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COMPARISON OF PHYSICAL WELLNESS OF SUBJECTS IN SEDENTARY AND ACTIVE WORK ENVIRONMENTS

By

LEE-ANNE NAICKER

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SUPERVISOR: DR P J du TOIT

CO-SUPERVISOR: PROF P E KRUGER

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Foreword

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Abstract

Title:	Comparison of physical wellness of subjects in sedentary and active work environments
Candidate:	Ms L Naicker
Supervisor:	Dr PJ du Toit
Department:	Physiology
Degree:	MSc: Human Physiology

The concept of wellness has transformed over the decades with the ever-adapting lifestyle of society and thus can be broadly defined as the responsibility of the individual through practicing health-promoting lifestyle behaviour. There are various factors that contribute to an individual's sense of overall physical wellbeing which can be categorised into skill-related and health-related components which have been extensively investigated. However, there is a considerable lack of evidence regarding the integration of these components. This study thus sought to determine a means of integrating the various components of physical wellness to provide an indication of wellness state.

This was approached from two avenues: the first (Study 1) explored a component of wellness to ascertain whether it can be used as a measure in determining overall physical wellness and the second (Study 2) assessed the influence of physical activity on various wellness parameters and utilised these wellness parameters in the derivation of an overall physical wellness indicator to determine an individual's state of overall wellbeing.

Study 1 involved comparing Sports vision between sedentary and active work environments in a sample of 158 university students and 230 training recruits. The participants were subjected to various visual skill assessments to determine if an active environment transfers to visual proficiency. The results indicate that while the recruits were more proficient in some skills, students displayed a greater aptitude in other areas. The findings obtained in this study are in concert with previous research, indicating that individuals exposed to physical activity, even for a short period of time, tend to acquire superior visual skills. However, the skills are honed according to the field of expertise due to the transfer effect that occurs in the brain.

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The concept of Sports vision that was explored in this study provided insight into its role in wellness and it was suggested that these assessments can be utilised in assessing overall physical wellness.

Study 2 delved into the area of overall physical wellness and explored the components and influence of an active work environment on these components. 165 undergraduate university students and 234 training recruits and law enforcement employees underwent several wellness assessments in a bid to compare overall physical wellness in sedentary and active work environments. The individual results were compared, and scored into risk areas that were ultimately compounded to formulate an overall physical wellness indicator. It was found that the students were superior in some areas of wellness; however the recruits possessed a greater state of overall physical wellness. This indicates that physical activity does contribute significantly to attaining a state of overall physical wellness and thus reduces the risk of developing lifestyle-related chronic conditions.

The overall findings suggest that maintaining a healthy lifestyle through physical activity and health-promoting behaviour will result in a greater state of wellness. This area of research has unfolded a host of possibilities for future research, especially into the overall wellness indicator and the integration of the health and skill-related components of overall physical wellness.

Key terms: wellbeing, sedentary lifestyle, active lifestyle, physical activity, overall physical wellness indicator

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Abstrak

Titel: Vergelyking van fisiese welstand van proefpersone in sedentêre en aktiewe werksomgewings

Kandidaat: Ms L Naicker

Promotor: Dr PJ du Toit

Departement: Fisiologie

Graad: MSc: Menslike Fisiologie

Die konsep van welstand het oor die dekades verander saam met die altyd aanpasbare lewenstyl van die samelewing en kan dus algemeen omskryf word as die verantwoordelikheid van die individu deur die beoefening van gesondheidsbevorderende lewenstyl gedrag. Daar is verskeie faktore wat bydra tot ŉ individu se gevoel van algehele fisiese welstand wat in vaardigheidsverwante en gesondheidsverwante komponente, wat al omvattend ondersoek is, gekategoriseer kan word. Daar is egter ŉ groot gebrek aan bewyse ten opsigte van die integrasie van hierdie komponente. Hierdie studie probeer dus om ŉ manier van integrasie van die verskillende komponente van fisieke welstand te bepaal om sodoende ŉ aanduiding van die welstand toestand te verskaf.

Dit is genader vanuit twee rigtings: die eerste (Studie 1) het die komponente van welstand ondersoek om vas te stel of dit as ŉ maatstaf vir die bepaling van vir algehele fisiese welstand gebruik kan word, en die tweede (Studie 2) het die invloed van fisiese aktiwiteit op hierdie verskillende welstand parameters geassesseer en het die welstand parameters benut in die derivasie van ŉ algemene fisiese welstand aanwyser om ŉ individu se toestand van algehele welstand te bepaal.

Studie 1 behels die vergelyking van Sportsvisie sedentêre en aktiewe werksomgewings in ŉ steekproef van 158 universiteitsstudente en 230 opleidings rekrute. Die deelnemers was onderworpe aan verskeie visuele vaardigheidsassesserings om te bepaal of ŉ aktiewe oordra tot visuele bekwaamheid. Die resultate dui daarop dat, terwyl die rekrute meer bekwaam was in sommige van die vaardighede , het die studente ŉ groter aanleg in ander gebiede getoon. Die bevindings verkry uit hierdie studie is in ooreenstemming met vorige navorsing, wat aandui dat individue wat aan fisiese aktiwiteit blootgestel word, selfs

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vir ʼn kort tydperk, geneig is om beter visuele vaardighede aan te leer. Egter, is die vaardighede geslyp volgend die gebied van kundigheid te danke aan die oordrag effek wat in die brein voorkom.

Die konsep van Sportsvisie wat in hierdie studie ondersoek is, verskaf insig in Sportsvisie se rol in welstand en dit was voorgestel dat hierdie assesserings kan benut word in die assessering van algehele fisiese welstand.

Studie 2 het gedelf in die gebied van algehele fisiese welstand en het die komponente en die invloed van ʼn aktiewe werksomgewing op hierdie komponente ondersoek. 165 voorgraadse universiteitsstudente en 234 opleidings rekrute en wetstoepassings werknemers het verskeie welstandsevaluerings ondergaan in ʼn poging om die algehele fisiese welstand in die sedentêre en aktiewe werksomgewings te vergelyk.Die individuele resultate was vergelyk, en punte toegeken in risiko-areas wat uiteindelik saamgestel is om ʼn algehele welstandsaanwyser te formuleer. Daar is gevind dat die studente beter in sommige gebiede van welstand was; maar die rekrute het ʼn groter toestand van algehele fisiese welstand beskik. Dit dui daarop dat fisiese aktiwiteit aansienlik bydra tot die verkryging van algehele fisiese welstand en dus die risiko te verminder om leefstyl-verwante chroniese toestande te ontwikkel.

Die algehele bevindinge dui daarop dat die handhawing van ʼn gesonde lewenstyl deur fisiese aktiwiteit en gesondheidsbevorderingsgedrag sal lei tot ʼn beter toestand van welstand.Die gebied van navorsing het menigte moontlikhede vir toekomstige navorsing ontvou, veral in die algehele welstandsaanwyser en die integrasie van die gesondheid en vaardigheidsverwante komponente van algehele fisiese welstand.

Sleutelterme: welsyn, sedentêre lewenstyl, aktiewe lewenstyl, fisiese aktiwiteit, algehele fisiese welstandsaanwyser

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Chapter 1 : Introduction

"The doctor of the future will give no medicine, but will interest his patients in the care of the human frame, in proper diet, and in the cause and prevention of disease" (1: p.273)

– Thomas Edison

1.1 Overview

In 1964 the World Health Organization (WHO) defined wellness as "a state of complete physical, social and mental wellbeing and not merely the absence of disease or infirmity" (2: p.354). This definition, while widely accepted, is highly idealistic since it is almost impossible for the individual to truly attain a sense of holistic wellbeing in all areas. Thus, Hurley et al., as cited in Edlin et al., (3) proposed an amended definition of wellness which places the responsibility of overall wellbeing on the individual through lifestyle behaviours which promote health. This ensures that the onus is on the individual to attain a holistic sense of well-being through lifestyle modifications.

At the dawn of the 20th century, the most common illnesses in Western society were communicable diseases such as influenza, polio, diphtheria and tuberculosis (4). Progress in the medical field has largely eliminated these diseases, thus affording people the privilege of a higher quality of life and longevity. With the advent of these advances, sedentary behaviour such as lack of physical activity, high-fat and low-fibre diets, and increased psychological stress was fostered. This paralleled an increase in the incidence of chronic diseases, including type 2 diabetes mellitus, cardiovascular disease, cancer and chronic respiratory disease. According to the WHO (5), these non-communicable diseases currently account for 60% of the total number of deaths worldwide.

While the incidence of chronic illnesses continued to increase, it was revealed that prevention is the most effective route in maintaining optimal health. This gave rise to the fitness and wellness movement, as findings showed that maintaining a healthy

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state is self-controlled and adhering to positive lifestyle habits could prove successful in preventing the leading causes of premature death (5).

There is ample evidence to suggest that exercise greatly improves an individual's quality of life. However, by the end of the 20th century it was confirmed that physical activity and exercise alone was insufficient to ensure better health and lower the risk of disease (6). The notion of being healthy as merely the absence of illness has long been discarded and is continuing to evolve as the effects of lifestyle factors on wellness is investigated (5). Attaining a state of wellness requires a concerted effort in staying healthy and achieving the highest potential for wellbeing. Wellness requires implementing positive lifestyle habits to change behaviour and in so doing, improvement in health, quality of life and total wellbeing can be achieved (5).

For all intents and purposes of this study, physical wellness will be partitioned into two components, namely health-related wellness and skill-related wellness. Health-related components are necessary for health and effective performance of daily functional activities (7-9). These components include heart health, muscular strength, muscular endurance, flexibility, body composition, stress perception and nutrition. Skill-related components comprise speed, power, agility, balance, reaction time and visual aptitude. Although these components are not crucial for improving health, they contribute primarily to achieving success in the sporting environment (8, 9).

Although wellness has been studied extensively, the focus has mostly been placed on the psychological and nutritional stance. However, the holistic approach of physical wellness which combines health-related and skill-related components have been neglected (10).

Owing to the increasing global crisis of health deterioration due to lifestyle, the necessity to focus on attaining a sense of wellness is particularly prevalent. Haby et al., (11) predicts that at the current obesity prevalence rate, 33% of Australian children between the ages 5-19 will be overweight or obese by the year 2025, as will 83% of males and 75% of females aged 20 years and older. This will have a

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considerable impact on the global disease burden with far-reaching consequences. Therefore, early recognition and intervention measures are essential in ensuring that this calculated prediction does not come to fruition.

Exploring the physiological components of wellness is prevalent especially in the corporate industry as there has been an explosion of popularity in the market of wellness centres (12, 13). These programmes offered by the wellness centres have received strong commercial support of late and are promoted with vigour and enthusiasm. Although there have been promising studies, drawbacks are caused through controversy and lack of evidence showing how these factors collectively result in an improvement in overall wellness. Taking this into account, the current study seeks to contrast sedentary and active environments in terms of overall physical wellness and identify which areas necessitate appropriate interventions.

1.2 Classifying sedentary and active work environments

Sedentary behaviour can be defined in two overlapping senses. Firstly, Lowry et al., (14) defines it as inadequate physical activity of moderate intensity. Secondly, Lovelady et al., (15) define sedentary as participating in exercise no more than once per week for the duration of three months.

In addition to defining sedentary behaviour, it is necessary to clearly define physical activity and exercise. The American College of Sports Medicine (ACSM) (16) defines physical activity as body movements caused by skeletal muscle contraction which results in a significant increment above that of resting energy expenditure. In their review on physical activity, exercise and physical fitness, Caspersen et al., (8) categorise exercise as a subdivision of physical activity that encompasses a structured, repetitive program for ultimately maintaining or improving physical fitness level. In addition, Caspersen et al., (8) describes physical fitness as health or skill related attributes that enable an individual to perform daily activities with vigour and alertness, while still being able to manage leisure-time pursuits and unforeseen circumstances without experiencing any undue fatigue.

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There is a dose-response correlation between physical activity and exercise and health outcomes, to the extent that the effects experienced from maintaining physiological health and fitness is a function of the quantity of physical activity pursued (17). The volume of physical activity can be partitioned into individual components, which is termed the 'FITT' principle. This denotes the frequency, intensity, type, and time (18). By modifying the components of this principle, physiological changes will occur on a gross and cellular scale. This adaptation will result in improved physical fitness (19). One of the ways to measure whether the amount of physical activity can be considered in the sedentary or active range is to measure intensity. This is done by assessing the metabolic equivalents (METs) which attempt to quantify the amount of energy expended in performing a particular activity. This can be described as the metabolic energy burning rate (20). Therefore, the achieved MET level can be considered as the overall level of exertion an individual experiences when participating in physical activity.

The ACSM and Centres for Disease Control and Prevention (CDC) (16) have defined physical activity according to METs: light physical activity requires less than 3 METs, moderate activities between 3-6 METs, and vigorous activities more than 6 METs. Table 1.1 classifies common activities as light, moderate or vigorous intensity according to the level of METs (16: p.4).

Several studies categorise sedentary activity with lifestyle-physical activity or leisure-physical activity, in that it is 3 METs or below. In previous reviews, lifestyle physical activity was defined as at least 30 minutes of moderate to vigorous intensity physical activity of the individual's choice per day; this can include either planned or unplanned leisure, occupational or household activities (21). In Dunn's review (21), it was found that in comparing a structured exercise program with lifestyle physical activity, both programmes displayed an improvement in risk factors such as cholesterol profile, systolic blood pressure, body composition and maximal oxygen consumption. However, the focus was to assess which group had the highest maintenance record.

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Table 1.1: Classification of various intensities of physical activity according to MET values (16)

LIGHT (< 3 METs)	MODERATE (3 – 6 METs)	VIGOROUS (> 6 METs)
Walking Walking slowly around home, store or office = 2.0	**Walking** Walking 3.0mph = 2.0 Walking at a very brisk pace (4.0 mph) = 5.0	**Walking, jogging and running** Walking at a very brisk pace (4.5 mph) = 6.3 Walking/hiking at a moderate pace and grade with no or light pack (< 10 pounds) = 7.0 Hiking at steep grades and pack 10 – 42 pounds = 7.5 – 9.0 Jogging at 5 mph = 8.0 Jogging at 7 mph = 11.5
Household and occupation Sitting – using computer, work at desk, using light hand tools = 1.5 Standing, performing light work, such as making bed, washing dishes, ironing, preparing food or store clerk = 2.0 – 2.5	**Household and occupation** Cleaning, heavy – washing windows, car, clean garage = 3.0 Sweeping floors or carpet, vacuuming, mopping = 3.0 – 3.5 Carpentry – general = 3.6 Mowing lawn = 5.5	**Household and occupation** Shoveling sand, coal, etc = 7.0 Carrying heavy loads, such as bricks = 7.5 Heavy farming, such as bailing hay = 8.0 Shoveling, digging ditches = 8.5
Leisure-time and sports Arts and crafts, playing cards = 1.5 Billiards = 2.5 Boating – power = 2.5 Croquet = 2.5 Darts = 2.5 Fishing – sitting = 2.5 Playing most musical instruments = 2.0 – 2.5	**Leisure time and sports** Badminton – recreational = 4.5 Basketball – shooting a round = 4.5 Bicycling on flat surface – light effort (10 – 12 mph) = 6.0 Dancing – ballroom, slow = 3.0 Ballroom, fast = 4.0 Fishing from river bank and walking = 4.0 Golf – walking, pulling clubs = 4.3 Swimming, leisurely = 6.0 Table tennis = 4.0 Tennis doubles = 5.0 Volleyball – non-competitive = 3.0 – 4.0	**Leisure-time and sports** Basketball game = 8.0 Bicycling on flat surface – moderate effort (12 – 14 mph) = 8.0; fast (14 – 16 mph) = 10.0 Soccer – casual = 7.0; competitive = 10.0 Swimming – moderate/hard = 8.0 – 11.0 Tennis – singles = 8.0 Volleyball – competitive at gym or beach = 8.0

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Another method of measuring sedentary or active lifestyle is through aerobic capacity, also known as VO_{2max}. This describes the volume of oxygen burned per minute per kilogram of body weight, or rather the maximal amount of oxygen that the muscles is able to efficiently utilize per minute during physical activity (17, 20). Studies have shown that achieving VO_{2max} values of 35 and 32.5 ml/Kg/min for men and women respectively through participating in physical activity may be sufficient for significantly lowering the risk of all-cause mortality (5). The decline in VO_{2max} with age progression has been well documented (22). Despite outcomes that VO_{2max} continued to decrease between 8-15% per decade in an age-related manner among endurance athletes with sustained exercise over a 20 year period, the mainstream findings are that individuals who are physically active sustain a 10-50% higher aerobic capacity than their sedentary counterparts (22).

1.3 Characterising overall physical wellness

The concepts of health and wellness are often used synonymously owing to their close association and interdependence since they both rely on the physiological, psychological, emotional, social, spiritual and environmental factors that contribute to the overall quality of a person’s life (3). However, Edlin et al., (3) make a clear distinction between health and wellness; health is a dynamic process that accounts for daily decisions in reaching a homeostatic balance, whereas wellness includes recognising that some influences and decisions are not healthy and finding suitable alternatives.

In order to maintain a state of wellbeing, individuals need to be physically active, display no signs of illness and be free of risk factors for lifestyle-induced diseases. The wellness continuum, as illustrated in Figure 1.1, displays the relationship between health and wellness (3: p.4, 5: p.14). Therefore, even though an individual demonstrates an adequate level of fitness when assessed, indulging in unhealthy lifestyle behaviours will increase the risk of developing chronic diseases and diminish the individual’s wellbeing (5).

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Figure 1.1: The Wellness Continuum (3, 5)

The association between physical activity, physical fitness and health is a complex interaction, as illustrated in Vanhees et al., (figure 1.2) (7). This approach highlights the health-related component of wellness, which is essentially *"the state of physical and physiological characteristics that define the risk levels for the premature development of diseases or morbid conditions presenting a relationship with a sedentary mode of life"* (7: p.103). In addition, this approach highlights the influence of exercise on the health-related and skill-related components of wellness (7).

Figure 1.2 depicts the relationship between physical activity, physical fitness and health; in so doing, the factors influencing health and wellness (7: p.103). The extent of this influence can be divided into three areas, namely modifiable, partially-modifiable and non-modifiable factors. Modifiable factors include lifestyle and health care. Lifestyle accounts for the most significant impact on health and wellness and has often been found to meet with adversity in terms of change. Amendments to lifestyle includes changing diet and exercise routines, as well as daily habits to fulfil all dimensions of wellness as discussed in the previous section. Health care includes attending routine assessments and empirically monitoring one's health status and making adjustments accordingly. In terms of maintaining a sense of wellness, the focus is on preventative health care as opposed to treating an existing condition. Genetic factors are classified as non-modifiable since a person can merely attempt

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to reduce the risk of developing certain conditions such as type 2 diabetes mellitus, hypertension, and atherosclerosis by making the necessary lifestyle and health-care adjustments. However, there are unavoidable genetic conditions that a person can gain a sense of wellbeing only through maintaining the condition and delay progression. Environmental influences are considered partially-modifiable as the individual has the capacity to change his or her environment. However, the premise of attaining a sense of wellness is to cope despite the external influences.

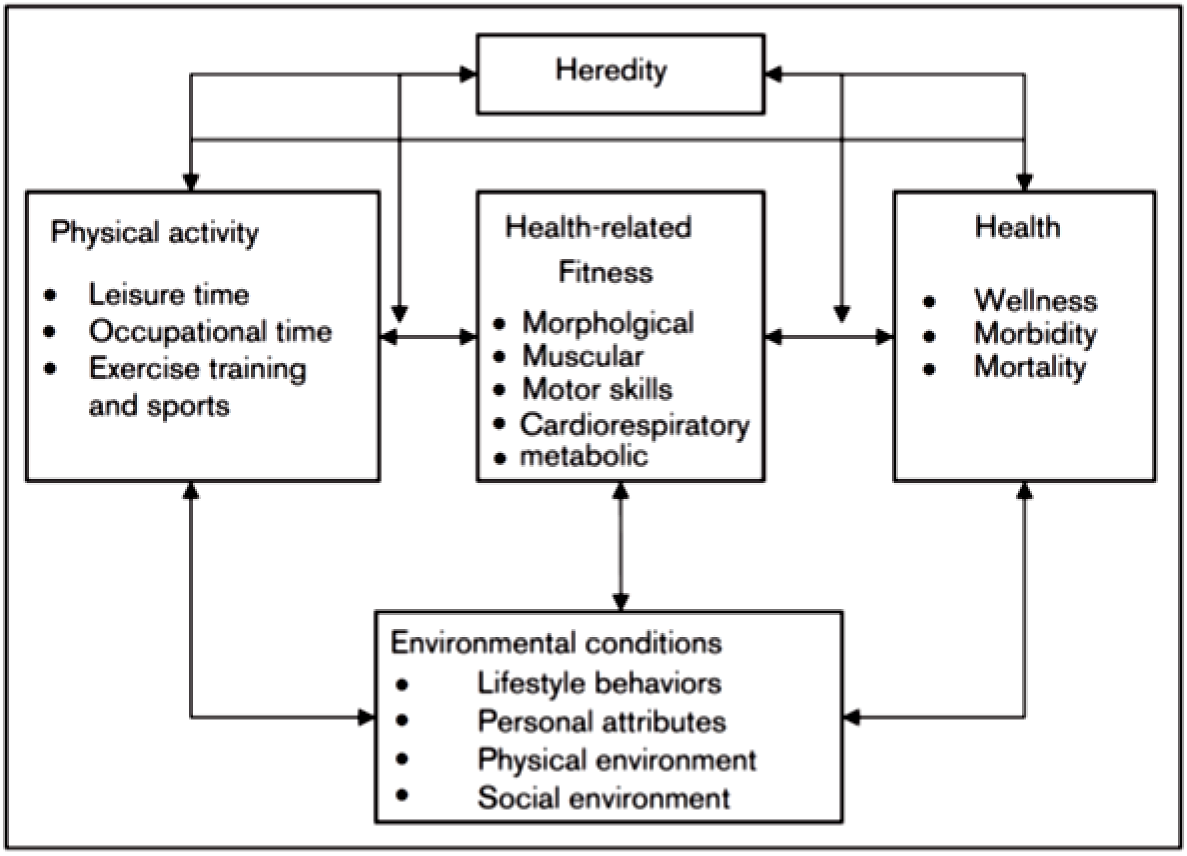

Figure 1.2: Factors affecting health and wellness (7)

With the increasing trend towards unhealthy lifestyle habits, the necessity for a means to elucidate which areas of wellness require attention seems warranted. In support of this notion, Ford et al., (23) conducted a study on 1,580,220 individuals between 1996 and 2007 to determine the trend in low-risk lifestyle factors. They found that as time progressed, the percentage of individuals meeting all low-risk lifestyle factors for chronic diseases, namely smoking cessation, participating in

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exercise, consuming the recommended amount of fruits and vegetables, as well as a body mass index (BMI) below 25, decreased from 8.5% in 1996 to 7.7% in 2007.

1.4 Dimensions of wellness

Owing to wellness being a dynamic process as well as continual, all dimensions are interrelated and integrated such that discord in one will influence the others. This is the manner by which lifestyle-related diseases are caused (3). Figure 1.3 illustrates the multidimensional quality of wellness and its interrelatedness. This shows that the concept of wellness merely surpasses the absence of disease. Wellness incorporates factors such as adequate fitness, proper nutrition, stress management, disease prevention, and spirituality, not smoking or abusing drugs, personal safety, routine physical examinations, health education, as well as environmental support (5).

Figure 1.3: Dimensions of Wellness (3)

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Physical wellness is the factor most commonly associated with being healthy. Physically well individuals exhibit proficiency in both health-related and skill-related areas of wellness (5). It involves maintaining a healthy body through adequate nutrition state, engaging in physical activity, avoiding harmful habits, making informed and responsible decisions regarding health, as well as participating in activities which help prevent illness (3).

Emotional wellness involves striving to ultimately attain emotional stability through an individual's understanding of his or her feelings and accepting limitations (5). Furthermore, it implies the ability to express emotions appropriately, adjust to change, and cope effectively with stress. Emotional wellness is accompanied with a certain degree of stability which includes the ability to view both successes and failures with equal regard and continue moving along a predetermined course. Emotional wellness also involves happiness which is considered to be a long-term state of mind that permeated the various facets and influences an individual's outlook (6). Research findings suggest that emotionally well people are subject to the same daily failures and set-backs as individuals who are not in that state of wellbeing; however the difference lies in the emotionally well individual's ability to recover (5).

Environmental wellness refers to the influence of an individual's general environment on his or her state of wellbeing. Adverse effects of health are experienced when exposed to a polluted, toxic and unsafe environment. Therefore, removing oneself from an adverse environment or taking measures to protect against environmental hazards is bound to ensure achieving a state of wellness in this aspect (5). The environmental aspect of wellness has been found to be pivotal in attaining a sense of well-being (5). This is especially relevant in terms of socio-economic status, level of education and patient history – it has been shown that individuals with a lower income, less than a high school qualification, or a history of hypertension or diabetes, display a disregard for striving to attain a sense of wellness and are less likely to adopt a healthy lifestyle (10).

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Mental wellness, also known as intellectual wellness, involves being open to new ideas and concepts. Intellectually-well individuals constantly seek new challenges and experiences (3). The key features of this dimension of wellness include application of knowledge gained through learning, creating opportunities to further education and constantly engaging the mind to interact with the environment (5).

Spiritual wellness is the state of harmony with oneself and with others. It is the ability to balance one's inner needs with the demands of the rest of the world. Spiritual wellness is said to provide a connection that integrates all dimensions of wellness (3). Pursuing these avenues may lead to personal freedom, including prayer, faith, love, closeness to others, peace, joy, fulfilment, and altruism. Several studies have reported a positive relationship among spiritual wellbeing, emotional wellbeing, and satisfaction with life (5).

Occupational wellness involves possessing a sense of fulfilment in a person's profession as well as in that person's contribution to society. In the professional environment it refers to having skills such as critical thinking, problem solving and good communication (3). Individuals who possess a sense of occupational wellness are able to maximise their skills while still having the ability to gain new ones. Occupational wellness enhances opportunity for advancement and recognition of achievement. Occupational wellness encourages collaboration and interaction among co-workers which fosters a sense of teamwork and support (5).

Social wellness refers to the effectiveness by which an individual is able to perform his or her role in a social construct (3). It involves a concern for self, humanity and the general environment. A hallmark of social wellness is the ability to relate to and interact with others. An individual's sense of self allows for the extension of respect and tolerance of others, thus enabling one to maintain close relationships with other people (5).

It is necessary to consider the interrelatedness of all dimensions of wellness in the exploration of a specific dimension. While the present investigation aims to delve into

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the area of physical wellness, aspects of the other dimensions of wellness are also considered owing to their extensive influence.

1.5 Benefits of attaining a sense of overall wellness

One of the primary modifiable contributors to overall wellness is physical activity. Physical activity has proven to reduce the risk of several conditions such as type 2 diabetes mellitus, cardiovascular disease, hypertension and hyperlipidaemia (24).

Several studies on the benefits of physical activity have been conducted and have indicated positive effects on the cardiovascular, respiratory, endocrine, and musculoskeletal systems. More specifically, physical benefits of exercise such as an increase in muscle strength, range of motion, flexibility, posture, and endurance; all promote self-sufficiency and decrease feelings of depression, dependence, and lack of control (25-27). Regular participation in physical activity also tends to reduce anxiety, improve mood, and enhance an individual's ability to perform daily tasks. These benefits are integral in creating a holistic sense of wellness and also risk reduction of several lifestyle-induced diseases.

King et al., (10) conducted a study on middle-aged individuals and found that adopting healthier lifestyle habits such as a diet which contains recommended quantities of fruits and vegetables, exercise, maintaining a healthy weight and smoking cessation reduced mortality by 40% and the risk of cardiovascular disease by 35% after a four year period in comparison to people with less healthy lifestyles. Furthermore, it was also found that this occurred independent of age, race, gender, patient history, and socioeconomic status (10).

One of the fundamental benefits of engaging in physical activity is the reduced risk of mortality. A review by Warburton et al., (27) asserted that increasing physical activity by 1 MET has the ability to reduce the mortality risk by 20%. Dubbert (28) reported an inverse dose-response relationship between physical activity and mortality in conditions such coronary heart disease, stroke, and colon cancer. There is also substantial evidence indicating the positive influence of physical activity on

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conditions such as non-insulin dependent diabetes mellitus, osteoarthritis and obesity (28). However, in some conditions such as cancers and non-insulin dependent diabetes mellitus, the exact mechanisms have yet to be established.
While several studies are in favour of 30 minutes of leisure activity coupled with an eight hour working day to combat cardiovascular disease (27), Shephard (29) reviewed that this is insufficient due to the low intensity and suggests that an intensity of six METs is required for cardiovascular benefit. Other reports indicate that light to moderate intensity, which is 40 – 60% VO_{2max} of aerobic activity, is sufficient to maintain a healthy lifestyle (29).

Lifestyle-related behaviour such as nutritional status is crucial in maintaining a sense of wellness. In their study, Andersen et al., (30) found that a program combining diet and exercise had positive effects on improving obesity, in other words weight, systolic blood pressure, and serum lipid and lipoprotein levels. The study compared lifestyle-physical activity with a structured exercise program and found that maintaining a healthy diet elicited those benefits irrespective of the type of exercise.

1.6 Consequences associated with sedentary behaviour

It is apparent that the risks produced by physical inactivity outweigh the benefits of physical activity. Physical inactivity contributes to an increased risk of various diseases such as cardiovascular disease, haemorrhagic stroke, reduced glucose tolerance and insulin sensitivity due to increased abdominal adiposity, hypertension, and hypercholesterolemia (27, 29, 31). The WHO (12) recognises physical inactivity as a global health concern and has ranked physical inactivity fourth in terms of risk factor-related overall mortality burden, accounting for 6% of deaths globally.

The human body relies on movement and physical activity for sustainability. Findings show that physical inactivity can result in serious health consequences and hasten the rate of deterioration of the human body. In this technological era, the necessity for physical activity especially in the work environment is almost completely eliminated. Most industrialised nations are experiencing an epidemic of physical inactivity, which is observed through the increased incidence in lifestyle-induced

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chronic conditions. Sedentary Death Syndrome, a phrase coined to describe the cause of deaths attributed to a lack of physical activity on a regular basis, is found to be the second greatest threat to health in the USA (tobacco use being the prevailing health threat and the largest cause of preventable deaths) (5).

The consequences of sedentary behaviour impede an individual's ability to attain a sense of physical wellbeing, and by extension overall wellbeing is hindered. Through focusing on the health-related and skill-related components of physical wellness, a greater sense of overall wellbeing can be achieved. The subsequent sections review the individual health-related and skill-related components of physical wellness, as well as the influence of physical activity on each component.

1.7 Health-Related Components of Wellness

1.7.1. Body Composition

There are several measures to assess body composition, ranging from sophisticated assessments such as imaging methods like DEXA (dual-energy X-ray absorptiometry), to the simpler techniques such as anthropometry (32). Anthropometry is used to predict subcutaneous fat content to the exclusion of age, gender and race. In larger epidemiological studies, anthropometrical measures are favoured due to the cost-effectiveness and accessibility. However, these are obtained at the cost of reliability and accuracy. Several studies have found a negative correlation between physical activity and adiposity, especially since physical activity may not necessarily result in decreased mass over time but rather induce changes in body composition and body fat distribution (33). As such, attempting to attain a sense of wellness through healthy lifestyle measures has shown significant declines in the waist-to-hip ratio (WHR) without any changes to body or fat mass following an increase in physical activity (33).

Body composition consists of three assessments, namely BMI, WHR, and body fat percentage (BF%).Table 1.2 indicates the anthropometrical measures used in this study and the range in each risk area. Studies over the years have made a clear

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connection between health risk and anthropometry, and so anthropometry became a predictor of cardiovascular disease, type 2 diabetes mellitus, coronary heart disease, and death (32, 34).

Al-naddaf et al., (35) indicated that the level of intensity and duration of exercise is especially relevant when correlating physical activity with body composition. It was shown that BF% and mass was reduced in both high and low intensity exercise groups; however increased duration promoted a negative energy balance by increasing energy expenditure. Furthermore, it was found that there was a direct correlation between energy expenditure associated with exercise intensity and the influence of exercise and metabolic rate (35).

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Table 1.2: Anthropometrical assessments and ranges according to risk areas (32, 34)

Assessment	Range	
	Males	**Females**
Body Mass Index	<18: Underweight – High Risk 18.5 – 24.9 Kg/m2 : Normal weight – Low Risk 25.0 – 29.9 Kg/m2 : Overweight – Moderate Risk > 30 Kg/m2 : Obese – High Risk	
Waist-to-Hip Ratio	< 0.80 : low risk 0.81 – 0.94 : moderate risk > 0.95 : high risk	< 0.70 : low risk 0.71 – 0.85 : moderate risk > 0.86 : high risk
Body Fat Percentage	20 - 29 years 5 – 12.9% : low risk 13 – 16.9% : moderate risk ≥ 17% : high risk 30 - 39 years 5 – 13.9% : low risk 14 – 17.9% : moderate risk ≥ 18% : high risk 40 - 49 years 5 – 15.9% : low risk 16 – 20.9% : moderate risk ≥ 21% : high risk 50 + years 5 – 16.9% : low risk 17 – 21.9% : moderate risk ≥ 22% : high risk	20 - 29 years 12 – 20.9% : low risk 21 – 23.9% : moderate risk ≥ 24% : high risk 30 - 39 years 12 – 21.9% : low risk 22 – 24.9% : moderate risk ≥ 25% : high risk 40 - 49 years 12 – 23.9% : low risk 24 – 27.9% : moderate risk ≥ 28% : high risk 50+ years 12 – 24.9% : low risk 25 – 30.9% : moderate risk ≥ 31% : high risk

BMI is generally positively correlated with adiposity. However, this correlation is influenced by various factors such as age, gender, race, and physical activity (32). Owing to the inter-individual variations of these factors, the use of BMI as an indication of adiposity is limited. This, together with the ill-consideration of skeletal muscle mass calls the validity of this measure into question (34). BMI is also positively associated with lean and skeletal muscle mass; however this is largely influenced by age and physical activity as well (32).

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Vaeyens et al., (36) conducted a five year longitudinal study on adolescent soccer players. The participants were divided into elite, sub-elite and non-elite groups and further sub-divided by age within each group. It was found that the maturity status, which was calculated as the difference between the skeletal age and chronological age, influences anthropometry as well as strength, power, flexibility and cardiorespiratory endurance (36). These factors also differed on a competitive level within each age group. However, BMI and adiposity were significantly less in elite and sub-elite players when compared to non-elite players. Based on BMI, individuals were classified according to risk areas for the development of chronic diseases (37). It was also found that the mortality rate in individuals at moderate risk in their BMI was 25% higher than low-risk individuals and that the mortality rate of high-risk individuals was 50-100% higher than low-risk individuals (38). In accordance with several similar investigations, Ojikutu et al., (38) found that a structured exercise program yielded a decrease in BMI in the participants' post-exercise evaluation.

WHR is often used in conjunction with BMI as an indicator of adiposity and is also used as a predictor of several conditions, such as obesity, cardiovascular diseases, type 2 diabetes mellitus and hypertension. However, WHR is a correlate of visceral adiposity, particularly abdominal subcutaneous fat. There are various factors which question WHR as diagnostic measure, namely that elevations in WHR could be due to either an elevated waist circumference or a low hip circumference. In addition, the difference in waist circumference is, to a greater extent, influenced by fat content, whereas the differences in hip circumference are more variable due to the ratio of skeletal muscle area to subcutaneous fat. This further complicates the interpretation of WHR since an elevated WHR could be the result of elevated abdominal adiposity (high waist circumference), low levels of lower body lean mass, low levels of lower body fat mass, or a combination (low hip circumference).

Subsequent to an exercise intervention the WHR could be influenced by the reduction in the waist circumference or increase in the hip circumference due to increases in lower body muscle mass (32). Furthermore, a diet and/or exercise intervention resulting in weight loss does not necessarily result in a change in WHR as there could be a greater reduction in the hip circumference relative to the waist.

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Furthermore, as mentioned previously, reduction in waist or hip circumference with weight loss could be a consequence of reduction in fat or lean mass. Thus, a change or lack of change in the ratio is difficult to interpret and changes in WHR may not necessarily reflect changes in abdominal adiposity. This is apparent when examining the relationship between corresponding changes in the WHR and visceral fat. Unlike waist circumference, changes in the WHR are not consistently associated with corresponding changes in visceral fat. Owing to this uncertainty, Ekelund et al., (33) conducted a prospective cohort study and found that increased levels of physical activity predicted a lower waist circumference, irrespective of baseline body mass and waist circumference. Thus, their results suggest that a small increment in physical activity has the potential to reduce central adiposity.

Tremblay et al., (39) conducted a study which sought to determine the effect of exercise intensity on body fat distribution. It was found that exercise intensity had no correlation with specific skin fold thickness, but was rather proportional to the overall response of subcutaneous fat. However, WHR reduction was directly proportional to intensity of exercise. This suggests that intensity of exercise is essential for the mobilisation of abdominal adipose tissue, as well as reducing abdominal adiposity and maintaining weight control (7). Conversely, Shephard (29) argues that in comparison to intense physical activity (≥ 5 METs), participants in the lifestyle-physical activity group lost more lean body mass and fat loss yielded no significant results between both groups. He also found that exercise intensity had no significant bearing on body mass.

1.7.2. Heart Health

Cardio stress index (CSI) is utilised as an indicator of cardiovascular health. It is calculated through using a complex algorithm integrating heart rate, heart rhythm, QRS duration and the standard deviation between R-R intervals (RRSD) (40-42). CSI is negatively correlated with heart rate variability (HRV) (43). Therefore, a high CSI translates to a low HRV and vice versa. The ViPort device is used to measure CSI (41-43).

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A study by Buchheit et al., (44) shows that HRV decreases with physical activity and is modulated by physiological factors for example age, adiposity, and physical fitness. Their study also highlighted the positive correlation of HRV with VO_{2max} (44). There is also a clear dose-response relationship between HRV and exercise intensity, independent of age (31). Furthermore, it was found that leisure-physical activity is insufficient to elicit a significant response in HRV (31). Physical activity has also been established to cause an increase in HRV, which is indicative of an improvement in autonomic regulation. Although further studies need to be conducted to elucidate the exact mechanism, a mechanism of altered parasympathetic control, in other words increased parasympathetic modulation and reduced sympathetic activity, with endurance training was proposed (45, 46).

Physical activity has been found to have several benefits in reducing the risk of lifestyle-induced diseases such as cardiovascular disease by decreasing the presence of inflammation markers. This was established by two independent studies which concluded that light to moderate physical activity is associated with lower levels of C-reactive protein, white blood cell counts and Amyloid-A levels, independent of age (43, 47). Shephard, as cited in Ojikutu et al., (38), asserts that maintaining one's level of physical fitness provides a significant degree of protection from cardiovascular risk factors and occurrence of developing cardiovascular disease.

Several studies have sought to correlate psychological stress with HRV and have found a link between conditions such as perceived stress, depression, and anxiety (26, 27, 48). However, it has been shown that the physiological adaptations to a stressful event, such as the increased sympathetic dominance, decreased vagal tone, elevated blood pressure and increased heart rate are collectively detrimental to cardiovascular health (49). This further corroborates the necessity to maintain a holistic sense of wellness, as body systems operate en masse and discord in one area could produce multiple repercussions. However, contrasting evidence suggests that mental health can be enhanced through physical exercise while cardiorespiratory fitness remains undetermined (28).

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Comparative studies conducted on sedentary and active populations have confirmed improvement in HRV parameters of both males and females in most age groups (31). A study conducted in California over nine years showed that the rate of premature death of sedentary individuals was twice as high in comparison to active individuals who undergo a frequent exercise routine (38). Sloan et al., (50) conducted a study on sedentary individuals and found that aerobic exercise, not strength conditioning, offers a cardioprotective function. However, they also found that sedentary deconditioning reversed these effects and that sexual dimorphism played a role in HRV in exercise conditions. On the other hand, contrasting evidence remains regarding the role of specific exercise conditions on HRV indicates a wellness area that requires further investigation.

1.7.3. Blood Pressure

An active lifestyle is considered an integral non-pharmacological intervention in the treatment of hypertension. Ferguson et al., as cited in Ojikutu et al., (38), found that there is a rapid positive response of blood pressure to physical activity in a period of three weeks to three months from commencement of training.

While other studies found that physical activity has a significant influence on systolic blood pressure in aiding emptying, Ojikutu et al., (38) observed a considerable effect of a structured exercise program on the resting systolic and diastolic blood pressure readings. There is sparse evidence that is in support of the necessity for exercise in maintaining blood pressure in normotensive individuals. Studies show no distinct association between physical activity and reduction in blood pressure in adolescents whose blood pressure is within the normal range (51). However, there is evidence to suggest that interventions of prolonged duration (12 – 32 weeks) and aerobic capacity have a beneficial effect on hypertensive adolescents. Overall, studies indicate that a physical activity intervention of at least 30 minutes, three times per week and intensity of 80% of the maximal heart rate (HR_{max}) can be effective in reducing blood pressure in individuals with primary hypertension (51). However, this would have to be on a continued basis to maintain the beneficial effect.

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1.7.4. Lifestyle

1.7.4.1. Psychological State and Stress

From an evolutionary perspective, the stress response can be regarded as being shaped by natural selection to improve an individual's capacity to deal with circumstances that require action or defence (52). It has been determined that physical activity has the potential to substantially alter stress levels by adjusting physiological mechanisms such as neurotransmitter release (7, 48). This is thought to account for a reduction in stress levels of individuals who exercise according to ACSM (16) recommendations, particularly advanced athletes.

Physical activity has proven to be beneficial to mental health. Evidence suggests that moderate relative-intensity exercise reduces anxiety and depression, as well as improves mood state (29, 34). According to the Surgeon General's Report (53), a curvilinear relationship exists between exercise and psychological conditions, particularly depression and anxiety. This, to an extent, indicates a dose-response relationship between exercise and mental benefits. However, it has been determined that athletes training excessively risks increased depressive symptoms, thus defining the extent to which physical activity benefits mental health.

Several studies state that the psychological profile of active individuals is such that they exhibit improved cognitive function assessment, decreased cardiovascular response to stress and reduced levels of anxiety and depression when compared to sedentary individuals (24). Physical activity has also been found to improve self-confidence and self-esteem, as well as attenuate cardiovascular and neurohormonal responses to mental stress, and thus possibly reduce Type-A Cardiac behaviour (24).

The psychological component of wellness has been studied extensively and various models have been devised in an attempt to conceptualise wellness. The Wheel of Wellness is among the most widely accepted models that integrate all aspects of wellness, in other words physical, emotional, social, intellectual, occupational and

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spiritual wellness, to derive a holistic approach to one's sense of self (2, 54). However, the physical aspect, which consists of exercise and nutrition, is somewhat neglected since the wheel delves into the psychological aspect of wellness without considering physical activity as a priority (2).

1.7.4.2. Nutritional State

There are several nutritional guidelines in circulation of which many provide contrasting information (34). However, it is widely accepted that nutritional status is reliant on energy requirement, body size and physical activity (55).

Nutritional status and exercise are interrelated through energy balance, which involves the association between energy intake and energy expenditure. A positive energy balance means that energy intake exceeds energy expenditure, which results in weight gain. Hence, a negative energy balance signifies that energy expenditure exceeds energy intake and results in weight loss. This can be measured using anthropometry techniques (55). Liebman et al., (56) maintain that while several factors can be attributed to weight gain in adulthood, principle factors include environmental influence which enables sedentary behaviour and encourages a nutritional status associated with a positive energy balance.

It is essential to amend one's diet according to volume of physical activity performed, as well as mode. A sensible diet can be grossly classified as caloric intake in correct proportion from all basic food groups. The defining aspects between sedentary and active individuals in their diet is the total number of calories required daily and the amount of carbohydrate intake needed during prolonged physical activity. Individuals who participate in intense physical activity or exercise tend to have higher caloric intake due to greater energy expenditure (6). For instance, as can be seen in Table 1.3, protein intake varies depending on the individual's level of physical activity.

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Table 1.3: Recommended daily protein intake based on level of activity (6)

Activity level	Intake in grams per kilogram of body mass
Sedentary	0.8
Lightly active	0.9
Very active	1.3
Extremely active	1.5

1.7.5. Genetic Influences

Evolutionary biology suggests that the human genome has retained the basic framework since the Late Paleolithic era where humans lived as hunter-gatherers (57). This was a means of survival which relied heavily on being constantly physically active and gene expression was selected to accommodate this lifestyle. However, with dawning of technological advancements, modern day humans are placed in an environment that supports sedentary behaviour.

Even though the genotype of present day *Homo sapiens* is strikingly similar to their Late Paleolithic ancestors, the phenotypic expression differs exceptionally. It is theorised that the reason for this difference is that evolutionary programmed Late Paleolithic genes are expressed in an environment that is largely sedentary at present (57). This results in a maladaptation of the genome of present day *Homo sapiens*, leading to abnormal gene expression and eventually manifests as what is referred to as lifestyle-related diseases. Booth et al., (57) speculate that these genes are responsible, in part for decreased survival through what can be considered a premature death from non-communicable diseases as a result of fostering a sedentary lifestyle. This is further corroborated by Gerber and Crews, as cited in Booth et al., (57), who assert that owing to the exposure of alleles to sedentary lifestyles, as well as diets rich in fat and sugar but poor in fibre put carriers at risk for chronic degenerative disease and reduced longevity.

It is widely contended that disruptions in homeostatic mechanisms are markedly attenuated in active individuals as opposed to sedentary individuals. Darwin's theory

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of natural selection supports this contention in that the natural selection of gene expression supports the physically active lifestyle displayed by the hunter-gatherers. Thus, it follows that genes evolved with the expectation of requiring an active lifestyle for normal physiologic gene expression, and thus exercising to maintain that active lifestyle will restore the perturbed homeostatic mechanisms toward the physiological range of the hunter-gatherers.

The model illustrated in Figure 1.4 provides a framework for the consequences of sedentary behaviour (57: p.401). The premise of this model is that physical inactivity disrupts homeostasis through the down-regulation of genes which require physical activity. This leads to essential protein inhibition and subsequent activation of disease-promoting proteins. These disease-promoting proteins, through a cascade of intracellular reactions, manifest in non-communicable conditions thus ultimately resulting in a decrease in life expectancy.

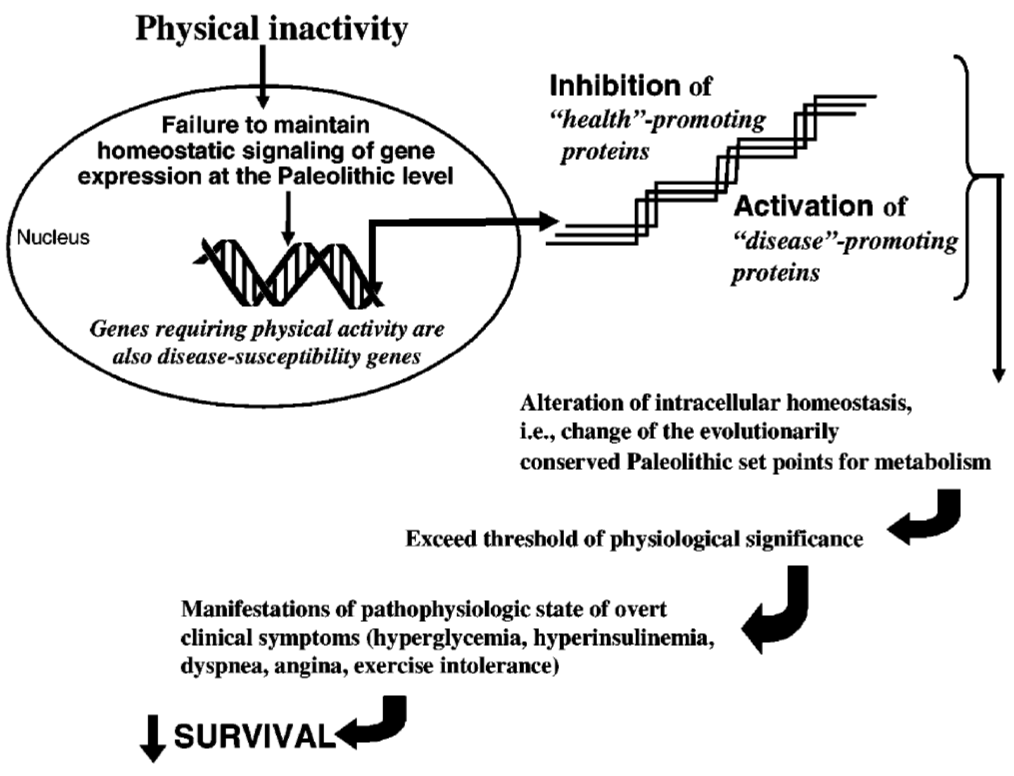

Figure 1.4: Influence of lifestyle factors on genetic susceptibility, resulting in a cascade of repercussions which ultimately engenders chronic conditions and reduces survival (57)

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1.8 Skill-Related Component of Wellness

1.8.1. Physical Wellness

Physical fitness can be referred to as a set of attributes (cardiorespiratory endurance, skeletal muscle endurance, strength and power, flexibility, agility, balance, reaction time, as well as body composition) that people have or achieve that relate to their ability to perform physical activity (27, 58). The physiological adaptation to physical activity is physical fitness which is said to be largely under genetic influence (25). This dates back to the hunter-gatherer era during which human ancestors relied on physical fitness to ensure survival of their species (59). The reliance on physical fitness is apparent in modern human-beings and can be seen in the multitude of lifestyle-induced diseases such as cardiovascular disease, type 2 diabetes mellitus, hypertension, and adverse lipid profiles.

Blair et al., as cited in Al-naddaf et al., (35), highlighted the importance of meeting the physical activity recommendations in their finding that the decrease in regular physical activity and not a positive energy balance is responsible for the increase in obesity prevalence.

The stress response produced by exercise has, with sympathetic nervous system and hypothalamic-pituitary-adrenal cortex axis activation, been well established (52). This activation results in the release of corticotrophin releasing hormone (CRH), which releases adrenocorticotrophin (ACTH) and subsequently cortisol to promote glycogenolysis by the liver to ensure sufficient amounts of glucose is readily available. CRH is also responsible for anxiety and activation of the locus coreleus where cell bodies for most noradrenergic neurons are located (52). It has recently been discovered that sympathetic nervous system activation following high intensity exercise results in an increase in basal metabolic rate (35). This parallels improvements in body composition through an increase in fat oxidation.

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1.8.2. Sports Vision

Studies have shown that ocular activities such as the lens changing shape, work of the ciliary muscles and increased complexity of electrochemical reactions conducted by the retina can be subjected to exertion during exercise. This implies that entrainment of vision is possible through interaction with the environment (60, 61). It has been established that by simply participating in physical activity, one is naturally able to improve his or her visual awareness as well as visual processing skills and visual-motor integration, thus implying that through Sports vision training one can considerably improve performance and skill (62-65).

Sports vision is necessary as it does not focus on a specific aspect of the body, rather on the body as an entire entity. The basis for Sports vision encompasses three processing stages: perception, decision making and response, which is, the execution of movement (66, 67). Perception involves receiving information from specialised receptors, such as the retina for visual information. This information is then conveyed to the central nervous system. The function of the perceptual mechanism is to reorganise and interpret the information. Decision making can be influenced by perceptual information, confidence levels, previous successes or failures stored in memory, the feedback system surrounding the individual, as well as the individual’s current situation. An appropriate strategy and subsequent response is made, based on the decision mechanism. The decision mechanism selects a motor response, where the relevant information is passed onto the effector mechanism, which organises and controls the sequence of the desired response (66). Neural commands are conducted from the central nervous system to the relevant muscle groups required for the specific movement via descending pathways. With regards to response, the focus should be on the imminent situation as a whole and not merely on the task. From a neurological stance, studies have shown that participating in physical activity altered neural activities through visual pathways (68).

The effectiveness of generalised visual training programs rests on three key assumptions: vision is directly related to sports performance (69, 70) (such that sub-

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normal vision is detrimental to sports performance and that supra-normal vision is beneficial to sports performance); key visual attributes for sport can be trained (71, 72); and that improved vision translates to improved sports performance (71, 72). If one of these assumptions is false, visual training programs of the generalised type currently prescribed, will not benefit sports performance or at least not through the putative mechanism of enhancing the visual skills prerequisite to expert performance. Relevant research exists to examine the truth of some but not all of these assumptions.

In a review by Hazel (73), it is suggested that exercise enhances one's visual efficiency and in so doing, the brain's reaction to a stimulus is increased and a quicker response can be made. This is further confirmed in a study comparing physical activity and visual attention, where it was shown that even sub-maximal exercise enhances visual acuity and visual attention (74). Exercise has also been shown to have a substantial influence in visual concentration, eye-hand coordination, proaction-reaction time as well as visual response speed and accuracy (75-77).

In evaluating visual skills in sedentary and active environments, it is possible to discount the learning effect of the brain and in so doing, empirically ascertain whether physical activity (or an active environment) does significantly improve visual proficiency.

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Chapter 2 : Study 1 – A comparison of visual skills in sedentary and active work environments

2.1 Introduction

Of all the special senses, vision may be considered among the most essential. The visual system serves to acquire information from one's surroundings and acts as the basis for the execution of appropriate motor tasks (1). Maintaining optimal visual clarity is imperative in several areas, especially if one leads a dynamic lifestyle. The eyes, therefore, should be able to sustain the demands made to them and function accordingly (2). Figure 2.1 details the structures involved in generating an image, as well as the path of light from the time it enters the eye to the formation of the image (3-6).

Although optimal functioning of the eyes is essential for visual clarity, it is imperative that the eyes and brain operate in synergy. This enables humans to see while moving, as the brain compensates for motion of the head by turning the eyes (4). From a physiological perspective, this ensures that the image falls on the fovea, making it necessary for visual perception and clarity. It has been established that to complete a task successfully, the visual system has to operate concurrently with the skeleto-muscular system as well as the environment (7). Thus, eye movement, which serves to "locate visual targets and stabilize images on the retina" (1: p.1060), performs a crucial function in attaining optimal visual clarity. This can especially be seen in sports such as tennis, volleyball and basketball that require saccadic eye movements, which entail rapid changes of fixation from one target to another, ensuring that the image falls on the fovea (2, 7).

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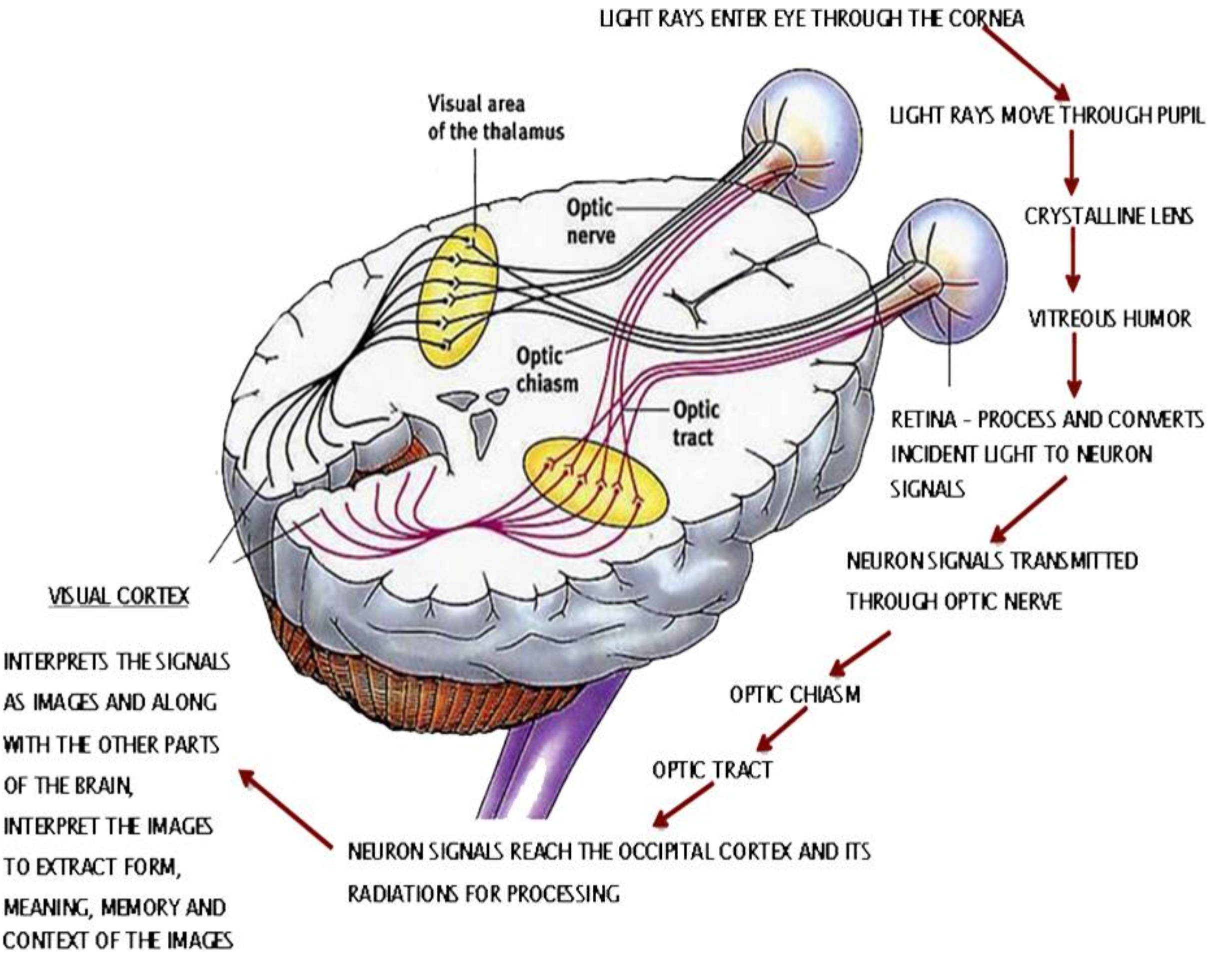

Figure 2.1: The mechanism of vision, tracing the path of light from entering the eye to formation of the image in the visual cortex (3-6)

It has been established that ocular activities such as the lens changing shape, work of the ciliary muscles and increased complexity of electrochemical reactions conducted by the retina can be subjected to exertion during exercise, implying that entrainment of vision is possible through interaction with the environment (8, 9). Studies have shown that by simply participating in physical activity, one naturally improves visual awareness as well as visual processing skills and visual-motor integration, suggesting that through Sports vision training one can considerably improve performance and skill (1, 10-12). However, Abernethy et al., (10) proved that physical attributes is not the only factor that influence visual excellence but rather the manner in which visual information is processed.

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2.1.1. Sports vision

Sports vision is essential since it focuses on the body as an entire entity. The basis of Sports vision encompasses three processing stages: perception, decision making and response, in other words the execution of movement (13, 14). Perception involves conveying information to the central nervous system. Decision making may be influenced by perceptual information, confidence levels, previous successes or failures stored in memory, the feedback system surrounding the individual, as well as the subject's current situation. With regard to response, one has to focus on the imminent situation as a whole, not just on the task, and base decisions accordingly. Motor functions are used to act on these decisions as they employ peripheral neurons to carry impulses to structures (13, 15). From a neurological stance, studies have shown that participating in physical activity alters neural activities through visual pathways (16).

Eye movements are necessary to ensure that an image falls on the fovea which accounts for optimal visual acuity. These eye movements include vergence and pursuit tracking. Vergence movements are characterised by opposing eye movements and refers to the convergence of the eyes to keep an image on both parts of the retina (4). It also involves pupil constriction to block out peripheral light rays that would otherwise block out the image, as well as accommodation of the lens (2, 4). Pursuit tracking functions to maintain gaze on moving objects (2).

Besides eye movements, a skill essential to attain visual excellence include sequencing which assesses how individuals interpret, organize and process visual sequences and are used to improve sequential processing (17). Visualization refers to the ability to concentrate as well as visualise and recall sequential arrangements. Athletes and recruits are often trained in visualisation to improve concentration and attention for longer periods of time (17).

Coordination is an integral component of Sports vision, which occurs when the motor system composes complex actions by combining simpler sub-movements. The process involves sharing information about the progress of the sub-movement with

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the centres controlling another sub-movement, to ensure that the second occurs in appropriate relation to the first (17). Eye-hand coordination is a measure of coordination which refers to the ability of the hands, eyes and body to operate as a single constituent, thereby ensuring an effective response to visual stimuli (18). Eye-hand coordination is assessed to improve fine motor control, eye movement speed and accuracy.

Peripheral awareness refers to the ability to focus on a single image while maintaining awareness of one's surroundings and is a vital component of one's efficiency in sporting performance (11). Sports vision testing and vision training can improve peripheral awareness, enabling one to focus on a task whilst making skilled and anticipated judgment, thus giving one the advantage over the opposition in the sporting environment and ensuring success (17, 19). Memmert et al., (20) confirmed the close association between vision and attention since the capacity of visual memory is linked to attention such that a difference in an individual's attention may well transfer to a difference in performance.

Various studies have been conducted in Sports vision. However, the results are highly contrasting and no accurate deduction can be derived from the results. When comparing athletes to non-athletes it would appear that, the results are in favour of athletes, thus supporting the notion that athletes possess superior visual skills (1, 21, 22). These results refer to specific skills only and not vision in its holistic sense. Studies by Memmert et al., (20), as well as Akarsu et al., (23) confirm that athletes do not differ from non-athletes in terms of basic visual skills such as "visual acuity, colour vision, peripheral response time, depth perception and ocular muscle balance" (20: p.147) but rather in terms of tasks specific to their sporting context namely "saccades, visual reaction time, peripheral awareness and dynamic visual acuity" (23: p.872).

A review by Hazel (22) suggests that exercise enhances one's visual efficiency and increases the brain's reaction to stimuli so that a quicker response is elicited. This is confirmed in a study which compared physical activity to visual attention and found that exercise even at a sub-maximal intensity enhances visual acuity and visual

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attention (24). Exercise has been shown to have a significant influence on visual concentration, eye-hand coordination, proaction-reaction time, as well as visual response speed and accuracy (18, 25, 26).

However, there is contrasting evidence suggesting that such regimens do not provoke significant changes in visual and motor performance and, while improvement in the battery may be evident, it does not result in improved sporting performance (27, 28). This is evident from a study conducted on clay target shooters in which visual differences between expert shooters and novices were negligible. The only noteworthy attribute was reaction time (10). Wood et al., (28), although producing results that implied the benefits of vision testing and vision training in their study, argue that other factors could contribute to the improvement, such as the placebo effect or an “illusory function of expectancy effects” (p.658).

This present study covers various features of visual skill assessment and how it is influenced by exercise and circumstances. The physical aspects of visual perception tested includes visual acuity in which the ability to identify a stationary object is tested (17). Assessing eye movements is essential in determining visual excellence since it tests the ability of the eyes to focus at varying distances, conduct point-to-point movements, as well as evaluate the speed and accuracy of saccades. Procedures that exemplify these aspects include focusing and tracking. These methods aim to enhance vision by improving the ability of the eyes to focus, as well as the accuracy of saccadic movements, and help the eyes to operate more accurately and efficiently for sustained periods of time.

Black et al., as cited in Pettee Gabriel et al., (29), define stress as a disruption in homeostasis due to physiological, psychological or environmental stressors. It has been determined that physical activity has the potential to substantially reduce stress levels by influencing the release of the neurotransmitters dopamine, endorphins and serotonin (29). Cañal-Bruland et al., (30) conducted a study which showed that in the sporting environment, a meagre level of anxiety experienced by players had a positive effect on performance. Nesse et al., (31) are in concurrence with these findings since in describing stress as a complex, carefully regulated adaptation that

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provides one with a selective advantage. However, a considerable increase in stress levels reduces overall performance. Therefore, it can be deduced that visual performance will also be affected. It is proposed that stress levels of recruits (cardio stress index) should fall following increased activity. Therefore, it is envisaged that the decline in stress levels should provide visual advantage in improving awareness, alertness and visual performance.

The aim of this study was to compare the differences in visual skills and CSI of sedentary and active individuals. It was hypothesised that active individuals would have superior visual skills and a lower CSI than sedentary individuals. The objective was to ascertain whether physical activity does influence visual proficiency.

2.2 Materials and Methods

The study design adopted was a comparative and quantitative study.

The participants consisted of 230 training recruits (Population 1) and 158 undergraduate university students (Population 2). Participants from Population 1 were selected based on compliance with the inclusion criterion, namely completing the informed consent, as the data has already been obtained as part of a greater study. Population 2 comprised those that enrolled for the second year physiology course at the University of Pretoria (UP), South Africa who opted to participate in the study and completed the informed consent. Population 1 comprised military trainees who underwent 12 weeks of intense training. Participants from population 2 spent an average of eight hours a day in classes. None indicated participation in more than light physical activity [3-6 metabolic equivalents (METs)] during the previous three months (32). Participants from Population 1 spent at least one hour a day engaging in vigorous (organised) physical activity (>6 METs). Informed consent was obtained from all participants and ethical clearance was granted by the UP Ethics Committee, South Africa.

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The level of visual skills was tested by means of five visual tests (17), while the health risk assessment consisted of two tests. The same criteria and testing procedures were used for both subject groups.

The battery of vision tests comprised the following (17):

- **Focusing** uses the near-far chart to assess the ability of the eyes to focus, as well as improvement in the ability to sustain clear vision at varying distances. The materials used were a small letter chart, a large letter chart and a stopwatch. The large letter chart was placed on a wall at a 1 metre from the participant and the small letter chart was held at nose level, about 10 cm away from the participant's face. The letters had to be read from left to right, alternating each letter between the near and far chart. Only the number of letters answered correctly were counted and recorded. This test was conducted twice and the average recorded as the final score.

- **Tracking** is practised to enhance the speed and accuracy of saccades and measures the ability of the eyes to conduct point-to-point movements. Three two-strip letter charts and a stopwatch were used for this test. While standing approximately at arm's length from the strips, participant had to read the letters from left to right down the column, alternating between the three strips. The number of letters read correctly in one minute was recorded. The test was repeated and the average of the two results was recorded.

- **Sequencing** aims to assess how individuals interpret, organise and process visual sequences. A hand sequencing sheet was used. The instructor sat opposite the table from the participant and showed a sequence consisting of three types of movement: palm faced down (P), hand placed on the side (S) or fist (F). The participant had to repeat the sequence to the instructor. As the participant successfully completed each sequence, the level of difficulty increased, that is, more movements were added to the sequence. The level at which the participant made the last correct sequence was recorded. The test

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was repeated twice to accommodate the learning effect of the brain and the average result was recorded.

- **Eye-hand coordination** was measured using the egg-carton catch method. This method tested motor control, speed and accuracy of eye movement. The materials required were a 12-pocket egg carton, a coin (preferably the size of a 10c coin), a marking pen and a stopwatch. The inside of each egg pocket was numbered. Numbers were written in sequence from top to bottom in two rows. The coin was placed in pocket numbered 1 and each participant had to flip the coin successively, until he/she reached number 12. The time in which the participant completed the task was recorded.

- **Visualisation** was tested using a deck of playing cards. The ace-to-seven method was employed to evaluate the subject's ability to concentrate as well as visualise and recall sequential arrangements. One at a time, the participants sat at a table. The instructor shuffled seven cards and placed them in front of the participant. The subject had to memorise the order and indicate when he/she successfully memorised the sequence. The cards were then flipped over face down and then flipped back in order, from ace to seven. Time was recorded from the moment the cards were revealed to the subject to the successful completion of the test.

Health Risk Assessments

- **CSI** was measured using a Viport (manufactured by Energy-Lab Technologies GmbH) which measures CSI, heart rate (HR), heart rhythm and QRS duration (33). While in a seated position and maintaining an upright posture, the top two electrodes of the Viport were placed on the first intercostal space of the subject. Prior to placing the Viport on the participant, the electrodes were moistened with conducting gel. Caution was exercised to ensure that all three electrodes were in contact with skin and not metallic objects such as jewellery which could interfere with electrode signalling. Once correctly placed on the

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participant, the Viport was started. While the reading was being taken uninterruptedly for two minutes, the subjects were instructed to maintain natural breathing and avoid sudden movements and speaking.

- **Blood pressure** readings were measured using the protocol as stipulated by the American Heart Association (34). A blood pressure cuff was placed slightly above the brachial artery of the left arm while participants were sitting in a relaxed, upright position. A stethoscope was placed on the brachial artery. The bulb of the sphygmomanometer was then pumped continuously to constrict the artery and loosened gradually. The point at which Korotkoff sounds were heard marked the systolic pressure. The stage at which the Korotkoff sounds disappeared marked the diastolic pressure. The final blood pressure reading of each participant was recorded as systolic pressure/diastolic pressure in millimetres mercury (mmHg).

Statistical analysis

The sample mean (m) and standard deviation (SD) for the various parameters were calculated using Number Cruncher Statistical Software (NCSS). Differences between the two groups of participants were computed using the independent samples t – test. The level of significance was set at $p \leq 0.05$.

2.3 Results

The values obtained for university students and training recruits in the Sports vision battery were compared to establish whether physical activity affects visual abilities. The mean and standard deviation were calculated in visual skills, health risk assessments and population characteristics. Differences between male and female participants within each group were also determined. Results that were significantly different are indicated by an asterisk.

In the visual skill assessments (Table 2.1), the recruits proved to be far superior in eye-hand coordination and visualisation. This implies that the recruits display a

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greater sense of fine motor control, eye movement speed and accuracy, ability to concentrate for prolonged periods, as well as ability to visualise and recall sequential arrangements. However, students produced better results in tracking and sequencing. Therefore, the students are more proficient in conducting point-to-point eye movements and sequential processing. No significant results were obtained with regards to focusing, thus both groups appear to be equally proficient in their ability to maintain a clear vision at near and far distances.

Table 2.1: Comparative results in Sports Vision testing battery between recruits and students

MEAN VISUAL SKILL DIFFERENCE		
Visual Test	**Population 1**	**Population 2**
Focusing (# Letters/min)	40.60 ± 20.13	41.42 ± 18.56
Tracking (# Letters/min)*	40.12 ± 18.72	56.95 ± 17.24
Sequencing (Correct Sequences)	1.56 ± 0.79	2.04 ± 0.92
Eye-Hand Coordination (Sec)*	25.66 ± 10.73	47.48 ± 31.18
Visualization (Sec)*	38.95 ± 22.03	52.61 ± 24.69
***p ≤ 0.05.**		

CSI readings (Table 2.2) indicate that training recruits exhibited lower results than students but the difference was not significant. This shows that recruits are able to cope with physical stressors placed on the cardiovascular system and have a lower risk of developing lifestyle-induced cardiovascular diseases.

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Table 2.2: Cardio stress index comparison between training recruits and students

MEAN DIFFERENCES IN CSI STATISTICS		
Characteristics	**Population 1**	**Population 2**
Mean CSI Males	24.39 ± 18.13	32.9 ± 25.37
Mean CSI Females	41.66 ± 22.28	36.92 ± 23.83
Mean Group CSI	31.9 ± 21.76	36.09 ± 24.13
Total CSI Risk (%)	52.17	57.23
CSI ≥ 25 indicates risk; *p < 0.05.		

Blood pressure differences (Table 2.3) were significant as it was higher in recruits. However, the blood pressure in recruits was still within the normal range.

Other factors, namely age, BMI and HR were considered (Table 2.3) on the premise that they may influence visual attributes. However, they all proved to be insignificant. This indicates that the visual system operates independent of these factors and that entrainment of the visual system is not reliant on these factors.

Table 2.3: Population characteristics proposed to be influenced by vision

MEAN DIFFERENCES IN POPULATION CHARACTERISTICS		
Characteristics	**Population 1**	**Population 2**
Age (Years)	20.46 ± 1.2	20.4 ± 1.1
Body Mass Index	22.95 ± 3.18	23.3 ± 4.5
Heart Rate (bpm)	82.87 ± 13.06	83.1 ± 14.8
Systolic Blood Pressure (mmHg)*	127.16 ± 13.31	119.9 ± 12.6
Diastolic Blood Pressure (mmHg)*	77.08 ± 7.89	72.0 ± 9.9
***p < 0.05**		

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2.4 Discussion

It is a common belief that some visual abilities can be trained under controlled conditions and that it will be observed as an increase in performance (22). This is in accordance with the results of this study, as in some areas such as eye-hand coordination and visualisation, recruits obtained far superior results. These results confirm previous findings as studies conducted by experts and novices demonstrate an improvement in eye-hand coordination as well as reaction time and visio-spatial intelligence. This indicates that an exercise or physical activity intervention could significantly affect these specific visual attributes (23, 35).

In their study, Cereatti et al., (24) contended that experienced athletes tended to have superior visual skills due to experience and that they "show highest flexibility in the allocation of visual attention" (p.137). It is also maintained that by training the visual system, the eyes can locate targets better, as well as focus centrally and functionally as a unit, which could result in reduced eye fatigue and improved consistency in performance (22). The same explanation applies to recruits, as they are in the process of acquiring a wealth of experience in the physical demands of their field of expertise.

In a study conducted on soccer players, a correlation between vision and attention was established, confirming that experts on the field are able to fixate their attention on a specific area for a shorter period of time than amateurs and still absorb more information, which accounted for their improved performance (20). This suggests that the brain can be processed to a greater degree though experience following increased physical activity. The association between vision and attention can also be seen in saccadic movements. Babu et al., (1) illustrated that attention revolves around the point of fixation and with regard to saccades athletes are more able to execute the saccadic movement as they possess a greater attention span.

In a study conducted on the effect of exercise on sporting performance it was shown that visual acuity was advanced among the more skilled players and that the visual

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field was enhanced (22). This can be construed as a transfer effect from physical activity to visual excellence. The transfer effect is explained as a gradual development in visual performance due to increased stimulus processing by the brain which can be observed as an improvement in overall performance.

Although some differences in visual skills between the students and the recruits are apparent, this study confirmed that students are more proficient in other skills. This is unrelated to their sedentary nature. Visual skills included pursuit tracking and sequencing. Literature advocates that the cause of these superior skills harnessed by students may be ascribed to environmental factors. In other words, the discipline students possess influences saccadic adaptation (1). It is also suggested that training one's visual field has to be precise and specific in order for it to translate to overall performance in the specific field. This accounts for the recruits being more proficient in some aspects of visual performance and the students being more skilled in other visual aspects (28). Determining the extent to which visual attributes can be entrained will benefit the recruit by giving an indication of which attributes can be honed. This should result in optimal performance in that particular field.

While most evidence correlates with the results obtained in this study, existing evidence indicates contradicting results, namely those obtained with the focusing, tracking and sequencing tests. This is confirmed by several studies indicating that basic visual abilities and attention skills are not influenced by exercise, and some studies suggest that modifiable factors can affect the relationship between attention and exercise. This is further complicated by the modifiable factors that affect performance such as "strength, technique, fitness, attitude and state of mind" (22: p.101). In other words, the extent to which these abilities affect performance may be determined, barring any external influences.

Stress has been implicated in various conditions such as cardiovascular disease. It has been established that increased stress levels tend to increase blood pressure. However, the results obtained in this study show that even though the recruits generally exhibited higher blood pressure than the students, their cardio stress index still proved to be lower than that of the students. This is postulated to be due to the

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increased level of physical activity conducted by the recruits which enables them to handle physical and visual stress associated with their job requirements. By overcoming these stressors, the recruit is able to deal with an enhanced level of physical and visual input efficiently.

From the neurological viewpoint of Sports vision testing and training, eye movement is programmed by the brain stem. However, horizontal rapid movements such as saccades and pursuit tracking are designed in the pons while vertical and torsion movements are programmed in the mesencephalon. The cerebellum eventually provides modifiable enhancements to these movements to prevent errors (4). An understanding of this complex physiology will make it possible to understand the mechanisms of visual acuity and excellence so that one would be able to determine which specific components of the visual system can be trained or 'fine- tuned'.

Future studies should investigate other factors that influence visual performance in addition to physical activity. Perhaps the neurophysiologic changes in visual function to physical activity should be determined as it has been shown from an optometric perspective that neurodevelopment exercises such as body motion activities, improve visual abilities like saccadic movements and pursuit tracking (8).

2.5 Concluding Remarks

To an extent, participating in physical activity does influence one's visual skills. This was evident in the superior visual skills possessed by the recruits. However, these skills are harnessed according to one's field of expertise and the transfer develops accordingly as indicated by the students' proficiency in specific assessments. The aim of the study was achieved in that it was proven that a physically active environment does promote an enhanced sense of Sports vision. The results obtained favour both supporting and contradicting evidence with regard to Sports vision testing and training, indicating an area of study that requires further investigation.

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Sports vision can be considered to be an essential component in physical wellness, especially in the sporting context and as such cannot be regarded in isolation. It has been shown that there are marked differences in Sports vision in opposing environments. Thus, comparing physical wellness in these sedentary and active environments is expected to provide more insight into the wellness arena, especially in terms of the influence of physical activity on an individual's state of wellbeing.

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Chapter 3 : Study 2 – Determining a physical wellness indicator through comparison of wellbeing of subjects in sedentary and active work environments

3.1 Introduction

In coining the concept of salutogenesis, Antonovsky, as cited in Harari et al., in 1979, recognised that factors contributing to greater health and well-being should be emphasised rather than focusing on a specific pathology (1). Based on this concept, the wellness movement, in which the focus of health moved from treatment and cure of disease to prevention, came into existence. The concept of wellness originated within medicine as a preventative health construct; this provided an alternative to a traditional view of health as merely the absence of disease. Dunn, as cited in Hattie et al., (2) provided a definition of wellness that focused on the integration of functioning which is orientated toward an individual reaching his or her full potential. It can be regarded as a process which constitutes an individual striving continually to improve his or her quality of life through balancing physical, mental and spiritual wellbeing (1).

Modern-day lifestyle has fostered sedentary behaviour through inadequate physical activity and dietary habits that favour positive energy balance. As a result the incidence of non-communicable diseases increased significantly over the past decade (3). This makes the likelihood of attaining a sense of overall wellness minimal. The premise of striving to attain a state of physical wellness is to ensure synchrony in all functional areas of the body, as well as improve quality of life and attempt to prevent illness. It has been shown in a large body of studies that physical activity has the capacity to influence several dimensions of wellness and thus result in a general improvement in overall wellbeing.

Recent physical activity recommendations recognise that the therapeutic value of moderate intensity activities for health promotion (4). The level of intensity should range between 3 - 6 METs (5). In recent studies, the exercise prescription has

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shifted from structured, intense exercise to lifestyle physical activity which is less structured (4). Lifestyle physical activity can be defined as ≥ 4.5 METs (6) (Table 1.1). A key problem faced in modern society is that individuals lack the motivation and have an unsuitable attitude towards physical activity. Individuals involved in a structured sport program have higher levels of moderate-to-vigorous physical activity, which in turn have several wellness benefits including weight control, less adiposity, increased bone mineral content, improved aerobic capacity, and improved muscular strength and endurance, as well as a greater sense of self-concept (7).

Physical fitness can be regarded as an integrated measure of most body functions, which encompasses the musculoskeletal, cardiorespiratory, circulatory, neuropsychological and endocrine systems. In addition, physical fitness influences in the performance of physical activity (8). Therefore, it can be inferred that while assessing physical fitness, the functionality of these systems are also being assessed. It is for this reason that physical fitness is considered an essential health marker and as such, it would be apt for physical fitness to be used as an integral measure in assessing physical wellness.

3.1.1. Influence of physical activity on state of overall wellbeing

A model devised by Walchs, as cited by Spence et al., (9), indicates that while physiological indicators, such as body composition and physical fitness are likely to influence the type and extent of physical activity pursued, it is not the reason for being physically active. It is supposed that psychological factors such as cognitive and personality constructs will more likely influence physical activity behaviour (9). This reflects the multidimensional nature of wellness, and also highlights the notion that no one dimension can be considered superior to the other. Physical activity has been shown to have a significant impact on all dimensions of wellness. Table 3.1 summarises the influence of physical activity on each dimension of wellness (10, 11).

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Table 3.1: Influence of physical activity on all dimensions of wellness (10, 11)

DIMENSION OF WELLNESS	INFLUENCE OF PHYSICAL ACTIVITY
Physical	The aging process is slowed down Posture and physical appearance is improved Reduces adiposity and decreases risk for obesity Improves flexibility and range of motion Increases muscular strength and endurance Improves bone health and reduces risk of developing osteoporosis Reduces the risk of developing coronary heart disease
Emotional	Relieves tension Assists with stress management Improves self-image Promotes psychological wellbeing
Social	Enhances personal relationships with family and friends as well as increases the opportunity for developing social connections Motivates toward improved personal habits (smoking cessation, reducing alcohol use, improved nutritional status)
Intellectual	Promotes a synergistic relationship between mind and body Increases alertness Enhances concentration Stimulates creative thoughts
Occupational	Reduces absenteeism rate and disability days Increases productivity Reduces health care utilisation and costs Increases networking possibilities
Spiritual	Enhances the appreciation for the unity between body, mind and soul as well as a healthy environment
Environmental	Changes attitude toward physical activity Increases willingness to participate in physical activity Enhances interest in eliminating toxins and chemicals from the food chain

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In terms of physical wellness, physical activity has been shown to have a positive influence on longevity by slowing down the aging process as well as increasing energy. Physical activity has also been shown to reduce adiposity. Cross-sectional and longitudinal studies conducted have shown that in both men and women, there is an inverse relationship between physical activity and adiposity (12). Studies have shown that a physical activity intervention in overweight children and adolescents resulted in a reduction in abdominal adiposity, while no significant influence was noted in children and adolescents of normal weight (12). It was shown that intensity and duration were paramount to obtaining a more suitable body fat percentage – interventions consisting of moderate to vigorous intensity and longer duration (30 – 60 minutes, 3 – 7 days per week) (12).

In contrast, Penedo et al., (13) showed that physical activity can overcome the risks associated with obesity, independent of its effects on weight. This has been shown in a study which was conducted over 4 years, where being "overweight or obese was associated with declines in physical health and development of a new physical difficulty such as mobility difficulties; however physical activity reduced the risk of declining physical health independently of the ability to achieve ideal body weight" (13: p.190). It was concluded that participating in physical activity may provide health benefits even in the absence of a significant reduction in weight.

Most studies highlight a positive relationship between physical activity and mental health or emotional wellbeing in improving anxiety and depression symptoms. However, this varies with the mode of activity (12), for instance aerobic exercise can combat psychological stress and depression (11). The intensity at which the exercise is performed also impacts stress reduction, such that drastically increasing or reducing the intensity has been found to have an insignificant stress-reducing effect (11). Several studies have shown the emotional wellness benefit of participating in physical activity in reducing symptoms of depression and anxiety as well as improving mood state (13). It has been shown that exercise interventions have proven more beneficial than medication or psychotropic treatment. A study conducted on older adults showed that a resistance training program performed 3

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times per week resulted in a significant improvement in mood state, as well as a reduction in confusion, anger and tension (13).
It has been proposed that a synergy exists between an individual and his or her environment (9). The influence that this synergy is said to exert far exceeds the individual characteristics, thus enabling the individual to modify his or her behaviour toward physical activity. In their review, Spence et al., (9) maintain that in order to understand the influence of physical activity on wellness, social and environmental constructs have to be reviewed.

The influence of physical activity on occupational wellness has been well explored, in increasing productivity, reducing absenteeism, improving social and networking constructs, and reducing health care costs (10). In support of these findings, Wang et al., (14) conducted a cross-sectional study on 42,520 retirees to investigate the influence of physical activity and BMI on health care utilisation and health care costs. The findings suggested that higher levels of physical activity incurred lower health care costs, as well as health care utilisation irrespective of BMI (14). Retirees that pursue physical activity on a regular basis were observed to have less health problems in comparison to their sedentary counterparts. Thus, a dose-response relationship was ascertained between physical activity and health care costs.

Physical ecology can be considered a subset of environmental influences of physical activity on wellness. This physical ecology has been recognised to have a direct influence on physiological and psychological factors that influence participation in physical activity (9). These factors can pose limitations to an individual's optimal capacity to perform physical activity. For example, extremes in temperature and air pollution can deter an individual's capability to participate in physical activity and influence his or her attitude. Therefore, these ecological influences also exert a psychological influence.

Data from several sources have identified the influence of physical activity on the individual physiological components of wellness, as illustrated in figure 3.1 (15: p.191). However, this is a function of the frequency, intensity, mode and duration of physical activity performed by the individual (11).

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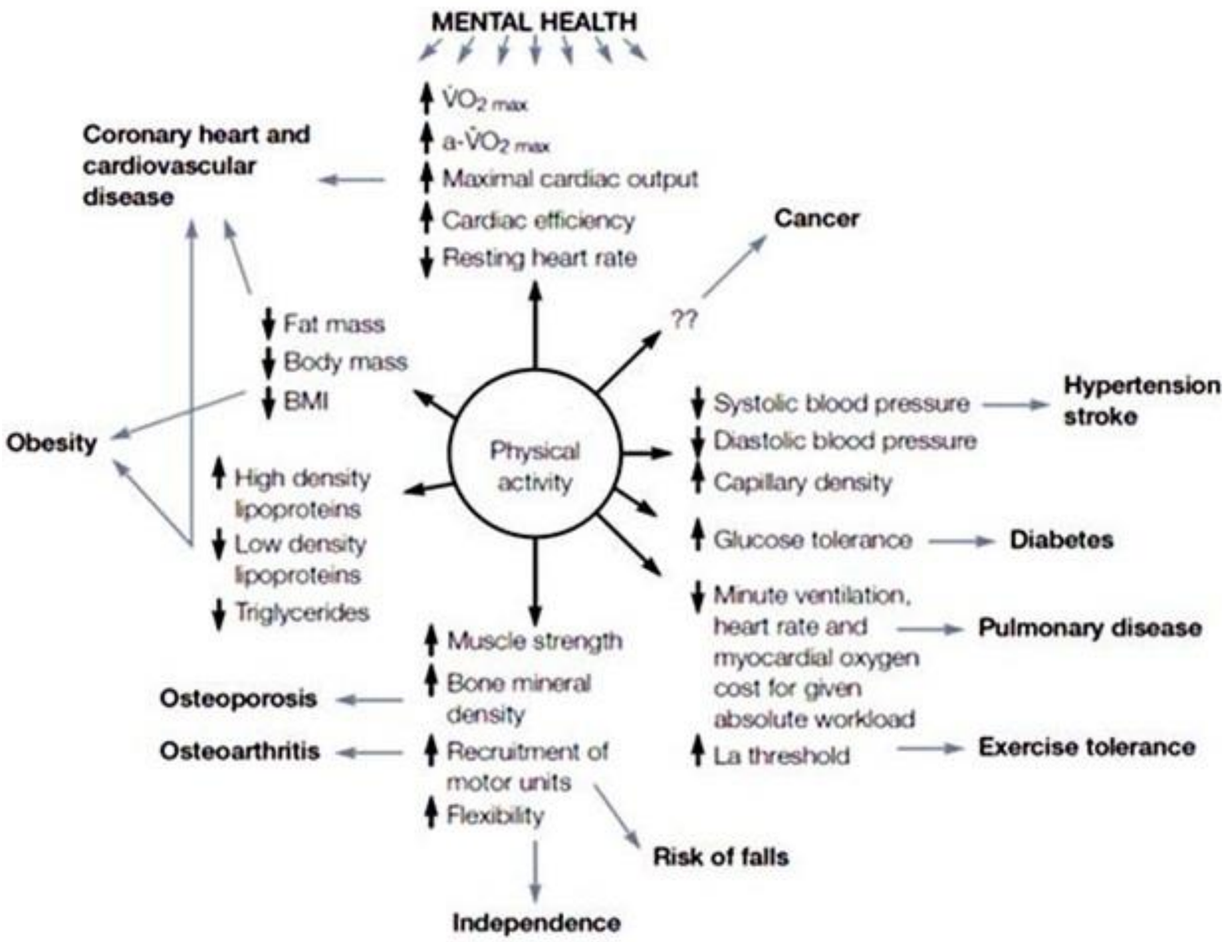

Figure 3.1: Physiological effects of physical activity and its contribution to prevention of chronic conditions (15)

The health benefits of physical activity reducing the risk of developing chronic diseases and other conditions is widely accepted (figure 3.1). In aiding the risk diminution of several conditions, physical activity can be considered a considerable contributor to attaining a sense of overall wellness.

3.1.2. Implications of overall wellness on public health

The human physique, from a physiological perspective, has not significantly differed from our Paleolithic ancestors in terms of energy balance and physical activity requirements (16). However, it was found that people especially in developed

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societies expend only about 38% of the energy than those from the hunter-gatherer era (9). Consequently, it was determined that, while the human body was genetically endowed for a high-energy lifestyle, the advent of modernisation facilitated a sedentary lifestyle and resulted in the emergence of chronic conditions in epidemic proportions (9).

Physical inactivity has of late added to the global burden of disease, and in terms of risk profile, is likened to smoking, hypertension and obesity (13). It has been found in the USA that health service usage is substantially higher among overweight/obese individuals, as well as physically inactive individuals owing to those diseases (14). This results in the increase in health care expenditure, which places a huge and unnecessary burden on society. There are also other determinants that contribute to physical inactivity and sedentary behaviour.

Socioeconomic status and level of education were also highlighted as contributing factors to sport participation (7). Individuals from low to middle income countries lack the facilities and adequate environment to support participation in physical activity (7). This has major psychological implications, which includes an unfavourable mind-set and perception towards physical activity. The economic and time constraints, together with negative attitude, provide a barrier towards physical activity and thus hindering any attempt at attaining overall wellness.

Figure 3.2 illustrates a model which is used to assess the effectiveness of interventions to increase physical activity (17: p.76). This shows the relationship between physical activity, physical fitness, as well as mortality and morbidity outcomes (17). It has been well established in literature that increasing physical activity results in physiological improvements such as body composition, muscular strength and endurance, insulin sensitivity, as well as lipid profiles (11). With respect to chronic conditions, these improvements have shown to impact health and quality of life.

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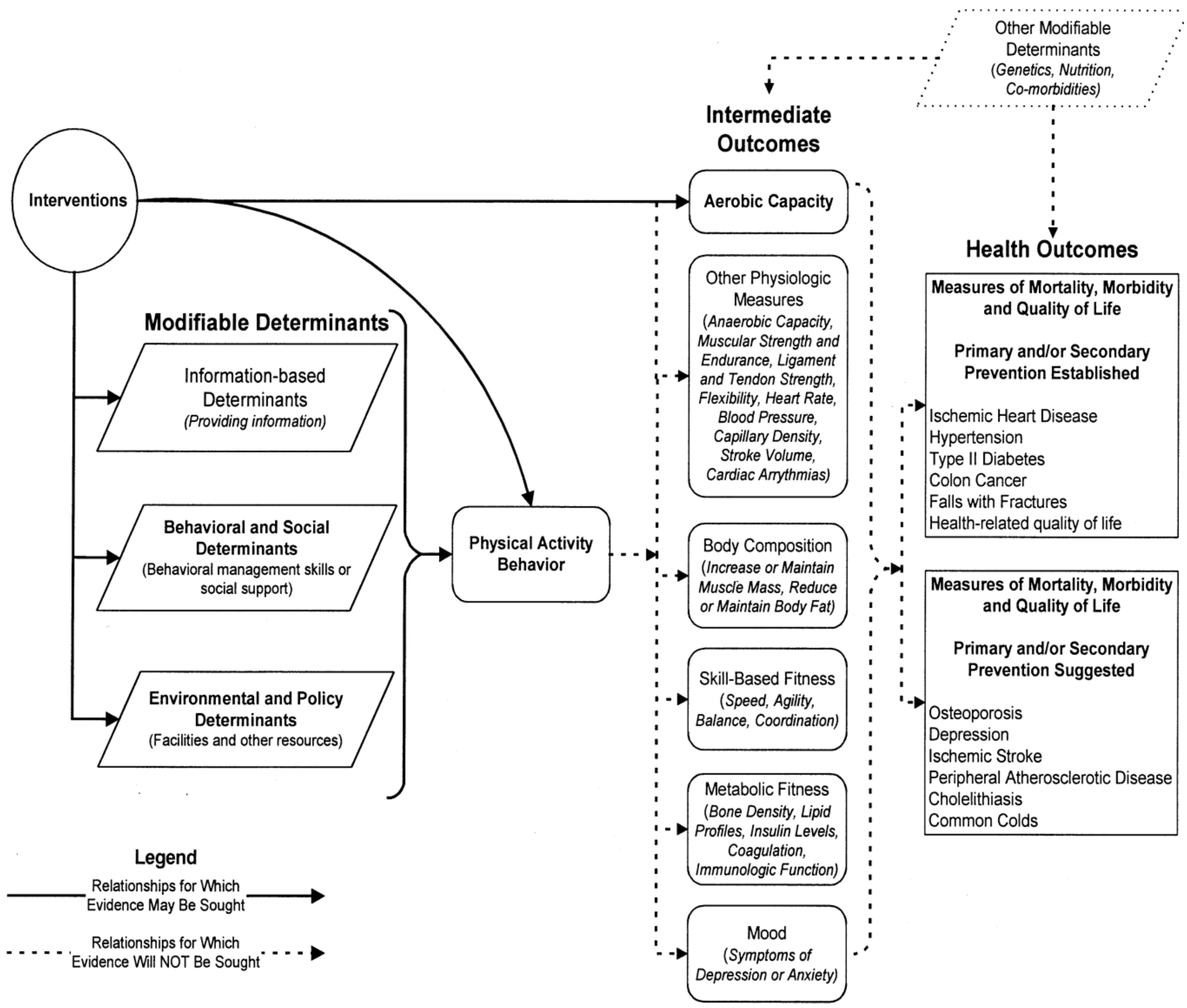

Figure 3.2: Model illustrating the various areas that physical activity interventions can influence, as well as the influence of physical activity on health outcomes, and modifiable- and non-modifiable factors (17)

Physical inactivity is acknowledged as a public health burden in the industrialised world. While physical activity interventions are successful in influencing health outcomes at various levels (17) (figure 3.2), the primary issue faced with physical activity interventions is long-term compliance. Long-term compliance is the reason for limited success shown in literature (9). It was found that while these interventions alter the individual's behaviour initially, it is likely that social and environmental factors are responsible for the individual reverting to the sedentary behaviour once

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the intervention is over (9). Environmental and social wellness can make an impact in the area of long-term compliance.

Owing to the continuing expansion of the South African economy, there appears to be an epidemiologic transition in the emergence of non-communicable diseases such as cardiovascular disease and type 2 diabetes mellitus (18). The 'Heart of Soweto' study was initiated in RSA to establish a baseline profile of heart disease and it antecedents in the population of Soweto. The prevalent risk factors in the study (high blood pressure, obesity and elevated serum cholesterol) were found to closely resemble that of the USA population (18). The study reflected a poor awareness of the modifiable risk factors for cardiovascular disease (18). This can be attributed to misconceptions, such as a loss of weight being attributed to poverty and AIDS-related wasting. Furthermore, food marketing promotes foods rich in fat, sugar and salt; low in potassium and more accessible and cost effective. This accounts for the epidemic of obesity with an almost non-existent public health response (18).

RSA is currently facing the quadruple burden of disease, namely diseases and conditions arising as a result poverty and underdevelopment, non-communicable diseases, injuries and the HIV epidemic (19). Therefore it has been acknowledged that there is a necessity for a shift in primary health-care from treatment or cure of a disease to prevention. Joubert et al., (20) attempted to empirically determine the burden of disease attributable to physical activity from the World Health Survey 2003 and found that 3.3% of all deaths and 1.1% of all disability adjusted life years (DALYs) occurred as a result of sedentary lifestyle.

Thus, the essence of introducing a method of indicating state of physical wellness and risk areas to the South African population is to enable individuals to monitor their sense of physical wellbeing, as well as to be notified of the areas that require attention.

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3.1.3. Devising a wellness indicator

In earlier studies, a reflection of an individual's state of health was by means of BMI (21). However, this was found to be inaccurate. Chen et al., (21) have acknowledged this, thus conducting a study which correlated BMI to health-related fitness. They found an inverse relationship between BMI and performance in fitness assessments. Therefore, it was deduced that in determining norms with which to determine BMI, it should be in a relatively fit, 'healthy' population. It was also established that BMI cannot be used in isolation to evaluate health-related components of wellness and should include other assessments to obtain a more holistic perspective (21).

Previous models were devised to assess an individual's measure of wellness. The perceived wellness survey (PWS) was constructed and utilised in earlier studies to assess the manner in which individuals function within each dimension (1). Harari et al., (1) conducted a study to assess the degree to which the PWS reflected all dimensions of wellness. They found that the PWS does not support the separate wellness dimensions which resulted in it being deemed inadequate.

The Health Risk Appraisal (HRA) has also been utilised for several years as a measure of wellness in occupational health promotion and disease prevention (22). The HRA comprise behavioural health risks, mortality risks and preventative services usage.

The wheel of wellness model attempted to incorporate all seven dimensions of overall wellness to analyse an individual's state of wellbeing (23). This model was well received in the psychological community but neglected the physiological factors such as the influence of physical activity on all dimensions of wellness.

The role of physical wellness on the other dimensions of wellness has been recognised, thus warranting a holistic approach in devising an indicator of wellness. Since an active environment is more conducive to an overall sense of wellbeing, it can be utilised as a platform for developing a physical wellness indicator by using a variety of physiologically based assessments. Comparing the results with those of a

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sedentary environment will not evaluate only the validity of the physical wellness indicator but also provide an indication of specific risk areas that warrant further attention.

3.1.4. Rationale of the study

Contribution to scientific knowledge and will be of immense benefit to individuals who lead both a sedentary and active lifestyle:

- The active individuals will be provided with empirical evidence of the effect of physical activity on their physical wellbeing.
- Owing to the standardized training program employed by the training academy, under which the FITT (frequency, intensity, type, time) conditions are controlled, this study will provide knowledge regarding the expected changes induced by physical activity.
- The individual will be able to ascertain which areas of wellness require further attention based on the physical wellness indicator.

It is hypothesised that the sedentary or less active student population will present an increased risk for developing non-communicable conditions, providing evidence that physical activity plays an immense role in the contribution to physical wellness and thus overall wellbeing. Since the individuals comprising the active population were in the process of undergoing their training regimen at the time of testing, it is hypothesised that the health risk posed due to physical inactivity will be substantially decreased. Therefore, the physical wellness indicator in recruits is expected to be much higher than that of students.

3.1.5. Research objectives

The objective of this study was to devise an anecdotal approach to complete wellness and determine the contribution of physical activity to one's sense of overall wellbeing. This will be done by developing a physical wellness indicator. The physical wellness indicator is proposed to provide an indication of an individual's current state of physical wellbeing and also attempts to indicate the risk to the

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individual's health. This notified the individual of whether he or she was prone to develop lifestyle-related conditions and which areas had to be focused on in attempting to mitigate that risk.

3.2 Procedures

3.2.1. Participants:

The participants comprised 234 training recruits and law enforcement employees, representing the active population (Population 1) and 165 undergraduate UP students, representing the sedentary population (Population 2). The participants in Population 1 were selected based on compliance with the criteria specified in the procedures as the data was already obtained as part of a greater study. The sample size of Population 2 was based on the estimated number of students who enrolled for the second year human physiology course. Participants from population 2 spent an average of eight hours a day in classes. None indicated participation in more than light physical activity [3-6 metabolic equivalents (METs)] during the previous three months (24). Participants from Population 1 spent at least one hour a day engaging in vigorous (organised) physical activity (>6 METs). The study included only participants who were willing to complete the Informed consent (Appendix A).

3.2.2. Participants' inclusion criteria:

- Recruits enrolled for the training program and law enforcement group, and second-year undergraduate students
- Age 18-29
- Appropriate completion of Informed Consent

3.2.3. Participants' exclusion criteria:

- Refusal to freely providing written informed consent
- If participants have any disorder or ailment preventing in performing the tests
- If the participants fail to adhere to test procedures

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3.2.4. Discontinuation criteria

After the study has commenced, individual participants will be eliminated from the study in the event of:

- Failure to comply with or finish with the testing procedures
- Sustaining an injury during the training program with regards to recruits
- Students obtaining an injury during the testing period that impeded performance

3.3 Materials and methods

3.3.1 Ethical considerations and participant screening

Ethical approval was granted by the UP, Faculty of Health Sciences Research Ethics Committee. The study conformed to the principles outlined in the Declaration of Helsinki.

An initial orientation session was organised, where potential participants were provided with details of the study: its purpose, what it entails, and extent of the various assessments, duration, participant's rights, risks/discomforts and confidentiality. Participants were provided with an opportunity to ask questions regarding the study and their involvement.

Informed consent forms (Appendix A) were provided to participants who wished to participate in the study. The participants who successfully completed the informed consent were screened to ensure compliance with the criteria listed in the procedures. It included screening for the criteria mentioned above through written completion of the Pre-Test questionnaire on health, fitness and stress status (Appendix B).

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3.3.2 General procedures and measurements

Procedures involving the recruits and law enforcement employees were executed in two areas, at the training academy in Ellisras/Lepalale and Durban. Both areas were facilities conforming to general recommendations for exercise test facilities. The students underwent assessment at the Sports vision laboratory at UP which complies with the recommendations for exercise test facilities.

This study adopted a cross-sectional, quantitative experimental design.

All of the tests were conducted under the same conditions. The physical wellness assessments of population 1 and population 2 were compared and compounded into an Overall Wellness Index to determine an individual's risk areas. The individual assessments are as follows:

3.3.3 Specific test procedures

3.3.3.1 Visual skill index (Sports vision) (25)

- **Focusing** made use of the near-far chart to assess the ability of the eyes to focus, as well as improvement in the ability to sustain clear vision at varying distances. Materials included a small letter chart, a large letter chart and a stopwatch. The large letter chart was placed on a wall at a distance of one meter from the participant on a wall and the small letter chart is held at nose level, about ten centimetres away from the participant. The letters need to be read from left to right, alternating each letter between the near and far chart. The number of letters called out correctly was counted and recorded. This test is conducted twice, with the average used as the final score.

- **Tracking** is practised to enhance the speed and accuracy of saccades and measures the ability of the eyes to conduct point-to-point movements. Three two-strip letter charts and a stopwatch were used for this test. While standing approximately an arm's length from the strips, the participant, had to read the

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letters from left to right, alternating between charts, down the column. The number of letters read correctly in one minute was recorded. The test was repeated and the average of the two results was recorded.

- **Vergence**, which determines a person's ability to maintain binocular vision, was tested by means of the pencil push-ups method. A tape measure and pencil was required to conduct this test. Each participant had to sit and maintain a relaxed, balanced posture. A pencil was held at arm's length at nose level and the participant had to fix his or her gaze on the pencil's point. The pencil had to be moved closer toward the participant's nose, while maintaining focus on the point. It was ensured that the participant moved the pencil slowly to ensure accuracy. As the pencil was moved closer, vision became blurry and eventually resulted in double vision. The participant had to indicate when double vision was experienced. At this point the distance between the pencil's point and the tip of the nose was measured. The test was conducted twice and the average of the two readings was recorded as the final score.

- **Eye-Hand Coordination** was measured using the egg-carton catch method. This method tests motor control, speed and accuracy of eye movements. The materials required encompassed a 12-pocket egg carton, a coin (the size preferably 10c), a marking pen and a stopwatch. The inside of each egg pocket was numbered sequentially, with number 1 in the upper leftmost pocket and number 2 in the pocket below number 1, ending with 12 below number 6 in the lower rightmost pocket. The coin was placed in the pocket numbered 1 and the participant had to flip the coin continuously until he/she reached number 12. The time each participant took to complete the task was recorded.

- **Visualization** was tested using a deck of playing cards. The ace-to-seven method was employed to evaluate the participant's ability to concentrate, as well as visualise and recall sequential arrangements. The participant had to sit at a table. The instructor shuffled seven cards and placed them in front of the

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participant. The participant had to memorise the order and indicate when he or she felt the sequence was successfully memorised. The cards were then flipped over, face down, and flipped back from ace to seven. The time was recorded from the time the cards were revealed to the participant up to the successful completion of the test.

- **Sequencing** aimed to assess how individuals interpret, organize and process visual sequences. A hand sequencing sheet was used. The instructor sat opposite the table from the participant and showed a sequence consisting of three types of movements: palm faced down (P), hand placed on the side (S) and fist (F). The participant had to repeat the sequence to the instructor. As the participant successfully completed each sequence, the level of difficulty increased through adding more movements to the sequence. The level at which the participant was able to indicate the last correct sequence was recorded. The test had to be repeated to accommodate the learning effect of the brain and the average result was recorded.

3.3.3.2 Body fat percentage (26)

Body fat percentage was determined using the sum of six skin folds measured with Lange callipers (Beta Technology Inc., Cambridge, Md) and the sex-specific formulas of Yuhasz. Skinfolds included triceps (vertical fold, midway between acromion, and olecranon processes on the posterior surface), scapular (diagonal fold next to the scapula), suprailiac (diagonal fold above the iliac crest even with the anterior axillary line), abdominal (vertical fold approximately 3 cm from umbilicus, right side), calve (vertical fold) and thigh (vertical fold on anterior surface, midway between anterior, superior iliac process and the proximal border of the patella).

Care was taken to ensure that all folds were taken from the right side of the body, a constant pressure was exerted with regards to both points and between individuals, and the location of the skin folds were maintained.

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3.3.3.3 Overall fitness score (26, 27)

- **Sit and Reach** was conducted to assess flexibility. The participant had to sit on the floor with bare feet, legs fully extended and the dorsum of the feet placed against the sit and reach table. The participant extended arms forward with hands placed on top of each other, palms down, reached forward and pushed fingers along the table as far as possible. The distance from the finger tips to the edge of the table represented the score for that person. This assessment was conducted in triplicate with the highest score recorded.

- **Press-ups** involved the participant lying prone on a mat with hands shoulder width apart, arms fully extended and toes touching the floor. The participant then had to lower the body until the elbows reached 90º after which the participant returned to the starting position. The push-up action had to be continuous without stopping. The total number of full body press-ups per minute was recorded.
  Since females tend to have a lower relative strength in the upper body, a modified press-up position - knees bent - was adopted to assess upper body strength.

- **Crunches** were assessed with the objective of measuring the development of the participant's abdominal muscles. The participant had to lie in a supine position on the floor, on a mat, with knees bent and dorsum of the feet on the floor and arms folded across the chest. The starting position constituted the participant lying with the back on the floor. The participant then had to raise him/herself to a 90º position and return to the starting position. The participant's feet could be held by the investigator. The number of crunches completed in one minute was recorded.

- **3-Minute Step Test** was measured to evaluate the participant's VO_{2max}. A 42cm step was used. The participant had to step up and down at a rate of 24 steps per minute for three minutes. Immediately after the 3 minutes of stepping, the participant had to sit down and locate the carotid pulse. A 60

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second pulse rate was taken five seconds after completion of stepping and recorded.

- **BMI** is determined by including the weight and height into the formula:

$$\text{BMI} = \frac{\text{Weight}}{\text{Height}^2}$$

The weight (Kg) is measured using a Seca calibrated scale and height (m) is measured using a Leicester measuring stick.

- **WHR** was measured using a tape measure, which assessed abdominal adiposity. The circumference of the waist (tape measure was placed midway between the lowest rib and the iliac crest) and hip (tape measure was placed around the widest part of buttocks) was measured and recorded in centimetres (cm). WHR was determined by means of the equation:

$$\text{WHR} = \frac{\text{Waist circumference (cm)}}{\text{Hip circumference (cm)}}$$

3.3.3.4 CSI (28)

Heart health was measured using a Viport (manufactured by Energy-LabTechnologies GmbH) and tests CSI, HR, heart rhythm, QRS duration and RRSD. While in a seated position and maintaining an upright posture, the top two electrodes of the Viport had to be placed on the first intercostal space of the left side of the thoracic cage. Prior to placing the Viport on the participant, the electrodes had to be moistened with conducting gel. Caution was exercised to ensure that all three electrodes were in contact with skin and no metallic objects (such as jewellery) interfered with electrode signalling. Once correctly placed on the participant, the Viport was started. While the reading was being taken for duration of two minutes, the participant was instructed to

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maintain natural breathing, and avoid sudden movements and speaking. Since the CSI is calculated from HR, heart rhythm, QRS duration and RRSD, only the CSI was considered in compounding the physical wellness indicator.

3.3.3.5 Blood pressure (27)

The blood pressure reading was obtained using a sphygmomanometer. The blood pressure cuff was placed slightly above the brachial artery while the participant was seated in a relaxed, upright position. A stethoscope was placed on the brachial artery. The bulb of the sphygmomanometer was then pumped continuously to constrict the artery and loosened gradually. The point at which Korotkoff sounds were heard was recorded as the systolic pressure. The stage at which the Korotkoff sounds disappeared was recorded as the diastolic pressure. The final blood pressure reading was recorded as systolic pressure/diastolic pressure in millimeters mercury (mmHg).

3.3.3.6 Lifestyle Index (29)

- **Nutritional Status** was evaluated by means of a questionnaire. A score was allocated to each option with the positive (least risk) being allocated a high score progressing to the high risk options being allocated a low score, and added up to provide a nutritional index. These scores were then compared with the standards to indicate the extent of health-risk.

- **Stress Index** assessed stress levels by means of a personal stress inventory questionnaire to assess the patterns of stress and how it is experienced, the factors that exacerbate it and the manner in which the participant copes with it. Each option was allocated a score, which was added to yield the stress index. All psychological-related evaluations were interpreted with assistance from the UP psychology department.

- **Lifestyle behaviour** is considered to be one of the critical factors that influence an individual's state of health, and therefore wellbeing. This

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evaluation was conducted by means of a questionnaire and assessed the participant's use of tobacco, alcohol and drugs; habits pertaining diet, exercise and fitness; stress control and safety. Each option was allocated a score, which was then added to yield an overall score. The overall score was compared with the norms to determine the health-risk of the participant.

Statistical analysis

The sample mean (m) and standard deviation (SD) for the various parameters were calculated using Number Cruncher Statistical Software (NCSS). Differences between the two groups of participants were computed using the independent samples t – test. The level of significance was set at $p \leq 0.05$.

3.4 Results

The various aspects of overall physical wellness were assessed between both populations and compared to establish whether individuals from an active environment possess a greater degree of physical wellbeing in comparison to their sedentary counterparts. The mean and standard deviation were calculated in both health- and skill-related areas of wellness and tabulated accordingly. Results that were significantly different are indicated by an asterisk (*). Each area of wellness was allocated a score based on the risk profile. Therefore, a high risk=1, medium risk=2, and low risk=3. The scores were compared between populations and the risk for the development of adverse health outcomes was assessed.

In terms of visual skill assessments, Population 1 proved to be significantly superior in tracking, visualisation, and eye-hand coordination (Table 3.2). This indicates that individuals who form part of an active environment are more proficient in saccadic eye movements, concentration, visualizing and recalling sequential arrangements, motor control, and speed and accuracy of eye movements. Although of no significance, Population 2 was more proficient in focusing and sequencing.

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Table 3.2: Evaluation of visual skills between active (population 1) and sedentary (population 2) individuals

MEAN VISUAL SKILL DIFFERENCE		
Visual Test	**Population 1**	**Population 2**
Focusing (# Letters/min)	47.56 ± 17.80	48.15 ± 22.62
Tracking (# Letters/min)*	49.39 ± 15.12	33.98 ± 21.13
Visualisation (Sec)*	35.59 ± 15.45	47.35 ± 20.13
Sequencing (Correct Sequences)	1.84 ± 0.67	1.94 ± 0.98
Vergence (cm)	3.62 ± 3.40	4.01 ± 3.83
Eye-Hand Coordination (Sec)*	20.17 ± 7.53	43.47 ± 24.36
***p ≤ 0.05**		

The individual visual skill assessments were utilised to formulate a visual skill index (Appendix C). Figure 3.3 shows that while population 2 was more competent in some visual skills, the accumulated visual skill score was lower than that of population 1.

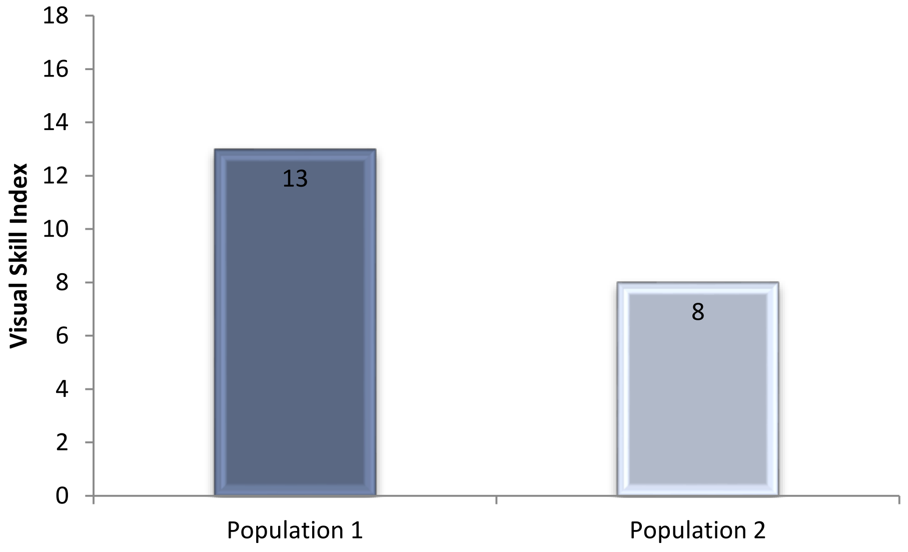

Figure 3.3: Visual Skill Index comparison, indicating overall proficiency in visual aptitude

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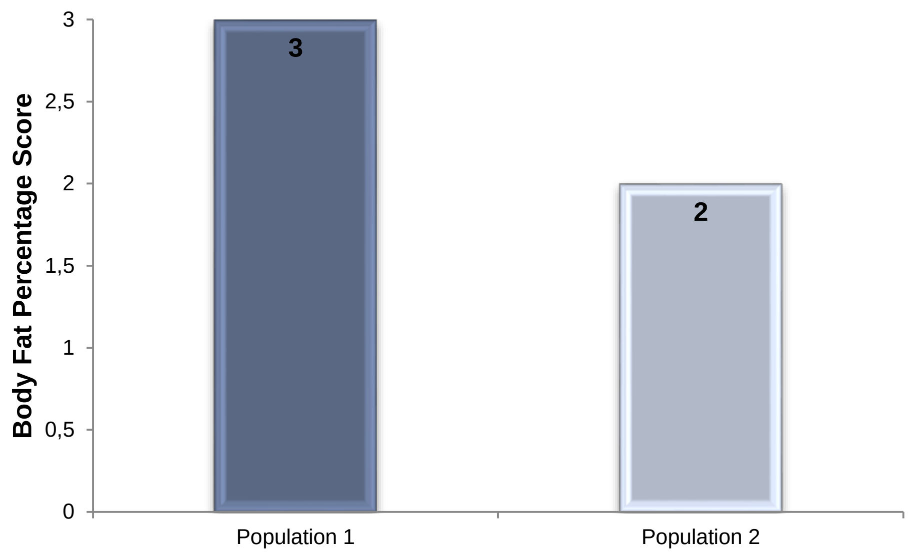
Table 3.3 indicates that being in an active environment is resultant in an improved body composition. Although not significant, population 1 showed a reduced body fat percentage in comparison to population 2.

<u>Table 3.3: Comparative results in body composition between sedentary and active populations</u>

MEAN DIFFERENCE IN BODY COMPOSITION		
Component	**Population 1**	**Population 2**
BF%	14.65 ± 7.78	19.99 ± 6.39
$^*p \leq 0.05$		

Body composition is an indicator of total body adiposity. The results indicate that the active population possess a decreased fat content, and are therefore at a lower risk for developing chronic conditions. This is illustrated in figure 3.4 indicating the low risk of the active population to non-communicable conditions, while the sedentary population are at moderate risk.



<u>Figure 3.4: Body fat percentage comparison as an indicator of total body adiposity and associated risks</u>

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The fitness assessments indicated that physical activity participation significantly improves flexibility, and VO_{2max}. Press-ups and crunches were better in the student population, indicating that the law enforcement group presents room for improvement. The health-related factors that constitute fitness, namely BMI and WHR, were improved in the active population.

Table 3.4: Comparing Fitness Scores between active and sedentary individuals

MEAN FITNESS ASSESSMENT DESCRIPTIVES		
Fitness Assessment	**Population 1**	**Population 2**
Step test (# beats/min)*	134.37 ± 60.19	167.58 ± 31.79
Push-ups (# completed/min)	29.84 ± 16.32	29.88 ± 12.77
Sit-ups (# completed/min)	42.42 ± 19.26	44.86 ± 12.11
Sit and Reach (cm)*	47.26 ± 5.18	27.52 ± 8.94
BMI	22.88 ± 3.14	23.16 ± 4.09
WHR	0.789 ± 0.057	0.816 ± 0.068
***p ≤ 0.05**		

Fitness assessments are highly specific and therefore the overall fitness score had to include a comprehensive assortment. Although the differences in the individual assessments were not significant (except the step test and sit and reach) when the scores were compounded to formulate the overall fitness index, a discernible difference was observed. Figure 3.5 illustrates the increased overall fitness capacity in an active environment.

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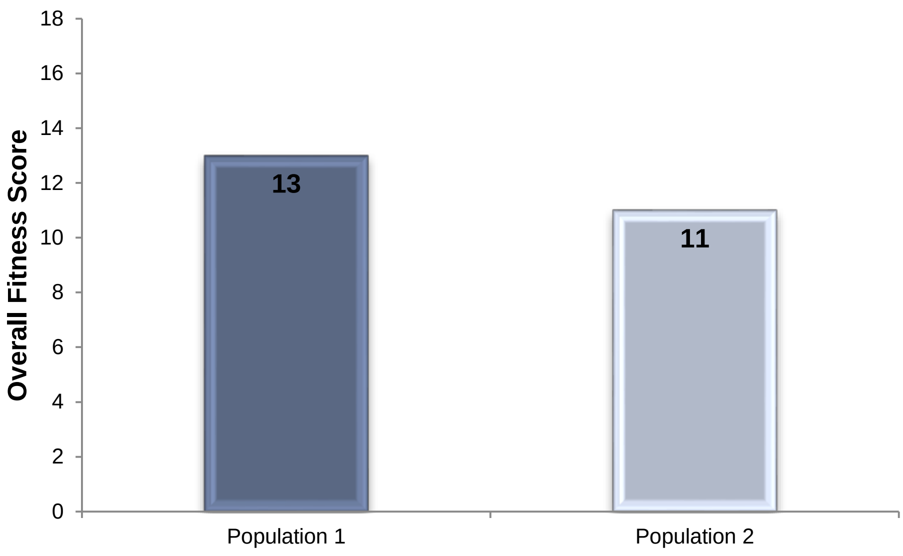

Figure 3.5: Overall fitness scores obtained from the amalgamation of fitness assessments

CSI is an indicator of the health state of the heart; whether the heart can handle the stress placed on it by intrinsic and extrinsic factors. It was observed that active individuals possess a greater capacity to handle stressors. The individual components of the CSI are also significantly improved in the active population.

Table 3.5: Comparison between mean CSI and respective components in sedentary and active populations

DIFFERENCES IN MEAN CARDIO STRESS INDEX		
Component	**Population 1**	**Population 2**
Cardio Stress Index*	23.71 ± 17.20	27.29 ± 20.44
Heart Rate (# beats/min)*	74.75 ± 11.05	78.20 ± 12.51
QRS Duration (Sec)*	74.84 ± 11.73	85.57 ± 11.63
***p ≤ 0.05**		

The CSI was scored according to the risk profile in which a decreased CSI is indicative of a low risk of adverse health outcomes. In terms of risk profile, the scores assigned to both populations, as shown in Figure 3.6, indicate that the sedentary

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population possess an increased risk for developing conditions associated with physical inactivity.

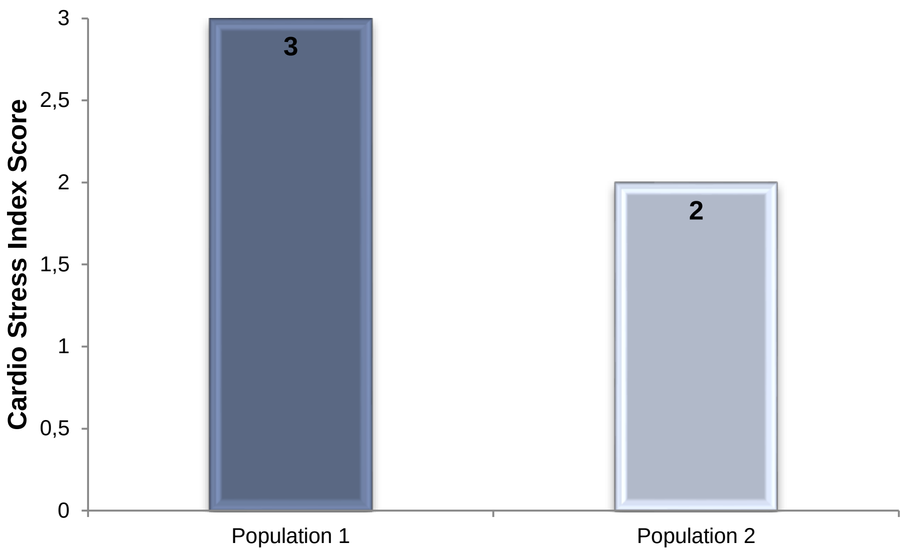

Figure 3.6: Comparison of CSI scores demonstrating the risk of developing lifestyle-associated cardiovascular diseases

While blood pressure was within the normal range in both populations, the diastolic blood pressure was significantly lower in the active population (table 3.6). This shows that there is a decreased pressure between contractions, when the heart is at rest, in active individuals when compared to sedentary counterparts. The increased blood pressure in population 2 signifies that the heart is required to exert a greater force to achieve the same functionality as population 1.

Table 3.6: Evaluation of blood pressure between populations

MEAN BLOOD PRESSURE DIFFERENCE		
Component	**Population 1**	**Population 2**
Systolic Blood Pressure (mmHg)	126.51 ± 12.29	124.09 ± 14.34
Diastolic Blood Pressure (mmHg)*	74.47 ± 7.62	80.31 ± 7.97
***p ≤ 0.05**		

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Owing to the blood pressure being within the normal range in both sedentary and active populations, the scores indicate that both populations performed well in this area of overall wellness (figure 3.7). Regarding this aspect, both populations are at a low risk of developing lifestyle-induced cardiovascular conditions.

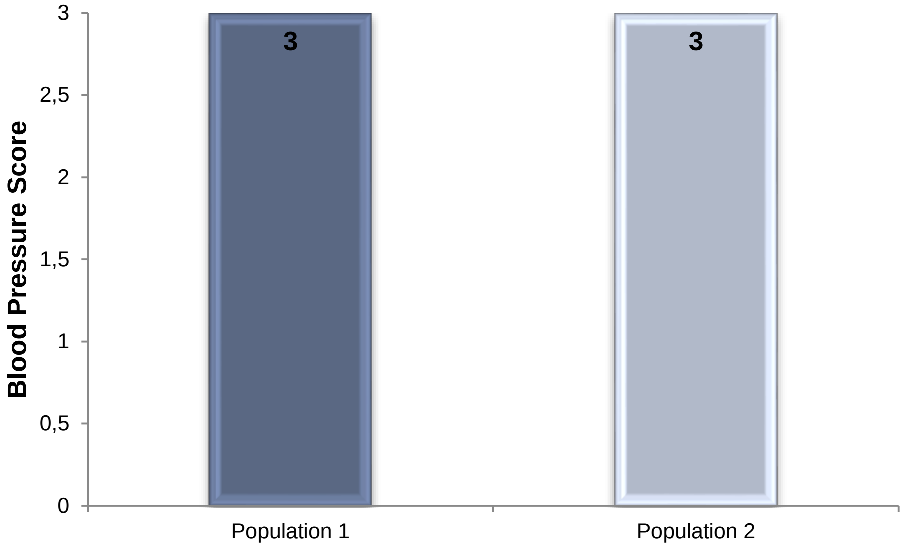

Figure 3.7: Blood Pressure differences in terms of risk category

In all components of lifestyle, active individuals performed significantly better than sedentary individuals, as shown in Table 3.7. These individual components, namely the stress index, nutrition, and lifestyle evaluation constitute the lifestyle index as explained in Figure 3.8.

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Table 3.7: Comparison in lifestyle measures between active populations and sedentary populations

MEAN VISUAL SKILL DIFFERENCE		
Component	**Population 1**	**Population 2**
Stress Index*	3.45 ± 2.20	6.22 ± 3.16
Nutritional Status*	7.69 ± 1.92	4.83 ± 2.16
Lifestyle Evaluation (Total)*	50.89 ± 7.64	46.47 ± 8.03
• Exercise/Fitness	6.51 ± 2.01	5.45 ± 2.64
• Tobacco Use*	5.72 ± 4.10	7.86 ± 3.15
• Alcohol and Drugs	8.38 ± 2.07	7.58 ± 2.46
• Emotional Health*	7.10 ± 1.04	6.36 ± 1.91
• Safety	9.13 ± 1.81	8.35 ± 1.25
• Disease Prevention	6.41 ± 2.03	6.04 ± 2.03
***p ≤ 0.05.**		

Figure 3.8 represents a combination of the stress index, nutrition, and lifestyle evaluation in a lifestyle index. It is a reflection of the improved lifestyle measures exhibited by active individuals.

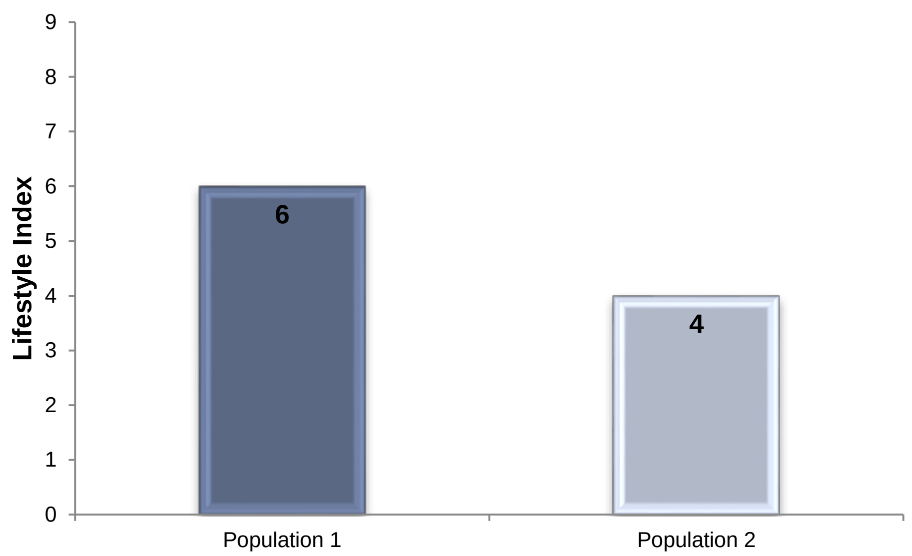

Figure 3.8: Lifestyle Index comparison between populations

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Based on the differences observed between the participants in sedentary and active environments, it is apparent that each facet assessed is necessitated in devising a marker to describe wellness in a holistic sense. In determining an overall physical wellness indicator, each facet of wellness was categorized into low-, medium-, and high-risk areas and scored accordingly (Appendix C). A high score signifies a low risk for developing chronic lifestyle-related conditions and vice versa. Each score was inserted into an equation to obtain an overall physical wellness indicator. Figure 3.9 indicates the various components involved in calculating a wellness indicator.

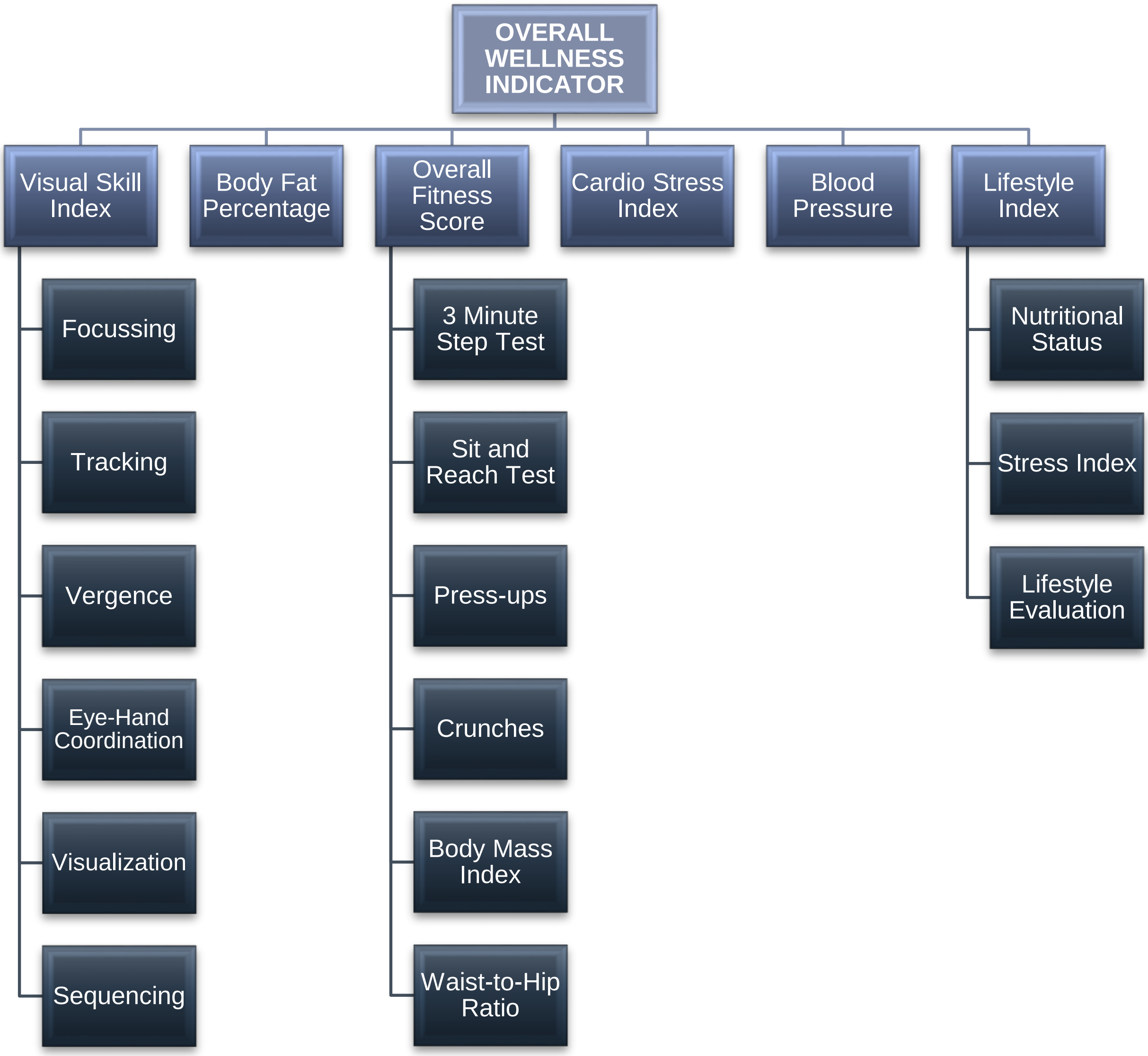

Figure 3.9: Components of Physical Wellness

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In utilising all components to formulate the overall physical wellness indicator, the scores were compounded and compared between sedentary and active populations. It is apparent that even though sedentary individuals were more proficient in some assessments, the active individuals possessed a more holistic sense of wellness. This is reflected in the higher score obtained by the active population, as shown in figure 3.10. The physical wellness index indicates that Population 1 is at low risk for developing lifestyle-related conditions, while Population 2 is at moderate risk (Appendix C). This is significant in terms of prospective health outcomes for the population groups.

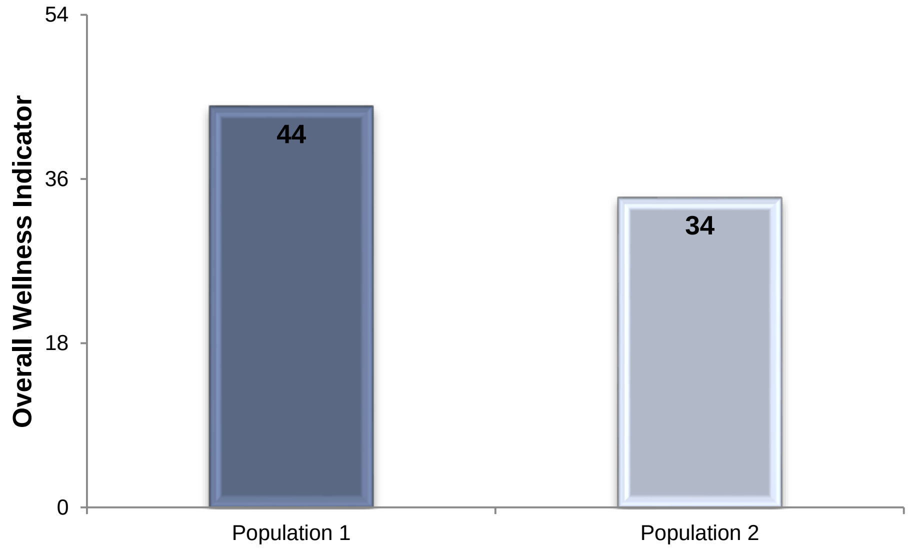

Figure 3.10: Comparison of overall wellness in sedentary and active populations through utilizing an Overall Wellness Indicator

3.5 Discussion

The results obtained in this study confirm the hypothesis that sedentary individuals have a diminished sense of physical wellness and as a result possess an increased risk for developing conditions such as obesity, type 2 diabetes mellitus, hypertension, coronary heart disease, depression and several types of cancer when compared to active individuals (30, 31). This study also corroborated a positive dose-response relationship between physical activity and overall wellness.

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Blair et al., (32), in their review attest to the dose-response relationship between physical activity and health outcomes. Since most studies assess the influence of physical activity on a variety of health outcomes, it was decided that empirically determining a dose-response gradient would be premature. However, it was conceded that there is a threshold to which benefits can be experienced (32). This is supported by Spence and Lee, who assert that there is a biological set-point that controls the extent to which an individual can participate in physical activity (9).

It was apparent that the exercise training program and increased fitness provided the recruits with an advantage in attaining a greater state of physical wellness. The recruits, having an increased overall fitness score, displayed improved outcomes and proved to be far superior in terms of physical wellness. The success of physical activity or exercise interventions on sedentary individuals has been presented in several studies. Friedenreich et al., (33) conducted a study on 320 post-menopausal, sedentary women and found that an exercise program conducted over a year significantly reduced adiposity. They also observed a positive correlation between a reduction in adiposity and quantity of exercise performed. These observations were noted in the absence of any other intervention (nutritional and psychological). In contrast, Ivester et al., (34) developed a wellness program, consisting of diet and exercise schedule together with a health-education component. 41 overweight-to-obese participants undertook the wellness program. The empirical evidence indicated a decrease in body mass and adiposity, a reduced risk for developing metabolic syndrome and an increase in self-reported wellness (34). The present study showed that the recruits had a significantly decreased body fat percentage as well as lower waist to hip ratio in comparison to the students. Thus, corroborating that physical activity leads to a decreased adiposity.

Exercise interventions have also proven successful in improving visual skills, resulting in a transfer effect of the brain to subsequently improve various neural characteristics such as concentration, commitment to memory, eye-hand coordination, proaction-reaction time, visual response speed and accuracy (35, 36). The results confirm the findings of other studies that leading an active lifestyle does

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improve visual aptitude. Sports vision testing was designed to utilise the visual system to assess the aforementioned neural characteristics (25). The sedentary population was more proficient in focusing and sequencing. This can be attributed to the learning effect of the brain as well as the environment of this population. Undergraduate students have had to hone these visual skills in order to cope with the volumes of reading and recalling their study material, which would elucidate the more developed ability to focus and sustain visual acuity, as well as interpret, organise and process visual sequences.

Physical activity increases vagal tone, thus causing a resting bradycardia and increasing HRV (37, 38). As previously mentioned, there is an inverse correlation between HRV and CSI, thus an increase in HRV translates to a decrease in CSI. A reduced CSI indicates that the heart is able to cope with the strain placed on it through adaptation, such as cardiac hypertrophy and increased stroke volume. This is evident in that the active population had a significantly lower CSI in comparison to the sedentary population. This means that the physical activity performed by the recruits offers a cardio-protective function, thus reducing the risk for developing lifestyle-related cardiovascular diseases (6). While several studies are in agreement with this contention, there is also contrasting evidence which suggests that there is no clear association between physical activity and HRV. Kluttig et al., (37) conducted a cross-sectional study on 1671 participants to determine the association between lifestyle behaviour and HRV. They found insignificant associations between physical activity, alcohol consumption and tobacco use on HRV and no association between dietary patterns and HRV. It was further suggested that the reason for the lack of association was that the frequency, intensity or duration of exercise was insufficient to increase HRV (37). The study also highlighted the importance of a holistic approach in determining heart health, in acknowledging that various lifestyle factors contribute to HRV, and therefore CSI, in addition to physical activity.

Blood pressure also contributes to cardiovascular health as it is a function of cardiac output and total peripheral resistance (39). There remains conflicting evidence with respect to the influence of physical activity on blood pressure. Young-Shin Lee et al., (40) found that blood pressure is maintained when older normotensive and controlled

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hypertensive individuals participate in lifestyle physical activity. However, Hearst et al., established a negative association between adiposity and physical activity but found no correlation between physical activity and blood pressure (41). The results of the current study suggest that while the systolic blood pressure yields no significant outcome; the diastolic blood pressure was significantly lower in the recruits. This suggests that in the active population, a decreased force is exerted on the vessel walls between contractions when the heart is at rest, requiring the heart to perform with less strain to achieve optimal functionality (42). A study conducted on 120 recreational sport practitioners corroborates the results obtained in this study in finding that a lack of physical activity (< 30 minutes of walking) resulted in an increase in diastolic blood pressure (39, 43). It is asserted that exercise, specifically aerobic and resistance training is effective in maintaining blood pressure within the norms; however this should be combined with a balanced nutritional status to significantly reduce resting blood pressure and improve body mass.

The earliest principles of wellness in Eastern medicine acknowledge that maintaining a healthy lifestyle is essential in that it "provides maximal enjoyment with minimal waste" (44: p.5). It has been established that participating in physical activity contributes substantially to promoting healthy behaviour such as a balanced diet, smoking cessation, emotional health, as well as disease and stress prevention (45). The present study confirms that participants who represented the active population led a significantly healthier lifestyle in comparison to the sedentary population in all areas especially stress management, lifestyle behaviour and nutritional status. This is further corroborated in a cross-sectional study conducted in Japan on 1724 participants, which showed that participants who displayed health-promoting behaviour were most likely to participate in physical activity (45). Furthermore, it was revealed that physically inactive participants displayed negative health habits and were more likely to smoke and abuse alcohol, as well as develop lifestyle-related conditions.

In addition to physical activity, maintaining a healthy lifestyle and pursuing health-promoting behaviour is integral to accomplish a state of wellbeing. The present study shows that these factors are essential components of overall wellness.

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Since the dawning of the wellness movement, several studies have sought to formulate ideals to ascertain an individual's measure of wellness (23). While these ideals were promising and successful in some instances in their respective studies, more recent evidence suggests that these ideals do not encompass a holistic view (23). A novel approach was hence necessitated to create an ideal with a comprehensive physiological methodology and is applicable to individuals from all environments. The physical wellness indicator devised in this study encompasses the multi-disciplinary nature of wellness and provides an indication of an individual's risk areas. Active individuals scored significantly higher than their sedentary counterparts in the physical wellness score as can be seen in Figure 3.10, placing them at a lower risk of developing lifestyle-related diseases. Upon further inspection of individual wellness areas, it was found that students were at high risk in terms of lifestyle, as well as moderate risk regarding CSI and overall fitness. Additionally, they displayed poor performance in the visual skill index. This highlights areas requiring improvement in the efforts to attain an improved sense of wellbeing.

3.6 Concluding Remarks

This study revealed that there are several factors from all dimensions of wellness that need to be considered when establishing an indicator that determines an individual's sense of wellbeing. Devising an overall wellness indicator has major implications on how wellness is viewed, especially when attempting to incorporate all areas of overall wellness. This study also revealed the essential role that physical activity and exercise plays in attaining a sense of overall wellness.

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Chapter 4 : Integrated discussion and conclusion

This study was designed on the premise that physiological benefits derived from participating in physical activity have the potential to influence all areas of overall wellness and thus contribute to attaining a sense of overall wellbeing. The benefit of leading a healthy and active lifestyle was extensively documented in previous research (1, 2) and confirmed by this study. While earlier investigations have sought to ascertain the influence of physical activity, this study attempted to incorporate the various disciplines of wellness through a holistic approach. The results yielded in this study are in accordance with the earlier findings: in order to attain a sense of wellness, leading a physically active lifestyle is a prerequisite (3).

The importance of physical activity was recognised in the earliest studies and therefore the ACSM designed recommendations in 1978 in an attempt to incorporate physical activity in the individual's lifestyle behaviour (4). This included high frequency, intensity and duration exercises utilising the large muscle groups. However, with the changing lifestyles of the general population the recommendations were revised in 1995 and changed to moderate-intensity and reduced duration with a greater frequency (5). In addition, the recommendations were updated in subsequent years to include resistance training, cardiorespiratory and muscle fitness, as well as flexibility as a measure of chronic disease prevention (4). This proved to be highly beneficial, since physical activity and exercise have been found to positively influence several conditions such as type-2 diabetes mellitus, cardiovascular disease, hypertension, certain cancers, osteoporosis and mental conditions such as anxiety and depression (4, 6, 7).

Physical activity is established to be a crucial element in overall wellness and thus it can be inferred that attaining a sense of overall wellbeing is also integral in chronic disease prevention. Several studies have also showed that physical activity in conjunction with other components of wellness such as dietary and lifestyle habits has a greater benefit in maintaining health and wellness (3, 8, 9).

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The research conducted on incorporating all components of wellness is sparse, especially in light of wellness assessments and the South African context. Taking this into account, the aim of this investigation was to explore the empirical association of an active and sedentary South African lifestyle on wellness areas and devise an anecdotal indicator to provide an indication of the individual's state of overall wellness.

Sports vision is a novel, simplistic, non-invasive approach in assessing cognitive and mental function, and motor skills through ocular activity. It is widely utilised in the sporting environment and there is evidence in support of this practice (10-13). The principles of Sports vision assessments are concomitant with assessing physical wellness. Therefore, in order to determine whether Sports vision can be utilised as a component in evaluating physical wellness, the scientific basis had to be explored as well as whether it is subject to improvement in an active environment. Hence, this study was partitioned into two components: the first component was to examine the validity of Sports vision and ascertain whether it would be viable as a component of overall wellness (Study 1). The second component of the research (Study 2) involved the exploration of the influence of an active lifestyle on various areas of overall wellness by comparing these areas between sedentary and active populations.

4.1 Study 1

Study 1 sought to assess Sports vision proficiency in 230 training recruits and 158 undergraduate university students to determine whether an active environment provides one with the visual advantage and therefore an improved mental capacity. Stress levels and descriptive statistics were also evaluated to ascertain whether these factors play a role in visual aptitude. The participants were required to complete a questionnaire, undergo visual skill assessments and stress assessment utilising the Viport.

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4.1.1 What Study 1 revealed about overall wellness

This component showed that entrainment of vision is possible through participation in physical activity. However, this entrainment is largely subject to environmental influences. This was discovered in that the students did prove to be more proficient in some areas of visual aptitude, while overall the recruits were superior. This study also revealed a transfer effect, in which the increased stimulus processing by the brain is observed as an improvement in visual performance.

It has been established that the systems controlling eye movements share commonalities with motor systems involved in movement in the same fashion as the spinal cord coordinating muscular movements about a joint and the reticular formation of the pons and midbrain controls ocular movements (14). Eye and muscular movements are also controlled by the basal ganglia and cerebellum which ensures the successful execution of motor behaviour in order for individuals to effortlessly interact with their surroundings (14).

This oculomotor control as well as the inverse relationship between visual proficiency and the stress response enabled Sports vision to be considered an area of wellness that can be empirically assessed. This study showed that Sports vision can be utilised to assess motor and neural capacity as a measure of mental wellbeing in overall wellness.

4.2 Study 2

By incorporating various aspects from all dimensions of wellness, Study 2 evaluated overall wellness in sedentary and active work environments. Sedentary participants comprised 165 undergraduate university students while the active population consisted of 234 training recruits and law enforcement employees. The participants were required to complete several wellness assessments, either by completing a questionnaire and undergoing a physical assessment. The individual assessments of the sedentary populations were compared to the active populations. Each component of overall wellness was also scored in terms of risk area and

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compounded to formulate an overall wellness indicator. This indicator was compared between populations and risk areas were identified. The aim of the study was to evaluate the influence of a physically active lifestyle on overall wellness in comparison to sedentary behaviour.

4.2.1 What Study 2 revealed about overall wellness

The premise of the overall wellness indicator was based on the tenets outlined in the health grid proposed by Dunn in 1959 (15). The health grid focused primarily on health and environmental influences as a measure of varying levels of wellness; and also recognised the spiritual, mental and emotional influences in attaining a sense of wellness. This provided a framework for the multidisciplinary approach to overall wellness used in this study through integrating all dimensions of wellness.

Study 2 revealed that while individuals from the sedentary environment obtained superior results in some assessments, the overall wellness indicator showed that active individuals were significantly superior in their state of overall wellbeing. This novel approach to assessing overall wellness is supported in various findings assessing the individual components of wellness (16-20). This study provided a platform for further investigation into wellness assessments and the overall wellness indicator in various applications and settings.

4.3 Overall Findings

Both studies reiterate the necessity and benefits of leading a physically active lifestyle and promoting healthy behaviour. The results yielded in both studies provide empirical evidence of the influence of physical activity on overall wellbeing, as well as anecdotal evidence of the areas that pose an increased risk for developing lifestyle-related chronic conditions.

The FITT conditions were controlled in the active population in Study 1 and Study 2, thus contributing to existing knowledge of the improvements owing to physical

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activity participation. The results obtained in the present study corroborate earlier findings, as described in previous chapters.

Several models and ideals have been devised to gain a holistic view of wellness, however none have attempted to measure state of wellbeing. This investigation showed that Sports vision can be used as a measure in wellness and the overall wellness indicator does indeed provide an innovative approach to wellness in its multidimensional context.

4.4 Applications for an overall wellness indicator

The overall wellness indicator does have the potential to be utilised in a public health setting as well as in the sporting environment. However, further research is necessitated to explore these applications.

From a public health viewpoint, this would be highly beneficial as an overall wellness indicator would offer guidance in terms of an individual's state of wellbeing, as well as provide an indication of the areas that pose a risk and require further attention. Fleischer et al assert that disease-prevention strategies focusing on changing behaviour are met with limited success (21). The overall wellness indicator presents a disease prevention strategy that could have far-reaching implications for the individual's quality of life, primary health-care system, as well as the greater economy since lower health care costs are projected resulting in a great diminution of health care utilisation (22, 23). It was found that even in developing countries, adverse health effects of a sedentary lifestyle and obesity are beginning to exceed malnutrition and infections as the main cause of premature death and disability (24). With RSA being a developing country and facing the quadruple burden of disease, the physical wellness indicator could possibly reduce the incidence of non-communicable diseases and in the long term, there would be more funds available in health-care for fulfilment of the Millennium Development Goals (25).

In the sporting environment, athletes are constantly searching for means of gaining an advantage over their opponents. Wellness employs a multidisciplinary approach,

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by gleaning knowledge from traditional sport science sub-disciplines such as physiology, biomechanics and psychology. Therefore, a physical wellness indicator could provide an indication of which areas need attention so that a state of wellbeing can be obtained and the athlete can perform at his or her optimal capacity. Future studies can look into incorporating sports-specific evaluations with the overall wellness indicator to yield a more accurate indication of an athlete's state of wellbeing.

4.5 Conclusion

This research confirms a positive trend of association between a physically active environment and overall wellness. It was shown and confirmed that leading an active lifestyle has the capacity to influence all dimensions of wellness, resulting in a state of overall wellbeing. Several novel ideas were introduced, such as the influence of Sports vision on overall wellness, the use of Sports vision in assessing overall wellness and the overall wellness indicator as a means to determine an individual's state of wellbeing. This research merely provided the foundation for future studies to delve into these areas.

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5. Appendix A: Subject information and informed consent

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YUNIBESITHI YA PRETORIA

Department of Physiology, Faculty of Health Sciences
PO Box 2034, Pretoria, 0001 - Republic of South Africa
Tel: (012) 420 4482 Fax: (012) 420 4483

Investigator
Lee-Anne Naicker
Department of Physiology
University of Pretoria
Tel: 083 2285 083
Email: leeanne.naicker@gmail.com

Supervisor
Dr PJ du Toit
Department of Physiology
University of Pretoria
Tel: (012) 420 2536
Email: peet.dutoit@up.ac.za

TITLE: <u>Comparison of physical wellness of subjects in sedentary and active work environments</u>

Introduction

You are invited to volunteer for a research study. This information leaflet will help you to decide if you would like to participate. Before you agree to take part in this study you should fully understand what is involved. If you have any questions, which are not fully explained in this leaflet, do not hesitate to ask the investigator. You should not agree to take part unless you are completely happy about all the procedures involved.

What is the purpose of this study?

The aim of the study is to determine the effects of a physical training program on physical wellness and compare these findings with a same-age group where no training will take place.

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What is the duration of this study?

The testing will be completed over a period of two weeks per sample group. Various measurements will be taken in order to determine physical wellness. Various health- and skill-related components of physical wellness will be tested with the aid of various physiological and psychological tests and questionnaires.

NOTE:

It is important to notify the investigator of any medicines (either prescriptions or over-the-counter medicines), alcohol or other substances that you are currently taking.

Has the study received ethical approval?

This research study protocol was submitted to the faculty of Health Science research Ethics Committee, University of Pretoria and written approval has been granted by the aforementioned committee.

What are your rights as a participant in this study?

Your participation in this trial is entirely voluntary and you can refuse to participate or stop at any time without stating a reason. Your withdrawal will not affect your access to other medical care or your career at the SANDF or your studies at the University of Pretoria. The investigator retains the right to withdraw you from the study if it is considered to be in your best interest. If it is detected that you did not give an accurate history you may be withdrawn from the study at any time.

You are entitled to psychological assistance at any point in the study and a psychologist will be on site should any difficulties be experienced. The psychologist will be available for the duration of the entire study to offer support and assistance where needed. The contact detail of the psychologist is as follows:

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Name: Dr.Nicoleen Coetzee

Contact number: 0844008394

May any of these study procedures result in discomfort or involve any sort of risks?

The only discomfort may be the fitness tests, in which muscular soreness and fatigue may be experienced, as well as possible emotional discomfort owing to the personal nature of certain questions. No blood will be drawn and no invasive procedures will be used.

Confidentiality

All information obtained during the course of this study is strictly confidential. Data that may be reported will not include any information which identifies you as a participant. In connection with this research, it might be important to the Faculty of Health Science Research Ethics Committee, the section Sports Medicine, University of Pretoria, as well as your doctor, to be able to review your medical records.

Any information uncovered regarding your tests result or state of health as a result of your participation in this research study will be held in strict confidence. Should you wish, you will be informed of any finding of importance to your health or continued participation in this study but this information will not be disclosed to any third party in addition to the ones mentioned above without your written permission. The only exception to this rule will be cases in which a law exists compelling us to report individuals infected with communicable diseases. In this case, you will be informed of our intent to disclose such information to the authorized state agency.

Note that should the scores obtained in the psychological evaluations be below the clinical threshold (indicating a psychological disorder such as depression), the participant will be referred to Dr. Nicoleen Coetzee for further evaluation and assistance. It is within the participant's right to decline the offer of psychological support.

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Informed concent

I hereby confirm that I have been informed by the investigator, L Naicker about the nature, conduct, benefits and risks of the research study. I have also received, read and understood the above written information (Patient Information Leaflet and Informed Consent) regarding the research study.

I am aware that the results of this study, including personal details regarding my sex, age, date of birth, initials, health and performance will be anonymously processed into a study report.

I may, at any stage, without prejudice, withdraw my consent and participation in the study. I have had sufficient opportunity to ask questions and (of my own free will) declare myself prepared to participate in this study.

Participant's name…………………………………………………………………...........

(Please print)

Participant's signature………………………………………….....................................

Date………………………………………………………...

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I, L Naicker herewith confirm that the above participation has been informed fully about the nature, conduct and risks of the above study.

Investigators name....................................Lee-Anne Naicker......................................

Investigator's signature……………………………………..

Date……………………………………………………..

Witness's name*………………………………………...

(Please print)

Witness's signature…………………...

Date………………..

*Consent procedure should be witnessed whenever possible

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6. Appendix B: Data sheet

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YUNIBESITHI YA PRETORIA

Department of Physiology, Faculty of Health Sciences
PO Box 2034, Pretoria, 0001 - Republic of South Africa
Tel: (012) 420 4482 Fax: (012) 420 4483

Subject Number: Number ________________ Date: DD | MM | YEAR

INDEMNITY

I hereby declare that I fully understand the procedure of the evaluation have had the opportunity to discuss all relevant matters. I participate in the evaluation exercises at my own risk and will not hold the University of Pretoria responsible for any injury obtained.

Signed____ Date__________________________

PERSONAL AND BIOGRAPHICAL INFORMATION

Age: YRS __________ Dominant hand: RIGHT/LEFT ________________

Ethnicity: [B] Black [C] Coloured [I] Indian [A] Asian [W] White

Gender: [M] Male [F] Female

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PERSONAL AND FAMILY MEDICAL HISTORY

Do any of your immediate family members (grandparents, parents, brother(s) or sister(s) suffer from, or take medication for the following health factors?

- ☐ Heat attack
- ☐ Heart disease
- ☐ Lung disease
- ☐ Any cancer
- ☐ Overweight
- ☐ High blood pressure
- ☐ High cholesterol levels
- ☐ Any dependency
- ☐ Renal disease
- ☐ Connective tissue disease
- ☐ Autoimmune disease
- ☐ Liver disease
- ☐ Neurological disease
- ☐ Psychiatric disease
- ☐ None

Have any of your immediate family members (grandparents, parents, brother(s) or sister(s) died from the following health factors?

- ☐ Heat attack
- ☐ Heart disease
- ☐ Lung disease
- ☐ Any cancer
- ☐ Overweight
- ☐ High blood pressure
- ☐ High cholesterol levels
- ☐ Any dependency
- ☐ Renal disease
- ☐ Connective tissue disease
- ☐ Autoimmune disease
- ☐ Liver disease
- ☐ Neurological disease
- ☐ Psychiatric disease
- ☐ None

Do you suffer or take medication for the following chronic conditions?

- ☐ Heat attack
- ☐ Heart disease
- ☐ Lung disease
- ☐ Any cancer
- ☐ Overweight
- ☐ High blood pressure
- ☐ High cholesterol levels
- ☐ Any dependency
- ☐ Renal disease
- ☐ Connective tissue disease
- ☐ Autoimmune disease
- ☐ Liver disease
- ☐ Neurological disease
- ☐ Psychiatric disease
- ☐ None

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NUTRITIONAL ASSESSMENT

Indicate the statement that best describes the frequency of your food-related behaviour, always (A), often (O), sometimes (S), rarely (R) or never (N)

	A	***O***	***S***	***R***	***N***
1. Everyday I eat a nutritious breakfast.	A	O	S	R	N
2. I try to include recommended servings from each of the food groups in my daily diet.	A	O	S	R	N
3. I eat unsalted food.	A	O	S	R	N
4. When I snack, I choose fruits, vegetables, low-fat yogurt, or cheese.	A	O	S	R	N
5. I try to include mostly fresh and less-processed foods in my daily diet.	A	O	S	R	N
6. I avoid fatty foods and trim off the visible fats from meats.	A	O	S	R	N
7. I include foods containing fibre, such as fruits, vegetables, whole grain products, and beans in my diet.	A	O	S	R	N
8. I drink skim milk instead of whole or 2% milk.	A	O	S	R	N
9. I consume fish at least once a week.	A	O	S	R	N
10. I consume caffeine-free beverages.	A	O	S	R	N
11. I avoid foods that contain large amounts of honey and sugar.	A	O	S	R	N
12. For reliable nutrition information, I ask a qualified nutritionist instead of relying on the popular press.	A	O	S	R	N
13. I do not drink alcoholic beverages.	A	O	S	R	N
14. I keep my weight within acceptable limits.	A	O	S	R	N
15. I obtain my nutrients through foods rather than relying on nutritional supplements	A	O	S	R	N

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PERSONAL STRESS INVENTORY

Choose YES (Y) of NO (N) for each question	*Y*	*N*
1. I have frequent arguments.	Y	N
2. I often get upset at work/school/university.	Y	N
3. I often have neck and/or shoulder pains due to anxiety/stress.	Y	N
4. I often get upset when I stand in long lines.	Y	N
5. I often get angry when I listen to the local, national or world news or read the newspaper.	Y	N
6. I do not have a sufficient amount of money for my needs.	Y	N
7. I often get upset when driving.	Y	N
8. At the end of a day I often feel stress-related fatigue.	Y	N
9. I have at least one constant source of stress/anxiety in my life (e.g., conflict with boss, neighbour, mother-in-law etc.).	Y	N
10. I often have stress-related headaches.	Y	N
11. I do not practice stress management techniques.	Y	N
12. I rarely take time for myself.	Y	N
13. I have difficulty in keeping my feeling of anger and hostility under control.	Y	N
14. I have difficulty in managing time wisely.	Y	N
15. I often have difficulty sleeping.	Y	N
16. I am generally in a hurry.	Y	N

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LIFESTYLE EVALUATION

For each question, choose the answer that best describes your behaviour, always (A), sometimes (S) or never (N). Answer always if you agree with a statement.

Exercise/Fitness	***A***	***S***	***N***
1. I engage in moderate exercise such as brisk walking or swimming for 20 to 60 minutes, three times a week.	A	S	N
2. I do exercise to develop muscular strength and endurance at least twice a week.	A	S	N
3. I spend some of my leisure time participation in individual, family, or even team activities such as gardening, bowling, or softball.	A	S	N
4. I maintain a healthy body weight and am not overweight or underweight.	A	S	N

Nutrition	***A***	***S***	***N***
1. I eat a variety of foods each day, including seven or more servings of fruit and/or vegetables.	A	S	N
2. I limit the amount of total fat and saturated trans fats in my diet.	A	S	N
3. I avoid skipping meals.	A	S	N
4. I limit the amount of salt and sugar I eat.	A	S	N

Tobacco use

If you never or no longer use tobacco, indicate always for both questions.	***A***	***S***	***N***
1. I avoid using tobacco.	A	S	N
2. I smoke only low-tar-and-nicotine cigarettes, or smoke a pipe or cigars, or I use smokeless tobacco.	A	S	N

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Alcohol and drugs	***A***	***S***	***N***
1. I avoid alcohol, or I drink no more than one (woman) or two (men) drinks a day.	A	S	N
2. I avoid using alcohol and/or other drugs.	A	S	N
3. I am careful not to drink alcohol when taking medications (such as cold or allergy medications) or when pregnant.	A	S	N
4. I read and follow the label directions when using prescribed and over-the-counter drugs.	A	S	N

Emotional health	***A***	***S***	***N***
1. I enjoy being a student and/or I have a job or do other work that I enjoy.	A	S	N
2. I find it easy to relax and express my feelings freely.	A	S	N
3. I manage stress well.	A	S	N
4. I have close friends, relatives, or others whom I can talk to about personal matters and call on for help when needed.	A	S	N

Safety	***A***	***S***	***N***
1. I wear a safety belt when riding in a car.	A	S	N
2. I avoid driving while under the influence of alcohol or other drugs.	A	S	N
3. I obey traffic rules and the speed limit when driving.	A	S	N
4. I read and follow instructions on the labels of potentially harmful products or substances, such as household cleaners.	A	S	N
5. I avoid smoking in bed.	A	S	N

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Disease prevention	***A***	***S***	***N***
1. I know the warning signs of cancer, heart attack, and stroke.	A	S	N
2. I avoid overexposure to the sun and use sunscreen.	A	S	N
3. I get recommended medical screening tests (such as blood pressure and cholesterol checks and Pap tests), immunizations and booster shots.	A	S	N
4. I practice monthly skin and breast/testicle self-exams.	A	S	N
5. I am not sexually active, or have sex with only one mutually faithful, uninfected partner, or I always engage in safe sex (using condoms), and I do not share needles to inject drugs	A	S	N

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YUNIBESITHI YA PRETORIA

Department of Physiology, Faculty of Health Sciences
PO Box 2034, Pretoria, 0001 - Republic of South Africa
Tel: (012) 420 4482 Fax: (012) 420 4483

Subject number: Number

Date: DD | MM | YEAR

BODY MASS

Height (cm): 1 | 2

Weight (Kg): 1 | 2

WAIST-TO-HIP RATIO

Waist (cm): 1 | 2

Hip (cm): 1 | 2

SUB-CUTANEOUS FAT

Biceps (mm): 1 | 2

Triceps (mm): 1 | 2

Sub-scapular (mm): 1 | 2

Abdominal (mm): 1 | 2

Suprailiac (mm): 1 | 2

Thigh (mm): 1 | 2

Calve (mm): 1 | 2

Pectoral (mm): 1 | 2

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VI-PORT

CSI (%):	1	2	HR (bpm):	1	2
Rhythm (Y/N):	1	2	QRS Dur. (ms):	1	2
RRSD (ms):	1	2			

BLOOD PRESSURE

Syst (mmHG):	1	2	Diast (mmHg):	1	2

SPORTS VISION

Focusing:	1	2	EH Coordination:	1	2
Tracking:	1	2	Visualisation:	1	2
Vergence:	1	2	Sequencing:	1	2

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FITNESS

*Sit and Reach:	Thigh	Shins	Toes

Use sit and reach box and do modified sit and reach test

**Push-ups (#/1 min): 1 Type of push-up: Half/Full

*****All men do full push-up and all women do half push-up***

Sit-ups (#/1 min): 1

3-Min Step test
(pulse/15 sec) 1

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7. Appendix C: Wellness assessment norms and compounding the physical wellness indicator

How the scores were calculated

Each sub-aspect of physical wellness is allocated a score based on the normative data for each assessment. The scores are risk profiles based on the percentiles of the normative data - for instance the values in the 80th percentile and above are allocated a score of 3 which indicates a low risk, values ranging from the 70th - 50th percentile are allocated a score of 2 which indicates a moderate risk, and values in the 40th percentile and below are allocated a score of 1 which indicates a high risk of developing non-communicable conditions.

Each sub-section score out of 3 was then added to yield an overall score (the maximum is indicated by square brackets) for each section (or index) of physical wellness to provide a risk profile for the section.

The physical wellness indicator was calculated by combining all sections to yield an overall score out of 54 to provide a broad indication of physical wellness.

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Wellness assessment norms

VISUAL SKILL INDEX		
Question scoring	**Focusing (# letters/min)** • ≥ 60: Excellent performance (3) • 40 – 59: Average performance (2) • ≤ 39: Low performance (1)	**Compounded visual index score [18]:** ≥ 15: Low risk 14 – 9: Moderate Risk ≤ 8: High risk
	Tracking (# letters/min) • ≥ 60: Excellent performance (3) • 40 – 59: Average performance (2) • ≤ 39: Low performance (1)	
	Vergence (cm) • ≤ 2.54: Excellent performance (3) • 2.55 – 4.21: Average performance (2) • ≥ 4.22: Low performance (1)	
	Eye-hand coordination (sec) • ≤ 20: Excellent performance (3) • 21 – 40: Average performance (2) • ≥ 41: Low performance (1)	
	Visualisation (sec) • ≤ 39: Excellent performance (3) • 40 – 69: Average performance (2) • ≥ 70: Low performance (1)	
	Sequencing (# correct sequences) • ≥ 5: Excellent performance (3) • 3 – 4: Average performance (2) • ≤ 2: Low performance (1)	

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BODY FAT PERCENTAGE	
Question scoring	**Males** • 5 – 12.9: Low risk (3) • 13 – 16.9: Moderate risk (2) • ≥ 17: High Risk (1)
	Females • 12 – 20.9: Low risk (3) • 21 – 23.9: Moderate risk (2) • ≥ 24: High Risk (1)

OVERALL FITNESS SCORE		
Question scoring	**3-Minute step test (beats/15 sec)** • ≤32: Low risk (3) • 33 – 35: Moderate risk (2) • ≥ 36: High risk (1)	**Compounded visual index score [18]:** ≥ 15: Low risk 14 – 9: Moderate Risk ≤ 8: High risk
	Sit and reach (cm/location) • Toes: Low risk (3) • Knees: Moderate risk (2) • Thighs: High risk (1)	
	Press-ups (#/min) **Full press-ups:** • ≥ 36: Low risk (3) • 35 – 17: Moderate risk (2) • ≤ 16: High risk (1) **Modified (half) press-ups:** • ≥ 51: Low risk (3) • 50 – 30: Moderate risk (2) • ≤ 29: High risk (1)	

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	Crunches (#/min) • ≤ 46: Excellent performance (3) • 45 – 25: Average performance (2) • ≥ 24: Low performance (1)	
	BMI • < 18: High risk (1) • 18.5 – 24.9: Low risk (3) • 25 – 29.9: Moderate risk (2) • ≥ 30: High risk (1)	
	WHR **Males:** • < 0.80: Low risk (3) • 0.81 – 0.94: Moderate risk (2) • > 0.95: High risk (1) **Females:** • < 0.70: Low risk (3) • 0.71 – 0.85: Moderate risk (2) • > 0.86: High risk (1)	

CARDIO STRESS INDEX	
Question scoring	**CSI (%) [3]:** • ≤ 25: Low risk (3) • 26 – 49: Moderate risk (2) • ≥ 50: High Risk (1)

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BLOOD PRESSURE		
Question scoring	**Systolic BP (mmHg)** • ≤ 139: Low risk (3) • 140 – 159: Moderate risk (2) • ≥ 160: High Risk (1)	**Compounded BP score [3]:** ≥ 5: Low risk (3) 4 – 3: Moderate Risk (2) ≤ 2: High risk (1)
	Diastolic BP (mmHg) • ≤ 89: Low risk (3) • 90 – 99: Moderate risk (2) • ≥ 100: High Risk (1)	

Lifestyle Index

The lifestyle index is compounded as follows:

Nutritional status [3]
+
Stress index [3]
+
Lifestyle evaluation [3]

} **Lifestyle index [9]**

NUTRITIONAL INDEX		
Question scoring	Always = 4 Often = 3 Sometimes = 2 Rarely = 1 Never = 0	**Compounded nutritional index score [3]:** ≥ 45: Low risk (3) 44 – 39: Moderate Risk (2) ≤ 38: High risk (1)

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STRESS INDEX		
Question scoring	Yes = 1 No = 0	**Compounded stress index score [3]:** ≤ 7: Low risk (3) 8 – 12: Moderate Risk (2) ≥ 13: High risk (1)

LIFESTYLE BEHAVIOUR		
Question scoring	**Exercise/fitness** • Always = 4 (Q1); 2 (Q2,3,4) • Sometimes = 1 • Never = 0 **Nutrition** • Always = 3 (Q1,2); 2 (Q3,4) • Sometimes = 1 • Never = 0 **Tobacco use** • Always = 5 • Sometimes = 3 • Never = 0 **Alcohol and drugs** • Always = 4 (Q1); 2 (Q2,3,4) • Sometimes = 1 • Never = 0 **Emotional health** • Always = 2 (Q1,4); 3 (Q2,3) • Sometimes = 1 • Never = 0 **Safety** • Always = 2 • Sometimes = 1 • Never = 0 **Disease prevention** • Always = 2 • Sometimes = 1 • Never = 0	**Per section:** ≥ 7: Low risk (3) 6 – 5: Moderate Risk (2) ≤4: High risk (1) **Compounded lifestyle behaviour score [3]:** ≥ 17: Low risk (3) 18 – 11: Moderate Risk (2) ≤10: High risk (1)

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Compounding the overall physical wellness indicator

The overall physical wellness indicator involves the integration of the wellness components to yield an overall score and is compounded as follows:

Visual skill index [18]

+

Body fat percentage [3]

+

Overall fitness score [18]

+

Cardio stress index [3]

+

Blood pressure [3]

+

Lifestyle index [9]

} **Overall wellness indicator [54]**

PHYSICAL WELLNESS INDEX	
Question scoring	**Physical Wellness Index [54]:** • ≥ 43: Low risk (3) • 27 – 42: Moderate risk (2) • ≤ 26: High risk (1)

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