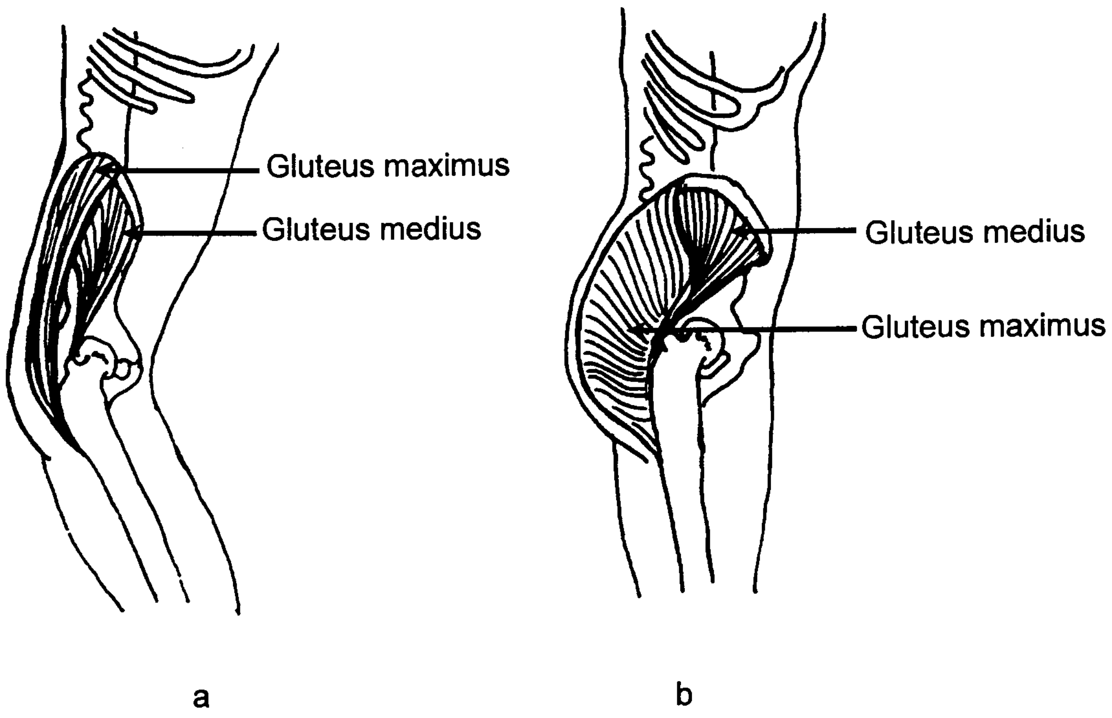

Fig. 3.4 **Anatomical adaptations in the pelvic area for the upright posture. (a) Quadruped (chimpanzee), (b) Human. Note new positions of muscles such as the *gluteus maximus*, and *gluteus medius* (Phelps *et al.*, 1956).**

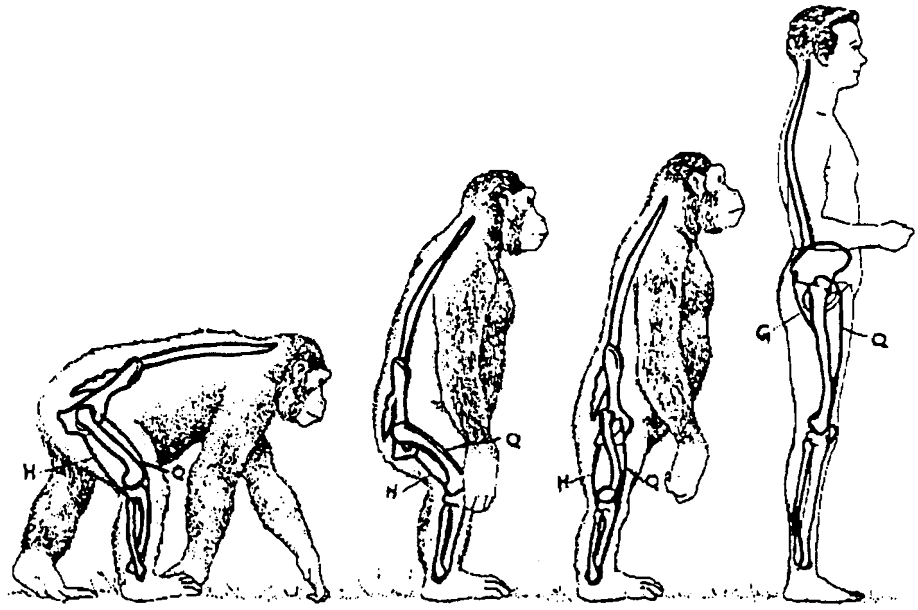

Fig. 3.5 **Quadrupedalism and bipedalism in a chimpanzee compared with bipedal man. G = Gluteus maximus, H = Hamstrings and Q = Quadriceps (Wolpoff, 1996).**

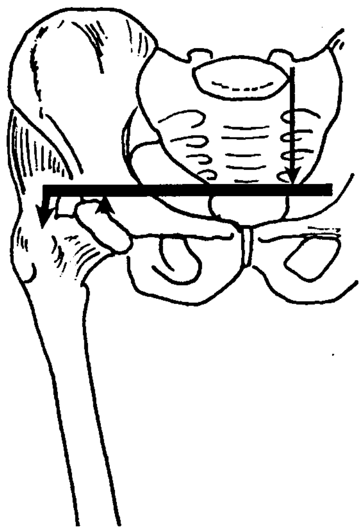

Fig. 3.6 **The function of the hip abductors in counterbalancing the torso when standing on one leg or with the body mass unevenly distributed. Note the long lever arm of the trunk in comparison to that of the abductors. The fulcrum is the hip joint (Lovejoy, 1988).**

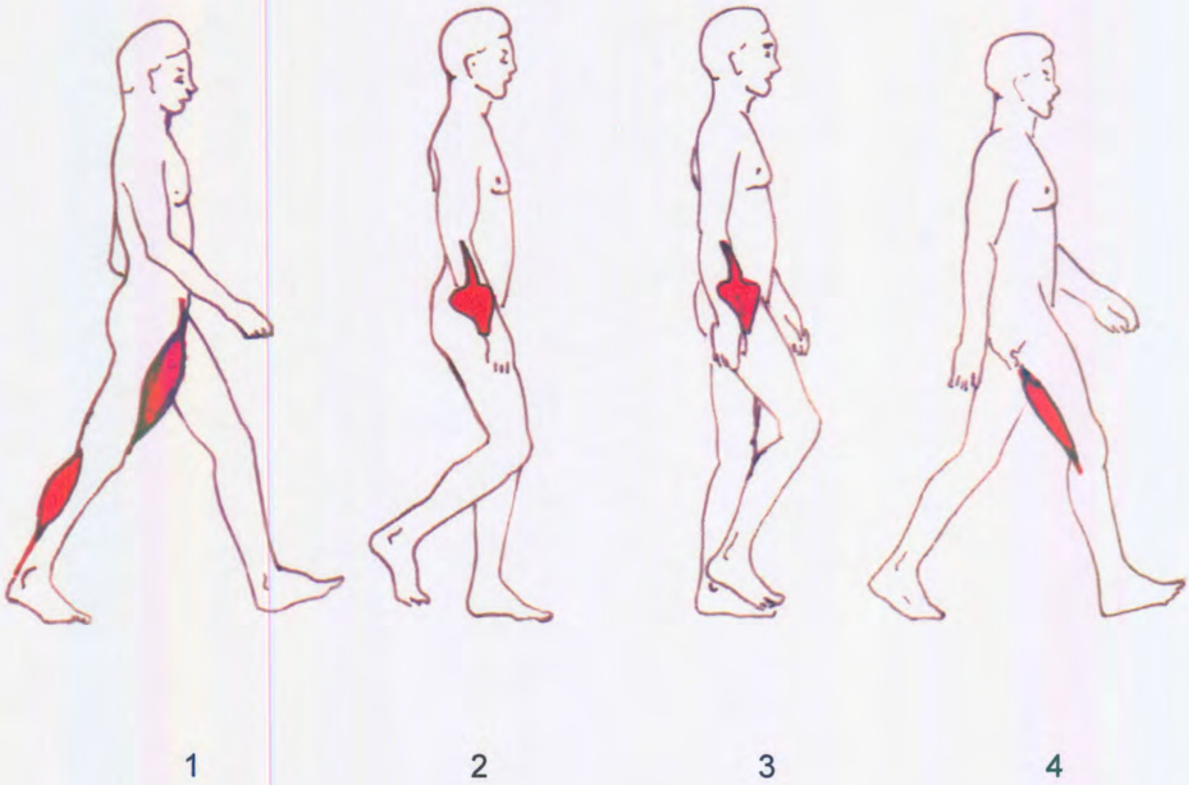

Fig. 3.7 Muscle activity during human striding. As the mass-bearing (right) leg becomes angled behind the torso (1) two muscle groups contract to extend it - the plantarflexors, which rotate the foot around the ankle, and the quadriceps, which straighten the knee - generating a "ground reaction" that propels the body forward. The right foot then leaves the ground as mass is transferred to the opposite leg. Contraction of the right *iliopsoas* begins to tug the right leg forward (2) while the knee flexes passively (3). Near the end of the right leg's swing the hamstrings contract to stop the forward motion of the right leg, and the foot is planted (4) (Lovejoy, 1988; Napier, 1967; Wolpoff, 1996).

In human beings, then, the demands of stabilizing the upright pelvis and controlling the limb occupy several muscle groups that serve for propulsion in quadrupeds. Only two muscle groups, the quadriceps and the plantar flexors, are left in positions to enable them to produce forward thrust during forward locomotion (Lovejoy, 1988), a situation which could be responsible for the human`s lack of speed when compared to that of quadrupeds.

Krogman (1962) postulated that human (as contrasted with hominid) evolution may well have begun in the pelvis. Three stages may be envisioned: 1) erect posture, due to changes in the size and proportions of the ilium; 2) balance, due to iliac-tubercle and iliac pillar changes; and 3) more nearly perfect bipedalism, as in man, due to ischial shortening and tubercle changes. This supports Morton (1926), who maintained that humanoid adaptations of the locomotor apparatus for terrestrial bipedalism preceded and outstripped the gross appearance of human changes in other structures. In any event, as seen above, the pelvis and hip region have been radically remodelled, producing low and broad iliac blades with outwardly oriented gluteal muscles permitting controlled rotation and tilt of the pelvis to minimize the centre of gravity displacement. A linked pattern of hip, knee and ankle flexion and extension and a particular pattern of weight transmission through the foot also emerged (Pilbeam, 1990).

Phelps *et al.* (1956: 11) were of a different opinion in that:

> *Man's hip joint mechanism is less well adapted than the shoulder. It is a much later acquisition. The lumbo-sacral junction is even less adapted. It is still in a transitory state of evolution.*

This is more in agreement with the recent viewpoint that changes in the shoulder and arm were primitive adaptations to life in the trees (Gebo, 1996).

3.3.2.4 Changes in the structure and function of the spine, thorax and neck

Function and structure of the spine adapted again when brachiation changed to terrestrial bipedalism. In brachiation it acted as a tactile support when hands were used in locomotion; in stance it became the supporting column. The rounded forward spinal curve, which previously extended throughout the length of the spine, remained, but was concentrated in the upper dorsal region (Phelps *et al.*, 1956).

The size of the vertebral bodies increases from the cervical area to the lumbar area to compensate for the increase in pressure from the head to the pelvis (Gorman, 1981; Williams & Warwick, 1980). The shapes of the vertebra are such that they cause the very human characteristic of the more curved spine. The cervical and lumbar areas of the human spinal column curve strongly convexly forward, while the thoracic and sacral regions have a concave curve. The most human features of the vertebral arrangement are the strong concave curvature of the sacrum and the powerful promontory at the lumbo-sacral border (Schultz, 1936, cited by Tobias, 1982).

The top of the spine migrated from its position in the back of the skull, to a point almost directly under the skull (Leonard, 1973). The brain developed upward and backward and the increase in size was offset by a reduction in the snout. The combination of facial flattening and bipedal posture resulted in a foramen magnum being relatively far forward (Pilbeam, 1990). Thus the cranium could be balanced over the centre of gravity of the body (Phelps *et al.*, 1956, Tobias, 1982). With an erect posture more of the mass of the head is carried directly by the neck vertebrae. The human head is thus well-balanced on the atlas and therefore does not need large muscles to keep it in place as is the case with the other primates. Subsequently the spinous processes of the cervical vertebrae decreased, reflecting the lesser role of the nuchal muscles (Tobias, 1982, 1983). Poking the head forward is a regression towards the ancestral ape-like condition, and puts unnecessary tension on the muscles in the neck, the upper back and shoulder girdle. This habit requires the use of long spinous processes such as found in the cervical spine of the ape (Tobias, 1982).

The elongated sternum of the human skeleton is a typical mammalian structure, probably confined to land vertebrates as it is absent in fish (Gorman, 1981; Williams & Warwick, 1980). It is considered as being part of the axial skeleton but has been associated with the shoulder girdle and ribs from its earliest appearance. Man has a flatter thoracic cage, compared to that of other primates and subsequently, the sternum lies closer to the spinal column (Tobias, 1982). The bodies of the thoracic spinal vertebra project well forward into the thoracic cavity, encroaching into the thoracic space and causing the horizontal section of the thorax to be kidney-shaped (Goldthwait *et al.,* 1952; Gorman, 1981).

The shape of the thorax is a matter of considerable significance from the point of view of body mechanics. According to Goldthwait *et al.* (1952) at the level of the ninth rib the antero-posterior diameter should be about two thirds of the lateral diameter and the circumference at this level should be greater than in the axillary region. The sternum in the erect posture should be convex anteriorly, with the lower end considerably anterior to the upper. Goldthwait *et al.'s* (1952) ideal shape of the thorax in the horizontal section seems rounder compared to the phylogenetically developed genetic shape proposed by Tobias (1982) and current average shape (Martini, 1992; Rolf, 1977; Tobias, 1982). Horizontal sections of this body part are not common in publications and only an approximate comparison can be made. However, from a biomechanical view the barrel shape of the monkey and ape chest is a sign of poor body mechanics when found in the human (Goldthwait *et al.*, 1952).

The curve of the thoracic spine is a remainder of the original foetal (or primary) curve which extended throughout the length of the spine. Throughout the phylogenetic development of man, the change in the thoracic spine was less marked than in the rest of the spine because the ribs and attachments of the chest discouraged flexibility (Phelps *et al.*, 1956). Flexion in the region is of relatively small range, extension is almost non-existent (Gorman, 1982).

3.3.2.5 Changes in the structure and function of the cranium

Kruger (1988) is of the opinion that man could only have a developed a human face in the presence of an upright posture. This became possible since the mouth lost its function of fighting or catching/holding prey. The massive jaw muscles could be dispensed with, and since the jaw is now less important in the self preservation of the individual, the human skull could develop upwards in order to accommodate a larger brain.

Because of the upright posture, smell has lost its orientative function, while vision and hearing have assumed domination. In the animal all structures associated with grasping and gripping, such as the jaws and muzzle are placed in the viceline of the eyes. The reason for this is that the arms, now being free to grasp, hold and carry, have taken over these functions (Kruger, 1988). These changes allowed the human to use the eyes to:

> *.....concentrate with an open look at distant things and rest fully on them, viewing them with detached interest and of wondering. This changing or changing of the human face into a seeing face is well expressed in the German word 'Gesicht', the Afrikaans 'gesig' and the English 'visage'* (Kruger, 1988: 46).

Having transformed the prominent animal and primate jaws into human mouths, one of the conditions for the development of language were fulfilled (Kruger, 1988). The front to back shortening of the human skull also ensured that the skull could be balanced with minimal muscular effort on the top of the cervical spine (see 3.3.2.4) (Tobias, 1982).

When highly developed vision was required for accurate targeting, binocular vision was acquired, giving three-dimensional vision and accurate assessment of distance. This happened when the eyes were brought to the front of the face, below the large brain. This meant that our ancestors had to tilt their heads backwards in order to see the front - producing the first concave curve of the spine, that of the neck (Barker, 1985).

3.3.2.6 Changes in the structure and function of the shoulder girdle and upper limbs

Phelps *et al.*, (1956) held the theory of two distinct stages in prehuman development. The first was the preparatory stage when quadrupeds grew upright into tree-living types and the second stage began when they moved to the ground and underwent the final transitions towards humanity - taking the first step on the road to modern humans (Leakey, 1995). This first adaptation required profound anatomical changes, especially to the arms and hands which had been used as forelimbs for walking, then for suspension from the trees and finally achieving freedom for tool-using when they became the upper extremities. During this process the shoulder girdle bones and muscles altered their positions and number. The scapulae migrated posteriorly from the lateral position and the *pectoralis minor* insertion shifted from the humerus to the *coracoid* process. Shoulder movements then became complex and precise (Phelps *et al.*, 1956). Waterland and Munson (1964) referred to the shoulder girdle and -joint as the most mobile arthrodial complex in the body, also noting that it has the same cortical area of representation in the brain as the little finger. The motor coordination of the multi-jointed upper extremities seems to be dependent on appropriate shoulder girdle modulation. The scapula, clavicle and shoulder joint form a mechanical unit joining the rest of the skeleton at the sterno-clavicular joint. In the human the clavicle rotates around the sternum, the scapula around the clavicle and the humerus around the scapula (Gorman, 1981).

Human shoulder structures and their positions were probably developed during the arboreal era. In this stage locomotion was divided between swinging from branches and walking on the ground. Suspension of the total body mass from the arms caused considerable traction and the structures of the shoulder joint, scapula and clavicle were profoundly modified. The greatest change was the development of power while the arms were in circumduction and in particular, abduction. Man is unique in this respect - he can move his arms in an infinite variety of positions and retain the grasping power in all of them (Gorman, 1981; Phelps *et al.*, 1956).

In the quadruped the scapulae lie symmetrically laterally on the sides of the thorax (Phelps *et al.*, 1956; Tobias, 1982). With the additional functions and movements of the arms, the scapulae came to lie further back on the thoracic wall, side by side, decreasing the distance between the scapulae and the midline of the back (Gorman, 1981; Phelps *et al.*, 1956).

The clavicle is absent or reduced in many running mammals (Gorman, 1981; Phelps *et al.*, 1956). In primates it was strengthened during the development of the arms for climbing and grasping activities and serves as a mobile strut for the limb to be steadied in a variety of positions (Gorman, 1981; Phelps *et al.*, 1956). In man this seemingly innocuous clavicle is central to the balance of the shoulder girdle and very important to the structure of the body as a whole (Rolf, 1977).

The size, shape and position of modern man's scapulae and clavicles seem to have developed their full and optimal potential during his arboreal stage (Phelps *et al.*, 1956). Present day's misuse leads to deformed shapes of the chest such as kyphosis, "wings" and hollow chest. One may speculate that doing exercises which emulate the movements of the arboreal stage, in other words, swinging from elevated supports, might return the bony structures of the shoulder girdle to their ideal locations.

A grasping type of hand evolved with the thumb becoming opposed to the fingers; shoulder girdle muscles altered their positions and number; the scapula migrated posteriorly and the *pectoralis minor* insertion shifted from the humerus to the coracoid process. Shoulder movements thus became complex and precise (Phelps *et al.*, 1956; Wolpoff, 1996). The clavicle was strengthened to give a firmer anchor for the powerful shoulder girdle muscles (Leonard, 1973).

3.3.2.7 Changes in the structure and function of the lower limbs

The head and neck of the femur, as well as the supra-acetabular region of the ilium of the human, adapted to mass bearing internally, by developing specialized trajectories of cancellous bone (Tobias, 1982). Externally the head of the femur and the acetabulum became relatively much larger in man, with a femur having a relatively long neck, straight and slender shaft, narrower condylar surface, with the line of mass passing through the lateral condyle (Dangerfield, 1996; Tobias, 1982).

The angle of the neck of the femur is depressed from 150 degrees to 125 in the adult human. The femur head and neck are rotated forward, so that during standing, most of the head faces forward. The femur is also bowed forward in man. While most quadruped knees are held in flexion [see literature on conformation of animals such as horses (Bürger, 1986) and dogs (Canadian Kennel Club, 1982)], in man the knee is held in extension (Hansson, 1945).

In quadrupeds the use of the **anterior** part of the feet, metatarsals and digits constitute the most important contact with the supporting surface such as the ground or tree branches. In the plantigrade foot the most important contact was moved backwards to a position between the heel and the metatarsal bones, especially as proficiency in plantigrade locomotion increased (Phelps *et al.,* 1956). The tarsal and metatarsal bones are in closer apposition than are the corresponding bones in the other primates (Hansson, 1945; Wolpoff, 1996). In quadrupeds all digits are normally held in flexion, but in the human the big toe is held in extension and the other toes in flexion (Hansson, 1945).

Lack of divergence of the big toe and loss of the grasping function of the foot are the most obvious modifications in the development of the human foot. The toes became shorter and weaker, the foot narrower, the calcaneus elongated and flexibility in the foot decreased. The human foot became a highly specialized organ of support and bipedal locomotion. The calcaneus became enlarged to give a firm base for mass bearing and greater leverage for the Achilles tendon during locomotion (Barker, 1985; Lawson-Wood & Lawson-Wood, 1977; Phelps *et al.*, 1956; Tobias, 1982). Gorman (1981: Section II, 7), however, emphasised that the evolution of the calcaneal lever system is a mammalian, and not a human modification:

> *Its high development in the human foot and the fact that other primate feet are more like hands, may give rise even to the superficial assumption that it is a human characteristic exclusively.*

Lewis (1972) has shown that there have been a number of rather subtle changes of individual tarsal and metatarsal bones and their articulations. He proposed that instead of the big toe becoming adducted towards the other toes, it rather appears that the lateral four digits became realigned towards the great toe and the subtalar axis, while at the same time the bones of the first digital ray became relatively larger.

The double arch of human feet - the transverse and the very well developed longitudinal arch - was an adaptation to balance and mass support during upright standing and locomotion (Gorman, 1981; Hansson, 1945; Latimer & Lovejoy, 1989). One load line runs through the human big toe, and even though the human foot is narrowed in comparison to that of the other primates, a new load line has evolved along the fifth ray (Lewis, 1972; also see Gorman, 1981). In this way during standing, the body mass of upright man is distributed through a left and right tripod, each comprising three mass-bearing centres: The heel, the big toe and small toe (Lewis, 1980).

During locomotion, however, the longitudinal arch serves a critical additional function by producing leverage for the muscles that are important in toe-off (see 2.3.2.2) - a function non-human primates do not have - and plantar flexing as the foot leaves the ground (Gorman, 1981; Latimer & Lovejoy, 1989, 1990a,b; Martin & Coe, 1991; Wolpoff, 1996).

Modern shoes, in view of the fact that they favour narrowing at the toes, tend to work against what was intended for proper functioning of the foot, in that the big toe is now abducted towards those lateral to it. By doing so some of the foot's most crucial functions are minimised, or even abolished, such as its mass bearing abilities and its provision of leverage for some muscles during toe off.

3.3.2.8 The double-spiral arrangement of the body musculature

> *In restoring the normal alignment of the head and neck with the trunk, they (the righting reactions) give man one of the most*

> *important features of human mobility; that is, rotation within the body axis, between the shoulders and the pelvis. For all our movements are in reality rotatory and even our joint surfaces are obliquely orientated* (Bobath, 1980: 6).

Dart's (1925, 1946, 1947, 1950, 1970) interest in the study of human evolution, the control of the body musculature and postural problems led to the eventual discovery of the double spiral arrangement of voluntary musculature, and from this discovery he was able to explain not only the development of *poise* (see Chapter 4) in man, but also the origins of malposture with great clarity.

In the first half of this century Dart (1947: 81) expressed concern about the lack of understanding *in respect of the apparatus of movement, that is the muscles, the nerves that supply them, and the manner in which they move the parts of the body by pulling on the bones.* Today this sentiment still applies, for although voluminous literature is available on the structure and function of different nervous structures and muscles, reductionistic approaches are given preference to integrated neuromusculo-skeletal function in texts on movement- and exercise science as well as in standard physiological textbooks. Dart (1947: 81) further stated:

> *The failure of the anatomist to present a simple picture of the musculature and its innervation is doubtless due to the recency of our comparative anatomical knowledge about these two systems; and the failure to understand the ancestral simplicity of the bodily needs and elementary material, from which their seeming complexity in man has been derived.*

3.3.2.8.1 The origin of the double-spiral arrangement of the body musculature in the vertebrates

The brain and spinal cord, the skeletal musculature and the skeleton together form a single purpose or unitary apparatus: ***a neuromusculo-skeletal (tripartite)***

movement apparatus (Dart, 1947, 1950). Initially this apparatus was developed in order to keep the body straight while it moved forward by means of undulant *lateral bending,* movement directed to keep the mouth end the body continuously pointed forwards and in active contact with food and the back end into a wagging tail (Figure 2.8) (Coghill, 1929; Dart, 1947).

When the ancestral coelenterates (sea anemones and jellyfish) first became transformed into a chordate[7] creature (Romer, 1964) with a permanently maintained antero-posterior orientation, the voluntary musculature became adapted anteriorly (cranially) to the bodily functions of eye movement, food seizure, swallowing and respiration and posteriorly to the bodily functions of defecation, micturition and parturition (front and back development) (Dart, 1950). This ability occurred as a result of the first splitting of the muscle producing embryonal tissue, and its cleavage into antero-posterior and bilaterally arranged somites[8], which then developed into segmentally arranged muscles of the body wall (Dart, 1950; Moody, 1953).

The segmental musculature became bilaterally arranged, each a mirror image of its fellow on the opposite side of the body. The *tripartite movement apparatus* enabled the early vertebrate creatures to produce massive lateral-bending movements of the whole body by alternating contractions of the entire

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[7] The Phylum: Chordata include all creatures with a *notochord* - a long flexible rod-like structure extending from head to tail - a structure still prominent in lower vertebrates where it forms the main support of the trunk. In other vertebrates (Subphylum: Vertebrata), including man, the notochord is only present during the early embryonic stage, but is later replaced by the vertebral column during further development of the embryo (Romer, 1964; also see Williams & Warwick, 1980).

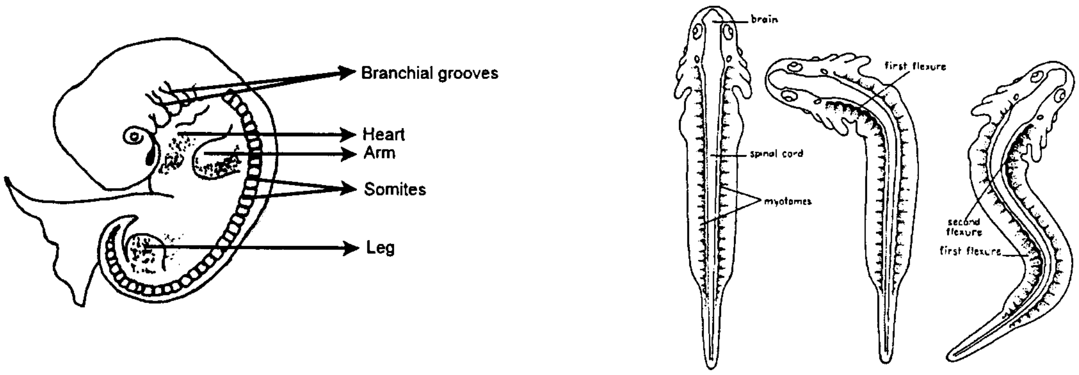
[8] Somites develop on both sides of the embryonal neural tube - these are more or less cubical blocks of mesodermal tissue forming between the ectoderm and endoderm. The first somite forms just below posterior to what will be the head. Their number is subsequently increased by somites posterior to these ones. Somites form, amongst other things, segmentally arranged **muscle plates** of the body wall - the **muscle segments or myotomes**. In the human embryo they develop during the third and fourth week. Myotomes eventually give rise to all skeletal muscles except certain muscles in the head, neck and those of the limbs. Since the muscle systems of all vertebrate embryos agree in beginning as rows of somites this pattern is probably an ancient one (Figure 3.8) (Coghill, 1929; Moody, 1953; Williams & Warwick, 1980).

musculature of the two sides (Coghill, 1929). This is the side to side wriggling movement of eels and tadpoles which allows them to move forward, and is the most ancient of all directional movement (Dart, 1947).

In the human foetus the first movement to appear at 8 weeks is lateral bending of the trunk and neck, a wriggling movement that can be elicited by stimulating the *upper lip* (Hooker, 1942). The corollary is that this is the oldest and functionally the most important tactual reflex pathway, involving head and body segments, as it brings the head in contact with the food supply.

The transverse processes of the spinal vertebrae, if taken serially, give rise to a most important morphological line - the lateral line of the body - which, superficially in fishes, is marked by a row of sense organs supplied by the vestibular nerve (Dart, 1947; Eckert & Randall, 1983). This lateral line of the body gave rise to the second fundamental division of the segmental musculature which was the antero-posterior splitting of the segmental musculature. This splitting separated the anterior or flexor half of each muscle segment in the body from its posterior or extensor half, each half being innervated by its corresponding anterior or posterior division of the spinal nerves (Figure 3.8) (Dart 1946; 1947). Division of the segmental musculature into four halves allowed the ventral halves of the myotomes on both sides of the body to contract or relax, separately or as a whole, independently from and antagonistically to the relaxing or contracting dorsal halves of the myotomes (Dart, 1950).

The laterally-bending creature could now also extend the body dorsally or flex it ventrally. At this stage it became possible for one part of the body to be in a state of tonic flexor contraction while simultaneously the other part remained in a state of tonic extension. The body could thus also bend up and down (Dart, 1947).



a b

Fig. 3.8 Somites and myotomes in embryos. (a) Human embryo at the end of the first month. Somites can be seen on its posterior aspect. Action of segmental body muscles is shown in (b) (Dart, 1950; Moody, 1953; Romer, 1964).

In creatures such as these, a number of different movements could be executed depending upon how the functions of lateral upward and downward bending were combined (Dart, 1946, 1947). Of these, one kind of movement, however, is of outstanding importance for the purposes of the present study. This is *rotation, torsion or twisting;* actions which are the result of combining simultaneously the three movements already described. Any asymmetry in the contracting parts leads to a rotation in the junctional region between the tonically flexed and tonically extended halves of the moving body with a resultant **postural torsion** (body twisting to one side) (Dart, 1947).

Rotational movements however, became increasingly important for maintaining the body's posture during evolution. This arrangement allowed the entire voluntary musculature of animal bodies to assume a perpetually twisted arrangement in order to produce:

a) Permanent postural twists. Examples of these are the inward rotations of the fore and hind limbs in all four footed creatures and the **upward rotation of the trunk upon the thighs in man** (Dart, 1947).

b) Facilitation of the further reflex and volitional twisting of the body and its parts.

The twists are phylogenetic achievements and are symmetrical in character. The interwoven spiral muscular sheets that encircle the human trunk (see below and Figure 3.9) resulted from the dominant part rotation plays in **each** body movement (Dart, 1947).

Since no further voluntary muscle development (splitting up of myotomes) took place, no other types of movement effected by voluntary musculature became possible. Splitting as it occurred, has therefore, been principally confined to the production of a three-sheeted layering assuming the form of two interwoven spirals:

a) Inner or transverse (circular),

b) Intermediate or internal oblique (diagonal) and

c) Outer or external oblique (diagonal) characteristic of the trunk flexors.

In a like fashion, the longitudinally split arrangement, characteristic of the double sheeted limb flexors and extensors, was produced, as were the subdivisions of the *sacrospinalis* mass (Dart, 1950). The double spiral arrangement of the body musculature is described by Dart (1950: 267-268) as follows:

> *This splitting into sheets, however, has given origin to a simple double-spiral mechanism of great importance to bodily economy, but the essential simplicity of which is frequently forgotten amidst anatomical detail. For example, let us follow the oblique direction of the fibres of the external oblique muscle, from the midline of the body, pubic symphysis and iliac crest upwards through the single morphological sheet formed by the external intercostals, ribs and scalene musculature to the transverse*

processes of the cervical vertebrae, and thence through the deeper-lying sheet, formed by the semi-spinalis musculature, to the cervical spines and occiput. Thus we get a picture, or bird's eye view, of the manner in which the single superficial sheet, formed by these two opposed diagonally-running flexor muscles in front, is continued, through a deeper-lying extensor sheet on each side of the spine behind, to suspend the pelvis from the occiput and neck vertebrae. This diagonal suspensional arrangement becomes the more impressive when we recognize that the diagonal direction of pull exercised by each external oblique sheet (intercostal muscles and levatores costarum) is continued across the midline through the deeper-lying internal oblique sheet to the perimeter of the pelvis on the opposite side of the body. Thus, any postural twist of the body (and the customary twist of a right-handed person is a twisting of the trunk to the left) results in a postural rotation of the thorax, shoulder (right) and head, together with the vertebral column itself, towards the opposite (left) iliac crest: there is also a relative inability to rotate the opposite or heterolateral (left) shoulder towards the homolateral (right) iliac crest.

These diagonally-disposed sheets, when followed in their continuity around the body, constitute two interwoven spiral layers. The pull exercised on the circumference of the pelvic basin, through the deeper-lying (internal oblique) sheet from the ribs and the transverse processes of the spinal vertebrae of the contralateral side, by the superficial layer of muscles (external oblque, quadratus lumborum, external intercostal, levatores costarum and scalene) is a plane of traction that is being simultaneously exerted upon the transverse processes themselves, and again along the deeper-lying plane of pull of the deep (multifidus-semispinalis)sheet of the sacrospinalis from the *spines of the vertebrae and the occiput. Thus, in a very real sense, the occiput and the spines of the vertebrae suspend the body by means of two spiral sheets of muscle encircling the trunk.*

This arrangement of the trunk musculature, in the form of interwoven double-spiral sheets, is continued across the dorsal *midline just as it is carried over the ventral midline. The superficial layer of the sacrospinalis sheet (ilio-costalis, longissimus and splenius) continues on to the posterior aspect of the ribs, cervical transverse processes and mastoid process the same oblique line of traction as is being exercised on the spines by the deep (or multifidus) sheet of the opposite side of the back. The whole trunk repeats, in its own fashion, the muscular story of the intestinal tract and of the heart, by becoming enwrapped by spiral coils of muscle, which are only prevented by the bony framework of the thorax and pelvis from completely emptying its contents when they are contracted forcibly.*

This double-spiral arrangement, discussed above can easily be pursued into the head, neck and limbs (Figure 3.9).

3.3.2.8.2 The postural twists, posture and malposture

Dart (1946, 1947, 1950) argued convincingly that man's postural twists contributed to his becoming upright and keeping him there. The permanent inward rotation of the leg musculature provides flat surfaces for the feet, inward rotation of the arms affords implement-using hands also capable of grasping and swinging. **Finally, the powerful hip musculature allows the whole body to twist permanently upwards**:

...and poise it in a state of postural fixation on top of his thigh bones. Thus, paradoxically enough, it is nature's most twisted, distorted creature (i.e. crooked Man), that is capable of the supreme achievements of poise: balancing on head, hand, heel or toe (Dart, 1946: 12).

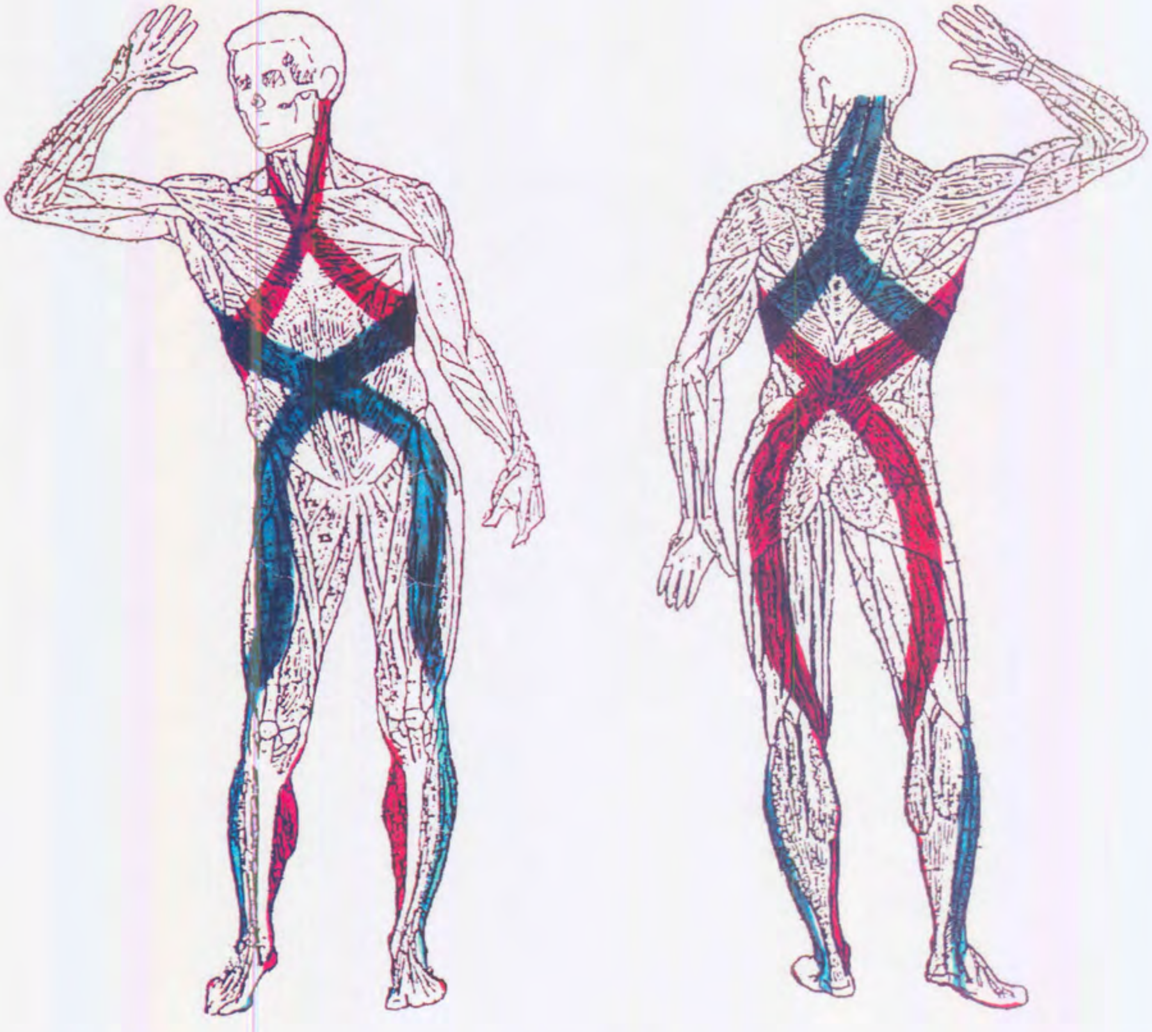


Fig. 3.9 The spiral arrangement of the body musculature. [Original drawings kindly provided by Mr Walter Carrington of the Constructive Training Centre (London)].

Hence man's place in nature is due to his conquest of the problems of *poise* by means of **postural twisting** (Dart, 1946). **Failure to develop a perfectly**

poised body merely represents a developmental arrest (Dart, 1946; Feldenkrais, 1985). This arrest in development is purely functional, and is not, as commonly accepted by the lay public, an inherited problem.

The consequence of the development of the tripartite movement system is that all muscles are either flexors or extensors: all torsions of the body as a whole or of its constituent parts - whether they be rotation of the spinal column, pronation, supination, inversion, eversion, abduction, adduction or circumduction of the extremities - are all based upon tonically maintained differential pulls between adjacent groups of flexor and extensor segments (Dart, 1950). The importance of these differential pulls should be one of the considerations in the prescription of exercise or physical activity programmes. This is so because any habitual asymmetrical adjustment of the body, either during states of mental anxiety that suppresses respiratory rhythm or during physical activity or exercise, results in postural torsion of the head, vertebral column and trunk, as a whole, towards the more commonly favoured or used side (Dart, 1950).

An example of the spiral arrangement of voluntary muscles in man is shown in Figure 3.9. In Dart's (1946, 1947, 1950) scheme both monoarticular and polyarticular muscles contribute to the spiral arrangement of the skeletal muscles, further emphasising the interrelation between posture and voluntary movement (Latash, 1998a; Roberts, 1995).

Thus we finally have man, the erect terrestrial biped with his large head balanced on his thin neck; a centre of gravity in a nearly straight line from the occipital condyles to the pelvis; free arms; manipulative hands and two feet on the ground.

3.3.2.9 Upright man - the sum total of it all

The sum total of the anatomical adjustments accompanying the acquisition of the upright posture and bipedal gait has produced an efficient mass-bearing system in the human. The result is a line of gravity of the body extending from the occipital condyles, in front of the spinal column to the upper, anterior sacrum, then across the ilium, through the femoral head, down the legs to the feet which form the pedal tripods (Dangerfield, 1996; Gorman, 1981).

The effect is 1) enhanced stability; 2) better balance while standing and walking and 3) minimal expenditure of muscular energy (Joseph, 1962; Tobias, 1982).

The recent notion that the size of the head (brain and cranium) does not determine intelligence (Gould, 1987) leads one to speculate, in the light of the importance of erectness in humanness, whether the large head did not lead to improved balance in the upright stance. This is inferred from the fact that newly found balance in the one to two year old is accompanied by perfect posture at a stage when the head is disproportionately large compared to the rest of the body (Gelb, 1981). Good posture is achieved in cultures with the habit of transporting burdens on their heads. This again causes an exorbitantly large head area, yet with an interesting consequence - the attainment of good posture.

Man's erectness allowed him the freedom to develop his intellect, culture and religion. This put the crown on his terrestrial success (Phelps *et al.*, 1956).

3.4 THE MECHANISM OF THE UPRIGHT HUMAN POSTURE DURING STANDING AND SITTING: BASED ON PALEO-ANTHROPOLOGICAL EVIDENCE

Nature has over-emphasised the extensor mechanism of man so that he might achieve the erect posture .....(Dart, 1946: 6).

3.4.1 General

The changes in design and function of anatomical structures which led to the upright position were considered in sections 3.3.2.1 to 3.3.2.8. In order to maintain the upright posture over a small base of support such as the feet and sitting bones, the integrated function of various musculo-skeletal structures and systems are required. DeVries (1965, 1968) was probably the first to show that upright standing requires some muscular action, although only to a small extent as will be discussed next.

Man's upright posture is nothing but a delicate balancing act, which requires the subtle **balancing of body structures** on top of one another as shown by Rolf (1977). This balancing act, which should be regarded as a skill, is maintained by the coordination of all the neuromuscular-skeletal (tripartite) systems in the human body. Standing or sitting upright in many ways requires learning like all other motor skills (Massion, 1992; Richardson, 1992).

Because of its ingenious design, man's upright position can be maintained with little energy expenditure (Hellebrandt, Brogdon & Tepper, 1940; Joseph, 1962; Joseph & McColl, 1961; McArdle *et al.*, 1991). **From this it can be concluded that the upright position should not be associated with undue muscular effort or parasitic muscle action** (Alexander, 1932; Feldenkrais, 1985; Robinson & Fisher, 1998). When posture is considered the emphasis should be on balance, and not the use of brute strength for something which relies on balance, the use of the correct muscles such as the deep slow-twitch extensor muscles (Armstrong, 1980), and therefore correct neuromuscular control and function. The emphasis on balance is indeed the general approach taken by those involved in bodywork (Barlow, 1990; Dart, 1947; Feldenkrais, 1972, 1985; Hanna, 1988). The main aim of all these techniques is to teach the individual the correct employment of the tripartite system in the body. These techniques will be discussed in greater detail in Chapter 7. From a physical point of view all the instigators of these techniques agree on one salient point, which is that the minimum muscular force should be used for whatever physical task needs to be done, in fact large parts of these techniques are devoted to the inhibition/release of unwanted muscle tension(s). It is with this aim in mind that the biomechanical/kinesiological control of posture will be discussed.

3.4.2 The standing posture

In Figure 3.10a,b the proposed function of the different anatomical structures in the maintenance of the upright posture is shown in accordance with paleo-anthropological evidence.

3.4.2.1 The pelvic structures

During standing, the upright human pelvis is balanced on the thighs, which act as fixed points from which the hip muscles act in order to stabilize the hip. Of particular significance in this model is the introduction of the *gluteus maximus* and other mono-articular (stabilizing) pelvic muscles in the creation and maintenance of the upright position and stabilization of the pelvis and the trunk (DonTigny, 1993).

Being an antigravity muscle (Richardson & Sims, 1991), the *gluteus maximus*, when acting from below[9] (the femur - see Figure 3.10) (Gorman, 1981), it is by way of its structure and position eminently suitable to tilt the top of the pelvis to the rear and to maintain the upright pelvic position. This action automatically positions the sacrum in such a way that it is now able to support the upright and lengthened spine above it. The small inner (stabilizing) muscles of the back are then allowed to take over the function for which they were originally intended, namely the maintenance of the position and stability of each vertebra and those adjacent to it.

Seen from the above perspective, the common modern malaise - low back pain - (Deyo, 1983), should be seen for what it really is: A disease of muscle imbalance

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[9] It is only for convenience of description that musculo-skeletal attachments are described as origin and insertion. The direction of pull of a muscle depends on which end is fixed (Bürger, 1986). When the origin of the biceps brachii is fixed, for example, its contraction will result in flexion of the elbow and lifting of the forearm and hand. When, on the other hand, the insertion (forearm) is fixed, contraction of this muscle will again lead to flexion of the elbow, but with the shoulder being pulled down towards the forearm and hand.

and its consequent malposture. Rehabilitation exercises for those who suffer from low back pain, should therefore rather concentrate on the functional cause of this malaise, which is to alleviate the functional imbalances[10] found in the lower back and pelvic areas (Janda &Schmidt, 1980). Janda (1993) and Janda and Schmidt (1980) for example, found a combination of tightness in the short hip flexors and *erector spinae* and a weakness in the abdominal and gluteal muscles - the pelvic crossed syndrome (Jull & Janda, 1987). The correction of structural imbalances such as these, as suggested by Barker (1985), Janda (1993), Jull & Janda (1987) and Richardson (1992) is, in view of the present theory, more acceptable than regimens in which exercising and strengthening of those muscles normally associated with voluntary movement of the back, such as the *erector spinae (sacrospinalis)* are recommended (Flint, 1958, 1964; Flint & Diehl, 1961; Graves, Pollock, Foster, Leggett, Carpenter, Vuoso & Jones, 1990; Manniche, Hesselsøe, Bentzen, Christensen & Lundberg, 1988).

Forward tilting of the pelvis is a function of muscles acting in an opposite direction to that of the *gluteus maximus*; the *iliopsoas* and to some extent, due to its anatomical position, the *gluteus minimus*. When the *iliopsoas* muscles contract from below they powerfully flex the pelvis and trunk forward during actions such as raising the trunk from the lying to the sitting position (Gorman, 1981). In this model these muscles contribute to the forward tilting of the pelvis during standing, not only if they contract or are tightened, but also if they are shortened (Jull & Janda, 1987; Lawson-Wood & Lawson-Wood, 1977; Rolf, 1977). The main function of the *gluteus medius* and *gluteus minimus* would be to keep the pelvis from sagging to either the left or right, especially apparent during standing on one leg (Gorman, 1981), but likewise seen so often in those supporting themselves mainly on one leg with the hips sticking out. When acting from below the mono-articular leg adductors (*adductor brevis, adductor longus,*

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[10] Muscle or functional imbalances in this context do not only imply muscular contraction, but also parameters such as habitual resting muscle length, the role of muscle connective tissue (fascia, for example), ligaments and use of tonic reflex or voluntary patterns in determining this length and the resistance of a muscle to lengthening (Alexander, 1932; Ayub, 1987; Barker, 1985; Bobath, 1980; Rolf, 1977; Smith, 1957). Muscle imbalance is further discussed in Chapter 5, section 5.9.7.

adductor magnus, and the *pectineus)* (Gorman, 1981; Kendall & McCreary, 1983) and other muscles such as the *piriformis* assist in laterally stabilizing the pelvis. The *gluteus medius* and *gluteus minimus* muscles are also involved in trying to right the trunk when the human leans backward.

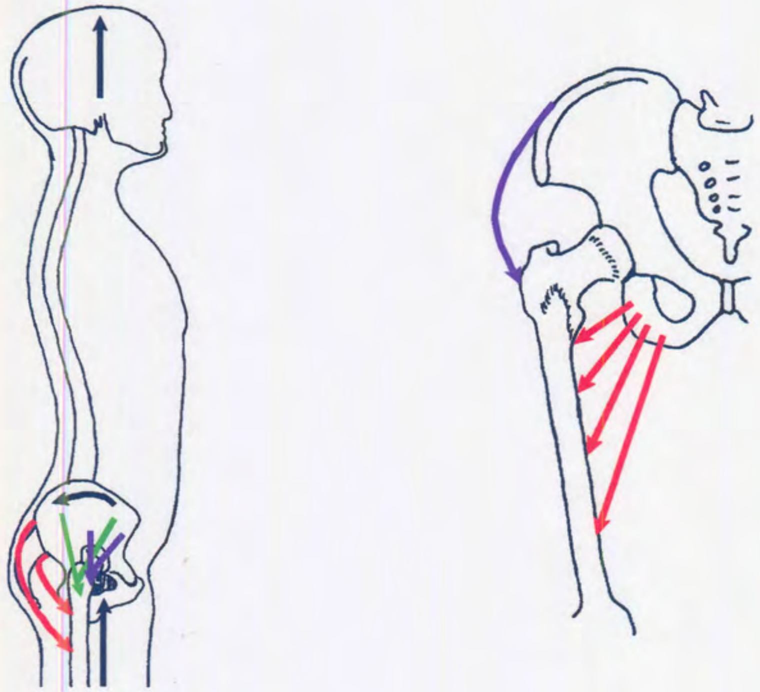

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Fig. 3.10 A paleo-anthropological model for the muscular control of the upright posture. The arrows indicate the direction in which the various muscles act in order to support the position of the pelvis on the femur. (a): Lateral view of the pelvis and spine, with direction of action of the *gluteus maximus* (red), the *gluteus minimus* (blue) and the *gluteus medius* (green). The direction and position of the upward force via the femur is also shown. Note that this is anterior to the spine. (b): The side to side stabilization of the pelvis by the *gluteus minimus, -medius* (blue) and the monoarticular adductor muscles (red). Spiral arrangements of the muscles are not shown.

We thus have a ring of muscles linking the femur to the pelvis fulfilling the important role in the standing human to stabilize and fix the pelvis in the correct position in order for it to support the structures above. It should be kept in mind though, that pelvic position is the result of the interaction between these and other muscles, and that it may be affected by the action of muscles near or even distant from it. This will be true, especially in cases where imbalances in the spiral muscle arrangement exist (see Figure 3.11) (Barlow, 1990; Dart, 1950).

Positioning of the hip joint sufficiently far forward in the pelvis so that the whole **of the spine and the line of gravity is posterior to the acetabula** ensures that the vertical force from the legs will have the tendency of moving the top of the hip backwards (Figure 3.10a) (Dontigny, 1983; Gorman, 1983). The best demonstration of the advantage of a system like this is when a large vertical force from the legs (during landing from a jump for example) acts on the pelvis, the natural response **is rounding, and not hollowing** of the lower spine. The latter response may lead to damage to the spine (Gorman, 1983). Forward tipping of the pelvis and sacrum, heavily strains the entire vertebral column with some vertebrae being wedged apart and others being crowded together (Rolf, 1977), and also releasing the self-bracing mechanism of the sacroiliac joint (DonTigny, 1993) (see Chapter 5, section 5.7.2).

When all or some of the muscles discussed above are inactive or weakened - as frequently seen in those with brain damage - an inability to laterally stabilize the pelvis makes it difficult for these patients to attain or maintain the upright position (Loots, J.M. - personal communication). Trying to compensate for this inability by means of the abdominal and quadriceps muscles is not successful.

3.4.2.2 The spine and thorax

> *The importance of the spinal column cannot be overemphasized. It provides for the foundation around which man's internal skeleton is built. Every animal that moves vigorously benefits from some stiff material to which to attach its muscles* (Leonard, 1973: 101).

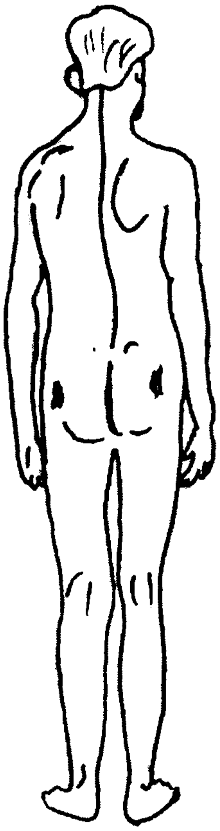

Fig. 3.11 Example of a young boy with scoliosis and distortion in the spiral arrangement of the musculature, seen in the torsion of the trunk (adapted from Barlow, 1990)

A column is found underneath the structure it upholds. In understanding the function of the spine it is important to realise that the spine is not a true column, since it is nearer to the dorsal surface of the body. It is rather like a beam upended. In the quadruped the spine acts as a horizontal beam. In man it became a vertical beam - a structure which cannot support itself (Rolf, 1977). Even though the spine is supported from below by the sacrum, and though each vertebra supports those above it, its off-centre position necessitates special measures to keep it upright during standing and sitting (Rolf, 1977). One of these is the spinal joints and ligaments (Macintosh & Bogduk, 1987) - a system which is able to stabilize an inert upright spine. The back, however, is subjected to continuous displacement, with the back muscles serving to correct such displacements (Macintosh & Bogduk, 1987).

To complicate matters further in man, the spine must meet two contradictory requirements: Plasticity and rigidity. The upright position of the spine, plasticity and rigidity are achieved by the presence of muscular stays built into it's very structure. Viewed as the mast of a ship resting on the pelvis as the deck, the mast extends to the base of the head, and at shoulder level supports a mainyard - the scapular girdle (Figure 3.12a) (Gorman, 1981). Unlike the rigid mast in a yacht the human mast (spine) is made up of a number of moveable elements (the vertebrae), which then necessitates a series of diamond shaped systems in which one vertebra is dependent on the support of the vertebra below it, and the action of the small back muscles and ligaments which link them together for stability (Figure 3.12b). Therefore, at all levels there are ligaments and muscle tighteners arranged as stays, linking the mast to the pelvis at the bottom. A second diamond shaped system of stays is related to the shoulder girdle. Careful examination of this system shows the possibility that the lower stays on the one side of the body connects to those linked to the shoulder girdle on the opposite side of the body, thus making sense of the idea that when the forces on either side of the body is in equilibrium with each other, the mast (spine) and the thorax will be straight, unrotated and vertical (also see Dart's spiral arrangement of body musculature - section 3.3.2.8).

The plasticity and rigidity of the spinal column lies in its makeup - multiple components superimposed on one another, interlinked by means of ligaments and short muscles, which are covered by sheets of larger muscles, which are in turn responsible for the torsional movement of the spine and thorax. The structure of the spine and thorax can thus be changed while at the same time maintaining its rigidity (Dart, 1950; Gorman, 1981).

Since the *erector spinae* muscles are multi-articular they are better suited for movement, such as extension and lateral flexion of the spine (Gorman, 1981), rather than serve as postural muscles. Postural function, such as the control of the upright position of the spine is best left to the deep short muscles of the back (*multifidus, rotatores, interspinalis* and *intertransversarii*) (Gorman, 1981).

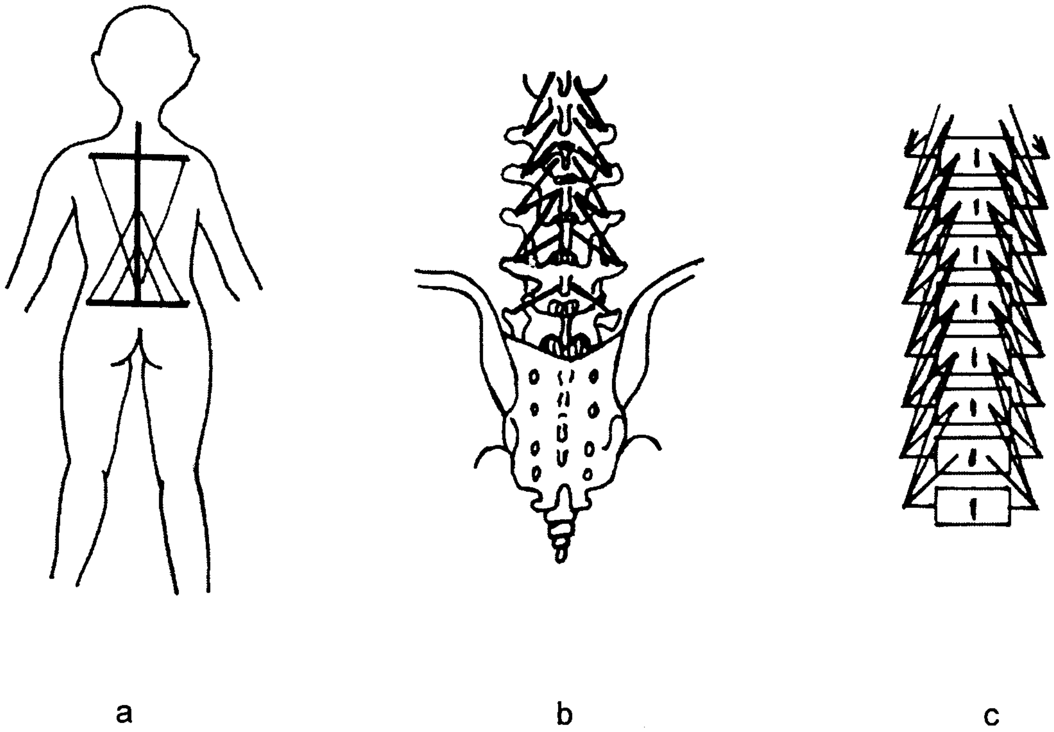

Fig. 3.12 **Maintenance of stability in the spinal column. The spinal column as a mast (Gorman, 1981; Rolf, 1977) (a). Maintenance of stability of individual vertebrae by those underneath, the interconnecting ligaments and the small muscles of the back (b) and (c). In (b) the connections of the *rotatores* are shown, and in (c) those in the smaller muscles of the spine, for example, the *multifidus*. Note the similarity to the system shown in (a), and its spiral arrangement.**

The role of the abdominal muscles in issues such as low back pain and posture has been the subject of much debate (Norris, 1995; Plowman, 1992; Pope, Frymoyer & Lehman, 1991b). Fox (1951), for example, found that forward pelvic tilt is not associated with any significant weakness of the abdominal muscles. Since the abdominal oblique muscles insert on the *erector spinae* fascia, a mechanism has been suggested in which strong oblique muscles reinforce the *erector spinae* and pull it laterally. This wide reinforced fascia is more efficient in supporting the spine, and in the process puts less strain on the spine (Plowman, 1992). This, of course, will depend on the point from which these muscles act. If they act from below (pelvis fixed), the tendency will be to pull the lower back forward, and if from the other direction, the pelvis will tend to rotate backwards. In this respect these muscles will then support the action of the *gluteus maximus* when it acts from below (see 3.4.1.1.1 and the following paragraph).

Action of the abdominal muscles will tend to tilt the pelvis backwards if the thorax is fixed (Gorman, 1981), but whether this is the intended function of these muscles is debatable. According to Gorman (1981) the antero-lateral group of abdominal muscles serve to provide a firm, but elastic wall to retain the abdominal viscera in position and to oppose the effect of gravity on them in the erect position. They may, however, be used in conjunction with the gluteal muscles to flatten the lumbar curve when effort is needed (Gorman, 1981). More correctly would be to view them as part of the double spiral system of the body musculature in which their principal role is twofold:

- ❑ Due to the fact that the fibres of the external oblique on one side with those of the internal oblique on the other these muscles as whole form a slanted web which determines the hollow of the waist (Gorman, 1981; Robinson & Thomson, 1999),

- ❑ These oblique and rotatory connections to the pelvis from the one side to the rib cage on the opposite side of the body allow them to participate in positioning these structures relative to each other, but to some extent also in the absolute positions of these structures. The outcome of rotation is shown in Figure 3.11.

3.4.2.3 The lower limbs

In the standing position the balance between the muscles surrounding the ankle must be such that the lower leg forms an angle of 90° with the supporting surface [see for example Barlow, (1990)]. This will then ensure that the knee- and hip joints are placed on the centre of gravity line. In the regulation of stance and gait the extensor muscles predominant role (Dietz, Horstmann & Berger, 1989).

3.4.2.4 The neck and head

Support for the head must come from below. Cohen-Nehemia (1983) and Cohen-Nehemia and Clinch (1982) have indicated a delicate interaction between the hips and the neck. Therefore it may be postulated that if the spine is supported as described in the previous sections the cervical vertebrae will rest on the thoracic in such a way that the head will balance on the top of the spine. Poking or retraction of the head will disturb this balance (Barlow, 1990; Jones, 1979).

3.4.3 The spiral arrangement of the body musculature and posture

According to paleo-anthropological evidence it seems that *poise* is based on two basic requirements namely support and balance of body structures in relation to each other. In the sections above (3.4.1 - 3.4.2) the development of-, and the need for a system to support body structures on top of each other, in the upright human, were extensively dealt with. It is clear that proper support depends on correct positioning of structures in relation to each other. The functional background of the system responsible for the balancing and positioning of body segments has not been dealt with up to this stage. According to Loots J.M. (personal communication) the solution is to be found in the double spiral arrangement of the body musculature (Dart, 1946, 1947, 1950). A spiral arrangement of the body musculature **allows the body to be suspended from the head (occiput) and spine** (Dart, 1946), thus "wrapping" the different body segments on top of each other. In order to function properly the system should be kept "taut", and once slackness enters the system, bulging of the belly and its concomitant hollowing of the lower back will be the consequence, for example (Loots, J.M. - personal communication). Each and every postural deviation can be thus traced back to a malfunctioning of this system, as put forward by Dart (1946; 1947). *Poise* on the other hand, depends on the proper control of this delicate mechanism, control, as will later emerge, which in modern civilization depends on conscious control (Alexander, 1996; Dart, 1947; Feldenkrais, 1985; Howorth, 1946).

3.4.4 The sitting posture

The reader is referred to the statement by Tobias (1982) that sitting gives greater stability to the body than standing, and it is therefore the preferred position when the hands are used in activities such as tool-making and tool-using. It is here that the greatest danger of sitting lies; and since it is so frequently used, it tends to be abused.

Sitting upright requires the same delicate neuromusculo-skeletal integration required for standing. Gorman (1983) suggested that the time and manner of sitting is the primary cause of the unnatural shape and joint mobility of the spine and thus the primary cause of low back pain.

Gorman (1983) is of the opinion that the human spine is inherently unsuited for sitting with the muscles of the spine relaxed, since it leads to the slumped position. Continuous sitting in this position, eventually leads to elongation of the posterior supra spinous ligament and distortion of the intervertebral discs. The correct shape of the spine should therefore be maintained by the judicious use of the back and trunk musculature.

During sitting the body mass should be borne by the sitting bones, rather than by the thighs (Figure 3. 13). This will ensure tilting of the pelvis and sacrum in such a way that the spine above it is supported in the upright position with the minimum of muscular effort. As in standing the *gluteus maximus* muscles should function from below in order to tilt the pelvis into the proper position for sitting and to position the centre of gravity line of the upper body ahead of the sitting bones. Correct and incorrect sitting positions are shown in Figure 3.13.

As shown in Figure 3.13 it is important to allow for open space beneath the chair for more optimal positioning of the legs (Keegan, 1953).

Grieco (1986) saw sitting at work for long periods at a time as “enforced posture”, something which should be seen as a risk factor for spinal problems of the same magnitude as the lifting of heavy weights and vibration, and that in particular, the most important risk factor for spinal problems is poor mobility of the workers.

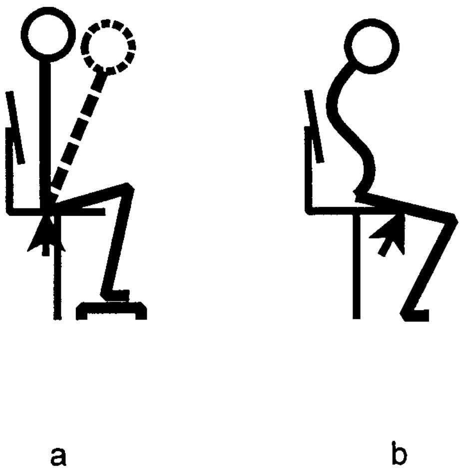

Fig. 3.13 The correct sitting posture (a) and sitting on the thigh position (b) (Gorman, 1983). Note the position of the sitting bones and the hip joints relative to the knee-joints in (a), where the knee joints are slightly higher than those of the hip. Leaning forward should be from the hip joint (Macdonald, 1998). Arrows indicate position of fulcrums.

CHAPTER 4

ONTOGENESIS: INDIVIDUAL DEVELOPMENT

In ontogeny, as in phylogeny, man grows and moves spirally (Dart, 1950: 268).

The human foetus, as it grows in the womb, passes through a cycle that roughly parallels the whole of human evolution, from fish to Homo sapiens. However, the baby does not develop its upright posture until after it has been born (Barker, 1985: 20).

Good posture ····· are not characterized by beauty but rather by a capacity to meet the environment and to conquer it successfully (Goff, 1953: 78)

4.1 INTRODUCTION

The upright posture in man is, despite its long history, still not an automatic activity such as breathing (Kruger, 1988). Even when all the physical conditions, like the development and maturation of tissues, postural reflexes and voluntary motor control, for example, are fulfilled, the infant still has to struggle to accomplish the upright posture (Kruger, 1988; Steyn, 1991). The initial attainment of the upright position in the infant, firstly when sitting unaided and secondly standing upright, is regarded by those around him as important first achievements (Kruger, 1988). With the approach of old age, however, maintaining this hard fought for uprightness may again become a problem (Barker, 1985; Hanna, 1988; Overstall *et al.*, 1977; Rolf, 1977).

In order to walk upright the infant must be able to support his mass, maintain his balance, and propel himself forward. Although the flexion and extension of the lower limbs at the hip- and knee-joints function at birth, the infant displays a decidedly helpless response to the force of gravity. The major task ahead of the infant, therefore, is to develop a system able to deal with and control the effects of gravity. This development is exceedingly gradual, and has a cephalo-caudal trend (McGraw, 1932).

From birth onwards the infant, later the child and adolescent, develops a mechanism which enables him to accomplish activities of daily living as well as activities which are highly complex. This mechanism, which functions automatically and largely unnoticed, is the postural reflex system (Bobath, 1980; Massion, 1992). According to Bobath (1980) this mechanism, which gives man the prerequisite for normal functional activity, is responsible for the evolution of three factors:

1) A normal postural tone; the activation of muscle synergies to control posture,

2) The great variety of interaction of opposing muscles, which may result in simultaneous contraction of opposing muscle groups, especially around the proximal parts (shoulders and hips), which allows the individual selective and skilled activity. In practice this means that skilled activity requires postural support and stability,

3) The great variety of patterns of posture and movement that are the common heritage of man. This is shown by the similarity in the fundamental sequences of the development of the motor mechanisms as the infant matures.

Thelen (1998) asserted that mainstream Western views of motor development, such as those of Bobath (1980) and McGraw (1932) discussed above, tend to look at things from inside out - waiting for the brain to mature in order to allow better body control. She (Thelen, 1998), is of the opinion that researchers today still use the assumption, that motor behaviour provides a good readout of the status of the central nervous system. She further added (p 268):

> *Rather, those pioneers failed to appreciate how much biomechanical challenges facing infants and their solutions to those challenges sculpt the brain. Bernstein, more than a half century before the recent discovery of brain plasticity, fully understood the bidirectionality of change. Researchers now must not ask not only how structural changes in the central nervous system allow and support body control but also how moving limbs and torso in a world of information and forces determine the connections in the brain.*

From a movement science perspective, the practical implication of Thelen's (1998) point of view is that the quality of postural- and movement development are not only dependent on the capabilities of the individual's central nervous system, but also on the quality of input from the environment and those responsible for the mental and physical development of the individual. In the sections below the importance of the latter will be highlighted.

4.2 PRENATAL AND POSTNATAL DEVELOPMENT

4.2.1 Prenatal development

The development of any embryo and the subsequent development of the newborn have one objective in mind, which is to become a fully integrated and functional adult as expeditiously as possible (Moody 1953). To accomplish this aim effectively the growing and developing individual has to go through a number of obligatory developmental phases, both structurally (Moody, 1953; Sinclair, 1991; Williams & Warwick, 1980) and functionally (Bobath, 1980; Gabbart, 1992; Payne & Isaacs, 1991; Thelen, 1998). These developmental phases will be reviewed on the following pages (section 4.2.2 to 4.6) with particular emphasis on the postural aspects.

Prior to birth the foetus lies comfortably in a position of flexion in his uterine bath. Growth takes place against the resistance of the elastic uterine wall. During foetal life the foetus is almost invariably in a position of **flexion.** The head is sharply flexed on the body, the arms and legs flexed on the torso. The convex curve of the spine lies in contact with the curve of the uterus (Asher, 1975; Phelps *et al.*, 1956). This is the posture which some individuals readily revert to later in life (Barlow, 1990; Goldthwait *et al.*, 1952; Hanna, 1988; Hellebrandt & Braun, 1939).

The foetus is surrounded by the uterus, partially suspended in amniotic fluid, of which the specific gravity is more or the less the same than that of the foetus. The gravitational effect of this is very similar to that exerted upon an individual submerged in sea water (Phelps *et al.*, 1956).

After birth the individual leaves his sea-like environment in order to move onto land. Now a very definitive change takes place in the newborn's environment, an environment which has an immense effect on the structure and posture of the newly born individual. After birth, gravity exerts its effects on the newborn in a medium with a much smaller specific gravity (air), and then the structure and mass of the child and its body segments become more important in relation to posture (Phelps *et al.*, 1956).

4.2.2 Postnatal development

During the first year, the infant spends a large amount of time in a horizontal position, either prone, supine or on its side. In this position, the child experiences the force of gravity on a horizontal plane, and tends to uncoil the *"coiling"* which it previously assumed in the uterus. In the prone position the flatness of the surface tends to fix the infant in a straighter position, while in the supine position the head and legs tend to lie flat, but are allowed greater freedom of movement (Phelps *et al.*, 1956). In those who have postural deviations or problems caused by poor posture, uncoiling of body structures is possible by the use of the mechanisms used by the infant (Barlow, 1990; Dart, 1947). These approaches will be discussed in Chapter 9.

When the supine infant tries out its muscles, this also serves as a way to straighten the back. Nevertheless, the C-shaped curve persists for several months after birth (Barker, 1985; Phelps *et al.*, 1956; Sinclair, 1991).

Since the newborn is flaccid it is simple for the parent to assist in the uncoiling of the infant's musculature by gently stretching it out in either the prone or supine position (Wenham, 1980). Due to this flaccidity the newborn is unable to maintain the sitting position, and falls into a "jack-knife" position when raised from a supine to a sitting position. A few days after birth, however, the infant will start showing a slight resistance to the forward fall, and will also be able to free his flexed limbs from beneath his body, thus getting him into a prone position (McGraw, 1932).

In the early months of postnatal life, when the baby extends his head, a small compensatory lordotic curve, convex forwards, appears in the cervical region. When he begins to sit up, a secondary lordotic curve, convex forwards, appears in the lumbar region (Asher, 1975). The vertebrae are then balanced squarely on top of each other and a minimum of effort is required to maintain the position (Wenham, 1980). The relatively heavy head gets pulled back into the upright position, its weight is brought over the centre of gravity, the eyes are pulled up and can look to the front. Initially the legs are spreadeagled to give a wide, triangular base for support as the balance is still poorly developed (Barker, 1985; Bril & Brenière, 1992). There is some persistent hip flexion during this stage which is associated with the upward rotation of the pelvis on the spine (Phelps *et al.*, 1956). It is noteworthy that at this stage the infant has to go through the same transformation than early man, when he progressed from quadrupedalism to the permanent erect position - a process which was discussed in Chapter 3, section 3.3.

The secondary spinal convex curves depend on differences in thickness of the intervertebral discs which become wedge-shaped to allow for necessary adaptation. The primary curves depend on differences in height between the anterior and posterior aspects of the vertebral bodies (Asher, 1975).

When the child is about to stand, the musculature of the extensors of the back and neck has become sufficiently well developed and the back is usually straight. The straightness results mainly from the slight tilting upwards of the front of the pelvis in full or nearly full extension of the legs (Phelps *et al.*, 1956). This is in agreement with the posture described in the previous chapter in section 3.4.

To reach the upright position the child develops a curve in the small of the back, the lumbar curve. This brings the head over the centre of gravity, the range of visibility is increased and the body weight can be supported by the bony frame. The only parts of the original spinal C-shaped curve (concave) which remain are in the chest and sacral regions (Barker, 1985).

There is a tendency towards full hip extension in the erect standing position as a means of easier and more perfect balance. At this moment the child is able to rotate his pelvis forward and upward by means of his *gluteus maximus* - a function which was discussed in great depth in the previous chapter (sections 3.3.2 & 3.4).

4.3 CHANGES IN BODY PROPORTIONS

At birth, sitting height accounts for 70% of total body length. By 3 years old, sitting height`s contribution to total body height has decreased to 57% (Gabbard, 1992; Payne & Isaacs, 1991). During this and subsequent growth periods the nervous system has to compensate for the change in body height, body mass and the size of different body structures in relation to each other by means of **learning** (Massion, 1992). This is possible if the growing individual is exposed to physical activities which will stimulate the adaptation and orientation of neural systems to the changes in body height, body mass, the centres of gravity of different body compartments and the relative sizes of body structures in relation to each other. In this regard, simple, yet effective physical activities sessions, will be those which alternate between actions such as walking, climbing, sliding, crawling, hanging and swinging (also refer to section 2.3).

During the first years of life the lumbar vertebrae grow rapidly in size, with consequent lengthening of the lumbar region and also of the loins. The lumbar development is probably associated with upright bipedalism; the longer muscles make walking easier and more efficient (Asher, 1975).

Until the age of 10 years for girls and 12 years for boys, both sexes exhibit almost the same increases in trunk length but usually boys have longer trunks. Boys are generally taller, thus prior to adolescence, boys have relatively shorter legs than girls regarding total body length. During adolescence and adulthood, females have shorter legs than males of equal stature (Asher, 1975; Payne & Isaacs, 1991).

One of the most noticeable characteristics in the newborn is the size of the head in relation to total body length. The head contributes about 25% to total body length, while the lower body limbs contribute only 15% (Gabbard, 1992; Payne & Isaacs, 1991).

Changes in body proportions are brought about by different growth rates of skeletal tissue. During infancy growth is most rapid, first in the head and later in the trunk. In the second year the legs begin to grow more quickly than the body, and this pattern continues until the onset of the growth spurt of puberty, when in both sexes the trunk grows faster than the limbs (Asher, 1975; Gabbard, 1992; Payne & Isaacs, 1991). Changes occur in lateral as well as in linear proportions. Although shoulder and hip width appear equal in the newborn, shoulder width is greater than hip width for all children. The adolescent boy experiences a more rapid rate of shoulder than hip growth, while girls have greater hip breadth gains relative to the shoulders (Gabbard, 1992).

4.4 CENTRE OF GRAVITY

The centre of gravity of the human body may be defined as a fixed point in the body through which the resultant of the gravity forces acting on all the molecules of the body may be said to act (Asher, 1975).

At birth the centre of gravity is located approximately 20 centimetres above the trochanters at the xiphoid process. During growth it descends slowly and at 6 years old has dropped through the diaphragm into the abdominal cavity and becomes located in the vicinity of the umbilicus. It rests at approximately 10 centimetres above the trochanters at maturity - on the level of the iliac crest at the second or third sacral vertebra. Although anatomical location of the centre of gravity changes with age, it remains a relatively constant proportion of total height. In the adult the ratio of the centre of gravity to the total height is 53% to 59% (Payne & Isaacs, 1991).

4.5 HEIGHT AND GROWTH RATE

The preferred measurement of body length is standing height (stature), which is the distance between the vertex and the floor.

The growth rates that occur during the 9 months preceding birth and the first year of life are the fastest that the body will experience. Typically the birth length increases by 50% in the first year and reaches approximately one - half of adult height by 2 years of age. Hereafter the growth rate slows to an average of 5 centrimetres per year until the onset of the pubescent growth spurt. A mid-growth spurt may occur between the ages of 5 ½ to 7 years. Females complete their peak growth period by 16 ½ years of age and males about 2 years later (Asher, 1975). According to Tanner (1978) maximum growth of the vertebral column may not be reached until about age 30, at which time an individual may add 2,5 to 5 millimetres to his or her height. Height remains relatively stable until sometime after the third decade of life when total height begins to regress (Gabbard, 1992).

Normal ageing causes bones to lose mass and the total height to decrease. Women begin to lose bone minerals at about age 30 and men at approximately 50 years. Stature decreases with age because of an increase in postural kyphosis, compression of intervertebral discs and deterioration of vertebrae (Brooks & Fahey, 1984). Estimates of height decreases from 35 to 75 years of age are about 2 ½ centimetres for males and 5 centimetres for females (Gabbard, 1992). In addition, the loss of trunk muscle strength approaches 1% per year, while passive tissue strength decreases by 30% in cartilage, 20% in bone and 18% in tendons and ligaments between the third and eighth decades (Ashton-Miller & Schultz, 1988).

4.6 POSTURAL PATTERNS IN CHILDHOOD

Postural patterns in childhood vary with age, sex, stage of development and body type. A constant pattern only emerges at the age of ten and older when a sufficient degree of development has been attained. Under 10 years old children are continually experimenting with different ways of reacting to gravity (Asher, 1975).

In the second and third years the characteristic picture of potbelly and lordosis is seen - the child`s method of distributing weight and ensuring balance. The pelvic tilt varies between 28 to 40 degrees but the child appears to vary the degree of lordosis by altering the curvature of the lumbar spine rather than altering the tilt of the pelvis. Balance is maintained by leaning forward and keeping the knees slightly bent (Asher, 1975).

At 4 years of age the child shows a comparatively constant average posture. The feet show a slight degree of pronation, a degree of dorsi-flexion well beyond a right angle is possible; the knees are straight when standing with a degree of incomplete extension when standing compared to the adult; the pelvis is tilted forward, abdomen prominent and lumbar lordosis fairly well marked; the dorsal spine is nearly straight and the neck shows a mild lordotic curve with no forward inclination. The increased size of the abdomen results frequently in a long lordosis extending to the upper dorsal region and producing prominent scapulae. This, and the less developed chest, are correlated with round shoulders (Phelps *et al.*, 1956).

The child who is 7 years old tends to tilt his pelvis and protrude his abdomen and hyper-extend his knees, thereby distributing his weight evenly (antero-posteriorly) on both sides of the line of gravity. The pelvic inclination varies between 30 and 40 degrees when measured with a Wiles inclinometer (Asher, 1975). Lumbar lordosis increases by about 10% between 7 and 17 years of age during which time the spine increases in length by about 26% (Ashton-Miller & Schultz, 1988).

During the time that posture is stabilizing, the pelvic tilt decreases and becomes more consistent. Pelvic inclination is an important mechanism in maintaining balance in the growing child - it enables him to distribute his weight about the line of gravity when body proportions alter. In tests using a Wiles inclinometer (Asher, 1975) pelvic inclination varied from 25 degrees to 40 degrees in the mid-school period, and settled down to less than 30 degrees during the growth spurt. It remained fairly constant at 20 degrees from the age of 18 onward (Asher, 1975).

4.7 NEUROPHYSIOLOGICAL ASPECTS

It would seem that the infant's inability to walk at birth is due more to an undeveloped equilibratory apparatus than to the absence of a walking mechanism. A primitive or vestigial mechanism exists, but it appears to be segmental and not integrated with related functions essential to upright ambulation (McGraw, 1932).

Cortically controlled voluntary movements develop in a fairly predictable sequence in infants. Gaining the walking mechanism follows the same pattern as gaining the act of standing erect. Voluntary movement follows a cephalo-caudal pattern of development. The head is the first body part to be voluntarily controlled - this allows the child to visually scan the environment more effectively (McGraw, 1932).

Body control is gained soon after control of the head. The upper body gains control first, with lower portions gradually acquiring voluntary movement. Control of the body enables appropriate positioning for the eventual acquisitioning of locomotion and allows the child to position the body in such a way as to free the hands for reaching and grasping (Payne & Isaacs, 1991).

Development of an erect posture and locomotion in infants adheres to the general laws of functional growth. Certain types of activities appear to function on a reflex level before they become a part of a controlled muscular pattern (see Bobath, 1980, for example). The reflexes tend to disappear before or about the time the controlled neuromuscular pattern emerges. For example, there is a diminution of the early reflex stepping movements before the controlled process of walking appears (Bobath, 1980). There is no evidence of a sudden emergence of a new totally integrated pattern when a new phase in the development starts. Rather, a new pattern unfolds slowly and takes over from the old pattern until it becomes dominant and finally is superimposed upon the old pattern.

Growth in the assumption of the erect posture and walking is an extraordinarily gradual procedure. It is dependent upon maturation of the nervous system, but also requires learning, which takes place during the various stages of the infant's development from the supine position to the eventual upright (Dart, 1947; McGraw, 1932; Thelen, 1998).

According to McGraw (1932) acquiring any new reaction pattern by the infant is associated with uncertainty or dyssynergia. Learning is unquestionably required to decrease the uncertainty and dyssynergia.

Infants come into the world seemingly ill designed for adaptive movement, especially as upright bipedal creatures (Thelen, 1998). They have large, heavy heads, narrow shoulders short legs and weak muscles, and come into the world from a supporting aquatic environment (see section. 4.2.1 & 4.3). From birth onwards nervous systems of infants have to contend with the effect of gravity, rapid changes in the infant's biomechanics, differences in a wide range of individual movement styles; problems which the nervous system could not have anticipated beforehand by hard-wiring all the solutions genetically. The only solution to this problem is that the system must be designed to learn by interaction with the environment (Thelen, 1998).

Added to this is that the weak-muscled infant has to achieve certain critical developmental phases before learning of specific skills become possible. Recent studies, for example, have emphasized the critical role of postural control in motor development, for example, visual pursuit of a target in two-month old infants depends on postural control of the torso. Children cannot begin to walk independently until they have sufficient extensor strength and postural control. It follows that whereas most of the components that appear to contribute to walking onset (for example, tonus control, articulatory differentiation, visual flow sensitivity, motivation) are functional, the lack of postural control and muscular strength prevents the development of independent walking (Bril & Brenière, 1992).

CHAPTER 5

MALPOSTURE

Remember that these relationships of one body part to another represent an ideal pattern
(Goss, 1986: 220).

You can tell a Najavo from a long way off by the straightness of his back
(Rees, 1995: 131).

5.1 INTRODUCTION

Many deformities develop during the growing years, mainly as the result of faulty body use. The normal growth and development of any bone are dependent upon the inherent tendency of the bone to grow in a certain manner as well as upon the stresses and strains that the bone endures during normal activities. Outside influences, however, can wholly change this inherent tendency to assume a certain shape (Roaf, 1960). Diseases of bone have the sole effect of softening of the bone and its ultimate shape depends entirely on mechanical factors. In the same way, permanent muscular weaknesses lead to failure in the normal support of a portion of the body, the position which it assumes depending on gravity, muscular imbalance and the general alignment of the entire body (Goldthwait, *et al.*, 1952). Muscles which become tight tend to pull at body segments to which they are attached, causing deviations in alignment. The antagonistic muscles may become weak and allow deviation of body parts due to their lack of support. The muscle tone will change via afferent impulses from the joint structures such as capsule, synovial membrane, ligaments and tendons. These impulses reflexively influence the tone of muscles (Ayub, 1987). In short, according to the Alexander principle: *Use affects functioning* (Barlow, 1990: 17).

5.2 MALPOSTURE SEEN FROM A TOTAL PERSPECTIVE

> *Faulty posture always expresses the emotional stress that has been responsible for its formation. The most frequent and observable one is the stress of insecurity in its different aspects, such as hesitation, fear, doubt, apprehension, servility, unquestioning compliance - and their exact counterparts* (Feldenkrais, 1985: 55).

> *It is alleged by teachers and physical culturists that bad posture is harmful. I venture to brave this opinion as ill-conceived. There is no general harm whatsoever in any awkward or ungainly configuration of the body in itself, except the minor local effect. A well-coordinated person can adopt any position for any length of time without the ill effects that accompany the same configuration (as they would put it) naturally. The ill effect that we do find is not due to an anatomical configuration that is harmful per se, but to the fact that it is compulsive and is the only one the ill-coordinated person uses for performing the act.*

> *.....The pattern of doing that has brought the person to this state is the harm producing agent, not the anatomical configuration* (Feldenkrais, 1985: 109).

> *I am not so much concerned with **attitudes** (that is to say, temporary postures and gestures), as with the basic **disposition** of the body, compounded as it is at any given time of the patterns which we have inherited and the patterns we have learned* (Barlow, 1955: 660).

Postural disorders of primary importance, according to Barlow (1955), are the head-neck relationship; joint surfaces which are pulled together and the pelvis being used as part of the leg. These postural disorders are, however, the result of behaviour rather than structure. This behaviour comprises all the habitual motor responses with which we react to the outside world and by means of which we adapt ourselves to its various stresses. Anxiety and muscle tension go together and a person's muscular tensions are a fundamental part of his defence against the world. Removing the tension state may cause a person to feel naked, defenceless and uncomfortable when going about his daily affairs and he may revert to his old tension state and the accompanying posture (Barlow, 1955).

Faulty integration of attitudinal and righting reflexes during the performance of a physical function, is the total problem of faulty posture and poise, according to Dart (1946). He pointed out that in the human disease of malposture, the bones, joints, muscles, nerves and coordinating brain are all complete in every detail. The malposture is purely functional - with a low neuromuscular coordination causing muscles to act in a less integrated manner; the smooth, balanced movements of body and limbs are lost (Dart, 1946).

Dart (1946, 1947) ascribed the lack of *poise* in human adults to inadequate exploiting, to short circuiting, or to actually eliminating the ancestral phases of posture - presented by the supine, ventrigrade and pronograde postures, to which the primate, anthropoid and humanoid stages may be added, during ontogeny (Chapter 4) in the infant's (or parent's) haste to become erect. He also reiterated the important role played by the position of the head in posture and movement:

> *But directly or indirectly every sort of bodily movement and skill illustrates the same principle: if the head containing the balancing organs is not the prime mover, if it is incorrectly placed and maintained for equilibrated execution of the movements planned, the movements will be unbalanced and in brief, caricatures of what those movements should be* (Dart, 1947: 11).

Stemming from incorrect use of the head, amongst other things, the vast majority of people tend to rely more on one torsional sheet than on the other, and then develop a right-handed or left-handed torque, an obliquity, twist or asymmetry of posture and movement (Dart, 1946; Chapter 9, sections 8.2 and 8.3). The neurophysiological background of this system is discussed in Chapter 6, section 6.4.6. In the sections that follow, malposture will be discussed in the various body segments.

5.3 THE UPPER QUARTER

5.3.1 The head and neck

Alexander (1932) emphasized the importance of the head and neck relationship, believing that misuse started there and then led to problems elsewhere. In the same vein, Sir Russell Brain (1959: 1491), physician of the London Hospital, noted:

> *At higher levels we need to consider the particular importance of the head, stressed by Sherrington, and the influence of the labyrinth and the neck upon bodily posture as a whole.*

5.3.1.1 Posture of the upper quarter

The large head is well-balanced on the flexible cervical spinal column with the *foramen magnum* opening towards the frontal plane and the heavy occipital portion offset by the large mandibula (Phelps *et al.*, 1956). The position of the head is significant in the determination of the overall body posture, as well as limb control. Abnormal positioning of the head on the cervical spine is increasingly significant when considering the importance of the upper cervical spine (the occiput on the atlas and the atlas on the axis) on the regulation of body posture. The essential afferent impulses for the static and dynamic regulation of body posture, as well as the ability to produce reflex changes in the motor unit activity of all four limb muscles, arise from the receptor systems located in the connective tissue structures and muscles within the upper vertebral synovial joints. The balancing of the head on the cervical column is like a lever system whose fulcrum lies at the level of the occipital condyles; the centre of gravity of the head is near the *sella turcica* and the apex of the cervical lordosis is located at the posterior-inferior border of the fourth cervical vertebra (C_4) (Ayub, 1987).

Flexion is achieved to a large extent by movements between the second and third and between the fifth and sixth cervical vertebrae. The first motion zone is the site of occasionally apparent forward displacement in children, while the latter region in adults shows the greatest osteoarthritic involvement (Barker, 1985; Barlow, 1990). The in-between vertebrae have some limited motion.

Rotation mainly takes place between the first and second vertebrae (Gorman, 1981; Phelps *et al.*, 1956). Neck muscles become activated during rotation, and in a balanced neck the longer muscles become activated, as well as the very short muscles (*rotatores, interspinales and transversales)* and short occipital muscles. Such a coordinated process produces stability and grace of movement (Rolf, 1977).

Normal movement of the neck depends on the superficial muscles attached to the shoulder structures (*trapezius, levator, sternocleidomastoid)* and on the deeper neck muscles (*semispinales, multifidus, longissimus capitis)* (Rolf, 1977). The intrinsic muscles of the atlanto-occipital and atlanto-axial joints all arise from the atlas or axis and have the function of moving the head on these joints and of holding the head securely. Movement at the atlanto-occipital joint is limited compared to the wide range of movement at the middle of the neck through the action of the large neck muscles. This points to a difference in function of the two groups of muscles: The first is a small movement within another large movement and the smaller movement is the all-important one of maintaining a proper balance of the cranium and a correct relationship between the cranium and the body. Poise and good posture come from the ability to control the function of these sub-occipital muscles (Alexander, 1941).

5.3.1.2 Developmental deformities of the upper quarter

Deformities about the head become apparent because of the symmetrical arrangement of the ears, eyes, nose, mouth and chin. One of the most common deformities is that of the tilted head position, either in the lateral or antero-posterior plane. With slumping of the head, there is not only a forward or lateral flexion, but usually also a twist. This latter may be the result of mild abnormalities in the cervical articular facets, the pedicles, or the transverse and the spinous processes which can be found on close inspection in almost every skeleton. Since this is the easiest position to assume, it becomes habitual if no effort is made to hold the head erect. The result is that soon contractures develop in those muscles which have had their origins and insertions brought closer together. This becomes a fixed position and the features of the face, the bones of the skull and the cervical spine adapt themselves to it (Goldthwait *et al.,* 1952). The extent to which each vertebra grows varies and in general cephalic vertebrae grow less than the caudal ones. In addition, the anterior elements grow faster than the posterior in the cervical regions (Roaf, 1960). This could have a transient effect on the posture of a young person.

5.3.1.3 Comments

Changes may occur in the skull in the shape of prominences in the regions of the occiput or temple. Occasionally these deformities may lead to obstruction in the upper air passages or in the accessory nasal sinuses and these are mainly the result of altered muscular pulls (Goldthwait *et al.,* 1952).

Vig, Showfety, and Phillips (1980) studied the effect of nasal obstruction on head posture and found that head extension was a result of closing the nasal airway. They stated that head posture was modifiable and that postural adaptations required altered muscular activity that might manifest itself in permanent changes to musculo-skeletal relations if it occurred during growth periods.

The importance of balanced mandibular posture to total systemic health has been expressed by many in the dental profession. Stenger, Lawson, Wright and Ricketts (1964) related mandibular over-closure to increased flexion of the cervical vertebrae in the area of C_2, C_3 and C_4, and Smith (1982) correlated muscular strength to jaw posture. Williams, Chaconas, and Bader (1983) concluded that mandibular position affects appendage muscle strength, and may be important to total body well-being. Kaufman and Kaufman (1983) linked headaches, neckaches, earaches and backaches to misaligned condyles in the temporomandibular joint. Repositioning the mandible to an anterior position and increasing the vertical dimension thus changing the head-posture relationship, alleviates stress and reduces pain. Repositioning the mandible with its condyles reduces stress placed on the spine by muscles and therefore, tension, stress and deformity on the body is also reduced. The result is a decrease in the curvature of the spine and, according to Kaufman (1980) an improvement in the scoliosis. Garbourg (1997) found that misalignment of the upper and lower front teeth was often reflected in some degree of crookedness of the spine. Aligning the teeth had a straightening effect on the spine, provided the curvature was not too pronounced.

Postural defects may be derived from deviations from the normal bite of the teeth. In a person with a prognathous bite, the jutting lower jaw could be the cause of slumped shoulders, a rounded back, and cervical and lumbar lordosis, as well as bowlegs and flat feet. In an individual with a retrognathous bite, the receding lower jaw is accompanied by cervical and lumbar lordosis, with the head tilted forward, the mouth open, nostrils dilated, narrow bridge of nose, fingers and toes straight, and the person standing almost on tiptoe. In a person where the biting surfaces of the upper and lower front teeth meet each other, the shoulders are pulled slightly back, the abdomen is thrust forward, the chest barrel shaped, cervical and lumbar lordosis is present, the heels are together, and the knees are locked; the head is raised and tilted tensely back. These observations were made by Garbourg (1997) during her fifty years of work with the body's sphincter muscles, a large part of it under the guidance of an orthopaedic surgeon. These specific observations will have to be verified by future research, the interesting point here though, is that Garbourg (1997) came to the same conclusion than Ayub, (1987) and Dart (1946), in that activity of the facial musculature has a profound effect on that of the muscles and structures in the rest of the body.

Chronically clenched or tightened jaw muscles are common and often distort the entire facial structure (Goss, 1986; Lowen, 1969). Strong emotions that are not expressed might be the cause. However, the universal distortion of a collapsed neck in which the chin moves forward out of alignment will often cause compensations in the jaw pattern (Goss, 1986).

Barker (1985) asserted that the double chin is largely a postural condition. It is often found in association with lordosis where the neck is usually held back excessively.

According to Barker (1985) the only part of the face affected directly by posture, is the area around the eyes. Sitting and looking down most of the day causes the lower eye lid to become creased and baggy.

Mobility of the head is largely dependent on the mobility of the mouth (the first survival tool) and the movements of the oral cavity are in turn dependent on those of the tempomandibular joint. Face pains, clenching jaws and teeth grinding are problems related to the tempomandibular syndrome (Gomez, 1988). This can affect the chewing motion. When chewing is done superficially and the oral cavity is not opened widely enough on the inside, the shoulders fall forward and the whole body droops (Garbourg, 1997).

Garbourg (1997) noticed that the shape of the lips had a decisive effect on the whole body. While a well-curved upper lip is usually associated with good posture, coordination, concentration, optimism and serenity, a flat upper lip indicates disturbed balance in the body such as the asymmetry of one shoulder being higher than the other. Contracted lips affect the back muscles and may lead to inner disquiet, restlessness and aggressiveness.

5.3.1.4 Movements of the head and neck

The spine provides an upthrust against the occipital condyles. The spine consists of a number of separate vertebrae linked firmly together by deformable intervertebral discs and this structural arrangement combines a very stiff resistance to longitudinal compression with a certain degree of flexibility in other directions (Roberts, 1995).

In man the cervical and upper thoracic vertebral joints are amongst the most flexible articulations of the spinal column. They allow the free movement of the head on the body, which in concert with the movement of the eyes forms the basis of much orientating, exploratory and reflex behaviour. However, the versatile mobility of the head-neck system places complex demands on the areas of the central nervous system concerned with postural stability and motor control (Dutia, 1991). The head is normally held pitched slightly forward, and maintained in this position by tonic activity in the muscles of the neck (Loeb, He & Levine, 1989).

The different cervical joints vary in their articulatory ability. The cervical vertebrae have at least 23 joints or points of contact at which motion occurs from the occiput down to the first thoracic vertebra (Kottke & Mundale, 1959) The articulation between the skull and the first cervical vertebra (the atlanto-occipital joint) allows a large amount of extension and flexion, but little or no axial rotation. The atlanto-axial joint, on the other hand, allows an axial rotation through a large angle of approximately 50 °, but little flexion and extension. The remaining cervical vertebrae (C_3-C_7) are less specialized, and have some freedom of movement in each direction. In man, horizontal turning movements of the head occur primarily around the C_1-C_2 joint, with the remainder of the cervical spine involved only in large head turns. The lateral flexibility (sideways bending) of the neck is limited by the geometry of the vertebral joints and ligaments, and involves mainly the lower cervical and upper thoracic vertebrae (Vidal, Waele, Graf & Berthoz, 1988).

Thus anatomical specialization of the vertebral column of the neck imposes mechanical restraints on the freedom of movement of the head-neck system in different planes. Movement of the head on the neck are not accommodated evenly over the serial linkages of the entire cervical vertebral column, but are accommodated instead by movements around particular vertebral joints or groups of joints, depending on the direction and amplitude of head displacement. Further specialization of vertebral motion of the neck, occurs as a consequence of the posture adopted by the head-neck system of the awake individual (Dutia, 1991).

Head movements may be made either in a distributed manner with small movements of many serially linked vertebrae, or in a more concentrated manner around a small number of appropriate joints, while the remainder are actively stabilized by compensatory neck muscle activity. In an individual at rest but awake, the major part of the cervical spine (C_2-C_5) is held in a characteristic near-vertical posture. This resting posture is attained by holding the lower cervical vertebral joints (C_5-C_7) nearly fully extended and the upper joints (Skull-C_1, C_1-C_2) nearly fully flexed. These are also the most mobile areas of the neck (Kottke & Mundale, 1959). Presumably this neck posture is the most energy-efficient for the support of the weight of the skull against gravity, reducing to a minimum the degree of tonic neck muscle activity required (Hellebrandt *et al.*, 1940; Joseph & McColl, 1961).

The location of both ends of the neck (being the vertical bridge between the head and shoulders) determines the stresses under which it functions. If the bridgeheads deviate, the structure is no longer vertical and is under strain; the flow of fluid to the head is constricted and the metabolic rate in head and brain lowered (Rolf, 1977).

The curved cervico-thoracic region of the spine with its associated muscles and ligaments, may also act as a damper or shock-absorbing system that isolates the head from perturbations affecting the body (Vidal, Graf & Berthoz, 1986). When the head is lowered, the cervico-thoracic joints presumably flex and come closer to their mid-range position, while the upper cervical joints remain more or less flexed as before. The lower cervical spine may then participate more significantly in head elevation than before: In effect, the patterns of neuromuscular activity required for head elevation may depend significantly on the original head-neck position, as does the posture taken up by the rest of the body (Abrahams, 1981; Dutia, 1991).

5.3.1.5 Muscles of the upper quarter

The cervical spine is invested with a rich assembly of muscles, reflecting the versatile mobility of its joints. In addition, the control of head position and movement is a complex task which depends upon the coordination of motor activity in multiple muscle groups, innervated by motoneurone pools in the entire length of the cervical- and upper thoracic spinal cord. This complexity is manifest not only in the control of voluntary head movements, but also in the dynamic stabilization of the head through coordinated reflex responses, to involuntary displacements. In addition, damage to neck muscles have resulted in disturbance of gait, dizziness and disorders of the occulomotor system (Abrahams, 1977, 1981; Jongkees, 1969).

A prominent feature of the anterior aspect of the neck, are the paired *sternocleido-mastoid* muscles. These muscles are attached to the mastoid process and to a considerable area of the occipital bone. At the lower end, some fibres run to the sternum and some to the clavicle. The mastoid portions of this muscle have the function of pulling the head and neck forward together without tipping and to control lateral movements of the head. The occipital fibres of this muscle form a crossed four-bar linkage with the skull, the vertebral column and the rib cage. The action of this linkage at any time is very dependent on what other muscles are doing at that time. If the cervical vertebral column is stiffened by the short-range muscles, the occipital fibres of the *sternocleido-mastoid* muscle will either pull the head and neck forward without tipping, or will tip the head backwards over the occipital condyles, according to whether or not the neck is permitted, by other muscles, to bend forward relative to the thorax. Unequal activity of these muscles on the two sides produces rotation of the skull around the long axis of the neck, as in shaking the head.

Under certain circumstances another set of muscles can influence the attitude of the head: The hyoid bone, lying in the neck just above the larynx, functions primarily as an anchorage for the tongue musculature. This bone is held in place by muscles running to the skull, to the lower jaw, to the sternum and to the clavicle. The sternum is thus linked to the skull through a chain of muscles, by way of the hyoid and the lower jaw. If the muscles stabilizing the hyoid are activated at the same time as the masticatory muscles that close the jaw, the combined effect can be to tip the head forward (Roberts, 1995). Appleton (1946) was of the opinion that the "poking" chin results from the fact certain muscles in the cervical spine are neglected.

The muscles of the neck possess a number of notable structural complexities: with the exception of the short intervertebral muscles, each of the neck muscles is innervated by branches of two to five spinal segmental nerves and the territory innervated by each spinal segment is clearly delineated. The dorsal neck extensor muscles are made up of compartments which are separated by tendinous bands that cross the entire width of the muscle (Roberts, 1978).

5.3.1.6 Innervation of the upper quarter

The spindles in the individual muscle compartments respond not only to the length of the compartment, but also to the contracting muscle, and to any differential length changes between compartments caused by unequal degrees of contraction.

The rich sensory innervation of the neck (which will be discussed in more detail in Chapter 6, section 6.3.2.3.1) is a reflection of its role in proprioception and its importance in the augmentation of reflexes controlling the posture of the legs and trunk. During natural movements of the head on the neck, simultaneous vestibular and neck afferent stimulation results in mutual cancellation of their reflex effects, allowing the head to move freely without disturbing the posture of the limbs and trunk (Roberts, 1978).

5.3.1.7 External appearance of the neck

The external appearance of the neck is affected by an individual's habits of using his body. In both types of postural abnormality (kyphotic and lordotic) the normal curvature of the cervical spine is altered. With both types there is an initial stretching of the neck. Later the skin becomes sagging, lifeless and parchment-like with creases at the back of the neck. The tall kyphotic type usually has an increased cervical curve to counterbalance an increased thoracic curve. The neck tends to become rigid and a nod backwards uses mainly the atlanto-occipital joint. The jaws tend to be thrust forward and jutting, stretching the skin of the front of the neck and creasing the skin at the back. A prominent Adam's Apple is common with age (Barker, 1985). These faulty body mechanics lead to antero-posterior flattening of the chest and result in the neck appearing longer (Goldthwait *et al.*, 1952).

Owing to the attachment of the deep cervical fascia, when the chin is thrust forward and there is cervical lordosis, the strands which pass down to the pericardium are relaxed, so that the heart sags down and with it the central tendon of the diaphragm, impairing both circulation and respiration (Forrester-Brown, 1930).

5.4 THE CERVICO-THORACIC REGION

5.4.1 General

Anatomists distinguish some 14 pairs of muscles attached to the skull and contributing to the task of supporting the head. The masses of the paired *sterno-cleido-mastoid* muscles, lying on each side of the larynx, are a prominent feature of the anterior aspect of the neck (Roberts, 1995).

In many necks the *m sternocleidomastoideus* is obvious and stands out like a rope (Rolf, 1977). This muscle is countered by the *m levator scapulae* and the *m splenius* and no "rope" is apparent when these three are in balance. The *m levator* scapulae arise from the transverse processes of the first four cervical vertebrae and inserts into the medial border of the scapula. It raises the shoulders in a shrug or gesture of protection. Habitual fear or - defence permanently shortens this muscle, which then deteriorates with patches of gristle (cartilage) at its insertion on the scapula bearing witness to its decreased mobility. Deterioration of the muscular function may glue one or both shoulder blades to the *trapezius* causing a new *trapezius-levator scapulae* complex which is unable to perform independent reciprocal movements, and forms the basis of the ineffectual rounded shoulders posture (Rolf, 1977).

5.4.2 Functional anatomy of the cervico-thoracic region

The cervic-thoracic region is a prominent area where the shape of the cervical vertebrae alters and the spinous processes become more prominent. This whole area at the base of the neck is a centre of muscular coordination which is affected by patterns of breathing and the use of the arms and shoulders. A good vertebral posture is required in this area for the mechanisms of speech and swallowing with the associated oesophagus, trachea and vocal structures to function well. The main nerve pathways pass through this area, including those nerves which control breathing, heart rate and blood pressure, and here the nerve roots become more liable to compression with increasing age. This is the area where 85% of the British population have arthritis by the time that they are 55 years old (Barlow, 1990).

5.4.2.1 Kyphosis in the upper back

Age increases the kyphotic curve (stoop), and fat may be deposited in the lower part of the back of the neck and over the shoulders. The extreme form of this is known as Dowager's Hump and cosmetic surgery has little to offer for this disfigurement which is caused by excessive and wrongly distributed muscle tension (Barker, 1985; Barlow, 1990). In a normal ribcage, the first rib approximates a straight line from front to back. The Dowager's Hump is the result of a major sagging of the ribcage, tilting the first dorsal and seventh cervical vertebrae. The strain here reflects also into the lumbar spine. In addition, the distortion at the cervicodorsal junction requires that the leg compensates by hyperextending (Rolf, 1977). Postural therapy will generally correct the problem painlessly and cheaply. If excessive curves are allowed to remain, osteoarthritis of the cervical and thoracic parts of the spine are likely to occur (Barker, 1985).

The cervic-thoracic area is where misuse of the body most frequently starts, according to proponents of the Alexander Technique. It is the area to start from to correct the multitudinous misuses that manifest in the rest of the body (Barlow, 1990; Macdonald, 1998).

5.4.2.2 Interrelationships between the cervico-thoracic structures

Waterland and Munson (1964) used a total of 1774 photographs to demonstrate the mutual interdependancy of the regions of the head, shoulder girdle and glenohumeral joint, that is activity in one area affects the behaviour of the others unless consciously inhibited. They found that the head affects the shoulder and then limb positions, and modification in limb positioning first affects shoulder girdle and then head posture.

5.4.2.3 Response of head and shoulder girdle to voluntary arm movements

Unilateral lateral rotation of the humerus evokes shoulder retraction, ipsilateral head rotation and atlanto-occipital ventral flexion. Medial rotation evokes the reversed position. Bilateral medial rotation results in protraction of the shoulders and ventral flexion of the cervical spine whereas retraction and cervical spine dorsal flexion result from bilateral lateral rotation (Waterland and Munson, 1964).

Glenohumeral flexion is associated with elevation and retraction of the shoulder girdle, dorsiflexion of the head and hyperextension of the vertebral column; extension at the glenohumeral joint shows the reverse of this pattern (Waterland and Munson, 1964).

Dorsal flexion of the head, occurring primarily at the atlanto-occipital joint, is linked with shoulder girdle elevation, ventral flexion with shoulder girdle depression (Waterland and Munson, 1964).

5.4.2.4 Responses of head and arms to shoulder movements

With shoulder girdle protraction-depression and retraction-elevation movements, the head and arms respond concurrently rather than in sequence. Retraction is associated with cervical spine dorsal flexion of the head; elevation with dorsal flexion occurring primarily at the atlanto-occipital joint. Protraction and depression is linked with cervical spine and atlanto-occipital ventral flexion, medial rotation and adduction of the arms (Waterland and Munson, 1964).

5.4.2.5 Response of shoulder girdle and arms to movement of the head

If the head is bent to the right side, it results in shoulder depression on the same side and elevation of the contralateral shoulder. Elevation of the arm on the chin side and depression on the skull side are thought to be a direct result of the changes evoked in shoulder positioning (Waterland and Munson, 1964).

Atlanto-occipital ventral flexion, linked with shoulder girdle depression generally evokes elbow flexion; dorsal flexion tied with shoulder elevation, evokes elbow extension. Cervical spine ventral flexion, which is involuntarily tied with shoulder protraction, is frequently associated with spinal flexion. Dorsal flexion of the head is associated with shoulder retraction and strong spinal extension (Waterland and Munson, 1964).

5.5 THE THORACIC REGION (CHEST)

It is easy to develop a sideways twist where the neck joins the back (at the base of the cervical spine). This is usually accompanied by the chest being twisted sideways in the opposite direction to the head. The clavicle on the side to which it is pushed over may be slightly higher than the other or both clavicles may be too high because of shoulder tension. The angle between the ribs will be sharper on one side and the chest may be more inflated on the other side with the cartilage of the lower ribs pushing more forward on that side. Such chest twists and rotations are often undetected and may be the cause of distressing pain in the chest (Barlow, 1990; Ayub, 1987).

Subsequent to the twist (torque force) at the base of the neck, there is a proportionate increase in thoracic kyphosis and a flat chest (Phelps, *et al.*, 1956). The increased thoracic convexity tends to abduct the scapulae and lengthen the rhomboid and lower *trapezius* muscles, while shortening the *serratus anterior*, *latissimus dorsi, subscapularis* and *teres major* muscles (Ayub, 1987).

5.5.1 Round shoulders

In addition, the increased scapular abduction shortens the pectoralis major and minor muscles, which, by their attachment to the coracoid processes of the scapulae, tend to pull the scapulae over the head of the humerus. The humerus then moves into internal rotation and the glenohumeral ligament is shortened. This may result in diminished shoulder abduction, lateral rotation and extension (Ayub, 1987) but not in increased tightness or lack of stretchability of the pectoral muscles (in women) according to Coppock (1958). Ayub (1987), however, accepted that a shortened muscle is a tight muscle which inhibits its antagonists, resulting in muscle imbalances. Thus, weakness of the lower *trapezius* muscle may result from shortening of the upper *trapezius, levator scapula* and *serratus anterior* muscles, whereas inhibition of the *rhomboid* muscles may occur in response to the shortening of the *teres major* muscle.

The movement of the scapula into abduction may result in increased acromioclavicular joint compression and shorten the conoid ligament, while lengthening the *trapezius* ligament. Due to the change in length of the rotator cuff muscles and the resulting dyskinesia, abnormal thickening of these tendons may occur, resulting in less space under the coracoacromial arch. The increased glenohumeral internal rotation stretches the rotator cuff and biceps tendon over the humeral head and may be a factor in their diminished blood supply. The vascularity of the rotator cuff is most impaired when the arm is adducted. Degenerative changes of the rotator cuff are frequent because of diminished blood supply at the watershed area, which translates to the distal portion of the *supraspinatus* tendon, proximal to its insertion into the humeral head. Therefore, small attritional tears have less capacity for repair (Ayub, 1987).

The shortening of the pectoral muscles pulling the scapulae anteriorly, as well as inferiorly, may approximate the acromion and humerus, decreasing the suprahumeral space. Activities such as abduction and shoulder elevation may impinge this already compromised region which may, over time, lead to the formation of osteophytes (Ayub, 1987).

5.5.2 The shape of the thorax

The shape of the thorax (chest cage) is of considerable importance in body mechanics. The antero-posterior diameter should be about two thirds of the lateral diameter and the circumference of the chest at the ninth rib should be greater than in the axillary region, while the sternum should be convex anteriorly (Phelps *et al.,* 1956). The shape of the chest in faulty body mechanics as well as in different body types varies greatly. Both Barker (1985) and Goldthwait *et al.* (1952) determined body type by measuring the subcostal angle at the join with the xiphisternal notch. The slender body type has a narrow angle, long thorax and smaller circumference whereas the stocky type has a wide angle, shorter thorax and greater circumference. Barker (1985) observed that the lower ribs of the slender type have a large range of movements and the wide angled have a small range of movements of the lower ribs. Goldthwait *et al.* (1952) noticed that the different body types were affected differently by the faulty body posture of kyphosis. In the slender type the costotransverse articulations are such that when the dorsal spine becomes more rounded, the head drops forward, causing an increased curve of the cervical spine, a downward and inward displacement of the sternum and the ribs may point downward instead of being at an angle of 30° to the spine. At the side of the chest the ribs are close together and the subcostal angle may become very narrow. In the stocky type, when the dorsal spine becomes more rounded, the head comes forward, the upper part of the chest and the sternum become more vertical and the lower ribs flare outward, both laterally and anteriorly. The ribs are close together but not as vertical as in the slender type.

The shape of the chest affects the muscles attached to the chest wall. When the chest droops downward the abdominal muscles (*recti*) are relaxed because their origins (the sternum and costal margin) and their insertions (Poupart's ligament and the pubis) have been brought closer together, thus making the function of these muscles less efficient (Goldthwait *et al.*, 1952). On the other hand, if *recti* are shortened and thickened through repetitive flexing, complications arise with the most apparent distortion in the ribcage. Chronic shortening of these muscles drags down the rib structure as a whole, bringing the lower ribs too close to the pelvic brim. This chronic flexion strains the entire body, since neck and cervical spine are inevitably included in the compensation.

The myofascial structures of the cervical spine become anteriorly shortened and therefore the head comes forward (Rolf, 1977).

5.5.3 Thoracic kyphosis

Curvature of the spine is lordosis if the bend is backwards; kyphosis if it is forwards; scoliosis if it is lateral (Inglis, 1978; Jayson, 1981).

Not much has been published about the mean degree and range of thoracic kyphosis in either children or adults (Willner, 1981). One study, however, showed that the normal range of kyphosis is related to both age and gender of a person. The degree and rate of increase with age is higher in females than in males after the age of forty. The increase of the kyphotic curve is associated with changes in the soft tissues and mineral content of the bones with increasing age. Compression wedging of the vertebrae and its narrowing of the intervertebral discs take place. Poor posture and physical inactivity may lead to decreased tone on spinal ligaments and muscles resulting in an increase in kyphosis (Fon, Pitt & Thies, 1980). Posture, however, varies during the growth period with a tendency for a reduction in size in the thoracic kyphosis from the age of 8-14 years and reaching a minimum at the age of 12. This applies for both sexes and is thus independent of growth velocity (Dickson, Lawton, Archer, & Butt, 1984; Willner & Johnson, 1983). However, Ashton-Miller and Schultz (1988) found that although growth has little effect on the magnitude of thoracic kyphosis, a few degrees of increase occur from age 5 to 20. Childhood "drooping" which persists during the growing years, may lead to a lasting deformity (Goldthwait *et al.,* 1952).

5.5.4 The diaphragm

The effect of posture on the diaphragm is inconclusive (Barker, 1985; Goldthwait *et al.*, 1952; Kuhns, 1936; Laplace & Nicholson, 1936). The effect of the diaphragm on total well-being is indisputed, however (Barlow, 1990; Lowen, 1994; Wilson, 1982), and an increase in vital capacity with correction of faulty posture, has been a constant finding (Hellebrandt *et al.*, 1940; Kuhns, 1936; Laplace & Nicholson, 1936).

> *Immediate or extreme attempts at correction of posture will frequently put so great a task on the musculature of the thorax and abdomen that vital capacity will be diminished* (Kuhns, 1936: 1012).

5.5.5 Receptors in the chest

Godwin-Austen (1969) demonstrated the presence of receptors which are sensitive to rib movement and which are situated in the costo-vertebral joints, averaging about two in each rib joint. These receptors are capable of defining the position of these joints and the direction of velocity of the movement of the joint. These are not to be confused with respiratory receptors. Previously Cohen (1958) mentioned that it was reasonable to assume that position sense accuracy bears some relation to receptor density and he stated that joint proprioceptors contribute greatly to the sense of limb position. These joint proprioceptors are little affected by muscle tension. The interesting point of Cohen (1958)'s findings is that during passive movement, the first sensation experienced is a vague sensation of movement, followed by an awareness of the general direction of movement and finally replaced by an appreciation of the exact position of the limb. It is assumed that the same proprioceptors are responsible for each of the sensations. The thresholds for all three sensations are so low that separate sensations are indistinguishable during usual joint movements. This gives an inkling about why man is usually unaware of the positions of various parts of his body. However, Jakobs, Miller and Schultz (1985) demonstrated that healthy adult subjects have the ability to sense the lateral position of the top of their thoracic spine and can centre it over their pelvises. This finding was supported by Jepsen, Miller, Green and Schultz (1987) who added that positioning was less accurate from the anterior than from the posterior direction and suggested that the spine postural control system also used afferent information from joint receptors. One may argue that the sense may exist voluntarily but is probably often suppressed. Becoming aware of it may assist in regaining spinal alignment.

5.6 THE LUMBAR REGION

5.6.1 General

> *Because he has a greater number of free lumbar joints and a greater thickness of lumbar discs, man, of all primates, has the greatest degree of lumbar spine flexibility* (Farfan, 1978: 337).

One of the most important parts of the spine from the mechanical point of view, is the dorsolumbar region where the vertebrae change from thoracic to lumbar and extremes of motion takes place. The exact location of the maximum motion depends on the anatomical type and may be anywhere from the tenth thoracic in the stocky type to the third lumbar in the slender type (Goldthwait *et al.*, 1952).

The sharp backward bend between the lumbar column and sacrum is a particular human characteristic. This lumbo-sacral angle, which on average amounts to 142° with men and 144° with women, is the base for the attitude of all vertebral bodies. Seventy percent of all extensions and hyperextensions of the lumbar column take place at this point (Tittel, 1990).

5.6.2 Lumbar lordosis

Sagittal curves of the spine change during the different growth stages of the body. A slow increase of the lumbar lordosis was observed in children between 8-16 years of age. Ashton-Miller and Schultz (1988) estimated the increase to be 10% between the ages of 7 and 17 years. The normal range of lumbar lordosis has been assumed to be between 40°-60°. The range of thoracic kyphosis and lumbar lordosis is assumed to be interdependent (Willner &

Johnson, 1983). Postures such as sway back and hyperlordosis tend to rely on ligamentous support rather than muscle activity, eventuallly leading to disuse in the postural muscles (Norris, 1995).

The lordotic curve often diminishes after 64 years of age. This may result from increasing kyphosis pushing the centre of gravity of the body forwards with loss of lordosis from compensatory straightening of the lower spine (Ashton-Miller & Schultz, 1988; Milne & Lauder, 1974).

5.6.2.1 Low back pain and posture

Byl and Sinnott (1991) found that those suffering from low back pain had increased body sway, poor one footed balance with eyes closed, a posterior position of the centre of gravity and a tendency to fulcrum about the hip and back to maintain uprightness when exposed to challenging balance tasks. Healthy controls maintained their fulcrum for the centre of balance around the ankle. These findings suggest a defect in the tripartite mechanism in the control of the upright and even the sitting position.

Because of the mobility of the dorsolumbar area, habitual faulty mechanics tends to, at some stage, cause strain with accompanying inflammatory processes around the articular facets and the joints of the spine as well as irritation at the spinal nerve roots. Referred pain from this may be the cause of painful symptoms in the region of the appendix, the lower abdomen and the gallbladder (Goldthwait *et al.*, 1952).

The lumber spine may be the site of numerous orthopaedic ailments, but by far the most common one is the low back pain syndrome (Nachemson, 1976). Several psycho-social factors influencing low back incapacity have been suggested, for example: Disturbed personality (MMP), alcoholism, divorce, religiosity and job dissatisfaction. Radiologic abnormalities in the lumbar spine with significance for low back pain that have questionable values are, amongst others, severe lumbar scoliosis and severe lordosis, as found by Nachemson

(1976). A study by Christie, Kumar and Warren (1995), found an increased lordosis in a chronic low back pain group. They noticed a discrepancy in posture between acute and chronic low-back pain sufferers: acute low back pain sufferers tended to develop thoracic kyphosis. They postulated that it is an open question whether poor posture leads to pain, or precipitation of pain necessitates postural aberrations. According to Barlow (1990), lordosis plus scoliosis will usually be present when there is chronic back pain and it is only in the acutely painful back that the lumbar curve is flattened by spasm.

Considering the anatomy and mechanics of the lumbar spine, excessive curvature (lordosis) probably has some sort of affect on the functioning of the body as has excessive flattening of the lumbar curve. In a lordotic posture the stress on the facet surfaces is high and may be responsible for the high incidence of osteoarthritis in these joints. Also, the possible extra-articular impingement between the facet tip and the adjacent lamina or pedicle in a lordotic posture could be a source of low back pain, especially if the joint capsule is trapped between the bony surfaces. The extremely lordotic spine increases the load on the axial skeleton by 55-65% (Tittel, 1990). However, if flexion is excessive, so that the posterior intervertebral ligaments are overstretched, the anterior vertebral body may be crushed or there may be a sudden posterior prolapse of the intervertebral disc (Adams & Hutton, 1985).

Muscular deficiency has also been cited as the cause of low back pain with the following sequence offered as the etiology for the syndrome: 1) disuse results in atrophic changes; 2) the weakening musculature must then work at an increasing percentage of its maximum voluntary contraction capability; 3) whereas the normal musculature can work for prolonged periods without any electromyographic evidence of fatigue, in the weaker muscles such activity results in constantly rising levels of activity which ultimately result in tonic local muscle spasm; 4) the tonic local muscle spasm produces localized areas of ischemia; 5) the ischemia causes pain; 6) the pain causes increased muscular contraction and a vicious cycle is born which has as its end result the typical low back pain syndrome (DeVries, 1968).

5.6.2.2 Balance between lumbar structures

Reciprocal balance between lumbar spine and sacrum is of major importance and low back problems indicate a deterioration of the normal internal balance between lumbar spine and pelvis (Rolf, 1977). However, asymmetry of spinal lateral flexion and probably of human body mechanisms in general, should also be noted in back pain studies (Mellin, Härkäpää, & Hurri, 1995).

Poor postural control leads to postural disequilibrium and this may be the cause of idiopathic scoliosis. The researchers coming to this conclusion reasoned that a crooked spine would not cause a postural dysfunction and as a decrease in postural sway was measured in the patients with scoliosis, the disequilibrium probably preceded the scoliosis (Sahlstrand, Örtengren & Nachemson, 1978).

Tilting the pelvis posteriorly decreases the absolute depth of the lumbar curve, and tilting the pelvis anteriorly increases the absolute depth of the lumbar curve (Day, Smidt & Lehman, 1984). For upright standing the lumbar curve appears to be oriented more towards the maximal trunk flexed position than toward the maximal extended position (Day *et al.*, 1984).

Most habitual or preferred standing postures (such as resting on one leg) cause some degree of lumbar flexion, compared with erect standing, leading to the assumption that people want to reduce the lumbar lordosis whenever possible, even at the expense of increasing back muscle activity. Evidence suggests that such postures may be advantageous (Adams & Hutton, 1985; Dolan, Adams & Hutton, 1988). The compressive force on the apophyseal joints is reduced in flexed postures and the transport of metabolites is improved. Deficient metabolite transport has been linked to degenerative changes in the disc (Nachemson, 1976).

With increasing flexion there is an increase of tension in the intervertebral ligaments until the flexed trunk is supported by the ligaments, at which point the *erectores spinae* muscles relax (Floyd & Silver, 1955). During flexion of the trunk, the points of attachment of the *erectores spinae* muscles and the intervertebral ligaments are drawn apart. The consequences of this is that muscle fibres lengthen while exerting tension and hence do negative work, and the tension in the ligaments increases (Floyd & Silver, 1955). The myoelectric activity increases as flexion increases, until full flexion is reached. In this position the activity level decreases and frequently, activity ceases almost completely. Intradiscal pressure increases significantly more during flexion than during extension (Andersson, Örtengren & Nachemson, 1977; Portnoy & Morin, 1956).

5.6.2.3 Relationship of the lumbar area to others

Lordosis is a primary contributor to the subjective and objective weakness that accompanies cervical anteriority, according to Rolf (1977). Conversely, gross cervical displacement makes it impossible to reorganize a lower back. Any satisfactory remedy must deal with these circular interplays.

During lumbar flexion (posterior pelvic tilt), there is an inverse relationship with the lumbar curve length (T_{12}- S_2) and the thoracic curve length (C_7-T_{12}). As the pelvis rotates posteriorly, the thoracic area is rotated in the anterior direction by the abdominal muscles. Thus the length of the lumbar segment increases and the thoracic length decreases. Minimal thoracic spine movement in flexion and extension occurs during anterior and posterior pelvic tilt and the maximum change in thoracic curve depth is less than 0.3 centrimetres (Day *et al.,* 1984).

Pain in the lumbar spine and pelvis are correlated with forward head posture (Christie *et al.*, 1995).

5.6.2.4 Use of the pelvic region

When the body is used correctly, the mass is carried on the bodies of the vertebrae. When it is used incorrectly, the weight in the lumbar and the cervical regions is displaced backward, so that it increasingly presses on the articular facets, forcing the joints more and more to the extreme position of their range of motion. Whether this extreme position will be reached at the lumbo-sacral joint or higher up depends on the individual body type - be it stocky or slender (Goldthwait *et al.,* 1952).

5.7. THE PELVIC REGION AND THE LOWER EXTREMITY

> *Reciprocal balance between lumbar spine and sacrum is of major importance. Low back problems indicate a deterioration of the normal internal balance between lumbar spine and pelvis* (Rolf, 1977).

According to Rolf (1977) the pelvis is the key to the well-being of the individual. But it is a dynamic key, a process key. Technically and anatomically, the pelvis is a bony basin. Vitally and physiologically, it is a relation of energies. Optimal performance of such a system occurs only at the narrow peak of balance, which necessarily has to be very precise.

5.7.1 Flexion at the hip

Motion at the hip is under control of the hip musculature, while motion of the lumbar spine is under control of active spinal musculature requiring a complex ligamentous system as additional support. The sequence of forward flexion according to Farfan (1978) is as follows: in the first stage, the lumbar joints flex as the extensors lower the body weight above the lowest lumbar joint. The activity of these muscles increases with the increasing moment. The change in geometry causes the posterior ligamentous system to become tight and to develop tension. At a point near 45^0 of forward flexion and onward, the ligament tension increases rapidly, reducing the necessity for muscle activity. Further forward rotation then occurs with pelvic rotation under control of the hip extensors, allowing the trunk above the fully flexed hip joint to be brought to a horizontal position or beyond when the extensor muscles relax.

5.7.2 Functional variations

In the hip region a tight tensor *fascia lata* will produce an increased pelvic inclination and a hyperlordosis. A weak gluteus maximus will permit a flexion position of greater degree accompanied by a tight quadriceps and flexed knee (Phelps *et al.,* 1956).

The pelvis serves as a container for the abdominal viscera. In many people the pelvis is tipped forward causing the viscera to spill over and be restrained by the muscles and skin of the abdominal wall. This leads to a protruding stomach (Rolf, 1977).

Faulty body mechanics may cause the rami of the pubis and the ischium to project further forward resulting in a deformity called ischium varum or valgum (Rolf, 1977). The superior and the posterior margin of the acetabulum may be altered by the constant forward inclination of the pelvis, which also leads to a relative instability in the hip joint. The muscles about this joint are attached in such a manner that in normal function their contraction tends to pull the head of the femur into the acetabulum. When this pull is changed, as occurs when the pelvis tips forward, the action of the muscles in stabilizing the hip is lost, resulting in irritation and later arthritis at the hip joint (Goldthwait *et al.,* 1952).

Freedom in the hip joint is lost when the hamstring muscles shorten from any cause. The hamstrings traverse the back of the thigh, joining the ischial tuberosity of the pelvis to the leg below the knee. They shorten and thicken as a result of over-exercising. The three hamstring muscles may become "glued" together, losing independent movement by shortening and forming a bulge at the back of the leg (Rolf, 1977). (Myofascial sheaths surrounding individual muscles become glued together and cause restrictions).

Rotation in the hip joint is limited by various poor postural habits. Movement of the pelvis subsequently becomes restricted, forcing the substitution of bending the spine to achieve upright postures. Eventually the pelvis exerts a downward pull through the muscles of the back, causing the head to begin locking on the cervical spine. This may lead to compression of the spine and the emergence of painful conditions (Cohen-Nehemia, 1983).

Very little movement takes place at the sacroiliac joints (DonTigny, 1993). Lavignolle, Vital, Senegas, Bestandau, Toson, Bouyx, Morlier, Delorme and Calabet (1983) reported a rotation of 12^0 and translation of 0.6 millimetres on average in young adults. However, this is the locus of low back sprain known as the sacroiliac syndrome. In 1927 Lusskin and Sonnenschein, after thorough research, declared disability due to pain in the lower back as a definite syndrome. The four cardinal signs are: Flat back, scoliosis, tenderness over the involved joint and hamstring spasm. Correction of any postural defect or of a weak foot, will aid in the prevention of the occurrence.

Structurally the sacrum is suspended from the ilia. Significant mass-bearing is precluded by the verticality of the neutrally suspended sacroiliac joints (DonTigny, 1993). Mass bearing may be increased by a self-bracing mechanism which occurs during flexion of the pelvis (Vleeming, Volkers, Snijders & Stoekart, 1990). Pelvic flexion, caused by any mechanism which will rotate the innominates posteriorly (posterior tilt of the ilia to the rear) will result in the tightening of the posterior interosseus ligaments, and the sacrotuberous ligament which then markedly increases the friction and mass-bearing capacity of the sacroiliac joint. Anterior rotation of the innominates on the sacrum, on the other hand, decreases the tension on the sacrotuberous ligament, releasing the self-bracing mechanism, decreasing the mass-bearing and increasing shear (DonTigny, 1993). For the maintenance of the integrity of the sacroiliac joints good posture, associated with support by the abdominal muscles are essential (DonTigny, 1993).

5.7.3 Pelvic tilt

Pelvic tilt is related directly to the position of the lumbar spine and the sacrum. A study by Levine and Whittle (1996) showed that pelvic tilt in the standing position significantly affects lordosis of the lumbar spine, the greater the forward tilt the greater the spinal lordosis and strain. In an unbalanced pelvis, the strain is reflected into the lumbo-sacral junction and movement is impeded. This is one of the most important joints in the body where a very slight mobility stimulates the autonomic plexi of the lumbar and sacral areas (Rolf, 1977).

Differences in leg lengths result in a lateral pelvic tilt (Phelps *et al.*, 1956). Lateral pelvic tilt produces apparent shortening of the leg which is usually the result of muscular imbalance in one ("shorter") leg where the adductors (inner leg muscles) are stronger than the abductors (Barker, 1985).

Pelvic tilt scoliosis is also caused by inequality of the length of the legs and has the secondary effect of minor, non-progressive, lumbar scoliosis. This accounts for 40% of spinal deformities (Dickson, 1983).

Deep muscles tend to cause the pelvic tilt, and the overlying and supporting muscles deteriorate. The tone of the muscles attached to the pelvis (*obliques, recti abdominis,* gluteal and rotator groups) reflect the general health and well-being of the pelvic and abdominal organs. A sagging potbelly and gluteals are not merely cosmetic offenses, but indicative of sagging reproductive and elimination organs. They also relate to the heavy, dragging gait of the individual (Rolf,1977).

An obvious lateral pelvic tilt is the relatively common postural fault when the person habitually stands with one knee bent and the opposite buttock pushed out. This results in stretching and weakness of the *gluteus medius.* Clinically, patients with this fault may present in one of three ways: backache; swollen hip, or pain referred to the abdomen (sometimes erroneously diagnosed as appendicitis) (Burt, 1950).

5.7.4 Sacrum and femur

The weight of the upper body tends to force the upper part of the sacrum forward and the upper coccyx may compensate by rotating backward. The strong ligaments binding the sacrum in place have the function of resisting these tendencies. An interosseous sacroiliac and sacrotuberous ligament form a joint of great strength that holds the sacrum fast against lateral rotation. The sacrospinous and sacrotuberous ligaments resist the tendency of the base of the sacrum to rotate forward. The piriformis (rotator muscle) lines the anterior surface of the sacrum and through this muscle deviation of the sacrum is transmitted as strain to the rotators of the thigh. A sacrum that is too deep causes as well as reflects inadequate support from the related rotators. Imbalanced rotators transmit disparate support; one or both femurs (together with the legs) will then be aberrant (Rolf, 1977).

Male and female femurs differ. In the male, the neck of the femur is not as horizontal as in the female and the head of the femur is inserted in the hip joint so that the neck of the femur is angled backward from the joint. The horizontal neck of the female femur causes wider hips and the appearance of knock-knees. With the female femur set forward, the lordotic curve is greater in order to bring the chest further back to counteract the forward weight of the thighs. Advancing years bring about increased lordosis and increased muscular imbalance. The buttocks project further and the little used gluteus muscles become enveloped in fat; the abdomen, breasts and chin sag and accumulate an excess of fat. The front thigh muscles never contract fully to straighten the knee and fat accumulates on them and behind the knee. Osteoarthritis may develop in the knees (Barker, 1985).

5.7.5 Lower extremities

Many workers in the field of posture and body-alignment, -mechanics and -treatment consider the feet as being of cardinal importance (Goldthwait *et al.*, 1952; Lowen, 1994; Rolf, 1977; Tobias 1982; Wikler, 1980). The body is balanced on the feet on the ground and the concepts of balance and grounding do have many interpretations.

Balance in the body begins with feet, for the basic work of foot and ankle is to offer a reliable base by which the upper body can relate to the horizontal plane of the earth. Competent feet and ankles must offer a mechanism for continual shifting and adjustment by the overlying body (Rolf, 1977: 45).

The foot is one of the most common sites of deformity in faulty body mechanics (Goldthwait *et al.*, 1952: 89).

Wikler (1951; 1980), a podiatrist, who worked for more than half a century on the mechanics and treatment of feet, attributed many prevalent diseases to wrong use of the feet. These range from breast cancer, cardiac diseases and diabetes to nervousness and emotional imbalances. He also showed that people with disordered feet tended to have round shoulders and with one foot worse than the other, one shoulder would droop more than the other.

5.7.5.1 Foot deformities

Abnormal supination is the inability of the foot to pronate effectively during stance and is commonly referred to as the high-arched foot. This is hypomobility of the joints of the foot and ankle that may result from muscle imbalances and soft tissue contractures. Abnormal supination is usually associated with a rigid structure which is unable to function as an efficient shock absorber or as an adapter to changing terrain. The abnormal supinators usually do not demonstrate a progressive breakdown in tissue (producing a hypermobile foot), such as occurs in the flexible, pronated foot. Rather it is an inflexible foot that causes tissue inflammation and possible joint destruction.

Congenital or acquired abnormal pronation (flat foot) changes the alignment of the calcaneus, talus, cuboid and navicular bones. The change in alignment produces poor articular congruity and alters the arthrokinematics of the ankle, subtalar and midtarsal joints. The excessive movements produce excessive forces within the foot and ankle and throughout the lower kinetic chain. The tibia, talus and calcaneus move simultaneously as the foot pronates. The talus and tibia are rotated medially and the calcaneus rolls laterally into eversion. In abnormal pronation the calcaneus subluxates under the talus. Such arthrokinematics are abnormal because they are excessive and persistent throughout the stance phase. Normal pronation is a temporary condition of the subtalar joint which might occur in response to a change in the terrain (Donatelli, 1990).

Changes in the mechanics of the rear foot and mid foot produce certain anatomic changes including everted position of the calcaneus, medial bulging of the navicular tuberosity, abduction of the forefoot on the rear foot and a reduction in the height of the medial arch. As a result of the excessive pronation, the soft tissue structures are traumatized over a long period of time, resulting in breakdown and pathology. Abnormal pronation (flat foot) can be a deformity present at birth or an acquired deformity due to extrinsic factors such as rotational deformities of the lower extremity and leg length discrepancies (Donatelli, 1990).

Lumbar lordosis and forward tilting of the pelvis moves the body's centre of gravity slightly forward, in front of the acetabula, and stabilisation is obtained by internally rotating the femora. This in turn causes toeing in which may be corrected either by external rotation at the knee or by eversion and abduction of the feet. As the former is not a comfortable permanent posture, the flatfoot position is assumed (Donatelli, 1990).

Another common factor in the production of flatfoot, is contraction of the posterior calf muscles, and referred to as a short Achilles tendon. The condition is characterised by the inability to fully dorsiflex the foot at the ankle joint (Goldthwait *et al.*, 1952; Wiles, 1937).

Foot problems also have a psychological aspect. Rolf (1977) noticed a deep, unconscious feeling of insecurity in people with any kind of foot problem, while

Lowen (1994) developed his famous grounding exercise to place the feet firmly in contact with the ground and in so doing establishing an emotional balance where it had been lacking, and bringing them in touch with reality.

5.7.5.2 The ankle joint

Much of the posture, weight and movement of the body are handled by the ankle joint. While standing, gravity constantly tends to carry the body forward around the axis of rotation of the ankle joint. This dorsi-flexing force is resisted, and the upright posture is maintained by active and passive forces tending to cause plantar flexion at the ankle. The active force is the result of a postural contraction which is located mainly in the triceps surae and the passive force is the result of tension in passive extra-articular tissues in the posterior crural region (Smith, 1957).

An ankle is a hinge joint (Donatelli, 1990; Rolf, 1977) - thus it operates most effectively if primary movement takes place in one directional line - fore and aft. Length and elasticity of individual tendons and ligaments determine the position of the bones and chronic shortening of any tendon will aberrate movement. In the normal ankle joint, tendons adjust to permit the sole of the foot to make contact with and to adapt to the ground surface (Rolf, 1977).

The ankles are formed by the lower prominences (malleoli) of the lateral fibula and medial tibia (Donatelli, 1990; Rolf, 1977). The muscles, tendons and ligaments holding these bones together may be affected by a persistent postural pattern causing a change in the contour of the ankle (Rolf, 1977).

5.7.5.3 The knees

The knees are also hinge joints and move forward and backward. Ideally, movement of knee- and ankle joints should be parallel and the joints themselves should be centred one above the other. Movement will then be graceful in a straight forward direction due to the fact that the muscles are in balance. Footprints should show a straight forward directional tracking (no deviation of the toes outward or inward) and a light weight transmission over the total area of the footprint. People walking with everted feet (one or both) have chronically shortened (hypertoned) peroneal muscles on the lateral side of the leg which over balance the tibialis group. Ankle movement then becomes limited and the ankle, knee and hip rotate (Rolf, 1977).

Postural aberrations of the knees are: hyper-flexion, hyper-extension, bandy-knees and knock-knees. These are not primary causes but symptoms of imbalance or of faulty body mechanics. In the child, changes take place in the neck of the growing femur. With the forward inclination of the pelvis and the subsequent internal rotation of the femur in order to bring support under the changed centre of gravity, a torsional stress is placed on the femoral neck which may produce a coxa vara and an anteversion. A twist or outward bowing may appear in the shaft of the femur. These changes develop more rapidly and to a greater extent if any conditions which weaken the bones are present. At the knee, with faulty carriage of the body, the weight is thrust more to the medial side of the joint, leading to a knock-knee deformity. The torsion of the femur may be carried into the tibia, leading to a twist or bending in this region. The forward inclination of the pelvis leads to a change of origin of the hamstring muscles and contraction of the iliopsoas group of muscles, causing a flexed or hyperextended knee when standing. Shortening of the heel cords is the most common cause of hyperextension at the knee. The mass is borne on the inner side of the foot and the big toe. The foot is inverted and turned inwards (pigeon toed). The angulation at the knee is difficult to realign, but if it continues for long the condition leads to deformity in the articular surfaces of the knee joint and in middle age is a common cause of arthritis of the knee joint (Barker, 1985; Goldthwait *et al.,* 1952; Phelps *et al.,* 1956).

All the mass is supported on the outer edges of the feet when a person has bandy-knees. To keep balance on one foot, the bandy person flattens the foot to bring more of it in contact with the ground, points the foot outwards and bends the knee forward and inwards. Using the inner leg muscles (adductors) constantly to frequently bring the leg across the mid-line, as is done during some sport activities, is often a cause of bandiness (Barker, 1985).

5.8 EFFECTS OF FAULTY POSTURE

5.8.1 Faulty posture

It is arguably easier to describe a faulty body posture than it is to describe the normal body posture. However, in order to determine an aberration, a norm has to be defined. There is a need for a wide definition because of the large variation in physique or body type (Forrester-Brown, 1930; Heptinstall, 1995). This can be classified according to Goff (1951) into the fat type, the muscular type, the thin elongated type and the balanced type. Sheldon's classification into ectomorph, mesomorph and endomorph was used by Burt (1950) and the stocky and slender type was favoured by Barker (1985) and Goldthwait *et al.* (1952).

The commonest test to determine posture, is to suspend a plumb line from the tip of the mastoid process. This line should pass through the greater tuberosity of the humerus (shoulder), the great trochanters of the femur (hip) and through a point approximately 45 millimetres in front of the lateral malleolus. This line will not pass through all these points if the chin is poked forward, the shoulders are rounded, or if there is a forward or backward carriage of the pelvis (Burt, 1950; Minton, 1990; Turner, 1965; Wiles, 1937).

Sweet (1939), a paediatrician, listed obstacles to be overcome before the complete upright posture can be obtained, obstacles which strongly resembles those listed in muscle imbalance (see section 5.9.3):

❑ 1) Short calf muscles or, occasionally, too long calf muscles,

- ❑ 2) Short hamstring muscles (*biceps, semimembranosus, semitendinous*),
- ❑ 3) Weak, underdeveloped external rotators of the thigh,
- ❑ 4) Weak, underdeveloped *glutei,*
- ❑ 5) Weak, underdeveloped muscles of the abdominal wall,
- ❑ 6) Strong, overdeveloped *erector spinae* muscles in the lumbar region and correspondingly weakened members in the dorsal region,
- ❑ 7) Strong, short, overdeveloped anterior shoulder girdle muscles and
- ❑ 8) Forward thrust of the head, with shortening of the upper *trapezius* and splenic muscles.

In addition to the fact that faulty posture moves the body out of the vertical line, it may also cause diminished length. Accentuation of the normal spinal curves, often coupled with bent knees, causes a reduction of stature. The increase in cervical lordosis forces the person to carry his head bent forward, the degree depending on the lordosis. To maintain the head positions puts extra work on the extensor muscles of the back of the neck, so a position of comfort unconsciously results in the bowing of the head. This necessitates a strain on the extra-ocular muscles (*superior recti*), it being easier to lift the eyes than to lift the head (De Puky, 1935; Kerr & Lagen, 1936).

Between the ages of 20 and 80 there is an increasing tendency for the stature to shorten, the waist to thicken, the chest to flatten and the head to thrust forward and down (Jones, Hanson, & Gray, 1964; Tanner, 1990).

Effects of faulty posture are: Inability to relax muscles, diminished agility and limitation of movement of the spine. Inability to relax muscles produces or increases fatigue and muscle pain. Ultimately it leads to muscle wasting for a muscle which never fully relaxes, never fully contracts and a period of incomplete muscular contraction is followed by wasting. Lack of agility and movement are also effects of incomplete muscular relaxation as well as myofascial adhesions between muscle fibres or muscle groups which interfere with muscular contraction (Burt, 1950; Rolf, 1977).

In view of the above, it is thus not surprising that a higher incidence of sports injuries are found in sportsmen with habitual malposture. Knee injuries were associated with lumbar lordosis and sway back; muscle strains with lumbar lordosis and abnormal knee interspace; back injuries with poor shoulder symmetry, scapulae abduction, back asymmetry, kyphosis, lordosis and scoliosis (Watson, 1995).

It is often not realised that although posture affects respiration, the reverse is also true. The whole position and shape of the rib cage is affected by patterns of respiration and this in turn has a profound effect on resting habitual upright posture (Painter, 1986; Plummer, 1982).

It has been suggested that the commonly used standing position for work tasks is a potentially harmful one, and it is one that has been reinforced in many schools and work situations. This deleterious position is one in which the feet are together, the lower limbs are stiffened and the upper body is in a flexed position. This posture produces sustained tension that may lead to loss of normal elasticity of the tissue, reduced circulatory efficiency, progressive reduction in the range of movement and chronic general fatigue (Turner, 1965).

People working with their hands while in a standing position tend to hyperextend the legs and to create excessive tension in the cervical and thoracic areas. Feet should be separated into a forward and backward position for balance and reduced tension while the legs are flexed and the neck and chest muscles are relaxed (Cooper, Adrian & Glassow, 1982).

Faulty posture does not only affect the physical aspects of a person. Educators have found that improving the total alignment and posture of a student, improves his learning ability and academic performance (de Quiros, 1976; Doane, 1959; Kohen-Raz, 1981; Kohen-Raz & Hiriartborde, 1979; Rosborough & Wilder, 1969; Sents & Marks, 1989). Cervical malposture could involve dysfunction of the hypothalamus and result in emotional imbalance (Rosborough & Wilder, 1969).

Studies have shown that correcting a student's slouching posture can bring about a total improvement, including social and intellectual, as well as increased attention span and improved attitude (Bell, McLauchlin & Hunsaker, 1979). Thorough research done by Riskind and Gotay (1982) on the slumped posture, indicated that even periodic slumping has a detrimental effect due to residual after-effects. In the slumped (depressed and submissive) physical posture subjects showed significantly lower persistence in the execution of certain problem-solving tasks and later, with an improved posture, had a strong feeling of helplessness when faced with a problem. The result of the studies suggest that the self-perception of being in a more slumped-over physical posture predisposes a person to more speedily develop self-perceptions of helplessness. Physical postures of the body frequently change with emotional experience (dejection, elation) but postures may constitute more than just passive indicators of emotions, because posture may have the capability of partially affecting the susceptibility of a person to such emotions (Riskind & Gotay, 1982).

5.8.2 Clinical manifestations of faulty posture

> *No disease is known to be caused by poor posture alone, but serious disturbances in function can occur in poor posture* (Kuhns, 1962: 64).

5.8.2.1 Back pain

Dull, aching pain in any region of the back which develops during the day, is made worse by standing and is relieved by a night's rest, is probably due to faulty posture. Muscular imbalance (see section 5.9.7) may lead to fatigue due to the fact that some muscles, being under-utilized, become too weak for prolonged use while others play too great a part in the maintenance of the erect posture (Barlow, 1990; Burt, 1950, Jull & Janda, 1987; Richardson, 1992; Turner, 1965).

Dysfunction of the sacroiliac joint as an impairment of the self bracing mechanism (section 5.7.2) is a common source of low back pain. It is a condition which is far more common than is suspected, and may mimic disc disease or give the impression of a multifactorial etiology of back pain (DonTigny, 1993).

5.8.2.2 Acroparaesthesia

The symptoms of acroparaesthesia are: pain down the arm, numbness and tingling of the hands of both sides, being worse at night and first thing in the morning. The condition may result due to an altered relation of the shoulder girdle and thoracic outlet secondary to poor tone of the shoulder girdle muscles. Traction and compression of the lower cord of the brachial plexus and subclavian artery are the essential mechanical factors underlying most cases of acroparaesthesia. The condition may be treated by correcting the sagging shoulders by improving the tone and strength of the elevator muscles (Burt, 1950; Dart, 1947).

5.8.2.3 Back strain

Back strain is a tear of a muscle, joint capsule or ligament causing acute back pain. The strain (tear) most likely occurs at the junction between elastic and less elastic tissues such as the attachment of tendon or ligament to bone. The reason why strains are particularly common in individuals with faulty posture, is because of their lack of agility and limitation of movement. The shortened muscles and ligaments are likely to be torn due to a sudden or relatively large movement (Burt, 1950; Turner, 1965).

5.8.2.4 Cervical spondylosis

Head and neck arthritis, fibrocytis or cervical disk pressure. The symptoms are numbness or tingling in the fingers of one hand due to pressure on nerve roots from the compressed and fore-shortened neck vertebrae. Sometimes the first symptom is severe pain in the neck, shoulder or arm, worse in the early morning. Rectifying the faulty posture or use which caused the condition usually brings relief to the symptoms (Barlow, 1990; Burt, 1950; Goldthwait *et al.,* 1952).

5.8.2.5 Fibrositic headache

Faulty posture of a long duration may cause a persistent, burning pain with a poor response to rest. The source of the pain of a fibrositis headache is at the insertion of the cervical muscles into the occiput. On palpation there is marked occipital tenderness. The pathology is the condition is similar to "tennis elbow" - it is due to trauma at the insertion of muscle into bone which is often caused and perpetuated by prolonged muscle tension (Turner, 1965).

5.8.2.6 Osteoarthritis

Osteoarthritis occurs in joints where the mechanism has been disturbed by disease, accident or faulty posture. This is a late effect where faulty posture has become chronic (Barker, 1985; Burt, 1950; Turner, 1965).

5.8.2.7 Vertigo

Postural imbalance may cause vertigo due to a head-neck disturbance, in association with nuchal myalgia, which may interfere with the neck reflexes. These patients are often relieved by postural correction (Turner, 1965).

5.9 POSTURAL IMBALANCES

> *Good dynamic posture frees one from tension and gives the body a feeling of lightness, of moving through space, rather than being earth bound. The body then becomes the instrument of the individual rather than the anchor dragging at the day's activities. The tendency to fatigue is reduced, and there is more energy left for other things. Accidents are far less common and usually less serious with good dynamic posture. The principles of good dynamic posture, precision, smoothness, power, balance, good timing, rhythm and coordination may be used not only for the physical body in action but as an approach to life* (Howorth, 1946: 1404).

Postural imbalances are such a common, and an accepted part of most people's appearances, habits and characteristics that they are quite unnoticed by their fellow man. Exceptional cases may be commented upon as being a recognizable feature, seldom as a defect.

Pilbeam's (1990) contention was that conservation is frequently found in evolution and new structures are rare; new configurations are produced by tinkering with old structures. Barker (1985), Dart (1946), Keith (1923), Lovejoy (1988), Phelps *et al.* (1956), Tobias (1982) and Wolpoff (1996) are some of the authors who explained at length the ingenious development of posture by the modification and adaption of existing anatomical structures, and its outcomes during the evolution of man (see Chapter 3), therefore it is an integral part of our being, an inborn knowledge (Roberts, 1995). Dart (1946) traced the evolution and development of human poise for whose endowment nature consumed millions of years. He (Dart, 1946: 12) referred to the:

> .....*well balanced but gyratory bodies nature aimed at for mankind, bodies which every person should possess. Secondly,*

> *we should realise that failure to develop a perfectly-poised body represents, like any other teratomous conditions, a developmental arrest.*

In a similar vein Feldenkrais (1985) came to the conclusion that good use of the body is a sign of maturity. Yet there is a lack of understanding and above all a lack of trust in this power of the body. In an overview of modern man`s postural habits Dart (1946: 13) had the following to say about lack of poise:

> *This lack is the more regrettable in that the underlying neuro-muscular knowledge is not a novel acquisition restricted to mankind but is something extremely ancient, his despised or neglected or overlooked heritage from the very remote past of phylogeny.*

Although the reasons given for the endemic poor postural habits are legion (Barker, 1985; Dart, 1946; 1947; Hanna, 1988; Jull & Janda, 1987; Lowen; 1969; Mandal, 1984; Richardson, 1992), all researchers ultimately agree - directly or indirectly - that what is affected in the end is that man's inherent tripartite mechanisms are not allowed to function in an integrated manner.

The human disease of malposture is purely functional, with low neuromuscular coordination and low muscular integration causing a lack of smooth, balanced movements of bodies and limbs (Dart, 1947). Feldenkrais (1985: 54) was in full accord with this when he said:

> *To have a good posture, therefore, it is necessary to be skilled in the use of the mechanism for projecting action patterns, to have a good configuration of the body segments and a coordinated smooth control of the muscles - not simply to stand in one particular way or to sit nicely.*

5.9.1 Postural imbalances due to the fear of falling and other fears

Due to the fact that man is precariously poised posturally, he is in a state of alarm as soon as he senses a potential loss of balance and responds by contracting his muscles (spastic rigidity). This leads to a habit of muscular fixation which overrides the basic righting reflexes (Dart, 1946, 1970), and also dampens muscle and joint sensations and leads to a restricted range of variation in movement - the range within which the individual feels secure.

> *So the primary fear to overcome is his fear of falling* (Dart, 1970: 32).

According to Feldenkrais (1985), a person who stands wider than necessary is doing so in order to prevent himself from falling. The infant balances himself on a wide base, and if there is a fear of falling, the habit becomes established. The reactions to falling in all onsets of fear, is that the flexor muscles are tensed and the extensors inhibited. The lowering of the head and sinking of the chest are actions to protect the body from injury and give a sense of relative security in the face of danger. According to Feldenkrais (1985) insufficient tone in the antigravity extensors is the resultant rule in bad posture.

Lowen (1994) also paid much attention to this basic fear of falling and since he considered this problem to be serious he devised an exercise to overcome this in order to overcome emotional fears at the same time. This exercise is discussed below because this procedure invariably highlights modern man`s lack of mastery over his reflex machinery and consequent intermeddling with "reflex details" (Dart, 1947), or man`s inability to allow things to happen of their own accord (Gallwey, 1974; 1976; Gallwey & Kriegel, 1977; Koizumi, 1986).
The exercise is done as follows:

❑ Place a rubber mat or heavy-folded blanket on the floor in order to prevent injury. The subject stands in front of this, so that when he falls, he will land on the mat/blanket. He then is requested to put all his mass on one leg, bending that knee fully. The other foot touches the floor lightly, only for balance. The person stands in that position until he is unable to maintain this position, and then falls, **but he is not allowed to *let* himself fall**. The subject should not allow to let himself self down consciously, since the subject then controls the descent. To be effective, the fall should have an involuntary quality. This is achieved by setting the mind on holding the position, then the fall will represent the release of the body from conscious control. Since most people are afraid to lose control of their bodies, this in itself is anxiety-provoking (Lowen, 1994).

Although the principle of "non action" is ascribed to Zen Buddism by many (Herrigel, 1985; Gallwey, 1974, 1976; Gallwey & Kriegel, 1977; Koizumi, 1986), studies on the control of posture and movement also emphasise the principle, which is to allow certain neurophysiological circuits to function without interference of the will (Dart, 1946, 1947; Magnus, 1926a; Roberts; 1995). "Central pattern generators" (Latash, 1998) (see Chapter 6) in the nervous system, which individually and collectively are responsible for the control of functions, such as posture, and which developed over a period of millions of years, are structures and systems imminently suitable for the control of human skeleto-muscular functions. Whether this system has adapted to modern ways of using the body (Alexander, 1996) such as sitting for long periods of time is debatable. In this respect a number of authors have noticed that poor posture and poor postural habits are pandemic in modern man, and refer to these problems as diseases of civilization (Dart, 1947; Zeller; 1982).

5.9.2 Psychological aspects

5.9.2.1 Malposture and the experience of physical and psychological pain

Plummer (1982) traced the cause of malposture to the experience of pain. The reaction to pain is muscle contraction - the body's attempt to form an armour to protect itself from pain. When pain is experienced biomechanically significant points come under stress and the receptors at these sites send off signals which are carried to the thalamus and limbic system, where endorphins and other neurotransmitters are liberated, resulting in a blockage of nociceptive impulses at the synapses and lack of pain perception. The effectiveness of this mechanism depends on the amount of available neurotransmitters and the extent of muscular armouring. If, during the healing phase, the full range of movement of all the tissues and structures involved is not carried out, then new lines of biomechanical force resulting from an abnormal resting position, cause reorganization and laying down of connective tissue. The tissue is laid down according to the direction of lines of stress to which it is being subjected. This results in fascial adhesions at the biomechanically significant points and are known as neural points or trigger points. The trigger points thus developed in the affected muscles perpetuate the armour and may exhibit a localized stretch reflex initiated by the biomechanically incorrect resting position of the muscle. Signs of unresolved physical trauma develop in this way and muscle imbalance results. Former painful sites continue being protected to the detriment of the person (Plummer, 1982).

Psychological trauma evokes certain patterns of muscular contraction (Hanna, 1988; Lowen, 1994; Painter, 1986; Plummer, 1982). The particular pattern depends upon the particular causal factor, sometimes it may be fear, sometimes aggression. The new resting positions of the muscle groups involved result in the development of new lines of biomechanical force with increased stress at biomechanically significant points. The result is the same as that of physical trauma described in the previous paragraph.

Plummer (1982) concluded that muscle imbalance or malposture is due to the accumulative effects of unresolved trauma whether it be physical or psychological. This is in total accordance with the theories of Lowen (1994) and Reich (Wilson, 1982). The physical characteristics of muscle imbalance will be discussed in section 5.9.7.

Another way of explaining malposture and unresolved traumas, is via the withdrawal reflex or startle pattern/response (Hanna, 1988; Jones, 1979). This is a total reflex involving the relation between the head and the trunk and is a primitive reflex of survival which is present in all mammals. (Even very simple organisms rapidly withdraw from threatening stimuli). This reflex action is elicited by a sudden loud noise and the sequence of events is as follows: Within 14 milliseconds the muscles of the jaw begin to contract; 20 milliseconds later the eyes and brow contract and at 25 milliseconds the *trapezius* and *levator scapulae* contract, raising the shoulders and bringing the head forward; at 60 milliseconds the elbows bend and then the hand turn palms downward. The descending neural impulses continue by contracting the abdominal muscle, bringing the trunk forward, pulling down the rib cage and stopping the breathing. This is followed by bending the knees, rolling the feet inward and lifting the toes up. This flexed, crouched position is the body's withdrawal from danger. Jones (1979) found that the startle pattern contained elements of extension as well as flexion and that the response begins with extension.

The impulse originates in the brain stem and reaches the muscles of the head region first before cascading down the nerve pathways to the lower parts of the body. The withdrawal reflex is more primitive than voluntary actions and is much faster. It happens before it can be consciously perceived or inhibited and is a basic neuromuscular response to stress. This is a protective response to negative stressors (Hanna, 1988). The startle response serves also as a model for other slower response patterns such as fatigue, anxiety, fear or pain which show postural changes similar to those of startle (Macdonald, 1998).

5.9.2.2 Psychological problems

> *There is a compelling propensity for most individuals to seek some sort of kinaesthetic satisfaction from frequent and unnecessary bodily movements, all of which bring about a measure of flexibility in the conformation of the body-image. In part at least this may be regarded as a sort of play - ie, the*

> *execution of movements for their own sake* (Critchley, 1950: 336).

> *Under the influence of tonic posture exercises the required level of vigilance and attention is sustained, operative memory is optimized; at monotonous kinds of work the development of the state of monotony is eliminated or slowed down; during the work with nervous tension unnecessary, excessive, unproductive nervous tension is reduced* (Briedis, Jurévics & Kaskina, 1978: 58).

Postures of sadness, aggression and fear are familiar to all, and are of a transient nature. Deep seated psychological problems such as depression and schizophrenia may also be detected in the person's posture (Barker, 1985; Lawson-Wood & Lawson-Wood, 1977; Lowen, 1971, 1994).

Self-image probably translates into posture. Positive and negative beliefs about the self form the basis of self-image and are the result of past experiences including thoughts and performances. Just as subliminal motor movement takes place during visualization of a physical performance, muscular contraction may result from a mental state. Mental practice to improve a specific skill imprints the mind, nervous- and muscular system with a blueprint of how to do the skill (Curtis, 1991). A blueprint for faulty posture may also develop if a habitual muscular contraction accompanies a certain emotion/mental state.

Kiernander (1956: 668) emphasised the relationship between posture and mood, and the necessity of recognising its importance:

> *An individual's mood is shown in his posture: The erect carriage and speedy movements of the happy person is shown at one end of the scale while the depressed or melancholy patient, with his drooping posture and retarded movements, is an example at the other end.* ***Before going into the other factors in***

> ***postural defects, this side must always be explored fully, inasmuch as even a temporary psychological upset will very frequently produce a deterioration in posture.*** *The child who has an unhappy home or is unhappy at school, or even one who has had a conflict with his family, friends or colleagues at work, will show this in a variety of postural defects, and unless the psychological difficulties are corrected he will not improve* (emphasis that of the present author).

Briedis *et al.* (1978) suggested the use of postural exercises in order to optimize the neurodynamics of the central nervous system, and by doing so reduce unproductive nervous tension.

5.9.3 Habituation

Constant repetition of a response leads to habituation. When someone exhibits any or all of the postural distortions of the withdrawal response, the posture has been imprinted in the neuromuscular system by habituation and the person has become maladapted in his neuromuscular habits. This can happen at any age, even in childhood (Kiernander, 1956), but the dowager's hump, round shoulders and bent knees always have the appearance of old age (Hanna, 1988).

In humans the startle reflex has a graded amplitude of response and the response can be low to very high. Initial fear or anxiety can cause a higher startle reaction or trigger the startle response more easily. In addition, the human neuromuscular system has the ability to adapt to a higher level of muscular tension, triggered by the withdrawal response. The chronic tension in the muscles lead to what Hanna (1988) calls sensory-motor amnesia and he designed his "Somatic Exercises", based on the work of Feldenkrais (1972; 1985), to reduce the effects thereof.

Dart (1947, 1950), similarly, developed a series of posture improving exercises. These, and other exercises will be discussed in Chapter 7 (Table 7.1 and sections 7.2.1-7.2.9).

5.9.4 Posture and fatigue

Feldenkrais (1985) was a great advocate of mono-motivational movement, declaring that parasitic movements cause unnecessary fatigue. Fatigue causes uncoordination, excessive movements and thus more fatigue. According to Cohen-Nehemia (1983) frequent body movement involving the pelvis release a defence mechanism in the body which prevents excessive muscle contraction by a timely release of the contracted muscle. Keeping the head in the balanced position and practising muscular inhibition, and inhibition of parasitic movements, reduces the occurrence of fatigue (Jones, 1965; Jones & O'Connell, 1958, Jones, Gray & Hanson & O'Connell, 1959).

Kubíček and Kubíčkova (1965) advised against the habit of keeping a group of muscles in the same position for a great length of time, since they tire easily, and the spinal column is deformed by the mass of its own body. Muscular exhaustion may lead to a more convex shape in the lumbar region of the spine, and this could cause a permanent deformity of the spine.

5.9.5 Affectation

There are fashions in posture as in any other cultural event. Prominent or admired public figures with a high profile often have their postures and mannerisms imitated. This is usually done unconsciously and is of a passing nature. It follows the same pattern as people in empathy with each other during a conversation mirroring each others gestures. Young people do sometimes voluntarily imitate a hero figure in order to be like the person if they look like the person. Any affectation, if performed long enough, may become a permanent habit (Barlow, 1990; Lawson-Wood & Lawson-Wood, 1977; Pease, 1981).

5.9.6 Habit

Physical habits may have many origins, both physically and psychologically. They are usually the result of occupational strains and stresses brought about by performing a certain task excessively. Examples are the dentist's rounded shoulders and the soccer player's bandy legs (Barlow, 1990; Cailliet, 1995; Lawson-Wood & Lawson-Wood, 1977; Phelps *et al.*, 1956).

5.9.7 Muscle imbalance

5.9.7.1 The concept of muscle imbalance

> *As far as body mechanics and joint protection are concerned, muscle imbalance probably presents a much greater danger for the joint system than muscle weakness alone* (Janda, 1993: 87).

> *.....we consider one of the main causes of the development of dysfunction and later degenerative joint lesions, in particular the vertebrogenic type, to be the impairment of central motor regulation resulting in defective or at least uneconomical movement patterns. As a consequence, imbalance between certain muscle groups develops. This imbalance is developing systematically and regularly and can even be predicted. In our opinion the discovery of this systematic reaction is the basis of a really solid, thorough and rational approach to preventive as well as therapeutic methods* (Janda & Schmidt, 1980: 3).

Barker (1985) and Lowman (1958) are of the opinion that muscle imbalance is the cause of poor posture. The strength-balance ratio between the trunk-flexor and trunk-extensor muscles, for example, was found to be an especially important variable in the alignment of the trunk and of the contribution of the trunk to anterior-posterior posture (Hutchings, 1965). The issue of muscle imbalance was recently reviewed by Janda (1993), Jull and Janda (1987) and Richardson (1992).

In 1964 Janda (cited by Janda, 1993) defined muscle imbalance as an impaired relationship between those muscles which are prone to develop tightness and shortness, and those muscles which are prone to inhibition. Under the term muscle imbalance, therefore, Janda (1993) was of the opinion that at least three factors should be considered, namely: Muscle length, the irritability threshold of specific muscles and altered recruitment of these muscles. An example of how factors such as these can influence posture is seen in the common collapse of the front of the body, and its concomitant tightening of the pectoral muscles, the pulling down of the head, and its associated tightened neck and upper *trapezius* muscles (Macdonald, 1998).

Sahrman (1987) considered muscle imbalance to be a failure of the agonist-antagonist relationship, and is present when one of a synergistic pair of muscles predominates during movement, or in the maintenance of posture. Richardson (1992: 127) agreed with this when he stated that:

> *The term 'muscle imbalance' represents a specific problem of movement dysfunction. One concerned with inadequate control and co-ordination of muscles for the protection of joints and surrounding structures.*

A typical example of muscle imbalance would be the common phenomenon of rounded shoulders, in which muscles such as the pectorals will be shortened and their antagonists lengthened and weakened.

Muscle imbalance has its root in the fact that many different muscles are capable of producing similar movements due to their anatomical location. A division between functional work exists between synergists, with some designed primarily for a stability role, while others, due to their anatomical and biomechanical features, are more suitable for the execution of so-called "goal directed" movements (Richardson, 1992).

Muscles tend to react by overactivation and tightening or by inhibition. The way in which muscles tend to react appears to be fairly consistent for the particular muscle concerned. Therefore tightness or weakness may vary in degree between subjects, but rarely in distribution (Jull & Janda, 1987). So, for example, do muscles which span more than one joint, show a tendency to become tight. In general, muscles which are prone to tightness are approximately one third stronger than those prone to inhibition (Jull & Janda, 1987). The underlying mechanisms of these muscle reactions are not known, but it is interesting to note that the typical muscle responses seen in malposture and joint pathologies are identical or very similar to those seen in lesions of the central nervous system (Janda, 1977 - cited by Jull & Janda, 1987). A typical hemiplegic posture may be an extreme expression of the imbalance between the muscular chains that exist to some extent under normal physiologic conditions (Jull & Janda, 1987).

One of the underlying causes of muscle imbalance is an impairment in control of the motor system (Jull & Janda, 1987; Richardson, 1992). The lifestyle activities of modern man tend to favour the use of multi-articular muscles. In the upright posture, for example, there is a tendency to rely more heavily on ligamentous support than on active muscle contraction. This leads to a rearrangement of the working muscles in response to the gravitational effect. An illustration of this is seen in anterior pelvic tilt where the supporting role is taken over by a two jointed muscle - the *tensor fascia latae* rather than the *gluteus medius* (Richardson, 1992). In working situations or sports increasing the speed of repetitions may also favour the movement synergist with less activation of the stabilization synergist (Richardson, 1992). Several other factors, such as lack of adequate sensory input, unreliable sensory appreciation, lack of variety in movement, arthrogenic inhibition, stress, emotional states and fatigue and poor postural habits, contribute to demonstrable changes in muscle tone, which is accompanied by poor quality of posture and movement and its control (Alexander, 1932, 1996; Cailliet, 1995; Janda, 1993; Jull & Janda, 1987; Lowen, 1969, 1971, 1975, 1994; Rolf, 1977). A question that arises from the above argumentation, is whether muscle imbalance and muscle armouring (discussed in Chapter 7, sections 7.2.1 & 7.2.2 and Figure 7.1) are not intimately related entities.

The significance of muscle imbalance, as far as posture is concerned, lies in its influence on the motor patterning process. A tightened muscle, for example, can influence posture and movement in several ways. The irritability threshold of tight muscles is lowered, which can lead to the situation where the tight muscle is activated more than is necessary (Jull & Janda, 1987).

With continued disuse the slow twitch muscle fibres in muscles with a prime antigravity/stability function undergo change to eventually resemble fast twitch fibres. In man exposing antigravity stability muscles to inactivity leads to decreased slow twitch (tonic) function, which is illustrated by either a decrease in the number of slow twitch fibres, a relative increase in IIB muscle fibres or faster contraction speeds (Richardson, 1992). This could possibly explain the weakness seen in postural muscles of those with poor postures (see Table 5.1 for example).

5.9.7.2 Syndromes involving the muscles

Jull and Janda (1987) identified three syndromes involving the musculature - syndromes which may affect posture locally and in general. These are:

- Common syndromes

The tendency of muscles to respond by overactivity and tightness or by inhibition is not random, but follows a set pattern according to Jull and Janda (1987). Also, muscle reactions do not remain in one region, but may facilitate a chain reaction, which eventually can affect the whole tripartite system, thus affecting total posture and movement.

- The pelvic crossed syndrome

Muscle imbalance tends to be more evident or starts to develop in two regions, namely the pelvic-hip complex and the upper quarter (shoulder-neck region). The former is characterised by the imbalance between shortened and tightened hip flexors and tight lumbar *erector spinae*, with weakened gluteal and abdominal muscles. Frequently the hamstrings are found to be tight, probably in an effort to lessen forward pelvic tilt. The muscle imbalance found in pelvic crossed syndrome promotes a forward pelvic tilt, increased lumbar lordosis, and a slightly flexed position of the hip. If the lordosis is deep and short the imbalance is principally located in the pelvic musculature. On the other hand, if it is shallow, but longer, as well as extending into the thoracic area, the muscle imbalance is more marked in the muscles of the trunk.

In the upper quarter this syndrome will be associated with shortened and tightened upper *trapezius, levator scapulae, sternocleidomastoid* and pectoral muscles, with weakened *rhomboid,* short cervical and lower *trapezius* muscles.

The pattern of muscle imbalance should be viewed not only from its ventro-dorsal crossed antagonist pattern, but also from the relationship between adjacent muscles. So, for example, will overtightness in the *erector spinae* associated with weakened *glutei,* alter the pattern of a fundamental gait pattern, such as hip extension.

Postures resulting from these imbalances can change the force distribution in both the lumbar motion segments, the hip joint and the upper quarter. In the erect posture, an increase in the forward pelvic tilt and associated lumbar lordosis results in a change in the posture of other areas in order to maintain postural equilibrium. An increased thoracic kyphosis leads to a compensatory cervical lordosis in an effort to balance the upper structure against gravity and to keep the head and eyes in an upright position. The way in which postural equilibrium is maintained in different individuals with muscular imbalance will be discussed in Chapter 8 (sections 8.2 & 8.3). Approaches and methods designed to deal with this problem is discussed in Chapter 7 (section 7.3.8.4).

- The layer syndrome

Marked impairment of motor control is associated with this form of muscle imbalance; an imbalance which is accompanied by poor movement patterns. This syndrome is characterized by alternating "layers" of hypertrophic and hypotrophic muscles, in which a layer of hypotrophied muscles in a body segment is alternated with a layer of hypertrophied muscles in an adjacent body segment. These "layers" are best observed from the dorsal aspect of the subject (Janda & Schmidt, 1980). These are listed in Table 5.1.

Table 5.1 Alternating layers of hypertrophied and hypotrophied muscles in subjects with layer syndrome (Jull & Janda, 1987)

Body segment	Muscle hypertrophy	Muscle hypotrophy
Cervical	Cervical *erector spinae*, upper *trapezius, levator scapulae*	
Shoulder girdle, upper thoracic		Lower stabilizers of the scapula
Thoracolumbar	Thoracolumbar *erector spinae*	
Lumbosacral		Lumbosacral *erector spinae*, *gluteus maximus*
Lower limbs	Hamstrings	

Inherent to the layer syndrome is poor muscular stability in the lumbosacral region, which could predispose to the development or perpetuation of low back pain (Jull & Janda, 1987).

Apart from the muscle hypertrophy and hypotrophy in the dorsal musculature listed in Table 5.1, there is also weakness of the abdominal muscles, particularly of the rectus abdominis and the *tranversus abdominus*. Contrary to this, the oblique abdominals appear to be overactive.

5.9.8 Clothing

Shoes are notorious for having a bad effect on posture. So, for instance are high heels responsible for an increase in lumbar lordosis (Twomey & Taylor, 1987; Wikler, 1980). Wearing of tight clothes prohibits proper rotation in the hip joint when seated (Barker, 1985; Cohen-Nehemia, 1983).

5.9.9 Sedentary lifestyle

Certain hollow-backed car seats force destructive slouching if a person sits sitting for long periods of time in a car. Passive entertainment (television), training (lectures) and sedentary employment bring about long hours of physical inactivity and sitting on poorly designed furniture (Cohen-Nehemia, 1983; Mandal, 1984), both leading to muscle imbalance and muscle weakness (Richardson, 1992) (see section 5.9.7.1).

5.9.10 Standing for prolonged periods

Standing for a long time tends to produce an increase in the lordosis of the lumbar spine as postural muscles begin to tire and as the slow "creep" of the soft tissues often emphasises the natural tendency towards extension of this region. Since most individuals tend to lean forward (Woodhull *et al.*, 1985), this is a problem in most individuals, because their line of gravity is put in front of the sacral promontory. The effect of gravity pulling through this centre tends to pull the lumbar spine into a more lordotic posture in those individuals (Twomey & Taylor, 1987).

5.9.11 Congenital deformity

Deformities acquired during foetal development are present at birth and usually need surgical intervention (Goldthwait *et al.*, 1952; Lawson-Wood & Lawson-Wood, 1977; Phelps *et al.*, 1956).

5.9.12 Injury

This covers a wide spectrum from an insignificant bruise to an amputation. Any injury leaves scar tissue which causes a degree of immobility in the area. Psychological injury has much the same effect (Lawson-Wood & Lawson-Wood, 1977; Lowen, 1994).

5.9.13 Illness

Chronic or acute diseases, for example, of the chest or bones usually have an effect on posture (Barker, 1985; Goldthwait *et al.,* 1952; Lawson-Wood & Lawson-Wood, 1977).

5.9.14 Accumulation

Postural defects are sometimes due to a succession of trivial and insignificant minor causes. The totality becomes important (Lawson-Wood & Lawson-Wood, 1977).

5.10 CONCLUSION

Posture is the appearance and use of the body. The ideal posture would be perfect vertical alignment, and a balance between all synergic muscle groups (Alexander, 1996; Barker, 1985; Rolf, 1977). This would lead to a perfect carriage as well as optimal functioning of all body organs and systems. Unfortunately body misuse is a common phenomenon and an inhibiting factor in smooth functioning of the body. Overcoming postural defects might lead to releasing the human potential and providing a more comfortable body which functions efficiently (Barlow, 1990; Dart, 1946, 1947).

A large number of factors are singly or jointly responsible for the common malaise of malposture (see sections 5.9.1-5.9.14). So, for example, is it possible that some psychological problem be responsible for the phenomenon of muscle imbalance? The resultant malposture may, in turn, lead to injury, which as a consequence compounds the malposture. For the practitioner involved in the creation of total well-being this presents an interesting problem. Recognising postural defects and being aware of their origins and causes might go a long way in preventing and treating postural imbalances. Knowing the short and long term effects of such misuses of the body may also strengthen the resolve to overcome the problem (Rolf, 1977).

CHAPTER 6

THE NEURAL CONTROL OF POSTURE AND EQUILIBRIUM

6.1 POSTURAL CONTROL

> *The fact that human beings are able to maintain* ***vertical posture*** *is in itself a miracle. One would have hard time imagining a mechanical system that is less stable in the field of gravity* (Latash, 1998a: 163).

> *Human beings should be able to discharge all their vital activities without their suffering from impediment of any kind whatsoever, in a state of* ***poise****: with their heads pivoted on their spinal columns, and their bodies pivoted upon their feet; while their convergent eyes are so pivoted upon their objective that the entire apparatus of movement is the reflexly operating instrument of their concentrated purpose* (Dart, 1947: 90).

The mind, the emotional substratum, is reflected in posture, but many vital factors which bring about posture, work below the threshold of consciousness. Posture is one of the expressions of neuromuscular habits and any improvement in posture must be due to re-education or reconditioning of the neuromuscular pathways (Denniston, 1938).

During analysis of vertical posture, the human body can be modelled as an inverted pendulum, which is inherently very unstable, and therefore not easy to equilibrate, especially in the presence of external perturbations and changes in orientation with respect to the field of gravity. The situation, however, is made more complicated by the presence of joints along the axis of the pendulum (Latash, 1998a). The best way to deal with a situation where the area of support for a human being is small (more or less 0,09 square metre), is to stack the body segments between these joints exactly on top of each other, and to fine-tune the position between body segments (Rolf, 1977), as well as the interaction of the movement between the different joints (Latash, 1998a).

The maintenance of the vertical posture is probably the most frequent motor task that the nervous system has to deal with (Latash, 1993), aiming to keep the centre of gravity of the body directly over the centre of the basis of support (Hellebrandt & Franseen, 1943). Frequent control of posture even applies to sedentary man, where the upright sitting position in chairs has to be maintained for extended periods of time, a lifestyle which may be unnatural (Gorman, 1983). According to Latash (1993) it is reasonable to presume that the mechanism of vertical postural control is well "defended" against external perturbations. The dynamic forces during natural limb movements are more than sufficient to destroy the fragile postural equilibrium. Amazing from an engineering point of view, is the fact that this unstable multi-link (multi-joint) inverted pendulum can walk and run, on even, uneven or undulating surfaces (Latash, 1998a). The implications of this are that in upright multi-link man, multiple goals have to be controlled simultaneously by the nervous system to maintain the selected static and dynamic posture.

A central issue in postural research at present is the coordinated nervous control of posture and movement (Latash, 1998a; Massion, 1992; Massion, Alexandrov & Vernassa, 1998). For postural control Nashner and McCollum (1985) proposed the existence of a repertoire of **postural synergies**[1], which are based mainly on the biomechanical characteristics of the multi-link chain. Specific postural synergies exist for the control and maintenance of the upright posture,

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[1] Nikolai Bernstein, the first scientist to work in the area now known as motor control (Latash, 1998b), was the first to initiate the concept of **synergies**, which are built-in **coordinated** combinations of motor commands to a number of joints or body segments leading to a desired goal. Synergies were viewed by Bernstein as building blocks for movements that could be scaled and **combined** according to a particular motor task. Nashner and McCollum (1985) defined muscle synergies **as the contraction of muscles in stereotyped patterns.** The presence of synergies is assumed to simplify the control of, and to diminish the computational burden associated with the control of vertical posture (Latash, 1998a) and voluntary movements in multisegmented limbs (Rymer, Dewald, Given & Beer, 1998). This is achieved by constraining a group of muscles, often spanning several joints, to **act as a single functional unit** or coordinative structure.(Tuller Turvey & Fitch,. 1982).

or its correction in the event of external or internal perturbations. Once a perturbation is felt, a specific postural synergy will be triggered in order to restore the initial posture, or to preserve the antero-posterior position of the centre of mass (Nashner & McCollum, 1985). Some of the postural synergies are discussed in section 6.3.

The execution of a motor task requires a combination of information from the senses regarding the movement. When standing upright, for example, knowledge of eye and head movements is essential to interpret visual motion information correctly. Additionally, the scheme for combining information from different sensory modalities has to take into account that each of the sensory modalities, senses body orientation to a different reference point, and that individual orientation points of reference can move in relation to one another. Postural control and orientation of the body in relation to the outside environment, and its segments in relation to each other, require integration and correct interpretation of information from various sensory sources (Latash, 1998a; Massion *et al.,* 1998; Nashner & McCollum, 1985). Malposture, induced either by sensory dysfunction (Alexander, 1987; Sherrington, 1946), or by inadequate stimulation, arises from an intersensory mismatch, with information from one system at variance with the others. The intensity of malposture is a function of the magnitude of the mismatch and is further increased if appropriate afferent information is eliminated, such as eye closure with an acute unilateral labyrinthine lesion (Lestienne & Gurfinkel, 1988). In a society characterized by malposture, the quality of the sensory awareness, and that of the integration of sensory input are questionable (Alexander, 1932, 1996; Feldenkrais, 1972, 1985; Sherrington, 1946). This may contribute to intersensory mismatch.

Postural control and maintenance can be accomplished through a complex anti-gravitational neuromuscular system based on integrated information from the proprioceptive, vestibular and visual systems (Lestienne & Gurfinkel, 1988). These systems overlap, which enables them to compensate partially for mutual deficiencies. Nashner, Black and Wall, (1982) assumed a dominant hierarchical influence of the vestibular system, this serving as a fixed orientation reference while vision, in normal subjects, subserves fine tuning of posture on the basis of the vestibular reference value within this multiloop-control (Paulus, Straube & Brandt, 1984).

Man will lose balance only if none of the three systems works correctly, or if the information given by the three systems is in disagreement. If one system functions at a lower level, the other systems usually take over the function of that system (Kapteyn, 1973).

6.2 NEUROMUSCULAR-SKELETAL CONTROL OF THE UPRIGHT POSTURE FROM A PALEO-ANTHROPOLOGICAL PERSPECTIVE

> *From the phylogenetic point of view, one would say that only movements able to take advantage of the enormously elaborate analysis of tactile messages provided by the development of the somatosensory cortex ascended during evolution to the motor cortex, while movements that work just as well without sophisticated tactile regulation (such as eye movements) maintained their centres at the older, lower levels of the central nervous system: i.e. the vestibular nuclei, reticular formation, and red nucleus; all three receive afferents from the cerebellum and the last two from the basal ganglia* (Kornhuber, 1974: 611).

In order to understand the gradual evolvement of the vertebrate nervous system to what it is today, a brief explanation of some terms used in neurophysiology is necessary.

6.2.1 Muscle synergies and Central Pattern Generators

Muscle synergies have already been discussed in the footnote on page 163. These muscle synergies are controlled, as far as stereotyped muscle acts are concerned, by Central Pattern Generators (CPG's) in the spine (Grillner & Wallén, 1985; Latash, 1998a). The neurons responsible for creating a particular motor pattern are referred to as a CPG. The term CPG rather refers to function and not to a circumscribed anatomical entity (Grillner & Wallén, 1985). Separate CPG's exist for each limb (for example the positive supporting reaction, section 6.3.2.1.1), and for the separate parts for the trunk. CPG's may be combined in different ways in order to create required musculoskeletal responses. In this respect they are under the control of higher control systems (Grillner & Wallén, 1985; Kornhuber, 1974). CPG's and CPG control systems are found both in lower and higher centres of the central nervous system (CNS) (Grillner & Wallén, 1985; Kornhuber, 1974). An example of such control is the regulation of the different limbs and trunk in the asymmetric tonic neck reflexes, discussed in section 6.3.2.3.2 - the action of each individual limb being controlled by a CPG, while integration of these GPG's are dealt with by control systems in the brain stem (Fukuda, 1961; Kornhuber, 1974; Magnus, 1926a,b).

The upright human body is made up of various segments, each controlled by its own CPG (Grillner & Wallén, 1985). The actions of the CPG's involved in the control of upright posture, can be envisaged being integrated (connected), or alternatively fractionated (disconnected), by means of higher control or interference by the will (Alexander, 1932). Upright posture in man is phylogenetically a new development (Chapter 3). Does the control of man's posture need a large sensory input and sensory cortex? Alexander (1932, 1941, 1987, 1996) and Feldenkrais (1985), by way of their practical experience, thought so, which is why they so strongly emphasized the importance of sensory awareness. Whether their opinions can be validated by research is a question that needs to be answered.

6.2.2 Evolvement of movement control

As vertebrates evolved from fish, with their simple undulating body movements, (described in Chapter 3, section 3.3.2.8), to the human, with the ability to perform delicate and intricate movements, such as those with individual digits, the more integrated the function of the nervous system had to become. Lower vertebrates tend to use their limbs in "whole limb" synergies involving mainly flexion and extension muscle synergies. The more evolved the animal, in the phylogenetic sense, the more versatile the tripartite motor system tends to be. This increased versatility eventually led to an adeptness in the fractionation of the motor pattern of the whole limb synergy. This development gradually took place in phylogeny from an independent control of the large joints to a precise control of the individual segments as is found in primates (Grillner & Wallén, 1985). (During ontogeny the reverse happens in the human infant, however). Development of precise motor control probably occurred in conjunction with the development of the somatosensory cortex, which in turn was associated with the elaboration of the analysis of tactile messages (Kornhuber, 1974).

The descending control over the segmental apparatus in lower tetrapods is relatively stereotyped, but a more refined motor control developed gradually during evolution. Descending motor systems gradually acquired a more specific control over parts of the spinal circuitry. In the primate, for example, the corticospinal tract, which is responsible for muscle synergies controlling independent finger movements, is well developed, while another descending tract, the rubrospinal, is associated with independent wrist movements (Grillner & Wallén, 1985; Lawrence & Kuypers, 1968a,b). Phylogenetically older descending tracts, such as the reticulospinal, which originate in the brain stem, are responsible for the control of muscle synergies in proximal parts of the limbs and that of the trunk (Lawrence & Kuypers, 1968a,b); the latter structures in primates also receive some corticospinal input (Williams & Warwick, 1980). The refined precision movements would thus use part of the old segmental motor apparatus (lower level CPG controllers), which in turn provide ready-made modules for activation of appropriate motor nuclei in the spinal cord and suppression of others.

The single limb, segmental and general control of the upright posture is discussed in section 6.3.2. In quadrupeds standing is dependant on CPG's and their integrative control from centres in the brain stem (Magnus, 1926a,b). Because of this, standing can be maintained for extended periods in animals with only the brain stem and spinal column intact (Magnus, 1926a,b). Humans, on the other hand, require an intact neocortex in order to stand upright (Latash, 1998a), despite the fact that human CPG's have access to control centres in the brain stem (Bobath, 1980; Fukuda, 1961; Gowitzke & Milner, 1988).

In the quadruped the trunk is supported between the four supporting limbs, and therefore does not fulfil a postural role. In upright man, however, the head and trunk are balanced upon only two limbs (Gorman, 1981). The spine is made up of a number of relatively freely moving segments (vertebrae) (Gorman, 1981). Each of these segments' position is probably controlled by its own CPG. In the more primitive CPG control systems of the brain stem, provision has not been made for integration of the function of these structures, and this function therefore had to be assigned to newly evolved neural systems - systems solely associated with upright man. Systems like these can only be accommodated by the newly developed neocortex with its extensive sensory input, and its extended ability to integrate functions of CPG-controlling centres in the brain stem, as well as CPG's in the spinal cord [see Kornhuber (1974), for example].

6.3 THE REACTIONS (REFLEXES) RESPONSIBLE FOR MAINTENANCE OF POSTURE

6.3.1 Introduction

For the maintenance of posture, appropriate forces must be exerted at every single joint which compromises the articulations of the skeleton. At the same time, the mass of the soft parts has to be appropriately suspended from the bony framework. Often the necessary forces are developed reflexly in response to the deformations that arise from the interaction between the effect of gravity and the nature of the available support (Roberts, 1978; Rolf, 1977).

Changes in posture are due to differences between the relative sensitivities of the stretch reflexes in the various groups of muscles. Thus a change in the angle at a particular joint may be produced by altering the reflex sensitivity in one of the muscles acting at that joint, or by increasing reflex sensitivity in one muscle, or decreasing it in the antagonist, or by making the two changes simultaneously (Roberts, 1982).

To maintain a stable posture during movement and the presence of perturbations the orientation information provided by the senses must be sufficient to accurately detect the position of the body, body part, environmental conditions and how the body relates to them, or the occurrence of a perturbation in posture (Alexander, 1996; Nashner & McCollum, 1985). This will determine the magnitude and direction of the postural reaction/correction. The orientation information is contributed by a combination of the three independent sensory modalities, proprioception (somesthesis), the vestibular system and vision. Since each of these modalities senses the orientation of the body or its parts in relation to a different internal or external reference, there is a potential continuum of different sensory input combinations that may contribute to the required orientation information (Nashner & McCollum, 1985), and a great possibility for conflicting and confusing interpretation of sensory input by the brain, which may arise from a defective kinaesthetic system (Alexander, 1996).

6.3.2 Somaesthetic (proprioceptive) reactions

These can, according to Magnus (1926a), be classified into local, segmental and general postural reactions. This arrangement fits in well with the recent concepts of how postural and other reactions are organized in the nervous system (Grillner & Wallén, 1985; Massion *et al.*, 1998; Nashner & McCollum, 1985). These reactions will be discussed briefly in sections 6.3.2.1-6.3.2.3.

6.3.2.1 Local postural reactions

Local reactions are those in which only one part of the body, for example the limb, is used (Magnus, 1926a,b).

6.3.2.1.1 The positive supporting reaction

To support the body in an upright standing position requires each of the limbs to act as quite a rigid pillar, a feat which is accomplished when all the joints in the limbs are fixed to a small extent by ligamentous support, but mainly by means of coactivated muscular action at each of the joints in the lower limb (Magnus, 1926a). The latter action is brought about by muscle synergies which cooperate in order to fix the joints in the supporting limb. The muscle synergies responsible for this are elicited by a specific complex stimulus situation. When the foot is placed on the ground, the distribution of forces in the inter-phalangeal joints of the digits alters in a characteristic way and the small *interosseus* muscles between the digits are stretched by the splaying of the foot. Certain combinations of these stimuli appear to be recognized by the spinal cord as signalling that the foot is in contact with a suitable support, and the appropriate stretch reflexes are facilitated so that the limb is converted to a fairly rigid pillar capable of supporting the mass of the body (Magnus, 1926a; Roberts, 1982, 1995). This phenomenon is known as the positive supporting reaction. Receptors in the skin are not essential for eliciting the reaction, nor is consciousness involved, and the supporting surface need not be uniform or smooth (Roberts, 1969, 1982). In the spine the positive supporting reaction is probably controlled by means of a CPG.

For the pressure on the foot to be classified as indicating the presence of an acceptable support, it is necessary that the information from other parts of the limb should conform to a particular pattern of change during the onset of the reflex contraction of the extensor muscles. If the pattern deviates in one direction, a stepping response is elicited instead of a supporting reaction (Roberts, 1978).

In the standing quadruped, for example, the positive supporting reaction elicited in all four limbs serves to support the trunk. The upright human, on the other hand, has to deal with the control of structures in the trunk which have to be supported one on top of the other (Chapter 3, section 3.4) in a similar way to that seen in the lower limbs. How and from which centres in the CNS this is controlled is an open question.

6.3.2.1.2 The negative supporting reaction

This reaction is the opposite of the positive supporting reaction, and is elicited by simply removing the stimuli responsible for evoking the positive reaction or the plantar flexion of the foot. The reaction is seen as a reflex relaxation of the extensor muscles in the leg - in this way the whole limb is loosened and becomes free for movement (Magnus, 1926a).

6.3.2.2 Segmental postural reactions

Here the stimulus and effect are not confined to one limb, but to the opposite limb in the same body segment. Segmental postural reactions require the use of two CPG's in the same spinal segment, CPG's which are interconnected from the one side of the spinal cord to the other (Magnus, 1926a).

Hanna (1988) developed an exercise to train pupils in the correct way of walking by making use of CPG's and their segmental interconnections. Walking is divided into a vertical and a horizontal component. The former is made up of the positive supporting reaction in one leg, while in the other leg the negative supporting reaction is elicited. Support on the one leg is accompanied by an upward movement in that side of the hip, with the bending and loosening of the other leg being augmented by the lowering of the other side of the pelvis. The loosened leg is now free to execute the horizontal aspect of walking which is the forward swing of the leg.

In the author's experience this exercise has proved to be an invaluable aid in the retraining of those with postural problems, and those who cannot walk correctly, as well as retraining the head injured in how to attain balance while standing and how to start walking again.

6.3.2.3 General postural reactions

In the general postural reactions more than one segment of the body, even the whole body, is involved (Magnus, 1926a). Here different CPG's interact to produce the different types of interlimb coordination (Grillner & Wallén, 1985) used in postures assumed in response to different sensory inputs. The system is probably organized in the same way as depicted in Figure 6.1.

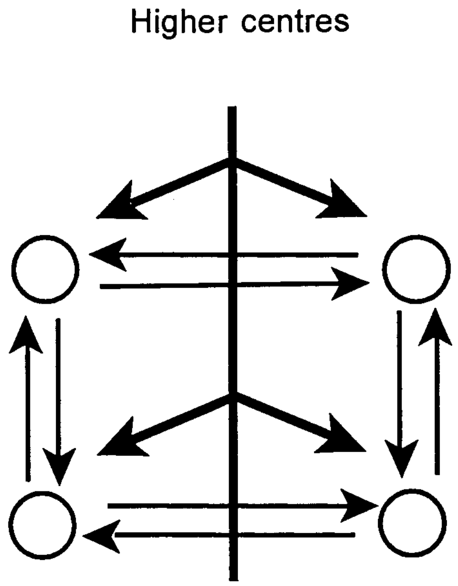

Fig. 6.1 Interaction between CPG's of the four limbs (Grillner, 1975; Grillner & Wallén, 1985).

6.3.2.3.1 The neck as a receptor

> *The importance of the motor system controlling head movements is obvious. Survival itself is often dependent on brisk orientation reflexes in which the head and eyes can be brought to bear on*

any new or unexpected stimulus. This action permits rapid analysis which initiates the appropriate behavioural response. The provision of a stable platform for the eyes is equally dependant upon the functioning of the head motor system. The motor physiologist who is concerned with the operation of the head motor system finds that these obvious functional roles are subserved by a system full of interesting specializations. Some parts of the system also play a much wider role in the regulation of posture. This wider role is clearly expressed in the function of the sensory apparatus of the neck (Abrahams, 1981: 24).

The neck as a receptor has long been an important concept in neurophysiology (Abrahams, 1977). Early work by Magnus (1926a,b) has shown that certain reactions (tonic neck reaction or reflexes) are due to the activation of receptors in the neck. The rich sensory innervation of the neck is a reflection of its role in proprioception (Taylor & McCloskey, 1988), and its importance in the elaboration of reflexes controlling the posture of the limbs and the trunk (Roberts, 1978). Aberrations in neck sensation can cause vertigo and disorientation (Cohen, 1961).

The major part of the sensory input from the neck is concerned with sensory receptors in the small intervertebral muscles and in the long muscles of the neck. These muscles contain relatively high densities of muscle spindles, Golgi tendon organs and Pacinian corpuscles (Abrahams, 1977, 1981; Richmond & Abrahams, 1975), with the intervertebral muscles extremely densely populated with muscle spindles (500 spindles/g muscle tissue) (Abrahams, 1981).

Information from these receptors goes to the first and second segments of the cervical spine (Magnus, 1926a). Powerful descending spinospinal tracts then interact with other areas in the spine (Abrahams, 1977). Little is known about the pathways which link sensory input to the neck and motorneurones in the spinal cord (Wilson, 1984). Integration of sensory input from the neck muscles probably occurs at medullary level in the brainstem, with the descending reticulo-spinal tracts responsible for regulation of spinal cord CPG's (see Fig. 6.1) (Wilson, 1984). According to Fredrickson, Schwarz and Kornhuber (1966) the vestibular nuclei also receive sensory input from the neck muscles.

6.3.2.3.2 The neck reactions (reflexes)

Magnus (1926a) referred to these reactions as the tonic neck reflexes. Despite its name the reflex is not purely tonic, but has phasic components as well (Fukuda, 1961; Wilson, 1984). These reflexes are present in the human at birth in a stereotyped form, and persist postnatally in compulsive form for a short period (Gowitzke & Milner, 1988). The following are typical neck reactions:

- ❑ Rotation of the head to one side causes extension of the upper and lower limbs, towards which the jaw is rotated, and relaxation of the limbs towards which the occiput is rotated - the asymmetric neck reflex. Inclination of the head towards one shoulder elicits a similar response (Magnus, 1926a).

- ❑ Dorsiflexion of the head causes extension of the upper limbs and relaxation of the lower limbs, while ventriflexion causes the opposite response - the symmetrical neck reaction (Magnus, 1926a).

In the human these reflexes become less apparent as motor development in the infant proceeds, and are no longer compulsive by the sixth to eighth week after birth (Gowitzke & Milner, 1988; Mysak, 1968). Their circuits remain intact throughout life, however, and interact with others. They have a prominent role in maintaining equilibrium in adults, as seen from the fact that surgical interference with the neck or the upper cervical nerve roots may lead to body disequilibrium similar to those seen in bilateral removal of the labyrinths (Kornhuber, 1974; Longet, 1845, quoted by Abrahams, 1981). The role of these and other primitive reactions in normal human posture will be discussed in section 6.4.6.

6.4 THE VESTIBULAR SYSTEM

Phylogenetically the primary function of the vestibular apparatus is to regulate body position, a function particularly important in organisms in which the head and body form a single unit, such as in the fish (Fredrickson *et al.,* 1966; Roberts, 1978). In higher vertebrates the regulation of body position becomes more complicated as the neck allows for a greater degree of independent head movement. Consequently, in higher vertebrates, the vestibular apparatus informs the central nervous system only with respect to head position and not that of the body (Fredrickson *et al.,* 1966).

Parts of the inner ear are associated with equilibrium. These parts are very similar in all surviving members of the vertebrates. The organ apparently evolved from the system of tubes which forms the lateral line organ still found in fishes and amphibia and has retained its original tube shape with patches of sensory epithelium in various places. The sacculus, utriculus and three semi-circular canals which make up the labyrinth are recognizable, although variable, in all species (Roberts, 1978; Romer, 1964). In the human these form the labyrinth which is imbedded in extremely hard temporal bone (Gorman, 1981).

Contained in the labyrinth of the ear, is the primary organ for equilibrium, namely the vestibular apparatus/complex. This sense organ is specialized to register the position and movements of the head in space. The information is used in the regulation of motor activity at subcortical level (Meyer, Meij & Meyer, 1994).
The combination of vestibule and semicircular canals make up the vestibular complex. The vestibule includes a pair of membranous sacs, the sacculus and the utriculus. Receptors in the sacculus and utriculus provide sensations of the effective direction in which gravity acts, as well as linear acceleration (Carpenter, 1984). Those in the semicircular canals are stimulated by rotation of the head (rotational acceleration). Together, the perceptions of the effective direction in which gravity act, linear and rotational acceleration, combine to provide the sense of equilibrium or balance (Martini, 1992).

The major contribution of the vestibular apparatus to posture is the reflex maintenance of the head and neck in the vertical position. Reflexes from neck muscles then affect other supporting muscles of the body and their reaction to change of position of the head in space. The vestibular contribution, therefore, may be measured by noting movement of the neck in relation to tilt of the body. In the normal person the neck maintains the vertical position - or may overreact away from the angle of tilt. In the case of any vestibular impairment, the neck falls with the angle of tilt (Brocklehurst, Robertson & James-Groom, 1982).

6.4.1 The semicircular canals and the orientation of the body

The orientation of a body is defined by the direction in space of any two non-parallel lines through fixed points on the body. Normally the head is in a vertical position and one of the lines of reference can be the horizontal line running through the centre of the external auditory meatus on each side of the head (Roberts, 1978).

The second reference line poses a problem because in man there are no obvious straight lines in the profile or on the skull, to serve as guides. Many points of reference have been proposed including the lower margin of the orbit, together with the upper margin of the external auditory meatus, to provide a standard plane for purpose of anthropometry. To decide on what the "normal" position of the head of man is, it is feasible to use the anatomical position of the horizontal semicircular canals, as suggested by Roberts (1978). He pointed out that when the horizontal semicircular canal is parallel to the horizon, the head is in the position characteristic for a boxer on the alert to defend his equilibrium. It corresponds to the attitude commonly used for reading or examining something held in the hand. In contrast, bringing the anthropometric reference plane into the horizontal position gives the head the unnaturally elevated attitude of a military parade (Roberts, 1978).

6.4.2 The neural pathways for equilibrium

Natural activation of canal or otolith receptors leads to a variety of responses of the head and body musculature, all tending to prevent falling and to maintain normal head position (Allum, Honegger & Pfaltz, 1989; Wilson & Peterson, 1978).

Hair cells of the vestibule and semicircular canals are monitored by sensory neurons located in adjacent vestibular ganglia. Sensory fibres from each ganglion form the vestibular branch of the vestibulocochlear nerve (N VIII). These fibres synapse on neurons within the vestibular nuclei at the boundary between the pons and medulla. The two vestibular nuclei: 1) Integrate the sensory information arriving from each side of the head, 2) Relay information to the cerebellum, 3) Relay information to the cerebral cortex, providing a conscious sense of position and movement and 4) Send commands to motor nuclei in the brain stem and spinal cord. These reflexive motor commands are distributed to the motor nuclei for cranial nerves involved with eye, head and neck movements (N III, IV, VI and XI). Descending instructions along the vestibulospinal tracts of the spinal cord adjust peripheral muscle tone to complement the reflexive movements of the head or neck (Martini, 1992).

Since the vestibular system informs the nervous system about head, and not body position, a close somato-vestibular integration exists in order to carry out the necessary coordination between head and body movement. Vestibular nuclei receive, apart from vestibular information, information pertaining to vertebral- and extremity joint movement, as well as some about the movements of the extremities *per se* (Fredrickson *et al.,* 1966).

6.4.3 Reflexes of balance

The central nervous system formulates the reflexes of balance response from information arriving from the labyrinth in conjunction with information from any other receptors. These responses include 1) acceleratory reflexes from the semicircular canals and 2) positional reflexes initiated from a variety of other reflexes, including the otolith organs in the labyrinth.

The purpose of the reflexes of balance are 1) to stabilize the direction of gaze of the eyeballs when the head moves and 2) to adjust the attitudes of the limbs and neck in order to compensate for asymmetries of the surface underfoot, as well as to stabilize the head (Roberts, 1978; Wilson & Peterson, 1978).

If the combination of stabilization and compensation fails to preserve balance, another set of responses, the "rescue reactions" are initiated at the point of overbalancing. The "righting reflexes" (see labyrinthine and righting reactions, sections 6.4.3.1 & 6.4.4) come into play after displacement, to restore the head and body toward a standard "normal" attitude (Roberts, 1978).

Higher vertebrates have a freely moving head, with the labyrinths indicating body position in conjunction with information from the neck. Therefore body position can only be stabilized if the position of the head relative to the body is taken into account. There is a conflict between the requirement for stability (mainly a specific position in defiance of external forces) and the requirement for mobility (executing movements that constitute natural behaviour). If the stabilizing mechanisms were absolute, no change in attitude would be possible - any attempt to move would be countered by reflex adjustments tending to restore the normal attitudes. If stabilizing mechanisms need to be disabled to permit voluntary movements, all benefits of stabilization are lost and loss of balance may occur (Roberts, 1978).

6.4.3.1 The labyrinthine reactions

These reactions were originally referred to as tonic labyrinthine reflexes by Magnus (1926a). These reactions are not evoked by movement *per se*, but rather by body position or inclination of the head (Gowitzke & Milner, 1988), and arise from the otolithic organs of the utriculus (Magnus, 1926a).

The supine position or corresponding orientation of the head with gravity facilitates extension in all limbs and inhibits flexion, while the prone position or head orientation result in the opposite response. Lying on the side or an equivalent position of the head induces extensor facilitation of the top limbs with reciprocal inhibition of the antagonists (Gowitzke & Milner, 1988).

6.4.4 Interactions between the neck and labyrinthine reactions

In many respects the neck and labyrinthine reactions are exact opposites (Kornhuber, 1974; Roberts, 1978, 1995) (Figure 6.2). Conflict between these reactions is resolved in the CNS so that the individual can move his head freely in any direction without altering the disposition of the trunk and limbs (Roberts, 1995). In Figure 6.3 these interactions are shown in a scheme of stick figures.

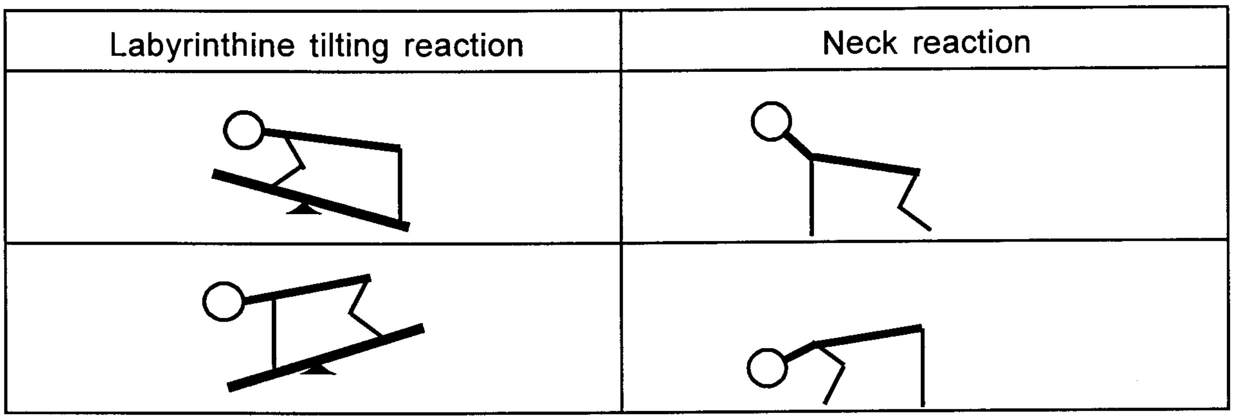

Fig. 6.2 **The symmetrical neck reflexes (responses to tilting of the head and neck) as antagonistic to the labyrinthine tilting reflexes (reactions of body in response to tilting of a platform for example) [Adapted from Kornhuber (1974)].**

When an infant's head is turned with the nose to the left, the asymmetric neck reaction will induce extension of the left arm and flexion of the right. Rapid lateral tilt with the nose turned to the left, however, causes extension of the right arm and flexion of the left. Labyrinthine reactions prevent falling during rapid tilt, while the neck reactions prevent falling due to labyrinthine reflexes, when only the head is moved (Kornhuber, 1974).

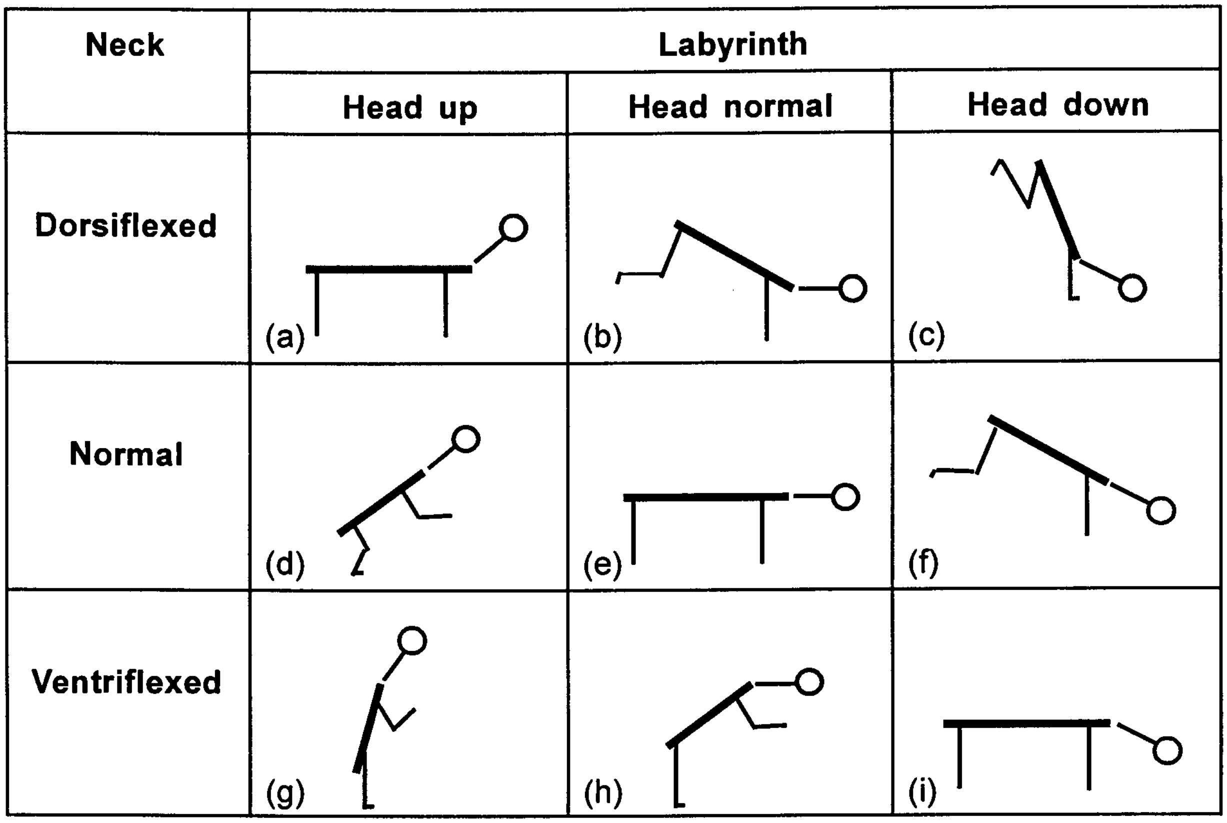

Fig. 6.3 Scheme of stick figures illustrating the interaction between positional reactions from the neck and the labyrinths. In (g) upright man is shown, in (d) the human orthograde posture and in (e) a crawling infant. Further extension in (c) will result in a handstand (Adapted from Roberts, 1995).

Magnus (1926a) was of the opinion that if both the neck and labyrinthine reactions are present (which in normal individuals is always the case), they cooperate so that the tone of every single muscle depends upon the algebraic sum of influences derived from the proprioceptive receptors in the neck and those from the utriculus. Kornhuber (1974) felt that Magnus (1926a) failed to appreciate the concept that the neck reactions were the exact opposite of the labyrinthine tilting reflexes (Figures 6.2 & 6.3). Von Holst and Mittelstaedt (1950) [quoted by Kornhuber (1974)] concluded that neck input must be subtracted from the labyrinthine to yield the correct signal to the motor systems in the brain stem. Integration of these two apparently conflicting inputs is probably done at brainstem level in the vestibular nuclei and reticular formation (see Figure 6.1). This interaction is shown in Figure 6.3.

6.4.5 The righting reactions

6.4.5.1 The five reactions

As growth and development proceed the labyrinthine reactions are supplanted by more complex responses - the righting reactions (Gowitzke & Milner, 1988).

In relation to gravity each vertebrate normally has a certain head and body position. When the position of the head or body changes in relation to the environment or horizon, reactions occur to enable the individual to recover the normal head and/or body position (Fukuda, 1961). This is accomplished by contraction of neck-, trunk- and limb muscles in order to raise the head and to attain the vertical posture. Five righting reactions were identified by Magnus (1926b), each serving a specific purpose. They are (Gowitzke & Milner, 1988; Magnus, 1926b):

- The labyrinthine righting reactions

These reactions provide for orientation of the head in relation to space, gravity being the controlling influence. Stimulation of the labyrinthine receptors evokes contractions of the neck muscles from a horizontal to a vertical position. These reactions may be divided into two groups: Symmetrical and asymmetrical. The former is elicited by stimulation of the receptors in the utriculus, while the latter is evoked from the sacculus.

- Body-on-head reactions

Asymmetrical stimulation of the skin receptors on one side of the body results in the activity of trunk and limb muscles, which raises the head in an upright position. Similar reactions may also be evoked, not only by stimulation of the trunk, but also from the soles and palms.

Abnormal positions of the head are corrected by these reactions, and are an indication of the importance of tactile stimulation for orientation of the head.

❑ Neck righting reactions

These reactions orientate the body in relation to the head. Impulses arising from the receptors in the neck produce contractions of body and limb muscles, aligning the body with the head. These reactions make it possible, by simple movements of the head, to bring the body of a large animal such as a bull to its side.

❑ Body righting reactions acting upon the body

The body righting reactions right the body in relation to the ground or any surface with which the body comes into contact. An example is climbing. These reactions make it possible to right the body even if the head is not in the normal position.

❑ Optical righting reactions

Visual feedback is used to orientate the head and body correctly to the environment.

In the attainment of the desired posture the integrity of every single factor is doubly ensured. The head is righted by labyrinthine, optical and tactile stimuli. The tactile stimuli act separately upon the body and upon the head. The orientation of the head and the body takes place in relation to the effect of gravity, the sustaining surface and to parts of the body - a very complex combination of reactions according to Magnus (1926b).

6.4.5.2 Centres for the righting reactions in the central nervous system

Centres in the CNS for the righting reflexes are found in different areas of the midbrain, with the *nucleus ruber* and its descending rubrospinal tract mainly involved in the labyrinthine and body reflexes acting upon the body. Body righting reflexes upon the head righting reactions have their centres at the same level in the midbrain, while the centres for the neck righting reflexes are found in the pons. Visual righting reactions are cortical (Magnus, 1926b).

6.4.6 The general reactions in man

In the adult the circuits of the neck and labyrinthine reactions are still intact, but they are influenced and even dominated by patterns developing later and, according to Gowitzke and Milner (1988) more useful patterns. The presence of the neck and labyrinthine reactions was demonstrated by Hellebrandt and Waterland (1962). Magnus, according to Fukuda (1961), failed to demonstrate these reflexes in normal monkeys, as well as in normal healthy adult humans as basic patterns for their daily movements. Magnus felt that in the human, these reactions were obscured by actions of higher centres, and also due to the fact that human posture differs radically from that of quadrupeds (Fukuda, 1961). With the aid of numerous examples Fukuda (1961) demonstrated the presence of these reactions in normal healthy adults. He came to the conclusion that the neck reactions form an important basic pattern which participates in the composition of momentary dynamic postures, and the righting reflexes (labyrinthine and visual) also play an important role in maintaining human postures. Alexander (1932, 1941, 1987, 1996) was well aware of this, and probably based his concept of the "primary control" (section 7.2.4.1.1.4) on the existence of these reflexes. Researchers, such as Dart (1946; 1947; 1970), Jones (1965; 1979), Jones & O'Connell (1958), Jones *et al.,* (1959), Jones *et al.,* (1964) and Sherrington (1946) also took cognisance of the importance of primitive reactions in human motor behaviour.

The role of these reactions in posture is best summed up by Magnus (1926a: 536) when he stated that they form a group of actions:

> *.....by which the body musculature can be integrated for a contained and a highly adaptive function. The entire body follows the direction assumed by the head, this being very often moved in a certain direction under the influence of the teleceptive higher sense-organs. This provides one of the ways in which the relation of the body to its environment is regulated.*

Dart (1946), agreed with this view in the human, and preceded those of Fukuda (1961) when he portrayed the practical aspects of the righting and the neck reflexes thus:

> *The tutelage that results in skill is devoted, whether recognised or not by the participants, to the process of coordinating the existing attitudinal and righting reflexes of the body (well-, badly- or indifferently-integrated as they already may be), with new movements now being personally designed for the first time. But if the new sets of movements have an asymmetrical attitudinal effect on the body, and the body as a result of its previous neuro-muscular experience has already attained an oblique postural state (i.e. with a bias or slope in one direction whether rightward or leftward) or asymmetry the new movements can have no other effect, however seemingly accurate their performance, than further emphasising and consolidating the postural asymmetry resulting ontogenetically from previous faulty integration. Faulty attitudinal integration or imperfections in the use of both spiral sheets and in the ability to secure the balance or body poise essential for this truly skilled execution of movements is the general characteristic of all human beings at the outset. Unfortunately, we understand so little of the reflex*

> *nature of the body poise we should be aiming at when as infants, we are becoming erect, that we prevent the emergence of the underlying attitudinal and body-righting reflexes essential to acquiring postural poise. We acquire despite our asymmetrical rigidity a passable degree of skill for one that succeeds in satisfying us, without ever knowing or experiencing the postural poise for whose endowment nature consumed millions of years* (Dart, 1946: 11).

6.4.7 The inner ear and the upright posture

Alfred Tomatis, the renowned musicologist, viewed the ear as the key organ in humanity's development of a vertical posture (Campbell, 1997). From the very first vertebrate life, the ear has been used not only for auditory purposes but also to regulate movement. The evolvement of the ear from the fish to the human, brought about progressive development of the organs in the inner ear that aid in establishing motion, laterality and verticality. This process has been critical in the evolution of the human into a being able to move forward, backward, up and down, and side to side at will (Campbell, 1997). He described the ear as choreographing the body's dance of balance, rhythm and movement:

> *The ear choreographs the body's dance of balance, rhythm, and movement. From the simple motions of jellyfish through the complex activities of homo sapiens, the ear is the gyroscope, the CPU, the orchestra conductor of the entire nervous system. The ear integrates the information conveyed by sound, organizes language, and gives us our ability to sense the horizontal and the vertical* (Campbell, 1997: 53).

Through the *medulla* the auditory nerve connects with all the muscles of the body. Thus muscle tone, equilibrium and flexibility are also directly influenced by sound. Sitting or standing upright allows maximum control over the listening process and stimulates the brain to full consciousness (Tomatis, quoted by Campbell, 1997). The ear's vestibular function influences the eye muscles, affecting vision and facial movements. Disorders or weakness in the vestibular function may result in speech impediments, poor motor coordination, and difficulties in standing, sitting, crawling or walking (Campbell, 1997).

Tomatis, according to Campbell (1997), asserted that following the labyrinthine thread of sound through the ear and central nervous system, and comprehending the way in which the inner ear affects jaw movement and the ability to turn, to bend and situate ourselves in space, is central to an understanding of human development. One wonders whether speech followed erectness.

6.5 VISION

6.5.1 The role of vision in postural stabilization

Vision plays a major role in the multisensory process of postural stabilization. Physiologically it attenuates self-generated body sway by 50%. Unlike vestibular stimuli, which invariably lead to the sensation of body motion (and therefore require a postural reaction in order to maintain balance), visual stimuli provide for two perceptual interpretations: either self-motion or object-motion. The decisive visual signal that starts active postural correction of body tilt may be dependent, either upon relative image shift on the retina of the stationary visual surroundings, or on 'efferent motion perception' when fixating stationary targets (Paulus *et al.,* 1984).

Vision becomes of greatest importance when the ankle - foot proprioception is missing, for example standing on a soft, compliant surface or narrow beam. In addition, the view that vision is also more important than the vestibular function, is held by Brocklehurst *et al.* (1982) and Fernie and Holliday (1979).

The eyes endeavour to keep the visual axis stationary in spite of movement of the head. This is accomplished by the three pairs of voluntary eye muscles. Tilting the head but keeping the angles of the neck-joints constant, elicits the labyrinthine effect. The eyes tilt in their sockets and these movements are compensatory, like those in the acceleratory reflexes. The positional reflexes maintain the compensatory pose in the new position. Roberts (1978) concluded that the compensatory pose of the eyes during maintained inclination of the head, is due to the activity of the otolith organs.

Taguchi (1980) claimed that maintaining the eyes in the normal position is so important that the body's centre of gravity moves in order to keep the head steady. The head moves slower than the centre of gravity, and the head's movement is controlled by the body's centre of gravity. The head containing the brain, eyes and vestibular organs, must maintain its balance so as to fix the gaze upon an object. In this way one orientates one's position in space. In order to attain these functions, the centre of gravity seems to move appropriately. The head's movement in relation to the centre of gravity constitutes the mechanism of the righting reflex. This point of view puts vision and vestibular function on equal footing (also see Roberts (1978).

The dominant eye for verticality in healthy subjects is the left one and this causes oscillations of the body axis predominantly to the right, thus deviation of the body axis is predominantly to the right. This is not influenced by handedness as both left- and right-handed subjects share this trait (as do blind subjects). Cernacek and Jagr (1972) explained these findings based on the observations of the functional prevalence of the right hemisphere for non-verbal, optic, auditory and somatosensory stimuli, contrasting with the better performance of the left hemisphere in the verbal sphere. This could also be extended to the vestibular system and seems to be the most probable explanation of the greater frequency of the deviation of the body axis to the right. This again indicates a close connection between eye and ear.

Visual stabilization of posture is obviously dependent on the performance of the visual system. Paulus *et al.* (1984) found that decreased visual acuity causes increased postural instability, indicated by body sway, twice as prominent for fore-aft than for lateral sway. Any measurable visual contribution for fore-aft sway ceases with a visual acuity lower than 0.03 and for lateral sway with an acuity lower than 0.01. The central area of the visual field dominates postural control with the foveal region exhibiting a powerful contribution, particularly for lateral sway.

Visual input has an additional effect on postural stabilization. A partial but significant visual stabilization is preserved with a visual input rate between 1 to 4 Hertz flicker frequency. As soon as continuous motion perception becomes involved with frequencies higher than 4 Hertz, visual stabilization gradually improves with a saturation at frequencies higher than 16 Hertz.

Amblard, Crémieux, Marchand and Carblanc (1985) suggested the existence of two modes of visual control of lateral balance in man, which are well separated in terms of the frequency range of body sway: the first mechanism operates below 2 Hertz and seems to control the orientation of the upper part of the body; the second mechanism operates above 4 Hertz, centres on 7 Hertz and seems to immobilize the body working upwards from the feet. Thus static visual cues may slowly control re-orientation or displacement, whereas dynamic visual cues may contribute to fast stabilization of the body. Interesting enough in this respect is the observation by Begbie (1969) that peripheral vision is more useful than central vision in aiding balancing.

Eye-object distance and lateral body sway are linearly related - body sway decreases with increasing distance (Amblard *et al.,* 1985).

Visual surroundings play a definite part in the maintenance of posture control. Soechting and Berthoz (1979) claimed that vision had a powerful influence on postural control but stressed that other sensory cues in the control of posture should not be precluded. Their work indicated that vision plays an important, direction-specific role in the control of postural reactions during sudden perturbation of stance. When the linear acceleration is of short duration (less than 10 seconds), visual influences become apparent only when the visual information conflicts with other sensory inputs. Motion of the visual environment produces a greater effect when tested in the dynamic condition of postural change than when tested in isolation in a static posture maintenance condition. A moving visual scene produces an illusion of translation to a stationary observer (Berthoz, Pavad & Young, 1975) and such moving visual environments result in postural readjustments of the observer. A visual surround moving in the antero-posterior direction produces an inclination (pitch) of an erect person in the direction of surround motion (Lestienne, Soechting & Berthoz, 1977) (the pitch amplitude can be up to 3 degrees which is approximately 50% of maximal tolerable body pitch compatible with postural stability). Brain stem structures, particularly the vestibular nuclei, are involved in the mediation of these effects in primates (Waespe & Henn, 1977).

6.5.2 Vision and vestibular function in the maintenance of posture

The importance of vision in the maintenance of posture has been well documented as has been shown in the previous section. It is also generally accepted that the role of the vestibular system during quiet stance is primarily to solve problems of conflicting sensory information (Amblard *et al.,* 1985), and that chronic vestibular deficits, in the absence of conflicting sensory information, are relatively well compensated for in quiet stance by vision, vestibular information and proprioception (Diener, Dichgans, Guschlbauer & Bacher, 1986; Dichgans & Diener, 1989). In contrast the exact consequences of somatosensory loss on the control of posture remain largely undetermined (Paulus *et al.*, 1984). The latter reflects on the many forms of somatosensory input which originate from sensory receptors in the joints, muscles, tendons and skin (Simoneau, Ulbrecht, Derr & Cavanagh, 1995).

6.6 ORGANIZATIONAL HYPOTHESIS FOR THE SENSES

Interpreting sensory information and coordinating muscle reactions are, according to Nashner and McCollum (1985), analogous organizational problems; in both processes potentially endless computational problems must be simplified. This is to avoid too much neural organization and neural computation. Such a mechanism would be to break down functions for posture and movement control into functional elements which then are executed by specialized subsystems (Nashner, Shumway-Cook & Marin, 1983).

If one assumes that posture is organized into distinct strategies related to separate regions within the body position space, then there is a simple scheme for organizing sensory inputs to posture, based upon the information requirements of the muscle synergies. Specifically, it is possible to reduce complex multidimensional orientation information to a series of simple scalar quantities which map directly onto specific parameters of the muscle strategies (Nashner & McCollum, 1985). The positive supporting reaction in which a single CPG is involved and the neck reactions in which a number of CPG's are involved, (sections 6.3.2.1.1 & 6.3.2.3.2) are examples of such an arrangement. In the first example proprioceptive information from the foot is linked to the posture of the lower limb. In the second example the position of the head and neck is linked to body posture and position of the limbs. In the latter example the sensory input is probably not only linked to the individual CPG's controlling the functions of the various body parts, but also to a system which integrates the function of the various CPG's (See Figure 6.1). Effective functioning of CPG's is only possible, however, if sensory input is sufficient and appropriate. For the equilibrium control centres, information on the position of the head relative to the shoulders (see neck reactions, section 6.3.2.3.2) is of no value if information on the position of the shoulders relative to the actual supporting surface is not available (Lund & Broberg, 1983).

6.7 A CONCEPTUAL MODEL FOR THE CONTROL OF POSTURE

A conceptual model for the control of posture was compiled by Hayes (1982). The model assumes two function generators or GPG's. The first provides the antigravity torque commands (suspension CPG), while the other is responsible for postural sway (sway CPG). These CPG's influence the musculature of the lower legs according to fixed muscle synergies. The output of the two CPG's are controlled by input from higher centres (Denny-Brown, 1964). Feedback about ankle rotation, including input from muscle proprioceptors, pressure receptors (within joints and the vertebral column) and joint afferent, regulates the activity of the sway generator (Hayes, 1982; Horstmann & Dietz, 1990). Likewise is the activity of the suspension generator regulated by input from afferent about the knee joint (Hayes, 1982).

Visual, vestibular and somatosensory inputs, together with inputs from brain areas associated with aspects such as emotion (see chapter 7) all converge to influence the overall output level of the CPG's, and contribute to the plasticity demanded of the system. This is accomplished by changing the "gain" of the inputs from the various proprioceptors (Hayes, 1982). The then pre-established pattern reflects a central "model" of the movement task, including the anticipation of external loads and disturbances. When the task is well learned and conditions predictable, the nervous system will adapt its "model" to the task (Nashner, 1976).

6.8 THE ANTICIPATORY TRAITS OF POSTURAL CONTROL

6.8.1 Cortical representation of the body surface (neural maps)

One of the obstacles in improving posture, lies in the fact that each person has difficulty in perceiving his own stature. People do not know what they look like. Alexander (1987) solved this problem by using the mirror as his most powerful tool in his own postural re-education. However, the dimensions and shape of the body have long been thought to be coded in the activity patterns of topographic somatosensory maps in the thalamus and cortex of the brain. Within this neural framework, limb length and trunk contours are represented by the discharge patterns of neurons in particular areas of the neural maps (Martini, 1992; Meyer *et al.,* 1994). Research indicated that more than the activity of somatotropic neural maps is involved in the perceptual specification of body configuration. Indeed, it became apparent that spatial information about other parts of the body is also implicated, and that position sense and the body schema represent a collaborative interaction of multiple afferent and efferent domains. These can result in a multitude of apparent positions and orientations, real or illusory, being generated (Lackner, 1988). This seems to be corroborated by the work of Lestiene and Gurfinkel (1988) who found that the implementation of different postural tasks requires the knowledge of the state of many variables which cannot be directly signalled by specific receptors, for example, body segment length and the sequence of the segment linkage. They postulated a hypothetical central organization of postural regulation based on an internal model of the body. This "body scheme" is characterised by: 1) an inborn structural organization of the body, such as the upper and lower end of the body, left and right side, dorsal and ventral surface; 2) a system of references connected to both the vestibular system (absolute vertical) and visual and proprioceptive systems (proprioceptive vertical) and 3) a higher form of sensory organization akin to a "sensory envelope" formed from active movements and everyday experiences. The main function of the "body scheme" is to predict the state of the complex multicomponent mobile system of balanced elements. This prediction is conceived as a dialogue between the external world, the state of the body segments and the body scheme (Lestienne & Gurfinkel, 1988).

6.8.2 Modification of neural maps

Some investigators have shown that there is considerable plasticity in the neuronal representation of the body surface in the somatosensory cortex; in fact, the cortical maps of somatosensation are modifiable (Kaas, 1983). Although the receptive fields of particular neurons may remain fixed, this stable organization appears to be the result of balancing dynamic influences. When this balance is disrupted by inactivating part of the peripheral sensory input, the organizations of the cortical maps are immediately altered and continue to change over time. Thus, even in the adult, the maps of somatosensation are dynamically organized and potentially modifiable. Lackner (1988) found that perceptual representations of the body surface in the adult human could be greatly modified and perceptual remappings could be generated within seconds. The limbs, which are the more mobile parts of the body, seem to have representational priority in affecting the body schema and this may have considerable functional significance in the body schema during the course of development and probably also in learning.

In the course of development, the dimensions of the body change greatly. These changes continue to a lesser extent in adulthood with variations in body mass being a relatively common occurrence and other changes, such as a gradual diminution in height, being less frequent. The "maps" underlying position sense and somatosensation have to be recalibrated to take into account changes in body dimensions. Position sense could possibly be updated on the basis of sensory motor transactions such as the reach of the arm to bring it in contact with an object. Thus, position sense of the independently mobile parts of the body can be maintained through transactions with the environment. The rest of the body is not subject to the same degree of interaction with the external environment and it may be that its somatosensory representation is updated by contact with the motile appendages of the body (limbs and eyes) and the position of the hands and other parts of the body can be accurately determined in relation to the head (Lackner, 1988).

6.8.3 Oculomotor control

Lackner (1988) suggested that the above notions of position sense could also be applied to oculomotor control and that limb position information could be used in calibrating the direction of the gaze of the eyes, because it is known that the apparent position of the eyes can be influenced by information about limb position (Levine & Lackner, 1979).

Posture and occulomotion may be linked in an additional way. Kohen-Raz (1981) explored the relationship between posture and academic achievements. He proposed a theory why posture and reading should be correlated: It is assumed that certain cerebral and cerebellar mechanisms control, via the gamma efferent system, the scanning of minute temporal and spatial sequences. This takes place both in the domain of postural functions, as well as in basic oculomotor perceptual and cognitive processes involved in the decoding, interpretation and transmodel transfer of visual and acoustic patterns of signals and symbols.

6.8.4 Centre of gravity control

Posture, which is the position and orientation of the body segments, and balance, the control of the centre of gravity of the body, are coupled. Most postural adjustments change the location of the centre of gravity. During stance and movement, the central nervous system presumably controls body segment alignment in order to control the location of the centre of gravity. Thus the brain controls posture to maintain balance (Riley *et al.,*1990). Postural control is then the ability to maintain equilibrium and orientation in a gravitational environment (Crosbie, Durward & Rowe, 1996).

The human body may attain equilibrium in an almost infinite number of postures, though postural adjustments are invariably associated with purposeful movements. Coordination between posture and movement is a task where multiple goals have to be controlled simultaneously during the same motor act.

6.8.5 Anticipatory postural adjustments

Gurfinkel and Shik (1973) noted that changes in postural activity have not only a compensating, but also an anticipatory character. The latter is essential since movement of the limbs, for example, can displace the body's centre of gravity, and anticipatory postural adjustments are known to occur to reduce instability (Forget & Lamarre, 1990).

On the basis of behavioural data and reaction time, a theory was formulated by Woollacott, Bonnet, and Yabe (1984), that changes in the activity of supraspinal structures activating postural muscles are triggered by preparatory advance information. Massion *et al.,* (1998) referred to this as anticipatory postural adjustments. Both peripheral and central mechanisms are used to guide responses to anticipated postural perturbations (Horak, Diener & Nashner, 1989) These responses usually precede the macro-movements and take into account the expected result of the movement. More recently it was stated that a prerequisite for understanding what is controlled by the anticipatory postural adjustments is to define which goals are achieved by these anticipations (Massion *et al.*, 1998).

When a voluntary movement is performed while standing, the muscle activation and the kinematic changes are not restricted to the segments which are the targets of the voluntary command, but also concern other segments involved in the control of the posture and equilibrium of the whole body. Voluntary bending movements of the trunk, for example, are accompanied by associated movements of hip and knee (Pedotti, Crenna, Deat, Frigo & Massion, 1989). It was found that during fast forward and backward bending, the onset of EMG activation or inhibition of not only the prime mover (trunk flexors or extensors), but also of the lower limb muscles involved in the associated movements (ankle, knee and hip flexors and extensors), clearly precedes the onset of the kinematic changes in any segment, indicating that they are all centrally programmed. Pedotti *et al.* (1989) concluded that the performance of movements which greatly disturb the maintenance of equilibrium is associated with the control of multijoint segments through synergies involving a given set of muscles. Prewired postural synergies responsible for the performance of fixed postural tasks probably exist, but a flexibility exists among the synergies regarding the timing of the onset of muscle activation and the combination of muscles involved. It has been suggested by Nashner and McCollum (1985) that only six muscle synergies are required for the control of balance in any direction: forward and backward ankle and hip synergies and upward and downward suspensory synergies. Anticipatory postural adjustments are achieved by a very limited set of muscle synergies and these postural synergies are organized at a lower level of the motor system hierarchy (Gahery & Massion, 1981). Cordo and Nashner (1982) proposed a separate central command for postural and focal muscle activation (executing a push or pull task). This is because time is needed for focal muscle activation and not for postural muscles. The timing is controlled by the central nervous system (Brown & Frank, 1987).

Most anticipatory postural adjustment goals are aimed at minimizing the postural or equilibrium disturbance provoked by a voluntary movement, for example during a load-lifting task the goal of the anticipatory postural adjustment is to provide a stable postural reference frame during the task. Two parallel controls exist, one for the postural anticipation and the other for the load-lifting movement. The main role of the voluntary movement is to provide a timing signal for the disturbance to occur. The highest control level is related to the selection of the postural reference position for the task to be performed by the moving hand. A lower level of control is in charge of executing the movement as well as the anticipatory postural adjustments. The motor field under control during the anticipatory postural adjustments is compatible with a change in the point of equilibrium. The anticipatory postural adjustments are based on a motor memory built during the acquisition of the task. The memorized motor skill is lateralized and not transferable (Massion *et al.*, 1998).

In the upper trunk bending paradigm, a single coordinated control exists, achieving simultaneously the movement and the postural adjustment. The central control would be simultaneously addressed to the various joints involved in the task, whether they contribute mainly to the movement or to the associated postural adjustment. Thus, there is an integration between postural and movement control.

This single, coordinated control would result from experience and practise. At the end of the acquisition process, a motor skill would have emerged from the interaction between the learned central command, the assisting feedback loops and the dynamic interaction between segments (Massion *et al.,* 1998).

Woollacott *et al.* (1984) proposed a model representing possible psychological processes and neurophysiological mechanisms underlying preparation and initiation of postural adjustments associated with voluntary movements. The preparation is the selection of the appropriate primary (movement of the arm, for example), and postural response synergies from a predetermined alternative (for example push or pull). The central circuits involved in the activation of these response synergies are progressively organised during the preparatory period after the selection process has taken place, and direction-specific changes occur only in the central circuits. It is suggested that the postural synergy output initially inhibits the primary synergy output (Cordo & Nashner, 1982). The reasons for this conclusion are that subjects sometimes responded with a postural output without subsequent activation of the primary synergy, and ageing subjects may activate a primary synergy without previous activation of the postural synergy and subsequently lose balance. Woollacott *et al.* (1984) thus proposed the existence of a possible inhibitory mechanism operating in the normal young adult, which delays the voluntary output until after the beginning of the activation of the postural synergy. Also, the postural system is modulated by preparatory processes.

CHAPTER 7

PSYCHOSOMATIC TREATMENTS, MIND-BODY THERAPIES AND BODY WORK

The correct posture alone has the power to open one's consciousness
(Belasik, 1990: 33).

.....posture is body language that depicts the emotions and excessive lordosis is not exempt
(Cailliet, 1995: 103).

7.1 INTRODUCTION: THE MIND-BODY PROBLEM

Following an analysis of ancient, modern, Eastern and Western perspectives on healing, Graham (1990: 90) came to the conclusion that:

> *Ancient, modern, Eastern and Western perspectives on 'life, the universe and everything' appear to be the same - quite literally.*
>
> *They are all holistic, all parts of the universe being seen as inter-related and inseparable, with no distinction between mind and matter; body, soul or spirit.*

As early as 1923, Alexander (1987) came to the conclusion that it is impossible to separate physical and mental operations in our concept of the working of the human organism, preceding the concept of "holism" in biological science introduced by General J.C. Smuts in 1926 (Smuts, 1987) by a few years.

Konrad Lorenz, a Nobel prize laureate, and one of the founders of the science of animal behaviour, also considered the issue of the mind-body problem from an epistomological point of view (Lorenz, 1988). The outcome of his deliberations on this issue is discussed on the following pages.

Undoubtably there has to be close connections between certain processes taking place within human bodies and the form in which they are experienced. Lorenz (1988: 90) was of the opinion that:

> *.....the isomorphism between what happens physiologically and what happens subjectively can be quite extensive and very reliable.*

To explain this isomorphism Lorenz (1988) suggested three hypotheses which are epistemologically equally legitimate.

1. The first hypothesis is that of **interaction:**

Here the physiological process is the cause of the corresponding experience, which in turn has a retroactive effect on what happens physiologically. A drooping head, for example, symbolises sorrow because it expresses a specific internal nervous situation which is regularly accompanied by the subjective indications of depression.

> ***The one cannot be the cause of the other since, in a certain sense, the one is itself the other, except that it is experienced from the other side*** (emphasis that of Lorenz) (Lorenz, 1988: 92).

2. The second hypothesis is the doctrine of **psycho-physical parallelism:**

Some highly complicated physiological processes are carried out constantly and completely unconsciously. Often qualitatively unmistakable subjective experiences are not correlated with objective and measurable physiological occurrences, despite the fact that transitions from mental processes to a physiological correlate is a common, demonstrable occurrence. Lorenz (1988) assumed that such definite correlates exist in all instances, in spite of the fact that physiological processes are not demonstrable. To explain this he considered the possibility that some physiological processes are of such delicacy and minimal energy, that they are untraceable.

3. The third approach to the mind-body problem, is that body and mind, physiological and emotional occurrences, are, in reality, in themselves, simply **one and the same**.

This approach (Lorenz, 1988) is the only one tenable for the evolutionary epistomologist; an approach which assumes that body and mind, physiological and mental occurrences are experienced and recognized as we do energy and matter, or energy radiated in the form of waves or particles by means of two independent and incommensurable cognitive capacities.

The above points of view are reflected in the approach that emotional and psychological ways of relating to the world and other people are physically reflected in the body (Graham, 1990; Lorenz, 1988). Likewise, according to Rolf, (1977) man is a unity in response to all that has happened to him, not two separate entities (body and soul), with each entity responding separately to various influences.

The body, and, for the present purpose, the muscles may therefore be a reflection of mental processes and emotions. Muscular imbalances and tensions, for example, can become a shield or armouring, protecting a person both from the emotional discomforts of life as well as from conscious experiences of the deep, inner hurts that have accumulated throughout life (Feldenkrais, 1985; Lowen, 1994; Rolf, 1977). These armourings or regions of tension, by virtue of their pull on the body, lead to postural distortions, rigidity and limitations in movement (Lowen, 1969, 1971, 1975; Painter; 1986). Thus the body's attitudes reflect both mental and emotional attitudes, and the relationship between our bodies and our minds should be approached as a single unified problem. In

Figure 7.1 the reciprocal links between behaviour, moods and emotions, thoughts and image patterns are clearly illustrated (Steyn, 1999). This model will allow for the effect of thoughts and/or emotions on physical behaviour as seen in aberrant postures.

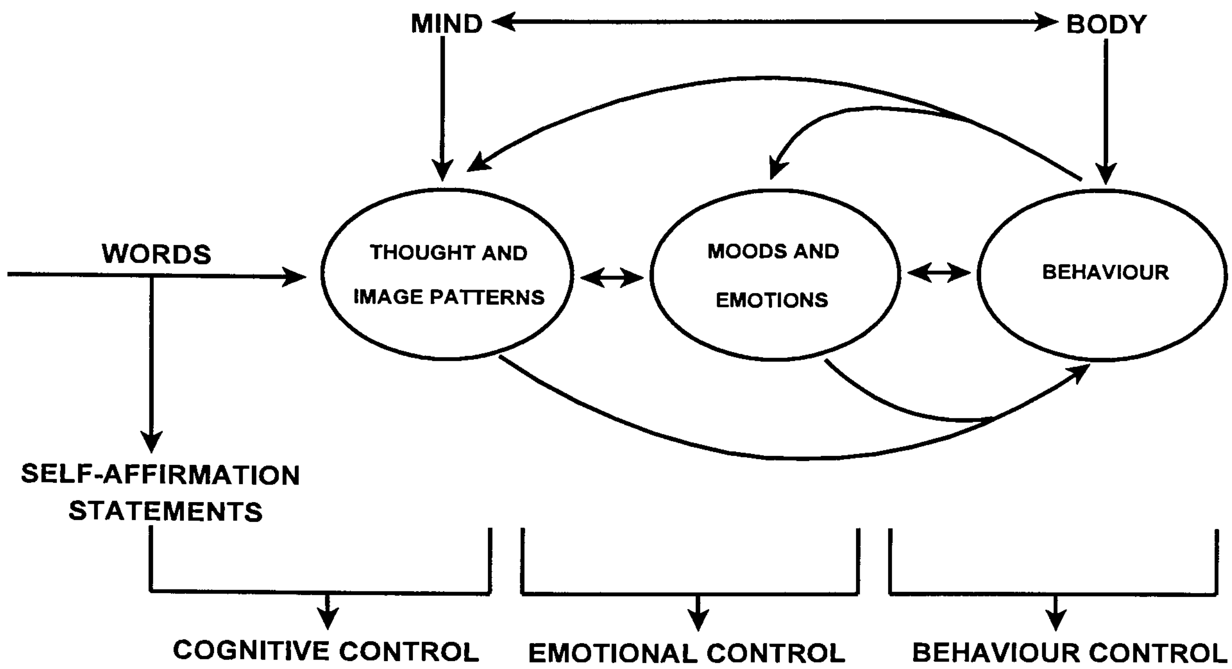

Fig. 7.1 The mind-body link (Steyn, 1999).

The contentions of Alexander (1932; 1987), Feldenkrais (1972; 1985), Hanna (1988), Lowen (1969, 1971, 1975), Painter (1986), Reich (1999) and Rolf (1977), all originators and practitioners of structural integration therapies, led them to implement the mind-body unity concept to develop practical therapies, which they applied to the benefit of their clients and patients. The connecting link between all these therapies, according to Plummer (1982), is posture. Since postural homeostasis is, in fact, one of the central issues in these and some other physical therapies (see Table 7.1), the relationship of posture to the mind becomes apparent. It is in this connection that the therapies discussed below should be considered.

7.2 CURRENT TECHNIQUES IN BODYWORK

Techniques developed to change posture and other associated aspects such as muscle imbalance, psychological problems may be divided into two groups from the subject's point of view, namely active and passive techniques (Plummer, 1982) (see Table 7.1). Active techniques require the involvement and full participation and cooperation of the subject in order to be effective. The subject must be motivated to improve his posture/use or else the techniques are useless. Passive techniques make the individual dependent on the therapist to some extent, although, according to recent personal information gained from those practising in this field, active participation and involvement of the subject is required (Plummer, 1982).

Techniques come and go, some undergo a rise and fall in popularity, but some withstand the test of time and become classics and remain as effective today as at the time of their inception. Five such techniques are highlighted here; and information about the instigator, development of the particular technique and the effectiveness of each technique is traced and evaluated. The five approaches which will be discussed on the following pages are Reichian Therapy, Bioenergetics, the Alexander Technique, Dart postures, and Rolfing. This will be followed by a brief overview of some active intermittent techniques mainly aimed at the correction of posture, muscle imbalances and neuromuscular coordination.

7.2.1 Reichian Therapy

A brilliant and emotional thinker, Wilhelm Reich (1897-1957) is considered today to be the father of most **body-oriented psychological therapies** (Hoff, 1978).

Because of this statement it was considered feasible to give a short overview of the relevant background of this enigmatic and complex person. His writings are extremely difficult to come by, therefore most of what follows is what has been obtained from secondary sources.

Table 7.1 *A classification of techniques for restoring postural homeostasis (Adapted from Dart, 1947; Norris, 1995; Pilates & Miller, 1998; Plummer, 1982; Putkisto, 1998; Schrecker, 1971)*

ACTIVE		**PASSIVE**	
Requires active participation, therapist-independent once learned		**Subject is passive, therapist-dependent**	
Continuous	**Intermittent**	**Peripheral**	**Central**
Alexander Technique	1. Anti-gravity exercises: yoga, t'ai chi ch'uan. 2. Sensory awareness: Dart postures, Feldenkrais technique, Bioenergetics, Reichian Therapy. 3. Muscle lengthening (stretching) exercises, Method Putkisto, orthotherapy, corrective gymnastics/exercises, kung fu, karate. 4. Deep muscle strengthening (Pilates).	Rolfing, shiatsu, acupuncture-acupressure, polarisation, trigger point therapy, neural point therapy, neural therapies, psychoperistaltic massage, connective tissue massage.	Chiropractic and other spinal manipulation methods.

7.2.1.1 The history of Wilhelm Reich

Wilhelm Reich was born on 24 March, 1897 in rural Austria. After graduating from the University of Vienna's medical school he became Sigmund Freud's assistant and contributed significantly to the development of psychoanalysis. During the 1930s he severed ties with Freud and started expounding controversial theories, as well as pioneering work in trying to relate neurosis to its physiological basis, in Oslo. Reich believed that a person's neurotic responses were indicated in his entire behaviour, including his characteristic muscular expressions and posture, which he termed "muscular armouring", and his character analysis was directed towards identifying and eliminating this. In 1939 he moved to the United States of America where he lectured and did research in New York City, discovered orgone energy and died in a Pennsylvania penitentiary in 1957, misunderstood and misinterpreted. Reich stated before his death that the world of his day was not ready for his work. He was dismissed as fanciful and pathetic by the scientific community of his time, but nevertheless attracted a number of enthusiastic supporters and his influence has proved to be considerable and largely underestimated (Boadella, 1985; Graham, 1990; Katchmer, 1993; Mann & Hoffman, 1990; Wilson, 1982).

7.2.1.2 Reich's theories and methods

Freud's ideas and methods were germinal to the development of Reich's mind and thoughts and had a profound influence on him throughout his life, although he deviated from Freud's movement early in his career and followed pathways in direct conflict with those of the psychoanalytic society. Reich's career started as a psychoanalyst and he enthusiastically contributed much to the development and expansion of this therapy. He soon began to evolve his own controversial techniques which were contrary to psychoanalysis as approved by the international organisations of the day, and he eventually severed ties with them (Boadella, 1985; Graham, 1990; Katchmer, 1993; Mann & Hoffman, 1990; Wilson, 1982).

7.2.1.2.1 Reich's character analysis

Originally Reich's reputation was built on the fact that he was a skilful psychotherapist with a method of attacking neurosis that was more positive, direct and a great deal quicker than psychoanalysis. This was called "character analysis" and was in contrast to symptom analysis of psychoanalytic treatments. According to Reich, neurosis was due to deep-seated inhibitions or resistances.

For the therapist to break down the resistances, he needed the patient's full cooperation and had to overcome the initial mistrust of patient towards therapist. The therapist/analyst's job was not to establish a polite, cooperative relationship with the patient, but to prod his tender spots and encourage him to express suffering and rage. Attacking the patient's character defences inevitably led to anger. The patient was made to consider him/herself and view him/herself as he/she was in a totally objective way. This was the first step at breaking down the resistance. The resistance is never straightforward, but exists in layer upon layer, and are memory traces of unpleasant past experience, namely emotional scars. The function of this armour is to protect against further hurt. The effect, however is that of keeping out pleasure while the person cowers inside the armour (Boadella, 1985; Graham, 1990; Katchmer, 1993; Mann & Hoffman, 1990; Wilson, 1982).

Following the character analysis theory came the full evolvement of the concept of "muscular armour" and *"vegetotherapy"*. It was Reich's notion that a neurosis is often accompanied by a rigidity in the muscles. For example, a person suppressing a great deal of anger might develop a rigidity of the back and shoulder muscles and poor circulation in the hands and arms (Boadella, 1985; Graham, 1990; Mann & Hoffman, 1990; Wilson, 1982).

In a therapy session the following happened step by step 1) noticing a person's stiff neck, 2) breaking down his resistance through psychotherapy, 3) finding the stiffness in the neck vanished together with the psychological resistance and 4) resulting in psychosomatic symptoms such as mottled skin, head and neck pains, diarrhoea and accelerated heart beat. This lead Reich to wonder: If release of psychological tensions could cause relaxation of the muscular armour, could the reverse also be true? If the muscular armour could somehow be destroyed, would the tension also vanish? His subsequent work proved him correct (Boadella, 1985; Graham, 1990; Mann & Hoffman, 1990; Wilson, 1982).

7.2.1.2.2 Reich's methods (muscular therapy)

Reich developed new clinical methods designed to pinpoint the resistances. He found that the therapist should be seated in a position so as to watch the patient's face in order to recognize resistance in any of its many forms. This was contrary to the habit of the time which was to face the patient's feet and simply listen to his words (Wilson, 1982).

Reich felt the muscles, for example around the jaw and neck, and finding a tight cord in the neck, would press hard until it hurt. He pinched, pressed, kneaded, jabbed and prodded the muscles all over the body with an unerring instinct for every tight and sore muscle. He was adamant that his treatment was quite different from physiological massage or manipulation since it was necessary to understand the role of each tension in the total armouring of the patient. He was guided by the emotional function of the tensions. If this was not grasped, mechanical pressure on muscle groups had only very superficial effects. Reich's technique was revolutionary and highly controversial because, in psychoanalysis, it was regarded as strictly forbidden to touch the patient. Physical and psychological distance was maintained at all times. He went to the opposite extreme (Boadella, 1985; Graham, 1990; Wilson, 1982).

During a therapy session Reich would encourage the patient to breathe deeply, while rolling the eyes around without moving the head. The eyes looked as far as possible to the side, at each wall in turn. Reich insisted that the first step in overcoming nervous tensions was to learn to breathe deeply, using the stomach and solar plexus as well as the chest. This caused many patients to feel vital and alive and experience a oneness with nature akin to a mystical experience (Graham, 1990).

An indispensable prerequisite for a therapist for whatever method he used, according to Reich, was that he must be in touch with his own sensations and emotions and be able to empathise fully with the patient and to feel in his own body the effect of a certain restriction. During sessions he would go so far as to imitate the patient's tensions in his own body, not only to feel them himself but to serve as mirror for the patient (Boadella, 1985; Wilson, 1982). Similarly Alexander (1932), observed himself and his actions in mirrors and related these to his perceptions and feelings (section 7.2.4).

Reich used a high degree of patience in making his patient aware of what he had noticed about his bodily tensions. The patient was led to experience and express what had not been discovered. Day after day and week after week he would call the patient's attention to an attitude, a tension, or a facial expression until the patient could sense it and feel what it implied. He was training his patients in self-observation and this played an important part in the cure of repressions (Wilson, 1982).

At the end of a session the patient was instructed to lie on a bed and do a bicycle kick, striking the bed hard with the calves until exhausted.

7.2.1.2.3 Outcomes of Reichian Therapy

After a session with Reich, the patient had a heightened awareness and perception, and all the senses were sharpened. Colours were brighter and objects seen with greater clarity. An increase in energy and vitality was also experienced (Boadella, 1985).

The effectiveness of the treatment came with the infinite patience revealed by Reich in continuing sessions. Patients gradually gave up more and more of their bodily armour, their breathing became much freer and their capacity to surrender to spontaneous and involuntary movements increased greatly. Slowly the various sensations of warmth, prickling in the skin and of shuddering movements in the limbs and trunk would begin to integrate themselves into a convulsive reflex movement of the whole body in which there were a clonic involuntary flexion and extension of the spine. The body as a whole seemed to expand and contract in a pulsatile manner (Boadella, 1985).

Half an hour of Reich's muscular therapy produced a more dramatic effect than six months of usual psychoanalysis (Boadella, 1985; Wilson, 1982). Reichian body work, as practised by his followers, is powerful. It provides quicker, surer access to areas of the unconscious that used to be virtually inaccessible. Profound, convulsive emotional releases, and even repressed memories from the earliest periods of life, emerge spontaneously, without special effort, simply as a byproduct of the continuous softening of the resistances. The free-flowing energy that has been liberated pushes into the remaining blocks, further weakening them, and setting in motion a process of spontaneous dissolution of armouring that ultimately reaches down to the deepest levels of biological functioning (Hoff, 1978).

7.2.1.2.4 Comments on Reichian Therapy

Reich's success (some called it brilliance) as therapist was attributed to his total concentration on his patient, along with his patience or tenacity. He apparently never missed the slightest movement, lightest inflection of the voice or smallest change in facial expression. He stubbornly called the patient's attention to an attitude, a tension or a facial expression until the patient could sense it and feel what it implied. This was part of his cure for repressions (Boadella, 1985; Wilson, 1982). In explaining his attitude to, and his methods of research, Reich, when discussing basic attitudes about correctness of one's own assumptions and combatting one's own beliefs, commented (Quoted by Boadella, 1985: 246):

> *So much for the basic attitudes which are essential to work of this kind. Their leading principle is: Believe nothing, convince oneself with one's own eyes, and never lose sight of a fact that has been observed until it has been thoroughly uncovered.*

The technique of observing the subject was later used to a great extent and very effectively by naturalists and anthropomorphologists such as Nikolas Tinbergen and Konrad Lorenz, as well as best selling authors in the biological field such as Desmond Morris[1] and Lyall Watson[2].

The therapeutic technique of empathising with the patient is current practice in body work therapies (Barlow, 1990; Gelb, 1981; Graham, 1990; Lawson-Wood & Lawson-Wood, 1977; Painter, 1986). By empathising here is meant the careful scrutiny of the reactions of the patient to stimuli.

> *The concept, "functional identity", which I had to introduce, means nothing more than that the muscular attitudes and character attitudes have the same function in the psychic mechanism: They can replace one another and can be influenced by one another. Basically, they cannot be separated. They are identical in their function* (Reich, 1999: 270-271).

Reich had clearly uncovered the holistic principle of mind-body, a principle which today is widely accepted (Graham, 1990). Reich, (1999: 271) explained it in more detail:

> *If the character armour could be expressed through the muscular armour, and vice versa, then the unity of psychic and somatic functioning had been grasped in principle, and could be influenced in a practical way. From that time on, I was able to make practical use of this unity whenever necessary. If a character inhibition did not respond to psychic influencing, I resorted to the corresponding somatic attitude. Conversely, if I had difficulty in getting at a disturbing somatic attitude, I worked*

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[1] Desmond Morris is well-known for his books on human and animal behaviour, such as *The Naked Ape*, *The Human Zoo, Manwatching, Horsewatching and Dogwatching.*

[2] Lyall Watson looks at life from a biological perspective and has gained popularity by means of books such as *Supernature, The Romeo Error, The Lightning Bird, The Nature of Things*.

on the expression in the patient's character and was able to loosen it.

Reich was thus able to bypass the psychological games of his patients and directly attack the basis of the dysfunction by treating the tenseness of the musculature (Katchmer, 1993). Massage therapists are today very aware of the effectiveness of this approach.

Releasing the body muscular tensions with resulting pulsating movements of the musculature, for which Reich was ridiculed for comparing it to jellyfish, was given credence two decades later when Dart (1946, 1947) used crawling movements in adults to rectify childhood deficiencies. Dart (1946, 1947, 1950) had no problems comparing human and animal movements, and based his theories and therapies on the evolutionary development of the human species. This aspect of Dart's approach to posture was discussed in Chapter 3, section 3.3.2.8, and will be further discussed in section 7.2.5.2 of this chapter.

Bioenergy (from the Greek: life force) is the term adopted in latter years for the somatic aspect of Reich's concept of orgone energy - the cosmic energy present everywhere. Reich showed that physical and psychological help is possible only when this energy flows freely in the body. The overall pattern of defensive body armouring was called character armouring (Reich, 1999; Whitfield, 1979). Character armouring is described by Reich (1999: 7-8) thus:

The character structure of modern man, who reproduces a six-thousand-year-old patriarchal authoritarian culture, is typified by characterological armouring against his inner nature and against the social misery which surrounds him. This characterological armouring is the basis of isolation, indigence, craving for authority, fear of responsibility, mystic longing, sexual misery, and neurologically impotent rebelliousness, as well as pathological tolerance. Man has alienated himself from, and has

> *grown hostile toward, life. This alienation is not of a biological but of a socio-economic origin. It is not found in the stages of human history prior to the development of patriarchy.*

The physicist, Alan Wolf (1987) noted that Reich was probably the first psychologist to realize that muscular contractions and consciousness could lead to malfunctioning and inappropriate tiredness. Wolf (1987: 32) explained the validity of Reich's theories and techniques according to current knowledge:

> *Reich would not have been aware that his concept of bio-energy was a real electrical discharge carried by calcium ions. Calcium mediates the contraction and relaxation of all muscles. We now know that when a muscle contracts, calcium ions bathe the sarcomeres causing the contraction to occur and therefore, the bio-energetic discharge Reich referred to, was the outflow of calcium ions from the regions of the sarcomeres.*

All muscles at rest give off heat at a low and constant rate (resting heat). When a muscle is stimulated to contract, a relatively larger amount of heat is given off (initial heat). When the muscle relaxes again, another bout of heat production takes place (recovery heat) and this is a measure of the electrical processes during the outflow of calcium ions and the recovery of ATP from ADP through the process of oxidation (Wolf, 1987).

Muscle under constant tension produces more heat and warm spots on the body indicate tension in those areas. The hotter muscles tire faster than the surrounding relaxed muscle tissue and need more food input. The tension is fuelled at the expense of energy needed for useful work by other muscles. In this way, by keeping muscle cells hot, consciousness is able to hold body memories as a defensive measure (Wolf, 1987).

Most people carry some muscular armour as a protection against intrusion, be it mental or physical (Wolf, 1987). For example constant noise or verbal abuse may lead to the middle-ear muscles remaining contracted, with calcium ions causing the contraction in an attempt to lessen the noise. The problem is that once the muscle is trained to protect, it is not easy to unlearn.

Wolf's (1987) theory was that the body's muscular armour is caused by the mind's altering the probability patterns of calcium production and release in the muscles (as with the quantum wave of probability). Once this armouring effect occurred, and once the muscle learned to continually release calcium from the sarcoplasmic reticulum or maintain its presence in the sarcomeres, the conscious mind no longer plays a role. Thus, the nerve impulses originally responsible for causing the inflow of calcium no longer have the effect of control. The muscle is then an **isolated pocket of consciousness,** unable to respond to the nerve command to relax. The calcium ions simply do not leave. Sometimes it is necessary to relax the muscle by means of repetitive slow and/or rapid passive lengthening, or sometimes in stubborn cases by procedures such as deep massage (Loots, J.M. - personal communication). If these concepts are correct, body armour can, for example, be altered by thought (Wolf, 1987). To the author`s mind, the manipulation of the tripartite movement system, as Reich attempted, could precipitate the following cycle: Mind/thought/brain causes muscle relaxation by means of motor pathways. The same effect can also be obtained in some instances by working with the muscle itself or repositioning a particular body part. The subsequent decrease in muscle tension will then alter the sensory input via the sensory pathways to the brain, which could influence the brain in the same way as the brain had influenced the muscle. A relaxed muscle could thus result in a relaxed mind.

Another of Reich's incredible discoveries, was that of the segmental arrangement of armouring. He realised that, in general, individual muscle blocks do not correspond to an individual muscle or nerve pathway but fall into a segmental arrangement. The segments function transversely, at right angles to the natural longitudinal flow of biological energy. They are like the rings of an earthworm: when the worm is pinched, its rings constrict, choking off and disrupting the natural sinuous flow of longitudinal energy streamings. Like the segmental arrangement of the spine, autonomic ganglia and intestines, they represent the worm in man (Hoff, 1978).

Reich identified seven major segments of armouring: The ocular (around the eyes), the oral (around the mouth and jaws), the cervical (the neck, throat and shoulders), the thoracic (the upper chest including the arms), the diaphragmatic (around the diaphragm and organs under it), the abdominal (including the large abdominal muscles, lower back muscles and rectum) and the pelvic (including the legs). Each segment is a ring of tension encircling the body and including the underlying internal organs. The relative independence of these segments is shown by the fact that any emotional or bioenergetic activity in one part of a segment will tend to influence its other parts, while the adjacent segments will remain relatively unaffected. If armouring is released in one segment, the adjacent segments will often show signs of increased armouring as a defensive reaction to the pressure of the released energy. Thus it is preferable to start releasing from the head (the topmost segment) and gradually proceed downward. Each step of loosening the armour almost inevitably means the patient will feel some anxiety at the new sensations of physical and emotional freedom that are emerging. For this reason, Reich felt, the armouring had to be broken down slowly, over a series of sessions, typically taking place over several months (Hoff, 1978; Mann & Hoffman, 1990).

7.2.2 Alexander Lowen and the concept of bioenergetics

Alexander Lowen, a pupil of Reich from 1940 to 1953, developed Bioenergetic Analysis as a systematic methodology for dealing with the relationship between somatic functioning and psychological trauma. He established the Institute of Bioenergetic Analysis in the United States of America in 1956 and since then it has been developed throughout Europe and elsewhere (Graham, 1990; Lowen, 1994; Whitfield, 1979). He was also a prolific writer on the subject with titles such as: *Physical Dynamics of Character Structure* (1958) which was later reprinted as *The Language of the Body, Love and Orgasm,* (1965), *The Betrayal* *of the Body (*1967), and *Bioenergetics* (1975) (dates of publication given here are the original, and not those of the copies used in the present study).

The aim of bioenergetics is the healthy integration of the body and mind through breathing, relaxing character structures and grounding (Graham, 1990).

> *Bioenergetics is a therapeutic technique to help a person get back together with his body and to help him enjoy to the fullest degree possible the life of the body* (Lowen, 1994: 43).

The emphasis on the body includes the basic functions of breathing, moving, feeling and self-expression:

> *A person who doesn't breathe deeply reduces the life of his body. If he doesn't move freely, he restricts the life of his body. If he doesn't feel fully, he narrows the life of his body. And if his self-expression is constricted, he limits the life of his body* (Lowen, 1994: 43).

> *The goal of bioenergetics is to help people regain their primary nature, which is the condition of being free, the state of being graceful and the quality of being beautiful. Freedom, grace and beauty are the natural attributes of every animal organism. Freedom is the absence of inner restraint to the flow of feeling, grace is the expression of this flow in movement, while beauty is a manifestation of the inner harmony such a flow engenders. They denote a healthy body and also, therefore, a healthy mind* (Lowen, 1994: 43-44).

> *Bioenergetics is an adventure in self-discovery. It differs from similar explorations into the nature of the self by attempting to understand the human personality in terms of the human body* (Lowen, 1994: 44).

> *My position is that the energetic processes of the body determine what goes on in the mind just as they determine what goes on in the body* (Lowen, 1994: 44).

7.2.2.1 Lowen's methods

Lowen was both trained and treated by Reich, whom he held in the highest regard, and his methods were an outflow of this association. Some of his methods and views resemble those of Reich closely, while others seem like a natural progression of some aspects of the Reichian methods (Lowen, 1994).

7.2.2.1.1 The concept of practical empathy

Empathy of the therapist with a patient/client by duplicating his body expression was an aspect of therapy with which Lowen was in complete agreement with Reich. Like Reich, Lowen (1994) suggested that the therapist "feels" the patient's emotion at a certain point by mimicking his expression to experience what the attitude signifies. For example, lifting the brows and raising the shoulders in the same way as the patient, causes the therapist to perceive that he/she has adopted an expression of fear.

7.2.2.1.2 The basis of bioenergetics

One aspect on which Lowen (1994) levelled criticism against Reich, was the question of what should be done after cessation of therapy. Lowen (1994) maintained that Reich never considered this question. Lowen (1994) himself found the solution in his "bioenergetic" exercises, developed to promote the effects of his therapy sessions. These exercises were prescribed to be followed as a regular routine at home.

Lowen (1994) was impressed with Eastern methods and the fact that they recognized the importance of some programme of bodily exercise as being essential to spiritual development. He found a similarity between Reichian Therapy and yoga, both systems placing the main emphasis on the importance of breathing. The difference between the two schools of thought was in their direction. In Yoga the direction is inward, toward spiritual development, whereas in Reichian Therapy it is outward, towards creativity and joy. Lowen (1969, 1971, 1975, 1994) considered bioenergetics to be a reconciliation between the two views, an integration of both Eastern and Western attitude. Some of the principles of his physical exercises - grounding, the fundamental stress position and character structure - are next discussed in sections 7.2.2.1.2.1 and 7.2.2.1.2.2.

7.2.2.1.2.1 Grounding

Grounding is a concept unique to bioenergetics. Lowen developed this concept slowly over the years as he perceived that all patients lacked a sense of having their feet planted firmly on the ground and consequently being out of touch with reality. Grounding means getting a person down to solid ground, establishing adequate contact with the ground, making a feeling and energetic contact and, according to bioenergetics, is the opposite of being hung up. Lowen developed a basic exercise to help people to become more grounded. He called it the arch or the bow and referred to it as the *fundamental stress position*. Later on he used the various ways in which this position is executed by different individuals to identify personality types and to prove the intimate relationship between the body and the personality (Lowen, 1969, 1994).

7.2.2.1.2.2 The fundamental stress position

A person pushes his knuckles into the small of his back and leans backwards as far as possible. The knees are fully flexed, the feet flat on the ground, the line from the heels to the back of the head forms a perfect arc, the head and trunk are centred, the breathing is abdominal and relaxed and the person is comfortable. A line superimposed on the profile of the whole body should form an arc. The correct position has the centre point of the shoulders directly above the centre point of the feet and the line joining these points is almost a perfect arc passing through the central point of the hip joint (see Figure 7.2). The use of this position was based on the principle that the body functions like a bow in many activities where it arcs backward to gain impetus for a forward thrust such as seen when a tennis player serves a ball, or a woodcutter swings an axe. After using this exercise therapeutically for decades, Lowen (1994) discovered that it is also a basic position used during Tai Chi Chuan exercises (Lowen, 1969, 1994).

When the body functions like a bow, its lower end is anchored to the ground through the feet, while the upper end is stabilized by the muscles of the back of the neck which hold the head firm. To Lowen (1969) this signified that an individual is moored to reality at both ends of his body, below through his contact with the ground and above through his ego.

Lowen (1994) stressed that the positions were not exercises, and if done mechanically would lead nowhere. If used to gain feeling in the body, they are simple and effective. No time limits were involved.

7.2.2.1.2.3 The bow and character structure

Various body disturbances prevent people from being able to form the perfect arc. They are listed below with their associated personality types.

1) Overall body rigidity

   The line joining the shoulder midpoint and the foot midpoint is a straight line. The legs are inflexible, the ankles cannot be fully flexed, tension in the lower back prevents arcing and the pelvis is slightly retracted. Overall body rigidity is associated with an inflexible personality/body type.

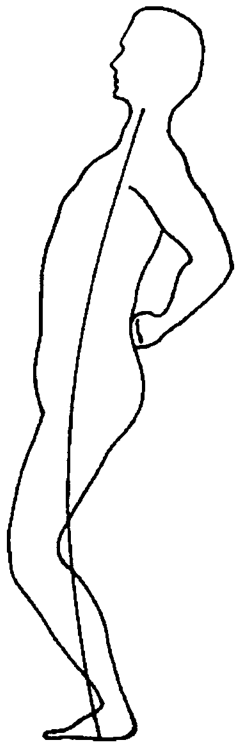

Fig. 7.2 The fundamental stress position (Lowen, 1994).

2) Hyperflexibility

In this case the body bends too much, denoting weakness in the back muscles. The lower back does not support the body, thus support comes from the abdominal muscles which are overcontracted and the pelvis is pushed too far forward. A hyperflexible body is associated with too pliable a personality type.

3) Break in the bow line

This happens due to a severe retraction of the pelvis. If the pelvis is pushed forward, the knees straighten and can only be bent by pulling the buttocks back. There is marked tension in the lower back and along the back of the legs.

When viewing the body in the bow position from the front, a splitting of the body segments is sometimes clear. The major parts of the body, the head and neck, the trunk, and the legs, simply do not line up. The head and neck are angled off to the right or left. The trunk is angled off in the opposite direction and the legs are also angled opposite to the trunk. These angulations represent a fragmentation of the integrity of the personality typical of a schizoid personality.

7.2.2.2 Physical characteristics and character structure

Character structure is important for the understanding of various character types. No person is a single type - the majority of people have all types present, each manifest under a given set of conditions. One or two may predominate but nobody is likely to be altogether free of them (Proto, 1989; Whitfield, 1979). Lowen (1969, 1971, 1994) identified major character structures in bioenergetics, each with its identifiable physical and emotional component.

7.2.2.2.1 The rigid character

Stiffening produces rigidity, both physically and emotionally, and this group is marked by the inflexibility of the ego structure. The rigid structure is characterized by the muscular pattern of protecting (holding back against exposing) the heart against further heartbreak. He has a need to be in control of his emotions. During unfavourable conditions, the rigid character tenses further but maintains contact, contrary to the oral character who withdraws from reality. Because of the rigidity, motility is decreased and the individual has feelings of lifelessness but not of inner emptiness. This character shows a total body rigidity. The back is rigid and unbending, the neck tight and the head held erect. The pelvis is retracted and held tightly (Lowen, 1971; Whitfield, 1979).

The front of the body is hard, as if armoured. Lowen (1971) conjectured that, although the erectness of man exposes his vulnerable belly area, there is no need for armouring as the freeing of the forelimbs for aggression in the human animal balanced the scales. Dynamically, the tension in the front is produced by pulling back the shoulders and pelvis, thus stretching and contracting the front muscles at the same time. The front and back of the body is thus encased in a rigid sheath and armoured. This armour binds anxiety and a change in character structure may be accomplished by a release of muscle tension. Armouring begins with surface muscles, in contrast with the spasticities associated with oral and masochistic structures. In time the individual may become more rigid, less flexible and the deeper muscles become affected. Loss of elasticity also leads to brittleness.

7.2.2.2.2 The oral character

The oral character is characterized by the muscular pattern of holding on against the dread of abandonment and isolation (Lowen, 1971; Whitfield, 1979).

The oral character tires rapidly when engaged in a continuous physical activity and many of these individuals feel they lack energy. This is only partly due to muscle fatigue as they frequently suffer from low blood pressure and low basal metabolism (Lowen, 1971; Whitfield, 1979).

The chest is generally deflated with a depressed sternum in some. The legs feel weak and tire rapidly during tension and coordination is inadequate. There is a tendency of locking the knees during standing to compensate for the weakness. The feet are weak, often with collapsed arches. The body mass rests on the heels, the spine supports the body since the legs are too weak, the buttocks and pelvis are held forward, the shoulders pulled back and the head thrust forward. The oral character tends to have a sway back. This person seems “disjointed” and the muscular system is underdeveloped compared to the skeletal system (Lowen, 1971; Whitfield, 1979).

Headaches are a common complaint in this character type, probably due to the tensions in the head and neck. They have a strong ring of tension about the shoulder girdle and at the root of the neck. The scapula is tightly bound to the thorax, the pectoral muscles overdeveloped in the man and in the woman the breasts tend to be large. The longitudinal muscles of the back are very tense, especially between the shoulder blades, at the level of the diaphragmatic crusa and at the insertion into the sacrum. The muscles of the pelvic girdle are tightly contracted. Muscle tension at the front of the body seems absent due to the deflated conditions of the chest and abdomen but the *rectus abdominis* muscle is usually spastic (Lowen, 1971; Whitfield, 1979).

This character type has a marked lack of aggression which Lowen saw reflected in the weak back, usually in the lumbar region, which might also be the cause of the tiredness (Lowen, 1971; Whitfield, 1979).

The need for acceptance and affection is great in the oral character and he does not armour himself either physically or mentally. A high degree of spiritual development, low motor function and lack of muscular development characterize this character type (Lowen, 1971; Whitfield, 1979).

7.2.2.2.3 The masochistic character

The masochistic character is characterized by a muscular pattern of holding in against asserting his rights and needs (Lowen, 1971; Whitfield, 1979).

This person has a muscle-bound condition in his arms and the rest of the body, as well as over-development of the muscles in the thigh. The hamstrings are tense and the arches of the feet are tightly contracted. This limits the contact with the ground and movement (Lowen, 1971, 1994; Whitfield,1979).

Severe muscle tensions are present in the shoulder girdle and the neck is thick and muscular without much rigidity (bull neck). The severe spasticity which shortens the neck is located in the deep seated muscles. Facial movements are limited and the facial expression of the masochistic character type is one of innocence or naivete. This may take the form of wide-eyed innocence, good natured smiling or an expression of grinning stupidity (Lowen, 1971; Whitfield, 1979).

In the lower half of the body there is a tendency to pull in the belly and raise the pelvic floor (Lowen, 1971; Whitfield,1979).

The muscles overdevelop to hold back negative impulses and to control natural ones. These people have feelings of inner tension and anxiety, but no inner emptiness. Although independent, they have a strong need for approval. There is little aggression. They have overdeveloped musculature but reduced spirituality (Lowen, 1971; Whitfield,1979).

To overcome the severe muscular contractions, movements involving stretch and elongation are required (Lowen, 1971).

7.2.2.2.4 The schizoid character

The schizoid character is characterized by muscular patterns of holding the body together against the dread of falling apart. His behaviour is that of being out of touch with his body (Lowen, 1969, 1971, 1975, 1994; Whitfield, 1979).

The head of the schizoid character never seems to be firmly attached to the neck. It is held at a slight angle and the person's attitude is one of detachment. The head is out of line with the rest of the body. There is a deep tension at the base of the skull and the head is contracted. The scalp across the head is tight; the facial expression gaunt and mask-like and cold with lack of expression in the eyes and thinned lips. The neck muscles have isolated tensions but no generalized rigidity (Lowen, 1969, 1971, 1975, 1994; Whitfield, 1979).

The arms have power but their movements seem mechanical and separate from the stiff, non-participating body. The muscle tensions in the shoulder segment are deep and based upon the immobility of the scapula (Lowen, 1969, 1971, 1975, 1994; Whitfield, 1979).

The spasticity deep at the base of the skull is reflected in a corresponding block in the small of the back at the junction of pelvis and spine. There is no freedom in the hip joint but a severe immobility of the pelvis. The muscles of the thighs and legs may be flabby or overdeveloped and show a lack of contact with the rest of the body. The metatarsal arch of the foot is weak, the foot is contracted and there is lack of contact with the ground. The joints are stiff, the ankle joint is especially inflexible (frozen). There is an inability to bend the knees fully when the feet are on the ground, and there is a general tendency to stand with locked knees and rigid legs (Lowen, 1969, 1971, 1975, 1994; Whitfield, 1979).

The schizoid character has a specific breathing pattern: the expansion of the chest cavity is accompanied by a contraction of the abdominal cavity. Apparently the diaphragm contracts, inhibiting the downward movement of the lungs. Breathing thus takes place only in the upper part of the chest. The belly is sucked in during inspiration, then pushed out during expiration. Normally, in the average person, the chest and belly tend to make the same movement and there is unity in the respiratory movement (Lowen, 1969, 1971, 1975, 1994; Whitfield, 1979).

An immediate result of the immobility of the diaphragm, is a division of the body into an upper and lower half due to the constriction of the body about the waist. There is thus a lack of unity in the body structure. The various body segments are functionally split off from each other. This, however, is a quantitative phenomenon and the schizoid character shows the splitting only as a tendency. This character structure is willing to make a sincere effort to overcome problems (Lowen, 1969, 1971, 1975, 1994; Whitfield, 1979).

7.2.2.2.5 The psychopathic character

This type of character denies its feelings. It emphasizes control and power, subverting the body striving for pleasure in favour of its 'ego image'. There is a marked displacement of energy towards the head. The upper half of the body is overdeveloped (Katchmer, 1993).

7.2.2.3 Bioenergetics in perspective

Bioenergetics gives a way of rapidly and dynamically analysing character without the use of words. The analysis can be checked or corroborated by the client. Through contact with the body the client can recognize his problem, find a way through to the integration of his body and his mind and thus move to a wholeness of self-understanding and awareness. He may relinquish his physical posture and his dread and find a new way beyond fear to pleasure (Whitfield, 1979). The principle of bioenergetics is a flow of energy that unites head, heart, genitals and feet in one uninterrupted movement. There is a feeling of rightness about it, for the person feels connected, unified and whole (Lowen, 1994).

Lowen (1994) developed a system of whole person therapy that identifies the person with his body, seeing that body as a functional system including the mind and the spirit. The system is an energy system seeking balance. Bioenergetics aims at removing blocks both in the musculature and in the psychic character to increase the energy and realistically and pleasurably discharge it so as to maximize the person's growth, self-expression and consciousness (Katchmer, 1993).

> *The underlying principle of bioenergetics is the simultaneous duality and unity of the human personality. Man is a creative thinker and a feeling animal - and he is just a man or a woman. He is a rational mind and a nonrational body - and he is just a living organism. He must live on all levels at once, and that is no easy task* (Lowen, 1994: 343).

7.2.3 Rolfing (Structural Integration)

Ida Pauline Rolf was born in New York in 1896. She received a Ph.D. in biological chemistry from the College of Physicians and Surgeons of Columbia University and worked at the Rockefeller Institute until the late 1920's. In the 1930's she developed the structural integration technique which was to become known as "Rolfing". According to her biographer and co-worker, Rosemary Feitis (1990), Rolf was much intrigued and influenced by Yoga and incorporated many of these teachings into her ideas. She did, however, also have a thorough knowledge of homeopathy and osteopathy and kept abreast of any new ideas of the time. Hill (1979) and Graham (1990) both alleged that Rolf drew heavily on the work of Reich and Feldenkrais. Consequently Rolfing is not simply a physical massage, but an increasingly deepening technique of freeing the body and also the mind and emotions, from their previous conditioning (Hill, 1979). According to Feitis (1990) Rolf had a gift of understanding basic principles, new and ancient, and the unique capacity to take them a step further, so that they evolved to a place of usefulness for her own day and age. Although Rolfing was developed in the 1930s in the United States, much of its fame was only achieved in the 1960s with the rise of the humanistic growth movement in California. The Rolf Institute in the United States of America draws students from across the world, including South Africa. Fritz Perls, father of the Gestalt therapy, as it is known today, was a frequent visitor to the Institute (Feitis, 1990).

7.2.3.1 Purpose of Rolfing

The aim of Rolfing is to relieve painful conditions, improve general functioning and to contribute to psychological well-being (Rolf, 1977).

> *(Structure)·····is a road map for a way of seeing which has led to the technique called Structural Integration. The system, like its name, underscores the need for patterned order in the human body. It is a physical method for producing better*

human functioning by aligning units of the body. Invariably, in matter, appropriate order is more economical of energy than disorder. Therefore, as man becomes more aware of himself as a more patterned structure, he feels himself revitalized. He no longer wastes his vital capital. Comprehensive recognition of human structure includes not only the physical person but also, eventually, the psychological personality - behaviour, attitudes, capacities (Rolf, 1977: 29).

7.2.3.2 Theory behind the Rolfing technique

Body segments, gravity and fascia are the three areas concentrated on by Rolfers. In this respect Rolf (1977: 30) observed that:

Symmetrical, balanced pattern in a man's segmented aggregates of material units allows his lesser field to be reinforced by the greater field (gravitational) of the earth.

and:

Balance reveals the flow of gravitational energy through the body. Asymmetry and randomness betray lack of support by the gravitational field.

Rolfing is a technique for reordering the body, to bring its major segments - head, shoulders, thorax, pelvis and legs - toward a vertical alignment by means of deep massage and manipulation of body structures (Pierce, 1978). Generally speaking, the Rolfing technique lengthens the body, approaching an ideal in which the left and right sides of the body are more equal in balance, and in which the pelvis approaches horizontal, permitting the mass of the trunk to fall directly over the pelvis; the head rides above the spine, the spinal curves are shallow, and the legs connect vertically to support the bottom of the pelvis (see section 3.4).

> *The vastly greater energy field of the earth's gravitational field can reinforce the smaller organic unit or destroy it, depending on the reciprocal interaction of the two in space.* ***Symmetrical, balanced pattern in a man's segmental aggregate of material units allows his lesser field to be reinforced by the greater field of the earth*** (Rolf, 1977: 30).

Due to man's erect, bipedal stance, his centre of gravity is high, giving him a state of high potential energy. The key to this efficient and graceful relationship to the field of gravity, is a body in which the mass transmission remains close to a vertical central axis. If the body is viewed as a stack of partially independent mass segments, the least energy will be expended in rotational movement when the blocks are stacked directly above one another. This stacking will also result in the highest possible centre of gravity, since the spinal curves will be shallow and the body consequently longer (Pierce, 1978; Rolf, 1977).

When the body's blocks (segments) are shifted in various directions out from the vertical axis and not stacked directly on top of one another, both skeleton and musculature are forced into an inefficient weight-bearing function. Skeletal muscles contract and relax to maintain posture and bring about movement. When they consistently take on the weight-bearing function of bone, their fascial envelopes tend to take on the hard and inelastic quality of bone. Tightness spreads through the fascial network, the body locks up and the joints lose their freedom (Pierce, 1978; Rolf, 1977, 1990). This situation is discussed in the example below.

If the bones of the lower leg are twisted outward and the bone of the thigh is twisted inward (a common appearance), the knee is likely to be unstable and troublesome. The movement of the leg, and thus the whole body, will lack the grace which comes from movement that is appropriate to the structure. Such a movement is not integrated and is labelled "disjointed". There might also be an imbalance between the voluntary musculature of the surface and the deeper, smaller, slower and more reflexive muscles such as those around the spinal column. Inability to lengthen the spine due to tightened fascia, will tend to diminish the use of the deeper muscles, resulting in a jerky style of movement which is neurologically imbalanced toward cerebral or voluntary control at the expense of the reflexive centres of the spinal cord (Rolf, 1977).

The state of balance or imbalance of the body (the relationship to the field of gravity) is reflected in the emotions, as the emotions are intimately involved with muscle tone. Being in balance is being prepared. Chronic muscle tension causes a permanent shortening of fascial structures leading to an incapability of lengthening. This influences both the way a person moves, as well as the way he feels. The effect is that the range of emotions becomes restricted so that one particular kind of emotion characterizes his response to a wide range of stimuli. The response is influenced by the past which caused reactions followed by imbalances. The programming marks a loss in the ability to respond with full appropriateness to a present situation (Pierce, 1978).

7.2.3.3 Rolfing: The technique

This therapy is essentially a method of very deep massage in which the therapist manipulates the client's body in order to return it to a desired postural and structural position. In so doing imbalances resulting from the armouring process are released and emotional and psychic blockages are discharged. It is not simply a physical massage but a technique for freeing the body, mind and emotions from their conditioning. Energies locked up in physical armour and defence mechanisms are released, prompting insight into the fears and inhibitions which initially provoked these responses (Pierce, 1978).

Rolfing involves loosening and lengthening of specific muscles and fascia of the body, repositioning of muscle fibres and returning them to their natural position (Pierce, 1978).

Loosening of the muscles and fascia leads to a repositioning of the muscle fibres and a migration back to their natural position. As a result, by manipulation of the fascia, the whole body can be radically altered. Granted a freedom of response, the body will naturally revert to its optimum function. Bony malalignments will, when the muscles and fascia have been freed, also resume as far as possible their normal relationships. Rolfing aims to rebuild the body rather than to just superficially alter it (Pierce, 1978).

The lengthening and centring of the body along its vertical axis, along with an increased engagement of the deep musculature, bring about a quieting, a flexible sense of self-possession that tends to replace earlier, restructured responses. This is clearly seen in the carriage of the body (Pierce, 1978).

A course of Rolfing therapy usually entails ten weekly sessions, the first seven of which attempt to remove ingrained stress patterns, postures and habitual responses. The initial session focuses on freeing the thoracic muscles to improve breathing, while at the same time unlocking the hips and loosening the outer fascial layers of the body. The second session concentrates on the feet and ankles. The psychological importance of the feet is to ground the patient and bring him in touch with reality and gravity. The focus of subsequent sessions is on the integration of newly loosened muscles into new patterns of movement by manipulating the layers of fascia in the appropriate directions (Graham, 1990; Hill, 1979; Rolf, 1977).

Rolfing proceeds from the surface of the body towards deeper levels and from the relief of specific local areas of contraction to the reorganization of the relationships between major segments of the body (Pierce, 1978).

7.2.4 The Alexander Technique

> *It is essential that the peoples of civilization should comprehend the value of their inheritance, that outcome of the long process*

> *of evolution which will enable them to govern the uses of their own physical mechanisms. By and through consciousness and the application of a reasoning intelligence, man may rise above the powers of all disease and physical disabilities. This triumph is not to be won in sleep, in trance, in submission, in paralysis, or in anaesthesia, but in a clear, open-eyed, reasoning, deliberate consciousness by mankind, the transcendent inheritance of a conscious mind* (Alexander, quoted by Brennan, 1992: 43).

Frederick Matthias Alexander was born in Tasmania in 1869. He trained as an actor in Melbourne, Australia, and due to problems with his own voice developed a method/therapy to rectify his problem. This later became known as the Alexander technique. He used his method therapeutically from 1894 in Australia and New Zealand and moved to London in 1904. From 1914 he divided his time between London and New York. He wrote four books on his technique; *Man's Supreme Inheritance* in 1910, *Constructive Conscious Control* in 1924, *The Use of the Self* in 1931 and *The Universal Constant in Living* in 1941. He also opened a school for children in 1924, and later a training centre for therapists (which he called teachers). Until his death in 1955 he continued actively to teach, train students, supervise the work of his assistants and develop the technique further. Although not a trained scientist or academic, his research and application of his work adhered to the highest scientific standards and was credited and used by the greatest and most distinguished scientists and philosophers of his time. Examples of these are Raymond Dart, John Dewey, the behavioural physiologist George Coghill, the authors Aldous Huxley and Bernard Shaw, and two Nobel prize laureates, namely Sir Charles Sherrington and Nikolaas Tinbergen. The Alexander Technique generated a large amount of literature and comment (Alexander, 1932, 1941, 1987, 1996; Barker, 1981; Barlow, 1946, 1955, 1956, 1959, 1978, 1990; Bowden, 1965; Brennan, 1992; Dart, 1970; Drake, 1991; Gelb, 1981; Jones, 1965, 1979; Jones & O'Connell, 1958; Jones *et al.*, 1959; Jones *et al.*, 1964; Macdonald, 1998; Robinson &

Fisher, 1998; Sherrington, 1946; Stevens, Bojsen Møller & Soames, 1989). Few therapists/teachers have elicited so much comment, needed a court case to verify his technique, and was used by such prominent personalities (listed above) as Alexander did. Proof of the success of the technique lies in the fact that it is more popular today than in Alexander's own time and teachers, students and training centres are found all over the world (Barlow, 1978, 1990; Graham, 1990; Macdonald, 1998; Stevens, 1979).

7.2.4.1 Theory behind the Alexander Technique

In each of his four books Alexander mainly addressed a central theme. These will give a good background of the development and the nature of Alexander's theories. Each central theme will first be addressed below, followed by a general discussion of his approach.

7.2.4.1.1 Alexander's writings

7.2.4.1.1.1 Man's Supreme Inheritance

In 1910 Alexander published his first book *Man's Supreme Inheritance* (Alexander, 1996), in which he contended that human beings cannot progress satisfactorily in civilization if they remain dependant on instinctive (subconscious) guidance and control. The reason for this state of affairs is that in modern civilization changes have occurred too rapidly for man to adapt, and that in these circumstances instinctive control came to survive its usefulness. Many new instincts were developed in man's quick attempts to meet the new demands of civilization - these proved to be unreliable. This degree of unreliability increased with time.

Sherrington (1946: 89) addressed this issue by observing that a chair unsuited to a child can quickly induce special and bad habits of sitting and of breathing, and also that:

> *.....verbal instruction as to how correct wrong habits of movement and posture is very difficult. The scantiness of our sensory perception of how we do them makes it so.*

According to Alexander (1996) an observant minority early in this century became aware of a gradual, but a most serious deterioration, in the human condition - a deterioration which they perceived to be only physical - a problem which they tried to set right by means of physical exercises. Compared to the unified exercises later proposed by Dart (1946; 1947; 1970), Feldenkrais (1972; 1985) and Hanna, (1988), these physical exercises were construed on mechanistic premises, and by doing so did not take man's inherent holistic way of functioning into account, and nor did they take into account what Alexander (1996) advocated in this book - **the unreliability of sensory appreciation.**

In order to combat misuse of the body Alexander (1996) advocated the use of conscious control in order to eradicate the habits of misuse. Man's ability to pass from subconscious to conscious control is, according to Alexander, "our supreme inheritance". Before conscious control could become a reality, it is necessary to beware of the differences between impulsive reactions and reasoned conceptions. This is why Alexander emphasized the importance of pausing before acting (Alexander, 1932, 1996; Gelb, 1981).

By means of the study on himself Alexander (1932, 1996) came to the conclusion that correction of misuse involved the development of a number of abilities. These were 1) the conscious inhibition of habitual interference with the upright posture, 2) the free control of the motivating factors responsible for the physical misuse of the body, as well as the conscious control of the body into an efficient posture and working state and 3) the maintenance of improved functioning in all activities, especially in unfamiliar circumstances. These abilities are only acquired by means of years of intensive introspection and study of the self as Alexander (1932) did, or by partaking in bodywork programmes as set out in Table 7.1 (Barlow, 1990; Cohen-Nehemia, 1983; Dart, 1947; Feldenkrais, 1972; Gelb, 1981; Hanna, 1988; Pang & Hock, 1984; Pierce, 1978; Plummer, 1982; Putkisto, 1997; Robinson & Fisher, 1998).

Habits involve the deterioration of the muscular sense that makes it difficult to distinguish between appropriate and inappropriate effort. Alexander (1996) early realised early that mind and body form a unity and therefore a habit could never be considered as simply being mental or physical, but should be recognised as a unified response of the whole of the individual.

7.2.4.1.1.2 Constructive Conscious Control of the Individual

In his second book Alexander (1987) considered man's sensory appreciation in relation to his evolutionary development, learning and learning to do. He reiterated man's inability to adapt to rapid changes in modern civilization, and that, as a whole modern man lacked the grace and *poise* of our ancestors. He observed, like Sherrington (1946) and Dart (1947) that modern man often displayed poor body use and inability to efficiently change his posture. The only way in which this could be achieved was by increasing sensory awareness. Feldenkrais (1972, 1985) also emphasised the importance of sensory awareness, but his methods of achieving this differed somewhat.

In this book Alexander (1987: 5) explained the terms "end-gaining" and "the means whereby", terms which he introduced in his previous publication:

> *The "end gaining" principle involves a direct procedure on the part of the person endeavouring to gain the desired "end." This direct procedure is associated with dependance on subconscious guidance and control, leading in cases where a condition of mal-co-ordination is present, to an unsatisfactory use of the mechanisms and to an increase in the defects and peculiarities already existing.*

> *The "means-whereby" principle on the other hand, involves a reasoning consideration of the causes and conditions present, and an indirect instead of a direct procedure on the part of the person endeavouring to gain the desired "end." This indirect procedure is that psycho-physical activity, associated with constructive conscious guidance and control and with the consequent satisfactory use of the mechanisms, which establishes the conditions essential to the increasing development of potentialities. Under these conditions defects, peculiarities, and misuse are not likely to be present within the organism.*

Alexander also argued about a crucial issue in the training of individuals, which is that an individual's conception of an idea or an instruction depends on his standard of sensory appreciation. This in the past led - and still does today - to the incorrect assumption that having asked someone to do something, he will be able to do it properly.

Alexander (1987: 181) addressed the issue of happiness arising from the ability to correctly interpret bodily sensations, and used the child as an example:

> *For the psycho-physical processes which precede and accompany the child's desire to acquire a knowledge of the mechanical working of inanimate machinery are the same as those which are called into activity in connexion with the acquisition of the knowledge of the satisfactory use of its own mechanisms. It should be obvious to concerned that in any process of growth of the child or adult, experience in employing the mechanics of the psycho-physical organism should precede all other mechanical experience, and that any experiences gained later in the sphere of inanimate mechanical experimentation would thus be materially increased in value.*

One can recall the expression of interest, happiness, and satisfaction exhibited by the child when one has enabled him to understand for the first time that his unduly stiffened neck with perhaps the head too far pulled back - is really not the fault of his neck at all, but due to the fact that he is trying to do with the muscles of his neck what should be done by other mechanisms.

7.2.4.1.1.3 The Use of the Self

This book has a detailed description of the development of Alexander's technique. During his ten-year study on himself Alexander made some important observations about human behaviour:

- *"Use affects Functioning"* (Barlow, 1990) became one of the underlying principles of the Alexander Technique. Alexander (1932) reiterated his belief in the unity of the human organism, and that if the individual understands the means whereby the use of his mechanisms can be directed in practice as a concerted activity, the principle of unity will work for the good. The reverse side to the picture, however, is that it is the nature of unity **that any change in a part means a change in the whole.** This means that if the concerted use of the tripartite mechanisms of an individual is faulty, any attempt to eradicate this defect by means otherwise than to change and improve this faulty concerted use is bound to throw out the balance somewhere else. This is, according to the present author's opinion one of the key issues which should be addressed by sport coaches and biokineticists working with individuals with known faulty technique(s), posture and poor execution of activities of daily living.

- One of Alexander's major discoveries, was that interference with the free *poise* of the head is followed by interference with the efficient working of the rest of the body. The dominance of the head in the hierarchy of the body he called the **Primary Control** (Alexander, 1932; Barlow, 1990; Gelb, 1981). This also refers to the relationship between the head, the neck and the back and is the first factor to deal with when unravelling the misuse of a body. The whole issue of primary control will be discussed in detail in section 7.2.5.2.1.

7.2.4.1.1.4 The Universal Constant in Living

The manner of use exerts a "constant" influence over general functioning and reaction. The fact that muscles are constantly used for this, affects our health. He argued that individuals can control and coordinate use of his musculature to the best of his advantage (Alexander, 1941).

Reacting to the "Report of the Physical Education Committee of the British Medical Association", he again pointed out the fallacies and limitations of physical exercise (Alexander, 1941). Here it should be emphasised, however, that Alexander only had issue with the prescription of exercises aimed at the correction of the then perceived physical deficiencies in civilized man and the correction of misuse. Rolf (1977) felt equally strongly about what she termed man's willful ignorance of his own processes which kept mankind in the dark. Much of her criticism was aimed at what was taught in physical education. The assumption in most physical education departments, she felt, was that endless "doing" - callisthenics, acrobatics, gymnastics, violent sports - built good bodies. Orthodox physical-fitness methods, according to Rolf (1977), often fail to take into account that differences in the structures of young people are vitally significant and should be a central determinant in any physical education programme - a programme that failed to differentiate fails, and therefore failed to give effective help.

If correctly designed, however, exercise may be useful in the correction of habitual misuse of the body, while simultaneously serving other purposes such as muscle strengthening and increase in stamina. These exercises will be discussed in sections 7.3.8.2 and 7.3.8.4. One of these - Pilates' Contrology (Pilates & Miller, 1998) - is now prescribed in conjunction with the Alexander Technique (Robinson & Fisher, 1998).

7.2.4.1.2 Discussion of Alexander's principles

Related to bioenergetic therapies, the Alexander Technique was developed for the improvement of postural and muscular activity. It does not separate mind and body and Alexander observed that every activity, whether physical, mental or spiritual is translated into muscular tension which becomes habitual and distorts thinking, feeling and doing. The technique develops an individual's self-awareness as to how certain activities are performed. It is concerned not with what is being done, but how it is accomplished, and as such demands the same kind of self-awareness as oriental disciplines like Zen, Yoga and Tai Chi Chuan (Graham, 1990).

Alexander maintained that malposture, which he preferred to call *"misuse of the self"*, was the end result of much deeper wrong processes, involving the whole person. He found that people live in almost complete ignorance of the way that they use their bodies. Most people distort the form and impair the working of the whole organism, by bad coordination, muscular overtension and misuse of the parts of the body in their relationship to one another.

7.2.4.1.2.1 The pattern of misuse

Alexander (1932) observed that a general pattern of misuse is found in everybody: Consistently, the muscles of the neck are overcontracted, causing loss of the free *poise* of the head on top of the spine. This leads to overcontraction of some muscles of the trunk and lack of proper tone in the other supporting muscles of the body, resulting in exaggeration of the natural curves of the spine, harmful pressure on the individual vertebrae and on the joints, coupled with overwork and wrong relationship of the limbs to the trunk. The wrong general principle on which the body is being used, is that of contracting every part of it into the nearest joint, beginning with the contraction of the head towards the trunk. Jull and Janda's (1987) patterns of muscle imbalance are to a large extent comparable to those described by Alexander.

7.2.4.1.2.2 Inhibition

Alexander realised the strength of habit and that little could be changed by *"doing".* He thus formulated a method of non-doing or inhibition.

The way a person uses his body is the end result of inner patterns found in the nervous system. The moment to control or change the habitual use is the instant when a stimulus to activity reaches the consciousness. Usually, when a stimulus comes, a person reacts to it according to habitual patterns that have been developed from his earliest years, without giving it a thought. Once he recognises his habitual responses, he can inhibit the immediate response and choose another one. Eventually old, wrong inner patterns are replaced by new ones resulting in a coordinated, trouble-free working body (Alexander, 1941; Barlow, 1978).

> *Alexander taught that there is one main field of work for each of us - work on ourselves to gain more light on our unconscious habits - work to use more constantly the one place of freedom we have, the moment of the impact on us of a stimulus, so that we increase the number of moments when we choose our reaction, instead of being driven by habit to react as we have always done in the past. For this we must be there - present and aware, at the crucial moment, to inhibit before we react* (Barlow, 1978: 25).

7.2.4.1.3 Alexander's methods

The mainspring of Alexander's life's work, was the development of consciousness and awareness in the individual.

> *Alexander used to say, "Everyone must do the **real** work for them-selves. The teacher can show the way, but cannot get inside the pupil's brain and control his reactions for him. Each person must apply it for himself"* (Barlow, 1978: 23).

The uniqueness of the Alexander method lies in the fact that it does not treat, but teaches instead. The method of teaching relies on verbal instructions only to a limited extent. The main component of an Alexander lesson, is the instructions given by the touch and pressure of the hands of the teacher on the pupil. The pupil allows himself to be consciously guided by the hands of the teacher to experience the sensation of good use of the body and good posture. Only individual classes are given, the teacher concentrating entirely on a single pupil at a time. The method does not include exercises or massage - it is a very gentle method.

A course of 10 to 30 Alexander lessons is usually recommended. During a lesson, the teacher guides a part of the pupil's body in a specific direction while the pupil is asked to think in that direction, while inhibiting his habitual responses. This allows the teacher to detect tensions in the pupil's body when he is ready to perform an action, to make him aware of the tensions and to give him the experience of performing an act effortlessly, smoothly and tension-free. Eventually the patient/pupil becomes willing to let go of deep-seated and unconscious tension patterns. This tension release is often accompanied by an emotional release and the premise of the Alexander Technique is that a balanced body leads to a balanced mind. The Alexander principle is psychophysical and it stresses the mental and emotional benefits that follow a course of lessons (Barlow, 1990).

During Alexander lessons the pupil/patient is made aware of a way in which the body can be used efficiently. It is then up to the pupil/patient to use the knowledge and training in his daily tasks.

7.2.4.1.4 Consequences of lessons in the Alexander Technique

The subject becomes aware of tensions in joints when executing certain tasks and is able to inhibit (stop) the tension-causing message, thus freeing the joint. The task can be completed in a smooth manner without unnecessary energy expenditure (Barlow, 1990; Brennan, 1992; Drake, 1991; Macdonald, 1998).

The *"becoming aware"* on a physical level can be transposed to the psychological level where the first step in handling a problem is to be made aware of it (habits of the mind are as stubborn as habits of the physical body). This however does not solve the problem, but the subsequent inhibition of habitual reactions may well eliminate it eventually (Barlow, 1990; McCullough, 1995).

Having learnt to "inhibit" harmful habits and uses of the body, a person stops interfering with himself and allows his full potential to develop (Barlow, 1990; Brennan, 1992; Drake, 1991; Macdonald, 1998).

The effect of a lesson is to experience lightness and ease within the body as well as a sense of being generally more in touch with the body. Calmness and clarity of thought are benefits of an Alexander lesson (Barlow, 1990; Brennan, 1992; Drake, 1991; Macdonald, 1998).

As is the case with other body-mind therapies, suppressed emotions such as sadness and anger may emerge. However, it is generally the positive emotions, such as happiness, joy, contentment, freedom that have been repressed which are released by an Alexander lesson (Brennan, 1992).

An Alexander lesson may be a Western way of achieving the Eastern ideal of movement. When writing about Iron Shirt Chi Kung I, Goss (1986: 221) stated:

> *In order for full movement potential to be possible, the body must spontaneously return to its "center" of relaxed alignment after movement. This is the relaxed "idling" position that is most unblocked and energetically economical, and out of which movement flows.*

This is also what Alexander (1932, 1987) was striving for.

7.2.5 Raymond Dart and the attainment of *poise*

7.2.5.1 Raymond Dart - a brief biography

Raymond Arthur Dart (1893-1985) was an Australian by birth, where he obtained his MD degree in 1917. From Australia he went to the University College, London, England. He then moved to South Africa where he contributed largely to the building up of the young Medical School at the University of the Witwatersrand in Johannesburg. There he filled the Chair of Anatomy for no less than 36 years up to his retirement in 1958. Concurrently with this, for 18 of those years, he also took on the Deanship of the Faculty of Medicine (Tobias, 1982).

It was, however, chiefly as a physical- and paleo-anthropologist that Dart achieved a secured place among the great scientists of this century. He was to make one of the most seminal offerings to our understanding of the origins of man. This started when Dart published the first account of the skull of a fossil child - the first of the small-brained hominids to be found (Tobias, 1982).

In 1943 he was introduced to the Alexander technique (Dart, 1970), and the writings of Alexander, which greatly influenced his thoughts when he wrote his papers on *poise* and the double spiral arrangement of the skeletal musculature (Tobias, 1982).

Dart felt that in a society where malposture is endemic, *poise* can be regained through careful study of oneself (Dart, 1946; 1947; 1970). He developed a series of posture improving exercises (postures), using as basis his considerable knowledge of neurophysiology, phylogeny and ontogeny (Dart, 1946, 1947, 1970).

Since Dart was greatly influenced by Alexander one finds a great similarity in their basic theories. Dart differed from Alexander, in one respect, in that he formulated a series of postures based on paleo-anthropological evidence and the motor development of the infant and child, in order to teach the individual the balanced state, while Alexander preferred to teach the pupil correct alignment and use of his/her body by using his hands and voice.

Proponents of the Alexander Technique make use of Dart's postures to a large extent (Brennan, 1992; Drake, 1991; Macdonald, 1998). The basic concepts developed by Dart (1946, 1947, 1970) are discussed in the next section.

7.2.5.2 Dart's basic concepts

- ❑ Malposture is pandemic in urbanised and industrialised communities (Dart, 1947).

- ❑ *Poise* is a state of balance, something which can be attained by means of careful education of the body (Dart, 1947).

- ❑ In the attainment of *poise*, Dart (1947) echoed the sentiments of Alexander (1996) and Feldenkrais (1972) that consciousness should be allowed to play its proper part. For this, the individual should have an interest in his acts (Dart, 1947). Dart (1947: 79) blamed a lot of our bodily ills on:

> *.....the attitude of neglecting or despising the body, as though it were beneath contempt, or of hating and even maltreating it, as though it were vile and foreign to its indwelling spirit.*

From a psychological point of view Reich (1975: 374) summed up man's lack of consciousness about himself as follows:

> *To dissociate himself from the animal kingdom, the human animal denied and finally ceased to perceive the senses of his organs; in this process he became biologically rigid.*

- The head is the prime mover and the position of the head in relation to the neck and the rest of the body, plays a predominant part (Dart, 1946; 1947 1951, 1970). He thus also saw the position of the head as the primary control; an approach which probably stemmed from his intimate knowledge of the work of Alexander (1932), Coghill (1929), Magnus (1926a,b), as well as his intimate knowledge of the development of the nervous system in the head, neck and shoulder area (Dart, 1946). This explains his firm belief that in every action the head should be the prime mover:

  > *But directly or indirectly every sort of bodily movement and skill illustrates the same principle: if the head containing the balancing organs is not the prime mover, if it is incorrectly placed and maintained for equilibrated execution of the movements planned, the movements will be unbalanced and in brief, caricatures of what those movements should be* (Dart, 1946: 11).

- The body is suspended in an upright position, from the base of the skull by two sheets of spirally arranged muscles (Dart, 1946, 1947, 1951). Marking the spirals on the surface of the body, they would run lateromedially upwards from each anterior iliac spine across the front of the body and around the back of the neck to the mastoid processes (see Figure 3.9). Bodily rotation, resulting from synergy and antagony of flexors and extensors, is the fundamental character of all voluntary movement. Asymmetry results from fixed postural twists due to imbalances in the tensions of the flexors and extensors. The solution to this problem is twofold; firstly factors producing asymmetry should be inhibited and secondly the body should be derotated (Dart, 1946, 1947).

7.2.5.3 Dart's postures to attain *poise*

Dart (1946, 1947, 1970) developed a series of exercises in which the individual is taken through the various phylogenetic and ontogenetic steps man has taken in order to come upright. These exercises require the individual to assume a series of postures, starting with the infantile supine and primary crawling postures. Each posture should be adopted and studied for an extended period. These postures serve as an educational process in the study of body mechanics, with the aim that of the attainment of *poise*. The postures follow man's evolutionary history, and are also found in the development of the supine newborn and further development to the upright stance. A given posture should be maintained and studied for 15-20 minutes. The postures and the order in which they are to be executed by the individual are discussed in the following paragraphs:

- ❑ The infantile supine posture

The subject reclines in a supine position on a carpeted floor, head on books (60-90 millimetres thick), feet on the floor, knees bent without muscular strain, elbows on floor and hands resting on the junction of thorax and abdomen.

This is the basic, safe, rest position which induces a gradual relaxation of the *sacrospinalis* and all the extensor musculature of the body as well as a temporary release from their inevitable state of torsional strain. An example is an untwisting between the scapulae and occiput. At the same time seven areas of the body are trained to share the body weight in an equilibrated way. These areas are: Occiput, scapulae, hip bones and feet and the supine body on a resistant base, allow exteroceptive sensual discrimination to be experienced. Long term persistence of the procedure produces widespread effects in derotating (refer to Chapter 3, section 3.3.2.8), and improving the equilibrium of the body, as well as bringing the head into a more appropriate relationship to the neck (Dart, 1946, 1947, 1970).

Feldenkrais (1985) elaborated on this exercise by including lifting of the head. This makes sense in ontogenetic terms, where lifting of the head is the first movement to follow the supine position of the infant. The purpose of the exercise is to educate the extensor muscles of the neck in inhibition. In correct control, contraction of the anterior neck muscles would reflectively reduce contraction in the dorsal neck muscles (inhibition) - muscles that in muscle imbalance, for example, oppose the lifting of the head. In faulty control the front muscles have to use force in order to bring the head into the desired position, while the dorsal neck muscles, which continue to contract, are stretched. The neck extensors (back) are voluntary muscles and their habitually maintained contraction goes beyond the inhibitory control. Maintaining the head raised for 30 seconds reduces the contraction of the extensors and enables them to lengthen, while the work done by the flexors decreases and the weight of the head is borne by the cervical vertebrae. This exercise brings about an awareness of the actions being performed, and the ability to command only the one for which there is motivation, thus a monomotivated act. Awareness of habitual acts which are parasitic and unwanted also takes place.

Hanna (1988) used the same exercise but added arching and flattening of the back. The abdominal muscle contracts as the lower back is flattened. The emotions of fear and apprehension also cause the abdominal muscle to contract and this exercise teaches the rudiments of controlling the withdrawal reflex.

- The primary crawling posture

The subject rests on the forehead, elbows and knees for 15-20 minutes subsequent to the rotational and relaxing influences effected by the previous supine posture.

This prone posture is the reverse of the previous position and is also devoid of fear being the crawling variety of the foetal posture. It approximates the primary mammalian posture, and has the direct effect of evoking the ancestral postural mass-reflexes of the body (Dart, 1946, 1947, 1970).

Dart (1946, 1947, 1970) placed great value on the crawling posture. In this posture correlational movements of the head and eyes are cultivated. These are important for maintaining equilibrium in the upright position. At the same time the extended head is freed from torsional and gravitational forces. He was, however, not unique in his use of crawling. Schrecker (1971) also appreciated the role of crawling in childhood development, and as an exercise in restoring a good posture. The prone position allows the trunk muscles to relax and the spine to extend so that the intervertebral discs expand and become more pliable. The exercise is recommended for symmetrical deformities of the spine. It achieves mobility of the spine and straightens the upper back. The exercise is also beneficial in correcting the position of the pelvis (Christaldi & Mueller, 1963).

Barker (1985: 78) made some interesting comments pertaining to the above, which may probably be construed as sexist:

> *The last fifty years have seen the disappearance of two activities, which did so much to maintain good posture in women, namely praying and scrubbing. Praying was an excellent exercise for the lower back and the buttocks, particularly if the arms were unsupported. Scrubbing the floors exercised the whole of the back, but particularly the upper back.*

- The prone posture (forehead-dorsum of hand-dorsum of foot)

From the supine position the subject turns over into the fully prone position with the arms down the sides, back of each hand and foot on the floor, book beneath the sternum and forehead resting on the floor.

This is the first and safest ancestral position for a terrestrial vertebrate. The subject can thus fearlessly, at a later date, execute synchronous movements of the upper and lower limbs or roll over slowly.

A similar postural exercise was devised by Denniston (1938) for the re-education and reconditioning of the neuromuscular pathways: The subject lies prone with the arms extended to the side in line with the shoulders and lifted from the floor. Thus he learns the feeling of contractions in the middle *trapezei* and *rhomboidei* for the replacement of his forward shoulders. She asserted that the mind is reflected in posture and feeling the correct posture is necessary for the improvement of posture. Placing of the subject's hand on a tight muscle and feeling it softening is also beneficial.

The forehead resting on the floor gives the frontal or forehead portions of the trigeminal nerves a chance of establishing mutual understandings with the vestibular (balancing) nerves (Dart, 1970).

This posture can also follow the primary crawling posture: as the supporting capacity of the elbows and knees improves, the distances may be increased until the body subsides with completely extended limbs into the completely prone position (Dart, 1946).

- The amphibian posture

From another angle, the prone posture produces the primary crawling posture by limb flexion. Further flexion produces the heel-haunch posture, the ventigrade or amphibian posture. Frog position. This posture provides exercises for levering the limbs upon the joints of the shoulders and hips, the spinal column and the joints of the ankle and wrist (Dart, 1947).

Dart (1946) considered the crawling posture as being a primary posture from where could be proceeded to the initial pronograde posture, or reverted to the ancestral ventigrade posture.

❑ The initial pronograde posture (forehead-palm-sole posture)

This is a foetal crouch on dorsi-flexed toes. Recoiling from this position onto the soles of the feet while knuckles support the body anteriorly, brings the body to the squatting posture in an equilibrated way. From the squatting position developed the erect position and mastering the squatting position is today still a prerequisite for a poised erect posture. Dart (1946) called this a natural evolution.

❑ The primate primate pronograde posture

The initial pronograde posture may evoke the desire to take the body mass principally upon the hypothenar eminences and medial borders of the hands, and the outer ball and lateral borders of the feet (Dart, 1947). Since the hands tend to assume a grasping attitude in this posture, this natural tendency could be exploited to strengthen this function by using objects such as pieces of hosepipe to form hand grips (Dart, 1947). The natural tendency to supinate the feet in this posture, could also be exploited to promote proper foot mechanics to the individual with abnormal pronation (flatfoot).

❑ The anthropoid pronograde posture

The primate pronograde posture may evolve naturally into the chimpanzoid posture, a posture in which the body mass is transferred from the hypothenar eminences and medial borders of the hands on to the ends of the fifth and fourth metacarpal knuckles (Dart, 1947).

Mass bearing upon metacarpal knuckles is an essential exercise for the development of flexibility, and digital skills necessary in all arts and crafts, where finger flexibility and digital skill is of utmost importance (Dart, 1947).

❑ The humanoid orthograde posture

With time, the repetition of the humanoid ontogeny, it becomes possible for the dorsum of the wrist, the proximal and distal rows of phalangeal knuckles, and eventually the finger tips to take up in succession their mass bearing functions and the body mass to be transferred from the hands to the feet.

Intermediary to full uprightness is the crouched, semi-erect or humanoid orthograde posture, still found in the Kalahari Bushman - a posture which can broadly be compared to Howorth's (1946) dynamic posture (Chapter 2, section 2.1.2). The human child elevates himself from the ground with the aid of any handy structure into this posture, not for the purpose of tree-climbing, but to rock and balance himself upon his lower limbs, and of eventually fully extending his upper limbs as equilibrating organs (Dart, 1947). Those involved in the Alexander principle refers to this as the posture of maximum mechanical advantage (Barlow, 1990) (Chapter 2, section 2.1.2).

These exercises portray postural ontogeny and although seemingly simple, experiencing each of these phases demonstrates their complexity.

When executing the postures advocated by Dart (1946, 1947, 1970) maintaining regular breathing throughout the exercises is important. The postures take the body systematically through the stages of phylogeny and cause the experience thereof and the use of joints in weight bearing for which they were developed and have subsequently fallen into misuse or uselessness, such as the knuckles and scapulae. The postures also assist in derotation of the skeletal muscles which surround the body in a double spiral arrangement (Chapter 3, section 3.3.2.8).

The Mitzvah Exercise (Cohen-Nehemia & Clinch, 1982), which will be described in Chapter 8 (section 8.5.2.1.2), also follows a developmental pattern, but is reminiscent of ontogeny. The lowered head and rounded back mimic the foetal position with the primary rounded curve of the spine in evidence. The spine then flattens (infant sitting position) before taking on the secondary curve of the adult upright position.

The rationale behind these types of exercises and positions is that experiencing the heritage strengthens correct development.

7.2.6 The Feldenkrais Method

Moshe Feldenkrais was a Russian-born Israeli, who received his D.Sc in physics at the Sorbonne. He became an internationally known physicist and engineer. He worked on atomic research in France, and during the second World War moved to England. He was an expert in judo and soccer. An old injury, which incapacitated him, left him with little hope to ever walk normally again. Feldenkrais then applied his extensive knowledge of anatomy, physiology, psychology, physics and martial arts to restore his own normal functioning. He then became a teacher of his method, and also wrote books such as *Awareness through Movement* (1972) and *The Potent Self* (1985) (The Feldenkrais Guild, U.K., ND). From his writings Plummer (1982) concluded that Feldenkrais could have developed his ideas from Reich, while Graham (1990) was of the opinion that the Feldenkrais exercises were in many ways similar to *Curative Eurythmy,* exercises developed by Rudolph Steiner, the originator of Anthroposophic Medicine for the treatment of energy imbalance. The Feldenkrais technique is difficult to follow, requires great concentration and may be time consuming (Plummer, 1982). Exercises, called *Somatics*, which were developed from

Feldenkrais' method by Hanna (1988) are, however, easy to follow and to implement and may be used by biokineticists and sport coaches alike.

7.2.6.1 Theory behind the Feldenkrais Method

There are great similarities in the theories underlying the Feldenkrais Method and those of Alexander and Dart (Alexander, 1932, 1987; Barlow, 1990; Dart, 1946, 1947; Macdonald, 1998), Lowen (1994) and Rolf (1977). The similarity in approach to Alexander, makes one wonder if Feldenkrais was not extensively aware of, and influenced by the writings and methods of Alexander. In fact a hands on approach, similar in some ways to that of Alexander (Barlow, 1990; Gelb, 1981) also forms part of the Feldenkrais Method (Rywerant, 1983).

Feldenkrais (1985) was deeply convinced of the existence of deep-seated patterns of emotionally evoked postures, as was Cailliet (1995), and the importance of improving the individual's self-image in order to bring about physical improvement and spontaneity in movement (Feldenkrais, 1972, 1985).

In accordance with Reich (Boadella, 1985; Mann & Hoffman, 1990) and Lowen (1969, 1971, 1975, 1994), Feldenkrais (1985) was of the opinion that repeated emotional upheavals in young children cause the child to adopt attitudes that ensure safety. This then leads to contraction of the flexor muscles, inhibiting extensor tone, the typical startle pattern described by Jones *et al.* (1964). An analogy of this is the reaction of animals, when they are frightened they react by violent contraction of all flexor muscles, thus inhibiting the extensor musculature, a reaction which prevents forward locomotion. In the newborn a similar reaction is elicited by the fear of falling. The attitude of a child exposed to repeated emotional stresses is that of flexion and the concurrent relaxation of the extensors. The physical outcome of all this is a posture in which there is flexing at the hips and spine with a forward head posture (Cailliet, 1995).

More than a thousand lessons were developed at the Feldenkrais Institute (Feldenkrais, 1972). These lessons were made up of movement exercises which involve the whole body and its essential activities. These lessons were designed in such a way that a certain number of goals could be met. These are listed below:

- Feldenkrais' exercises were designed to improve physical ability. Feldenkrais (1972) believed in making exercise easy and pleasant, in order for these activities to become part of man's habitual life, and to serve him for the rest of his life.

- Ability and will-power can be counterproductive. There are basically two ways to obtain an objective. If the individual relies too much on will power the ability to strain will be developed, with the individual gradually becoming accustomed to the application of excessive amounts of effort and energy to execute tasks which normally require much less effort. Alexander was also aware of the problem and advocated the use of minimal amount of energy for even the simplest of tasks (Gelb, 1981). Feldenkrais, being a physicist, realised that force not converted into useful movement does not simply disappear, but is dissipated into damage done to bodily structures (Feldenkrais, 1972).

- In order to learn, the individual needs time, attention and discrimination. In order to discriminate the individual must be able to sense. According to Feldenkrais (1972) in order to learn effectively the individual must sharpen his powers of sensing. Feldenkrais (1972, 1985) probably obtained this idea from his experience in Martial arts, in which the ability to distinguish even the slightest touch, is emphasized - in this respect Feldenkrais (1972) was mainly concerned with the use of undue muscular force, something which may prevent improvement.

- The individual should be able to feel the difference between one action and another, and without this ability there can be no learning (Feldenkrais, 1972). One of the main aims of exercises used in the Feldenkrais Method is to reduce the effort involved in the execution of any movement. More delicate tripatite control is possible only through the increase of sensitivity; through a greater ability to sense differences (Feldenkrais, 1972).

- Like Alexander (1932), Feldenkrais (1972, 1985) became acutely aware of the difficulty of breaking faulty habits of posture and movement. This is so even after the problem has clearly been recognized. Practical experience by the author has shown that verbally instructing individuals to "sit upright" led to all sorts of different "upright" postures and the invariable use of excess muscular force. Apart from the use of heightened sensory awareness, Feldenkrais (1972) was of the opinion that some conscious effort also has to be made by the individual until the adjusted position/movement/effort ceases to feel abnormal and becomes a new habit. Alexander (1932) discovered that in order to bring about adjustment in posture, for example, the directions required for these adjustments should be mentally rehearsed many times before doing it physically for the first time. This then should be rehearsed many times before the new "means whereby" is used in real life situations. Alexander (1932) felt that this is an example of what John Dewey has called "thinking in activity".

- Feldenkrais (1972, 1985) designed his exercises in such a way that postural adjustments may be made, while the exercise is in progress. In this way the individual learns to act while he thinks and to think while he acts. As suggested by Alexander (1932) the thinking should revolve around the "means whereby".

- Feldenkrais (1985) was of the opinion that in the systems of teaching generally accepted today, emphasis is placed on achieving a certain aim at any price, without any regard for the amount of disorganised and diffused effort that has gone into it. To Feldenkrais (1985) the key to good action is the absence of the sensation of effort, no matter what the actual expenditure of energy is. All inefficient action is accompanied by this sensation; it is therefore a sign of incompetence. The outcome is the wasting of energy associated with excessive muscular effort in the individual's actions. The common idea that one should "try harder" is, according to the author's experience the root cause of problems such as overexertion, and physical breakdown, in many sportsmen.

Externally the sensation of effort can be identified through hardly perceptable breaks in the breathing rhythm, poor performance, halting of breathing, kinks in the curvature of the spine (that usually develop from uneven bending or twisting of the vertebrae, where some are held rigidly in groups with possibly only one or two of these being bent and twisted to their anatomical limits), and unnecessary fixation of joints in space (Feldenkrais, 1985). *Poise* is associated with the absence of resistance; the sensation of resistance being absent with a particular fault in the distribution of contraction in the musculature. The power producing muscles are located around the pelvis, something known to practitioners of martial arts for centuries (Claremon, 1991).

The muscles of the limbs only place the bones in such a relationship as to transmit the power moving the body. They direct the transmission of power most of the time, but are not the major source of it. In correct ***acture***[3]*, no matter what the movement is - standing up, sitting down, pushing or pulling - power is transmitted from the pelvic joints through the spine to the head* (Feldenkrais, 1985: 113).

For the sake of proper posture, muscle contractions along the spine are only synergetic, and just enough to keep the spine in the position for adequate power transmission, and there is no voluntary (and parasitic) contraction of the muscles of the head- and neck-joints unless this is

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[3] Acture: Feldenkrais (1985) emphasised that posture relates to action rather than to the maintenance of any given position. *Acture,* he felt, would perhaps be a better word for it.

the object of the action. The sensation of resistance arises when the limbs, the back, the chest, the shoulders, or any other part of the body is made to do the job of the pelvic and abdominal muscles (Feldenkrais, 1985). Excellent examples of this (Barlow, 1990; Jones, 1979), and which the author has also frequently seen, is the excessive force and parasitic muscle movements used by individuals rising from a chair. Inevitably the pattern is shortening of the neck and back extensor muscles, pushing of the hands on the upper thighs or arms of the chair, and lifting of the shoulders.

- The main feature of posture in all procedures depending on and existing within the scope of voluntary action is **reversibility** (Feldenkrais, 1985). If an act is well-balanced, it can at any given moment be stopped, withheld from continuing or reversed without any preliminary change of attitude and without effort. This approach falls well within Dart's (1947) concept of *poise*, in which a well-balanced body will always keep its balance, whatever the external demands placed on it.

- One of the clearest observable sign of malposture is the holding of the individual's breath. The body image that these individuals form is such that they have to produce a preparatory rearrangement of their throats, chests, and abdomens before they can start to speak or initiate any movement whatsoever. Simple respiratory physiology tells us that upsetting normal ventilation may affect the acid base balance in the blood (Martini, 1992).

7.2.7 Anti-gravity exercises

7.2.7.1 Tai Chi Chuan

> *T'ai Chi encourages the fulfilment of the entire person, yet also emphasises that this goal should be achieved through moderate, natural ways of living* (Liao, 1990: 7).

Tai Chi Chuan develops sensory awareness, and has the effect of bringing about muscle balance or postural homeostasis. It involves continuous but slow movements, which should be performed correctly in order to improve posture (Pang & Hock, 1984; Plummer, 1982). Initially the movements feel "unnatural" and difficult. If the movements are done to "feel natural" it only reinforces muscle-imbalance. This is because habitual muscle imbalance causes proprioceptors to become adapted to incorrect muscle lengths and forces, and thus doing movements correctly in Tai Chi Chuan does not feel natural or easy (Plummer, 1982). The same feelings are experienced during an Alexander lesson - a person feels unbalanced and in danger of falling when he stands aligned and vertical (Barlow, 1990). True verticality is also the goal of structural integration (Rolf, 1977). Feldenkrais incorporated elements of the Alexander Technique into his method, but it differs from it in emphasising body motion rather than body posture (Heggie, 1993). Graham (1990) likened the Feldenkrais Method to a Western form of Tai Chi Chuan. Lowen's bow posture is a common Tai Chi Chuan exercise (Lowen, 1994) (section 7.2.2.1.2.2).

During training emphasis is placed on the correct execution of the movements and the placing of the feet, arms, hands and other body segments (Galant, 1984; Pang & Hock, 1984). The participant is constantly monitored by means of visual feedback or by the teacher. Slow movements and the emphasis on its correct execution lead to the adaptation of proprioceptors and an increase in sensory awareness (Plummer, 1982). Another way by which Tai Chi Chuan increases sensory awareness is by making the individual aware of the mass of each individual body segment (Plummer, 1982), the main effect of Tai Chi Chuan is to develop each muscle in the body as an antigravity muscle, thus developing muscle balance or *poise*.

The mechanism by which Tai Chi Chuan improves postural homeostasis is the same as that described for the Alexander Technique and Joseph Pilates' Contrology (Pilates & Miller, 1998; Robinson & Fisher, 1998), in which weaker muscles hypertrophy and exert a stronger "pull" on their stronger, but shortened antagonists (Plummer, 1982). This mechanism will be addressed in more detail in section 7.3.8.4.

7.2.7.2 Yoga

Yoga involves the adoption and maintenance of certain antigravity postures. The assumption of yoga is that bodies need to lengthen (Iyengar, 1968). Alexander (1932), Feldenkrais (1972, 1985) and Rolf (1977), for example, were adamant about lengthening of the body. Yoga recognises that increasing orderliness in the physical body somehow fosters order in the psychological personality (Iyengar, 1968). Alexander (1932; 1987) Feldenkrais (1972, 1985) and Rolf (1977) adhered to this principle.

7.2.8 Muscle lengthening and strengthening exercises

7.2.8.1 Introduction

Lowen (1994) devised a range of muscle lengthening exercises which deal mainly with the psychological aspects of the subject. Muscle lengthening or stretching involves the reorganisation of connective tissue. This is exactly what Rolfing (Rolf, 1977), and exercises developed by Pilates (Pilates & Miller, 1998; Robinson & Thomson, 1997) and Marja Putkisto (Putkisto, 1997) aim to achieve. Briedis *et al.* (1978) suggested that tonic postural exercises can be a means of optimizing the process of brain activation, functions of the vegetative system and functional regime of the skeletal muscles including their postural component.

7.2.8.2 Joseph Pilates' Contrology

Recently there has been an upsurge in the interest in the exercises developed by Joseph Pilates (Pilates & Miller, 1998; Robinson & Thomson, 1999). Health professionals, both in conventional and complementary medicine became impressed with the method's amazing success with back problems and spinal injuries, other conditions such as osteoarthritis, osteoporosis, joint injuries, the relieving of stress and headaches (Robinson & Thomson, 1999). Olympic athletes, international rugby and cricket players are joining ballet dancers in the use of Pilates exercises for physical conditioning (Robinson & Thomson, 1999).

> *Contrology is complete coordination of the body, mind, and spirit. Through Contrology you first purposefully acquire complete control of your own body and then through proper repetition of its exercises you gradually and progressively acquire that natural rhythm and coordination associated with all your subconscious activities. This true rhythm and control is observed both in domestic pets and wild animals - without known exceptions.*
>
> *Contrology develops the body uniformly, corrects wrong postures, restores physical vitality, invigorates the mind, and elevates the mind* (Pilates & Miller, 1998: 9).

Pilates' "Contrology"; unlike other physical regimens, works on the deep architecture of the body by targeting the key postural muscles, so that the individual literally works from the inside out. The exercises are designed to correct misalignments, muscle imbalances and to provide structural support for the body and works well with the Alexander Technique (Robinson & Fisher, 1998).

7.2.8.2.1 Principles of Pilates' Contrology

Modern sedentary lifestyles lead to muscular imbalances in the body (Barker, 1985; Richardson, 1992). An example of this is sitting hunched behind a desk or the steering wheel of a car all day, the muscles around the front of the chest become excessively tight. Add to this the common startle response to stress (Jones *et al.,* 1964), the individual ends up with overworked muscles of the upper shoulders and neck (Robinson & Fisher, 1998). Muscles in the mid-back -

in particular those who stabilize the shoulder blades may become overlengthened, overstretched and weak (Robinson & Fisher, 1998). Sitting for extended periods of time tends to overuse the hip flexors (Mandal; 1984; Robinson & Fisher, 1998). The gluteal- and the abdominal muscles become weak, the hamstrings shorten, the lower back becomes stiff and immobile (Robinson & Fisher, 1998).

Muscle imbalances may be corrected by physical exercises according to Barker (1985), Jull and Janda (1987), Richardson (1992) and Schrecker (1971), for example. Barlow (1990), Robinson and Fisher (1998) and Richardson (1992) were of the opinion that most of these physical exercises do not accommodate for faulty habitual movement patterns. According to them, as well as Gurfinkel and Cordo (1998) Massion *et al.* (1998) and Richardson (1992), muscles work in a coordinated fashion to produce a given posture and movement. If one muscle in a group is too tight or weak, or is used improperly, the muscle group mainly responsible for a specific action cannot function properly - so the body resorts to the use of substitute muscles to do the work (Robinson & Fisher, 1998; Richardson, 1992). The use of muscular substitutes is then the cause of "habitual misuse" of the body (Alexander, 1932; Richardson, 1992), or as Feldenkrais (1985) termed it: "parasitic movements".

The aim of Pilates' Contrology is to release and lengthen the tight muscles, then strengthen the weak ones, and thereafter, teach the body the correct muscle combinations and sound movement patterns (Robinson & Fisher, 1998). This is also the approach advocated by Jull and Janda, (1987), and the other exercises such as Tai chi Chuan and Yoga (see sections 7.2.7.1 & 7.2.7.2).

7.2.8.3 Method Putkisto

Method Putkisto was developed by a Finnish fitness and dance teacher Marja Putkisto (Putkisto, 1997). She studied Pilates' techniques and collaborated with Finnish sports-medical practitioners, physiotherapists and chiropractors in the development of her method.

Flexibility is the link to your body's strength and balance. In principle, each muscle should be longer than the bone whose movement it initiates or supports (Putkisto, 1997: 14).

Method Putkisto places an emphasis on opening and lengthening muscles which are too tight and short, unlike conventional exercise which can result in shortening the muscles. This enables you to achieve suppleness, strength, balance, well-being and awareness (Putkisto, 1997: 12).

As with all the body work techniques discussed above the central approach is to work on the body as well as on the mind - the latter being achieved by increasing the individual's awareness and well-being.

As basis of her method, Putkisto (1997) makes use of deep stretches - a stretch which begins where a normal stretch ends. Deep stretching takes muscle to a new length by working at a deeper level and with different timing and dynamics. A stretch is worked on for a minimum of 2-3 minutes and up to 5 minutes. Passive and active stretching can be carried to the level of deep stretch. The basic aim of these stretches are probably to correct muscle imbalance (Janda, 1993) (see Chapter 5, section 5.9.7 and section 7.2.8.4).

7.2.8.4 Correction of muscle imbalances

Correction of muscle imbalances are based on the following principles according to Jull and Janda (1987) and Norris (1995):

- ❑ Shortened muscles are stretched and lengthened muscles are shortened. Lengthened muscles are shortened by exercising them in their shortened position or by splinting them in this position. Slow twitch muscle function is then restored by training with low loads [20-30% of maximal voluntary contraction (MVC)]. Shortened and tight muscles are stretched using appropriate stretching exercises.

- When the above is achieved muscle strengthening can commence.

Richardson (1992)'s approach to the problem of muscle imbalance, on the other hand, is to change the pattern of muscle use through postural correction, an approach which is also advocated by Alexander (1932), Barlow (1990), Dart, (1946, 1947), Feldenkrais (1985), Hanna (1988), Rolf, (1977) and the proponents of Tai Chi Chuan (Pang & Hock, 1984) and Yoga (Iyengar, 1968). The methods proposed by Richardson (1992) are based on the neuroplasticity of the tripartite system and involve treatment methods that can be instigated to break the cycles which perpetuate muscle imbalance. This can be achieved by either increasing tonic input to the antigravity/stability muscles, or by reducing the tonic input to movement muscles. Clinically, Richardson (1992) found the former method to be effective, a finding which is in agreement with what has been found by Dart (1947; 1970) on himself, Feldenkrais (1985), Hanna (1988) and teachers of the Alexander Technique (Barlow, 1990; Brennan, 1992; Macdonald, 1998).

Increasing tonic input to stability synergists requires, according to Richardson (1992), precise treatment techniques, since the other muscles capable of performing similar movements do not require enhanced input/activation. For this reason the stability synergist needs to be separated from the movement synergist and then selectively activated. Richardson (1992) formulated a series of steps to facilitate this process:

- Isolate and activate the stability synergist, a task which requires precise and controlled muscle action. As substitution by the overactive movement synergist poses the most difficult problem, the ability to isolate a stability synergist is a difficult skill for an individual, and requires a finite period of learning. The teaching of this skill depends on an initial emphasis on cognitive processes (Martiniuk, 1979) with specific and accurate verbal descriptions and feedback (Richardson, 1992). Alexander Technique teachers gently direct their pupils into biomechanical balanced positions, thus activating the use of stability synergists. They also emphasised sensory awareness of the new, and often unusual, position of the body and its parts (Barlow, 1990; Macdonald, 1998). Cohen-Nehemia (1983), Feldenkrais (1972; 1985) and Hanna (1988) recommended specific exercises in order to attain correct function of the stabilizing muscles in the body. Since the protocols of Alexander (Barlow, 1990), Cohen-Nehemia (1983), Dart (1947), Feldenkrais (1972; 1985) and Hanna (1988) all concentrate extensively on the position of the head and neck [the primary control of Alexander (1932), see sections 7.2.4.1.1.3 & 7.2.5.2)], stability synergists are then selectively activated by means of the neck and labyrinthine reactions (sections 6.3 & 6.4) (Loots, J.M. - personal communication).

- Increase the tonic neural patterns to the muscle in order to re-establish slow twitch muscle function. To this end Richardson (1992) suggested specific exercises or electrical stimulation. Specific types of movement and specific types of muscle contraction can be used to enhance the tonic function of the stability muscles.

  Movement should be static, with no sudden or jerky movements (Richardson, 1992). Contractions should initially be isometric and not phasic, at low percentages (20-30% MVC), in order to encourage activation of the tonic (stabilizing) rather than the phasic (movement) motor units. Contractions should be sustained over long periods of time, but in order to avoid fatigue, several repetitions of sustained contraction (approximately 10 seconds) may be more beneficial. This is essential if interference of movement muscles is to be avoided.

  Since they require the holding of body positions with minimum effort, and the movements are slowly executed, exercises like those prescribed by Barlow, (1990), Brennan (1992), Cohen-Nehemia (1983), Dart (1947), Feldenkrais (1972; 1985) and Hanna (1988) are admirably suited for the purpose of training the stability muscles. Holding of body positions and slow movements are also found in Tai Chi Chuan (Pang & Hock, 1984), Yoga (Iyengar, 1968) and recent versions of Pilates' exercises (Robinson & Fisher, 1998; Robinson & Thomson, 1999). Balanced standing, sitting and movement gradually become more and more prevalent following exposure to the above training regimens, resulting in continual further training of the stability muscles.

Sensory awareness also forms part of Richardson's (1992) programme. Techniques to increase proprioception, such as joint compression, stretching and eccentric muscle contractions may help to maintain activation of tonic muscle fibres.

- The last phase in Richardson (1992)'s programme is progressive interaction of synergists for functional rehabilitation. Although the initial preparation of the muscles through the first two steps form the most essential part of the treatment of muscle imbalance by Richardson, (1992), the stability and movement synergies need to work appropriately for their ultimate functional role. Rehabilitation must therefore proceed to enhance the interaction of both groups through slowly increasing loads and speeds.

  The division of the rehabilitation programme into sequential phases by Richardson (1992) is contrary to the approach taken by others such as Alexander (1932), Barlow (1990), Cohen-Nehemia (1983), Dart (1946; 1947), Feldenkrais (1972; 1975), Hanna (1988), Rolf (1977) and Painter (1986), who believed that rehabilitation should always be approached in an integrated manner.

7.2.9 Passive, peripheral techniques

These techniques originated from Rolfing, which is also strong massaging at acupuncture points, and Reichian vegetotherapy. A form of psychoperistaltic massage has been developed in the United Kingdom. This involves identifying the tight muscles of the Reichian muscular (character) armouring by ways of physical examination following pointers supplied by Lowen's body language. The subject is then massaged (Rolfed) until the specific muscles involved release and relax. The procedure is accompanied by memory flashbacks and emotional release as well as increased intestinal peristaltic reaction (Graham, 1990; Plummer, 1982).

7.3 DISCUSSION

The connecting link between all the mind-body therapies is posture (Plummer, 1982) and its associated muscle balance (see Chapter 5, section 5.6.3.3). In order to compare the above examined therapies, they will be viewed in the context of general techniques for restoring postural balance as found in Table 7.1.

Reich laid the foundations of a somatic psychology and for psychosomatic treatments which address the psyche (mind or soul) by way of the body (Boadella, 1985; Mann & Hoffman, 1990). He recognized that emotional and psychological ways of relating to the world are reflected physically in the body, and vice versa. He used his hands to effect emotional release by pressing on tight muscles. Subsequently many different forms of psychosomatic treatments have evolved from the Reichian tradition with the common aim of relaxing the body and releasing the energy held back by various tensions. One such treatment is that of bioenergetic analysis, developed by Lowen (1994) with the aim of integrating body and mind through, amongst others, relaxing character structures. Related to Bioenergetic therapy is the Alexander Technique for the improvement of postural and muscular activity. Alexander (1932, 1987) observed that every activity, whether physical, mental or spiritual is translated into muscular tension, which becomes habitual and distorts thinking, feeling and doing. Rolf also drew heavily on the work of Reich to create a method of deep massage whereby the therapist manipulates the subject's body into a desired postural and structural position, at the same time releasing imbalances resulting from the armouring process and discharging emotional and psychic blockages (Graham, 1990).

The therapies reviewed all have the common goal of bringing about postural balance with the added benefit of balancing the mind. The methods used all involve physical interaction between therapist and subject, not simply depending upon verbal instructions, but using manual intervention so that the subject can feel the benefit. Often mirrors are also used. The subject can thus hear and feel the instructions of the therapist as well as seeing the effect and experiencing it emotionally. The many senses involved seem to increase the effectiveness of the treatment (Graham, 1990).

In comparing the Feldenkrais Method with the Alexander Technique, Heggie (1993) noted that the two practices were different ways of getting a similar experience. Whereas in the Feldenkrais Method the student is taken out of the context which produces the habitual action, in the Alexander Technique the teacher works with the student directly in action. The two approaches are actually more complementary than contradictory.

Both Alexander (1932) and Dart (1947) emphasised that the head is the prime mover and the position of the head in relation to the neck and the rest of the body plays a predominant part in posture and movement. This concept is supported by Magnus' (1926a,b) work on local, segmental and general reactions in the mammalian body and Sherrington (1946: 89) who stated:

> *Mr Alexander has done a service to the subject* (the correction of movements by working on proprioceptive reflexes) *by insistently treating each act as involving the whole integrated individual, the whole psycho-physical man. To take a step is an affair, not of this or that limb solely, but of the total*

neuromuscular activity of the moment - not least of the head and neck.

Alexander (1932) formulated much of his technique on the concept of *primary control* which he defined as a control that *depends upon a certain use of the head and neck in relation to the rest of the body* and Barlow (1990), following Alexander and proceeding with his work, also stressed the importance of the head position. Magnus (1926a) used animal studies to show that the primary factors determining reflex posture are the position of the animal's head in space and its relationship to the body.

> *Our concept of posture is based on the principle that all other relations between parts are subordinate to the relation of the head to the trunk* (Jones & O'Connell, 1958: 288).

Jones (1965, 1979), Jones and O'Connell (1958), Jones *et al.* (1959), Jones *et al.* (1964) executed a series of experiments to demonstrate the importance of the head-neck relationship in movement. They found that refraining the head from pulling back and the neck from stiffening on the initiation of a movement, such as from sitting to standing, led to a reflexive straightening of the body against gravity, accompanied by a feeling of lightness and ease of movement. The fixed position of the head is released, the righting (antigravity) response is initiated and the body follows where the head leads. This action then suspends the body and its segments from the head (Dart, 1946 and Chapter3, section 3.4). Feldenkrais (1972) developed a series of exercises to make the individual aware of the dependance of all the muscles of the body on the action of the muscles in the head and neck.

Others, however, found a balanced posture originating from the other end of the body. Cohen-Nehemia (1983), originator of the Mitzvah Exercise (see Chapter 8, section 8.5.2.1.2), contended that man has a built-in defence mechanism which protects muscles by releasing contracted muscles before they adapt to their contracted state by shortening. This defence mechanism is activated involuntarily by movements involving the pelvis (Cohen-Nehemia, 1983: 6):

> *An upward ripple of movement is triggered from the pelvis causing the spine to lengthen, the back to widen, the chest to expand, and the head to rebalance itself on top of its spinal support.*

Feldenkrais (1985) too, favoured the pelvis as prime mover, maintaining that no correct posture is possible without the pelvis being able to move freely. He explained that, although the first movement was lifting the head off the ground, it needed the chest to be anchored to the pelvis before the head could be lifted:

> *The pelvis supports the whole weight of the body, and in that respect is the most important part of it. The head, in which all of the most precise organs of orientation are located, cannot be properly held without the pelvis supporting the body so that no unnecessary muscular strain exists all along the spine. Without proper pelvic control, adjustment of the head carriage is a laborious and thankless job* (Feldenkrais, 1985: 176).

The supporting role of the pelvis was also pointed out in Chapter 3 (section 3.4). Feldenkrais (1985) also observed that the pelvic muscles are the first to contract in all extensive and rapid movements (Feldenkrais, 1985), which is in agreement with the Tai Chi Chuan concept that inner strength is controlled by the waist (Horwitz & Kimmelman, 1987).

Inhibition is a concept much used in the Alexander technique (Alexander, 1941; Gelb, 1981). Inhibition in this sense is not to be confused with repression, rather it is the choice of selection of a response to a stimulus so that an appropriate activity may follow. It is the fundamental process, conscious or unconscious, by which a person's integrity is maintained while a particular response is being carried out, or not carried out, as the case may be (Alexander, 1987; Barlow, 1990; Jones, 1979).

Inhibition was used by Feldenkrais (1985) as a method of overcoming inappropriate, residual childhood habits or excesses in behaviour in the growth to maturity. He advocated learning a new response to existing stimuli, the response being inhibition. He explained it in the following way: When learning a new skill, the muscles perform the projected act as well as unnecessary and contradictory movements. This is because before one is able to excite a precise pattern of cells in the wanted order, the neighbouring cells all along the pattern of the cells essential to the movement become active. When proficiency is achieved, only those cells that command the muscles for the desired act send out impulses. All the others are inhibited.

> *One of the most important mechanisms for directing action is inhibition and the associated phenomenon of induction. In order to obtain a monomotivated action, we must learn to inhibit the adjacent parasitic activity due to habit as well as the parasitic activity due to the topology of the cortex of the brain. If we could manipulate the nervous system itself, rearrange its nervous paths, and influence directly the different sources of impulses, we could probably obtain the wanted changes directly. As it is, we can learn to influence the nervous system by acting on its envelope. Mental processes are set going together with body action, and by the alternate switching of our attention from one plane to the other we obtain a unique mental motivation and feel the muscular sensation of such an act. It is through a series of such successive approximations that we can make sure of the correct use of the internal mechanisms of which we have no direct feeling or knowledge* (Feldenkrais, 1985: 133-134).

Once this is mastered, action will become coordinated, and such action seems, and feels effortless, no matter how great the actual work involved may be

(Feldenkrais, 1985; Gelb, 1981). In this respect Feldenkrais (1985: 86) was of the opinion that:

> *This assertion may seem sweeping, but it can be shown to be true in every case. It suffices to watch the skilful performance of masters in their trades or arts to become convinced that the presence of effort is the indication of imperfect action.*

The Mitzvah Exercise (Cohen-Nehemia, 1983), also aims at inhibiting neuromuscular interference patterns in order to obtain a maximum accomplishment. The defence mechanism of the body which releases contracted muscles before they shorten permanently, and which is activated by the Mitzvah exercise, aims to minimize interference patterns.

Combining the psychological with the physiological, Jones (1965) paid much attention to inhibition when he developed a method for changing certain postural behaviour patterns. He found inhibition to be the basic principle in his paradigm for postural change and described inhibition as a positive, not a negative, force. Inhibition is a physiological process which does not need to be conscious to operate, but when brought to the conscious level it establishes an indirect control over antigravity responses as well as facilitating the learning of new habits and unlearning old ones.

Exercises *per se* are not recommended for improvement of faulty posture, as exercising, repeating and stretching strengthen the faulty action (Alexander, 1987; Barlow, 1990; Dart, 1946; Feldenkrais, 1985, Painter, 1986; Plummer, 1982), probably by over emphasizing the action of the movement muscles (Richardson, 1992) (see section 7.2.8.4). Neuromuscular patterns causing tension build-up also strengthen with continuous use (Cohen-Nehemia, 1983). Attempting a sporting activity with a poor posture will affect the performance adversely (Dart, 1946; Gelb, 1981; Jull & Janda, 1987; Watson, 1983, 1995). The tightness and adhesions, which are the consequence of malposture, increase the susceptibility to injuries as well as impairing the efficiency and execution of limb movements

(Pritchard, 1985; Watson, 1983). Exceptions, as far as the use of exercise to correct malposture and poor use are concerned, are those developed by Pilates (Pilates & Miller, 1998; section 7.3.8.2) and Putkisto (1997; section 7.3.8.3) and Jull and Janda (1987) (Chapter 5, section 5.9.7 and section 7.2.8.4) and Schrecker (1971).

Dart (1946, 1947, 1970) was of the opinion that *poise* can be attained by firstly inhibiting the factors promoting asymmetry, and secondly by derotating the twisted body. To this end he devised a series of simple postures, which, if executed regularly, will over a period of time achieve these aims. These postures were discussed in section 7.2.5.3.

CHAPTER 8

AN INVESTIGATION INTO SOME ASPECTS OF POSTURE

The erect posture has NOT been attained by the overwhelming majority of mankind. It is true that human beings approximate more or less the upright stance: It is just this more-or-lessness that conceals from people the fact that their stance and dynamic posture is still inefficient, uneconomical, and wastes a very great deal of vital energy (Lawson-Wood & Lawson-Wood, 1977: 13).

Nearly all the chronic conditions have what may be termed an orthopaedic facet to their solution in the need for correcting the poor posture of the body (Cochrane, 1924: 310).

Can any of us civilized human individuals claim physical and mental perfection? On the contrary such statistics as we possess ·····proclaim the virtual universality of human physical and mental imperfections; despite the hundreds of millions of years that geologists, zoologists and physicists inform us have elapsed in our long evolutionary journey from a pre-molecular state of existence to the manhood that has been deemed worthy of being called sapient (Dart, 1970: 9).

8.1 INTRODUCTION

Dart (1947) and Barlow (1955) both emphasized the fact that faulty posture was a prevalent condition of the human body affecting, for example, between 70 and 95% of children up to the age of 18 years (Barlow, 1990). In 1924 Cochrane drew attention to Swain's (ND) declaration that he saw no more than 20 well-postured individuals among 3000 patients at a sanatorium, and at a training camp for youths and men, Cochrane (1924) found that 75% were physically inefficient. This is in contrast with the findings of Fenton (1973), who found that 9% of children in his study were overcurved when standing, 17% leant forward or backward when standing and at least 5% had a noticeable lateral curvature of the spine.

In this chapter research projects, which were undertaken at the Sport and Training Institute of the University of Pretoria, to determine body posture and deviations thereof in different sectors of the population, will be reported on. The purpose of these studies was to evaluate the posture of some members of the South African male population and to determine the range and area of postural deviations. It was inconceivable to obtain a representative sample of the South African population at the time of the study. Therefore it was decided to investigate firstly the effect of two factors (stressful lifestyle and regular participation in physical activity) on posture in groups of male subjects, and secondly, the consequences of postural rehabilitation on selected small groups. These data could provide an indication as to body use and misuse of sectors in the population, and to facilitate selection by therapists and educators of therapies suitable for improvements in body use.

All of the studies made use of the conventional, non-invasive method of photography for the recording of static posture. In addition to being portable and relatively cost effective, the camera can be depended upon to always give a true representation of the subject (Jones, 1979). For the purpose of simple documentation the operator does not require extensive training (see Chapter 2, section 2.3.4). Photographs provide a reliable data record and a stable surface from which to measure and calculate angles. Barlow (1990) has also shown that valuable information may be obtained about muscle tension and use from the scrutiny of photographs.

8.2 POSTURE OF MIDDLE AGED MALES

8.2.1 Introduction

Malposture is pandemic in modern society (Dart, 1947; Lawson-Wood & Lawson-Wood, 1977; Rolf, 1977; Sherrington, 1946). The extent of this problem is not known in this country at present. Lack of body awareness, modern sedentary lifestyle, stress, poor use are to be blamed for this unfortunate state of affairs (Alexander, 1987, 1996; Dart, 1947; Feldenkrais, 1985; Richardson, 1992; Rolf, 1977). A group in which all these aspects are most likely to be combined, is that of senior executives. The purpose of this study, therefore, was to determine the incidence of postural defects, and use of musculature during the static act of standing, in a group of middle aged senior executives.

8.2.2 Subjects and methods

The subjects of the study consisted of 43 senior executives from two large companies in the Pretoria area. The ages of the subjects ranged from 31 to 61 years, with a mean age of 44,5 years. The subjects were included in the study because of their excessively sedentary lifestyles.

All data were obtained by the use of photography. The equipment consisted of a Pentax camera mounted on a tripod. In order to minimise image distortion a Takumar zoom lens, set at a focal length of 85 millimetres was used. Images were recorded on black and white film.

The subjects were placed against a plumbline on the wall and photographed from a distance of 4,5 metres. The subjects were instructed to assume a typical stance, the one they usually stood comfortably in, with arms hanging at their sides. The posture was to be the habitual standing posture with no aim towards the ideal. The subjects were then photographed laterally from both sides, and also from the front and from the back.

The photographic prints were analysed according to the pro forma suggested by Barlow (1956, 1990), which was a useful guide in assessing a given subject's postural defects and the associated muscular tensions. Details of this pro forma are found in Table 8.3. This pro forma enables one not only to analyse the subject's posture, but also the relationship and position of the various body parts in relation to each other, and the tension in the body musculature needed for the

the maintenance of this posture. Defects were scored in different body segments by two well-trained observers, whose scores always tallied, on a basis of1, 2 or 3 marks according to the severity of the defect, with 1 denoting a slight-, 2 a moderate- and 3 a severe postural defect using examples from Barlow (1990) and Robinow, Leonard and Anderson (1943) as guidelines. Finally, all the scores were added in order to obtain the total score. The lower the total score, the closer to the attainment of *poise* (Barlow, 1956, 1990; Dart, 1947).

According to the use of their bodies, the quality of subjects' total body posture were assessed according to the categories shown in Table 8.1.

Table 8.1 Classification and scoring of body use (based on Barlow, 1956, 1990).

USE	TOTAL SCORE
Excellent use/*poised*	0-3
Slight postural defects	4-5
Severe postural defects	6-9
Very severe postural defects	10-14
Gross deformity	15 and over

8.2.3 Results

8.2.3.1 Postural defects and their incidence

Of the group of 43 male subjects none had excellent use (*poise*), only 1 subject was classified as having slight defects (score 5), while more than half of the group had severe and very severe defects according to their total scores. The mean total score was 11,8, of which the lowest was 5 and the highest 21 (Table 8.2). The mean score of almost 12, placed the subjects studied in the category of very serious defects (Table 8.2).

Table 8.2 Incidence and severity of postural defects in male senior executives.

POSTURAL DEFECTS	NUMBERS	PERCENTAGE
Excellent use/*poised*	0	0
Slight postural defects	1	2.3
Severe postural defects	10	23.3
Very severe postural defects	25	58.1
Gross deformity	7	16.3

8.2.3.2 Occurrence and mean score of postural defects in the various body segments

Postural defects in the various body segments, their mean score, as well as their occurrence in the sample studied are listed in Table 8.3. Mean scores were calculated according to the formula:

$$\text{Mean score} = \frac{\text{Total score}}{\text{Number of subjects with defects}}$$

This score is therefore an indication of the severity of the postural defect in a segment.

Mean scores were low, ranging from 1,0 to 1,4, while postural faults occurred in all body segments. The highest incidence of postural defects was observed in the back, shoulders and the neck, with kyphosis a problem present in all the subjects studied.

Table 8.3 *Occurrence and mean score of postural defects in different body segments.*

REGION	FAULTS	% OF CASES	MEAN SCORE
Head	Poked	14	1.2
	Retracted	79	1.1
	Tilted backwards	51	1.0
Shoulders	Raised	77	1.4
	Rotated	9	1.3
	Pulled together	33	1.1
	Dropped	14	1.2
Pelvis	Tilted forwards	42	1.3
Spine	Kyphosis	100	1.3
	Lordosis	70	1.8
	Scoliosis	72	1.4
	Thorax Displacement	47	1.2
Stance	Forward Inclination	81	1.4
	Hyperextended Knees	86	1.1
	Internal Rotation of Knees	12	1.0
	Asymmetry	58	1.2
Tension	General	9	1.3
	Local	84	1.1

None of the subjects appeared to have a comfortable, balanced stance. A tight, "holding on" type of stance was the general posture. Typical examples of standing postures in the sample are shown in Figure 8.1.

In Figure 8.1a & b examples of the postural consequences of scoliosis are shown. In the subject shown in Figure 8.1b, torsional rotation in response to spinal scoliosis is particularly evident. In Figure 8.1c the upright posture is maintained by means of excessive muscle tension. The subject in Figure 8.1d leans far forward, putting unnecessary strain on his lower calf muscles.

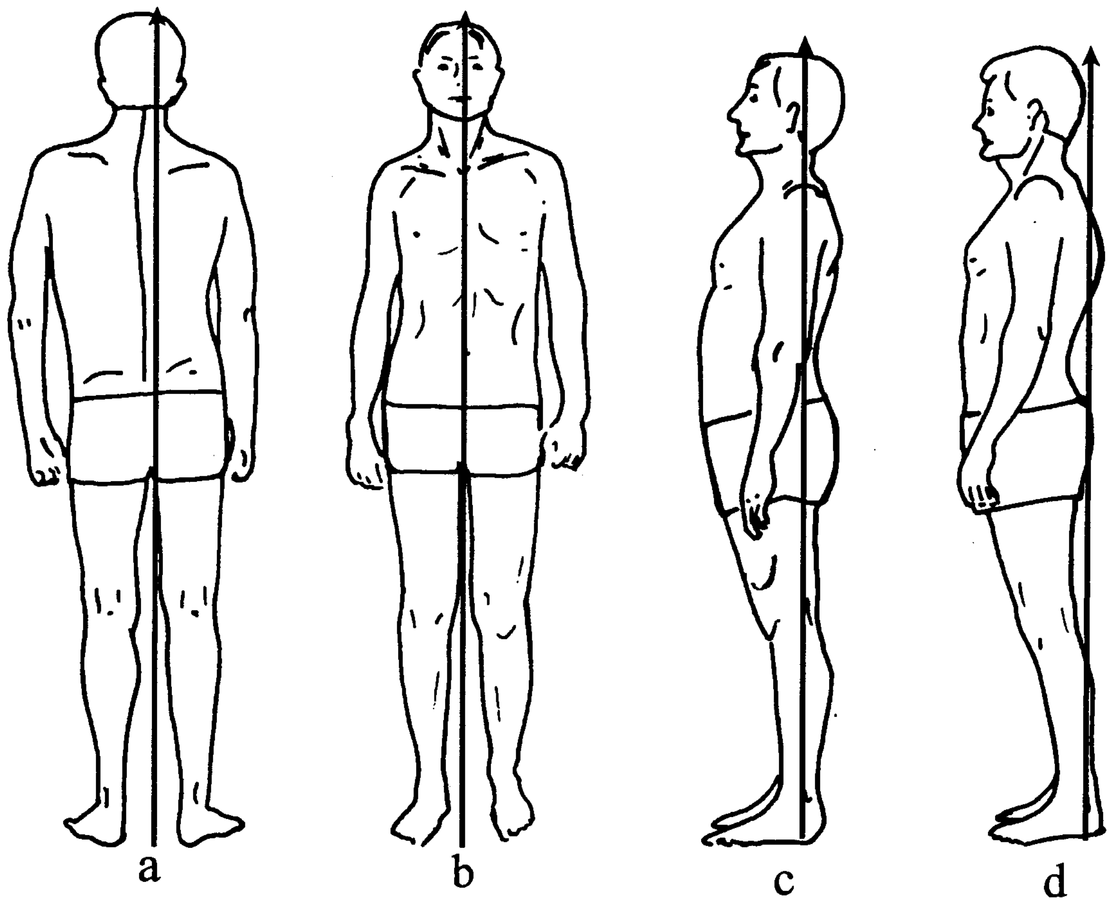


Fig. 8.1 Examples of some of the postures assumed by subjects.

Figure 8.2 shows different ways of carrying the upper quarter in 6 subjects - in all the examples head and neck position are maintained by means of excessive muscle tension, a feature which is evident in the tight shoulder and neck muscles, and which contributed to the high incidence of localized tension (Table 8.3).

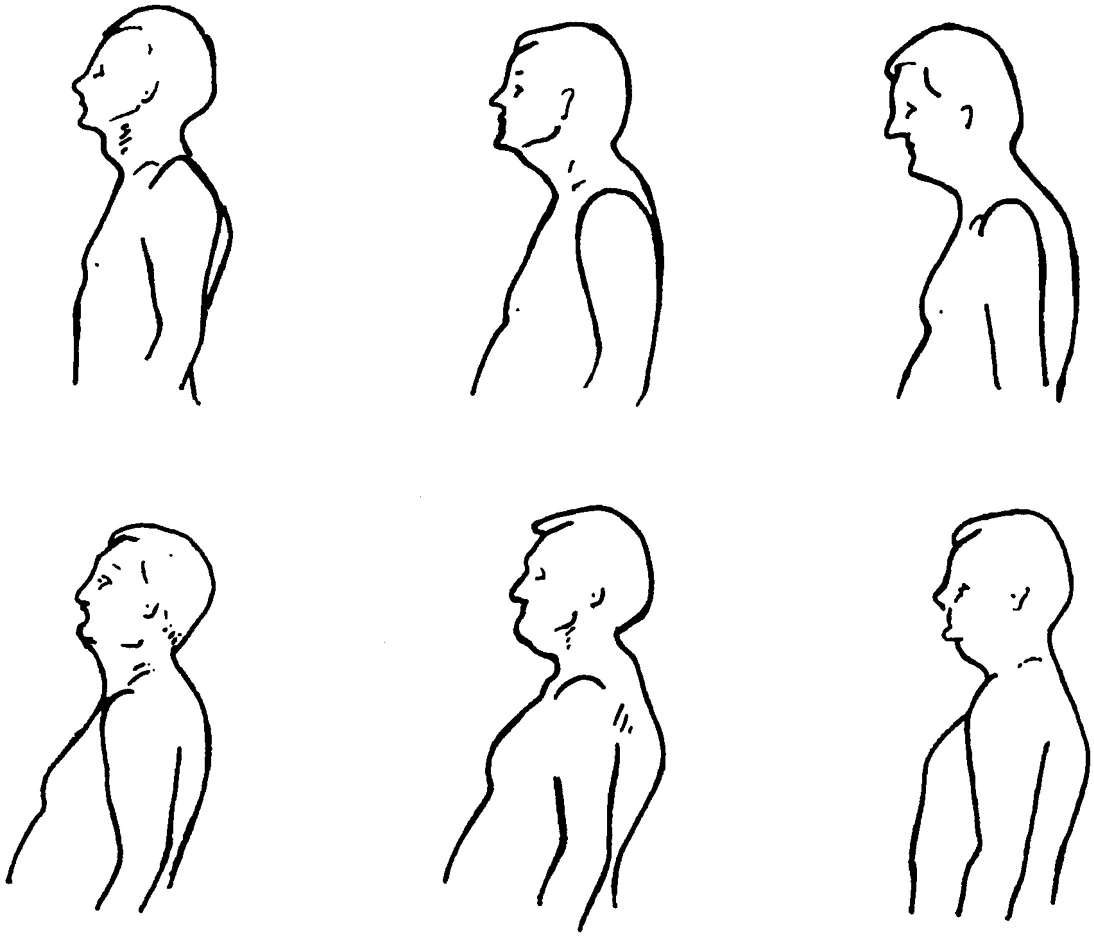


Fig. 8.2 Head and neck position in 6 subjects, showing the variability in which head carriage is being dealt with, in different individuals.

8.2.4 Discussion

The purpose of this section of the study was to investigate the postural consequences of modern Western lifestyle characterized by a sedentary lifestyle (National Institutes of Health, 1997), lack of body awareness, stress and poor use (Alexander, 1987, 1996; Barlow, 1959; 1990; Dart, 1947; Feldenkrais, 1985; Rolf, 1977). The results of this section of the present study support others who were of the opinion that malposture is pandemic (Dart, 1947; Lawson-Wood & Lawson-Wood, 1977; Sherrington, 1946). Apart from the high percentage of subjects with severe and more than severe postural defects (97.7%, Table 8.2) analysis of Table 8.3 indicates an alarming tendency of more than one postural defect per body segment. Examples of this are the high incidence of head retraction (79%) concurrent with 51% of the heads tilted backward. Kyphosis was found in all of the subjects. This was associated with a 70%, 72% and 42% incidence in lordosis, scoliosis and thoracic displacement, respectively. Scoliosis starts to develop at the age of 6 years, and progresses with advancing age (Farkas, 1941). The high incidence (72%) of scoliosis observed in the subjects of the present study, is about twice as high as the estimated incidence (about 30%) in schoolchildren (Dickson, 1983), thus supporting Farkas' (1941) findings.

Local muscular tension was observed in 84% of the subjects. This tension in different areas of the body can be seen in all of the subjects in Figures 8.1 and 8.2. Prominent here are tension in the neck, shoulder area and upper back (expressed for example in the 79% occurrence of retracted necks and a 100% incidence of kyphosis). With the exception of 1, none of the subjects in the present study were able to maintain body alignment without undue muscular tension. Barlow (1959: 345) was of the opinion that this constitutes an additional stress:

> *Muscular hypertension, then, is the residual tension and postural deformity which remains after stress activity, or after any other activity for that matter, since any activity which leaves residual muscular tension is to that extent a stress activity.*

Comparison of the postural faults in the subjects of the present study with those made by Barlow (1956, 1990) on drama and physical education students (Figure 8.3) presents a bleak picture. In the subjects of the present study the incidence of very severe postural defects and gross deformity are higher than that found by Barlow (1956, 1990).

The observations of the present study indicate that the middle aged, sedentary subjects all have poor postures, and according to the observations of others, it is possible that the faulty postures could be due to misuse of their bodies, and an inability to deal with physical and emotional stress (Alexander, 1932; Feldenkrais, 1985; Rolf, 1977). The subjects would not be able to perform certain movements adequately or easily, and there is also a possibility that minor pains of the moment might develop into pathologies in the future (Barlow, 1959; Goldthwait *et al.*, 1952).

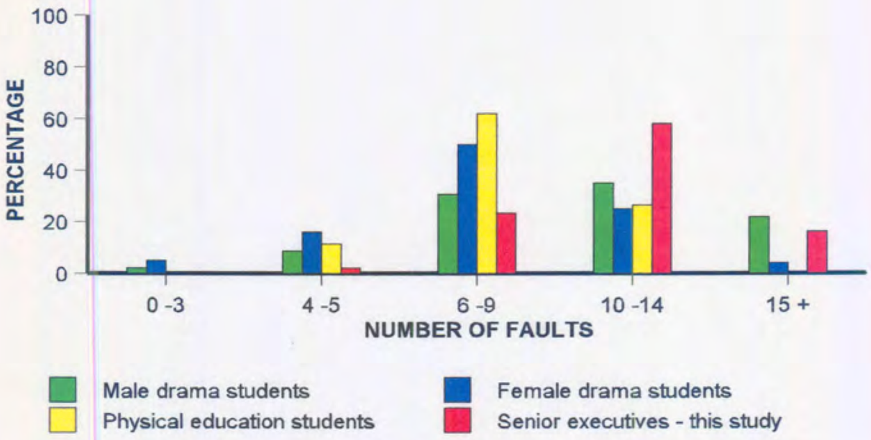


Fig. 8.3 Comparison between the number of postural faults in studies by Barlow (1956, 1990) on two groups of drama students (green and blue bars), physical education students (yellow bars) and the subjects of the present study (red bars).

8.3 BODY ALIGNMENT AND POSTURE OF PRIMARY SCHOOL BOYS

8.3.1 Introduction

Participation in physical activity and sport does not necessarily lead to good posture, according to Alexander (1996), Feldenkrais (1985) and the studies done by Barlow (1956, 1990). To try and resolve this issue, and in order to obtain detailed postural information about South African children, a study was undertaken on healthy primary school boys. These subjects all came from rural areas and actively participated in sport such as athletics (track and field), gymnastics, swimming and tennis.

8.3.2 Subjects

The subject population consisted of 58 male primary school boys who participated actively in sport. The subjects were selected by their schools to attend an annual Vleissentraal Sport Junior coaching clinic at the Institute. None had had back surgery or other major health problems. Their ages varied between 8 and 12 years. Girls who also participated in the clinic were not included in order to avoid the embarrassment of being photographed with a minimal amount of clothing.

8.3.3 Methods

All data were recorded photographically by means of a Pentax camera mounted on a stand. A plumb-line was brought on permanently against the wall and followed through on the floor with a 2 centimetres wide strip. Each subject was instructed to stand comfortably in front of the plumb-line with the floor-line between the feet, and hands placed at the sides. The subject was photographed from the front, the back and each side at a distance of 4,5 metres.

Anthropometric data were collected on the vertex, trochanter, tibial and acromion heights. The five body landmarks were located as follows: the ankle, 1 centimetre in front of the posterior edge of the lateral malleolus; the knee at the lateral epicondyle; the hip at the projection of the greater trochanter; the shoulder at the centre of the head of the humerus and the ear vertically below the external meatus (Woodhull *et al.*, 1985). Each point was marked with a small black dot for consistency of location in the photographs.

Special attention was given to the angles of mass bearing joint centres in posture and deviations thereof. The children were also analyzed according to the pro forma based on that of Barlow (1990) (section 8.2.2) in order to ascertain postural defects.

8.3.4 Results

8.3.4.1 Body alignment

The average heights and positions in front of the ankle of the body landmarks in the individuals of the present study are shown in Table 8.4 and Figure 8.4. The knee, hip, shoulder and ear were usually located forward (anterior) to the ankle joint in typical standing. Averaging across individuals in the present sample, the knee was 40,2 millimetres, the hip is 53,4 millimetres, the shoulder 49,6 millimetres and the ear 50,8 millimetres (±27 millimetres S.D.) in front of the ankle. Some individuals were more variable than others, but the between-subject variations were large compared to variations within subjects (Figure 8.6).

Table 8.4 Mean positions of body landmarks and their standard deviation.

BODY LANDMARK	POSITION IN FRONT OF ANKLE (MM)	STANDARD DEVIATION	BODY HEIGHT (MM)	STANDARD DEVIATION
Knee	40.2	21.4	426.7	69.2
Hip	53.4	25.3	781.3	78.5
Shoulder	49.6	25.4	1203.7	85.2
Ear	50.8	27.2	1451	95.8

8.3.4.2 Posture and postural defects

In Table 8.5 the incidence of the various postural defects is shown. None of the subjects had excellent use and only two had slight postural defects (3,4%). Severe postural defects were detected in about a fifth of the subjects (20,7%), while nearly half of the subjects had a total score which put them in the very severe posture defect category. Gross deformity was found in 28,7% of the subjects.

Table 8.5 Occurrence and intensity of postural defects.

USE	NUMBERS	PERCENTAGE
Excellent use/*poised*	0	0
Slight postural defects	2	3.4
Severe postural defects	12	20.7
Very severe postural defects	28	48.3
Gross deformity	16	27.6

Table 8.6 Occurrence and mean score of postural defects in different body segments.

REGION	FAULTS	% OF CASES	MEAN SCORE
Head	Poked	31	1.2
	Retracted	32.8	1.1
	Tilted backwards	52	1.0
Shoulders	Raised	74.1	1.6
	Rotated	51.7	1.0
	Pulled together	15.5	1.2
	Dropped	17	1.0
Pelvis	Tilted forwards	95	1.3
Spine	Kyphosis	89.7	1.4
	Lordosis	93.1	1.6
	Scoliosis	39.7	1.0
	Thorax Displacement	60.3	1.1
Stance	Forward Inclination	86.2	1.3
	Hyperextended Knees	24.1	1.0
	Internal Rotation of Knees	31	1.1
	Asymmetry	84.5	1.0
Tension	General	55.2	1.3
	Local	87.9	1.4

Postural faults in the various regions of the body are shown in Table 8.6. The greatest number of faults was found in the spine and pelvis, kyphosis being present in 89,7%, lordosis in 93,1% and a forward tilting pelvis in 95,0% of all subjects. Forward inclination was found in 86,2% of the individuals, as previously mentioned (section 8.3.4.1).

Asymmetry in body segments while standing was apparent in an unusually high percentage of the subjects (84,5%), which indicates a large incidence of muscle-imbalance, especially when associated with a nearly 40% occurrence of scoliosis. General tension was observed in 55% of the subjects while local tension was a common occurrence (88%) - which was mainly present in the upper quarter.

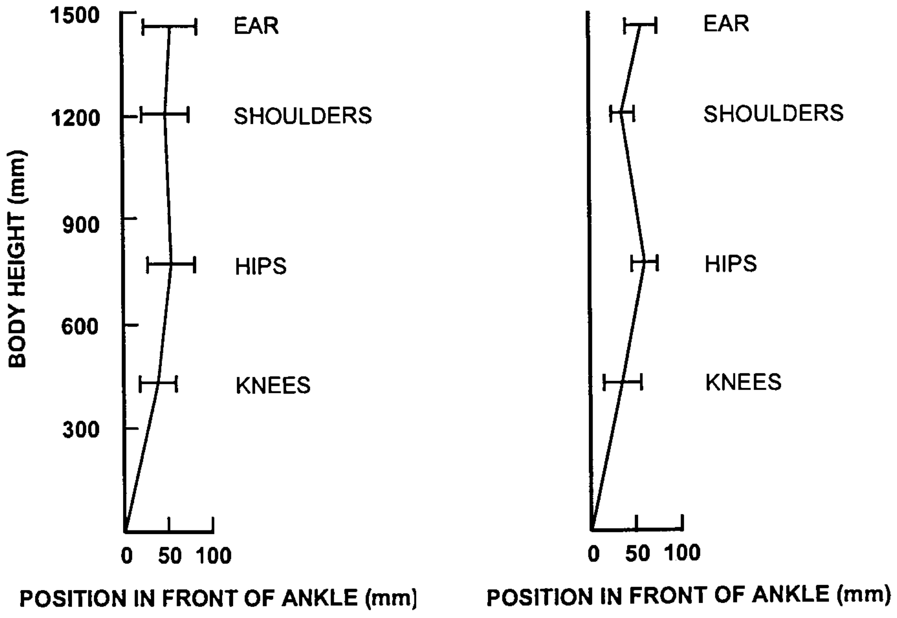
8.3.5 Discussion

8.3.5.1 Body alignment

Only 2 subjects in the present study were close to a linear alignment of joint centres. The positions of the body landmarks found in the present study were compared to those found by Woodhull *et al.* (1985), in 15 normal volunteers, aged 18 to 29 years (Figure 8.4). In the subjects of both studies the landmarks were arranged on top of each other in an S-shaped pattern, with alternate landmarks in line with each other. This can be clearly seen in Figure 8.4b where the hip joints were aligned directly beneath the ears and the knees beneath the shoulders, the sigmoid shape being more pronounced in the subjects of Woodhull *et al.* (1985).

Mean values of landmark positions in front of the ankle joint indicated that the subjects in both studies were not vertical, with differences between the relative positions of the ear, shoulders and hips more marked in the subjects of Woodhull *et al.* (1985). The position of the hips was about 9 millimetres further forward in Woodhull *et al.*'s (1985) subjects than in those of the present study (62,0 versus 53,4 millimetres, respectively), the shoulder joints, on the other hand, were further back in Woodhull *et al.*'s (1985) subjects by about 11 millimetres (38 versus 49,6 millimetres, respectively) (Figure 8.4).

It appears that on average vertical alignment and the position of the body segments relative to each other in the adults were worse than those of the school children (Figure 8.4a,b). Asmussen and Klausen (1962) cited a study by Heelbøll-Nielsen (1958), in which the form and function of 201 boys, whose ages ranged from 8 to 15 years, were reported upon. Heelbøll-Nielsen's (1958, cited by Asmussen & Klausen, 1962) children showed a definite trend towards greater forward inclination with increasing age (Figure 8.5). The large individual variation in vertical alignment of the subjects in the present study unfortunately did not allow for a similar analysis.



a b

Fig. 8.4 Mean positions of body landmarks in front of ankle and standard deviation in subjects of the present study and that of Woodhull *et al.* (1985) (drawn on the same scale).

Fig. 8.5 Change in vertical alignment with increasing age. Mean age of subjects 8,3 years (blue line) and 15,8 years (red line), respectively (Adapted from data in Fig 12. of Asmussen & Klausen, 1962).

Individual parameters tended to vary in the subjects of the present study, and the position of one landmark did not appreciably influence those of the others above it (Table 8.7).

Table 8.7 Correlations between the different body-landmarks

	EAR	SHOULDER	HIP	KNEE
Ear	100	66	47	58
Shoulder	66	100	43	53
Hip	44	43	100	45
Knee	58	53	45	100

This is obvious from the low correlation between the different body landmarks in front of the vertical, the lowest being 0,43 and the highest being 0,66, which implies that at the utmost only 46,6% of the position of the ear landmark could be explained by the position of the one directly below it - the shoulder. In Woodhull *et al.*'s (1985) study these correlations were of the same magnitude, ranging from 0,394 to 0,714.

It seems that each subject compensated in his own individual way for the position of the different body segments in relation to each other, as well as for the direction of the force of gravity. This is clearly shown in the large variation in vertical alignment - some more effective than others - adopted by subjects of the present study, and those of Woodhull *et al.* (1985) (Figure 8.6a,b).

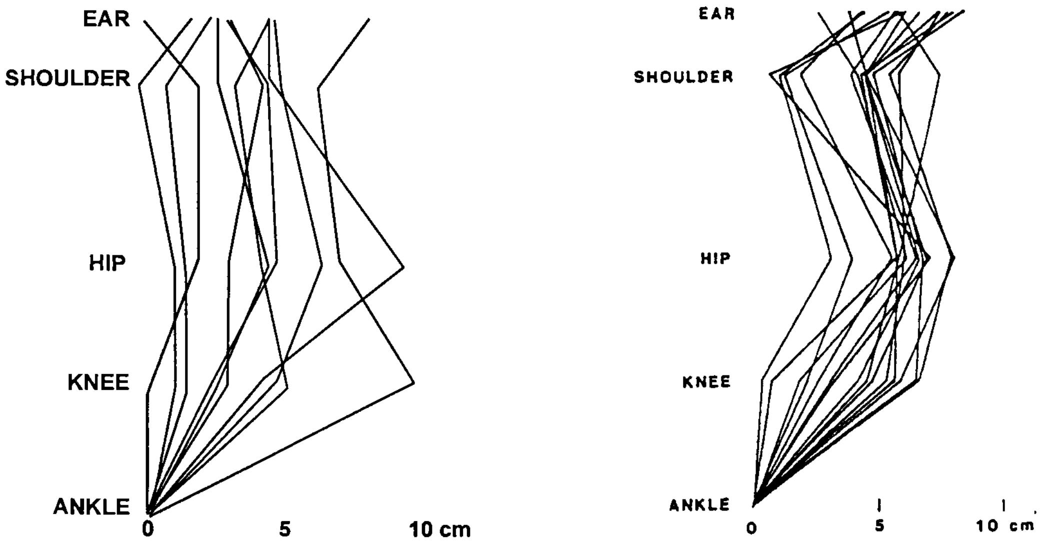


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Fig. 8.6 Body alignment of 10 primary school boys in the present study (a), and adults in the Woodhull *et al.* (1985) study (b), showing individual variation in posture.

8.3.5.2 Postural defects

The White House report in 1932 painted a bleak picture about postural defects in American school children (Kiernander, 1956). Postural defects were detected in 92% of the children studied, with 44% of these having extremely bad postural defects. Bang and Bojlén, (1950, cited by Asmussen & Heelbøll-Nielsen, 1959) in a group of more than a 1000 school children found that 55% of these had postures that were poor and 20% very poor. The subjects of the present study all had postural defects with very severe postural defects (48, 3%) and gross deformity (27,6%) adding up to a total percentage of 75,9 of the boys studied, indicating an increase in the incidence and severity of postural problems amongst school children.

By the age of 11, 70% of all children will already show obvious muscular and posture deficiencies. Usually these defects appear as passing inefficiencies and difficulties in learning, becoming accentuated in emotional situations. During adolescence the childhood faults become fully fledged defects and by the age of 18, 65% of the population will have severe defects and 15% will have very severe defects (Barlow, 1990).

The postural defects found in the subjects of the present study agree with those reported by others (Asher, 1975; Barlow, 1990; Dickson, 1983; Fenton, 1973; Rolf, 1977), in that kyphosis (and its associated rounded shoulders), lordosis and scoliosis are common postural problems, with other postural defects also being present. Additionally, in the present study 49 of the subjects (84,5%) had abducted and "winged" scapulae, while the remaining 9 (15,5%), had shoulders that were pulled together.

Kyphosis in a minor degree appears to be a common occurrence in infancy, childhood and adolescence and ·····*is reminiscent of the days before our ancestors assumed their upright posture* (Asher, 1975: 26). Asmussen and Klausen, (1962) supported this by stating that thoracic kyphosis is a feature common to all mammals. The incidence of increased kyphosis increases between the ages of 11 and 16 and diminishes thereafter (Asher, 1975). In the present study kyphosis was prevalent (89,7% of all subjects, Table 8,7).

Kendall and McCreary (1983) identified four abnormal posture types, namely: Lordotic, kypholordotic, sway back and flat back. The first two of these are, according to Kendall and McCreary (1983), associated with an anteriorly tilted pelvis and hyperextended knees. Some of these types are shown in Figure 8.6. In the present study 5,1% of the subjects were lordotic and 85% kypholordotic. Of these all had forward tilted pelvises, but only 24% had hyperextended knees. None of the subjects in the present study had flat or sway backs.

Scoliosis, however, is rarely seen under 8 years of age, and not often thereafter. If a single lateral curve, usually to the left, is observed which disappears on flexion of the spine or when lying down, the condition is of postural origin (Asher, 1975). Dickson (1983), however, found scoliosis in 14,48% of a sample of 5303 schoolchildren studied. With more accurate evaluation this figure may be as high as 30% (Burwell, James, Johnson, & Webb, 1982), which is more in agreement with the results (39,7%) of the present study. An interesting explanation for this problem by Dickson *et al.* (1984) is that idiophatic scoliosis (biplanar spinal asymmetry) is the reverse of Scheuermann's disease.

Round shoulders was a term used by Asher (1975) to describe a whole range of postures in children namely: forward shoulders, poking head, poking neck, kyphosis and mobile scapula. She found that in most primary school children the tip of the acromion process appeared to be pointing forward, and in the older group round shoulders was a serious postural defect which was used as a position of rest. She advocated discovering where the main fault lay and making the child appreciate the importance of recognizing the fault, as this particular posture was frequently part of the body image, and a new body image needed to be established (Asher, 1975). Body image is a term used for the visual, mental and memory images that a person has of his body. It influences the way the body is habitually used, as well as forming the background to his perceptions and it is embedded in his habitual resting state while influencing his posture, movement and communication (Barlow, 1990).

The subjects in the present study all competed in some sport or other physical activity, and therefore could, to some extent, be used to determine the effects of regular participation in physical activity/sport on posture. Postural defects of the subjects in the present study were therefore, compared to those in the study undertaken by Barlow (1956, 1990).

In collaboration with Tanner, from the Institute of Child Health, Barlow (1956, 1990) conducted studies on physical education students. This study was done at some of the leading physical education colleges in the United Kingdom. When the postural faults of the students in Barlow's (1956, 1990) study and the subjects of the present study are compared (Figure 8.7), a definite pattern emerged, in that the largest percentage of subjects in both the present and the study by Barlow (1956, 1990) fell in the categories of severe and very severe postural defects. Notably disturbing is the fact that in the group of physical education students in the Barlow (1956, 1990) study, the majority showed severe (62,0%), or very severe (26,5%) postural defects. In the present study these values were 20,7% and 48,3%, respectively, with gross deformities found in an appreciable number of the subjects (27,6%). None of the subjects in the present study had *poise*, with only a very small percentage having slight postural defects (3,4%).

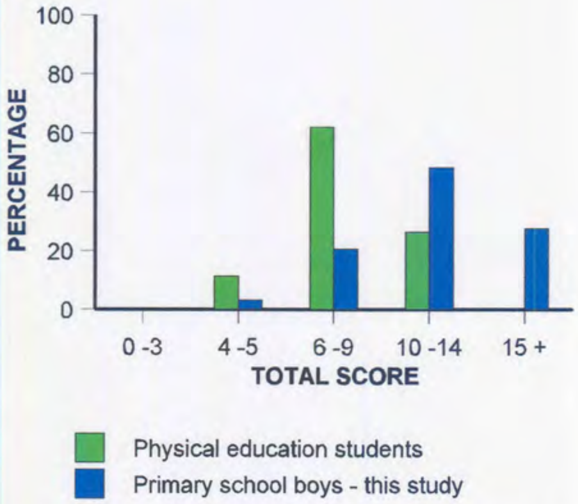

Fig. 8.7 A comparison between the postural defects in physical education students in the Barlow (1956, 1990) study, and primary school boys of the present study.

In the United Kingdom high physical standards were required on entry into a tertiary training institution which drew on some of the best athletes and games players in the country. The large number of postural faults in physically active and fit individuals do **not** support the idea that: *.....plenty of fresh air and exercise will ensure a reasonably good USE*[1] (Barlow, 1990: 187).

8.4 GENERAL DISCUSSION ON THE UPRIGHT POSTURE

8.4.1 Vertical alignment of the body

Results from all the above-mentioned research projects indicate that the subjects had an average body alignment which is not in accordance with the biomechanical ideal proposed by some (Barlow, 1990; Kendall & McCreary, 1983). Woodhull *et al.* (1985) were of the opinion that a forward leaning upright stance is the norm, rather than the exception. The upright stance of Barker (1985) and Dangerfield (1996) also allows for some forward leaning, with the vertical line passing from the ear, through the acromion and trochanter, in front of the knee joint and the malleolus. Burt (1950) suspended a plumb line from the tip of the mastoid process which should pass through the greater tuberosity of the humerus, the great trochanters of the femur and through a point about 45 millimetres in front of the lateral malleolus, if the posture is good. In the present study and that of Woodhull *et al*, (1985) the vertical line did not pass through all the body landmarks - in fact a zig-zag pattern was found, with a great variation found between subjects (see Figure 8.5). All the body landmarks, however, were well in front of a plumbline going through the lateral maleolus. The vertical line going through the highest body landmark - the ear - would go 50,8 millimetres and 59,0 millimetres in front of the malleolus in the present study and in that of Woodhull *et al.* (1985) respectively, thus supporting the opinions of Barker (1985), Burt (1950) and Dangerfield (1996).

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[1] In this sense the word *use* is not used here in the limited sense of the use of any specific body part, as, for instance, the use of an arm or a leg, **but in a much wider and comprehensive sense applying to the working of the body in general** (Alexander, 1932).

A crucial element of *poise* (Dart, 1946, 1947) is the vertical alignment of body structures on top of each other, thus favouring the ideal biomechanical posture (Macdonald, 1998; Kendall & McCreary, 1983; Rolf, 1977) during the upright stance (see Figure 2.1a). Whether this assumption, and not that of Barker (1985), Dangerfield (1996) and Woodhull *et al.* (1985), is the correct one, is debatable. Approached from a biomechanical perspective, however, vertical alignment of structures on top of each other makes more sense (Barker, 1985; Rolf, 1977). Posture is dynamic, and although a static photograph can only record the posture of a moment, postural patterns are habitual, and a photograph represents an individual's typical postural pattern (Flint & Diehl, 1961).

The study of posture gives an indication whether the body as a whole is "out of line" or not. When it has moved from the ideal position of balance, and is thus out of balance, the body segments are not properly aligned on top of each other (Barker, 1985; Rolf, 1977). A physical reason for this could be muscle imbalance in certain areas, an aspect which has received some consideration (Flint & Diehl, 1961; Janda, 1993; Janda & Schmidt, 1980; Jull & Janda, 1987; Norris, 1995). Low, but significant, relationships, between antero-posterior alignment of the trunk, and back-extensor muscle strength and abdominal strength was found by Flint and Diehl (1961). The curvature of the lumbar spine, and that in the upper quarters may be influenced by muscle imbalance (Ayub, 1987; Janda, 1993; Janda & Schmidt, 1980; Jull & Janda, 1987; Norris, 1995; Chapter 5, section 5.9.3). Asmussen and Heelbøll-Nielsen (1959), in this respect, noted that in school children the stronger backs exhibited more pronounced curves.

8.4.2 Misalignment and intellectual potential

One of the implications of this misalignment is that full intellectual potential is not being reached, as evidence shows that equilibrium shifts in an anterior direction are correlated with lower academic performances (Kohen-Raz, 1981). Even an inappropriate sitting posture lowers the IQ score of preschoolers (Sents & Marks, 1989). According to Brown (1992: 62):

The lack of equilibrium in the so-called "physical" sphere will be found in every case to go hand-in-hand with a corresponding lack of equilibrium in the so-called "mental" spheres.

8.4.3 Awareness of body regions

Lestienne and Gurfinkel (1988) postulated that the body has an inborn structural organization for posture (body scheme), incorporating upper and lower, left and right, front and back sides of the body. Alexander (1987) and Lowen (1994) advocated "awareness". In order to prevent malposture or improve the use of the body, it is necessary to be aware of positions and activities of body parts. Perhaps the leaning forward posture is due to the fact that most people are not aware of their backs and thus do not stimulate the area of the brain representing the back. (Even in the event of back pain the person is usually aware of the pain, rather than the back) (Martini, 1992).

8.4.4 Implications of the rounded shoulder posture

Many of the subjects, both young and old, had a rounded shoulder or slumped posture. This has been called the 'fatigue posture' by Christaldi and Mueller (1963) who blamed it on physical unfitness and suggested postural exercises. According to Riskind and Gotay's (1982) experimental research, this posture has a detrimental effect on a person's ability to perform tasks effectively. Lower persistence in execution of tasks, and feelings of helplessness were features that developed as result of this posture.

8.4.4.1 The startle pattern posture

Jones (1965) and Jones *et al.* (1964) demonstrated that the sound of a slamming door immediately produces a bad posture. He called this a "startle pattern" and it is characterized by raised, forward shoulders, flattened chest and head thrust forward. This is the posture detected in many subjects of the present study. According to Jones (1979) and Jones *et al.* (1964) the stimuli for startle, for anxiety and for fear are always with us and bad posture could be a reflection of a response to these powerful stimuli. He suggested that finding the origin of the response may be a more profitable way of improving posture than exercises would be, which means that curing the anxiety is the first step in curing the malposture. Lowen (1971) and Reich (Wilson, 1982) held the same views.

8.4.4.2 Reversion

Forward, rounded shoulders are reminiscent of an earlier phase in the phylogenetic development of the human. McGraw (1932), studying the ontogenetic development of the human individual, suggested that during development of the infant a new pattern unfolds bit by bit and dovetails with the old pattern and gradually the new pattern becomes more and more dominant until finally it is superimposed upon the old pattern. However, in times of stress and strain the infant will revert to the less mature response. This leads one to wonder whether, in later life, stress and strain might also cause a reversion to an earlier pattern in development (see chapter 2). When a child can maintain and control posture, position and attitudes he has achieved equilibrium (de Quiros, 1976). Stooping and submissive postures are derived from feelings of abasement and abandonment associated with infantile regression according to Le Vay (1947). The infant's first unsupported sitting posture is that of the "open-jack-knife" position (the infant is still very vulnerable and dependent at this stage). This is followed by the upright sitting position and a more independent infant. One might conjecture that in later life the flat back reverts to the rounded back of early infant life during periods of stress.

8.4.4.3 Protection

The rounded shoulders are a mechanism for protecting the vital organs in the chest. Today the projected message is one of submission with the intended purpose that cringing will avert the wrath of the (momentarily) superior individual. These are ancient behavioural patterns that are commonly found in animal behaviour (Lorenz, 1957; Morris, 1984). It is a primitive, lower-brain reflex of survival (Hanna, 1988).

Feldenkrais (1985) described the protective acts as lowering the head, sinking the chest, protecting the throat and stomach. These are accomplished by flexor contraction and are effective measures that give a sense of security in the face of danger. The result is the offer to the threat of a hard, bony obstacle or the withdrawal of the soft organs. The motive for all of this is the fear of falling and the effect is a bad posture, similar to that seen in the research subjects. According to Feldenkrais (1985) the anxiety originates in early childhood when lowering the head and sinking the chest are the best movements to protect the body from injury expected to come from above, when flight or hitting back is unthinkable.

8.4.5 The forward head position

A significant percentage of the subjects evaluated in the study assumed a forward head position. Findings by Enwemeka, Bonet and Ingle, (1986) indicated that persons who habitually assume a forward head position often develop neck pain and spasm of the posterior neck muscles. Neck pain is frequently accompanied by protective muscle spasms which develop pressure within the muscles which then produces ischemia, more pain and abnormal neck posture (Barlow, 1990; Enwemeka *et al.,* 1986; Plummer, 1982). Postural correction *per se* was found to relieve neck pain as effectively as some other physical therapy treatment procedures (Enwemeka *et al.,* 1986).

8.5 POSTURAL REHABILITATION

8.5.1 Introduction

In the first two studies described in this chapter an attempt was made to gain more insight into posture of primary school boys and adult males (sections 8.2

& 8.3, respectively). Both studies indicated the correctness of Woodhull *et al.*'s (1985) conclusion that a forward leaning posture is the norm, as well as the prevalence of misalignment between body segments. Scrutiny of work done by those involved in postural training, however, showed that this resulted in a change towards a more vertical stance, as well as an improved alignment between body segments (Barker, 1985; Barlow, 1990; Gelb, 1981; Lawson-Wood & Lawson-Wood, 1977; Macdonald; 1998; Rolf, 1977; Turner, 1965). In the following sections (8.5.2 & 8.5.3) two studies investigating the consequences of postural rehabilitation will be described. The first of these studies deals with the outcome of the use of an active-intermittent technique, while the second considers physical and mental impacts of participation in exercises/procedures aiming at the attainment of *poise.*

8.5.2 Body re-alignment and its effects on simple body movements

8.5.2.1 Methods

8.5.2.1.1 Subjects

Four young tennis players (2 boys and 2 girls) volunteered to take part in the study. Their ages ranged from 11 to 16 years.

8.5.2.1.2 Procedures

Before training commenced, the subjects were photographed in their usual standing positions with arms along their sides. Anterior, posterior and lateral pictures were obtained. Simple movements of walking and running were recorded on videotape. Similar procedures were used for re-evaluation.

The postural training course decided upon was the Mitzvah Exercise (Cohen-Nehemia, 1983; Cohen-Nehemia & Clinch, 1982). This exercise is an active-intermittent technique, which is easy to learn, and which can be practised without the presence of a highly trained instructor. The Mitzvah Exercise comprises a series of simple acts to be used in getting up from and sitting down in a chair and is designed to re-align the body, exercise every muscle and rebalance the body in relation to gravity.

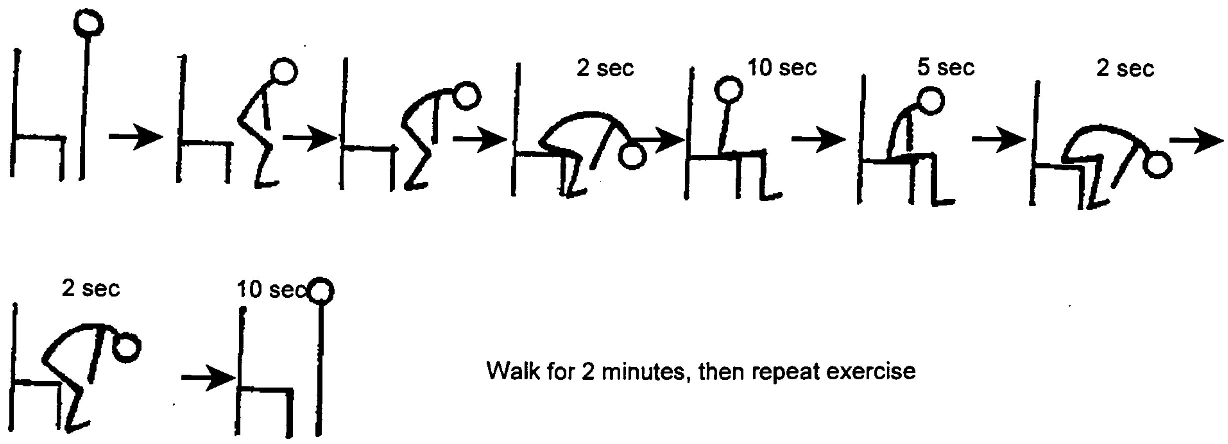

Fig. 8.8 The Mitzvah Exercise (Cohen-Nehemia, 1983; Cohen-Nehemia & Clinch, 1982). Postures are held for the periods indicated

The exercise is shown diagrammatically in Figure 8.8. The exercise consists of a series of simple acts to be used in getting up from and sitting down in a chair. No attributes to correct sitting or standing positions are given. Attention was paid to the process of changing from sitting to standing and vice versa (Cohen-Nehemia & Clinch, 1982).

The subjects were requested to do the set of exercises at home at least once daily. Their progress and correct execution of the exercise were monitored on a twice per week basis. They were again re-evaluated after a period of twelve weeks.

8.5.2.2 Results

The changes in body alignment are shown in Figure 8.9. In all the subjects a clear tendency towards a more vertical and balanced stance could be observed. The changes were observed in both the coronal and saggital planes.

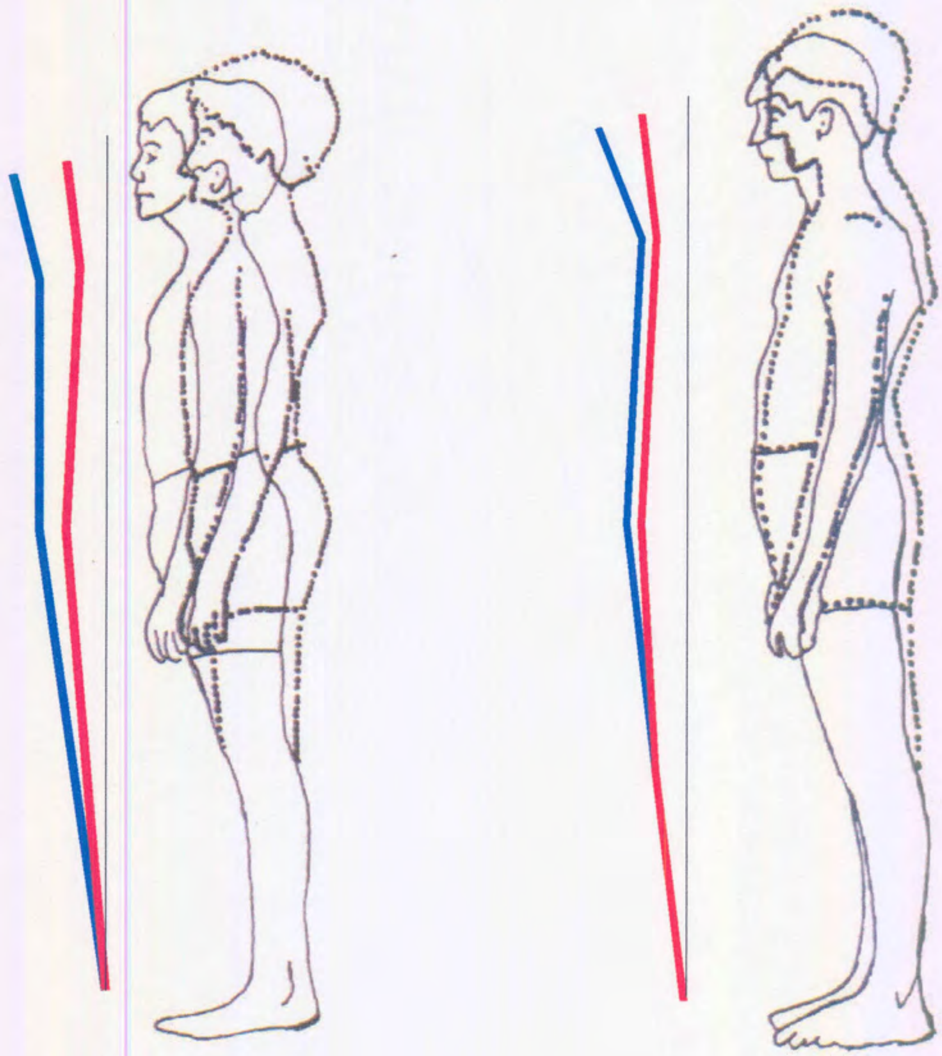

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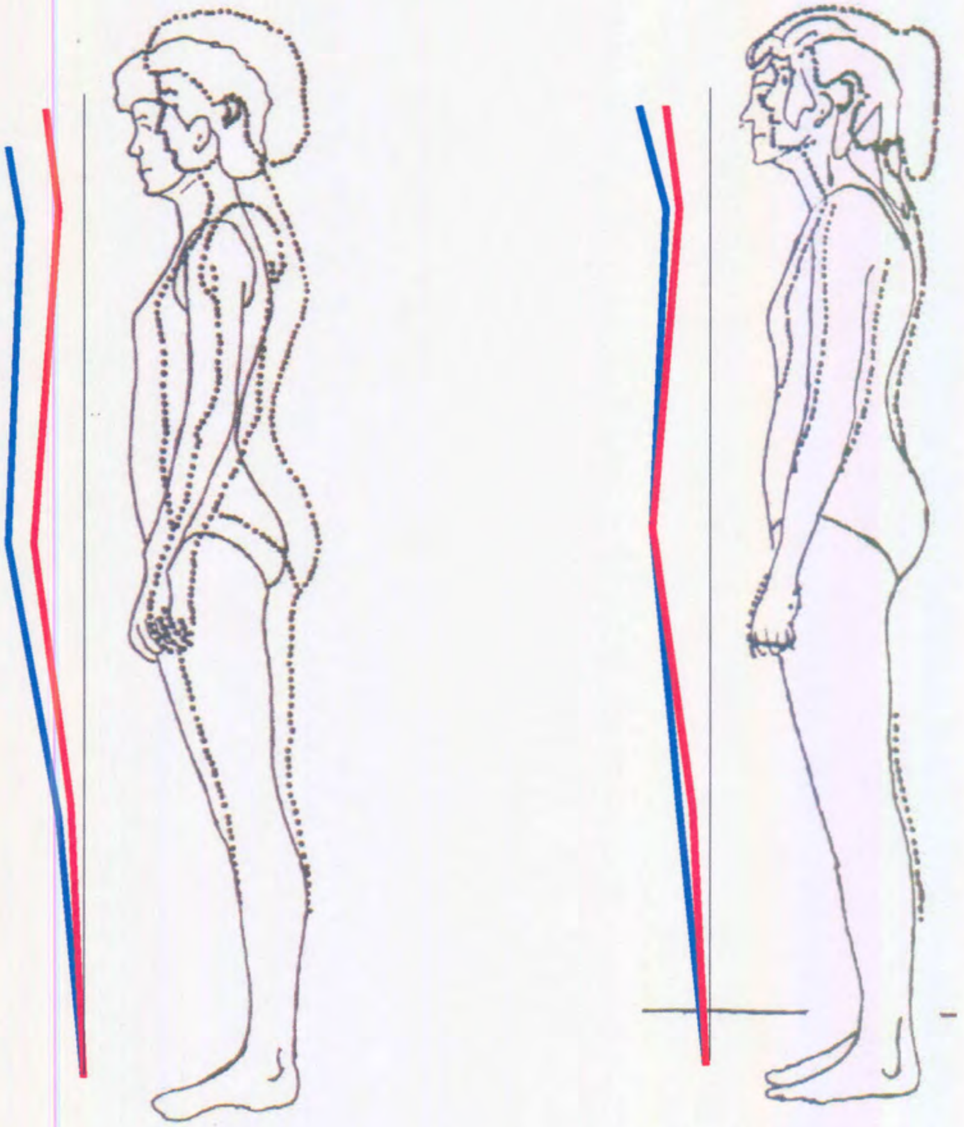
Fig. 8.9 The effect of the Mitzvah Exercise on posture of subjects. Before and after treatment postures are shown. Vertical alignment before treatment is shown in blue, while the effects of the Mitzvah Exercise on vertical alignment is shown in red.



c d

Fig. 8.9 (continued)

With time all subjects became aware of undue muscular tensions in their bodies, as well as a greater ease in movement.

Little or no change was found in the spinal curvature. Head carriage was improved in all subjects and forward poking of the chin decreased.

Walking and running were executed more economically, straighter and with less uncoordinated movement of the arms and legs. One subject noted a distinct change in the way he awaited a serve in tennis - prior to the Mitzvah Exercise he tended to assume a broad-based stance, which subsequent to intervention, narrowed to the feet being hip-width apart.

8.5.2.3 Discussion

Postural education/rehabilitation produces a more vertical and efficient biomechanical arrangement of the upright body and its segments. In the 1932 White House survey, it was found that exposure of children with postural defects, to a year of remedial exercises, resulted in improvement in posture in 62% of the subjects, 37% did not change, while 1% regressed (Kiernander, 1956).

Examples of the effect of postural rehabilitation was taken from the literature and is shown in Figure 8.10. For this purpose a series of photographs were selected from the literature (Barlow, 1990; Lawson-Wood & Lawson-Wood, 1977; Rolf, 1977; Turner, 1965) in order to demonstrate the physical outcomes of postural rehabilitation. All in all postural changes in 5 subjects were evaluated. Postural education/rehabilitation in these subjects was done by using various approaches, namely: The Alexander technique (Barker, 1981; Barlow, 1990; Macdonald, 1988), physical exercises (Turner, 1965), deep massage such as Rolfing (Lawson-Wood & Lawson-Wood, 1977; Rolf, 1977). In all the subjects examined the upright stance became more vertical, with a decrease in the spinal curvatures. The subject in Figure 8.10b shows a particularly well-balanced posture well in accordance with the idea of structures balanced on top of each other proposed by Barker (1985) and Rolf (1977).

For the duration period of the study, the Mitzvah Exercise did not result in any significant change in the curvature of the spine (Figure 8.9). In the subjects of the present study two basic changes were evident, namely a more vertical standing posture (Figure 8.9), and more economical movement. This may indicate that a change in posture could lead to concomitant changes in other aspects of motor control such as locomotion and other forms of movement. An example is the relationship between the superb bodily use and posture of the excellent riders from the Spanish Riding School in Vienna (Pevsner 1980). Watson (1995) observed that better posture was associated with decreased possibilities of injury. Another practical consequence of a more vertical stance, according to Pritchard (1985) is less tension in the calf and hamstring muscles (Watson, 1995), while Gelb, (1981) found that it improved running.

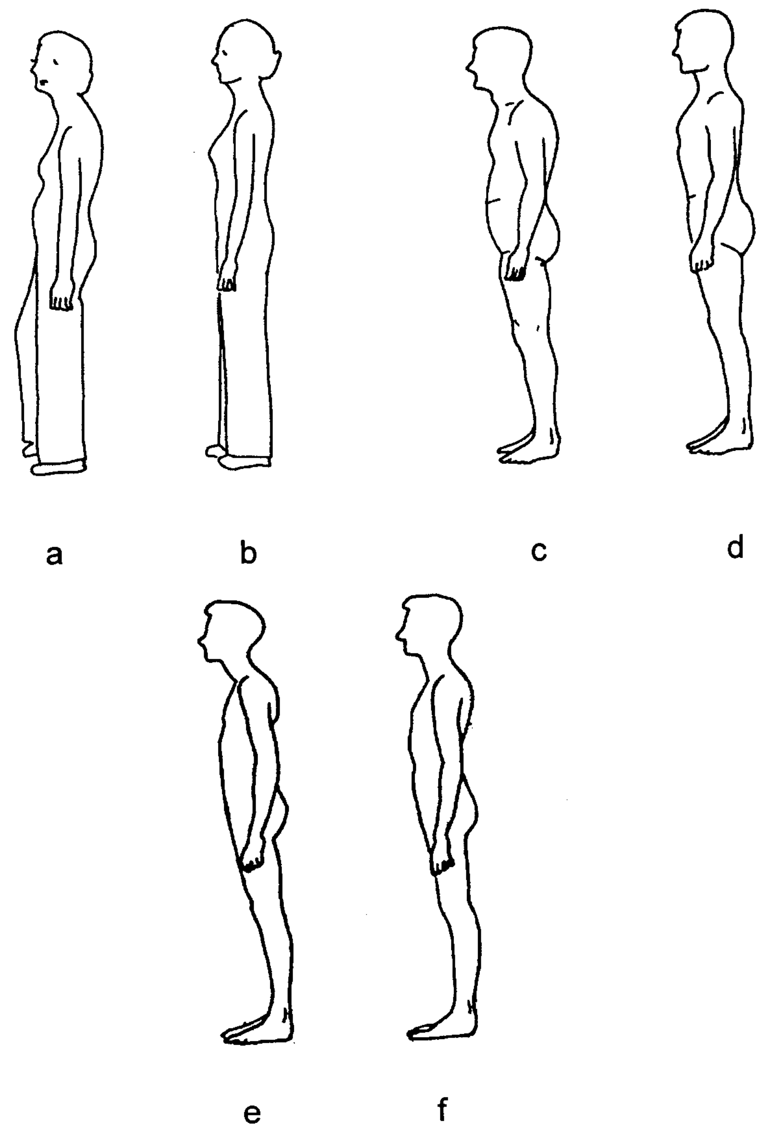


Fig. 8.10 **Some postures of those who underwent postural education/rehabilitation (adapted from Barlow, 1990; Barker, 1981; Lawson-Wood & Lawson-Wood, 1977; Rolf, 1977; Turner, 1965).**

The more vertical stance in the subjects was probably not only due to a mechanical change, but also due to a change in the way motor acts are controlled by the central nervous system. According to Cohen-Nehemia (1983) the body has a defence mechanism which can release contracted muscles before they adapt to their shortened, contracted state. Shortened, contracted muscles lose their sensory sensitivity (Plummer, 1982). The defence system can restore sensory sensitivity throughout the body and prevent loss of muscular stretching ability, strain of joints and connective tissue which gradually lead to distortion of the skeletal framework. In a body which functions efficiently the defence mechanism is activated instinctively by frequent body movements which involve the pelvis, thus freeing the body from pressures which interfere with its efficiency, realigns the body for better functionality, exercises every muscle and rebalances the body in relation to gravity (Cohen-Nehemia, 1983).

8.5.3 Subjective responses to postural education/rehabilitation in adults

Subjective responses of individuals who have undergone postural rehabilitation were investigated in this section of the study. The measurement tools were two questionnaires.

8.5.3.1 Methods

8.5.3.1.1 Subjects

For the purpose of this section of the study 6 subjects were selected. Two were trained in the Alexander Technique (Barlow, 1990; Brennan, 1992; Gelb, 1981), 1 in a combination of the Alexander Technique and Tai Chi Chuan, 2 in a combination of Somatics (Hanna, 1988) and the Alexander Technique and 1 had postural education on horseback. All the subjects had undergone at least a full year's (12 months) training and at least two years had elapsed since the training commenced. Physically, all the subjects have a near vertical alignment, with good body use.

8.5.3.1.2 The questionnaires

Two questionnaires (Tables 8.8 & 8.9) were compiled. The purpose of the first of these questionnaires was to obtain subjective information on the physical and psychological outcomes after receiving education in postural education/rehabilitation. Questions in this questionnaire were largely based on those proposed by Cailliet (1995), De Beer (1996) and Fischer (1995) for those who suffer from low back pain and osteoarthritis. The purpose of the second questionnaire was to determine whether assumptions made by those involved in bodywork (Brennan, 1992) can be verified. The gathering of information was not restricted to the questionnaires only - additional information was also obtained by means of free interviews with the subjects.

Table 8.8 Questionnaire to determine the physical and emotional outcomes of postural rehabilitation (Y = yes, N = no and U = unsure).

QUESTIONS			RESPONSES		
A: BEFORE REHABILITATION					
What was the main purpose for going for postural integration/rehabilitation?					
			Y	N	U
1.	Were you aware of any postural problem in your body? If yes please state whether you were aware of the following:				
	a	Hollow neck, forward poked head, shortened neck or retracted head?			
	b	Rounded shoulders and upper back?			
	c	Hollow back?			
	d	Stiffness in the neck?			
	e	Stiffness in the back?			
	f	Neck pain?			
	g	Pain in the back?			

QUESTIONS		RESPONSES		
		Y	N	U
h	Problems with activities of daily life such as walking, sitting, sitting down, getting up, climbing stairs, etc?			
2.	Were you aware of strain in any body-part before it became stiff or painful?			
3.	Did you have a tendency to tire easily?			
B: AFTER REHABILITATION		**Y**	**N**	**U**
1.	Are you currently aware of any problem in the body? If yes, go to the questions below:			
	a Has the position of your neck improved?			
	b Is your upper back straighter, and your shoulder blades more flat against your thorax?			
	c Is your lower back more flat?			
	d Do you still suffer from stiffness in the neck?			
	e Do you still experience stiffness in the back?			
	f Are you still suffering from neck pain?			
	g Is back pain still a problem?			
	h Are you aware of any problems with activities of daily life?			
2.	Are you still aware of strains in your body?			
3.	Has your concentration ability improved?			
4.	Do you still have a tendency to tire easily?			
5.	Did postural rehabilitation affect you emotionally? If so:			
	a Was it in a negative way?			
	b Was it in a positive way?			

Table 8.9 Questionnaire to evaluate feelings of subjects about their bodies based on the possible outcomes of postural integration as proposed by Brennan (1992) (Y = yes, N = no and U = unsure).

QUESTIONS		RESPONSES		
		Y	N	U
1.	Do you have a better understanding of the working of the body?			
2.	Do you have a heightened awareness of yourself and the world around you?			
3.	Do you find that you are using your body in a way that maintains your physical and psychological equilibrium?			
4.	Do you recognise interferences that you inflict upon the body's natural functions?			
5.	Do you use your thinking capacity to bring about desired change so that you may go about your daily activities in a more coordinated fashion?			
6.	Do you feel more aware on many levels?			
7.	Do you find that you can move in a way that carries a minimum amount of tension?			

8.5.3.2 Results and discussion

In an unbalanced body extra energy is expended in order to overcome the negative effects thereof (Robinson & Fisher, 1998). Tristan Roberts, formerly Reader in Physiology at the University of Glasgow (Macdonald, 1998: 18), explains this more explicitly:

> *The correction of some postural habits can significantly improve a person's well-being. For example, many people exert additional effort to supplement the muscular actions called for in maintaining uprightness and in supporting the limbs. As this*

extra effort frequently involves simultaneous activity in opposing muscle groups, the effect is to stiffen the joints and cause undue fatigue and even pain. To correct such habitual inappropriate muscular activity, the therapist must somehow induce the patient to become aware of the proprioceptive signals that initiate the unwanted activity. If this awareness can be achieved, the patient is provided with an opportunity of voluntary refraining from initiating the stiffening actions. His posture thereafter becomes more supple and, consequently, more comfortable to maintain.

All the subjects interviewed tired easily before treatment commenced (Table 8.10). After postural integration rehabilitation, only 1 subject alleged that she still tired easily. This supports Jones (1979) and Feldenkrais (1985) who maintained that well-balanced physical bodies are not prone to fatigue.

Before treatment all the subjects interviewed were aware of physical problems in their bodies (Table 8.10). After treatment five of the subjects were still aware of problems in their bodies.

The second questionnaire (Table 8.11) evaluated emotional responses to postural rehabilitation. All the participants responded positively to the whole of the questionnaire except for one subject who responded negatively to one of the 7 questions. The overwhelmingly positive emotional results to postural integration supports the contention that the mind and emotions can be affected by balance in the physical body. As the body becomes more symmetrical and upright, the personality becomes more open, expressive and softer (Painter, 1986).

The subject who still became easily tired, was also the only subject who reportedly did not feel more aware on many levels. This subject received her postural training in conjunction with sport training (riding lessons), and one could speculate that the two learning processes should rather be separated than integrated. However, much more work needs to be done in this field before a final opinion can be formulated.

Stiffness in the back was alleviated in all subjects, indicating that people with back problems could benefit from postural integration.

Stiffness in the neck seems to be a more persistent problem with all but 2 subjects retaining stiffness in the neck, despite therapy in postural integration.

All the subjects experienced a marked improvement in posture, irrespective of their initial postural shortcomings.

The reasons for attendance of postural rehabilitation training were varied, namely curiosity, low back and neck pain, and improvement of physical and mental awareness.

One of the aims as well as results of most bodywork techniques is the improvement of awareness, which can bring an improvement in a variety of mental attitudes such as focus and consciousness (Alexander, 1996; Feldenkrais, 1985; Painter, 1986; Rolf, 1977). Following treatment all the subjects reported a heightened awareness and understanding of their bodies (Table 8.11), emphasizing the fact that postural rehabilitation has the ability to bring about changes in the perception of the self as advocated, for example, by teachers of the Alexander Technique (Brennan, 1992).

Table 8.10 ***Response to questions about physical awareness about problems in the body before and after postural rehabilitation.***

QUESTIONS			RESPONSES	
A: BEFORE REHABILITATION			**Y**	**N**
1.	Awareness of postural problems in the body:		6	0
	a	Hollow neck, forward poked head, shortened neck or retracted head	4	2
	b.	Rounded shoulders and upper back	3	3
	c	Hollow back	4	2
	d	Stiffness in the neck	4	2
	e	Stiffness in the back	3	3
	f	Neck pain	4	2
	g	Back pain	3	3
	h	Problems with activities of daily life	0	6
2.	Awareness of strain in any body-part before it became stiff or painful		2	4
3.	Tendency to tire easily		5	1
B: AFTER REHABILITATION			**Y**	**N**
1.	Current awareness of any problem in the body:		5	1
	a	Improvement in the position of the neck	6	0
	b	Improvement in the shape of the upper back, and position of shoulder blades against the thorax	6	0
	c	Improvement in lordotic curve of lower back	6	0
	d	Decrease in stiffness in the neck	2	4
	e	Decrease in stiffness in the back	1	5
	f	Presence of neck pain	2	4
	g	Presence of back pain	1	5
	h	Problems with activities of daily life	3	3
2.	Awareness of strains in the body		5	1
3.	Improvement in concentration		4	2
4.	Tendency to tire easily		1	5

QUESTIONS		RESPONSES	
		Y	N
5.	Emotional response to postural rehabilitation	6	0
	a Negatively	0	0
	b Positively	6	0

Table 8.11 *Subjective responses to postural re-education.*

QUESTIONS		RESPONSES	
		Y	N
1.	Improved understanding of the working of the body	6	0
2.	Heightened awareness of oneself and the environment	6	0
3.	Using the body in a way that maintains physical and psychological equilibrium	6	0
4.	Recognition of interferences inflicted upon the body's natural functions	6	0
5.	Use of thinking capacity to bring about desired changes, in order to go about daily activities in a more coordinated fashion	6	0
6.	Increase of awareness on many levels	5	1
7.	Moving in a way that carries a minimum amount of tension	6	0

CHAPTER 9

CONCLUSION AND RECOMMENDATIONS

An individual in trouble unconsciously modifies his flesh, solidifies his mental attitude into biological concrete. When he does, the here-and-now goal of psychotherapy fails to have meaning for him (Rolf, 1977: 37).

9.1 CONCLUSION

When the present study was initiated, it was mainly with the intention of answering the following questions: Why do people not stand erect, and what significant physical and psychological consequences result from malposture? These questions led to interesting and sometimes unexpected answers. At the conclusion of this study the inference drawn is that posture should not be taken for granted as it is not simply a random occurrence. It was carefully developed by the human species over a period of millions of years, and as far as the individual is concerned, for most of his growing years. Yet, at present, this important aspect of humanness is unappreciated to such an extent that malposture has become an endemic problem, indicating individuals in trouble.

From an anthropological perspective, the erect, bipedal stance, which is exclusive to man, evolved over millions of years. Structures and their usages changed with time and requirement. Man adapted to his physical changes, not randomly but by developing specific deeper voluntary/skeletal muscles for posture which had previously been used only for movement. Muscular imbalances in the present time result from the fact that muscles are not used for their intended purpose, with the postural muscles, for example, showing an increased tendency to tighten or weaken (Alexander, 1932; Norris, 1995; Robinson & Fisher, 1998). This is probably the underlying physical cause of the various aspects of malposture such as scoliosis, lordosis, muscular imbalance and undue muscular tension (Alexander, 1932; Barlow; 1990; Janda & Schmidt, 1980; Lowen, 1994; Reich, 1999, Rolf, 1977).

Postural muscles, the stabilizing and endurance muscles, should work in synergy with the mobilizing, superficial muscles to attain the most favourable posture which would be the perfect posture (Robinson & Fisher, 1998; Robinson & Thomson, 1999). This ideal state is prevented by alterations in motor control, which may be brought about by stimulation of the limbic system, due to emotional factors and stress or by impairment of afferent input through a reduction in proprioception (Boadella, 1985; Lowen, 1969, 1971, 1975, 1994; Norris, 1995). Mobilizers may then take on a stabilizing role (Robinson & Thomson, 1999).

> *By the time we reach adult life, if not before, most of us will have developed tension habits which are harmful. The habits at first may show themselves only as trifling inconsistencies of behaviour, or perhaps as occasional muscular pain or clumsiness. Frequently, however, they show themselves as infuriating blockages which prevent us from giving our best just when we most need to, whether it be in the everyday business of personal relations, or in the more exacting situations of competitive sport, public speaking, making music or making love. In any situation, in fact, in which our FUNCTIONING is affected by our USE* (Barlow, 1990: 22).

> *It is the soma's internal process of self-regulation that guarantees the existence of the external bodily structure. Hence, the dictum that is universally valid in somatics: function maintains structure* (Hanna, 1986a: 6).

The present study provided convincing support for the concept of an integrated mind-body unity. This is an ancient Eastern concept, which views the human being as a single unity with many gradations. The human is thus a being of many interconnected layered depths, the body gaining its meaning in the spirit and the spirit its expressiveness in the body (Hanna, 1986b).

Hanna (1986b) considered the mind-body problem to have been solved during the past generation (30 years). During that time somatic ethics and somatic science came into being and self-responsibility, following on self-awareness, became the norm. There is now an increasing awareness of the fact that the condition of the human body can be influenced by how it is voluntarily used during its daily activities, as well as by external factors like nutrition and pollution. In the words of Hanna (1986b: 179) *.....somatic science is a science of self-awareness, a self-knowledge that surprisingly leads directly to self-control.*

In the wake of this spirit of taking responsibility for the own body, comes the spirit of learning. While a few decades ago there was a willingness to entrust the body's well-being to professionals, the trend is now more towards taking responsibility for the own body and working in conjunction with the professional. The attitude of being a victim of external forces such as circumstances or people, has been replaced by a willingness to actively take part in personal improvement and not to expect it to come from somewhere else or even to become dependent on a therapy (McCullough, 1995). Many therapies tend to be learning processes where people are trained in correct ways of using the mind and the body, and developing both to their maximum potential (Alexander, 1932; Barlow, 1990: Feldenkrais, 1972, 1985; Hanna, 1988; Hannaford, 1995; Lowen; 1994; Pang & Hock, 1984; Perls, Hefferline & Goodman, 1980; Pilates & Miller, 1998; Putkisto, 1997).

This attitude has particular significance in the realm of posture. Proponents of improved posture for physical benefits, have throughout this century advocated inner awareness of the physical body for the improvement of posture, with added psychological benefits as a side-effect. The ground-breaking work of teacher-therapists, rather than of exclusively therapists, is remembered today and is still being followed. Notable amongst these are Alexander, Dart, Feldenkrais, Lowen, Reich and Rolf (refer to Chapter 7), brave individuals who had practical experience of the effect of the body on the mind and who used the mind-body concept at a time before it became more generally accepted by conventional practitioners in the field of health.

Posture, having both a mind and body component, needs to be viewed from both a first person perspective as well as from a third person perspective. The observable, measurable and analysable body reveals universal physical and chemical principles from the third person point of view. Different data are observed from a first person viewpoint. Here somatic information is communicated to proprioceptive centres and self-observation takes place which is immediately factual - no interpretation through universal laws is necessary. The human being experiencing himself from the inside is a somatic phenomenon causing self-awareness and self-regulation (Hanna, 1986a).

Conditioning, however, is a procedure imposed upon an individual by external manipulations which reduce the repertoire of voluntary consciousness. Thus a condition termed sensory-motor amnesia may be the conditioned result of long-term stress conditions. Stressful stimuli constantly repeated, will cause loss of conscious voluntary control and sensation in areas of the body's musculature (Hanna, 1986a; Lowen, 1994; Reich, 1999). This phenomenon has been described by Mann (1999) in relation to another endemic condition, namely that of high blood pressure. He found a crucial connection between high blood pressure and emotions, not emotions actively experienced, but those harboured and not felt. In other words, most people with high blood pressure do not claim to feel particularly tense or angry, yet there was ample physical proof of their tenseness (Mann, 1999). This is an example of the effects of loss of bodily awareness as brought about by conditioning due to stress, and can be directly applied to malposture.

Due to the fact that malposture is many times more prevalent than good posture (Dart, 1947; Kiernander, 1956; Lawson-Wood & Lawson-Wood, 1977; Sherrington, 1946 and Chapter 8, this study), it is hardly noticed from either a first person or a third person viewpoint. However, once the condition is rectified, it is thoroughly noticed, both by the self and others. Improvement in posture facilitates ease of movement and smoother execution of physical tasks (Chapter 8, section 8.5). This is appreciated by both the self and the observer. Learning to bring the physical body into balance, allows the release of uncomfortable strains in some muscles with the added benefit of a more efficient energy use (Roberts, cited by Macdonald, 1998). Achieving a good posture and giving up a bad posture, is a serious commitment as patience is needed for this long term task. Effective posture training is accomplished by attempting it from the inside. Postural muscles are the deeper muscles that are stimulated, stretched or relaxed as the need may be. At the same time, following the evolutionary, developmental route of becoming erect, assures that the segments of the body attain the balance they were intended for.

Individuals are recognized by their postures; posture and personality are thus intertwined. As an example, protective or defensive attitudes of the shoulders are usually direct results of an emotional state of an individual, not necessarily an immediate feeling, but an unresolved past experience. The inner feelings become external expressions carried in the posture and inner imbalance translates into muscular imbalance which may become a permanent habit (Cailliet, 1995; Feldenkrais, 1985; Kiernander, 1956; Lowen, 1994; Reich, 1999). Muscular imbalances around the neck and shoulders affect the cervical or thoracic curve (or both) and the increase or decrease of any of these curves directly affects the rest of the spinal curves. Muscular imbalances in other parts of the body are then experienced, usually accompanied by misalignment. The result of the original defensive or protective attitude is malposture. The suggestion now is that reversing the procedure and treating the malposture, could probably result in eliminating the emotional imbalance (Katchmer, 1993). Once the body is free from the restraints of misalignment and/or malposture, a natural sigmoid shape asserts itself and undulates wavelike from the feet to the head when the body is viewed from the side. The spiral arrangement of the voluntary muscles becomes apparent in their functioning and in addition to the feelings of certainty and power inherent in the balanced position, free and flowing movements are executed.

Fostering an awareness of posture from an early age could serve as a preventative measure for many modern lifestyle diseases such as headaches and backaches ,while also playing a role in mental health.

9.2 RECOMMENDATIONS

9.2.1 Postural training

Early in this century Cochrane (1924: 312) remarked on what he perceived to be a necessity for modern mankind:

> *Problems relating to man's posture have a direct bearing on medical and surgical practice. Many of the chronic conditions requiring treatment represent a derangement of the mechanism which regulates and maintains the proper and correct posture of the body.*

Posture encompasses more than medical and surgical practice, numerous other aspects of human life can be improved by timely implementation of the following:

- ❑ Postural training in schools could profit scholars on an academic level and in the delicate childhood emotional sphere, since postures reflect the thoughts, feelings and moods (Kiernander, 1956; Sherrill, 1980) of children. They are more than passive indicators of emotions; they may have the capability of partially affecting the susceptibility to emotions (Riskind & Gotay, 1982). Alleviating malposture could go a long way in establishing emotional balance. Awareness and discipline brought about by postural training could benefit communication at all levels and improve inter-learner and inter-generation relationships.

- ❑ Posture forms the basis of all physical activity (Latash, 1998a; Massion et al., 1998). Any physical and/or sporting activity at any age should therefore be preceded and/or accompanied by postural training. This strategy could decrease unnecessary energy expenditure, ensure smoother movements and reduce the incidence of sport injuries (Watson, 1983, 1995). Once muscle balance has been brought about, any sporting activity can be approached with impunity.

  > *The lack of physical education in the young of our communities, especially at colleges and universities, is to be deplored. The lines on which such*

education should be carried out are indicated in an appreciation of proper posture and its resulting efficiency. Such work by the orthopaedic surgeon and educator represents the best kind of preventive medicine and should have a place in the programme of those who have charge of the health of the country (Cochrane, 1924; 312).

It is incredible that a pandemic problem (Dart, 1947) which has been identified so long ago, with its accompanying solution, should at present still elicit so little attention; especially when other problems such as obesity receive front page attention on a magazine such as *Time,* and on which millions are spent world wide (Gleic, 1999).

- ❑ Postural exercises, especially if linked to exercises suggested by Pilates and Miller (1998) and Wikler (1980), for example, can increase physical capacity and output at the work place. This is a way of optimizing the process of brain activation, leading to sustained vigilance, attention and memory span. Monotony at work may be diminished or eliminated and excessive, unproductive nervous tension reduced (Briedis *et al.,* 1978). Paying attention to the ergonomic designs of furniture and tools plays a great role in preventing malposture (Mandal, 1984). Loss of man-hours and financial expenditures can be prevented by eliminating headaches and backaches due to malposture.

- ❑ Health professionals may benefit their patients by being aware of the fact that some diseases have a postural origin, and therefore have a postural solution. More information about malposture and its implications can be to the advantage of health professionals.

- ❑ Training of therapists such as physical educators, biokineticists and physiotherapists in preventative and rehabilitatory methods in the field of posture, could make a significant impact on the general health of society. An in depth instruction in the function of the neuromuscular-skeletal (tripartite) system, postural muscles and nervous control of posture, is essential if a worthwhile contribution by therapists is to be made.

9.3 AREAS FOR FUTURE RESEARCH

Areas for future research were identified from this study. Some of them may include aspects discussed under "Recommendations" (section 9.2). Main areas would be in the realms of the physical and the psychological.

9.3.1 The physical aspects of posture

In the physical domain the following aspects of posture need careful consideration:

- A critical issue which has never been fully investigated is that of what actually constitutes optimum posture and body alignment. Most of this research will firstly have to be based on in-depth studies on the ideal theoretical biomechanical models of posture during standing, sitting and movement, and secondly on the investigation of these principles on human subjects, especially on those who are well trained in correct body mechanics.

- The nature and extent of postural defects in the South African population. Especially relevant would be an investigation into postures and body mechanics of urban and rural populations. In this respect rural populations would constitute those who still live outside the influence of western civilization.
- Empirical studies on the extent of the link between posture and movement could examine the connection between posture and movement as found in daily functional movements, as well in the realm of performing arts and competitive sport.

- Physical problems such as chronic muscle pain, low back and neck pain, pain resulting from tension in so-called trigger points.

9.2.2.2 The psychological and social aspects of posture

Psychological and social aspects of the study merit further investigation. These comprise the following:

- The nature and the extent of the link between posture (use) and the psyche in all its ramifications, such as emotions, intelligence, moods, performance in cognitive and learning tasks, personality and its disorders,

- The role and effect of posture in verbal and non-verbal communication.

- Posture as the cause of stress and posture rehabilitation in the ability to cope with stress.

- The role of posture training in the prevention of mood- and anxiety disorders as well as antisocial behaviour, which may include criminality.

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