CHAPTER 5

DISCUSSION OF RESULTS

5.1. INTRODUCTION

The aim of this study was to investigate if developmental milestones such as sitting, crawling and walking could influence the development of spinal deformities in adolescents. Other factors which may have played a role, such as the gestation period, preference of lying position and the use of aids, such as sit chairs, walking rings, and "jolly jumpers", were also taken into consideration. Factors such as defective eyesight and defective hearing were noted as they may also have contributed to the development of postural abnormalities.

In order to determine whether the subjects complied with the criteria for the case or control group, a thorough objective evaluation of each adolescent had to be performed. The subjects were then allocated to either the case or control group, according to the inclusion criteria for each group. A questionnaire was completed to record the developmental milestones of each of the case and control subjects. Although previous researchers have hypothesised that abnormal developmental milestones may be a neuromuscular cause of spinal deformities[20], no research to validate or negate the hypotheses was found in the literature review. The hypothesis that certain developmental milestones and other factors are associated with the prevalence of spinal deformities was only partially supported in this study. The study did, however, indicate that:

- babies who walked later (after twelve months) appeared to be more at risk to develop spinal deformities during adolescence
- babies who did not crawl and commenced walking at an age after twelve months seemed to have a non-significant risk to develop spinal deformities.

The sample in this study is not representative of the population in South Africa. Therefore generalisation of the results to a multiracial population cannot be made. The results are only applicable to the white population of Middelburg, Mpumalanga.

Spinal deformities have a variety of aetiological factors[39] which were also investigated in this study. Poor posture due to hypotonia could develop into a postural disorder.[5,23] Abnormal developmental milestones, leading to impairment of neuromuscular control, were investigated as a possible aetiological factor in the development of spinal deformities.

5.2. PHYSICAL EVALUATION

5.2.1. CASES AND CONTROLS

There were 104 adolescents who complied with the criteria for either the case or the control group. Following the physical examination, more subjects (58,7 %) were allocated to the case than to the control group (41,3 %). The prevalence of deformities in this sample is much higher than the prevalence given in the literature for the general population, that is 0,5 % for scolioses,[9] and 0,5 to 8 % for Scheuermann's kyphoses.[20] Hyperkyphoses of more than 35 degrees were found in 13,5 % of adolescents.[17] All the studies referred to in the literature were done overseas, and not in South Africa. The percentages in the two groups may have resulted from the fact that subjects volunteered to participate in the study. Approximately one third of the mothers of volunteers knew that their offspring had a deformity. This was a sample of convenience, and therefore, subjects who knew or suspected that they had a deformity, were probably more willing to volunteer for the study.

5.2.2. ETHNICITY

Unfortunately the sample in this study was not representative of the population in South Africa due to the fact that only white mothers responded to the request for volunteers. This may be due to the fact that the mothers of black and / or Asian scholars are possibly unaware of the significance of spinal deformities in adolescents.

5.2.3. GENDER

There was an uneven distribution of girls and boys in the total study group. There were more girls in the case as well as in the control group (table 1).

A higher percentage of the girls compared to the boys presented with a deformity in the coronal plane and a slightly higher percentage of the boys presented with a sagittal plane deformity (table 2) . Although these findings were non-significant, the trend correlates with the literature which indicates that the frequency of idiopathic scoliosis is significantly higher in girls than boys.[9,31,34] However, kyphoses are found more frequently in boys.[17]

The fact that a smaller percentage of boys in this study presented with a sagittal plane deformity than coronal plane deformity, is probably due to the fact that the combined coronal and sagittal plane deformities were separated from those who presented with a sagittal plane deformity only (table 2). The literature states that a scoliosis is present in the area of maximum kyphotic deformity.[11,45] This implies that sagittal and coronal plane deformities were grouped together, and not considered separately.

5.2.4. AGE

The mean age for the case group (14,85 years) was higher than the mean age of the control group (13,84 years). This is probably due to the fact that adolescents tend to develop deformities during puberty when their growth spurts take place.[5,6,7] The subjects were allocated to the case or control group according to whether a deformity was present or not. It is therefore more likely for subjects with deformities to be older than their counterparts.

5.2.5. MENARCHE

There was a significantly higher percentage (p=0,013) of subjects in the case group who had reached their menarche at the time of the evaluation (figure 16) . While growth is considered to be one of the aetiological factors of spinal deformities, the onset of puberty and menarche in girls are associated with the age of sudden growth.[1,3,29] These factors, as well as the fact that girls from the case group were significantly taller (p<0,0001) than girls from the control group, correlate with the higher percentage of girls who had reached their menarche. (See 5.2.5.)

5.2.6. HEIGHT

Girls as well as boys from the case group were taller than those from the control group (p value for girls: <0,0001 ; boys = 0,092).(See figure 17) The mean height for boys was more than the mean height for girls. Taller adolescents, especially girls, tend to be more prone to develop idiopathic scoliosis.[1,3,5,31,] Increased height also influences the development of a kyphosis.[17,32] These findings from previous studies found in the literature are verified by this study.

It was interesting to note that the subjects with combined sagittal and coronal plane deformities were significantly taller than those with only sagittal plane deformities (p=0,02), whilst there was a trend for subjects with combined sagittal and coronal plane deformities to be taller than those with only coronal plane deformities (p=0,07). No significant height difference was found between the presence of either a coronal plane or sagittal plane deformity. No relevant information could be found in the literature that compared the mean height of subjects with coronal or sagittal plane deformities, or to compare the mean height of combined coronal and sagittal deformities with single plane deformities.

5.2.7. LEG LENGTH DISCREPANCY

There was not much difference between the cases and controls regarding leg length. A very slight higher mean in the leg length discrepancy was found in the control group, but this was non-significant. (See appendix G figure 45) More left sided (41,3 %) than right sided (30,8 %) longer legs were found. (See appendix G figure 46) There was no correlation between the different planes of deformities and the presence of leg length discrepancies. The slight leg length discrepancies observed in this study did not influence the deformities. A leg length discrepancy is commonly present in the general population, but a difference of ten millimetres is needed to cause asymmetry of the spine.[54]

5.2.8. STRAIGHT LEG RAISE

There was no significant difference between the case and control groups regarding the range of hip flexion when performing a straight leg raise. The mean range for the straight leg raise for both the groups on the left-, as well as the right-hand sides, varied from 54,40 to 55,5 degrees. This was only slightly higher than the minimum norm of 50 degrees hip

flexion stated in the literature.[59] This general lack of flexibility could be due to the fact that adolescents spend the major part of their day sitting at school and doing homework. Unfortunately the physical activity of participating subjects was not considered in this investigation. The difference between the straight leg raise on the left and right sides in both the case and control groups, showed no significance. (See appendix G figure 47) The literature indicates that tight hamstrings could be expected with hyper-kyphoses[48], but the mean straight leg raise in subjects with different planes of deformities did not show a significant difference. (See appendix G table 8) Therefore there was no correlation between the decreased hamstring flexibility and the presence of deformities in this study.

5.2.9. THOMAS TEST

Most of the subjects from the case (95,08 %) and the control group (97,67 %) presented with hip flexor tightness. (See appendix G figure 48) A normal Thomas test (where the hip joint remained in neutral[53]) was found in only six of the left hip flexors and four of the right hip flexors. Once again, the fact that adolescents spend a great deal of the time during the day in a sitting position at school could result in hip flexor tightness. Although there was a slight tendency for a higher mean for left-sided hip flexor tightness than right sided tightness in all the subjects, the difference was non-significant.(See appendix G figure 49) No relevant literature could be found.

5.2.10. HUMP SIZE

Thoracic humps of more than six millimetres were most frequently measured in the thoracic area (figure 20). Right-sided thoracic humps were present significantly more frequently than left-sided humps (p=0,05). The literature states that 80 % of the thoracic curves were found to be convex to the right[11,32,33], which supports the findings of this

study. Although only a few lumbar humps were observed in this study, there was a tendency for more left-sided lumbar humps of more than six millimetres to be present. However, the difference between the presence of left- and right-sided lumbar humps were non-significant.(p=0,32). The literature indicates that spinal curves in the lumbar area are present towards the left in 90 % of the lumbar curves.[11,32]

In this study, thoraco-lumbar humps were found significantly more frequently than lumbar humps (p=0,0003). Thoraco-lumbar humps of more than six millimetres were also present more frequently on the right-hand side than on the left-hand side but this was non-significant (p=0,22). (See figure 20) Due to the fact that no radiographs were taken in this study, it was difficult to determine the presence of double curves. A trend was noticed that right-sided thoracic humps of at least six millimetres and more, were present more frequently than thoraco-lumbar humps on the right-hand side (p=0,08).

The thoracic area is more vulnerable for the development of scolioses than any other spinal area. This study, as well as previous studies[11,32,33], indicate that right sided thoracic curves develop more frequently than left sided thoracic curves.

5.2.11. ANGLE OF TRUNK ROTATION

An angle of trunk rotation of five degrees and more was present in 41 % of subjects from the case group, and in 68 % of subjects from the case group who presented with a hump size of six millimetres or more. A significant correlation was found between the angle of trunk rotation, measured by means of the inclinometer, and the hump sizes, measured by means of a spirit level and a graduated ruler.

5.2.12. PLUMBLINE

A deviation of the plumbline from the gluteal cleft occurred more frequently (p=0,06) towards the left hand side in subjects from the case group. Due to the fact that double curves and pelvic deviations were not taken into consideration, this deviation of the plumbline was not necessarily an indication of the side of the primary curve.

It was interesting to note that almost half of the subjects from the control group also presented with a deviation from the plumbline. This could be an indication of the number of subjects with poor postures who participated in this study. Although non-significant, this deviation of the plumbline from the gluteal cleft was present more often towards the right in the control group. This could be an indication of the postures that develop due to the unilateral carrying of school bags.

The spinal area where a deviation from the plumbline was most frequently present was the thoracic area, which was also the area where most of the humps occurred. The literature indicates that any deviation from the plumbline of less than ten millimetres can be considered as normal.[36] The measurements in millimetres of the distance of the plumbline from the gluteal cleft and from the midline of the spine were influenced by the sway of the body, due to weight transfer, and the fact that many of the subjects struggled to stand still: These measurements were thus considered unreliable and were discarded from the results of this study.

5.2.13. KYPHOSIS AND LORDOSIS

Almost half of the subjects from the case group (49,2 %) presented with a hyperkyphosis. This percentage consisted of subjects who presented with only a sagittal plane deformity

and those who had combined sagittal and coronal plane deformities. The mean measurement of kyphosis for the group with hyperkyphosis was 53,1 degrees. In the literature the mean for normal subjects varied.[2,8,17,47,78,88] As guidelines by the Scoliosis Research Society state that a normal kyphosis should not exceed 45 degrees, this was considered the gold standard for this study.[47]

The postural round back could be a result of weak postural muscles and could proceed to develop into a structural kyphosis.[5,23,51] Therefore the data for the postural round back as well as the structural hyperkyphosis were included in this study. No postural correction of the subjects was done prior to taking measurements.

Only 6,6 % of the subjects presented with a hypokyphosis (mean of 16,65 degrees; standard deviation: 4,3)). One subject presented with a hypolordosis, and hyperlordoses were not found in this sample.

5.2.14. FORWARD HEAD POSTURE

A forward head posture was present in 45,9 % of subjects from the case group 56,7 % of subjects with a hyperkyphosis also presented with a forward head posture. There was a trend for a forward head posture to be present with a hyperkyphosis but this was non-significant (p=0,15). No study was found to correlate hyperkyphoses with forward head postures, but Hilibrand *et al* (1995)[38] did determine a significant relationship between hypokyphoses seen in idiopathic scolioses and the flattening of cervical lordoses.

5.2.15. WINGING OF SCAPULAE

Asymmetrical winging of the scapulae was observed in both the case (54,74 %) and control group (37,21 %). The asymmetrical winging of the scapulae was significantly more frequently present on the right side (p=0,02) in the case group, while the left-sided asymmetrical winging in the control group was observed more frequently (p=0,079). The higher percentage of winging on the right hand side of subjects from the case group correlates with the fact that more right sided thoracic humps were present in this study, as well as results in the literature.[11,32,33] Once again the high percentage of asymmetrical winging of the scapulae could be an indication of poor postural control of subjects in this study.

5.2.16. ASYMMETRICAL ELEVATED SHOULDER

The presence of an asymmetrically elevated shoulder was observed in both the case and control groups (figure 12). In the case group a trend for more right-sided elevation of the shoulder was observed (p=0,95). This correlates with the higher percentage of right sided asymmetrical scapular winging and the higher percentage of right sided thoracic humps. The literature indicates that a right sided thoracic scoliosis would result in the right sided scapula to be elevated and forcibly lifted by the rib hump.[32]

The asymmetrical elevation of the shoulder girdle was significantly more frequently present on the left-hand side in subjects from the control group (p<0,0001). This asymmetrical posture could possibly be due to the fact that adolescents carry their school bags in one hand only, pulling the right hand shoulder down. Unfortunately, this study did not include the side of preference for carrying a school bag, nor the dominant side of the subjects.

5.2.17. ARM DISTANCE FROM TRUNK

The presence of one arm further away from the trunk was also observed in both the case and control groups (figure 26). Most of the subjects from the case and the control groups presented with the left arm significantly further from the trunk ($p<0,0001$ in the case and the control groups). With the higher percentage of thoracic humps it would be expected that the case group would lean more towards the right, causing the right arm to be further away from the body. This incongruity in data could be due to the fact that double curves were not noted. Only the arm hanging further from the trunk was noted and not the flank folds. It was initially decided not to include the flank folds because it could be possible that flank folds have not yet developed in early scoliosis.

A "normal spine" (kyphosis/lordosis within normal limits, without deviation from the plumbline and no humps of six millimetres and more) was present in 17,3 % of the total number of subjects. The literature indicates that symmetrical spines have a prevalence of 22 %.[55]

Once the objective evaluation was complete, the mother was interviewed with regard to developmental milestones and other factors which may have influenced the development of adolescent spinal deformities.

5.3. QUESTIONNAIRE

An analysis of information obtained during interviews with the mothers follows. Findings with regard to the developmental milestones (sitting, crawling and walking) will be discussed, followed by other possible contributing factors such as developmental aids, family history, gestation, birth method, lying position, defective hearing and vision, and growth spurt.

5.3.1. DEVELOPMENTAL MILESTONES

5.3.1.1. SITTING

Most of the subjects from the case and the control groups sat at an average developmental time of between six and nine months (figure 27). Although a baby should be able to sit independently by the age of six to nine months, postural control in this position has not yet developed.[102,113,120]

Slightly more subjects from the case group than the control group sat before six months, but this was non-significant (figure 27). Sufficient postural tone is present by the age of six months to maintain the body against gravity in a sitting position, but the position is not yet erect.[114] It would appear that a possible lack of postural control before six months, results in a tendency for subjects who sat early, to develop a deformity.

5.3.1.2. CRAWLING

Only 13,11 % of the subjects from the case and 4,65 % from the control group did not crawl (figure 28). The literature indicates that 82 % of infants are crawlers.[25] This study presented with 86,9 % of crawlers in the case group, compared to the 95,4 % in the control group. The percentage of crawlers was higher in the control group (p=0,075) than in the case group. This trend could indicate that crawling is an important milestone in the developing sufficient postural control to prevent spinal deformities at a later stage.

Crawling on hands and knees is the most important pre-standing locomotion activity[25]. Researchers found that crawlers, who were evaluated at an age of five years, showed no asymmetry, whilst children who shuffled or just stood up and walked, did show asymmetry

in their motor activity. Hypotonia in the central trunk is related to the choice of locomotion before walking.[24] The fact that non-crawling subjects from this study, showed the highest association with the presence of spinal deformities (table 5), supports the findings of the aforementioned researchers, as well as the unsupported hypothesis of Boachie-Adjei *et al* (1996)[2] , stating that abnormal developmental milestones may be a cause of spinal deformities.

Crawling (case and control groups) mostly commenced at an age of six to nine months (figure 29). Slightly more (non-significant, p=0,2) subjects from the case than from the control group crawled at the age of six to nine months. Although crawling at an age of six to nine months cannot really be considered pathological, the literature does show that the normal average age at which crawling should commence, is between nine and twelve months.[114] In this study, a slightly higher percentage (non-significant, p=0,14) of subjects from the control group commenced to crawl between nine to twelve months (figure 29). There was one subject from the case group who crawled very late (12 - 15 months). It was interesting to note that this subject was very tall (172,5 centimetres) at the age of 15 years and 10 months, and presented with a hyperkyphosis of 60,3 degrees. Once again it can be postulated that a lack of postural control, due to late gross motor milestones, could have contributed to the development of this hyperkyphosis.

Subjects who did crawl , mostly crawled for long periods (figure 30). The period of crawling most frequently noted in the case and control groups, was two to three months. Although non-significant (p=0,38), slightly more subjects from the case group were reported to have crawled for this period of time. The period of crawling for longer than three months, was noted equally in the case and control groups. Crawling for less than one month was reported slightly more frequently in subjects from the control than from the case group, but this was non-significant (figure 30). Although it can be reported that crawling is an important factor in the prevention of hypotonia and subsequent deformities,

this study showed no evidence that a short or long period of crawling was beneficial. The literature states that crawling develops between 10 and 12 months and during this period diagonal trunk control should develop[114] ; but the ideal time period necessary to develop this motor skill, before walking commences, was not found in the literature.

More subjects from the case group were reported to have had an alternative method of locomotion prior to walking. However, no significant comparison concerning the alternative method of locomotion could be made between subjects from the case and the control groups. (See table 4)

5.3.1.3. WALKING

Humans do not acquire sufficient postural control to stand upright and walk until the last month of their first year.[102,114,116] There were very early and very late walkers in both the case and the control groups in this study (figure 32). More subjects from the control group had walked by the end of their first year (figure 32). It was, however, in the time period of 12 to 15 months, that a trend for a higher frequency of subjects from the case group, 42,37 % cases compared to 28,57 % controls, were reported to have started walking (p=0,078). Although this period for commencing walking is not considered abnormal, it can be considered slightly late.[114,116] It could be hypothesised that the late walkers had a degree of hypotonia and that this delayed the walking milestone. This can be verified by the fact that, according to the Logit analysis, the subjects who did not crawl and commenced walking after the age of 12 months, were more prone to develop spinal deformities (probability of 0,90). Bottos *et al* (1989)[24] found that missing the stages of crawling or creeping did not influence the neurodevelopmental evolution up to an age of five years. However, from the results of this study, it would seem that the fact that the subjects did not crawl could be attributed to hypotonia during babyhood and that they therefore became late walkers.

5.3.2. DEVELOPMENTAL AIDS

5.3.2.1. SIT CHAIR

Very little literature was found on the effect of developmental aids on the milestones of babies. Bottos et al (1989)[24] suggest that babies should move on the floor in their first year of life. Children who are restricted from moving freely, due to overprotective parents and continuous choice of locomotion by parents, could be limited in their experience of locomotive strategies.[24]

There was a slightly higher tendency for subjects from the case group to be placed in a sit chair more frequently than subjects from the control group (p=0,41). (See figure 33) There was no evidence that the duration of use of a sit chair had any influence on the development of deformities. There was, however, an interesting tendency for more subjects from the case group to have used the sit chair for less than one hour, compared to the tendency for subjects from the control group to have used the sit chair for one to two hours (figure 34). It could be postulated that subjects from the case group were removed from the sit chair earlier (less than an hour) because they became tired as a result of weak postural muscles. Unfortunately, this study did not investigate why the mothers removed the subjects from their sit chairs at a specific time.

5.3.2.2. WALKING RING

There was a trend for subjects from the case group to use walking rings more frequently than subjects from the control group (p=0,14). (See figure 35) Postural control was possibly not stimulated due to a lack of full weight bearing in a walking ring. This could be why the use of a walking ring was reported more frequently amongst case subjects.

Although non-significant, the time period of one to two hours' use of the walking ring was reported more frequently amongst the subjects from the case group, while the shorter period (under one hour) was reported more frequently in subjects from the control group. This finding could possibly suggest that the longer subjects were placed in the walking ring the less postural control they developed.

5.3.2.3. "JOLLY JUMPER"

A small percentage of the subjects from case and control groups were placed in "jolly jumpers" as babies. There was a slightly higher percentage for subjects from the control group to use a "jolly jumper". A possible explanation for this could be that the jumping action in the "jolly jumper" may have stimulated muscle contraction and therefore contributed to postural control. There was no significant evidence of any influence of the time period in the "jolly jumper" on the development of spinal deformities (figure 38).

5.3.3. OTHER FACTORS

5.3.3.1. FAMILY HISTORY

A family history of deformities was reported significantly more frequently in the case group than in the control group. The literature also indicates that both adolescent idiopathic scoliosis[1,2,5,9,11,28,32] and Scheuermann's kyphosis[11] have a genetic basis. It was interesting to note that more mothers from the control than case group had a family history of deformities although this was of no statistical significance. Deformities of the grandmothers and grandfathers may have been due to geriatric changes. The researcher was unable to determine whether their deformities were definitely due to changes during adolescence.

No family history of deformities in distant family on the paternal side were reported in the control group. This could be due to the fact that only the mothers were questioned, and that they were uncertain of the paternal family history.

5.3.3.2. GESTATION

Most of the subjects (62,75 %) were born after a gestation period of 40 weeks (figure 40). The percentage of the cases compared to the percentage of the controls who were full term, were more or less equal (figure 40). The thirty eight week gestation period was reported more frequently in subjects from the control group, but this could be due to more Caesarean deliveries in the control group (figure 41).

5.3.3.3. BIRTH METHOD

Normal births were seen almost equally in the case and control groups. Normal births with the aid of instruments occurred slightly more frequently in the case group, while births by means of Caesarean section were reported slightly more often in the control group (figure 41). Birth method had no significant influence on deformities.

5.3.3.4. LYING POSITION

The most preferred lying position for subjects from both the case (35,19 %) and the control group (40 %), was side lying. This could be due to the fact that most of the nursing homes and hospitals teach mothers to position their babies in side lying in order to prevent choking (cot deaths). Lying on a specific side could be a likely cause of trunk asymmetry[114,117], although no evidence to support this statement was found in this study.

More subjects from the case than control group preferred back lying in babyhood but this was non-significant (p=0,25). Babies who are positioned in supine are rarely symmetrical,[114,117] and a posterior tilting of the pelvis and increased flexor tone could lead to a more kyphotic posture.[114] This could be a reason for the higher percentage of subjects from the case group who preferred back lying.

Prone encourages symmetrical positioning[117] and was reported more or less equally in the case and in the control groups. Infants who sleep in a prone position roll over sooner than infants who prefer side or back lying.[118] Unfortunately, rolling over as a gross motor milestone, was not evaluated in this study.

5.3.3.5. DEFECTIVE HEARING

A slightly higher percentage of subjects from the control group (11,63 %) than from the case group (9,84 %) presented with defective hearing.(See appendix G figure 50) The deformities noted amongst those with defective hearing were: one subject with a sagittal plane deformity, two with a coronal plane and three with combined sagittal and coronal plane deformities. Only 8 % of case subjects with coronal and combined coronal and sagittal plane deformities presented with defective hearing. This is an indication that defective hearing did not have an influence on the development of asymmetry in this study. To date the effect of defective hearing on an asymmetrical spine has not yet been researched.

5.3.3.6. DEFECTIVE VISION

A slightly higher percentage of subjects from the case than from the control group presented with defective eyesight (appendix G figure 51). However, only 30 % of those with defective eyesight presented with a forward head posture, and there was an equal

distribution of sagittal and coronal plane deformities amongst the subjects with defective eyesight. Correlation between defective eyesight and deformities was not found in this study. The literature only describes the association of lateral gaze palsy with progressive scoliosis[22]. It can only be postulated that poor eyesight could have an influence on the development of a forward head posture.

5.3.3.7. KNOWLEDGE OF DEFORMITY

It was interesting to note that 67,21 % of mothers of subjects in the case group did not realise that their offspring had a deformity. Those mothers who were aware of a deformity noticed it at an age between 10 and 15 years. This time period correlates with the ages when growth spurts occur in adolescents and when adolescent scolioses develop.[1,9]

5.3.3.8. GROWTH SPURT

A significantly higher percentage (p=0,009) of sudden growth spurt in subjects from the case group was reported (figure 30).This growth spurt occurred most frequently in the ten to fifteen years age period. The growth velocity *per se* is not a primary cause of adolescent idiopathic scoliosis, but it appears that taller adolescents develop deformities.[4,5,7,31] Progression of the spinal curve occurs during a growth spurt which takes place at around twelve years in girls and two years later in boys.[1] The growth spurts noted in this study are in accordance with those reported in the literature.[1,5,6,8,9]

5.4. SUMMARY

Although recall bias must be taken into consideration, it was clear from this discussion of the results that some data correlates with that found in the literature. Screening of adolescents in

this study indicated that poor postures and deformities are widely prevalent amongst white adolescents in Middelburg, Mpumalanga. This far exceeds the prevalence of deformities given in the literature. The results of the information obtained from the questionnaire also indicate some correlation with the literature.

This study showed some correlation with the literature with regard to certain aspects: the ratio of deformities according to – gender, age, family history, age of milestones and the effect of growth spurts. Once again it must be noted that no generalisation of results can be made as the sample was limited to white adolescents. The effect of other factors such as the use of walking rings and "jolly jumpers" on the development of spinal deformities was not found in the literature.

The fact that much of the information with regard to developmental milestones was given retrospectively, may have affected the validity of this study.

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CHAPTER 6

CONCLUSION AND RECOMMENDATIONS

6.1. INTRODUCTION

The specific aims of this study were to determine the influence of certain developmental milestones, the use of developmental aids and certain other factors on the development of spinal deformities. The developmental milestones were:

- the age at which the subjects sat independently as babies
- whether the subjects crawled or not
- the age at which the subjects crawled as babies
- other ways of locomotion that the subjects used before they walked
- the age at which the subjects walked independently

The developmental aids were sit chairs, walking rings and "jolly jumpers"

Other factors observed were:

- family history
- period of gestation
- birth method
- preference of lying position
- the effect of hearing defects
- the effect of poor eyesight
- growth spurt.

6.2. CONCLUSIONS

Considering the ethnicity of the sample, the following conclusions with regard to the aims of this study were made and would therefore be applicable to white adolescents in Middelburg, Mpumalanga:

6.2.1. DEVELOPMENTAL MILESTONES

⇒ No significant influence of the gross motor milestone of sitting and development of deformities was found in this study, although more subjects from the case group sat at an earlier age.

⇒ There was a non-significant trend for more crawlers to be present in the control group. More subjects in the control than in the case group crawled between nine to twelve months (considered the normal period). Although this was statistically non-significant, it appears from the literature that crawling at this stage is beneficial to the development of postural control.[114] No evidence of the advantage of a short or long period of crawling was obtained from this study. An alternative method of locomotion, other than crawling, showed no significant influence on the development of deformities.

⇒ Late walkers (twelve to fifteen months) were associated with the development of spinal deformities. The Logit analysis indicated that late walkers who also did not crawl had the highest probability of developing spinal deformities.

6.2.2. DEVELOPMENTAL AIDS

⇒ The sit chair had no significant influence on the development of spinal deformities, although subjects from the case group were placed in a sit chair slightly more frequently than their counterparts.

⇒ A walking ring was used more frequently in subjects from the case group, although this was statistically non-significant. It can, however, be postulated that a walking ring may negatively influence the development of postural control.

⇒ Although no significant influence of a "jolly jumper" on spinal deformities was found, there was a slightly higher tendency for subjects from the control group to use a "jolly jumper". This could imply that possible stimulation of muscle contraction could have positively influenced the postural control.

6.2.3. OTHER FACTORS

- A correlation between spinal deformities and a family history of deformities was found.

- The gestation period as well as the birth method had no influence on the development of spinal deformities.

- The most preferred lying position for both the case and control group subjects was side lying, possibly due to the fact that this is the position preferred by nursing homes to prevent choking. Although non-significant, a higher percentage of subjects from the case group preferred back lying which may have tended to influence the development of kyphotic posture.

- Defective hearing did not have an influence on the development of asymmetry.

- No correlation between poor vision and spinal deformities was found. It can only be postulated that poor vision may have a negative influence resulting in a forward head posture.

- Many mothers in Middelburg, Mpumalanga, were unaware of the presence of deformities in their offspring.

- A sudden growth spurt was reported significantly more frequently in the case than in the control group.

- Although non-significant, there was a higher percentage of girls who presented with deformities in the coronal plane, while a higher percentage of boys presented with a sagittal plane deformity.

- The mean age was higher in the case group.

- Significantly more subjects from the case group had reached their menarche at the time of evaluation.

- The girls and boys from the case group were significantly taller than those from the control group. Subjects with combined sagittal and coronal plane deformities were significantly taller those with only a sagittal plane deformity. A trend was noted for subjects with combined coronal and sagittal plane deformities to be taller than those with only a coronal plane deformity.

- The leg length discrepancies of subjects in this study were minimal and, not associated with the presence of deformities.

- No correlation was found between decreased hamstring flexibility and the presence of deformities.

- Most of the subjects presented with hip flexor tightness, but a significant association with deformities was not found.

- The thoracic area is the most vulnerable area for deformities of the spine. Right-sided thoracic curves occurred significantly more frequently than left-sided thoracic curves. Thoraco-lumbar curves were found significantly more frequently than lumbar curves.

- There was a trend for more spinal deviation to the left side of the gluteal cleft to be present in subjects of the case group subjects. Deviations of the spine occurred most frequently in the thoracic area.

- Almost half of the subjects from the case group presented with a hyperkyphosis.

- There was a tendency for a forward head posture to be present with a hyperkyphosis, although this was statistically non-significant.

- Significantly more right than left-sided winging of the scapula, as well as a trend for more right-sided elevated shoulders, were present in the subjects from the case group, which correlated with the higher occurrence of right sided thoracic curves.

- Subjects from the case and control groups, presented with the left arm hanging further from the trunk significantly more frequently, than to the right side.

- A "normal spine" (where the kyphosis and lordosis were within normal limits, no deviation from the plumbline was present, and no humps of six millimetres and more were measured) was present in only 17,3 % of subjects in this study compared to 22% in the literature.[55]

6.3. CRITICAL EVALUATION OF THE STUDY

The following shortcomings were identified after the completion of this study:

- Recall bias – milestones reported by the mothers were obtained retrospectively making the accuracy of this information dubious.
- The study was conducted on a limited population. No generalisation of results can be made.
- A sample of convenience was conducted, possibly resulting in more subjects who knew or suspected that they had a deformity, to be willing to participate in the study.
- The age of 12 to 17 years was used in this study to enable the sample to be large enough for statistical analysis. It would have been ideal to evaluate subjects of the same age. It is possible that the younger subjects could still develop a deformity later.
- Due to the fact that the sample was not large enough, statistically significant results were not always possible. A larger sample would have made it possible to make more valid conclusions with regard to the different planes of deformities.
- An equal sampling of boys and girls in each of the groups would have been better.
- As no radiographs were taken, the level of the kyphosis and scoliosis could not be determined precisely. The end vertebrae were thus not determined.
- Babies most frequently walk at the age of one year. The categories used in this study with regard to walking could have been confusing. The age of one year (12 months) should have been the median of a category of walking (11-13 months).

- The knowledge of mothers with regard to visual and auditory problems was not always accurate.
- The questionnaires were completed with only the help of the mothers, which caused possible bias with regard to information of deformities on the paternal side
- Hand dominance of subjects was not evaluated. Although some authors suggest that hand dominance should be evaluated, no correlation between hand dominance and idiopathic scoliosis was found in the literature.[33,49] Hand dominance could, however, give important information with regard to posture and the preference of carrying a school bag.
- A standing evaluation of leg length discrepancy would have been better to determine the direct effect of any difference on the posture or spine
- Measurement of the distance from the plumbline to the spine was inaccurate and therefore not taken into consideration in this study.
- The fact that there were too many variables made the analysis of the study difficult. In view of the fact that the plumbline measurements were ineffective, it could have been left out completely. The aim of the objective evaluation was to identify whether a spinal deformity was present in order to allocate the subject to a case or control group. Although tightness of the hip flexors and hamstring muscles may influence a spinal deformity, the focus in this study should have been limited to the presence of the deformity. It was difficult to determine the exact influence of auditory and visual impairment on spinal deformities. Family history has previously been proven to have an influence on spinal deformities and was not the focus of this study. The questionnaire could have been limited to the developmental aspects only.
- Participation in sports and physical education were not considered. Physical activities may play a role in the development, prevention and / or stabilising of deformities.

6.4. RECOMMENDATIONS

This study has highlighted the difficulty of identifying developmental milestone predictors for the prevalence of spinal deformities. The retrospective nature of reports received from the mothers may have affected the validity and reliability of information.

The following recommendations are made in view of the shortcomings of this study:

- Conduct a longitudinal study in co-operation with baby clinics in South Africa to determine the influence of developmental milestones on the prevalence of spinal deformities. An accurate detailed recording of the developmental milestones of babies should be made at their follow-up visits to clinics, and the babies should be followed up until the age of 16 years to determine the prevalence of spinal deformities. More accurate information with regard to the developmental milestones, gestation period and birth process will be obtained. The sample will also be more representative of the general population.
- Conduct a comparative study, considering the different ethnic groups, to determine the influence of developmental milestones on the development of adolescent spinal deformities.
- The use of aids such as sit chairs, walking rings and "jolly jumpers" and their possible association with the development of spinal deformities should receive more attention.
- Determine auditory and visual disabilities by means of specialised evaluations.
- The sway of the body due to weight transfer and the fact that many of the subjects struggled to stand still, could be corrected in future studies by letting the subjects hold onto a horizontal bar.
- Education of mothers with regard to the importance of normal developmental milestones and the possible negative effect of a walking ring as a developmental aid should be

emphasised. The relationship between sudden growth spurts, taller subjects and a genetic factor and the presence of spinal deformities was highly significant. Mothers of subjects should be educated to evaluate the spines of their offspring, especially where these aforementioned factors are relevant.

- A further study should be conducted to investigate whether the physical activities of scholars affect the development, progression, prevention and / or stabilisation of deformities.
- The fact that no black, or Asian mothers responded to the request for participation in this trial is an interesting point, and leads to further research questions:
  - what is the prevalence of spinal deformities in these ethnic groups
  - is it necessary to educate the previously disadvantaged population of South Africa with regard to the possible development of spinal deformities and significance thereof ?

  The fact that no literature was found comparing spinal deformities in adolescents of ethnic groups, identifies a gap in research in South Africa.

6.5. SUMMARY

It would appear, from the study, that deviations from normal developmental milestones, and certain other factors (as described earlier), did not have a significant influence on the prevalence of spinal deformities in white adolescents in Middelburg, Mpumalanga. Developmental milestones cannot be considered to be an aetiological factor, but they may affect postural tone in adolescents.

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