A Study to Determine the Motor Proficiency of Children Between the Ages of Six and Ten Years Diagnosed with ADHD in the Cape Metropole.

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Thesis presented in partial fulfilment of the requirements for the degree of Master of Physiotherapy at the University of Stellenbosch.

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Declaration

I, the undersigned, hereby declare that the work contained in this thesis is my own original work and I have not previously in its entirety or in part submitted it at any university for a degree.

Signature

Date

ABSTRACT

Background:

Children with Attention Deficit Hyperactivity Disorder (ADHD) have been reported to have motor proficiency problems. Few studies have established the extent of these motor problems and few studies investigate both gross and fine motor proficiency. The studies which do investigate motor proficiency, often also include other aspects, for example physical fitness, grip strength or kinaesthesia. It is important to be able to identify motor proficiency deficit in this population group early for appropriate intervention to be as effective as possible. The first step in this process is to identify the areas of motor proficiency deficits experienced by these children.

Study Design:

A cross-sectional descriptive study was done.

Objective:

The main aim of this study was to establish if children with ADHD demonstrate motor proficiency problems. A second aim was to identify in which areas of motor proficiency they have the most problems.

Method:

A sample of 28 boys and 9 girls (n = 37) children with ADHD, between the ages of six and ten, were identified by the medical practitioners at four school clinics in the Cape Metropole. The Bruininks-Oseretsky Test of Motor Proficiency was used to test the children. The demographic and other factors that could have affected the motor proficiency in these children were recorded.

Results:

The range, mean and standard deviation were calculated for all the subtests and the three composite scores. Eighty–one percent of children scored below the expected norm on the Battery Composite Score (20^{th} percentile) with the difference in age equivalent scores being significantly different ($p < 0.01$), the Gross Motor Composite Score (20^{th} percentile and $p < 0.01$) and on the Running Speed and Agility Subtest ($p < 0.01$), the Balance Subtest ($p < 0.01$), Strength Subtest ($p < 0.01$) and the Upper Limb Coordination Subtest ($p < 0.01$). No significant motor proficiency problems were identified in the Fine Motor Composite Score (35^{th} percentile), the Bilateral Coordination Subtest, the Response Speed Subtest, the Visual motor Subtest or the Visual Motor Control Subtest.

Conclusions:

These results support the literature in so far as motor proficiency deficits are present in children with ADHD, which in turn supports the need for early identification of these problems.

ABSTRAK

Agergrond:

Kinders met Aandag Afleibaarheid Hiperaktiwiteit Sindroom (ADHD) demonstreer probleme met motoriese vaardighede. 'n Paar studies is gedoen om dié bepaalde motoriese vaardighede te bepaal en sommige studies kombineer die ondersoek met ander aspekte van motoriese vaardigheid soos, fiksheid, greep sterkte of kinestesie. Dit is belangrik om die tekortkominge vroeg te identifiseer om effektiewe intervensie so vroeg moontlik te inisieer. Die eerste stap is om die spesifieke vaardighede waarmee hierdie groep kinders probleme ondervind, te identifiseer.

Studie:

'n Dwarssnit beskrywende studie is uitgevoer.

Doel:

Die doel van die studie was om te bepaal of kinders met ADHD motoriese probleme het en of daar spesifieke aspekte van motoriese vaardigheid is waar hulle tekortkominge toon.

Metodiek:

'n Steekproef van 28 seuns en 9 dogters ($n = 37$) tussen die ouderdomme van ses tot tien jaar, met ADHD is deur die mediese praktisyns geïdentifiseer, en getoets. Die Bruininks-Oseretsky Toets vir Motoriese Vaardigheid is gebruik. Enige faktore wat motoriese vaardigheid kon beïnvloed is gedokumenteer.

Resultate:

Die reikwydte, gemiddelde en standaard afwyking is bereken vir al die sub-toetse en die drie saamgestelde tellings. Een en tagtig persent van die kinders het tellings onder die verwagte norm behaal vir die Saamgestelde Telling van die Battery van toetse (20ste persentiel) met die verskil in ouderdomtelling beduidend verskillend ($p<0.01$). Die Growwe Motoriese Saamgesteldetelling was (20ste persentiel en $p<0.01$), die Hardloopspoed- en Ratsheidsubtoets ($p<0.01$), die Balanssubtoets ($p<0.01$), Kragsubtoets ($p<0.01$) en die Boonste Ledemaat Koördinasie-subtoets ($p<0.01$). Geen beduidende tekorte is deur middel van die Saamgestelde Fyn Motoriese Vaardigheidstoetse (35ste persentiel), die Bilaterale Koördinasiesubtoets, die Reaksiespoed-subtoets, die Visuele Motoriese subtoets of die Visuele Motoriese Beheer-subtoets gevind nie.

Gevolgtrekkings:

Die resultate ondersteun die bevindinge uit die literatuur rakende die probleme wat kinders met ADHD met motoriese vaadigheid ervaar en ondersteun die behoefte vir vroeë identifisering om effektiewe intervensie so vroeg moontlik te begin.

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1 INTRODUCTION

Attention Deficit Hyperactivity Disorder (ADHD) presents with a complex interaction of hyperactivity, impulsivity and inattentiveness. The children with this syndrome are often disruptive in the classroom situation because they are unable to sit still for any length of time, have problems socialising and do not pay attention to their tasks. In a review on hyperkinesis (a term used to describe ADHD symptoms principally in the United Kingdom) Churton (1989) gives the following definitions:

> Hyperactivity is involuntary and constant overactivity, which occurs with advanced motor development (throwing objects, walking, running). The child is always on the move, will run rather than walk and rarely sits still.
> Impulsiveness means that the child does things on the spur of the moment without thinking, seems to be unable to tolerate any delay in gratification of his/her needs, does not look ahead towards future goals and thinks only of the immediate present situation (Churton 1989:318).

ADHD affects a 3-5% of children more boys than girls. Early diagnosis would benefit the children affected so that early intervention could be possible. Often the diagnosis is made when they enter the formal education sector, which may be pre-school or even primary school. The diagnosis of ADHD is usually made in the first three years of school and therefore children between six years and ten years were included in the study population (Barkley 1990).

ADHD often occurs with other psychiatric disorders such as conduct disorder or oppositional defiant disorder. This comorbidity increases the complexity of clear diagnoses in these children. Psychologists, psychiatrists, child neurologists or paediatricians make the diagnosis of ADHD using the criteria laid down in the Diagnostic and Statistical Manual of Mental Disorders (1994) published by the American Psychiatric Association.

The assessment of children with ADHD after the diagnosis of ADHD is made, is a complex task requiring several different assessments. As the name ADHD suggests the problem of attention deficit is regarded as the main problem for the child and the people affected in his environment. Most studies regarding ADHD used psychological tests, behavioural tests and a few use neurological tests. Children with this disorder are frequently referred to physiotherapists for assessment and treatment of motor problems. Very little information is available to the physiotherapist identifying the motor skill deficits that these children may experience. No studies were found relating to South African children with ADHD and motor proficiency problems.

Many studies have been conducted that investigate ADHD. However, they usually refer to the behavioural symptoms found in ADHD. Little emphasis has been placed on the motor proficiency of the children with ADHD. Recently a number of studies relating to this topic have appeared in the literature. However there are conflicting findings about the extent of these problems. ADHD is a complex syndrome and the assessment of the motor involvement in it does not seem to be less complex.

The neurological involvement is thought to be caused by prefrontal and frontal lobe dysfunction (Barkley 1990). A number of morphological studies conducted on children with ADHD indicate the following: the size of the corpus callosum seems to be affected (Giedd et al 1994), as is the size of the basal ganglia (Aylward 1996). Also affected is the size of the posterior lobe of the cerebellum (Berquin et al 1998). It appears that these children may in fact be anatomically different to their normal counter parts. In all cases the areas of the brain investigated could have some influence on motor performance.

The definition and recent research of ADHD indicates that motor skill deficits are present in children with ADHD. It is for these reasons that the researcher decided to investigate further and to establish the existence and range of the motor proficiency deficits that may be present in children with this disorder.

The Bruininks-Oseretsky Test of Motor Proficiency (BOTMP) was designed to test motor function in school aged children with mild/moderate motor proficiency deficits (Cole et al 1994). For the purposes of this study a deficit is regarded as any motor performance below the expected norm. This is in accordance with the Concise Oxford Dictionary definition of the term “deficit”.

1.1 Research Question

Do children between six and ten years diagnosed with ADHD have motor proficiency deficits according to the Bruininks–Oseretsky Test of Motor Proficiency?

1.1.1 Hypothesis

The mean Battery Composite Score on the BOTMP for ADHD children between six and ten years is lower than that of the population on which the BOTMP was standardised.

Null Hypothesis — H_0: The mean score of the children with ADHD between six and ten years, in the Cape Metropole, is equal to the mean score of the standardised sample for the BTOMP.

$$\mu_{ADHD} = \mu_{BTOMP}$$

Alternative hypothesis — H_1: The mean score of the children with ADHD between six and ten years, in the Cape Metropole, is less than the mean score of the standardisation sample for the BOTMP.

$$\mu_{ADHD} < \mu_{BTOMP}$$

1.1.2 Further Aim

To establish the specific areas of motor proficiency deficits in children with ADHD according to the Bruininks–Oseretsky Test of Motor Proficiency.

2 LITERATURE REVIEW

Both the current and the past literature were reviewed to assess the complex nature of Attention Deficit Hyperactivity Disorder (ADHD) and the evolving understanding of ADHD. This review will also present the research that has been completed to date relating to motor proficiency deficits which may be present in children presenting with symptoms of impulsiveness, hyperactivity and inattention. The review has been divided into three main sections each describing one of the main components of this study. Firstly a discussion of the condition ADHD itself. Secondly, a brief overview of the development of normal motor proficiency is presented, as a background for what can be expected from the child with ADHD. Thirdly, the different standardised tests for testing motor skills, which could be used to research this topic, will be reviewed.

2.1 Attention Deficit Hyperactivity Disorder

Attention Deficit Hyperactivity Disorder (ADHD) is defined as a neurologically based developmental disability affecting 3-5% of the school population. The main characteristics are deficits in attention performance, especially on vigilance tasks and effortful attention, as well as motor hyperactivity, impulsivity, and distractibility (Castellanos et al 1994).

2.1.1 Historical Background

Over the past 30 years numerous behavioural and learning disorders in children were thought to be due to Minimal Brain Dysfunction (MBD). This term is no longer in use as the different problems that the children presented with are no longer thought to be due to any form of brain damage (Gillberg 1995). Research into ADHD and allied disorders in children has been ongoing since before the mid 1980's. Different groups i.e. in America, in Scandinavia and in the United Kingdom developed their own approach to this very complex and involved task. In America the American Psychiatric Association developed a set of criteria in the DSM-III for the diagnosis of Attention Deficit Disorder (ADD) in 1980. Revisions of these criteria were made as the unfolding understanding of the syndrome came about. The Scandinavian countries developed their own approach to children with these symptoms and similarly the British literature referred to the same symptoms with a different terminology. A table of the most common syndromes with overlapping symptoms and brief explanations follows:

Table 2.1 Syndromes with partly overlapping concepts attributed to ADHD/MBD. (Adapted from Gillberg 1995:139).

Diagnostic Label	**Comments**
MBD (Minimal Brain Dysfunction)	Originally referred to as minimal brain damage. Used until 1980's. Usually refers to combinations of attention and motor/learning problems.
ADD (Attention Deficit Disorder)	DSM-III-label (APA 1980) Widespread use in USA. Diagnostic criteria very loose and subjective. Pervasiveness not required. With or with out learning/motor problems.
ADHD (Attention Deficit Hyperactivity Disorder)	DSM-III-R label (APA 1987) Does not account for cases without hyperactivity. If categorised as 'severe', then pervasiveness required. With or without motor/learning problems.
ADHD (Attention Deficit Hyperactivity Disorder)	DSM-IV (APA, 1994) Accounts for cases without clear hyperactivity.
Hyperkinetic disorders	Mainly used in the UK. Usually refers to a syndrome of pervasive hyperactivity. Was regarded as extremely rare. Now often diagnosed with other conduct disorders
DAMP (Deficits in Attention, Motor control and Perception)	Mainly in Scandinavian countries. It is an umbrella concept for combinations of motor control and perceptual problems in conjunction with attentional problems in children who do not show mental retardation or cerebral palsy.
DCD (Development Co-ordination Disorder)	DSM-IV (APA 1994) Chronic motor impairment which interferes with normal function and academic achievement.

At present, the most accepted criteria for the diagnosis of ADHD is the DSM-IV, which is published by the American Psychiatric Association in the Diagnostic and Statistical Manual of Mental Disorders (APA, 1994). Much of the literature, from America, reporting on ADHD was researched before the DSM-IV was published and therefore the DSM-III and its revised version the DSM-IIIR were used to make the diagnosis. This means that the diagnoses were made using the earlier versions of the criteria and these used slightly different criteria, for the diagnosis of ADHD. These differences allowed more/slightly different children to be included in this diagnosis, and therefore the samples of children are a little different to those diagnosed at present. In a comparative study by Wolraich et al (1996) in which the criteria for the DSM-III-R were compared with the criteria for the DSM-IV, they concluded that the new DSM-IV criteria were likely to increase the prevalence rates for ADHD in comparison with the DSM-III-R criteria. The definitions of the different subgroups of ADHD were first included in the DSM-IV (Wolraich et al 1996, APA 1987, APA 1994).

The overlapping symptoms, makes the results of the American and the Scandinavian research difficult to compare.

The literature from the Scandinavian countries, did not use the DSM criteria until at least 1994. The symptoms of Deficits in Attention, Motor Control and Perception were grouped together and named DAMP. This is a diagnostic term that overlaps with the diagnosis of ADHD and DCD (Christiansen et al 2000).

Landgren et al (1996) conducted a study using a population of 589 children. The aim was to establish the prevalence of DAMP, ADHD, Motor Perception Dysfunction (MPD), mental retardation and Tourettes syndrome. The prevalence rates for DAMP were between 5.3% - 6.9% and for ADHD between 2.4% - 4.0% of the population. They also commented on the amount of overlap between the different diagnoses that exists between these to conditions (Landgren et al 1996).

Kadesjö and Gillberg (1998) completed a study in a small town in Sweden in which attention deficits and clumsiness were investigated. Using the criteria for diagnosis for ADHD from both the DSM-III-R and the World Health Organisation (WHO) 1993 criteria, as well as the criteria for DCD, MPD and Oppositional Defiant Disorder (ODD), they assessed 409 Swedish children. The aim of the study was to establish if DAMP is a valid diagnostic construct. Using assessments by a doctor, the parents and the teachers, they found the following overlap in symptoms between all the different diagnoses.

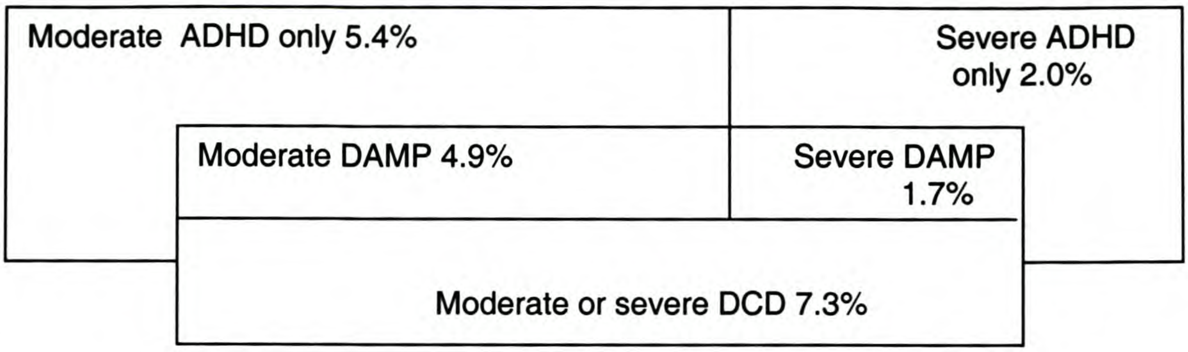

Figure 2.1 The Overlap of ADHD/DCD and the concept of DAMP in the study by Kadesjö and Gillberg (1998:800).

Further differences in nomenclature exist in the British literature where the term hyperkinesis is used, meaning "severe persistent hyperactivity" which is used in the World Health Organisation and the ICD 10 (International Classification of Disease). Hyperkinesis is a more restrictive term than the DSM IV criteria, as it only takes into account one of the main symptoms of ADHD (Kewsley 1998:1594).

2.2 Diagnosis

The diagnosis of ADHD is made using the DSM-IV criteria. The diagnostic features of ADHD include a "persistent pattern of inattention and/or hyperactivity/impulsivity that is more frequent and severe than is typically observed in individuals at a comparable level of development" (APA 1994:78).

The DSM IV goes on to name four other major criteria for making the diagnosis of ADHD. Firstly, the early onset of symptoms before 7 years of age. Secondly, the affect of the impairment must be noticed in two or more settings in which the child operates. Thirdly, there must be evidence of the developmentally appropriate social, academic or occupational function being affected. Lastly other psychiatric disorders may also be present. This assessment is done using information from the parents, the teacher and the medical practitioner. The diagnostic criteria are clearly laid down and the symptoms are marked off on a questionnaire. If more than 6 of the cluster of possible behaviours for either inattention or hyperactivity are present the diagnosis is confirmed.

The DSM IV differentiates between 3 different subgroups of ADHD. The diagnosis is made depending on the number of symptoms present in either the inattentive or the hyperactivity/impulsiveness subgroups. The predominant pattern should be based on the six months prior to making the diagnosis. The subtypes are

- Attention Deficit Hyperactivity Disorder, Combined Type (ADHD-C). These children present with more than six symptoms from both the inattentive and the hyperactivity/impulsivity lists.
- Attention Deficit Hyperactivity Disorder, Predominantly Inattentive Type (ADGD-PI). These children present with more than six symptoms from the inattentive list and fewer than six symptoms from the hyperactivity/impulsivity list.
- Attention Deficit/Hyperactivity Disorder, Predominantly Hyperactive-Impulsive Type (ADHD-HI). These children present with more than six symptoms from the hyperactivity/impulsivity list and fewer than six of the inattentive list (APA 1994).

2.2.1 Assessment Following Diagnosis

Once diagnosed, other tests are used to establish the extent of the child's problems. The assessment of children with ADHD is a complex task as each child presents with their individual set of symptoms, therefore several different assessments may be required. These assessments are undertaken by a variety of professionals such as psychiatrists, psychologists, neurologists, paediatricians, teachers, physiotherapists, occupational therapists etc. Most studies regarding ADHD used psychological tests to establish the intelligence quotient (IQ) of the children, for example the Wechsler Intelligence Scale for Children is used. Behavioural tests to assess behaviour in a number of different environments, and parent and teacher questionnaires have been designed to help with the assessment and management of these children, for example the Connors Parent Questionnaire and the Parent Psychomotor Questionnaire (Collett 2003). The earlier studies used neurological tests or short neurodevelopmental examinations which had been used/designed to ensure that the children did not have any gross neurological deficits. Most of these were not standardised tests but designed for the specific project or research. (Kadesjö andGillberg 1998, Barbaresi 1996, Weiler et al 1999, du Paul et al 2001).

The following discussion will report only the literature that is relevant to the motor development or motor proficiency of children diagnosed with ADHD. In the early stages much of the research was trying to establish the extent of the problems, so large epidemiological studies were undertaken or screening was done to establish if this syndrome could be diagnosed early. In these studies little attention was paid to the motor problems that these children exhibit. The following studies have been reviewed with the emphasis on the motor components of the studies.

2.2.2 Screening and Epidemiological Studies

Gillberg et al (1983) designed a screening test for neurological and neurodevelopmental skills which included ten items. The research study included 141 seven-year-old children with different psychiatric diagnoses. This study defined MBD as those children who "showed attention deficit disorder in combination with either fine motor, marked gross motor or marked perception dysfunction" (Gillberg et al 1983:120). The neurodevelopmental screening items for the tests were, hopping on one leg, standing on one leg, associated movements when walking on the lateral sides of the feet, diadochokinesis, cutting out a circle of paper, a labyrinth test, checking for choreatiform movements (twitching), walking on tiptoe and a qualitative assessment of gross motor movements. The results indicate that the children with MBD performed more poorly on the neurological test than the control children did. The shortcomings of this study were that the sample size for the MBD group was only nine children, and that the neurological/neurodevelopmental test, although containing relevant items, was not standardised, making comparison with other groups difficult. However it did indicate that these children had problems with both fine and gross motor abilities. It is also clear that no definite criteria had been laid down relating to the diagnosis of ADHD and many of the symptoms investigated were emphasised for the specific investigation by the researchers making studies difficult to compare (Gillberg et al 1983).

Larsson (1995) in a study to develop screening mechanisms for MBD/DAMP measured the results of a motor test in relation to perinatal conditions, development and family situation. They used the same neurological screening test that Gillberg et al (1983) used in the previous study. In this study the researchers screened 234 six-year-old children with MBD/DAMP. Diagnosis of Attention Deficit Disorder (ADD) was made using the DSM III. Only a weak correlation between the psychoneurological examination and the diagnosis of ADD was found.

As the research continued the diagnoses became more standardised and criteria were laid down which made the vague terminology of the past more defined. A study by Landgren et al (1996) investigated the epidemiology and co-morbidity of 6-year-old children with ADHD. This study used several different types of tests to investigate the co-morbidity with other psychiatric disorders of these children. They included the Connors Parent Questionnaire, the Parent Psychomotor Questionnaire and the Wechsler Intelligence Scale for Children (3rd edition) as a base for this study. The physical part of the assessment included a routine physical examination and a brief neurodevelopmental-screening test. This brief screening test had five items, three are gross motor items and two are fine motor items. No clear results discussing the prevalence of motor dysfunction were discussed in this article (Landgren et al 1996).

As can be seen from these studies, the emphasis was placed on establishing a broader perspective of the ADHD problem. However as time progressed more and more interest was shown in the motor proficiency of these children and the following section will review the work that then emerged.

2.2.3 Motor Activity in ADHD

Two studies were found that investigated the spontaneous motor activity in these children. One by Porrino et al (1983) investigated the motor activity in hyperactive boys. This study was done before the DSM III criteria were in general use so the diagnosis was based on hyperactivity and inattention as reported by the parents, school teachers and other professionals that had assessed the children. The study measured the motor activity of the child for twenty four hours a day i.e. at home, at school and during sleep. The monitors, which measured the motor activity, were placed on the trunk of the child, and were only removed for short times. These movement monitors measured the truncal movements of each child. The ADHD boys showed significantly higher activity levels when compared to the controls. The strength of this study was that the measurement of the activity did not affect the children and was an accurate measure of their normal daily lives (Porrino et al 1983).

A study by Teicher et al (1996) also investigated the spontaneous body movements of children with ADHD. During a continuous performance task, in which the children had to respond to visual stimuli on a computer screen in front of them, the children's movements were recorded by an infrared motion analysis system. They found that children with ADHD did move more and in a larger area than the controls did. This supported the reports that children with ADHD fidget and move continuously in the classroom (Teicher et al 1996).

2.2.4 Neurological Differences Occurring in Children with ADHD

The neurological involvement in ADHD is discussed in the next section under the following headings, kinaesthetic acuity, brain morphology studies, and deficient inhibitory control in ADHD.

Kinaesthetic acuity

Kinaesthetic acuity is the ability to assess the relative body position in space and the direction of movement of the body part. Kinaesthesia forms part of the unconscious proprioception along with joint position sense (Fitzgerald 1992). The neural pathways involved in this sense are the normal proprioceptive pathways with fibres from the neuromuscular and neurotendinous spindles and the Pacinian corpuscles between the muscles and the joint capsules. The fibres from these receptors then progress via the posterior horn of the spinal cord to the spinocerebellar tracts and to the cerebellum.

> The spinocerebellar tracts report the instantaneous progress of movements and the activity of muscle groups to the cerebellum. The cerebellum is then capable of modifying the action of the muscle groups so that movements are performed smoothly and accurately (Gatz 1966:18).

A study by Whitmont and Clark (1996) investigated only fine motor skills and kinaesthetic acuity in ADHD. This study investigated 24 children, between the ages of 7 and 12 years, diagnosed with ADHD according to the DSM III criteria. A control group was used and the groups were matched for age, intellectual ability, sex, learning achievement and occupational status of their parents. This study used the Bruininks–Oseretsky Test of Motor Proficiency (BOTMP) to assess the fine motor skills in the study population. The results showed that children with ADHD had significantly reduced kinaesthetic acuity and fine motor skills compared to their controls. The results also showed a weak relationship between the BOTMP fine motor scores and kinaesthetic acuity. This study may however have been affected by selection bias as the groups were obtained by advertisement. The inclusion and exclusion criteria were not noted in the article. Unexpectedly or "relatively" high scores on the BOTMP fine motor scores were noted. The authors explained these away as, Australian children having different norms to those of North American children (Whitmont and Clark 1996).

A further study, which investigated kinaesthesia and motor co-ordination, was conducted by Piek et al (1999). Two groups of boys were used for this study, one group diagnosed with ADHD according to the DSM IV, the other a control group matched for age and verbal IQ. The authors found that kinaesthetic acuity between the two groups did not differ significantly. However motor co-ordination between the groups did differ. The groups of boys with ADHD consisted of different two sub-groups of ADHD, one group predominantly the inattentive type (ADHD-PI) and the second group the combined type (ADHD-C). The researchers found a difference between these groups regarding their motor co-ordination suggesting that the inattentive type have greater fine motor difficulties and that the combined type have greater difficulty with gross motor skills. The sample sizes in this study are small however and the differentiation between these subgroups will need further investigation.

Brain morphology studies

The possibility of neurological involvement in ADHD has been investigated as many of the symptoms of ADHD are similar to those of patients who have had injuries to the prefrontal region (Barkley 1997). A number of authors discuss the likelihood of frontal lobe dysfunction in children with ADHD (Barkley 1997, Mattes 1980). In addition to this, investigations into the function and structure of the brain in children with ADHD have been done using electroencephalogrem (EEG), neuroanatomic imaging with magnetic resonance imaging (MRI), and emission tomography to establish the cerebral blood flow (Mattes 1980, Lou et al 1989, Casetellanos et al 1994, Giedd et al 1994, Simrud- Clikemen 1994, Aylward et al 1996, Berquin et al 1998).

Giedd et al (1994) compared 18 boys with ADHD to 18 matched normal counterparts, using MRI studies and found that a significant difference in the size the corpus callosum is present in the boys with ADHD. The authors found that the corpus callosum was smaller than those of the control group. The rostral body was also significantly smaller and this could have some influence on motor function. Giedd et al (1994) examined the anterior part of the corpus callosum and reported the size of the rostrum and the rostral body were both smaller in the ADHD subjects. The role of the corpus callosum is to connect the frontal, parietal and occipital lobes of both hemispheres of the brain. Semrud-Clikeman et al (1994) also reported that the corpus callosum is smaller in boys with ADHD. They measured the splenium in the posterior part of the corpus callosum. Both authors conclude that these findings support the fact that children with ADHD have sustained attention deficits.

-The basal ganglia (caudate nucleus, putamen, globus pallidus and the amygdala and the claustrum) and the striatal regions (caudate nucleus, putamen, globus pallidus and the internal capsule) of the brain (Gatz 1966, Wright 1972) have also been investigated. The basal ganglia form part of the extrapyramidal system which is part of the of an inhibitory motor pathway (Wright 1972). Three of these investigations also indicated differences in the ADHD group (Lou et al 1989, Castellanos 1994, and Aylward 1996). Lou et al (1989) studied the perfusion of the striatal region in ADHD subjects and found that there was less perfusion of this area of the brain than expected. The left globus pallidus was significantly smaller in boys with ADHD (Aylward 1996) while low volumes in the caudate nucleus were reported by Castellanos et al (1994). These three studies also indicate the neurological component of ADHD.

A study investigating the morphology of the cerebellum and the size of the brain (Berquin et al 1998) indicated that there is a structural difference in the brain size of 46 right handed boys with ADHD compared to 47 matched healthy controls. These changes were noted particularly in the posterior inferior lobe. The authors discuss the possibility of the differences affecting "motor control dysfunctions such as subtle neurological deficits in motor inhibition responsible for clumsiness and poor co-ordination" concluding that "a cerebello-thalamic-prefrontal circuit dysfunction may subserve the motor control, inhibition, and executive deficits encountered in ADHD" (Berquin et al 1998:1087).

These children may be anatomically different to their normal counter parts. In all these research reports the areas of the brain investigated could have some influence on motor control and motor performance in children with ADHD.

Deficient inhibitory control in ADHD

According to Barkley (1997) four executive functions which are well described in the field of neuropsychiatry are affected in children with ADHD. These are firstly and secondly the verbal and nonverbal working memory, the third involves motivational appraisal system, which directs the affect/ motivational/ arousal states involved in "future-directed behaviour" and the fourth, which involves the analytic and synthetic processes of the prefrontal cortex. This author maintains that these four executive functions are the basis of normal behaviour. It follows that if the child with ADHD has behavioural inhibition these four executive functions will be affected. Only the possible effects on motor ability will be discussed here (Barkley 1990, Barkley 1997:65).

A study conducted by Schachar et al (1995) used a control group of children and a group of children diagnosed with ADHD using the DSM-III-R. A stop-signal paradigm test was used to assess inhibitory control. This involved the children being exposed to a stimulus and performing a task. At different times the task was interrupted with a signal to stop and the child had to stop the task and then continue with the task. The results showed that the children with ADHD, who presented with symptoms in more than one setting, showed statistically significant results for deficient inhibitory control ($p < 0.05$ and $< 0 .01$) in some of the tests. However when all the subgroups of ADHD were considered together no significant difference in inhibitory control was found.

Numerous other studies and articles relating to the lack of inhibitory control have been published regarding this effect on ADHD children (Barkley 1990, Oosterlaan and Sergent 1996, Barkley 1997, Schachar 1995). Barkley (1997) has proposed a new model for describing ADHD on the basis of behavioural inhibition shown by these children. The four executive neuropsychological functions seem to all have an effect on motor control and could therefore affect the motor proficiency of the child. Due to the behavioural inhibition, children with ADHD are frequently treated with methylphenidate. This is a psychostimulant that has an effect on the dopaminergic receptors. Methylphenidate has been shown to improve the classroom behaviour of children with ADHD and normalise their attention. Numerous studies have been done to investigate the use of this drug in children with ADHD (Rapport et al 1994, du Paul et al 1994, Ghuman et al 2001). Studies have reported an improvement in hand writing and motor skills while the children are on methylphenidate (Piek 1999, Pitcher 2003, Barkley 1990). In the studies investigating motor proficiency in

these children some are done with the child still under the influence of methylphenidate and others are done without the interaction of the drug. It is very important to clearly state whether or not the child is using methylphenidate because of the different results obtained under the different conditions.
As can be seen from the discussion above there is evidence that children with ADHD have motor proficiency deficits however only a small part of the motor proficiency repertoire has been researched. There is a need for further enquiry into the nature and extent of the motor proficiency problems experienced by these children.

2.3 Normal Development of Motor Proficiency

The background and discussion on Normal Development of Motor Proficiency will give the base from which the researcher worked when considering the present study. To begin with definitions of the terms motor proficiency, motor development and motor control will be given. Motor development refers to the growth and development of the child through the normal stages of development which allow normal motor skills, motor proficiency refers to the how adept the child is when performing these motor skills and motor control refers to the mechanisms which the child uses to stabilize the body via the balance and postural control mechanisms and then move it (Shumway-Cook and Woollacott 1995, Cratty 1979, Cech and Martin 1995). It to be established has been established that children with ADHD have motor proficiency problems but few of the studies have established the extent of the problem with regard to motor proficiency alone (Pitcher et al 2003, Kroes et al 2002, Piek et al 1999). Many of the studies combine the evaluation of part of the motor proficiency with other attributes e.g. kinaesthesia or physical fitness (Whitmont and Clark 1996, Harvey et al 1997, Pereira 2000). To understand the motor proficiency in children with ADHD it is necessary to have a clear insight into normal motor development. It is also important to note that children with ADHD are not reported to have developmental delays in infancy and early childhood.

The process of development of motor proficiency follows a predictable path with the major components of movements appearing in the first year of life. Between the ages of one and five the development of most motor skills is refined. The review of normal development of motor proficiency will establish that the BOTMP is testing age appropriate motor proficiency. The main concepts underlying the development of normal motor proficiency are motor control, postural control, the musculoskeletal system, the sensory systems and motor learning (Alexander et al 1993).

Motor control is defined by Shumway-Cook and Woollacott (1995) as dealing with two main issues:

- Firstly stabilising the body in space, that is motor control as it is applies to postural and balance control.
- Secondly moving the body in space, that is motor control as it applies to movement.

The normal development of the musculoskeletal system is very important in the development of normal movement. This allows the development of the normal biomechanics which in turn lead to efficient movement (Alexander 1993).

Movement is also dependent on the information provided by the sensory systems. The information that is provided by the sensory systems (visual, tactile, kinaesthetic, vestibular, and auditory) is used in both feedback–type movements and feedforward–type movements (Alexander 1993).

2.3.1 Normal Motor Development Theories

In an attempt to predict and understand normal motor development, numerous theories have been developed. Some of the most relevant theories will be briefly discussed here.

Neuromaturationists

As reported in Campbell (1994), the main proponents of this theory were, researchers, Gesell and McGraw. The basis of this theory is that without biologic maturation, normal motor development will be unable to take place. These theories were developed following detailed observation of developing children. Gesell maintained that development of functional movement was age specific and did not recognise individual differences. McGraw's work is often believed to follow the neuromaturationists theory. This author studied the influence of environmental and physical stimulation on very young children. The findings were that stimulation did not lead to earlier development of skills, therefore McGraw concluded neuromaturation was necessary before certain motor skills could be developed (Campbell, 1994).

Cognitive theories

The first of these theories is that of behavioural theory. This theory discusses the individual's ability to develop by responding to and learning from the environment in which he finds himself. This theory is based on the concept of stimuli, which require certain responses and are then assimilated into the individual's behaviour. Therefore all human behaviour is learned by observation and imitation and can therefore be conditioned (taught) by the process of reinforcement of responses by the environment.

The second in this group of theories is that of Piaget. Piaget believed that both maturation and the environment influence human behaviour. The response that led the individual to adapt to his environment developed through complex psychologic processes which interacted with the neural structures. This process depended on maturation of the neural structures and experience (Campbell, 1994).

Dynamic Systems theory

This theory places the importance on a number of different, but equally important, systems in the development of normal functional movement. Thelen and colleagues developed this theory and is an approach allowing both internal components of the child and external influences in the movement performance. Each influencing subsystem develops at its own rate and is constrained and supported by both physical and environmental factors. (Campbell 1994).

Each of these theories developed as a result of investigations at the time of the development of the theory. Each has certain important facts to contribute to the theory of normal motor development. At present the dynamic systems theory is receiving most recognition as it is very broad and allows for individual differences. This is a useful approach with a disorder like ADHD, in which many individual variables may be present. Due to the complexity of ADHD it may however be necessary to use certain concepts from each of the theories discussed above when attempting to explain some of the deficits present in ADHD.

2.3.2 Gross Motor Abilities

The development of gross motor abilities will be briefly reported in the following section with the emphasis on postural control and balance, kinaesthetic sense, and locomotion. The reviewed sections relate directly to the abilities that the child will need to be able to complete the BOTMP.

Postural control and balance

The development of posture and balance is the base of all other movement. There are two main approaches to the development of postural control. The first is the Reflex-Hierarchical Model, which maintains that the development of postural control occurs with the changes in the reflexes in the infant. These are the attitudinal reflexes and the righting reflexes which together form the postural reflex mechanism. The attitudinal reflexes include the asymmetrical tonic neck reflex, the symmetrical tonic neck reflex, and the tonic labyrinthine neck reflex. The righting reactions include the optical righting reaction, the labyrinthine righting reaction, the body-on-head righting reaction, the neck-on-body righting reaction and the body-on-body righting reaction. These reactions then emerge as three main balance reactions namely the tilting reaction, the postural fixation reaction and protective responses. The second main approach is the Dynamic Systems approach. The emphasis of this approach is the necessity for the contributions from both the sensory systems and motor co-ordination. By the time the child is six years old the "adult"-like positional control is in place in the neurologically intact child. (Shumway-Cook and Woollacott, 1995).

Development of postural sway in children develops from an early age. It is a complex interaction between a number of systems including the neural system and the musculoskeletal system (Riach and Hayes 1987, Shumway-Cook and Woollacott 1995). Research done by Shumway-Cook and Woollacott (1985) on three groups of children of differing ages, indicated that a group of 15-31 month-old children demonstrated postural synergies when their balance was disturbed. However these synergies of muscle activity were not in the adult form. Their responses were consistent, although the body movements were too large and overcompensation did occur. This young group of children also depended more on the visual cues, than on their somatosensory systems as did their older counterparts. The movement synergies in the second group of 4-6 year old children were developing into more mature synergies even though they showed less consistency in their movement patterns. They also showed development towards more adult like control. This is thought to be a transition phase for the development of postural control. Children in the third group between the ages of 7-10 showed adult like responses to the movement of their base and the removal of visual cues (Shumway-Cook and Woollacott 1995).

Kinaesthetic sense

This is one element of the sensory motor system and is thought to be essential to normal movement. Kinaesthesia forms part of the unconscious proprioception along with joint position sense (Fitzgerald 1992). It is difficult to assess in children, as the test must remove all visual cues from the child (Doyle et al 1986). A number of different studies have been done to assess kinaesthetic acuity in normal, clumsy and ADHD children (Elliott et al 1988, Smyth and Mason 1998, Hoare and Larkin 1991). Controversy exists in the findings of these various studies as to the importance of kinaesthetic sense in motor skills. It has been established that there is little relationship between kinaesthetic acuity and normal movement in normal subjects (Elliott et al 1988). Research investigating kinaesthetic acuity in clumsy children reported differing results. Lord and Hume (1987) found that kinaesthetic acuity in clumsy children was not different to their normal counterparts. Hoare and Larkin (1991) found clumsy children scored poorly on three of the seven tasks and suggested a range of tasks, not only one test, was necessary to assess kinaesthetic acuity. Smyth and Mason (1998) found that the test for kinaesthetic acuity did not predict poor motor performance in clumsy children. Those studies relating to ADHD specifically have been discussed under the ADHD section of this review.

Locomotion

In the infant, rolling is the first pattern of locomotion that the child develops. This requires the dissociation of movement of the body segments of the body. At approximately eighteen months the child will make attempts at increasing the speed of walking and by two to three years will have developed a true run. The development and refinement of running then continues until the child is six years old.

Jumping starts to develop when the child reaches eighteen months, as the child will attempt to step off a low step. This development progresses usually from lifting one foot at a time to lifting both feet together. By the time the child has reached five years old they are capable of doing a standing broad jump (Cratty 1979, Burns and MacDonald 1996).

2.3.3 Fine Motor Abilities

The development of fine motor abilities follows and the main focus will be on hand preference, ball skills and manipulative skills.

Hand preference

Children start to show a tendency to prefer one hand from about 12 months onwards. Burns states that task related preference may be noted in the lower extremities where stability may be better on the preferred side (Burns and MacDonald 1996). The development of hand preference is usually more stable i.e. the same hand is used more often than the same foot in children (Cratty 1979).

Ball skills

The development of throwing skills starts between the ages of two and three with little trunk rotation or foot movement during the throw. Throwing gradually becomes stronger and more refined so that by the time the child is five or six the unilateral throwing pattern has developed (Butterfield and Loovis 1993). The propulsion of the throw being about twelve feet (approximately four meters) by the time the child is four and a half years old (Cratty 1979).

Catching a ball is a more difficult task and starts to develop at about three and a half years old and by the time the child is five years old they can catch a large ball with both arms able to accept the ball with ease.

Manipulative skills

The development of manipulative skills begins in infancy with the development of different grasp and release skills. By the end of the first year, the child will be able to do the inferior pincer grasp, the pincer grasp, the superior pincer grasp and the three-jaw chuck which allows the child to hold a block with wrist extension and ulnar deviation while the ability to release the object is still maturing.

Denkla (1973) investigated the speed in successive finger movements in normal children between five and eight years old and found that increasing age led to better performance of the tasks and that girls performed the tasks more rapidly than boys did.

The acquisition of a pencil grip also occurs in the following sequence. At the age of between one and two years the child uses a palmar supinate grip to hold a pencil but by between two and three the child is holding a pencil using a digital-pronate grip. This then progresses to a static pronate grip and at four years old the child manages a dynamic-tripod grip. The dynamic tripod grip is the only functional grip that a child may use when writing at school (Cech and Martin 1995).

Cutting out with scissors requires that the child is able to isolate the index finger and thumb abduction and is difficult for a pre-school child to master (Burns and MacDonald 1996). Cutting with scissors is a bimanual task, which develops in the preschool child with various other self care items and the use of tools and instruments (Cech and Martin 1995). By between six and seven the child shows consistent use and more efficient use of one hand during writing (Cech and Martin 1995).

All the skills reviewed in the above discussion are necessary for normal motor proficiency and can be expected to be present in the normal child. The normal motor development i.e. the milestones of rolling, sitting, walking have not been reported to be delayed in children with ADHD. Any assessment of the motor proficiency of children with ADHD will need to done by a test that can discriminate between slight motor dysfunction and normal motor proficiency.

2.4 Standardised Tests of Motor Function in Children

Research has shown that motor skills can be divided into gross motor skills and fine motor skills. Gross motor skills can include speed, static balance, dynamic balance, co-ordination, and strength. The following include both gross and fine motor skills viz. visual motor tracking, response speed to a visual stimulus, visual motor control of the hand and upper limb speed and precision of movement (Campbell 1985). It is also possible to divide all motor proficiency into two main areas namely speed – precision – strength and balance – co-ordination (Krus et al 1981).

There are only a few standardised tests that assess motor proficiency in children between the ages of six and ten years. These do not all measure the same components of motor proficiency. Only three standardised tests are available for use in the age group six to ten years for children with mild to moderate motor proficiency deficits. These are the Gross Motor Function Test (GMF), the Movement Assessment Battery for Children (M-ABC) and the Bruininks-Oseretsky Test of Motor Proficiency (BOTMP). (Campbell 1985, Bruininks 1978, Cole et al 1994, Henderson and Snugden 1992).

Of these three tests only two were possible for use in this study as the GMF only tests gross motor skills and the scope of this study included both gross and fine motor proficiency because of the nature of ADHD. The BOTMP and the M-ABC will now be discussed with reference to the current study.

The M-ABC was developed from the Test of Motor Impairment (TOMI) and was first published in 1992. It was designed to test and to identify impairment in motor skills. It takes between 20-30 minutes to administer. The movement components that are tested are manual dexterity (three items), ball skills (two items) and balance (two items). The components of movement not assessed in this test are strength and endurance (Henderson and Snugden 1992)

The BOTMP is an individually administered test, which assess the full range of motor functioning in children between the ages of 4½ and 14½ years. The complete battery is made up of eight subtests, which include 46 separate items. The components of movement that are included in the test are Running Speed and Agility, Balance, Bilateral Co-ordination, Strength, Upper Limb Co-ordination, Response speed, Visual Motor Control and Upper Limb Speed and Dexterity. It takes approximately one hour to administer the BOTMP. This test has the ability to assess across the whole range of children from normal to mild / moderate motor problems and is sensitive to children who are performing above the norm as well (Bruininks 1978, Henderson and Snugden 1992). The BOTMP was standardised in USA and Canada on a sample that included 11% of children who were black or of other than white origin. It has however not been standardised in a South African setting (Bruininks 1978).

Table 2.3 A Summary of the Components of Movement in the BOTMP and the M-ABC.

Components of Movement	BOTMP	M-ABC
Speed	Yes	Yes
Balance	Yes	Yes
Co-ordination	Some	Some
Strength	Some	No
Manual dexterity	Yes	Yes
Visual motor	Yes	Yes
Sensation/ perception	Some	No
Posture	No	No
ROM	No	No
Endurance	No	No
Qualitative information	No	Yes

According to Barnhart (2003), studies conducted comparing the BOTMP and M-ABC have had differing results, some have a high levels agreement in the results (kappa =.62) while others have a lower agreement in the results (kappa =.41).

Two primary factors may explain the difference in outcomes between the BOTMP and the M-ABC. The BOTMP allows the tester to verbally prompt and correct the child during the testing procedure. This allows the child who is more dependent on external controls of behaviour, to do better on the BOTMP. The M-ABC requires more careful instruction on the part of the examiner and allows more opportunities for the examinee to practice, but does not allow any verbal or physical prompting by the person examining. It is possible that children with attention problems may have more difficulty with following the careful instructions for the M-ABC (Barnhart 2003).

In conclusion due to the nature of ADHD itself and the research that has been done to date on motor proficiency in children with ADHD it is necessary to establish the nature and range of motor deficits in children presenting with ADHD. The aim of this study is to establish the nature of the motor proficiency deficits present in children with ADHD in the Cape Metropole. The BOTMP will be used to test this.

3 METHODOLOGY

This section will describe the methodology used in this study. Firstly the study structure, study population, the criteria for exclusion and the pilot trial will be reported. This will be followed by a detailed description of the instrumentation, procedure and logistical arrangements for the study. Lastly the scoring methods, the statistical procedures and the ethical considerations will be reported.

3.1 Study Structure

The study was structured as a cross-sectional descriptive study.

3.2 Study Population

The study population consisted of all six to ten year old children who have been diagnosed with ADHD, using the DSM-IV in the Cape Metropole.

The study sample was a sample of convenience and was drawn from the population of children diagnosed, by the School doctors, with ADHD that fell within the six to ten year old age group and attended the participating school clinics Athlone, Newlands, Fishhoek and Parow.

3.3 Criteria for Exclusion

The exclusion criteria used were:

- The child must not have received any therapy (viz. physiotherapy or occupational therapy) that could have affected their motor proficiency before the date of testing.
- The child must not be affected by any other condition, either orthopaedic or neurological that could affect his motor functioning or his understanding of the instructions for the tests.
- The child must not present with symptoms of other psychiatric diseases that may be co-morbid with ADHD.

3.4 Pilot Study

A pilot trial was conducted on five Afrikaans children who ranged in age from six to ten years and had not been diagnosed with ADHD. The aim of this pilot trial was to ensure that the translated test instructions were clear. No changes were necessary, as the pilot trial did not indicate any consistent problems in the childrens' understanding of the test instructions in Afrikaans.

3.5 Instrumentation

The following four instruments were used to collect the data.

3.5.1 Scale

The children were all weighed on a battery operated Soehnle electronic scale, which was manufactured in Germany.

3.5.2 Response Speed Stick

The Response Speed Stick and the tape measure from the BOTMP test kit were used. These were used to ensure the accuracy of the height measurements. The stick is a 5 mm thick rigid stick.

3.5.3 Bruininks-Oseretsky Test of Motor Proficiency (Long form).

The motor proficiency of the sample was tested using the BOTMP. The test kit including the Testers Manual belonging to the Department of Physiotherapy at the University of Stellenbosch was used and additional data sheets were purchased. A diagrammatic representation of the structure of the BOTMP showing the eight subtests and what they test is given below.

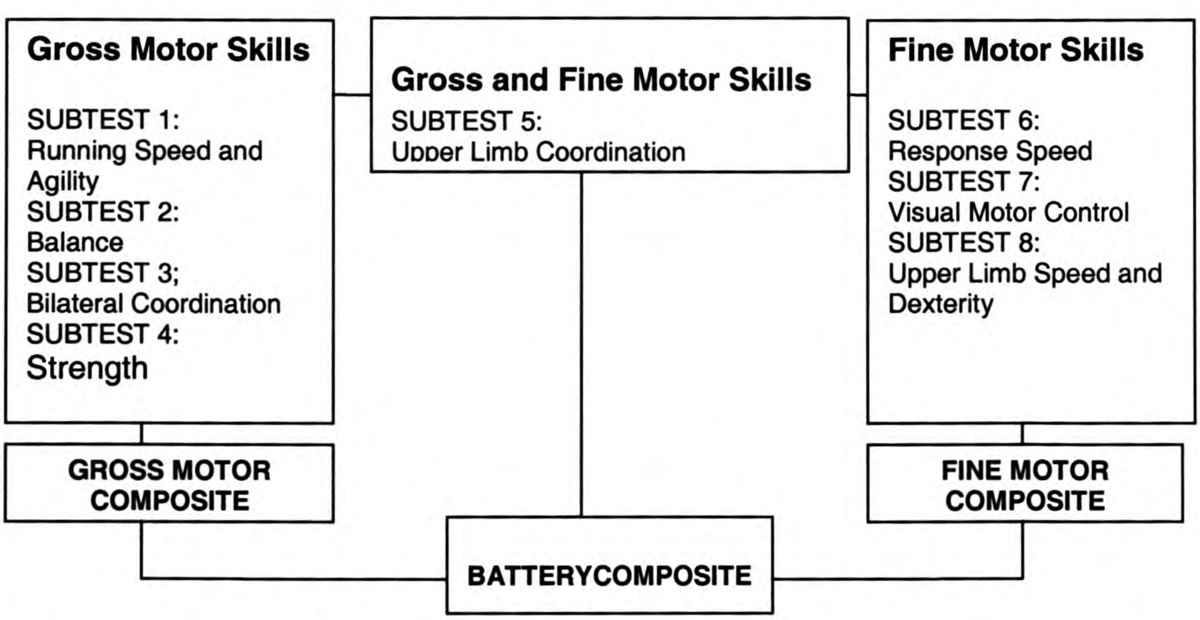

Figure 3.1 The Structure of the Bruininks-Oseretsky Test of Motor Proficiency (Bruininks 1978:12).

The BOTMP test is divided into two main sections, the first tests gross motor skills and the second tests fine motor skills, and one subtest, which includes both gross and fine motor skills. The 46 items are arranged into the eight subtests. This test was individually administered by the researcher and took approximately one hour to complete. The testing procedure was followed from the Examiners Manual of the BOTMP.

Two changes were made to the described instructions. The first one being that not all the children owned trainers; therefore the researcher allowed the children to complete the test in either rubber soled school shoes or trainers. The second change was that the researcher supplied left-handed scissors for those children who were left-handed.

This test is reliable and valid for children from 4½ years to 14½ years and has been designed to assess the motor functioning of children thus making it suitable for this research. This test was standardised on 765 children. The test-retest reliability was established for the BOTMP. The reliability coefficients of the gross motor composite scores were 0.77 and for the fine motor was composite was 0.88. The reliability coefficient of the battery composite was 0.89.

The BOTMP was standardised on all race groups in the USA. Recognising that socio-economic factors might play a role in motor proficiency, the purpose of this study was to test motor proficiency in ADHD children per se. The sample population was observed to represent all race groups and the children were from similar socio-economic backgrounds.

3.5.4 The Data Capturing Sheet

The information needed about each child to complete this study was documented on this self-developed sheet. The purpose of this study was not to differentiate between the cultural and socio-economic influences and therefore these factors were not documented. The following data was recorded from the accompanying adult for all children.

- Name
- Age at the time of testing
- School Grade
- School attended by the child
- School clinic attended by the child
- Referring school doctor
- Parents names
- Residential addresses
- Hobbies and activities of the child
- Hobbies and activities of the family

- Weight
- Height
- Home address
- Exclusion criteria
- Ritalin use.

(See Appendix A).

3.6 Procedure

Approval from the Education Research Directorate of the Department of Education was obtained. The researcher e-mailed the study protocol to the Head of the Directorate with the request to be able to do the research at the school clinic. The approval was faxed back to the researcher with the conditions of the agreement (See Appendix B). Approval form the Research Ethics Committee at the University of Stellenbosch was also obtained before the study was started.

3.6.1 Sampling Procedure

The study sample was obtained from the doctors at the school clinics who were willing to assist in the study. Three doctors at the participating school clinics (Athlone, Newlands, Parow and Fish Hoek) made the diagnosis of ADHD. The criteria used to make the diagnosis of ADHD are laid down in the DSM IV. The doctors who participated in this study were the school doctors who were working in the participating school clinics and therefore no identification process was used for the doctors.

The three doctors put 48 children's names forward. Two of the children's parents refused to allow the testing, one child was lost to follow up as he no longer attended a school in the area, and eight children had already been diagnosed with motor deficiencies and had had either physiotherapy or occupational therapy.

All the parents were approached for consent. Participation was voluntary - no child was forced to complete the test if they are unwilling to do so. The study sample was all the children who fulfilled the criteria and agreed to take part in the study. The study sample therefore consisted of 37 children.

3.6.2 Logistical arrangements

Four school clinics were used as the place of testing for 35 children was at the school clinics (Fish Hoek, Newlands, Athlone and Parow). Having obtained approval for the research from the Education Directorate, permission from the Head of each Unit to use their facilities for testing was also obtained (See Appendix B). All subsequent arrangements regarding testing were made with the secretary of the school clinic. Two children were tested at their respective schools because they could not get to the school clinics. In these cases permission was obtained from the Headmaster of each school for use of the school's facilities for testing.

The doctors involved supplied all the contact information needed to contact the parents of the children included in the study sample. The researcher then telephoned the parents of each child involved and explained the aim of the study. If the parents agreed to allow the testing an appointment, which suited both parties, was made. If the parent was unable to accompany the child to the testing, the contents of the consent form was explained to the parents and verbal agreement was obtained. In addition, permission was obtained for the adult who was to accompany the child to the testing to act as proxy for the parent in signing the consent form (See Appendix C).

Any child taking methylphenidate (Ritalin) at the time of testing was asked not to take it on the day of testing so that there would be no influence from the drug. This was adhered to in all cases. The withdrawal of methylphenidate for at least 15 hours prior to testing was discussed with the referring doctors, who prescribed type and dosage for each child. It was agreed that the withdrawal of methylphenidate for this period of time would minimize the effect of the drug and therefore the tests results would not be affected by the methylphenidate (Fairburn 2002). This procedure was also followed by Pitcher et al (2003) in their study.

On the day of testing the parent or carer, who had the parents' permission to sign the consent form, came into the testing room where the aims of the study were explained and any questions were discussed. The child was included in the discussion. The consent form was then signed, a contact number for the researcher was given to all the adults who accompanied the children, and the testing started after the adult had left the area.

3.6.3 Data Collection

The data collection including the data capture sheet, the measurement of weight and height, and the motor proficiency testing is described in detail in this section.

- Data capturing sheet

The information needed to complete the data capturing sheet was completed by the researcher. The adult who accompanied each child gave the necessary information and this was recorded for each child on the sheet itself. The scoring on the data capture sheet relating to the hobbies, sport and leisure activities for the child and the family was done by documenting any physical activities that were performed by the child alone or with the family. These were scored as yes/no answers.

- Weight

Three readings were taken and the mean of the three readings was used. The position of the feet was marked on the scale so that all the children would stand in the same position. Each reading was taken when the scale had returned to zero. The child then stepped onto the scale remained on the scale until the child was still and the scale reading was stable. The reading was then recorded, the child stepped off the scale and the process was repeated three times. The mean of the three readings was then recorded on the data capturing sheet.

- Height

The children's height was then measured. Children stood with their heels next to the wall, and the response speed stick was placed on the top of the child's head with the head in neutral and with the ruler at 90° to the wall, a mark was then placed on the wall. The researcher could ensure that the end of the ruler was flush with the wall, ensuring a right angle with the wall. The measurements were all made with the measuring tape provided in the test kit. The measurements taken three times by the researcher to confirm their accuracy before they were documented.

- Motor Proficiency

Before the test itself is started the hand and foot preference is establish according to the method in the Examiners Manual (Bruininks 1978). Each test has criteria for passing and failing the test and the maximum scores are on the record sheets for the test. This test consists of 8 subtests each assessing an area of motor proficiency. These are:

- Running Speed and Agility Subtest (Gross Motor)

  This subtest has one item in it and measures the child's running speed and agility using a shuttle run. The child is required to run 13.7 meters and back; the course was laid out with a 15.2 cm gap between the starting/finishing line and the timing line. The child had to run and pick up a baton at the end of the 13.7m and run as fast as he/she could back to the start/finish line. The test was explained to the child, who then carried out the instructions, with encouragement from the researcher. Two trials were completed and the fastest time is used on the scoring sheet.

- Balance Subtest (Gross Motor)

  This subtest includes eight items. These items are:
  - Standing on the preferred leg on the floor for 10 seconds.
  - Standing on the preferred leg on the balance beam for 10 seconds.
  - Standing on the preferred leg on the balance beam with eyes closed for 10 seconds.
  - Walking forward on a line on the floor for six steps.
  - Walking forward on the balance beam for six steps.
  - Walking forward heel-to-toe on the line for six steps.
  - Walking forward heel-to-toe on the balance beam for six steps.
  - Walking and stepping over the response stick on the balance beam.

  In each case the child was shown what to do and given a second chance if the highest score was not achieved in the first trial. Some of these items are timed or the numbers of repetitions are documented.

- Bilateral Co-ordination Subtest (Gross Motor)

  This subtest includes eight items:
  - Tapping the feet alternately while making circles with the fingers.
  - Tapping the feet alternately while tapping the index finger and foot on the same side synchronised.
  - Tapping the feet alternately while tapping the index finger and foot on the opposite side synchronised.

- Jumping in place with the arm and leg on the same side synchronised.
- Jumping in place with the arm and leg on the opposite side synchronised.
- Jumping up and clapping hands at the same time.
- Jumping up and touching both heels with the hands at the same time.
- Sitting and drawing lines and crosses simultaneously, with both hands.

All tests were demonstrated and additional instruction was given if needed. A 90-second maximum was given in each of the first five tests and then the next test was started. The last three tests were timed and the child was given a chance to practice before the testing started. A second trial was given if the maximum score was not achieved at the first trial. The number of correct repetitions was recorded.

- Strength Subtest (Gross Motor)

  This subtest includes three items, which are timed, and both strength and endurance are tested.

  - A standing broad jump.
  - Sit-ups.
  - Knee push-ups for boys under eight years and all girls or full push-ups for boys eight years and older.

  These tests were all demonstrated and the instruction was repeated to the child if the test was not correctly performed. The length of the jump was measured using the marked tape measure in the test kit. This then became the documented score. In the subtests for sit-ups and push-ups the repetitions correctly completed in 20 seconds were counted and documented.

- Upper Limb Co-ordination Subtest (Gross and Fine Motor)

  This subtest consists of eight items.

  - Bouncing a ball and catching it with both hands.
  - Bouncing a ball and catching it with the preferred hand.
  - Catching a tossed ball with both hands.
  - Catching a tossed ball with the preferred hand.
  - Throwing a ball at a target with the preferred hand.
  - Touching a swinging ball with the preferred hand.
  - Touching the nose and index fingers with the eyes closed.
  - Touching the thumb to fingertips with the eyes closed.
  - Pivoting the thumb and index finger.

These tests were explained to the child and the test was carried out and the child was given the opportunity to practice before timing began. These items are not timed and the number of correct repetitions measured here.

- Response Speed Subtest (Fine Motor)

  This subtest consisted of one item during which the Response Speed Stick is dropped and the child must stop it falling to the ground. This is repeated seven times, the first two trials being practice trials. The speed with which the child could stop the falling response speed stick was recorded by documenting the level at which of the speed stick was stopped against the marked tape on the wall. This test measures speed of reaction to a visual cue i.e. movement of the Response Speed Stick. The child watches a moving target and responds immediately by stopping it. This item is timed and requires a reflex reaction.

- Visual Motor Control Subtest (Fine Motor)

  This subtest consists of eight items.

  - Cutting out a circle with the preferred hand.
  - Drawing a line through a crooked path wit the preferred hand.
  - Drawing a line through a straight path with the preferred hand.
  - Drawing a line through a curved path with the preferred hand.
  - Copying a circle with the preferred hand.
  - Copying a triangle with the preferred hand.
  - Copying a horizontal diamond with the preferred hand.
  - Copying overlapping pencils with the preferred hand.

  These tests were not timed the child was given as much time as they needed to complete the task. The quality and accuracy of motor skill is important in this test.

- Upper Limb Speed and Dexterity Subtest (Fine Motor)

  This subtest consists of eight items.

- Placing pennies in a box with the preferred hand. 24 pennies could be placed into the box on the marked square as fast as possible. The number of correctly placed pennies were counted and documented.

- Placing pennies in two boxes with both hands. 24 pennies were placed on either side of the boxes and they were placed in the boxes together. The number of correctly placed pennies were counted and documented.
- Sorting shape cards with the preferred hand. A pack of cards with two different shapes on them was given to the child to be sorted. The child was timed for 15 seconds to sort as many cards as possible. The number of correctly sorted cards were counted and documented.
- Stringing beads with the preferred hand. The child was given beads and a string from the test kit. The child then had to string as many of the beads as possible in 15 seconds. The number of beads on the string was counted and this was documented.
- Displacing pegs with the preferred hand. 20 pegs were placed into the pegboard and the child was required to move the pegs forward, one peg at a time as fast as possible in 15 seconds. The number of correctly moved pegs was documented.
- Drawing vertical lines with the preferred hand. The child was required to draw as many vertical lines as possible in 15 seconds in the lines provided in the Student booklet. The number of correctly drawn lines was counted and documented.
- Making dots within circles with the preferred hand. This subtest required the child to make dots in as many circles as possible in 15 seconds; the number of correct dots made was documented.
- Making dots with the preferred hand. This subtest required the child to make as many dots as possible on the given page in 15 seconds. The number made was then counted and documented.

These items are timed and therefore speed and accuracy are elements of the test.

3.7 Scoring the Bruininks-Oseretsky Test of Motor Proficiency

The test is scored on a standard score sheet which is then checked against a standard table. A complete battery composite score for motor proficiency, as well as separate scores for gross and fine motor composite scores were calculated. Due to the complexity of the scoring a research assistant was used to check and correct any mistakes that were made in the scoring of the BOTMP results (See Appendix D). These were then entered onto a spreadsheet and analysed.

3.7.1 Battery Composite Score

The Battery Composite Score is derived from the age equivalent scores of all the subtests. These are numbered, in order of age equivalent score achieved by the child from the highest score to the lowest, from 1 to 8. To compute the median score, the average between the 4th and 5th age equivalent scores was calculated.

The Battery Composite Score was also calculated into a percentile score. This was done adding the standard scores from the Gross Motor Composite Standard Score, the Upper-Limb Co-ordination Standard Score and the Fine Motor Composite Standard Score together and converted into the composite score. The percentile rank is then read off the relevant table provided in the Examiners Manual of the BOTMP.

3.7.2 Gross Motor Composite Score

The Gross Motor Composite age equivalent scores were calculated by working out the median score of the Running Speed and Agility Subtest, the Balance Subtest, the Bilateral Co-ordination Subtest and the Strength Subtest. The test scores of the four subtests were numbered from highest to lowest and the two middle scores were found and the average between these two scores was calculated to give the median age equivalent score for gross motor proficiency.

The Gross Motor Composite Test standard score was obtained by adding the standard test scores from the four gross motor tests to give a composite score, which was then converted into a percentile rank.

3.7.3 Fine Motor Composite Score

The Fine Motor Composite age equivalent score was calculated by taking the median age equivalent score of the three subtests Response Speed, Visual Motor Control, and Upper Limb Speed and Dexterity, that is the middle score of the three.

The percentile rank for the Fine Motor Composite score was calculated by adding the standard score for the three fine motor tests and converting them into composite scores from which the percentile rank was obtained.

3.7.4 Running Speed and Agility Subtest

This subtest is a timed performance and is one test repeated to get the best score. The test time was documented and converted into the point score. The point score was then converted into a standard test score. This score was then used to read the age equivalent score from the table given in the Examiners Manual.

3.7.5 Balance Subtest

The scores for this subtest included timed effort, number of steps per unit time and a pass or fail step test. The point score for this subtest was obtained by documenting the test result and adding all the test results together. The point score was then converted into a standard test score, which in turn was used to obtain the age equivalent score.

3.7.6 Bilateral Coordination Subtest

This subtest consists of eight items the scores were obtained by measuring number of actions in a fixed time, number of errors made and a pass or fail for certain required sequences of movement. The scores for each test were documented and added together to obtain standard test score which in turn was used to obtain the age equivalent score.

3.7.7 Strength Subtest

The scores for the strength test were measured as the number of activities in a fixed amount of time and a distance jump. The scores obtained for each test, and were added together to obtain the point score for the subtest. As above this was converted into a standard test score and then converted into an age equivalent score.

3.7.8 Upper Limb Co-ordination Subtest

This subtest has nine items in it. The scores are for accuracy of movement of arms, hands and fingers. The scores in this subtest are not used in either the Gross Motor Composite Score or the Fine Motor Composite Score, because the activities include both gross and fine motor tests. The score is however calculated into the Battery Composite Score. The point scores from the tests are converted into a standard test score and then into an age equivalent score.

3.7.9 Response Speed Subtest

This subtest has one item in it, which is repeated seven times. The median score, in this case the fourth trial of this subtest, becomes the point score, which then is converted into a standard test score and then into the age equivalent score.

3.7.10 Visual Motor Control Subtest

This subtest has eight items in it and no tests are timed in this test. The results for each of the items are added together to obtain the point score for the subtest. This is then converted into the standard score for the subtest from which age equivalent score is obtained.

3.7.11 Upper Limb Speed and Dexterity Subtest

The Upper Limb Speed and Dexterity Subtest consists of eight items. The child's score for each item are added together and the point score for the subtest is obtained. This is converted into the standard score and then into the age equivalent score.

3.8 Statistical Analysis

In consultation with a statistician the following statistical procedures were used. The data was analysed to obtain the range of age equivalent scores, the mean age equivalent scores, the standard deviation and the percentage of children scoring above the norm and those scoring below the norm.

3.8.1 *t*-Test for the Difference of Means

The *t*-Test was used to test the Null Hypothesis to establish if the mean score of children between six and ten years diagnosed with ADHD, in the Cape Metropole, is equal to the mean score of the standardised sample for the BTOMP. A one-tailed test was used because the Alternative Hypothesis stated that the mean score of the ADHD children is less than the mean score of the standarised sample (Roscoe 1975).

3.8.2 Percentile Ranks

The percentile ranks for the results were computed as following the instructions in the Examiners Manual. The age equivalent scores for the subtests were also calculated according to the instructions in the BOTMP Examiners Manual. These scores were used in the analysis of the results. These are not the most reliable scores when used on individual children, according to Bruininks (1978), they should be interpreted with caution. However since no control group was tested and no South African norms are available for the BOTMP it was decided that the age equivalent scores would be used for this study. These age equivalent scores are only used for the whole group i.e. the mean age equivalent scores for the 37 children were used in the analysis of the data.

3.8.3 Repeated Measures Analysis of Variance

The Repeated Measures Analysis of Variance (RANOVA) was used firstly to evaluate if the difference between the age equivalent scores and the chronological age of the children was statistically significant or not. Secondly, it was used to establish if any of the factors that could affect the motor proficiency of the children did have a statistically significant affect on the scoring pattern of the results or not.

3.8.4 The Spearman Rank Order Correlation

The Spearman Rank Order Correlation was done to establish if the BOTMP was able to discriminate between the different age groups in this sample. The BOTMP was designed and standardised in the United States of America, it is possible that a South African sample would perform differently on the BOTMP when compared to norms for the BOTMP. For this reason the Spearman Rank order correlation was planned to see if a positive correlation exits between the actual age of the group and the age equivalent score of the group.

3.9 Ethical Considerations

This is a descriptive study and therefore has few ethical problems. The following were taken into account:

- Confidentiality: all participants and their parents were assured of the fact that personal information would be kept confidential. Personal information was only available to the researcher.
- Consent: Informed consent was obtained from all the children's parents. A signed Consent Form was used.
- Voluntary participation: The children took part on a voluntary basis and were not forced to take part in the study even if their parents had signed a consent form.
- The parents of each child received a short report documenting the results of the test and giving appropriate recommendations.
- The reports were all made available to the referring doctors.
- Permission was obtained from the Directorate of Education to do the study and all conditions have been adhered to.
- Permission was obtained to use the Bruininks-Oseretsky Test of Motor Proficiency Test Kit from the Department of Physiotherapy.
- The study was registered with the Faculty of Health Sciences at the University of Stellenbosch.
- Approval for the study was obtained from the Human Research Ethics Committee at the University of Stellenbosch.
- Withholding methylphenidate was discussed with the referring doctors and only on their recommendation was this done. The parents were also requested not to administer the drug on the day of testing. None did not comply with this request.

4 RESULTS

A total of 48 children were identified by the school clinic doctors for the present study. Of these 48 children, 8 had been referred for physiotherapy or occupational therapy, which excluded them from the sample, two refused to be tested and one, was lost to follow up. The final sample size was therefore 37 children (n = 37).

4.1 Profile of the sample

The age range was 6 years 9 months to 10 years 10 months (3.2 years). The mean age for the group was 9.0 years. The factors that could possibly affect the motor proficiency of the children were noted and the RANOVA analysis used to establish whether or not they did affect the BOTMP test scores. These are listed below and discussed only in as much as is necessary to establish any possible effect on the results.

- Gender – 9 girls and 28 boys.
- Language – 32 English speaking and 5 Afrikaans speaking.
- School clinic attendance – 5 at Parow ; 4 at Athlone; 7 at Newlands; 21 at Fish Hoek
- Extramural sport participation – 24 taking part in sport; 13 not taking part in sport
- Family sport participation – 34 had no family participation; 3 had family participation.
- Arm preference – 32 right preference, 3 left preference and 2 mixed preference.
- Leg preference – 31 right preference, 3 left preference and 3 mixed preference.
- School Grade – the mean age for the groups in each grade were at the expected age norm in the South African educational system.

Table 4.1 The mean chronological ages for each grade.

Grade	No. of children	Mean chronological age
0	1	7.0
1	4	7.5
2	8	8.11
3	17	9.39
4	6	10.10
5	1	10.80

- Weight – the range in weight was from 16.70 kg to 43.57 kg with the mean weight of 30.68 kg.
- Height – the range in height was 1.14 m to 1.59m with the mean height of 1.36m

The height and weight for each child was compared to the " Weight And Height Percentile Table For Boys And Girls" (Lowery 1978). This table gives the norms at six monthly age intervals. The height and weight tables indicate that this group of children would conform to a normal distribution curve, indicating that their weight and height fall within normal limits. The mean for the group was also checked against this table and this group of children fall just above the 50% percentile for both height and weight. The height and weight of the children were also analysed to ensure that there was no effect on the subtest scores.

In order to establish if height and weight had any effect on the subtest scores of this group of children scatter plots were drawn for all the subtests. There was no correlation between the scores and the height of the children so this could not have affected the scores in the subtests.

The scatter plots for the weight of the children showed a tendency to affect the scores in the Running Speed and Agility Subtest and the Upper Limb Coordination Subtest. However on further analysis the one child who was over the 90 percentile in weight was removed from the analysis and the scatter plots were redrawn. On this analysis there was no correlation between the weight of the child and the scores on the subtests. Therefore it was concluded that neither the height of the child nor the weight of the child affected the scores on the subtests in the BOTMP.

The number of children referred from each clinic was not equivalent. Referals from the Fish Hoek School Clinic for example were 57%. In order to assess if this had any affect on the results, the performance of the children from the different school clinics was compared. No difference was found between the performance of the children from the different school clinics. Therefore although there was a higher representation of children from the Fish Hoek School Clinic it did not influence the results.

4.2 Summary of Test Score Results

Five types of analysis were performed on the data. Firstly, a one tailed *t*-Test was used to determine whether or not the Null Hypothesis holds true. Secondly, the range of age equivalent scores, the means of the age equivalent scores, the standard deviation, and numbers of children scoring above or below the norm was calculated (see Table 4.2). Thirdly, the percentile ranks for the three composite scores was calculated (see Figure 4.1). Fourthly, the Repeated Measures Analysis of Variance (RANOVA) was applied to the data (See Appendix E). This was used to establish if there was a statistical difference between the age equivalent scores of the BOTMP subtests of the sample and the norms found in the Examiners Manual for the BOTMP (see Table 4.2 for the p values for the test scores). The RANOVA analysis was also used to establish if any of the factors that could have influenced the motor proficiency scores did in fact influence them (Figures 4.3 - 4.16). Fifthly the Spearman Rank Order Correlation was done to establish whether or not the BOTMP discriminated between the different age groups in this sample (see Table 4.3).

When the *t*-Test score was calculated, the *t* value obtained was 3.19 which is significant at $p < 0.001$. Therefore the Null Hypothesis is rejected and the Alternative Hypothesis is accepted. This means that the mean score of children with ADHD between six and ten years is less than the mean score of the standardisation sample of the BOTMP.

A summary of the initial analysis is presented in Table 4.2. This shows the range of age equivalent scores, the mean of the age equivalent scores, the standard deviation, and the number of children scoring on/or above the expected norm, and the number of children scoring below the expected norm. The RANOVA results establishing if there was a significant difference between the age equivalent scores and the chronological age of the children are also reported in Table 4.2. The battery composite score, the gross motor composite score and the fine motor composite score appear first and thereafter the individual subtests results follow. The battery composite score, the gross motor composite score and the fine motor score are the most reliable and valid scores because they combine the scores for a number of the subtests (Bruininks 1979).

Table 4.2 Summary of the Results for All the Tests

	Range of age equivalent scores in years	Mean age equivalent scores in years	S D	% of children scoring on or above age	% of children scoring below age	p value
Battery Composite score	5.66 – 11.16	8.27	1.39	18.91%	81.08%	p < 0.01*
Gross motor Composite score	5.50 – 10.75	7.96	1.34	10.81%	89.19%	p< 0.01*
Fine motor Composite score	5.66 – 15.66	8.99	2.11	45.51%	54.05%	p = 0.44
Running Speed and Agility	4.66 – 14.16	7.53	1.92	16.21%	83.78%	p < 0.01*
Balance	4.16 – 10.16	6.91	1.86	16.21%	83.78%	p < 0.01*
Bilateral Coordination	4.42 – 15.42	8.92	2.25	37.83%	62.16%	p = 0.55
Strength	5.42 – 11.17	8.36	1.62	32.43%	67.56%	p < 0.01*
Upper limb Coordination	5.17 – 12.67	8.53	2.13	27.02%	72.97%	p = 0.02*
Response Speed	5.67 – 15.92	9.63	3.07	54.05%	45.94%	p = 0.35
Visual Motor Control	5.17 – 15.92	9.40	3.34	45.94%	54.05%	p = 0.57
Upper Limb Speed and Dexterity	5.67 – 11.92	8.80	1.39	45.94%	54.05%	p = 0.13

*** Indicates statistical significance**

p values refer to the differences between the chronological age and the age equivalent scores for the subtests.

The mean chronological age for the group was 9.0 years

4.3 Percentile Ranks.

The percentile ranks for the Battery Composite Scores, the Gross Motor Composite Scores and the Fine Motor Scores are shown in Figure 4.1.

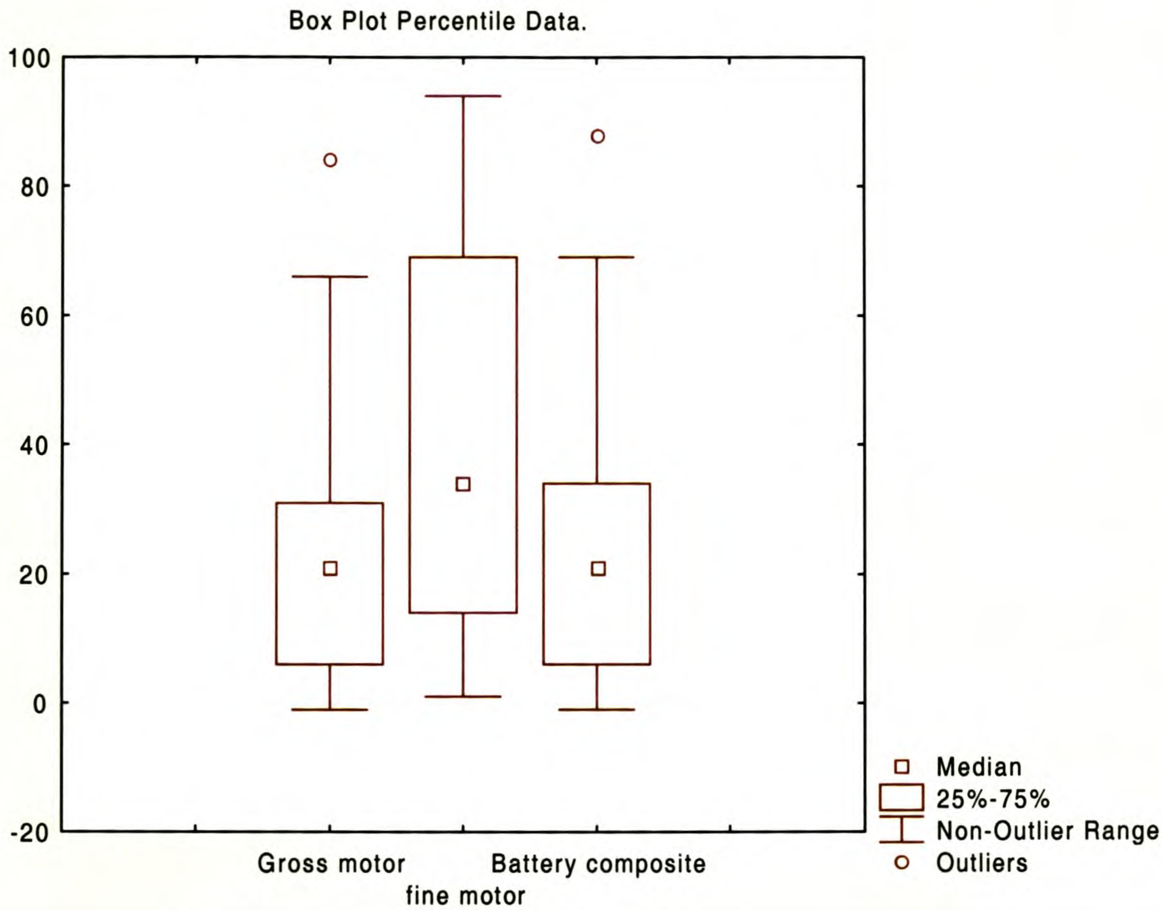

Figure 4.1 The Box plot showing the percentile ranks of the Battery Composite Scores, the Gross Motor Composite Scores and the Fine Motor Composite Scores

In Figure 4.1 The square marker demarcates the median percentile score for the group, while the box represents approximately 50% of the data and the whiskers represent the other 50% of the data, with the outliers being represented by the small circles.

Figure 4.1 shows the median percentile rank for the Battery Composite Scores and the Gross Motor Scores are on the 20th percentile while the Fine Motor Composite Scores is on the 35th percentile.

Because of the normal differences in the motor proficiency between girls and boys, the sex differentiated tables were used to assess any differences in the effect of gender on the percentile ranks on the scores and no difference was found.

4.4 The Efficiency of the Bruininks-Oseretsky Test of Motor Proficiency in the Sample.

The Spearman rank order correlation was done to establish if the BOTMP was able to discriminate between the different age groups in the sample as no control group was tested. This was done because the BOTMP is an American test and no South African norms for motor proficiency of children in this age group are available for the BOTMP. The results of the correlations are seen in Table 4.3.

Table 4.3 Results of Spearman Rank Order Correlation Test

Pair of Variables	Valid n	Spearman R	t(N-2)	p-level
Age & Running Speed and Agility	37	0.30	1.85	0.07
Age & Balance	37	0.34	2.39	0.02
Age & Bilateral Coordination	37	0.57	4.12	0.00
Age & Strength	37	0.57	4.16	0.00
Age & Upper limb coordination	37	0.87	7.37	0.00
Age & Response Speed	37	0.52	3.62	0.00
Age & Visual Motor Control	37	0.37	2.36	0.02
Age & Upper Limb Speed & Dexterity	37	0.63	4.79	0.00
Age & Gross Motor Composite Score	37	0.63	4.77	0.00
Age & Fine Motor Composite Score	37	0.57	4.15	0.00
Age & Battery Composite Score	37	0.70	5.86	0.00

As can be seen from Table 4.3 a positive correlation is present for all the subtests although the Running Speed and Agility Subtest has the weakest correlation ($p = 0.07$). However it appears that the BOTMP is able to discriminate between the different ages in this sample. This gives an indication that these results can be useful in the South African context.

Further verification of the BOTMP's ability to discriminate the children's motor skills was seen in the analysis of the results of the age equivalent scores in each grade. In all cases there was a significant difference ($p = 0.000$) in the age equivalent scores of each grade. The younger children scored more poorly on the BOTMP. This is expected as their motor ability improves normally with age. However in the context of this study it means that the BOTMP was discriminating between the different grades. To establish if the age of each the children in the grades was at the expected/normal age (within the South African Educational System) the mean age for each grade was calculated. Table 4.1 shows the mean age for each grade.

Figure 4.2 shows the graphical representation of the results of the Battery Composite Score for each grade.

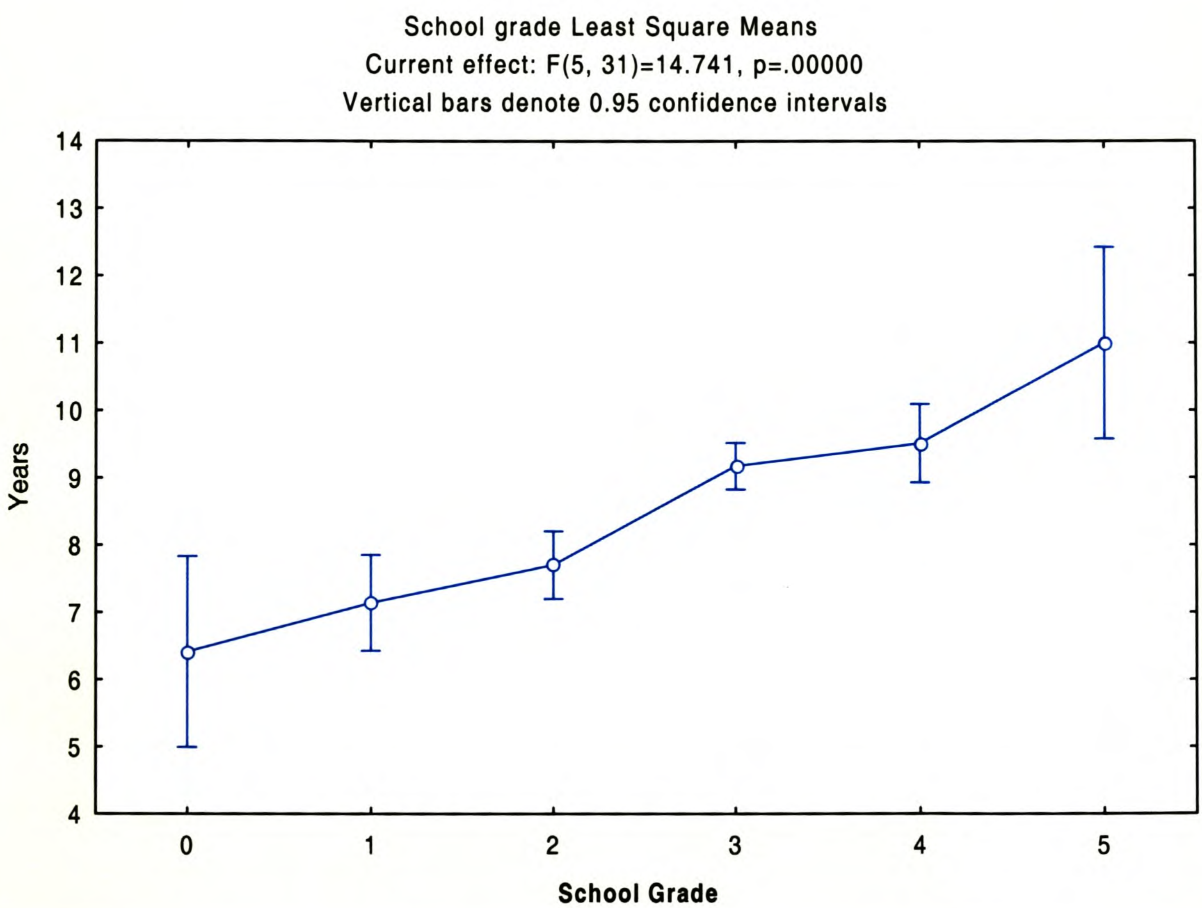

Figure 4.2 The Age Equivalent Scores for Each Grade for the Battery Composite Score

The difference in performance for each grade is clearly illustrated on Figure 4.2 and shows that the BOTMP is discriminating motor proficiency according to age in this sample.

The graphical representation of the RANOVA results is presented below. The factors that were investigated for each test score result were gender, arm preference, leg preference, language, school clinic, school grade, extramural sport by the child, extramural sport by the family. Only those factors from the data collection sheet that could have affected the age equivalent score results will be reported after the main results have been reported.

4.5 Composite Score Results

4.5.1 Battery Composite Score Results

As can be seen in Table 4.1 a significant number of children scored below their chronological age for the Battery Composite Score.

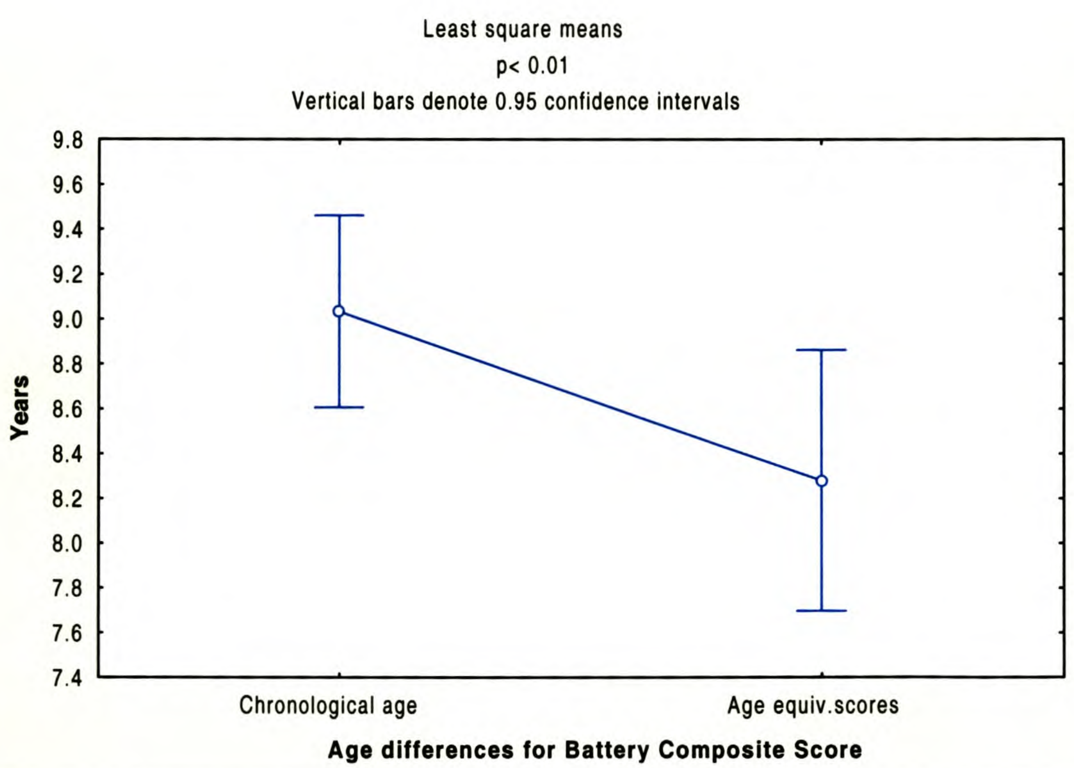

Figure 4.3 Age Differences for the Battery Composite Score.

The battery composite scores showed that the children in this sample scored age equivalent scores significantly lower than their chronological age ($p < 0.01$). Figure 4.3 shows the difference between the mean actual age (9.0 years) and the mean age equivalent score (8.27 years) for the whole group. The factor that could have affected the age equivalent scores was language. Figure 4.4 shows the results of the analysis of the differences between the two language groups.

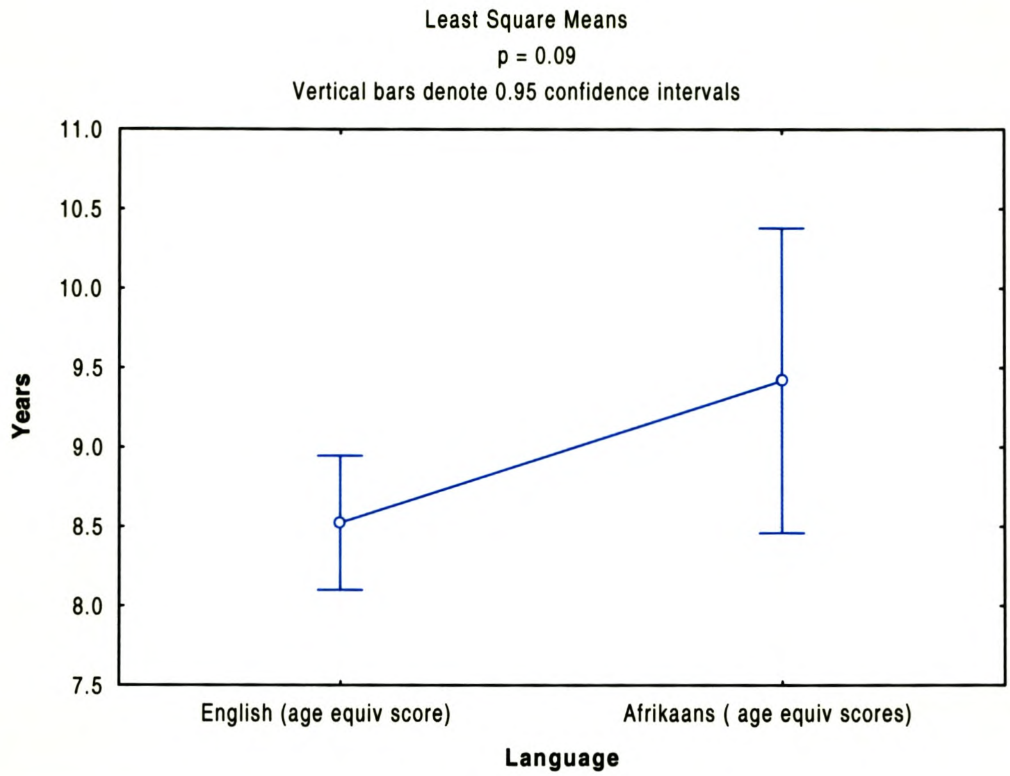

Figure 4.4 The difference in the age equivalent scores between the English and Afrikaans speaking children.

There is a slight tendency for the English children to score more poorly than the Afrikaans children ($p = 0.09$). See figure 4.4. Further analysis showed the differences between the two groups as can be seen on Figure 4.5.

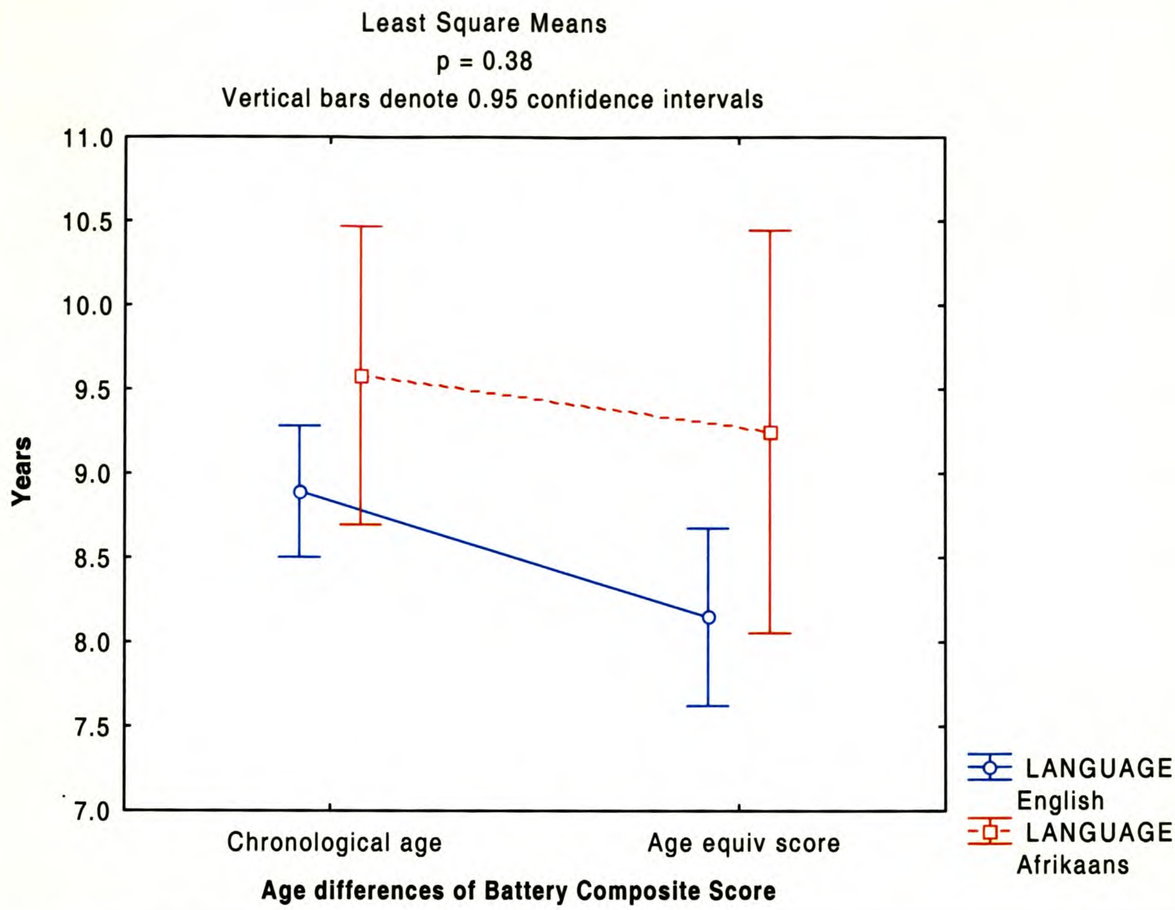

Figure 4.5 The differences in the chronological age and age equivalent scores for the English and Afrikaans speaking groups for the Battery Composite Scores.

Figure 4.5 shows that even though the English group was younger than the Afrikaans group they both showed the same pattern by scoring below their chronological age in the Battery Composite Score (p = 0.38).

However, the Afrikaans group consisted of only boys and when the performance of the two groups of boys was compared no difference in their scores was shown. Therefore the differences, which initially appeared to be due to language, were actually reflecting the differences between the gender groups. Thus no further results that indicated a difference in motor proficiency due to language will be reported.

4.5.2 Gross Motor Composite Score Results

As can be seen in Table 4.2 the mean age equivalent scores for the group is 7.96 years, which is 1.04 years (12.48 months) lower than the actual mean for the group. Of the group, 89.19% scored below their actual age (SD for the group is 1.34).

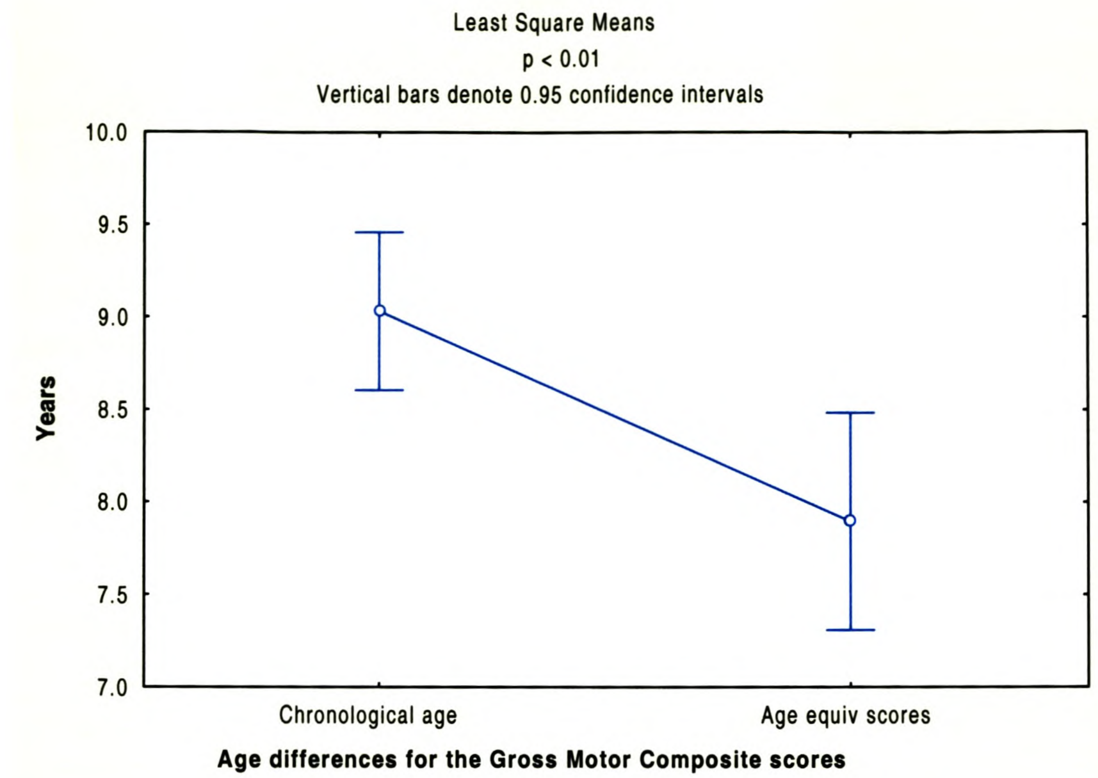

Figure 4.6 Age differences between chronological age and age equivalent scores for Gross Motor Composite Score.

The results indicated that the Gross Motor Composite age equivalent scores are significantly lower than the chronological age of the children ($p < 0.01$). This is illustrated in figure 4.6.

The only factor that was found to have affected the scores in the Gross Motor Composite Score is gender.

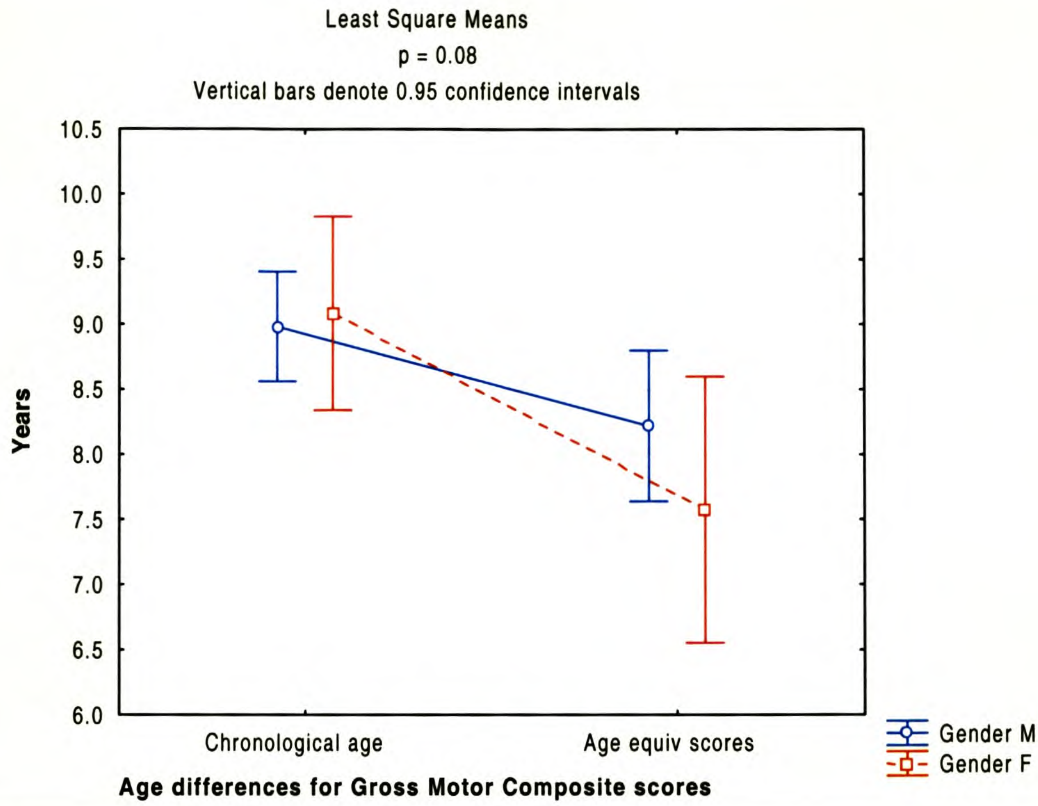

Figure 4.7 Differences in the chronological ages and age equivalent scores for girls and boys

The boys and girls were approximately the same age, but, there was a bigger difference between chronological age and age equivalent scores for the girls, than for the boys (however this was not strictly significant (p = 0.08). The difference found in Figure 4.6 can thus be attributed more to the girls than the boys.

4.5.3 Fine Motor Composite Score

The analysis showed that the children's age equivalent scores on the BOTMP were not significantly different from their chronological ages. As can be seen from table 4.1, above, the age equivalent mean was very close to the mean chronological age for the group. The age range of the results was 10 years (the actual age range was 3.2 years). The analysis showed that none of the factors investigated affected the children's age equivalent scores.

4.6 Subtest Results

The results of the eight individual subtests will be reported in the order in which they are completed on the BOTMP record sheet.

4.6.1 Running Speed and Agility Subtest results:

Table 4.2 clearly indicates that the age equivalent scores for the Running Speed and Agility Subtest was a range of 9.5 years. The group scored 1.47 years (17.64 months) below the mean chronological age for the group.

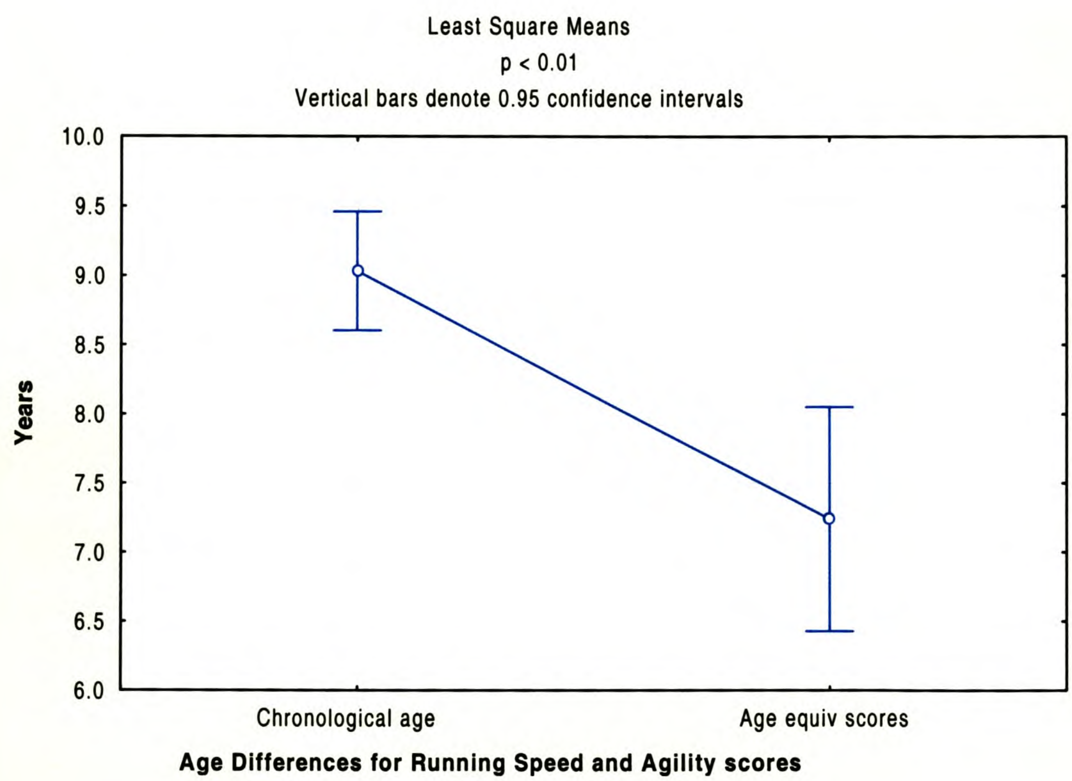

Figure 4.8 Differences in the mean chronological age and the age equivalent scores for the Running Speed and Agility Subtest.

The mean age equivalent scores for the sample were significantly lower than the mean actual age for the group ($p < 0.01$) as can be seen in figure 4.8. The mean age equivalent score was 7.53 years.

The factor that was found to have influenced the test score results in the Running Speed and Agility Subtest was gender.

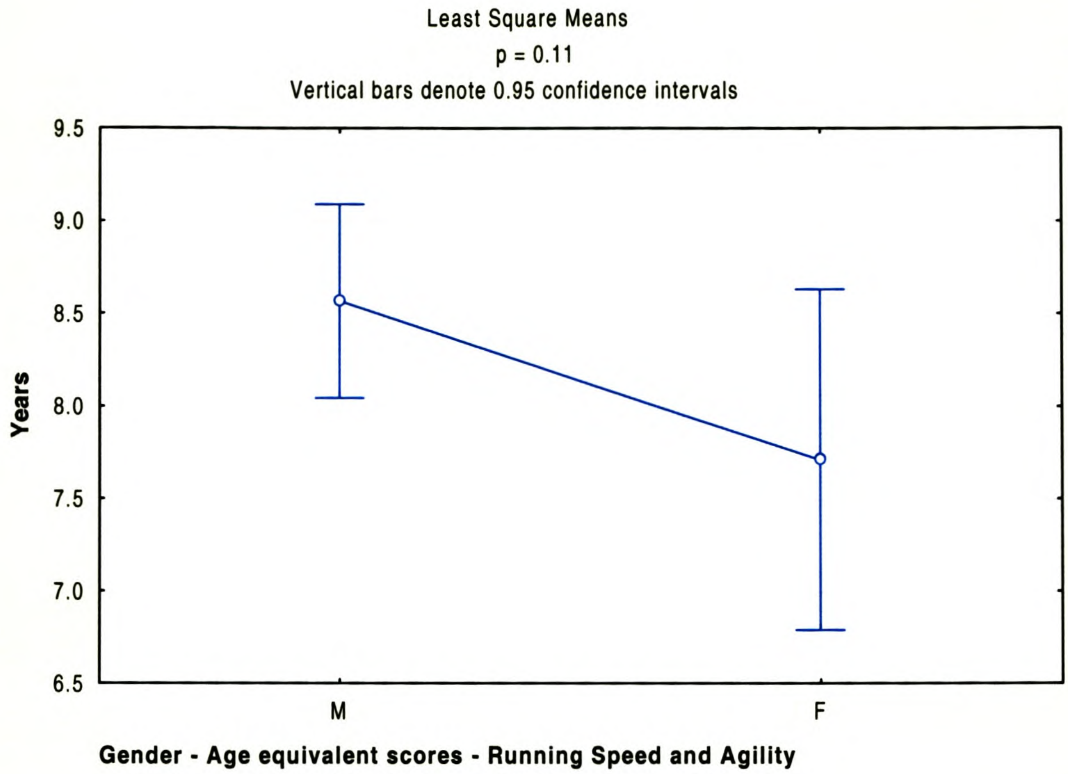

Figure 4.9 Differences in the age equivalent scores for girls and boys in the Running Speed and Agility Subtest.

Figure 4.9 shows a tendency for the girls' age equivalent scores in the Running Speed and Agility Subtest to be lower than those of the boys, ($p = 0.11$). When these scores were analysed further, it showed the differences between the groups, as can be seen in figure 4.10.

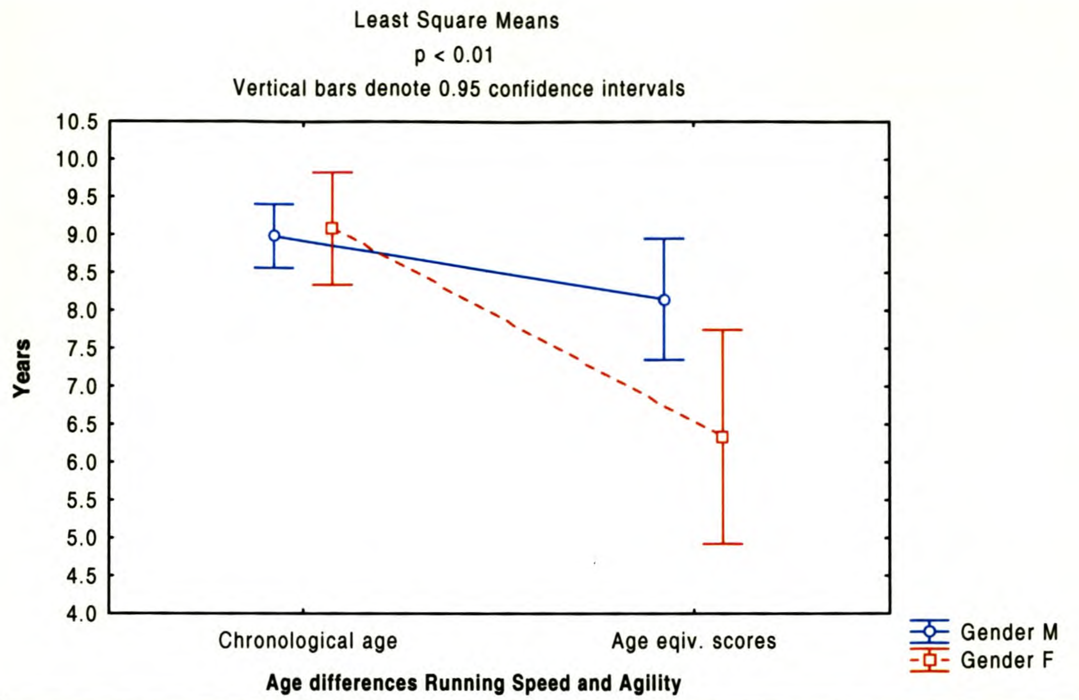

Figure 4.10 Differences in the mean chronological age and the age equivalent scores for the girls and boys in the Running Speed and Agility Subtest.

There was a significant difference between the age equivalent scores of the girls and boys in this test. The girls scoring lower age equivalent scores than the boys ($p < 0.01$) see Figure 4.10.

From this graph it can be seen that there was a small difference between the chronological age and the age equivalent scores for the boys, but there was a large difference for the girls. The reason why there was no difference for the group was because there were more boys(n=27) than girls (n= 9).

4.6.2 Balance Subtest Results:

Table 4.2 indicates the mean age equivalent score for this group of children was 6.91 years. This score is 2.09 years below their actual age, and 83.78% of them scored below the chronological age mean. The range of age equivalent scores was 6 years (actual age range 3.2 years).

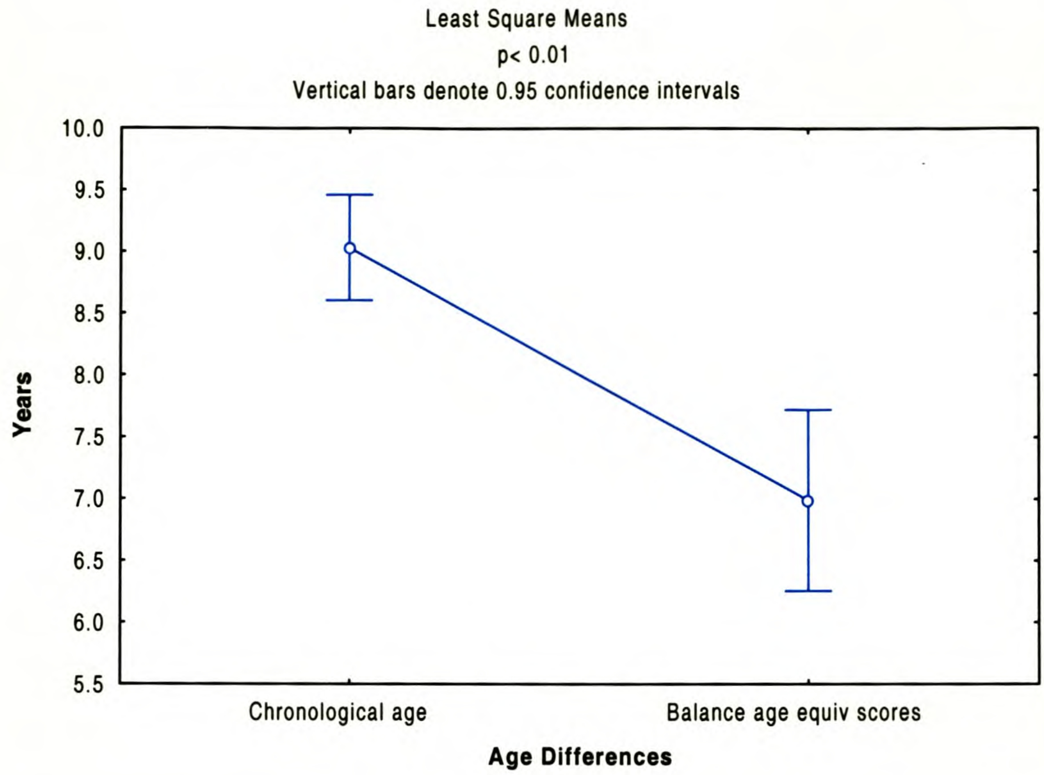

Figure 4.11 Differences in mean chronological age and age equivalent scores for the Balance Subtest.

The average age equivalent scores were significantly lower than the average age of the children ($p < 0.01$). This is shown in figure 4.11.

None of the factors investigated had any influence on the results in the Balance Subtest results.

4.6.3 Bilateral Coordination Subtest Results:

As can be seen from the Table 4.2, 62.16% of the children tested, scored under the age equivalent score. The range of age equivalent scores was 11 years (the actual age range was 3.2 years). The mean age equivalent score was very close to the norm for the test. There was no significant difference between the chronological age and the age equivalent scores for this subtest.

None of the factors investigated had any influence on the results in the Bilateral Co-ordination Subtest results.

4.6.4 Strength Subtest Results:

As can be seen in Table 4.2 the range of age equivalent scores was 5.75 years (the actual age range was 3.2 years). The mean age equivalent score was 8.36 years. This is 0.64 years (7.68 months) below the mean chronological age for the group. Figure 4.12 gives the results for this subtest.

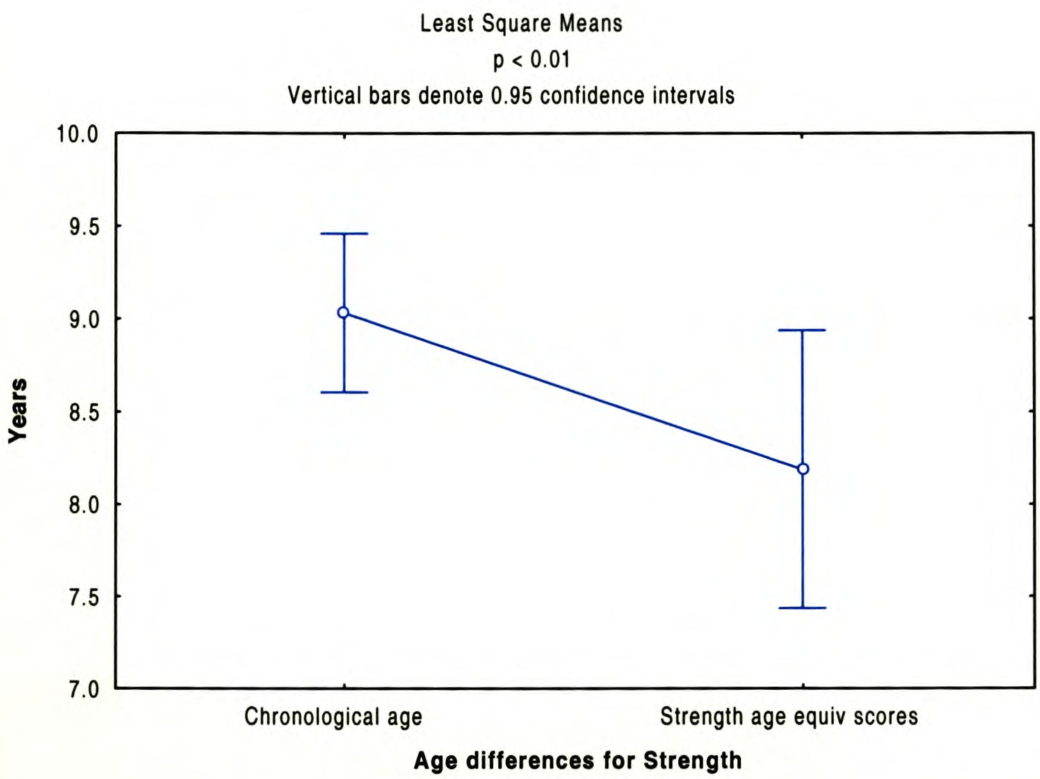

Figure 4.12 Differences in chronological age and age equivalent scores for the Strength Subtest.

The average age equivalent score was significantly lower than the average age of the children ($p < 0.01$). This is shown in Figure 4.12.

The variable that was shown to have influenced the results in the Strength Subtest was gender.

When the two gender groups were compared there was not a significant difference between the two groups, ($p = 0.3$) however the girls scored more poorly than the boys. On further analysis, it can be seen that although the mean scores were not significantly different the two groups did perform differently in the Strength Subtest. Figure 4.13 shows the boys and girls scores separately on the same graph.

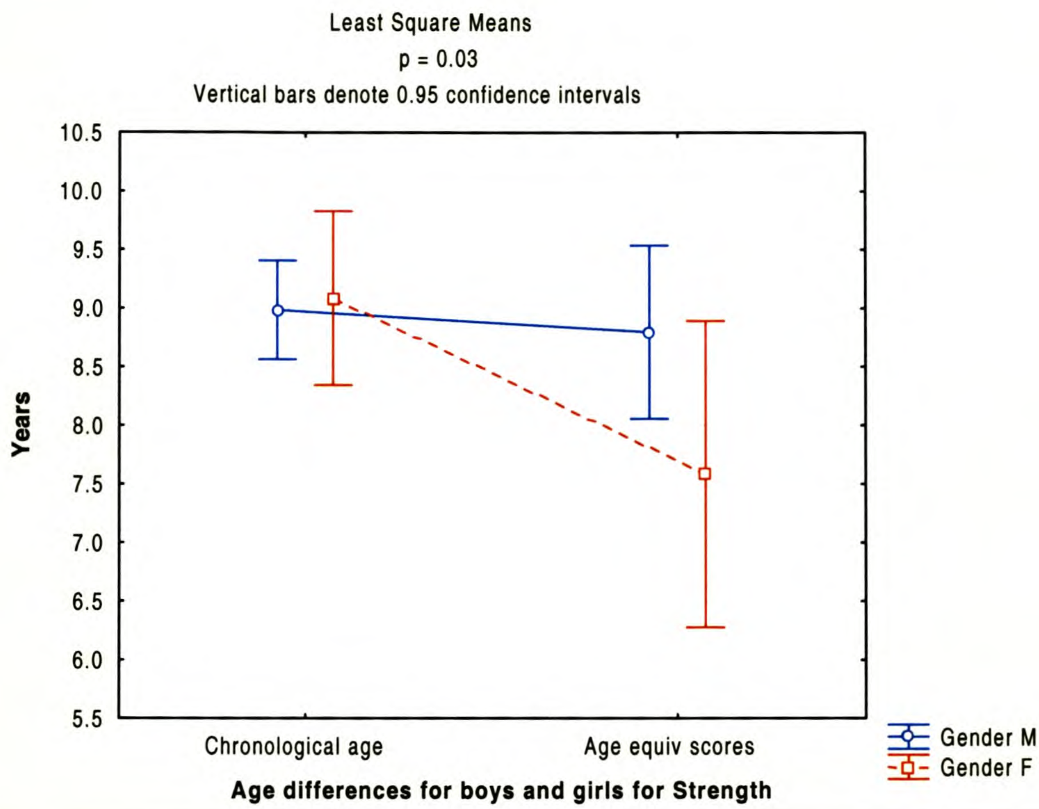

Figure 4.13 Differences in chronological age and the age equivalent scores between the girls and the boys for the Strength Subtest.

The interaction between the girls' age equivalent scores and the boys' age equivalent scores was significant ($p = 0.03$). The differences seen in Figure 4.13 show that the girls actually caused the low scores for the group on the subtest for Strength. There was no difference seen in the boys' scores. Therefore it is the influence of the girls' age equivalent scores that is seen on Figure 4.12.

4.6.5 Upper Limb Coordination Subtest Results

Table 4.1 indicates that this group of children 72.97% scored below their chronological age for this subtest. The mean age equivalent score is 8.53 years (5.64 months) below the mean chronological age for the sample. The range of age equivalent scores is between 5.17 and 12.67 years, and the SD is 2.13. Figure 4.14 shows the statistical analysis of the data.

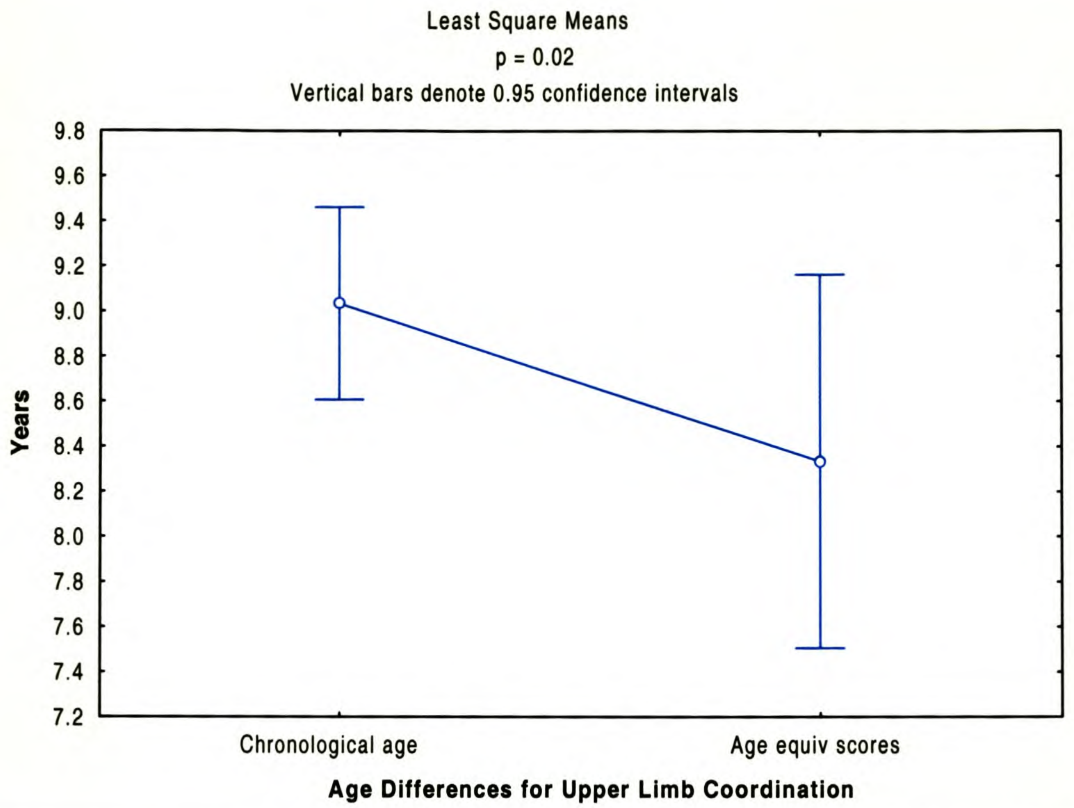

Figure 4.14 Age differences between the mean chronological age and the mean age equivalent scores for the Upper Limb Coordination Subtest.

The mean age equivalent score for the group was statistically lower than the mean actual age for the group (p = 0.02), as can be seen on figure 4.14. None of the factors investigated had any influence on the results in the Upper Limb Coordination Subtest results.

4.6.6 Response Speed Subtest Results:

The results of this test showed that the average age equivalent score was not significantly lower than average actual age of the children. Only 45.94% of children scored below their actual age. The range of scores was 10,25 years with the mean age equivalent score actually being higher than the mean chronological age for the group.

None of the factors investigated had any influence on the results in the Response Speed Subtest results.

4.6.7 Visual Motor Control Subtest Results

A range of 10.75 years was found in age equivalent scores in this test (the actual age range was 3.2 years). The mean age equivalent score was 0.47 years above the mean chronological age for the group.

The only factor that was found to have affected the results in this subtest was extramural sport. As can be seen in Figure 4.15 the two groups obtained different scores on this subtest.

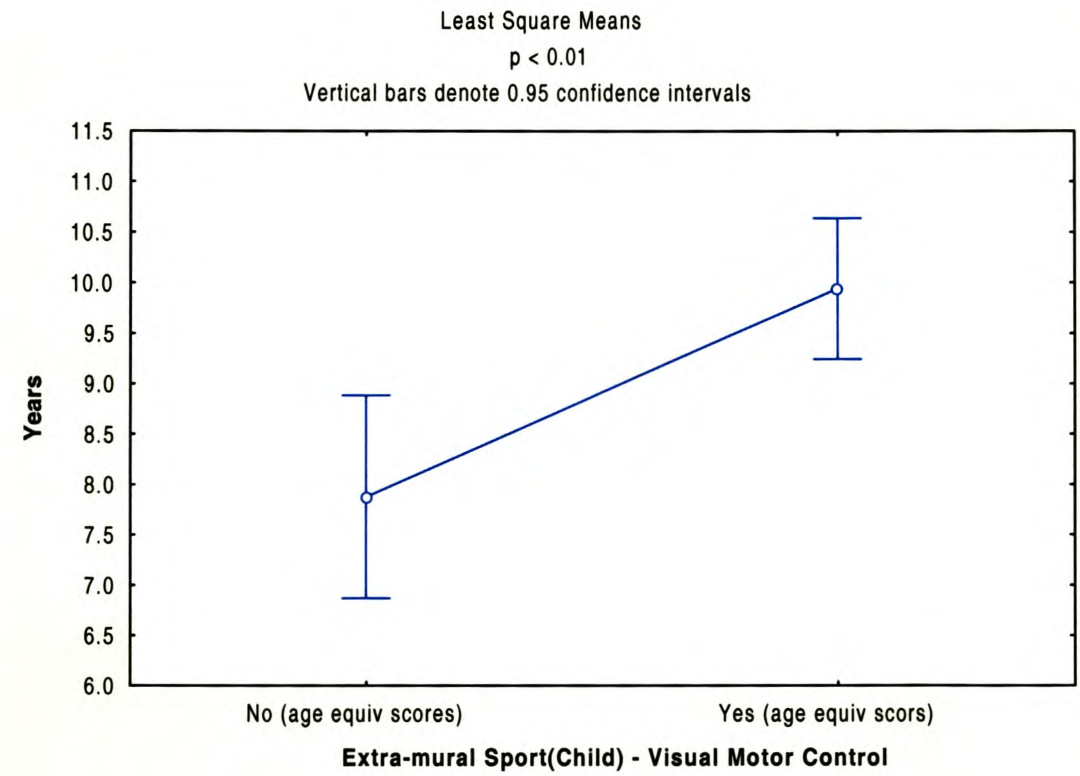

Figure 4.15 Age differences between the age equivalent scores for the groups that took part in sport and the groups that did not.

The average age equivalent score for the group of children taking part in sport was significantly higher than the age equivalent score for the group not taking part in sport ($p < 0.01$) see Figure 4.15. After further analysis the following graph was drawn.

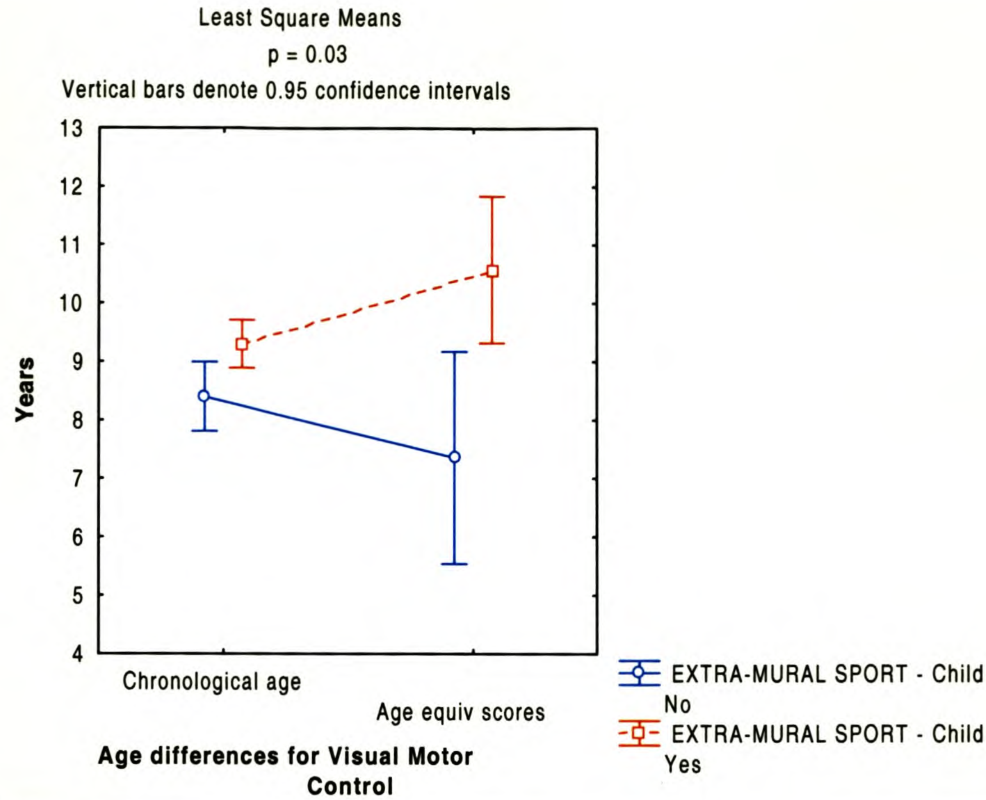

Figure 4.16 Age differences between the chronological age and the age equivalent scores for the group attending extramural sport and the group not attending sport for the Visual Motor Control Subtest.

As can be seen on the Figure 4.16 the two groups represent different age groups of children, with the mean age for the group attending sport being 9.3 years while the group not attending sport was 8.4 years.

A tendency for the children taking part in extramural sport to perform better as a group and therefore affect the total test results is seen with (p = 0.03) as is shown in Figure 4.16. The group attending extramural sport scored well above their chronological age in this test while the group not taking part in sport scored well below their chronological age.

This trend, although not statistically significant, was also present in the Bilateral Coordination Subtest and the Fine Motor Composite Score.

4.6.8 Upper Limb Speed and Dexterity Results

There was not a significant difference in the age equivalent scores and the chronological age for this group of children. The range of sores was 5.67 – 11.92 years and the standard deviation was 1.39 years.

None of the factors investigated had any influence on the results in the Upper Limb Speed and Dexterity Subtest results.

4.7 Conclusion

In conclusion this sample of children, between the ages of six and ten diagnosed with ADHD in the Cape Metropole do have motor proficiency deficits as tested on the BOTMP. The percentile rank scores indicate that this group of children is scoring on the 20^{th} percentile for the Battery Composite score and the Gross Motor Composite score and the 35^{th} percentile for the Fine Motor Composite score.

As the results show for the Battery Composite Score 81% of the children scored below the expected norm and there was a statistical difference between the age equivalent scores and the chronological age of the children ($p < 0.01$). The Gross Motor Composite Scores also showed that 89% of the children were scoring below the expected norm and there was a statistical difference between the age equivalent scores and the chronological age of the children. These two scores indicate that the children have motor proficiency deficits. However the Fine Motor Composite score did not indicate significant differences in the age equivalent scores and 54% of them scored below the expected norm. The composite scores are the most reliable scores because they include the results from a number of tests. The use of the median score in the scoring process also eliminates the very high and very low scores therefore giving a very fair score.

This research has also shown statistically significant differences in the age equivalent scores and the norms for this group of children, in four of the subtests. These subtests are Running Speed and Agility, Balance, Strength, and Upper Limb Co-ordination, showing motor deficits in these areas of motor proficiency.

The research has shown no significant differences in the age equivalent scores for the following subtests Bilateral Co-ordination, Response Speed, Visual Motor Control and Upper Limb Speed and Dexterity. Therefore deficits in these areas of motor proficiency are less likely.

Gender caused statistically significant differences in age equivalent scores in comparison to the actual age of the sample in the Gross Motor composite Score, the Running Speed and Agility Subtest scores, and the Strength Subtest scores. The attendance of extramural sport was shown to have caused a statistically significant difference in the scores of the children in the Visual Motor Control Subtest. This will be discussed further in the next chapter.

5 DISCUSSION

The profile of the sample in this study indicates that the composition of this sample of children was largely English speaking, children who took part in sport, and mainly preferred to use both the right hand and leg. On the whole there was very little family sport or activity which involved the children. From a demographic point of view this sample had nine girls in it which is close to the correct ratio of girls to boys according to Arnold (1996) who states that the diagnosis of ADHD in boys is 3:1 or 2:1 to that of girls. Most other studies only investigate boys and little is known about the effects of ADHD in girls. This is discussed in more detail where it is appropriate in the discussion.

The results of this study show that this group of children with ADHD has motor proficiency deficits. It appears in this study that they have more gross motor problems than fine motor problems. This is contrary to the literature, which reports more fine motor deficits than gross motor deficits (Barkley 1990, Whitmont and Clark 1996). However, controversy in the recent literature shows that not all children diagnosed with ADHD do have poor fine motor skills (Pitcher et al 2003, Piek et al 1999).

Recent research has indicated that the motor problems encountered by these children differ depending on the main symptoms that they display. In a study conducted by Pitcher et al (2003) the boys with ADHD were divided into the three groups as described in the DSM-IV. Their motor ability was tested using the M-ABC and the Purdue Pegboard Test. The findings indicated that the ADHD children had significantly poorer movement ability than the control group. Both the ADHD-PI (inattentive group) and the ADHD-C (combined group) in the study showed significantly poorer fine motor skills The researchers then divided the children into another category, in which children with low motor score on the M-ABC were labelled ADHD+DCD. The results analysed in this way showed that children with only ADHD did not have fine motor deficits, compared to the control group. (Pitcher et al 2003).

In a study by Piek et al (1999) which investigated motor coordination and kinaesthesis in boys with ADHD two of the subgroups of ADHD, were tested using the M-ABC and compared to a control group. They found that the two subgroups, the first being ADHD-PI were more inclined to have fine motor problems than the second group which was ADHD-C which was more inclined to show problems with gross motor skills. The third subtype, ADHD-HI predominantly hyperactive/impulsive type was not investigated. They concluded, "a high percentage of children with ADHD had significantly poorer movement ability than the control children" (Piek 1999:159), as was found in the present study.

It is clear from these two recent studies that clarity on the extent and affect of motor deficits in children with ADHD is still not clear.

The children in the present study group were diagnosed with ADHD according to the DSM-IV, however they were not put into the groups that the DSM-IV categorises. The researcher was given access to their names and in some cases to their files and no categorisation according to the groups was done when the diagnosis was made, as in the study by Kroes et al (2002). If this had been done by the doctors concerned it is likely that the subgroups would have been too small to be used.

The results of the present study will now be discussed and possible reasons for the findings will be put forward. Firstly the results of the Composite Scores will be discussed and then the results of the subtests will be discussed with possible reasons for the score obtained in this study. This will be followed by an analysis of the postural control requirements of the BOTMP relating to the results of the study. The behaviour during testing will be discussed in light of the results and the literature.

5.1 Battery Composite Score Results

The Battery Composite Score is the median score of all the subtests on the BOTMP and according to Bruininks (1978) is the most reliable of all the test score results. Of the sample, 81% scored below their own chronological age in the battery composite score. The range of the scores was 6.5 years.

The present study is supported by findings in previous research findings, which will now be discussed. In a study conducted by Beyer (1999) where the motor proficiency of boys with ADHD was compared with that of boys with learning difficulties, the boys with ADHD showed a significantly poorer motor performance than the boys with learning difficulties in all but three subtests. The subtests that did not show a significant difference were Balance, Upper Limb Co-ordination and Response Speed. This research was done using the

BOTMP long form (as was the present study) and the children on methylphenidate took their medication as usual, which the present study did not allow. It is difficult to compare these results with the present study as the comparison was between the two different groups i.e. ADHD and learning difficulties. A comparison with a control group that did not have motor problems of their own would have added more to the understanding of the motor problems that occur in ADHD alone (Beyer 1999). Few studies are reported that have also used the long form of the BOTMP and a direct comparison with the present study would have been possible.

Pereira et al (2000) conducted a study to establish differences in grip lift in children with ADHD and a control group. Grip lift is a fine motor test combined with hand strength. Before the test for grip lift was done, the twenty-five boys diagnosed with ADHD were tested on the M-ABC to establish if any motor deficits were present. Sixteen of the twenty five presented with what the authors termed "additional motor problems" i.e. they scored below the 10^{th} percentile on the M-ABC test, and nine presented with ADHD who scored above the 10^{th} percentile that is 64% of the ADHD group presented with "additional" motor problems. The original groups were then separated into two groups, the ADHD+ group (the group with the additional motor problems) and the ADHD group, the two new groups were compared to a control group. Their findings were that a large variability in performance was noted in the children with ADHD+ and that the motor problems were likely to have a multifactorial background. When compared to the present study the scores for motor impairment were high with 64% of the ADHD scoring below the 10^{th} percentile whereas the present study found that the Battery Composite median for the group was on the 20^{th} percentile. This indicates that the present study group did not score as poorly as the sample group in the Pereira et al (2000) study.

There is a tendency in recent studies to create groups of ADHD children who have "added" motor problems (Pereira et al 2000, Pitcher et al 2003). As the extent of motor proficiency problems has not yet been fully understood there is an assumption, that children with severe motor proficiency problems must belong to a different group/diagnosis comorbid with the diagnosis of ADHD, for example DCD, ODD, and CD.

5.2 Gross Motor Composite Score Results

As can be seen from the results the present study indicated that in this group of children, 89% had mainly gross motor proficiency problems and it is possible that more of them were from the ADHD-C subtype rather than the other subtypes as discussed by Piek et al (1999).

The Gross Motor Composite score is a combination of the test score results for the following subtests: Running Speed and Agility, Balance, Bilateral Co-ordination, and Strength. A number of studies used only the Gross Motor section of the BOTMP. This subtest has been found to be a reliable and valid test of Gross Motor function itself and has been used alone in studies investigating only gross motor function (Miyahara 1994, Schoeman et al 2002).

The present study is supported by the findings in a research study to determine the motor performance and physical fitness of children with ADHD (Harvey et al 1997). This study established that the Gross Motor performance and physical fitness of children with ADHD are substantially below average. They used the Test of Gross Motor Development to assess motor proficiency of 19 children between the ages of seven and twelve. This group included both boys and girls, but in the group of 19, only 2 were female (hence the girls were under represented). Harvey et al (1997) found that the results for 6 of the 8 variables on the test were significantly different from what could be expected in a normal population. These were Flexibility, Shuttle Run, Sit Ups, Object Control Skills and Locomotor Skills. The two variables that did not show a significant difference were Push Ups and Total Grip Strength. It is difficult to compare the results in the present study, in which push ups are tested in the Strength subtest and Total Grip Strength is not tested in the BOTMP at all. The individual results from these components could not be separated in the BOTMP as all the scores are combined to give each subtest score. The present study also found deficits in the shuttle run for the Running Speed and Agility Subtest, the Strength Subtest, which includes sit-ups, and the Upper Limb Co-ordination Subtest, which includes ball skills.

5.3 Fine Motor Composite Score

The Fine Motor Composite Score is a combination of the test score results for the following subtests: Response Speed, Visual Motor Control, and Upper Limb Speed and Dexterity.

The present study found that there was no significant difference between the chronological age and the age equivalent scores of the group. However, 54% of the group scored below age for both the Visual Motor Control and Upper Limb Speed and Dexterity Subtests, while 46% of the group scored below the expected age on the Response Speed Subtest. The children scored better than expected from the literature as poor fine motor ability is one of the expected motor deficiencies in children with ADHD (Levine 1995, Whitmont and Clark 1996).

Whitmont and Clark (1996), investigated kinaesthetic acuity and fine motor skills in children with ADHD, and found that children with ADHD scored significantly lower than the controls in the Fine Motor Composite score of the BOTMP. They also found that the kinaesthetic acuity in these children was lower but that there was only a weak association between the Fine Motor Composite Score and the kinaesthetic acuity scores. Whitmont and Clark (1996:1096) found "unexpectedly good motor competency on the BOTMP" which they suggested may be due to the fact that the BOTMP Fine Motor subtests were standardised in the United States of America and that Australian children may score better than their counterparts in America. This may also be valid for the South African population.

In a review on the BOTMP, Hattie and Edwards (1987) criticised both the Visual Motor Coordination Subtest and the Upper-Limb Speed and Dexterity Subtest for having very low estimates of internal reliability. In a factor analysis of the BOTMP by Krus et al (1981) they state that "The fine motor subtests did not cluster together on clearly identifiable factors as was true of the gross motor subtests". These opinions on the structure of the test itself would raise questions about the reliability of the results on the Fine Motor Composite scores.

Functionally these children are reported to have problems with handwriting (Whitmont and Clark 1996, Barkley 1990). The BOTMP does not explicitly test handwriting skills. It has a few drawing items in it but these do not require the refined fine motor skills that handwriting does. The drawing and track drawing tests do not replicate the movements of the interphalangeal joints of the fingers, wrist and arm movements that the ability to write does (Levine 1995).

5.4 Discussion of the Results of the Subtests

During the analysis of the results, the researcher noted that the different subtests in the BOTMP in which the children scored significantly low scores were predominately the subtests in which the children were required to stand and perform the movements/tasks for the test. Those subtests in which the children were able to sit and complete the task did not show significant results. The question of postural stability therefore was raised. No research could be found relating to the issues of central/core stability in children with ADHD although one study indicated that further investigation into this could be necessary. The following section will start with the requirements for good stability and postural stability and then continue to relate these to the results found in the present study.

5.4.1 Stabilisation and Postural Control

Many subsystems interact to achieve normal motor movement and stabilisation of the body is essential to this process. The ability to maintain control of the body is dependent on two major systems, namely balance and stability. Balance is defined as the ability to maintain equilibrium of the body, and can be divided into static balance and dynamic balance. Stability refers to the structural components such as the base of support and lower centre of gravity (Eckert 1979). Postural control and stability are used synonymously with balance for which three main systems are responsible, these are the sensory system, the motor system and the biomechanical system (Westcott et al 1997, Habib et al 1999). When considering stabilisation in the broader sense the child would require the ability to interact all of these systems at once for normal voluntary movement. In the Dynamic Systems approach a number of systems are required to maintain stability both structurally and posturally namely sensory mechanisms, neuromuscular components, musculoskeletal systems, normal central nervous system components, individual movement strategies, and adaptive mechanisms (Shumway-Cook and Woollacott 1995).

The relationship between balance and stability is a complex one with many different researchers defining it in different ways (Shumway-Cook and Woollacott 1984, Shumway-Cook and Woollacott 1995, Eckert 1979, Westcott et al 1997, Habib et al 1999). Depending on how this relationship is defined, so there is a variation in which are the controlling systems in the body.

Eckert states

> The relationship between balance and stability may be considered as paradoxical in that greater stability has the potential for enhancing balance performance but may, because of its lesser demands upon the balancing assemblies, actually act as a deterrent to the optimal development of sensory - motor systems associated with functional equilibrium Eckhart (1979:149).

The interrelatedness of these two concepts is seen in the definition of balance, which is the ability to maintain functional equilibrium, while stability describes the structural components needed to maintain equilibrium (Eckert 1979).

In Shumway-Cook and Woollacott (1995), postural control is defined as the individual's ability to maintain the centre of mass of the body within certain limits without changing the base. The term stability is used interchangeably with equilibrium or balance. For postural control to be possible a complex interaction of neural and musculoskeletal systems is essential. The neural components of this control include sensory systems such as visual, vestibular and somatosensory systems, motor processes, which include neuromuscular response synergies and more complex interactions of anticipatory and adaptive strategies. The discussion continues about the complexity of functional tasks, as the postural control mechanism is constantly being required to adapt. The BOTMP can be regarded as a functional test as the children are required to be able to do or learn new movements that they could be required to do in everyday life.

Extensive research has been done investigating the development of postural control and stability in children (Shumway-Cook and Woollacott 1985, Wetscott et al 1977, Eckert 1979, Habib et al 1999) as was discussed in 2.2.2.

Teicher et al (1996) investigated the movement patterns of 18 boys (not medicated) with ADHD. In a study that used a computer-based programme, the amount of spontaneous movement each child performed during a repetitive task was measured. The children were seated. The boys' movements were measured during a continuous performance task, using infrared motion analysis. It was established that these children not only moved more frequently than their normal counterparts, but that the quality of movement was more linear and less complex than those of the control group. The boys moved their heads 2.3 times more than those of normal children and covered a greater area (space) than the control group. These movement patterns were also noted in the trunk and arms. They concluded that "The relative inability of boys with ADHD to sit still can be objectively verified and 'fidgeting' appears to consist of more frequent, large amplitude, whole body movements" (Teicher et al 1996:334).

5.4.2 A Detailed Analysis of the Tasks Required on the BOTMP with Relation to the Postural Stability

The researcher analysed all the items in the BOTMP with regard to the required balance and postural control of the tasks that the children were required to perform in the BOTMP. The concepts of muscle stabilisation of the trunk that have been used in this discussion are based in the work of O'Sullivan et al (2002), Richardson et al (1999), and Richardson and Jull (1995). This work describes the importance of the stabilising role of the trunk and lumbar musculature in the maintenance of upright postures and the functional movements. No literature on the development of the stabilising muscles in children is available as yet, so this analysis of the movements cannot be compared to any literature. Psychologists, paediatric neurologists and psychiatrists have done most of the research in the field of motor proficiency in ADHD so this functional approach has not been used in any of the other literature.

In the first subtest Running Speed and Agility the child is required to run a certain distance, slow down and pick up an object and then turn and run back to the start. This requires dynamic balance when running, the ability to control the slowing down (inhibition or deceleration) of the run so as to pick up the object (lower centre of gravity to achieve this postural control so as not to fall over) and then to be able to speed up again to complete the run. It is a demanding task when analysed from a balance and postural stability perspective. From the results of the present study it can be seen that the children in this sample definitely had difficulty with this task with 83.78% of them scoring below the norm for their age.

There are eight items in the Balance Subtest. It is a comprehensive test for balance requiring both static and dynamic balance, and it removes the visual cues by requiring the children to close their eyes. Clearly from the results (see Table 4.2) these children found these tasks difficult to accomplish. Although this subtest tests static and dynamic balance it also tests postural stability, all the items are performed standing or walking which themselves require strong enough muscles and sensory input which allows for quick responses. The Balance Subtest tests only the child's preferred side i.e. the right side or the left side. According to the literature the side used for kicking may in fact not be the preferred side, as it is possible that the child may be more stable on the preferred side. This would result in the use of the other less stabile side for kicking. Therefore one cannot assume that the kicking was done with the preferred side (Cratty 1979). The test would be improved if both sides were tested giving the child the chance to show their best performance.

The Strength Subtest involves firstly (item 1) a standing broad jump that requires static balance, dynamic balance, postural control and deceleration so as to control the end of the jump and land without falling. Secondly (item 2) consists of lying on the ground doing sit-ups. This item requires less input form the balance subsystems because the starting position is lying and the end position is with the shoulders raised and the arms stretched forwards. The strength of the muscles, which are crucial in central postural control, are tested in this test. Not only the central stabilisers are tested but also the main abdominal movers are being tested. This would mean that if the children doing the BOTMP had poor abdominal stabilisers and weak movers it would be a very difficult item for them to complete. The final item (item 3) in this subtest is push-ups (depending on the age, full push-ups or knee push-ups). The performance of this item requires good central stabilisers or else the child simply stretches the arms up while the abdomen remains on the ground. Again less testing of the balance subsystems occurs in this subtest but the strength of the trunk stabilisers, arm stabilisers as well as the movers of both are all tested. Evidence of their difficulty with this subtest is seen in the fact that 83% of them scored below the expected norm (Table 4.2).

The Bilateral Co-ordination subtest did not show a statistically significant result. However, of the BOTMP results that did not show a statistically significant result, it had the highest percentage of children who scored below their chronological age - 63%. When the requirements for the subtest items were analysed for stability it could be seen that four of the eight subtest items were performed in the seated position while four were performed in standing. The seated items appeared to be more stable because of the support of the seat, floor and the lower centre of gravity. On analysis, the muscle work required for the first item required the child to be able to sit upright and hold the arms slightly below shoulder height, (this requires both good trunk stabilisation and good shoulder stabilisation) and alternately tap the feet (which would otherwise be used to support the legs even though the heels remain on the ground) and making circles with the fingers (isolated distal movement of the fingers which also requires good central stabilisation). This is a very demanding task.

The following two items in this subtest are both seated with tapping alternate feet (heels on the floor) and finger one using the same finger and foot, and then, using the opposite finger and foot. These two items are less demanding on the stabilisation systems as the trunk is in one position and the finger, wrist and elbow movements are performed close to the midline). The last item in this subtest is also done in the seated position but both hands are used at the same time to draw different items. In this subtest however the feet are both placed on the floor and therefore provide positive support for the child.

The remaining four items in this subtest all require the child to stand and jump moving the arms in different ways. Two items require the child to be able to move the arms either on the same side as the leg or on the opposite side. The final two tests require the child to jump and either clap the hands in front of the face or to touch both feet simultaneously. All four tests require both good dynamic balance and good central stability to allow for the independent arm movements.

As can be seen from the discussion above, half of the Bilateral Coordination Subtest is less demanding on the stabilisation systems in the trunk while the other half of the items are more demanding of the stabilisation systems of the trunk which could have affected the results of this subtest.

The Upper Limb Co-ordination Subtest results were also significant (Table 4.2). The six of the nine items in this subtest involve throwing, catching and aiming a ball and three items test hand and finger movements. On analysing the requirements of the tasks in the first four items of the subtest, the child is required to bounce a ball in front of themselves, throw and catch a ball to the tester three metres away. This requires good static balance, dynamic balance and good central stabilisers, which would allow for the throwing and aiming activities with the preferred arm. The children may not use their bodies to catch the ball, which would encourage them to fixate with their shoulders. The fifth and sixth items require the child to stand and to aim a ball at a target, and to touch a moving target. Both of these items require a complex interaction between the core stabilisers and the arm movers as well as the integration of the visual cues. The seventh item requires the child to stand still with both arms out at right angles and then touch the nose alternately with the eyes closed. This requires central stability, shoulder stability and postural control with extended arms and no visual cues. The final two items are seated but both involve bilateral hand movements and the manipulation of the hands and fingers, one with the eyes closed and the other with them open.

This is a demanding test from a stabilisation and postural contol point of view and 73% of the children scored below the expected norm as can be seen in the results (Table 4.2). This is supported by the literature, which states that children with ADHD have problems with ball skills (Barkley 1990, Harvey et al 1997). No difference was seen between the boys' and girls' scores which could have been expected as normally boys score better on throwing activities than girls do (Butterfield and Loovis 1993). This was not seen in the subtest results in the present study.

The fewest number of children scored below the age appropriate score in the Response Speed Subtest with 54% of them scoring on or above the age equivalent score and the mean was 9.63 years, which is above the mean chronological age for the group (see Table 4.2). When the task was analysed it became clear that this task is probably the most stable task in the whole test, as the child is seated and does not use the feet, therefore they have the support from their feet and they lean forward and place the preferred hand on to the wall in front of them. The only part of their bodies that is required to move is the thumb of the preferred hand in response to a visual cue.

The Visual Motor Control Subtest results showed 54% scoring below the expected norm. This subtest includes eight items during which the child was seated. Posturally the most complex task was the first item, which was cutting out a circle as both hands were needed for this task, one to stabilise and the other to cut. The other items include following a path with a pencil and drawing four large shapes.

The final test was the Upper Limb Speed and Dexterity Subtest during which the child was also seated with a variety of hand activities, some unilateral and some bilateral. However none of these tests required any foot movement and therefore were more posturally stable. The results also showed that only 54.05% of these children scored below the expected norm.

The previous discussion has briefly analysed the tasks on the BOTMP from a postural point of view. It is possible that children with ADHD have poor central stabilisation mechanisms however this was beyond the scope of this study and it would require added evaluation techniques to establish.

5.5 ADHD in Girls

The present study included 9 girls of the 37 children. Most of the research studies refer only to boys. This is because the ratio of boys affected by ADHD is higher than that of girls, about 2:1 to 3:1 (Arnold 1996). The girls in the present study scored more poorly than the boys did on two of the subtests. These were Running Speed and Agility and the Strength Subtests. This affected the Gross Motor Composite score where their age equivalent score showed a trend towards being lower than the boys ($p = 0.08$). In both the Running Speed and Agility and the Strength Subtests, the girls scored significantly more poorly than the boys did influencing the scores for the whole group. Because so little research on the affects of ADHD in girls has been done, it is not possible to compare these results with other research studies.

The following three studies relating to girls have been included in this discussion as they have reported some additional information on the affect of ADHD on girls. All of them question the possibility of the effects of ADHD being more severe in girls than boys. The first of these was conducted by Ernst et al (1994) who investigated the brain metabolism in hyperactive girls. A group of twenty hyperactive girls was compared to a control group of normal girls, using positron emission tomography and the cerebral glucose metabolism was monitored during a continuous auditory task. Their findings were that girls had greater brain metabolism abnormalities than normal girls did and also than their male counterparts with ADHD.

The second was conducted by Brito et al (1995) in Brazil; a behaviour assessment scale was drawn up to assess the children with ADHD, using the DSM-III-R. The results of this study found that boys displayed more symptoms of ADHD than the girls did. No motor abilities were tested in this study. A third study done by Harvey et al (1997) included girls in the sample however only two of the nineteen subjects were girls. It appears from the above studies that girls have been under represented in the research to date. There is little evidence to compare the results of the present study to and further investigation in this field is essential.

The suggestions and comments following the Conference on Sex Differences in ADHD in 1994, held under the auspices of the National Institute for Mental Health (NIMH) in the United States of America, were that little is understood about the manifestation of ADHD in girls and women. Research into this field is essential for women themselves and also to improve the recognition and diagnosis of ADHD in women, as this could influence early detection and treatment (Arnold 1996).

Following these suggestions from the NIMH conference in 1994, several studies have been completed with the emphasis on girls, most of them out of the scope of this study because they relate to behavioural differences in girls. It is important to note that all of the studies emphasise that the effects of ADHD may be more severe in girls than in boys particularly the psychiatric symptoms (Rucklidge and Tannock 2001, Biederman et al 1999). The only recent study relating to motor functioning in girls was conducted by Castellanous et al (2000). This study examined the effect of executive functions in girls while performing an oculomotor task. They found the same results as in boys with ADHD. This could mean girls also have same sort of motor proficiency deficits since the executive functions affect motor control (Barkley 1997).

The present study indicates that girls have more deficits in certain areas of motor proficiency than boys did, even after the sex differentiated scores had been calculated for the percentile ranks of the composite scores.

5.6 The Effects of Sport on Children with ADHD

The present study found that the influence of sport at school had a positive effect only on the Visual Motor Control Subtest ($p= 0.03$) of the BOTMP. One would expect that the practice of motor skills would lead to an improvement in motor performance. The group of children who did attend sport was about one year older than the group that did not play sport. There was a tendency for the two groups to score differently in the different subtests i.e. Bilateral Co-ordination and Fine Motor Subtest score but not enough to show any significant statistical difference.

In the study by Harvey et al (1997) the authors investigated the gross motor proficiency and physical fitness in boys with ADHD. One of the findings was that the better the Gross Motor performance level, the better the fitness level and vice versa. In the present study one third of the children did not attend sport, which is available at the schools which the sample group attended.

It is possible that the behaviours exhibited by these children on the sports field and their lack of ability to attend to the task would make sport a negative experience for them and create a barrier to practising and improving their motor proficiency. It may also be necessary for special programmes to be developed to allow the intergration of children into sport (Denckler and Voege 1992, Bishop and Beyer 1995). As Harvey et al (1997) stated, "poor motor performance and physical fitness may be a result of a lack of sustained effort and practice which, in turn, may lead to low levels of self esteem and consequently low levels of participation".

5.7 Quality of Movement in ADHD

Observations during testing supported the fact that children with ADHD do move more than their normal counterparts. Their behavioural inhibition was expressed in a number of different ways. They battle to sit still for any length of time (minutes) and look for things to do, touch or fidget with a lot of the time. The BOTMP makes very little allowance for the evaluation of quality of movement in the test itself. Some quality evaluation is built into the criteria for passing an item but this usually does not take into account patterns of movement. An example of this is found in the Balance Subtest, where the criteria for passing are stated relating to the position of the foot. The instructions are clear on the position of the arms to start the test. However if the starting position of the arms is not maintained e.g. many of the children broaden their base by extending their arms or some other of the trunk movement that they may do to stabilise themselves, no criteria exist to document or evaluate this. In a study by Kroes et al (2002) both qualitative and quantitative aspects of motor performance were measured in a group of five to six year olds, using the Maastricht Motor Test. This test was developed so that both qualitative and quantitative aspect of movement can be scored. The children were tested and then retested eighteen months later. These scores were then compared to the scores for a group of adolescents with ADHD. The findings were that, unlike quantitative movement, qualitative movement was predictive of ADHD. This finding is very important in the field of motor proficiency, as it is the only study found investigating normal movement patterns and quality of movement. The present study did not analyse quality of movement of the children but the researcher observed problems with the quality of movement in this sample of children. Two examples of this were that, firstly, many of them stabilised themselves with the opposite arm, or the same arm when drawing, and secondly, a number of them battled to cross the midline with ease when doing the task that requires them to draw between the lines across the midline.

5.8 Response Speed Results

The literature documents that there is a lack of inhibitory control and the slower reaction to changing task (Smith et al 2002, Schachar et al 1995, Barkley 1990, Barkley 1997). The results of the Response Speed Subtest were better than expected, as it could be expected that this group of children would score below the expected norm for their chronological age. A possible explanation for this could be that the BOTMP allows the child two practices before the test itself starts, to allow the child to reach proficiency on the test. Seven trials follow and the fourth best score is the one that is used as the test score's results. In effect the children have five trials before the score is used which is not done anywhere else in the BOTMP.

5.9 Possible Neurological Influences in Motor Proficiency

Although beyond the scope of this study, this discussion would not be complete without mentioning the possible neurological reasons for the motor problems that these children with ADHD show. It is well documented that the affects of ADHD are thought to be due to dysfunction in the frontal region of the brain (Barkley 1990, Barkley 1997, Mattes 1980). It has also been established that it is possible that some structures in the extrapyramidal sytem are smaller than in their normal counterparts (Aylward et al 1996, Castellanous et al 1994, Semrud-Clikeman et al 1994). The vestibular system is also implicated due to the size differences in the posterior lobe of the cerebellum (Berquin et al 1998). Both the extrapyramidal system and the cerebellum play a subtle but important role in motor control and the control of normal movement. It would appear that the possibility of neurological involvement in the motor difficulties that these children have, cannot be ignored and in fact may play an important role in further investigations into the motor abilities in children with ADHD.

5.10 Behaviour During Testing

Observation of the children during testing confirmed some of the symptoms that these children exhibit:

- Firstly, they battled to stick to the task and often needed reminding to refocus on the task.

- Many of them found the timing of 15 seconds frustrating because once busy with the task, e.g. sorting cards, they wanted to finish sorting all the cards in their hands and not stop after the allotted time.

- Lack of behavioural inhibition was also noted in the tasks where they had to draw lines or make dots, the researcher had to mark the spot where they drew the line at the allotted time or else stop them by blocking further writing or drawing so as to ensure accuracy in the test.

- If they found a task difficult, e.g. the finger tapping task, they would frequently stop and refuse to try again. It was unusual for a child to be prepared to try for the 90 seconds if they felt that they could not manage. Once they refused to carry on with a task the researcher moved to the next task and the child was encouraged to try the new task.

5.11 Conclusion

In conclusion the motor performance of the children with ADHD is a complex task to analyse. It appears that there are definitely problems with their motor proficiency although these may differ with the subgroup of ADHD within which the child may fall. These children do have problems with spontaneous motor activity and possibly with the muscle stabilisers of the trunk. It is possible that there is an overriding neurological influence, which could have an effect on motor ability. Definite differences were found in the results of the girls as compared to the boys. Sport does seem to have some effect on the motor proficiency in children with ADHD.

The one of the main clinical implications from the results of this study is that each child with ADHD presents differently. This can be seen in the range of age equivalent scores the children achieved on each of the subtests. The actual range in chronological age was 3.2 years and the range of age equivalent scores for the subtest varied from 5.5 years for the Battery Composite Score to 11 years for the Bilateral Co-ordination Subtest. This highlights the fact that each child will need to be carefully and individually assessed to achieve the most benefit from any intervention.

Of the forty-eight children originally identified to take part in this study, eight of them had already been referred to physiotherapy or occupational therapy. Assuming that they were referred for motor proficiency problems, the number of children displaying motor proficiency problems would be thirty (scoring below the expected norm for the Battery Composite Score) and the eight already referred giving a total of thirty eight of the original forty eight. This is a high percentage of children showing that the problems of motor proficiency in children with ADHD cannot be ignored.

It is an important matter to address for the children with ADHD as “it is erroneous to believe that children with mild to moderate motor problems will out grow them” (Sugden and Snugden 1991:330).

6 RECOMMENDATIONS

6.1 Recommendations to Improve This Study

The present study would have produced more reliable results if the sample group had been compared to a matched control group. This would have allowed the subtest score results to have been compared with each other and without the use of the age equivalent scores as presented in the BOTMP. This would also have improved the relevance of the study to the South African situation. The need to develop South African norms for motor proficiency is particularly important so as to allow better interpretation of the results within this context.

This study also needed to include measures to assess the posture alignment and strength of the postural muscles. This would have given data that could have been compared with the individual results of subtests and any correlation between the data could have been calculated.

Having an added tool to support the findings in the BOTMP especially as the functional problems reported mainly relate to handwriting skills would have enhanced the fine motor assessment.

A measure of qualitative assessment would also have enhanced the study. Poor motor performance is postulated to have an adverse effect on the self image of the children affected by it and a measure of these effects could also have added to the interpretation and understanding of the child's difficulties within the motor arena.

Although the children in this study all attended normal schools and they were in the correct class for age, it still would have enhanced the study to have had the IQ scores for the children to ensure that there was no problem with the understanding of the test. This did not seem to be a problem during testing but the formal score would have proved it.

6.2 Recommendations for Further Studies

Screening tools to assess if a child needs to go for in-depth motor assessments should be developed to assist the doctors diagnosing ADHD. This would encourage early referrals for therapy. Physiotherapy or occupational therapy, that is only considered after the child is six or seven, could be more effectively introduced at an earlier age.

Further studies into the effects of ADHD on motor problems in girls are essential. This study is one of the few that included girls in approximately the correct ratio of incidence and differences between the genders were clear. It may be appropriate to have studies that considered only girls as there are many studies that have considered only boys and therefore a lot of data is available for boys.

Research into the development of the postural stabilisers in children is essential. Lack of postural stability is a problem in a number of childhood developmental problems and research is needed to investigate the muscle development and recruitment of the stabilisers in normal children and children with motor problems.

A good standardised tool to measure quality of movement in children would greatly enhance the ability to assess the motor problems more accurately.

Methylphenidate is reported to improve motor function and handwriting in the classroom situation. This is well documented but the effects are only temporary. Once the child is no longer under the influence of methylphenidate the motor proficiency returns to its normal state. No studies have been done on the long-term effects of methylphenidate on the motor proficiency of children with ADHD. If strengthening and improved motor function is to be long term, the influence of methylphenidate in this regard would need to be assessed.

In conclusion, there is wide scope for further investigation into this field that would enhance our understanding and ability to plan more effective treatment for children that present with these problems.

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APPENDIX A

Data Capture Sheet

INFORMATION SHEET

Name: ____

Date of birth: ____

School grade: ____

School clinic attending: __________________________________

Weight: ______________ Height: ________________________

School that the child is attending: ________________________

Referring doctor: _______________________________________

Fathers name: _________________ Occupation: _________________

Mothers Name: ________________ Occupation: _________________

Home address: ____

____

Hobbies and sport/leisure activities of child: _____________________

____

Hobbies and leisure activities of family: _________________________

____

Inclusion/ exclusion CRITERIA;

1. Does your child understand English or Afrikaans?
2. Has your child received any formal therapy motor abilities?
3. Does the child have any conditions affecting his/her bones, movement?
4. Does your child take Ritalin?

APPENDIX B

Permission Letter from the Directorate of Education Research

Wes-Kaap Onderwysdepartement

Western Cape Education Department

ISebe leMfundo leNtshona Koloni

Naam / Enquiries / IMibuzo: Ronald Cornelissen

Telefoon / Telephone / IFoni: (021) 425-7400 ext 2236

Faks / Fax / IFeksi: (021) 425-7445

Verwysing / Reference / ISalathiso: 20020530-0003

Mrs Sue Statham
Department of Physiotherapy
Faculty of Health Sciences
University of Stellenbosch
STELLENBOSCH
7599

RESEARCH PROPOSAL: THE PREVALENCE OF MOTOR PROFICENCY DEFICITS IN CHILDREN IN GRADE ONE - GRADE THREE WITH ATTENTION DEFICIT HYPERACTIVITY DISORDER (ADHD) AT SCHOOL CLINICS IN THE CAPE METROPOLE.

Your application to conduct the above-mentioned research in schools/school clinics in the Western Cape has been approved subject to the following conditions:

1. Principals, educators and learners are under no obligation to assist you in your investigation.
2. Principals, educators, learners, schools and school clinics should not be identifiable in any way from the results of the investigation.
3. You make all the arrangements concerning your investigation.
4. Educators' programmes are not to be interrupted.
5. The investigation is to be conducted during June 2002 to September 2002.
6. Should you wish to extend the period of your survey at the school(s), please contact R. Cornelissen at the contact numbers above.
7. No research will be allowed during the fourth school term.
8. A photocopy of this letter is submitted to the principal of the school/school clinic where the intended research is to be conducted.
9. Your research will be limited to the School Clinics in the Cape Metropole.
10. A brief summary of the content, findings and recommendations is provided to the Director: Education Research.
11. The Department receives a copy of the completed report/dissertation/thesis addressed to:

The Director: Research
Western Cape Education Department
Private Bag 9114
CAPE TOWN
8000

We wish you success in your research.

Kind regards.

ACTING HEAD: EDUCATION
DATE: 2002 : 05 : 30

APPENDIX C

Informed Consent Form

PARTICIPANT INFORMATION AND CONSENT FORM

A STUDY TO DETERMINE THE PREVALENCE OF MOTOR DEFICITS IN CHILDREN IN GRADES 1 – 3 DIAGNOSED WITH ADHD AT SCHOOL CLINICS IN THE CAPE METROPOLE

REFERENCE NUMBER:

STATEMENT BY OR IN LIEU OF PARTICIPANT

I, the undersigned ……………………………………………………………………., parent / guardian of ………………………………… give permission for …………………………………… to undergo testing (using the BOTMP).

A. I confirm that:

1. My child has been invited to participate in the above mentioned research project which is initiated through the University of Stellenbosch.

2.1 It has been explained to me that the objective of the study is to
  a) establish if the children participating in the project have gross and fine motor deficits.
  b) establish which areas of motor deficits are more affected.

2.2 It has been explained to me that my child will be tested for about one hour.

2.3 I am aware that about 40 other children will be tested in this project, this year.

3. It has been explained to me that no negative effects can be expected after the test.

4. It has been explained to me that all the information will be handled confidentially. Information may be used for a thesis, a publication in scientific journals and presentation at professional presentations.

5. It has been explained to me that I will receive a short report giving the results of my child's tests and appropriate recommendations.

6. I have been informed that my child may refuse to participate in this project and that any such refusal or stoppage will not in anyway negatively influence any further treatment at the school clinic my child may receive.

7. The information above has been explained to me by ………………………………………… in English / Afrikaans* and that I am proficient in that language.

8. There has been no force placed on me to consent to my child's participation in this project and that I realise that he/she may stop at any time without penalty.

9. Participation in this project will not lead to additional costs for myself and that I will not benefit from it financially.

B I hereby declare that I will voluntarily participate in the above project

Signed at ………………………………………………………… on …………………………… 20……

……………………………………………… ……………………………………………….
Parent signature or fingerprint Witness

STATEMENT BY RESEARCHER

I, Sue Statham, state that:

1. I have explained the information in this document to ………………………………………. and his/her parents*;

2. I have invited him/her/parents* to ask me questions in the case of uncertainty;

3. This conversation was held in English/Afrikaans and that no translator has been used / that this conversation has been held in ……………………………………

Signed at ………………………………………………………… on …………………………… 20……

………………………………………………. ……………………………………………….
Researcher (Sue Statham) Witness

*** Delete if not relevant**

IMPORTANT INFORMATION

Dear Participant,

Thank you very much for your participation in this study. Should you have any questions during the duration of this study regarding

1. Problems as a result of testing of your child
2. Questions regarding information about your child

please contact me at the following telephone number ……………………………….

Ms Sue Statham

DEELNEMERS INLIGTINGS- EN TOESTEMMINGSVORM

A STUDY TO DETERMINE THE PREVALENCE OF MOTOR DEFICITS IN CHILDREN IN GRADES 1 – 3 DIAGNOSED WITH ADHD AT SCHOOL CLINICS IN THE CAPE METROPOLE

VERWYSINGSNOMMER:

VERKLARING DEUR OF NAMENS DEELNEMER

Ek, die ondergetekende ...., ouer / voog van .... gee toestemming vir .... om toetsing deur die Bruininks Osertesky Test of Motor Porficiency deur te gaan.

B. Ek bevestig dat:

1. My kind is uitgenooi om deel te neem aan bogenoemde navorsingsprojek, wat deur die Universiteit Stellenbosch onderneem word.

2.1 Daar aan my verduidelik is dat die doel van die studie is om
   a) uit te vind of die kinders probleme met hulle groot en klein motoriese beweging ondervind.
   b) uit te vind watter areas van beweging meer geaffekteer is.

2.2 Daar aan my verduidelik is dat my kind vir een uur getoets sal word.

2.3 Ek bewus is dat ongeveer 40 ander kinders so getoets sal word in hierdie projek hierdie jaar.

3. Dit is aan my meegedeel dat geen newe effekte kan verwag word na toetsing nie.

4. Daar aan my verduidelik is dat alle inligting vertroulik en konfidensieël behandel sal word. Die inligting kan gebruik word vir 'n tesis, publikasie in vaktydskrifte of 'n professionele voordrag.

5. Daar aan my verduidelik is dat ek die resultate van my kind se toetsing sal kry in die vorm van 'n kort rapport met toepaslike aanbevelings.

6. Daar aan my verduidelik is dat my kind mag weier om deel te neem aan die toetsing en dat sodanige weiering of staking nie enige verdere behandeling by die skool kliniek beïnvloed nie.

7. Die inligting hierbo aan my weergegee is deur .... in Engels / Afrikaans* en dat ek die taal goed magtig is.

8. Daar geen dwang op my geplaas is om toe te stem tot my kind se deelname aan hierdie projek nie en dat hy / sy mag weier of staak sonder enige penalisasie.

9. Deelname aan hierdie projek geen addisionele koste vir my inhou nie en dat ek ook nie finansieel daarby sal baat vind nie.

B Ek stem hiermee vrywillig in om deel te neem aan die bogemelde projek.

Geteken te .... op .... 20…...

....

Deelnemer / Verteenwoordiger se handtekening of vingerafdruk

Getuie

VERKLARING DEUR NAVORSER

Ek, Sue Statham, verklaar dat ek:

1. Die inligting vervat in hierdie dokument aan .... en of sy/haar* verteenwoordiger .... verduidelik het;

2. Hy/sy/hulle* versoek het om vrae aan my te stel indien enigiets onduidelik was;

3. Dat hierdie gesprek in Engels/Afrikaans plaasgevind het en dat geen tolk gebruik is nie.

Geteken te .... op .... 20…...

....

Navorser (Sue Statham)

Getuie

*** Haal deur indien nie relevant nie**

BELANGRIKE INLIGTING

Geagte Deelnemer,

Baie dankie vir u deelname aan hierdie studie. Indien daar te enige tyd tydens die duur van die projek

1. Probleme ondervind na die toetsing van u kind
2. Vrae het oor inligting oor u kind

Kontak my asseblief per telefoon by ....

Mev Sue Statham

APPENDIX D

The Bruininks – Oseretsky Test of Motor proficiency Score Sheet

Bruininks-Oseretsky Test of Motor Proficiency
Robert H. Bruininks, Ph.D.

INDIVIDUAL RECORD FORM
Complete Battery and Short Form

NAME ______ SEX: Boy ☒ Girl ☐ GRADE ______
SCHOOL/AGENCY ______ CITY ______ STATE ______
EXAMINER ______ REFERRED BY ______
PURPOSE OF TESTING ______

Arm Preference: *(circle one)*
(RIGHT) LEFT MIXED

Leg Preference: *(circle one)*
(RIGHT) LEFT MIXED

	Year	Month	Day
Date Tested	2002	07	24
Date of Birth	1993	06	15
Chronological Age	9	1	

TEST SCORE SUMMARY

Complete Battery:

SUBTEST	POINT SCORE Maximum	POINT SCORE Subject's	STANDARD SCORE Test (Table 23)	STANDARD SCORE Composite (Table 24)	PERCENTILE RANK (Table 25)	STANINE (Table 25)	OTHER
GROSS MOTOR SUBTESTS:							
1. Running Speed and Agility	15	9	14				5 8-11
2. Balance	32	23	13				8 7-5
3. Bilateral Coordination	20	10	13				6 8-8
4. Strength	42	11	13				7 8-8
GROSS MOTOR COMPOSITE			*53 SUM	45	31	4	8-8
5. Upper-Limb Coordination	21	19	*17				1 12-8
FINE MOTOR SUBTESTS:							
6. Response Speed	17	10	18				2 11-8
7. Visual-Motor Control	24	19	13				4 9-2
8. Upper-Limb Speed and Dexterity	72	40	15				3 9-5
FINE MOTOR COMPOSITE			*46 SUM	52	58	5	9-5
BATTERY COMPOSITE			*118 SUM	50	50	5	9-0

*To obtain Battery Composite: Add Gross Motor Composite, Subtest 5 Standard Score, and Fine Motor Composite. Check result by adding Standard Scores on Subtests 1-8.

Short Form:

SHORT FORM

DIRECTIONS

Complete Battery:

1. During test administration, record subject's response for each trial.

2. After test administration, convert performance on each item (item raw score) to a point score, using scale provided. For an item with more than one trial, choose best performance. Record item point score in *circle* to right of scale.

3. For each subtest, add item point scores; record total in circle provided at end of each subtest and in Test Score Summary section. Consult *Examiner's Manual* for norms tables.

Short Form:

1. Follow Steps 1 and 2 for Complete Battery, except record each point score in *box* to right of scale.

2. Add point scores for all 14 Short Form items and record total in Test Score Summary section. Consult *Examiner's Manual* for norms tables.

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SUBTEST 1: Running Speed and Agility

1. Running Speed and Agility[SF] *

TRIAL 1: ______ seconds TRIAL 2: [illegible] seconds

Raw Score	Above 11.0	10.9-11.0	10.5-10.8	9.9-10.4	9.5-9.8	8.9-9.4	8.5-8.8	7.9-8.4	7.5-7.8	6.9-7.4	6.7-6.8	6.3-6.6	6.1-6.2	5.7-6.0	5.5-5.6	Below 5.5
Point Score	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15

9

SUBTEST 2: Balance

1. Standing on Preferred Leg on Floor *(10 seconds maximum per trial)*

TRIAL 1: 10 seconds TRIAL 2: 0,6 seconds

Raw Score	0	1-3	4-5	6-8	9-10
Point Score	0	1	2	3	4

4

2. Standing on Preferred Leg on Balance Beam[SF] *(10 seconds maximum per trial)*

TRIAL 1: 0,1 seconds TRIAL 2: 10 seconds

Raw Score	0	1-2	3-4	5-6	7-8	9	10
Point Score	0	1	2	3	4	5	6

6

3. Standing on Preferred Leg on Balance Beam—Eyes Closed *(10 seconds maximum per trial)*

TRIAL 1: 0,2 seconds TRIAL 2: 0,2 seconds

Raw Score	0	1-3	4-5	6	7	8	9	10
Point Score	0	1	2	3	4	5	6	7

1

4. Walking Forward on Walking Line *(6 steps maximum per trial)*

TRIAL 1: 6 steps TRIAL 2: 6 steps

Raw Score	0	1-3	4-5	6
Point Score	0	1	2	3

3

5. Walking Forward on Balance Beam *(6 steps maximum per trial)*

TRIAL 1: 6 steps TRIAL 2: 6 steps

Raw Score	0	1-3	4	5	6
Point Score	0	1	2	3	4

4

6. Walking Forward Heel-to-Toe on Walking Line *(6 steps maximum per trial)*

TRIAL 1: ✓ ✓ ✓ ✓ ✓ ✓ = 6 steps TRIAL 2: ✓ ✓ ✓ ✓ ✓ ✓ = 6 steps

Raw Score	0	1-3	4-5	6
Point Score	0	1	2	3

3

7. Walking Forward Heel-to-Toe on Balance Beam[SF] *(6 steps maximum per trial)*

TRIAL 1: ✓ ✓ ✓ ✓ - - = 4 steps TRIAL 2: ✓ ✓ ✓ - - - = 3 steps

Raw Score	0	1-3	4	5	6
Point Score	0	1	2	3	4

2

8. Stepping Over Response Speed Stick on Balance Beam

TRIAL 1: Fail Pass TRIAL 2: Fail Pass

Raw Score	Fail	Pass
Point Score	0	1

0

23

*SF and the box in left-hand margin indicate Short Form items.

SUBTEST 3: Bilateral Coordination

1. Tapping Feet Alternately While Making Circles with FingersSF *(90 seconds maximum)*

* Raw Score	Fail	Pass
Point Score	0	1

wrist

0

2. Tapping—Foot and Finger on Same Side Synchronized *(90 seconds maximum)*

* Raw Score	Fail	Pass
Point Score	0	1

1

3. Tapping—Foot and Finger on Opposite Side Synchronized *(90 seconds maximum)*

* Raw Score	Fail	Pass
Point Score	0	1

0

4. Jumping in Place—Leg and Arm on Same Side Synchronized *(90 seconds maximum)*

* Raw Score	Fail	Pass
Point Score	0	1

1

5. Jumping in Place—Leg and Arm on Opposite Side Synchronized *(90 seconds maximum)*

* Raw Score	Fail	Pass
Point Score	0	1

1

6. Jumping Up and Clapping HandsSF

TRIAL 1: 3 claps TRIAL 2: 3 claps

Raw Score	0	1	2	3	4	Above 4
Point Score	0	1	2	3	4	5

3

7. Jumping Up and Touching Heels with Hands

TRIAL 1: Fail Pass TRIAL 2: Fail Pass

Raw Score	Fail	Pass
Point Score	0	1

1

8. Drawing Lines and Crosses Simultaneously *(15 seconds)*

NUMBER OF PAIRS CORRECT: 5

collapsing feet

Raw Score	0	1	2-3	4-5	6-7	8-9	10-11	12-14	15-17	Above 17
Point Score	0	1	2	3	4	5	6	7	8	9

3

10

SUBTEST 4: Strength

1. Standing Broad JumpSF *(record number from tape measure)*

TRIAL 1: 8 TRIAL 2: 6 TRIAL 3: 5

Raw Score	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
Point Score	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16

8

2. Sit-ups *(20 seconds)*

NUMBER: 8

Raw Score	0	1-2	3-4	5-6	7-8	9-10	11-12	13-15	16-18	19-20	Above 20
Point Score	0	1	2	3	4	5	6	7	8	9	10

4

3a. Knee Push-ups (For Boys Under Age 8 and All Girls) *(20 seconds)*

NUMBER: ______

Raw Score	0	1-2	3-5	6-7	8-9	–	–	10-12	–	–	13-15	–	16-18	–	–	19-20	Above 20
Point Score	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16

5

3b. Full Push-ups (For Boys Age 8 and Older) *(20 seconds)*

NUMBER: 5

Raw Score	0	–	–	–	–	1-5	6-9	–	10-11	12-13	–	14-15	–	16-17	18-20	–	Above 20
Point Score	0	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16

5

17

*For Subtest 3, circle pass or fail in Items 1-5

RECORD POINT SCORE

1. Bouncing a Ball and Catching It with Both Hands *(5 trials)*

NUMBER OF CATCHES: 5

Raw Score	0	1-2	3-4	(5)
Point Score	0	1	2	3

3

2. Bouncing a Ball and Catching It with Preferred Hand *(5 trials)*

NUMBER OF CATCHES: 5

Raw Score	0	1-2	3-4	(5)
Point Score	0	1	2	3

3

3. Catching a Tossed Ball with Both HandsSF *(5 trials)*

NUMBER OF CATCHES: 5

Raw Score	0	1-2	3-4	(5)
Point Score	0	1	2	3

3

4. Catching a Tossed Ball with Preferred Hand *(5 trials)*

NUMBER OF CATCHES: 5

Raw Score	0	1-2	3-4	(5)
Point Score	0	1	2	3

3

5. Throwing a Ball at a Target with Preferred HandSF *(5 trials)*

✓	✓	–	✓	✓	= HITS

Raw Score	0	1-2	(3-4)	5
Point Score	0	1	(2)	3

2

6. Touching a Swinging Ball with Preferred Hand *(5 trials)*

NUMBER OF HITS: 3

Raw Score	0	1-2	(3-4)	5
Point Score	0	1	(2)	3

2

7. Touching Nose with Index Fingers—Eyes Closed *(90 seconds maximum)*

* Raw Score	Fail	(Pass)
Point Score	0	1

1

8. Touching Thumb to Fingertips—Eyes Closed *(90 seconds maximum)*

* Raw Score	Fail	(Pass)
Point Score	0	1

1

9. Pivoting Thumb and Index Finger *(90 seconds maximum)*

* Raw Score	Fail	(Pass)
Point Score	0	1

1

19 POINT SCORE SUBTEST 5 (Max: 21)

SUBTEST 6: Response Speed

1. Response SpeedSF

TRIAL	SECONDS TO WAIT	SCORE[1]		RANKED TRIAL SCORES[2]
Practice 1	1	XXXX		
Practice 2	3	7 XXXX		
1	2	16 ✓	HIGHEST	16
2	3	15 ✓		15
3	1	10		14
4	3	14	MEDIAN	12
5	2	3		12
6	1	12		6
7	1	6	LOWEST	3

10 POINT SCORE SUBTEST 6 (Max: 17)

[1]Record number from response speed stick in this column

[2]Rank all seven trial scores, highest to lowest, in boxes provided. The point score for Subtest 6 is the median (middle), or fourth, score from the top.

*For Subtest 5, circle pass or fail in Items 7-9

SUBTEST 7: Visual-Motor Control

RECORD POINT SCORES FOR COMPLETE BATTERY

1. Cutting Out a Circle with Preferred Hand

NUMBER OF ERRORS: 0

Raw Score	Above 10	10	8-9	3-7	(0-2)
Point Score	0	1	2	3	(4)

Point score: 4

2. Drawing a Line Through a Crooked Path with Preferred Hand

NUMBER OF ERRORS: 0

Raw Score	Above 6	6	2-5	1	(0)
Point Score	0	1	2	3	4

Point score: 4

3. Drawing a Line Through a Straight Path with Preferred Hand[SF]

NUMBER OF ERRORS: 0

Raw Score	Above 6	6	2-5	1	(0)
Point Score	0	1	2	3	4

Point score: 4

4. Drawing a Line Through a Curved Path with Preferred Hand

NUMBER OF ERRORS: 6

Raw Score	Above 6	(6)	2-5	1	0
Point Score	0	1	2	3	4

Point score: 1

5. Copying a Circle with Preferred Hand[SF]

SCORE: 2

* Raw Score	0	1	(2)
Point Score	0	1	2

Point score: 2

6. Copying a Triangle with Preferred Hand

SCORE: 2

* Raw Score	0	1	(2)
Point Score	0	1	2

Point score: 2

7. Copying a Horizontal Diamond with Preferred Hand

SCORE: 1

* Raw Score	0	(1)	2
Point Score	0	1	2

Point score: 1

8. Copying Overlapping Pencils with Preferred Hand[SF]

SCORE: 1

* Raw Score	0	(1)	2
Point Score	0	1	2

Point score: 1

POINT SCORE SUBTEST: 19

*See scoring criteria for Items 5-8 in Appendix A of *Examiner's Manual.*

1. Placing Pennies in a Box with Preferred Hand *(15 seconds)*

NUMBER OF PENNIES: 19

Raw Score	0-5	6-10	11-13	14-15	16-17	18-19	20-21	22-23	24
Point Score	0	1	2	3	4	5	6	7	8

5

2. Placing Pennies in Two Boxes with Both Hands *(50 seconds maximum for seven correct pairs)*

PAIRS CORRECT: ✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓ ✓ TIME IN SECONDS: 14.50

Raw Score	Above 49	41-49	31-40	26-30	21-25	18-20	16-17	14-15	12-13	10-11	Below 10
Point Score	0	1	2	3	4	5	6	7	8	9	10

7

3. Sorting Shape Cards with Preferred Hand[SF] *(15 seconds)*

NUMBER OF CARDS: 23

Raw Score	0	1-8	9-12	13-16	17-20	21-25	26-29	30-33	34-37	38-41	Above 41
Point Score	0	1	2	3	4	5	6	7	8	9	10

☐ 7

4. Stringing Beads with Preferred Hand *(15 seconds)*

NUMBER OF BEADS: 5

Raw Score	0-1	2-4	5	6	7	8	9	Above 9
Point Score	0	1	2	3	4	5	6	7

2

5. Displacing Pegs with Preferred Hand *(15 seconds)*

NUMBER OF PEGS: 14

Raw Score	0	1-5	6-7	8-9	10-11	12-13	14-15	16-18	19-20
Point Score	0	1	2	3	4	5	6	7	8

6

6. Drawing Vertical Lines with Preferred Hand *(15 seconds)*

NUMBER OF LINES: 8

Raw Score	0	1-3	4-6	7-9	10-12	13-16	17-20	21-24	25-35	Above 35
Point Score	0	1	2	3	4	5	6	7	8	9

3

7. Making Dots in Circles with Preferred Hand[SF] *(15 seconds)*

NUMBER OF CIRCLES WITH DOTS: 23

Raw Score	0	1-10	11-15	16-20	21-25	26-30	31-35	36-40	41-50	51-60	Above 60
Point Score	0	1	2	3	4	5	6	7	8	9	10

☐ 6

8. Making Dots with Preferred Hand *(15 seconds)*

NUMBER OF DOTS: 52

Raw Score	Below 10	10-25	26-35	36-45	46-55	56-65	66-75	76-85	86-95	96-105	Above 105
Point Score	0	1	2	3	4	5	6	7	8	9	10

4

40

NOTES/OBSERVATIONS

For additional forms, call or write AGS, 4201 Woodland Road, Circle Pines, MN 55014-1796; **toll-free 1-800-328-2560**. Ask for item 1584, B.O. Record Forms (25 per package).

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APPENDIX E

The RANOVA Results

RESULTS OF THE RANOVA ANALYSIS

Sex of Child (p Scores)

	Least Squared Mean	Age Difference Least Squared Mean	Age Difference and Sex Least Squared Mean
Running Speed & Agility	0.11	< 0.00	0.01
Balance	0.76	< 0.00	0.89
Bi-lateral Coordination	0.69	0.54	0.37
Strength	0.29	0.07	0.03
Upper Limb Coordination	0.56	0.23	0.16
Response Speed	0.84	0.35	0.64
Visual Motor Control	0.28	0.15	0.25
Upper Limb Speed & Dexterity	0.64	0.35	0.61
Gross Motor Composite	0.56	< 0.00	0.09
Fine Motor Composite	0.26	0.44	0.14
Battery Composite	0.91	< 0.00	0.45

Arm Dominance (p Scores)

	Least Squared Mean	Age Difference Least Squared Mean	Age Difference and Sex Least Squared Mean
Running Speed & Agility	0.31	0.02	0.85
Balance	0.25	< 0.00	0.70
Bi-lateral Coordination	0.32	0.44	0.72
Strength	0.53	0.76	0.71
Upper Limb Coordination	0.20	0.04	0.36
Response Speed	0.85	0.23	0.82
Visual Motor Control	0.41	0.93	0.34
Upper Limb Speed & Dexterity	0.31	0.37	0.13
Gross Motor Composite	0.42	0.01	0.79
Fine Motor Composite	0.51	0.46	0.67
Battery Composite	0.37	0.34	0.96

Leg Dominance (p Scores)

	Least Squared Mean	Age Difference Least Squared Mean	Age Difference and Sex Least Squared Mean
Running Speed & Agility	0.27	0.05	0.97
Balance	0.26	< 0.00	0.61
Bi-lateral Coordination	0.21	0.85	0.95
Strength	0.26	0.27	0.95
Upper Limb Coordination	0.14	0.24	0.71
Response Speed	0.21	0.14	0.27
Visual Motor Control	0.09	0.67	0.47
Upper Limb Speed & Dexterity	0.03	0.65	0.18
Gross Motor Composite	0.24	0.17	0.83
Fine Motor Composite	0.12	0.97	0.68
Battery Composite	0.15	0.45	0.97

Language (p Scores)

	Least Squared Mean	Age Difference Least Squared Mean	Age Difference and Sex Least Squared Mean
Running Speed & Agility	0.04	0.05	0.24
Balance	0.36	< 0.00	0.66
Bi-lateral Coordination	0.31	0.30	0.09
Strength	0.03	0.77	0.09
Upper Limb Coordination	0.01	0.68	0.01
Response Speed	0.48	0.37	0.87
Visual Motor Control	0.21	0.27	0.57
Upper Limb Speed & Dexterity	0.36	0.09	0.32
Gross Motor Composite	0.04	0.01	0.13
Fine Motor Composite	0.59	0.57	0.39
Battery Composite	0.09	0.20	0.38

School Clinic (p Scores)

	Least Squared Mean	Age Difference Least Squared Mean	Age Difference and Sex Least Squared Mean
Running Speed & Agility	0.36	< 0.00	0.10
Balance	0.33	< 0.00	0.67
Bi-lateral Coordination	0.05	0.32	0.01
Strength	0.20	0.59	0.08
Upper Limb Coordination	0.28	0.13	0.76
Response Speed	0.09	0.60	0.76
Visual Motor Control	0.28	0.16	0.08
Upper Limb Speed & Dexterity	0.05	0.23	0.58
Gross Motor Composite	0.27	< 0.00	0.27
Fine Motor Composite	0.05	0.77	0.92
Battery Composite	0.16	0.01	0.48

School Grade (p Scores)

	Least Squared Mean	Age Difference Least Squared Mean	Age Difference and Sex Least Squared Mean
Running Speed & Agility	< 0.00	0.78	0.09
Balance	< 0.00	< 0.00	0.51
Bi-lateral Coordination	< 0.00	0.38	0.75
Strength	< 0.00	0.23	0.72
Upper Limb Coordination	< 0.00	0.28	0.23
Response Speed	< 0.00	0.85	0.76
Visual Motor Control	< 0.00	0.42	0.34
Upper Limb Speed & Dexterity	< 0.00	0.13	0.33
Gross Motor Composite	< 0.00	< 0.00	0.89
Fine Motor Composite	< 0.00	0.61	0.66
Battery Composite	< 0.00	0.02	0.56

Child Participating in Extra Mural Sport (p Scores)

	Least Squared Mean	Age Difference Least Squared Mean	Age Difference and Sex Least Squared Mean
Running Speed & Agility	0.21	< 0.00	0.44
Balance	0.02	< 0.00	0.86
Bi-lateral Coordination	0.01	0.52	0.18
Strength	0.03	0.07	0.72
Upper Limb Coordination	0.01	0.04	0.17
Response Speed	0.15	0.22	0.93
Visual Motor Control	< 0.00	0.83	0.04
Upper Limb Speed & Dexterity	< 0.00	0.10	0.33
Gross Motor Composite	0.01	< 0.00	0.39
Fine Motor Composite	< 0.00	0.58	0.11
Battery Composite	< 0.00	< 0.00	0.14

Family Participating in Extra Mural Sport (p Scores)

	Least Squared Mean	Age Difference Least Squared Mean	Age Difference and Sex Least Squared Mean
Running Speed & Agility	0.73	0.06	0.91
Balance	0.82	0.01	0.34
Bi-lateral Coordination	0.47	0.62	0.63
Strength	0.52	0.19	0.72
Upper Limb Coordination	0.22	0.08	< 0.00
Response Speed	0.37	0.03	0.09
Visual Motor Control	0.78	0.58	0.97
Upper Limb Speed & Dexterity	0.93	0.94	0.32
Gross Motor Composite	0.61	0.01	0.99
Fine Motor Composite	0.91	0.68	0.63
Battery Composite	0.94	0.31	0.17

CORRELATION TABLES

R Scores

	Height	Weight	Weight (without Case 11)
Running Speed & Agility	-0.07	-0.27	-0.11
Balance	-0.05	-0.16	-0.28
Bi-lateral Coordination	0.13	0.12	0.22
Strength	0.10	-0.04	0.22
Upper Limb Coordination	0.38	0.29	0.33
Response Speed	0.23	0.18	0.19
Visual Motor Control	0.11	0.16	0.05
Upper Limb Speed & Dexterity	-0.05	-0.06	-0.06
Gross Motor Composite	0.01	-0.18	0.02
Fine Motor Composite	0.09	0.11	0.08
Battery Composite	0.10	0.02	0.08