# The relationship between sprinting speed, explosive jumping and grip strength in school children from the Western Cape.

by

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# SUMMARY

To ensure success for athletes at the highest level, it is of outmost importance to develop them to the best of their abilities. There is a wide range of laboratory and field-based tests to identify talent and help develop these biomotor abilities. The long term athlete development models can help coaches to develop children to the best of their sporting abilities at the correct tempo.

A total of 550 children, 275 boys and 275 girls, took part voluntarily in the study. The study design was an observational study design. The different biomotor abilities of speed, power and strength were investigated with field-based testing equipment in children.

The two primary findings in the current study were the correlation between SLJ and sprinting performance in children and also the correct phase when children should train the various biomotor abilities. The boys had significantly performed better than the girls in speed (p=0.01-0.05), SLJ (p=0.01-0.05) and handgrip strength (p=0.01-0.05).

The results indicated a strong correlation (r=0.61-0.85) between SLJ (measuring power) and sprinting speeds at 2.5 m, 5 m, 10 m and 20 m for boys and girls. Furthermore, the results correspond well with the YPD model that proposes that a child's speed, power and strength can be trained and developed over an extended period throughout childhood. Initially the LTAD model were the front runner the theory that children should systematically be trained throughout childhood, but according to this model there were only specific windows of opportunities at certain ages to train certain biomotor abilities.

According to results found in this study the newer athlete development models, the models after the LTAD model, is more inline and this approach should be used in future to develop children to the best of their abilities to succeed in sport at the highest level. Coaches can use reliable field-based tests like SLJ to develop talent and discover new talent.

**Key Words:** Speed, Standing Long Jump, Handgrip, Long Term Athlete Development, Children.

# OPSOMMING

Om sukses van 'n atleet op die hoogste vlak te verseker, is dit van kardinale belang dat die persoon tot die beste van sy vermoë ontwikkel word. Daar is 'n groot verskeidenheid van laboratorium- en veld-gebaseerde toetse wat gedoen kan word om talent raak te sien en te ontwikkel. Die langtermyn atleet ontwikkelingsmodel help 'n afrigter om 'n kind teen die regte tempo al die verskillende vaardighede aan te leer.

'n Totaal van 550 kinders, 275 seuns en 275 meisies, het vrywilliglik aan hierdie studie deel geneem. Die studieontwerp was 'n waarnemings studie ontwerp. Die verskillende biomotoriese vaardighede van spoed, veerkrag en krag is ge-evalueer in kinders met die behulp van veld gebaseerde toetsinstrumente.

Die twee primêre bevindings in hierdie studie was dat daar 'n korrelasie is tussen staande verspring en naelloop prestasie in kinders en ook is bepaal wanneer sal die regte tyd wees om die verskillende biomotoriese vaardighede vir kinders aan te leer. Die seuns het statisties beduidend beter gevaar as die meisies in spoed (p=0.01-0.05), staande verspring (p=0.01-0.05) en in handgreep krag (p=0.01-0.05).

Die resultate van die studie toon 'n sterk korrelasie (r=0.61-0.85) tussen staande verspring (meet veerkrag) en spoedtye van 2.5 m, 5 m, 10 m en 20 m vir beide seuns en meisies. Verder is hierdie in ooreenstemming met, wat die YPD model voorstel, dat kinders se spoed, krag en sterkte regdeur hulle kinderjare geoefen en ontwikkel kan word. Oorspronklik het die LTAD model begin met die teorie dat kinders stelselmatig die verskillende biomotoriese vaardighede moet aanleer, maar volgens hierdie model was daar slegs spesifieke ouderdomme wanneer sekere vaardighede aangeleer kon word.

Hierdie studie het bevind dat die nutter atleet ontwikkeling modelle, wat na die LTAD model ontwikkel is, meer in lyn is en die benadering wat gevolg moet word in die toekoms om kinders te help om te ontwikkel tot die beste van hulle vermoë om op die hoogste vlak in sport sukses te kan behaal. Afrigters kan gebruik maak van betroubare veld gebaseerde toetse soos die staandeverspring om talent te ontwikkel en nuwe talent te identifiseer.

**Sleutelwoorde:** Spoed, Staandeverspring, Handgreep, Langtermyn Atleet Ontwikkeling, Kinders.

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# LIST OF ABBREVIATIONS

**ABC's:** Agility, balance, coordination and speed

**BF:** Barefoot

**cm:** Centimetre

**CMJ:** Countermovement jump

**DJ:** Drop jumps

**DMSP:** Developmental Model of Sports Participation

**FMS:** Fundamental movement skill

**kg:** Kilogram

**L:** Left

**LTAD:** Long Term Athlete Development

**m:** Meter

**PHV:** Peak height velocity

**R:** Right

**s:** Seconds

**SH:** Shod

**SJ:** Squat jump

**SLJ:** Standing long jump

**SSC:** Stretch-shorten cycle

**VJ:** Vertical jump

**YPD:** Youth Physical Development

# CHAPTER ONE

# INTRODUCTION

## A Introduction

If athletes wish to succeed in a sporting environment it is of the outmost importance that they should develop their biomotor abilities to the best of their abilities. A variety of biomotor abilities are needed to be successful. Different sporting codes require different biomotor abilities or different combinations of biomotor abilities. Biomotor abilities can be divided into the following performance factors: power, strength, speed, agility, coordination, quickness, flexibility and muscle- and cardiovascular endurance (Foran, 2001). For the purpose of the current study, the following three biomotor abilities will be investigated, namely speed, power and strength, to discover how these three biomotor abilities develop and influence each other as a child grows and matures through the years. The athlete development models which are often used as guidelines in children's sport will be explained.

The reason for selecting sprinting performance, SLJ and handgrip strength for the three biomotor abilities to investigate in this research study is the following. The current study was part of the bigger Barefoot LIFE project and these three biomotor abilities where part of their study (Hollander, van der Zwaard, de Villiers, Braumann, Venter & Zech, 2016). Sprinting performance, standing long jump (SLJ) and upper body strength tests have also been part of test batteries used in national surveys for physical fitness in many countries since 1958 (Malina, 2007; Shephard, 2007).

Anaerobic power tests, such as sprinting performance less than three seconds and vertical jumps, should be as short as possible when it is used to test children (Tomkinson & Olds, 2007). According to Tomkinson and Olds (2007) vertical jump (VJ) or SLJ tests are commonly used as field based tests to test leg muscular power. The handgrip tests is widely used in experimental and epidemiological studies, also with children and adolescences (Ruiz, Ortega, Gutierrez, Meusel, Sjöström & Castillo, 2006).

**Speed**

The word speed is a diverse term that can be broken down into the following terms that are associated with the broad spectrum of speed. Firstly, there is first step quickness that is associated with speeds of 5m or less. Secondly, acceleration is normally measured over 10m. Thirdly, the maximal speed the athlete can reach is usually measured over a 20-30m distance with team sport athletes. Lastly, there is game speed that is specific to the sport requirements (Cronin & Hansen, 2005; Vescovi & McGuigan, 2008; Hammami, Makhlouf, Chtara, Padulo & Chaouachi, 2015), for example, a hockey player needs to run as fast as possible, but should still stay in control of the ball with the hockey stick. Research done by Hammami *et al.* (2015) suggests as a child develops and grows these components of speed also improves. A child is only fully developed physically once sexual maturity or even adulthood is reached (Rumpf, Cronin, Pinder, Oliver & Hughes, 2012) and therefor speed can constantly improve.

**Power**

Morin, Bourdin, Edouard, Peyrot, Samozino and Lacour (2012) believe the best indicator for an athlete's sprinting ability is through their jumping power. In the adult athletes population a variety of jumping tests were seen as valid and reliable measurement methods to determine their leg power indirectly (Meylan, Cronin, Oliver, Hughes & McMaster, 2012).

Standing long jump (SLJ) and vertical jump (VJ) are two very well respected field-based tests to measure lower body muscular strength indirectly in young athletes (Milliken, Faigenbaum, Loud & Westcott, 2008; Castro-Piñero, Ortega, Artero, Girela-Rejón, Mora, Sjöström & Ruiz, 2010). However SLJ is seen to be a better predictor of lower body muscular strength than VJ (Milliken *et al.*, 2008).

The research on and results found with children regarding jumping assessment is limited and unknown. In most scientific studies squat jumps (SJ), counter movement jumps (CMJ) and drop jumps (DJ) are used to measure dynamic and explosive strength. The problem with these jumps, however, is it requires coordination and activation of motor units which not all the children have mastered nor learnt the correct techniques for performing these jumps (Kukolj, Ropret, Ugarkovic & Jaric, 1999; Hammami *et al.*, 2015).

For this study, power will be measured in a school setting where time and cost of equipment will play an important role. Therefore SLJ was used because it is more cost efficient, less time consuming when working with large groups and less complex to do with children than the SJ, CMJ and DJ (Castro-Piñero, Ortega, *et al.*, 2010).

**Strength**

For many years there was a stigma associated with the strength training of children, so much so that they were not allowed to take part in strength training (Faigenbaum, 2001). There is however scientific evidence that shows regular strength training do have health, fitness and sport performance benefits for children (Lloyd, Faigenbaum, Stone, Oliver, Jeffreys, Moody, Brewer, Pierce, McCambridge, Howard, Herrington, Hainline, Micheli, Jaques, Kraemer, McBride, Best, Chu, Alvar & Myer, 2014). The health, fitness and sport performance benefits of strength training has be found to be the following, it improves muscular strength, power production, running velocity, change of direction speed, motor performance skills, decreases body composition, enhances bone-mineral with the result that fewer sport related injuries occur (Faigenbaum, 2001; Faigenbaum, Kraemer, Blimkie, Jeffreys, Micheli & Rowland, 2009; Lloyd, Faigenbaum, *et al.*, 2014).

According to Faigenbaum *et al.* (2009) it is possible to determine the maximal strength of a child with a one rep max test, but it is a very time consuming and labour intensive process. In studies done by Milliken *et al.* (2008) and Castro-Pinero *et al.* (2010) it was discovered that there is a strong correlation between upper body muscular strength and a child's handgrip strength. Thus the handgrip test can be seen as a valid, reliable and easy to use field-based test to measure the upper body strength of children.

**Athlete Development Models**

The main purpose of the various models from different countries is backed up by two main aims. Firstly, to get as many children as possible involved with sport, but also to ensure that these children will stay active for life and involved in sport. The second aim is to identify talent and develop these children into elite athletes or to help each child to develop to the best of their own abilities, but also prevent early specialization in one particular sport and make sure the enjoyment factor is always present ("Planning for Long Term Success", 2005, "Long-Term participant development programme: From grassroots to Proteas", 2011).

All the success of the athlete development models is built around the following three factors: Firstly, it takes into account the child's developmental age instead of the chronological age (Lloyd, Oliver, Faigenbaum, Myer & De Ste Croix, 2014). Secondly, the models are not built on short term success, but rather on long term success and lifelong involvement with sport. Lastly, it prescribes the correct load ratio between training, competition and recovering for the children during developmental age groups ("Long-Term participant development programme: From grassroots to Proteas", 2011).

There are various athlete development models. The LTAD model was one of the first athlete development models and the other models were built from the LTAD model. The Youth Physical Development (YPD) model has the same principles as the LTAD model, but approaches the process in a different way. The distinct difference between the two models is that the YPD model does not have specific windows of opportunity for a specific skill to be trained at a certain age. The YPD model rather believes all skills are trainable at all ages, but at certain ages the focus might shift more towards a specific set of skills (Lloyd & Oliver, 2012). The newest athlete development model is the FTEM framework and also has a different approach. Their approach has four macro cycle that is further divided into 10 smaller cycles and athlete can slide up and down through these cycle at any given time and age (Gulbin, Croser, Morley & Weissensteiner, 2013)

## B Aim of the Study

The primary aim of this study was to determine the relationship between SLJ, sprinting speed at 2.5 meter (m), 5m, 10m and 20m and handgrip strength in children aged 6 to 17 years from the Western Cape. The secondary aim of the study was to compare performance on biomotor abilities (speed, power and strength) with the windows of opportunity as suggested by LTAD models.

## C Research Objectives of the Study

The following objectives were set out to guide the research:

1) To determine differences in standing long jump (SLJ) performance in children between ages 6-17.
2) To determine the difference between boys and girls in SLJ performance.
3) To determine the influence of footwear (shod and barefoot) on SLJ performance.
4) To determine differences in sprinting speed performance (2.5m, 5m, 10m and 20m) in children between ages 6-17.

5) To determine the difference between boys and girls in sprinting speed performance.

6) To determine the influence of footwear (shod and barefoot) on sprinting performance.

7) To determine the relationship between SLJ performance and sprinting speed.

8) To determine the relationship of handgrip strength on SLJ performance.

9) To determine the relationship of handgrip strength on sprinting speed performance.

10) To compare performance on biomotor abilities (speed, power and strength) with the windows of opportunity as suggested by LTAD (Balyi, 2001; Rumpf *et al.*, 2012).

## D Scope of the Study

A total of 550 children, 275 boys and 275 girls, between the ages of 6 and 17 took part in the study. The study design was an observational study design. The different biomotor abilities of speed, power and strength were investigated in children with field-based testing equipment.

The field-based testing took place at various schools in the Western Cape. Testing was conducted during the physical education period at school. The Ethics Committee of Stellenbosch University (Reference number HS1153/2014; Appendix 1) and the Western Cape Government Department of Education (Reference number 20160128-

7123; Appendix 2 and Appendix 3) provided permission for the research to be conducted in the various schools.

The following testing measurements were taken, height, body weight, SLJ distance, 2.5m, 5m, 10m and 20m sprinting speeds and the handgrip strength. The height was measured in centimetres (cm) with a stadiometer (Charder, HM 200P Portstad, Germany). A calibrated electronic scale (Masscot UC-321, A&D personal precision scale, Tokyo, Japan) was used to measure the body weight in kilogram (kg). SLJ was measured with a metal measuring tape to the nearest 0.5cm (Hoffman, 2006). The sprinting speeds were measured automatically with the help of the Brower Timing System (Salt Lake City, UT, USA) with the accuracy of 0.01 seconds (s) (Hammami *et al.*, 2015). A handgrip dynamometer was used to measure the handgrip strength of the children.

## E Outline of the Thesis

Chapter Two consists of the theoretical context for this study and reviews literature, and related studies on speed, power and strength in the sport performance of children. Furthermore it provides insight into the athlete development models on how children develop their biomotor abilities as they grow and mature. In Chapter Three the specific methods for data collection are discussed. The results are presented in Chapter Four. Chapter Five contains a discussion of the main findings, as well as a conclusion to this study, limitations of the study, and recommendations for future research.

# CHAPTER TWO

# THEORETICAL CONTEXT

## A Introduction

To be successful in sport it is important that athletes should develop in their skills to the best of their ability. If athletes wish to develop their specific sporting code, they should develop their biomotor abilities. The different athlete development models have different strategies on when and where the different biomotor abilities are more assessable to training. Field base testing usually contains speed and jumping assessments as speed and explosiveness are important elements in becoming a successful athlete at the top level (Vescovi & McGuigan, 2008).

The aim of the chapter is to describe biomotor abilities applicable to the objectives of the current study and to define and discuss speed, power and strength. Lastly, it will examine the athlete development models and determine if all these factors have certain windows of opportunities to improve sport performance as suggested by the LTAD model.

## B Biomotor Abilities for Team Sport Athletes

The biomotor ability that is required by a team sport player depends on the specific sport code or even the position in which the player plays in that specific sport code. For example, the biomotor abilities for a cricket player will differ from that of a rugby player. The biomotor abilities required by the prop and the wing in the rugby team will also differ from one another due to the different positions that require different biomotor abilities (Bompa & Haff, 2009).

These biomotor abilities can be taken from the following performance factors that are associated with sport: power, strength, speed, agility, coordination, quickness, flexibility, muscle- and cardiovascular endurance (Foran, 2001). Bompa & Haff (2009) divided these performance factors into five biomotor abilities: strength, endurance, speed, coordination and flexibility. Bompa & Haff (2009) highlights strength, endurance and speed as the three major biomotor abilities. For a team sport player to succeed, these three major biomotor abilities should be used in conjunction with each other.

These three major biomotor abilities indirectly affect each other (Bompa & Haff, 2009), and the effects on each other can be positive or negative depending on the training objective of the biomotor ability. For example, if strength was the objective to be increased through the training programme, speed will benefit positively from this. However, if endurance is the main objective for the training programme then speed and strength could be affected negatively (Bompa & Haff, 2009).

According to Hammami *et al.,* (2015) strength and power are the most important factors for evaluating physical fitness. Consequently speed is affected by an athlete's strength and power (Rumpf *et al.*, 2012). Although a variety of tests exist to measure speed, power and strength, this section will focus on tests that are relatively easy to use by a coach or fitness trainer and will also be cost effective. These tests also relate to the context of the current study where data were collected in a school setting.

## Sprinting Speed Performance

To succeed in sport and to be an elite sport athlete there are a variety of skills that an athlete has to acquire (Cronin & Hansen, 2005; Hammami *et al.*, 2015). One of the important skills is speed. This is because most sports are played on a sporting field (Hammami *et al.*, 2015). These sports require the athletes to run and sprint on the field to be successful in the sport. Hammami *et al*. (2015:1) defines speed for team sport athletes as “the ability to move rapidly, within over ground sports”.

Speed can be divided into various forms namely, first step quickness (5m or less), acceleration (10m), maximal speed (20-30m) and game speed (sport specific) (Cronin & Hansen, 2005; Vescovi & McGuigan, 2008; Hammami *et al.*, 2015). First step quickness is used in a sport like netball where often only one or two quick steps are required for the athlete to move into position. Acceleration is used in a sport like rugby where the athlete quickly needs to accelerate into or through a gap in the opponents’ defence. Maximal speed is performed in a sport like athletics during the 100m sprint. Game speed is used in a sport such as hockey for example, where the athlete needs to run as fast as possible, but still keep control of the ball with their hockey stick (Cronin & Hansen, 2005; Vescovi & McGuigan, 2008).

The main difference between maximal speed and game speed: is that one is from a standing start (max speed) and the other one from a running start (game speed) (Vescovi & McGuigan, 2008). Due to the nature of track sprinting events, athletes start from a standing start, in starting blocks. In contrast, field-based sporting codes have athletes using a running start. For due to the nature of the sport the athletes are already in a moving motion when they start sprinting. The difference between a standing start and a running start seems to cause a difference in the running mechanics of a field based athlete compared to a track sprinter (Sayers, 2000) and causes a difference in acceleration in maximal speed for a track sprinter compared to a field based athlete (Vescovi & McGuigan, 2008). Therefore, it is necessary to investigate the performance and relationships between linear running, agility and jumping performances of field based athletes (Vescovi & McGuigan, 2008; Hammami *et al.*, 2015). Field based athletes, especially ball sport athletes, reach their maximal speed between 15-30m and track athlete sprinters reach their maximal speed between 30-50m (Kukolj *et al.*, 1999).

Hammami *et al*. (2015) suggested that as children develop and grow, their first step quickness, acceleration, maximal speed and game speed improve. This is due to the fact that as children develop, grow and mature, their postural control, static and dynamic balance improve and also their running pattern (Rumpf *et al.*, 2012; Vando, Filingeri, Maurino, Chaabène, Bianco, Salernitano, Foti & Padulo, 2013; Vando, Unim, Cassarino, Padulo & Masala, 2013; Haywood & Getchell, 2014). A better developed postural control and improvement in balance lead to better neuromuscular qualities and locomotion tasks. Hammami *et al.* (2015) is of the opinion that it is important to know what effect transferring neuromuscular abilities into locomotion tasks like sprinting, will have.

According to Vescovi and Mcguigan (2008) biological age and training experience may influence the athlete's locomotor skill of running. Due to the fact that neuromuscular qualities affect locomotion tasks (Hammami *et al.*, 2015) it is important to evaluate the effect of strength and power on an athlete's speed. According to Lloyd and Oliver (2012) prepubescents will respond better with neural activation exercises (plyometrics, technical competency and sprint work), whereas adolescents benefit more from a combination of neural and structural development exercises (strength training, plyometrics and sprint work) to increase their sprinting speed. The reason why prepubescent's respond better to neural activation exercises and adolescents to a combination of neural and structural development, is because between the ages of two to five the myelination of the nervous system is rapidly changing, but is only fully developed by the time the children reach sexual maturity or even adulthood (Rumpf *et al.*, 2012). Therefore van Praag (1998) suggested that training activities such as coordination, speed of movement and stride frequency would be beneficial to the neuromuscular system during a child's prepubescent's. Furthermore, Rumpf *et al.* (2012) found that when adolescents reach their peak height velocity (PHV) during the adolescent years (age 12-17) their strength improves and therefore, indirectly, their power output and subsequently their speed. This is why they should do neural and structural development exercises in combination with each other.

Explosive strength directly influences an athlete's acceleration and maximal speed (Meylan *et al.*, 2012; Hammami *et al.*, 2015). Running consists of horizontal and vertical strength and power components. The horizontal force is responsible for propelling the athlete forward (Hammami *et al.*, 2015). Although the horizontal force propels the athlete forward, vertical forces are necessary for helping the running motion to keep going forward (Hammami *et al.*, 2015). The running motions in the lower limbs of the athlete make use of a common athletic movement (Meylan *et al.*, 2012), the short stretching cycle (SSC), to generate the power and force needed for running. The SSC is a combination of an eccentric followed by a concentric muscle contraction over two or more joints (Meylan *et al.*, 2012). During the running movement the SSC runs through the hip, knee and ankle joints.

**Power**

An athlete's sporting success can be affected by the athlete's ability to generate power (Pandy & Zajac, 1991). Most field-based test batteries include speed and some form of jumping ability as part of assessments of performance in team sports athletes. Standing long jump (SLJ) and vertical jump (VJ) are two respectable field-based tests used to test lower body muscular power indirectly in youth athletes (Milliken *et al.*, 2008; Castro-Piñero, Ortega, *et al.*, 2010).

Morin *et al.* (2012) suggests that the best indicator for an athlete's sprinting ability is through the athlete's jumping power. Lower limb power capability is measured with a jumping test and proved a valid assessment of muscular power (Kale, Asci, Bayrak & Acikada, 2009; Lloyd, Oliver, *et al.*, 2014). Indirect leg power can be measured through a variety of jump tests and has been found to be valid and reliable in the adult population (Meylan *et al.*, 2012). Mackata *et al.* (2015) conducted a study on the relationship between 100m sprint time and an elite athletes' jumping ability. In the study Mackata *et al.* (2015) broke speed down into 10m, 30m and 100m sprints and compared the athlete's time for each distance with the standing long jump test, the five consecutive standing jump test and the ten consecutive standing jump test. The study consisted of eleven elite sprinters and eleven student sprinters (age 21.7 ± 1.08 years). Mackata *et al.* found strong correlations between 10m (r=-0.74), 30m (r=-0.62) and 100m (r=-0.82) sprinting speed and the athlete's standing long jump scores. Hammami *et al.* (2015) conducted a study on the relationship between 5m, 10m, 20m and 30m sprinting time performance and the athlete's SLJ distance. Hammami *et al.* (2015) have found a moderate correlation between 10m (r=0.4) and 30m (r=0.48). With the 20m running start, Hammami *et al.* (2015) found large correlation (r=0.52).

Cronin and Hansen (2005) argue that jumps can be divided into a slow stretch-shorten cycle and a fast stretch-shorten cycle. As mentioned previously the SSC compliments athletic movement during running. Therefore jumping may have the following effects on an athlete's sprinting performance: the slow SSC is more important during the initial stage of sprinting while the fast SSC is used during maximal speed (Cronin & Hansen, 2005). The slow SSC is measured with a counter movement jump (CMJ) and is >250 milliseconds and the fast SSC is measured with drop jumps and is <250 milliseconds (Cronin & Hansen, 2005).

The height of the CMJ correlates better with an athlete's maximal speed (r=0.48) than during the acceleration phase (r=0.09) (Kukolj *et al.*, 1999). Vescovi and McGuigan (2008) provide evidence that the height of the CMJ is inversely related to the sprinting time of an athlete. The longer the sprinting distances the stronger the correlation becomes (Vescovi & McGuigan, 2008). However the CMJ has a weak to moderate effect on 1m, 2m, 3m and 6m sprinting times (Vescovi & McGuigan, 2008), which means this occurs during first step quickness. Furthermore Vescovi and McGuigan (2008) argued that CMJ performance results could explain the variance in speed times better in college athletes (ages 18-20) (43-60%) than (24-33%) in high school athletes (ages 14-16) (Vescovi & McGuigan, 2008).

Previous research has found relationships of speed between first step quickness, acceleration and maximal speed (Kale *et al.*, 2009). Osinski (1988) suggests that there is a correlation between SLJ and an athlete's maximal speed in the 100m sprint. Other research studies also show relationships between SLJ and 30m to 100m sprint speed of athletes (Kale *et al.*, 2009). Mackala, Fostiak and Kowalski (2015) found that there is a strong correlation between a sprinting athlete's maximal strength, horizontal jumping ability - especially SLJ - and acceleration speed. The correlation between 10m and SLJ was r=0.77 and for 30m and SLJ was r=0.70 (Maćkała, Fostiak & Kowalski, 2015).

Castro-Pinero *et al.* (2010) provide evidence that between SLJ, VJ and CMJ the best correlation was SLJ (r=0.83-0.84) with the lower body muscular tests and (r=0.69-0.85) for the upper body strength tests. Milliken *et al*. (2008) are of the opinion that SLJ predicts lower body muscular strength better than VJ. The data of SLJ and speed times can be used to assess: firstly, the explosive strength and locomotor profile of the athlete and, secondly, it can monitor the neuromuscular recovery and training effectiveness of the athlete (Al Haddad, Simpson & Buchheit, 2015).

Most research has been done with adult population and limited research on children. According to Haywood and Getchell (2014) children have learned the correct jumping patterns at the age of six. Children use a step by step process to eventually master the full variety of jumps at the age of six. Haywood and Getchell (2014) discuss the step by step process in detail. Firstly, the child will step down form a higher object with one foot and then the other foot. Secondly, they will start to jump off the floor with both feet. Thirdly, they progress to where they learn to gradually jump off higher objects landing on both feet. Lastly, they progress to the stage where they start to jump forward, jump over objects and hop on one leg. Furthermore Clark, Phillips and Petersen (1989) indicated that the jumping pattern of leg coordination used by adults and children (ages 3, 5, 7 and 9 years) are the same.

Al Haddad, Simpson and Buchheit (2015) found that there is a strong correlation between 20m sprinting speed and SLJ for both boys and girls (age ten to eleven years old). The boys performed much better than the girls in the 20m sprinting speed, SLJ and VJ.  The boys' 20m speeds and SLJ were respectively 3.7±0.35s and

162.61±24.64m compared to the girls' speeds respectively 3.96±0.33s and 154.51±20.78m (Al Haddad *et al.*, 2015). The correlation for the boys between 20m speed and SLJ was (r=-0.61) and for VJ (r=-0.62) compared to the girls' correlation for 20m speed and SLJ was (r=-0.64) and for VJ (r=-0.46) (Al Haddad *et al.*, 2015). Another study also found that boys aged ten to eleven years old significantly better scored on 20m sprint speed and SLJ distance than girls (Jones & Lorenzo, 2013). Haywood and Getchell (2014) found that children, during the elementary school years (age 7 until 13) increase their SLJ distance by between eight and thirteen centimetres per year and their VJ height with five centimetres.

SLJ and VJ use an arm swing in performing the jumps and the arm movement leads to improvement in the jumping performance (Castro-Piñero, Ortega, *et al.*, 2010). The arm swing provides the athlete with better balance and control of the movement (Ashby & Heegaard, 2002). According to Ashby and Heegaard (2002) the arm action caused a 21.2% or more than 36cm improvement in the jumping distance of the athletes. Haywood and Getchell (2014) explain the different positions and movement speed of SLJ and VJ in the next example. When athletes perform the SLJ, their hips are more flexed than when they perform the VJ movement from the initial crouch to take off. Furthermore during SLJ the athletes' hips extend faster, but during performing the VJ the athletes' knees and ankles extend faster.

SJ, CMJ and drop jumps (DJ) are most commonly used in scientific studies. The SJ measures the dynamic and explosive strength and requires concentric activation, the CMJ measures with SSC the reactive strength and requires an eccentric activation and, lastly, DJ uses SSC to elicit high power output in a short time (Kukolj *et al.*, 1999; Meylan *et al.*, 2012). All three jumps require coordination and activation of the motor units and therefor make it difficult to be performed by children that have not yet learned the correct technique (Kukolj *et al.*, 1999; Hammami *et al.*, 2015).

In a school environment, when fitness tests are done to assess players' performance, CMJ and squat jumps (SJ) may not be as feasible as SLJ and VJ (Castro-Piñero, Ortega, *et al.*, 2010). The first reason being that equipment needs to be low in cost and as few and simple as possible (Castro-Piñero, Ortega, *et al.*, 2010). The second reason being that it needs to be easy to test a large group of people at the same time because time is limited in a school environment (Castro-Piñero, Ortega, *et al.*, 2010).

According to Castro-Pinero *et al.* (2010), SLJ has three factors that make it very technical: anthropometry, mechanics and coordinative factors. The height and weight are the biggest concern (Meylan *et al.*, 2012; Hammami *et al.*, 2015). Although SLJ has a technical component that needs to be learned to perform the jump, it is still a very natural jump to perform and is used in a variety of sports, plus it is feasible to perform it in a school setting (Hammami *et al.*, 2015). Reliability studies show a r=0.83-0.99 correlation coefficient for SLJ (Hammami *et al.*, 2015).

**Strength**

To perform optimally during sprinting the degree of muscle mass and the neural control mechanisms of the muscles play an important role. These components are built on the maximal strength of an athlete (Sander, Keiner, Wirth & Schmidtbleicher, 2013). Strength training is associated with resistance and plyometric training. In the general population there is the assumption that children cannot take part in strength training (Faigenbaum, 2001). This assumption was created by a report from a research study that was conducted in 1964 by Kato and Ishiko on Japanese children that did seven hours of hard labour each day and shorted stunted growth. The problem with this study, however was that the researchers did not take into account the etiological factors of the children, for example poor nutrition (Faigenbaum, 2001).

The assumptions or main concerns as to why children should not take part in strength training are as follows. Firstly, strength training has the stigma that it is a high risk exercise that causes injuries in children. Secondly, the safety and suitability aspects for children to take part in a strength training programme are important. Lastly, strength training may be harmful to the growth cartilages of children during development years (Faigenbaum, 2001; Faigenbaum *et al.*, 2009; Lloyd, Faigenbaum, *et al.*, 2014). There is scientific evidence that if children participate in regular strength training they will receive health, fitness and sport performance benefits (Lloyd et al. 2014). A study conducted by Sander *et al.* (2013) on elite youth soccer players (ages thirteen to seventeen years old) have found that strength training improved the players maximal strength and sprinting ability.

Strength training does have a risk of muscle injuries, but the risk is not greater than other sports or recreational activities that children take part in on a daily basis (Faigenbaum *et al.*, 2009). It is important that the correct techniques for the strength exercises are taught to children and that the trainer ensures that the child's posture and body alignment is correct during the exercise (Lloyd, Faigenbaum, *et al.*, 2014). Of the acute injuries that do occur with strength training, 77.2% of these injuries are avoidable (Myer, Quatman, Khoury, Wall & Hewett, 2009). These acute injuries are normally caused by the use of incorrect training techniques, lifting of too heavy loads, inadequate equipment and no supervision by a qualified trainer (Faigenbaum *et al.*, 2009; Lloyd, Faigenbaum, *et al.*, 2014). Various research studies point out that strength, plyometric or short-stretch cycle, training can be a safe and valuable method of training for children if it is arranged and implemented correctly (Faigenbaum *et al.*, 2009). It is safe to start strength training with children as young as the age of six years old (Faigenbaum, Westcott, Loud & Long, 1999; Annesi, Westcott, Faigenbaum & Unruh, 2005; Kaufman & Schiling, 2007). Children naturally train with plyometric a movement on the playground with a variety of hops and jumps when they are playing recreational games with each other during break time (Faigenbaum *et al.*, 2009). Although this is not a formal way of training it increases a child's speed and power (Chu, Faigenbaum & Falkel, 2006). During a child's developing stage before puberty there is no increase in the child's muscle mass due to strength training, however, there is an improvement in the child's strength. Two reasons for why, due to neural and intrinsic muscle adaptations. The neural adaptations increase the motor unit activation, coordination, recruitment and firing, whereas, the intrinsic adaptation increases the twitch torque in the muscle (Faigenbaum *et al.*, 2009). A strength training programme has the following benefits for children: it improves muscular strength, power production, running velocity, change of direction speed, motor performance skills, decreases body composition, enhances bone-mineral and fewer sport related injuries occurred (Faigenbaum, 2001; Faigenbaum *et al.*, 2009; Lloyd, Faigenbaum, *et al.*, 2014).

Strength training in children indicates muscular strength gains of 30-50% in children with a training programme of 8-20 weeks (Faigenbaum, 2001; Lloyd, Faigenbaum, *et al.*, 2014). The relative strength gains during childhood before and after puberty (preadolescents vs adolescents) are similar (Faigenbaum, 2001; Faigenbaum *et al.*, 2009; Lloyd, Faigenbaum, *et al.*, 2014). Before puberty the strength for boys and girls do not differ (Faigenbaum *et al.*, 2009). The absolute values indicate that adolescents are stronger than pre-adolescents and adults are stronger than adolescents (Faigenbaum *et al.*, 2009). However it is important to manage the intensity, volume and frequency of strength training, especially in children, to prevent injuries (Faigenbaum *et al.*, 2009). The trainer need to remember that the biological age among children may differ, although they are the same chronological age. Children need to be trained according to their biological age (Lloyd, Faigenbaum, *et al.*, 2014).

Another concern with strength training in children was the damage that strength training may cause to their growth cartilages (Faigenbaum, 2001; Faigenbaum *et al.*, 2009; Lloyd, Faigenbaum, *et al.*, 2014). The perception is that because growth cartilage is “pre-bone” it is more fragile in the case of strength exercises that might cause repetitive microtrauma on the cartilage (Micheli, 1998). With this in mind no research study has yet reported any cartilage damage due to strength training and there is no scientific research that indicates that strength training influences linear growth of children or reduce their eventual height in adulthood (Falk & Eliakim, 2003; Malina, 2006; Lloyd, Faigenbaum, *et al.*, 2014).

Maximal strength can be determined with a one rep max test in children, but it is very time consuming and labour intensive (Faigenbaum *et al.*, 2009). Therefore researchers should rather use field-based testing like handgrip strength and long jump (Milliken *et al.*, 2008). The handgrip strength test screens for upper body motor neuron and functioning of the motor units of a person (Newman, Pearn, Barnes, Young, Kehoe & Newman, 1984). The handgrip test is an easy to use field-based test to measure the upper body strength of a person (Milliken *et al.*, 2008). Milliken *et al.* (2010) found a significant correlation between upper body muscular strength and the handgrip test, and the study was conducted with 91 children (39 girls and 52 boys between the ages of 6 and 12). A study done by Castro-Pinero *et al.* (2010) was done on 94 children (45 girls and 49 boys between the ages of 8 and 14) and showed a strong correlation between SLJ lower body strength (r=0.83-0.86) and for upper body strength (r=0.69-0.85). Furthermore handgrip strength is seen as an important general health indicator for any person and it is the most reliable clinical measurement of human strength (Newman *et al.*, 1984).

Newman *et al.* (1984) and Innes (1999) pointed out that age affects handgrip in three ways. Firstly the handgrip strength of boys will increase linearly throughout all ages. Secondly the handgrip strength of girls will only increase until the age of 13 and thereafter the handgrip strength will plateau. Lastly at the age of 20 the handgrip strength of men will be twice that of women. Newman *et al.* (1984) also argue that height and weight do not influence the handgrip strength of a child at all.

## C Athlete development models

Most countries are willing to invest time and effort to develop elite athletes to represent their countries at international level, which has led to the development of “sports pathways”, Gulbin *et al.* (2013:1319), as guidelines for taking young athletes on the road to success. A number of athlete development models have been proposed. **Table 2.1** gives a summary of some models which was developed since 2000.

**Table 2.1**: A summary of athlete development models since 2000.

| Athlete Development Model | Main Phases or Stages |
|---|---|
| Long Term Athlete Development (LTAD) (Balyi & Hamilton, 2004) | Six stages.<br>1) The Fundamental Stage<br>2) The Learning to Train Stage<br>3) The Training to Train Stage<br>4) The Training to Compete Stage<br>5) The Training to Win Stage<br>6) The Retirement / Retention Stage |
| Differentiated Model of Giftedness and Talent (DMGT) (Gagne, 2004) | Three components to transform gifts into talents:<br>1) Activities<br>2) Investment<br>3) Progress |
| Life-span Model of Acquisition & Retention of Perceptual-Motor Expertise (Starkes, Cullen & MacMahon, 2004) | Four phases:<br>1) Acquisition<br>2) Condensation<br>3) Routine expertise<br>4) Transcendent expertise |
| Developmental Model of Sports Participation (DMSP) (Cête & Fraser-Thomas, 2007) | Three routes for development:<br>1) Sport sampling (6-12 years): leads to<br>• Recreational sport participation.<br>2) Sports sampling (6-12 years and Sports specialisation (13-15): leads to<br>• Elite performance<br>3) Early specialisation (6+ years): leads to<br>• Elite performance with and Investment phase and a Perfection phase. |
| Athletic Talent Development Environment Model (Henriksen, Stambulova & Roessler, 2010) | No clear phases.<br>Focuses on the environment needed for development of elite athletes. |
| Youth Physical Development (YPD) Model (Lloyd & Oliver, 2012) | Has four age periods:<br>1) Early Childhood<br>2) Middle Childhood<br>3) Adolescence<br>4) Adulthood<br>In each age period the all physical qualities are trained, but at different intensities. |

| | |
|---|---|
| FTEM Framework (Gulbin *et al.*, 2013) | Four macro stages of skill and performance development; differentiated into 10 micrp phases.<br>1) Foundations (F)<br>• Learning and acquisition of basic movement<br>• Extension and refinement<br>• Sports specific commitment and/or completion<br>2) Talent (T)<br>• Demonstrate high performance potential<br>• Talent verification<br>• Practising and achieving<br>• Breakthrough and reward<br>3) Elite (E)<br>• Senior elite representation<br>• Senior elite success<br>4) Mastery (M)<br>• Sustained elite success or mastery |

### Long Term Athlete Development (LTAD)

As shown in **Table 2.1**, a number of models have been proposed as guide for the development of athletes from junior to senior level. The LTAD by Balyi has been a popular model and adopted by a number of countries and sports codes (Arellano, 2010). National governing bodies of sport in England, for example, are required to have a sport-specific LTAD plan in order to receive state funding (Lang & Light, 2010). Because of the popularity of the LTAD, it will be discussed in more detail.

In modern day society with the prevalence of professional sport and the live coverage of sporting events there is a commonly held belief that anyone who is good, can be the world's next superstar at the of age 18. Balyi (2001:1) call this the "peaking by Friday approach".

Sport is categorised into early specialization (gymnastics, figure skating, diving and table tennis) and late specialization (athletics, cycling, racquet sport, rowing and team sports) sports (Balyi, 2001). When young athletes show potential and excel early in childhood, it is of utmost importance to manage and develop them correctly to prevent burn out or drop out in that specific sport (Balyi, 2001).

Ericsson, Krampe and Tesch-Romer (1993) made the concept of deliberate practise popular, stating that young talented athletes need about eight to twelve years of training to become an elite athlete. Previously, this notion was held by other researchers (Bloom, 1985; Ericsson, Krampe, Tesch-Romer, Ashworth, Carey, Grassia, Hastie, Heizmann, Kellogg, Levin, Lewis, Oliver, Poison, Rehder, Schlesinger, Schneider & Tesch-Römer, 1993; Ericsson & Charness, 1994; Balyi, 2001). Ericsson's deliberate practise led to the 10 000 hours of training rule to be successful. The idea was based on case studies with musicians, and has received criticism and been disproved (Gulbin *et al.*, 2013).

During this time frame it is important to ensure that athletes receive the necessary training guidelines with a well-structured training programme. To maximize optimal development within a well-structured training programme emphasised the importance of competition and recovery schedules for athletes. Based on research done by Balyi (2001) and other researchers, the long term athlete development (LTAD) model was developed by various countries in an attempt to ensure optimal development of their athletes.

The LTAD model is a well-structured developing programme and the most important factor is that it focuses on athletes with different abilities and not only on the athletes that excel in sport. The main purpose of the LTAD training model is to involve as many children as possible in sport. It also allows trying to prevent children from specializing too early in one specific sport ("Planning for Long Term Success", 2005, "Long-Term participant development programme: From grassroots to Proteas", 2011). The LTAD model has become important because in modern day society children are less active due to a variety of reasons and early specialization causes a lot of sport-related injuries (Ridgers & Stratton, 2005; Faigenbaum *et al.*, 2009; Jones & Lorenzo, 2013). The LTAD model can help prevent shortcomings such as physical, technical, tactical and mental abilities that are normally associated with athletes that are pushed to the next level too early (Balyi, 2001).

The LTAD model has several aims in mind: 1) To get more children active and involved in a variety of sports to prevent early specialization, but also, 2) to try to ensure that the children will stay active for life ("Planning for Long Term Success", 2005, "Long-Term participant development programme: From grassroots to Proteas", 2011). 3) The other side of the LTAD model is to identify talent and develop elite athletes or each child according to their own potential and make sure that the enjoyment factor stays present ("Planning for Long Term Success", 2005, "Long-Term participant development programme: From grassroots to Proteas", 2011).

As already mentioned, some sports require early specialization, but the majority of sports require late specialization. Late specialization only starts after the age of ten years old (Balyi, 2001). The reason being if it is before the age of ten it can most likely  lead to burn out, drop out or retirement from training and competition at a very young age (Balyi, 2001). There are also other reasons why it is important not to encourage early specialization in sport. Children undergo physical, mental and emotional changes from childhood until adulthood, but at different a rate and times

(“Planning for Long Term Success”, 2005). Girls tend to mature at a faster rate than boys and for this reason the LTAD model have guidelines for boys and girls.

The success of the LTAD model is built upon the following three factors. Firstly, it takes into account the developmental age, and not chronological age, based on early, average and late maturity of the child (“Long-Term participant development programme: From grassroots to Proteas”, 2011). Biological age is the process involved as the child develops and matures, but timing and tempo differ for each child (Lloyd, Oliver, *et al.*, 2014). The chronological age is measured at a specific moment in time from the date of birth (Lloyd, Oliver, *et al.*, 2014). Secondly, the focus of the LTAD model is not based on short term success but on long term success and lifelong involvement in sport (“Long-Term participant development programme: From grassroots to Proteas”, 2011). Lastly, the LTAD model works out the correct ratio and combination between training, competition and recovery during the various development age groups (“Long-Term participant development programme: From grassroots to Proteas”, 2011).

The LTAD model consists of seven stages (Balyi, 2001; “Planning for Long Term Success”, 2005, “Long-Term participant development programme: From grassroots to Proteas”, 2011; Norris, 2010). 1) Active start, 2) **fundamentals**, 3) learn to train, 4) **train to train**, 5) train to compete, 6) train to win and 7) active for life. Stages two and four contain the key windows of opportunity to develop speed during childhood (as mentioned early when the speed section was discussed). The chronological ages for boys during stage two (fundamentals) is age seven to nine, and age thirteen to sixteen during stage four (train to train) (Balyi, 2001; “Planning for Long Term Success”, 2005, “Long-Term participant development programme: From grassroots to Proteas”, 2011; Norris, 2010). The chronological age for the girls during stage two (fundamentals), is age six to eight, and during stage four (train to train) age eleven to thirteen (Balyi, 2001; "Planning for Long Term Success", 2005, "Long-Term participant development programme: From grassroots to Proteas", 2011; Norris, 2010).

Stage two, the **fundamental stage**, ensures that the fundamentals of the ABC's (agility, balance, coordination and speed) are taught to the children (Balyi, 2001; "Planning for Long Term Success", 2005, "Long-Term participant development programme: From grassroots to Proteas", 2011; Norris, 2010). The ABC's are the foundation from where sporting excellence is built for later stages in life (Balyi, 2001). The motor development of a child is also developing during this stage and has a limited window of opportunity. Motor development is a key factor for long-term sport specific development (Balyi, 2001). The important and key aspect to remember during this stage is that children need to experience fun while they are learning the different skills.

During stage four, the **train to train stage**, the main aims are training stamina, speed, strength and maintaining the ABC's. The children will reach the end of their peak growth velocity, that means their coordination and motor skills can now be developed to the full potential without fluctuating again due to the body that keeps on growing ("Long-Term participant development programme: From grassroots to Proteas", 2011). The child's strength and motor control will improve due to a stronger muscular and bone structure (neuromuscular adaptations) and their aerobic endurance will improve due to more red blood cells (particularly boys due to more testosterone) ("Long-Term participant development programme: From grassroots to Proteas", 2011). Lastly at the end of stage four the central nervous system will be fully developed and this will enable the athlete to fully train the ABC's ("Long-Term participant development programme: From grassroots to Proteas", 2011).

The LTAD plan has received some criticism over the years. It is seen as model that emphasises physiology and conditioning and not technical and tactical skill components, that it is chronologically descriptive, and that it was originally developed for alpine skiing before being proposed as a general model for all sports (Arellano, 2010; Lang & Light, 2010; Gulbin *et al.*, 2013). The fundamental principle of the LTAD states that children should participate in a range of sports and physical activity, but the high volumes of training implemented in a sport like swimming triggered criticism from swimming coaches (Lang & Light, 2010). Holt (2010) argues that the LTAD model was not based on empirical evidence with a lack of published papers in scientific peer-reviewed journals. He also adds that the standard LTAD plan was based on general principles from physiology and physical training.

It is emphasised that the efficacy and effectiveness of the LTAD should be determined. Research is needed to evaluate the LTAD, also against other available athlete development models. The LTAD was proposed in 2004 and received a lot of criticism as shown above. Three models that were more recently developed will be summarised.

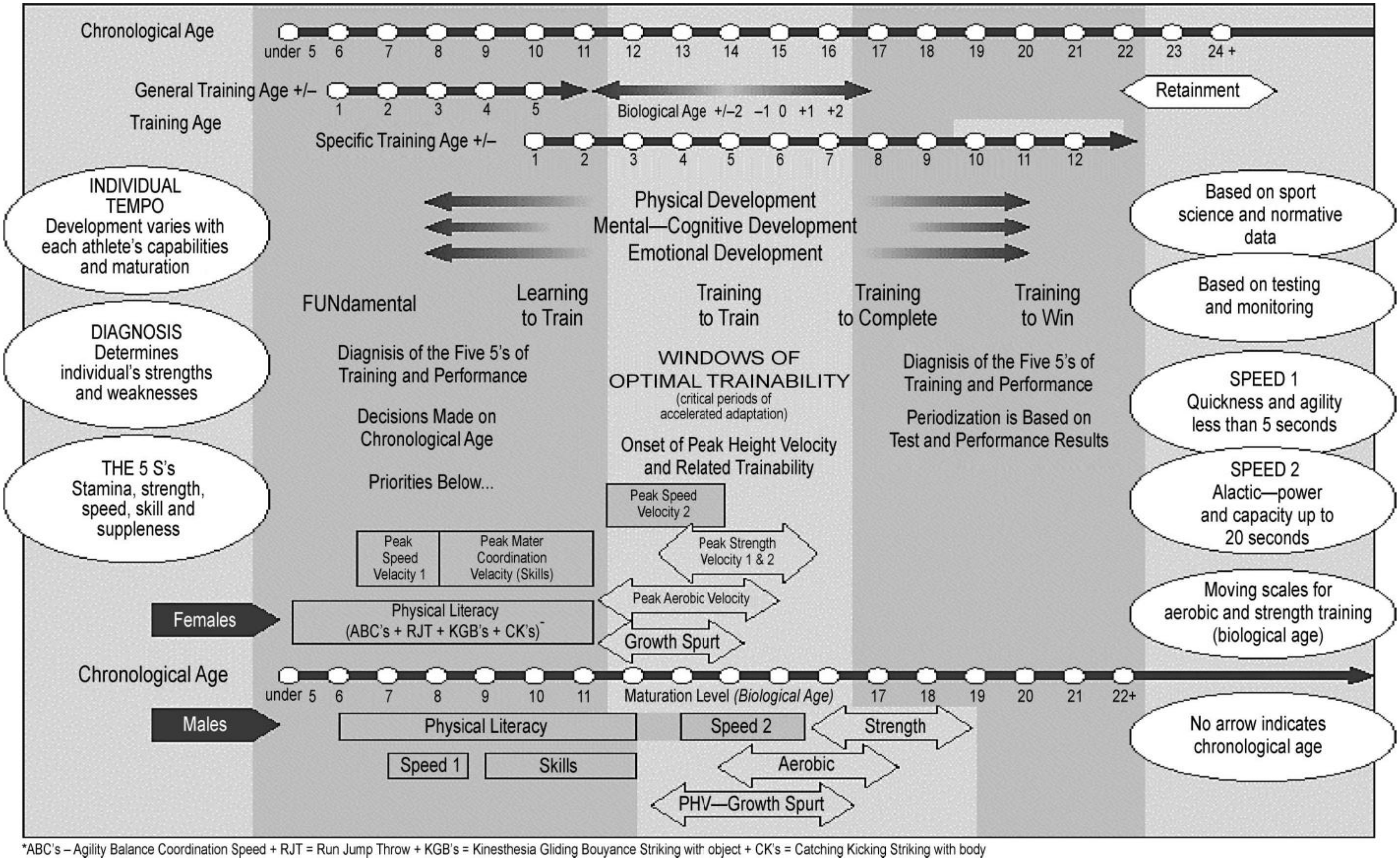


**Figure 2.1:** The LTAD model for females and males (Ford, De Ste Croix, Lloyd, Meyers, Moosavi, Oliver, Till, Williams & Croix, 2011:391).

## Developmental Model of Sports Participation (DMSP)

Brenner (2016) describes the two distinct pathways are suggested in this model, namely either early diversification or early specialization. The main aspects of early diversification include involvement in multiple sports and participation in deliberate play. The benefits of early diversification

Are explained as the experience of different physical, cognitive, affective and psycho-social environments. It is implied that athletes acquire fundamental skills to allow them to specialize later.  Examples of deliberate play include the soccer games in the park and backyard cricket games usually organized by children.

Early specialization involves focusing on one sport with an emphasis on specific organised practice and little deliberate play. Focus can be on performance from six years old. Practices are very structured and have no immediate rewards. It is also described as focusing on improving performance and less enjoyment.

Positive comments on the DMSP are related to the fact it the model has been researched over a period of 15 years with empirical and practical evidence (Côté & Vierimaa, 2014)

## Youth Physical Development (YPD)

The YPD model consist out of four age periods namely, early childhood, middle childhood, adolescence and adulthood. The ages in these age periods differ slightly between boys and girls. During these age periods all skills are trained, but at certain ages the training focus is shifted more towards certain skills (Lloyd & Oliver, 2012).

The YPD model focuses more on speed training during middle adulthood and adolescence. Speed is influenced by a child's maturation (Rumpf *et al.*, 2012) and that speed is trainable throughout childhood (Lloyd & Oliver, 2012). As mentioned during the speed section, the most beneficial training for athletes in their prepubescent age is high levels of neural activation whereas adolescents respond better to a combination of neural and structural development (Lloyd & Oliver, 2012).

Power is one of the key factors for an athlete to be successful, the YPD model identified the key period for power training, at the onset of adolescence until adulthood (Lloyd & Oliver, 2012). Although this is the key period to develop power, the YPD model also suggests starting with power training in the prepubertal phase even though the rate of development will only start to increase rapidly after adolescence (Lloyd & Oliver, 2012).

The YPD model suggesting that strength training should be a priority across all stages. The reasoning being that there is a close relationship between strength, running speed (Weyand, Sternlight, Bellizzi & Wright, 2000), change of direction speed (Negrete & Brophy, 2010) and muscular power (Stone, Sanborn, O'Bryant, Hartman, Stone, Proulx, Ward & Hruby, 2003; Wisløff, Castagna, Helgerud, Jones & Hoff, 2004). Behringer *et al.* (2011) provide evidence that strength is an important element to ensure successful fundamental movement skill (FMS) development. A child's motor skills (throwing, jumping and sprinting) tend to have variability up to 70% due to the child's muscular strength abilities (Lloyd & Oliver, 2012).

The YPD model provides space for agility and mobility where this is important components that influence sport performance. The YPD model acknowledges that the boys and girls mature, develop and grow at different rates. Furthermore, the model will sacrifice short term success for long term and sustainable success later in life for the athlete.

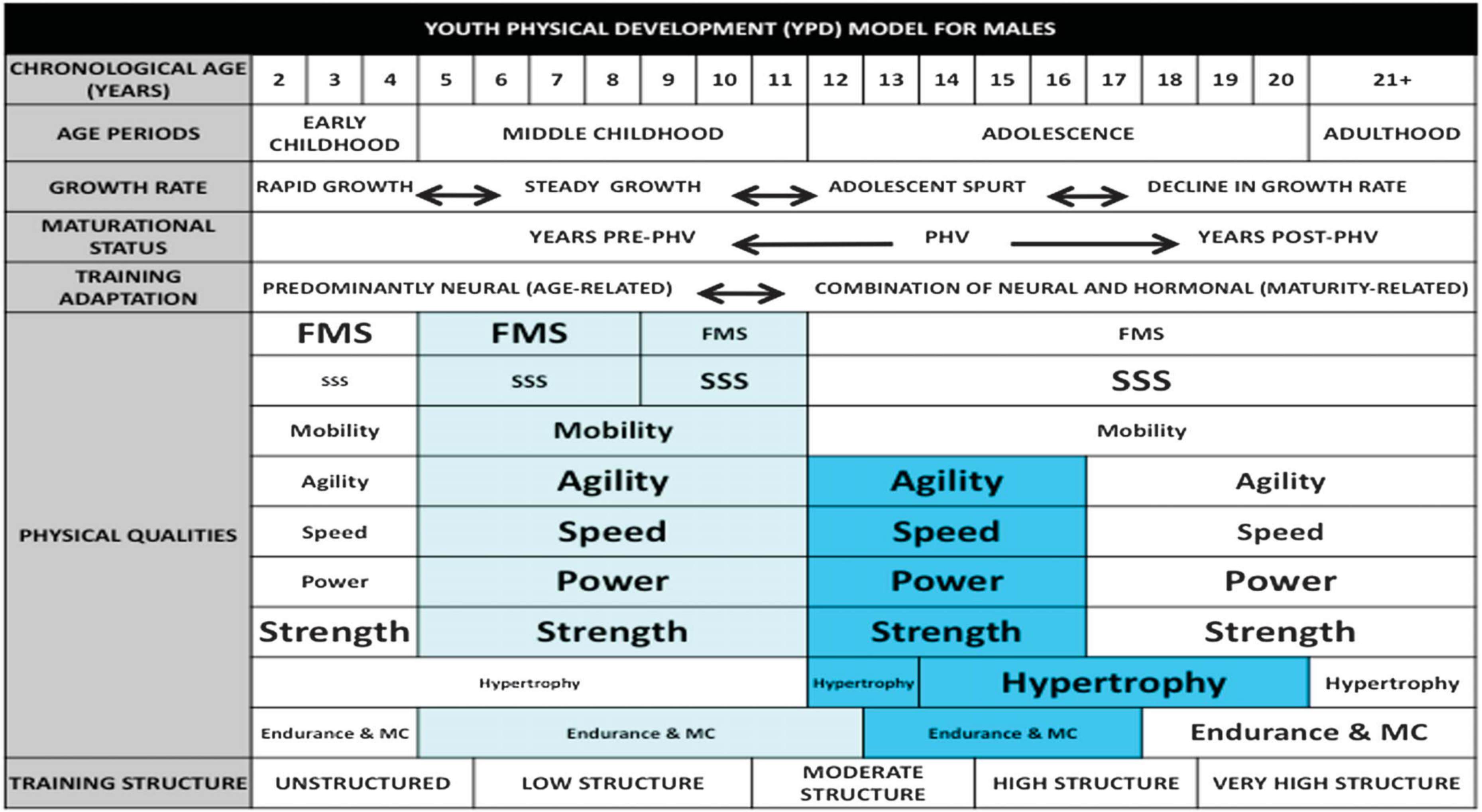


**Figure 2.2:** The YPD model for males (Lloyd & Oliver, 2012:63).

<table>
<tr><th colspan="21">YOUTH PHYSICAL DEVELOPMENT (YPD) MODEL FOR FEMALES</th></tr>
<tr><td>CHRONOLOGICAL AGE (YEARS)</td><td>2</td><td>3</td><td>4</td><td>5</td><td>6</td><td>7</td><td>8</td><td>9</td><td>10</td><td>11</td><td>12</td><td>13</td><td>14</td><td>15</td><td>16</td><td>17</td><td>18</td><td>19</td><td>20</td><td>21+</td></tr>
<tr><td>AGE PERIODS</td><td colspan="3">EARLY CHILDHOOD</td><td colspan="5">MIDDLE CHILDHOOD</td><td colspan="10">ADOLESCENCE</td><td colspan="2">ADULTHOOD</td></tr>
<tr><td>GROWTH RATE</td><td colspan="20">RAPID GROWTH ↔ STEADY GROWTH ↔ ADOLESCENT SPURT ↔ DECLINE IN GROWTH RATE</td></tr>
<tr><td>MATURATIONAL STATUS</td><td colspan="20">YEARS PRE-PHV ← PHV → YEARS POST-PHV</td></tr>
<tr><td>TRAINING ADAPTATION</td><td colspan="20">PREDOMINANTLY NEURAL (AGE-RELATED) ↔ COMBINATION OF NEURAL AND HORMONAL (MATURITY-RELATED)</td></tr>
<tr><td rowspan="9">PHYSICAL QUALITIES</td><td colspan="3">FMS</td><td colspan="3">FMS</td><td colspan="2">FMS</td><td colspan="12">FMS</td></tr>
<tr><td colspan="3">SSS</td><td colspan="3">SSS</td><td colspan="2">SSS</td><td colspan="12">SSS</td></tr>
<tr><td colspan="3">Mobility</td><td colspan="5">Mobility</td><td colspan="12">Mobility</td></tr>
<tr><td colspan="3">Agility</td><td colspan="5">Agility</td><td colspan="6">Agility</td><td colspan="6">Agility</td></tr>
<tr><td colspan="3">Speed</td><td colspan="5">Speed</td><td colspan="6">Speed</td><td colspan="6">Speed</td></tr>
<tr><td colspan="3">Power</td><td colspan="5">Power</td><td colspan="6">Power</td><td colspan="6">Power</td></tr>
<tr><td colspan="3">Strength</td><td colspan="5">Strength</td><td colspan="6">Strength</td><td colspan="6">Strength</td></tr>
<tr><td colspan="8">Hypertrophy</td><td>Hypertrophy</td><td colspan="9">Hypertrophy</td><td colspan="2">Hypertrophy</td></tr>
<tr><td colspan="3">Endurance & MC</td><td colspan="6">Endurance & MC</td><td colspan="7">Endurance & MC</td><td colspan="4">Endurance & MC</td></tr>
<tr><td>TRAINING STRUCTURE</td><td colspan="4">UNSTRUCTURED</td><td colspan="5">LOW STRUCTURE</td><td colspan="4">MODERATE STRUCTURE</td><td colspan="4">HIGH STRUCTURE</td><td colspan="3">VERY HIGH STRUCTURE</td></tr>
</table>

**Figure 2.3:** The YPD model for females (Lloyd & Oliver, 2012:64).

### FTEM (Foundations, Talent, Elite, Master) Framework

The FTEM framework work is represented with four macro of skill and performance development that is differentiated into 10 micro phases, as illustrated in **Figure 2.4**. The four macro stages are Foundations, Talent, Elite and Mater as represented by the FTEM framework. The word framework represent the holistic integration of the "3 world's" namely, active lifestyle, sports participation and sporting excellence (Bailey, Collins, Ford, MacNamara, Toms & Pearce, 2010). The FTEM framework moved away from fixed age boundaries to train specific skills as most other models development stages are bond to chronological age of the athletes (Balyi & Hamilton, 2004; Gulbin *et al.*, 2013).

In the FTEM framework the age boundaries has little effect on the development of the athlete that might be a late developing talent or transferring athlete who only start to develop their talent during adulthood (Gulbin *et al.*, 2013). The FTEM framework also lend itself to or jump between different phases in any direction (Gulbin *et al.*, 2013). For example an athlete that was not identified to become an elite athlete, but eventually become an elite athlete or the other way round, but both athletes is accommodated within this framework.

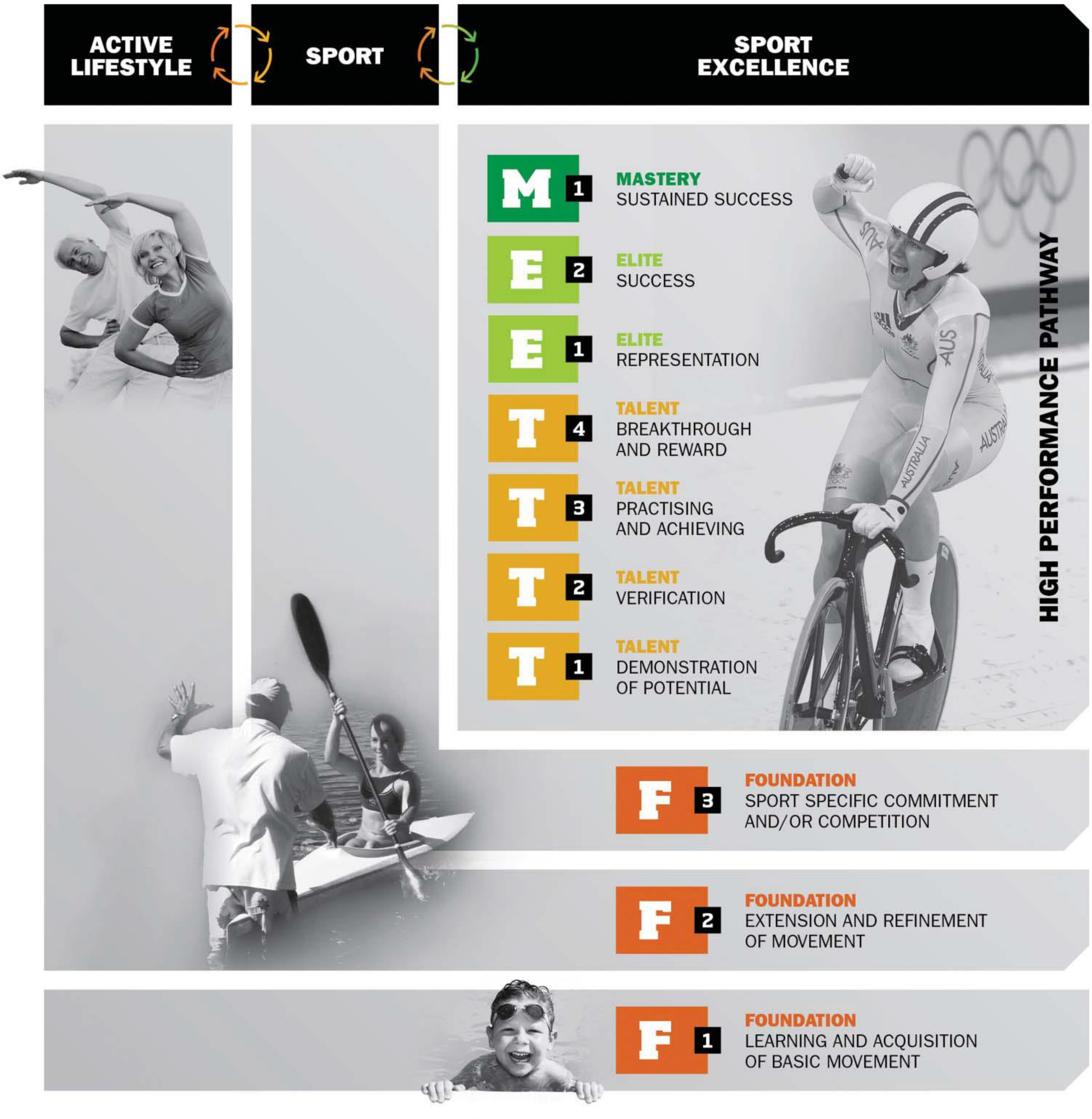


**Figure 2.4**: FTEM framework (Gulbin *et al.*, 2013)

## D Summary

Almost all field-based sport fitness testing contains an element that tests the athletes' speed and jumping abilities of athletes. Speed is broken down into the following: first step quickness, acceleration, maximal speed and game speed. As children develop their neuromuscular system also improves and they are more likely to improve their running performance. The power of an athlete is measured through lower body jumping ability. In a school setting, SLJ and VJ are two reliable and feasible tests to conduct in order to measure lower body power. For sprinting, as well as for jumping tests, the SSC was used to perform the movement. Research has found correlations between sprinting performance and the jumping performance of athletes.

Strength has an important role to play in an athlete's sprinting ability. There are, however, three concerns regarding strength training in children: 1) strength training has the stigma that it is a high risk exercise that can cause injuries in children, 2) the safety and suitability of strength training as part of a training programme for children and 3) strength training may be harmful to the growth cartilages of children during development years (Faigenbaum, 2001; Faigenbaum *et al.*, 2009; Lloyd, Oliver, *et al.*, 2014). Research studies have discovered that these three assumptions are not true and that children can take part in strength training with the correct supervision of a trainer and using the correct training techniques and loads.

There are a variety of training models. The main purpose of the models is to create an environment for children to be involved in sport and stay active in sport for the rest of their lives, but at the same time to try to prevent early specialization in only one sport. The LTAD model has a variety of stages, but for this study we will focus on the window of opportunities of speed in stage two and four.

However the LTAD model, has a few limitations, but there is newer models that try to fixed these limitations. The YPD, suggests all abilities should be trained at all ages, but at certain ages a larger percentage of time needs to be given to certain abilities. The FTEM framework has four macros of skill and performance development and does not have specific age's attaches to them. Furthermore athletes can slide up and down between the four macros. All the models focus on long term athlete development, but do not always have the same-view point when to training the different biomotor abilities. The models, however, acknowledge the fact that girls and boys mature at different rates.

# CHAPTER THREE

# METHODOLOGY

## A Introduction

This research study was part of a bigger research study namely the Barefoot LIFE research project. The project investigated the effects of being habitually barefoot on foot mechanics and motor performance in children and adolescents aged 6-18 years: study protocol for a multicentre crossectional study (Hollander *et al.*, 2016). The primary aim of the current study was to determine if there is a relationship between standing long jump (SLJ), sprinting speed at 2.5m, 5m, 10m and 20m and handgrip strength in children aged 6 to 17 years in the Western Cape. The boys and girls were divided into age groups (**Table 3.1**). This chapter will report on the specific methods used to address the aim and objectives of this study.

**Table 3.1:** The age group categories for boys and girls, according to Balyi (2001) and Rumpf *et al.* (2012).

| Boys | Girls |
|---|---|
| 6-9 | 6-8 |
| 10-12 | 9-10 |
| 13-16 | 11-13 |
| 17 | 14-17 |

## B Study Design

This was an observational study design. It investigated the relationship between different biomotor abilities (speed, power and strength) through the use of field-based performance tests in children. The tests were the 20m sprint test, SLJ test and handgrip test. The correlation between the child's development of biomotor abilities and age was also investigated. Data were collected through a once-off assessment and no intervention programme was conducted.

## C Participants

For the purpose of this study the target population was school children from grade 1 to grade 12 (age 6-17). A randomized stratified sample was used to recruit a variety of schools in the Western Cape. The Western Cape consists of five regions and schools were selected from the different regions. Random sampling was done to identify the seven towns and 12 schools where data was captured. Participation in the study was voluntarily. Written, informed assent was provided by the participants. Because the children were under the age of 18, the parents or legal guardian also provided written, informed consent.

The children were divided into groups according to their age. The age groups differed for boys and girls due to the fact that boys and girls mature at different rates (Lloyd & Oliver, 2012). Guidelines from the Long Term Athlete Development (LTAD) model were used to group the children into age groups (Balyi, 2001; Rumpf *et al.*, 2012), (**Table 3.2)**.

**Table 3.2:** The age group categories for boys and girls, according to Balyi (2001) and Rumpf *et al.* (2012).

| Boys | Girls |
|---|---|
| 6-9 | 6-8 |
| 10-12 | 9-10 |
| 13-16 | 11-13 |
| 17 | 14-17 |

### Inclusion and exclusion criteria

Only children from the 12 schools, between the ages of 6 and 17 were included. The parents or legal guardian had to provide consent. Furthermore, the children had to complete all the tests to be included in the study. Any child that carried an injury at time of testing or had a form of disability that could influence the outcome of their performance was excluded from the study.

## D Experimental Design

### Place of Study

This was a field-based study and testing was conducted at the various schools. Testing was done either outside on the tennis or netball courts or inside the school hall, depending on the availability of facilities and weather conditions.

## Procedures

Testing was done during the physical education period at the school. Once the children arrived at their physical education class, the testing protocol was explained to them and the completed consent and assent forms were collected. The testing procedure started off by measuring the child's height and weight. Followed by a five minute warm-up that consisted of light jogging and dynamic stretches (butt kicks, high knees, side shuffles, elephant walks and lunges). After the warm-up, the children were randomly divided into the three different testing stations 20m speed, standing long jump (SLJ) and handgrip strength tests respectively. Each child received a number and was a signed to one of the testing station in no specific order and once done with a test the child was send to the next available testing station. At each testing station the children received a verbal explanation of the test (each child was only allowed to visit each testing station once). At the SLJ and handgrip stations they also received a visual demonstration on how to perform the test. Children were verbally motivated to give their best effort during testing. The researcher collected all the SLJ and handgrip strength test data. Research assistants, postgraduate students trained in and familiar with the equipment, collected the 20m speed data, as well as height and weight.

## E Ethics

Ethical clearance for the study was given by both the Ethics Committee of Stellenbosch University (Reference number HS1153/2014; Appendix 1) and the Western Cape Government Department of Education (Reference number 20160128-7123, Appendix 2 and Appendix 3) enabled the researcher to conduct the study at schools in the Western Cape. Before testing commenced an appointment was made with the headmasters of each school to explain the study and request permission to conduct testing at the schools. Project information forms and consent forms were distributed about a week before the testing date. Furthermore, each child provided assent and the child's parent or legal guardian also provided consent. All the parties involved had received the necessary information explaining to them what the research study was about before they provided consent for the study. It was emphasised that participation was completely voluntary and that the child may withdraw at any given time without any consequences.

## F Tests and Measurements

### Height

A stadiometer (Charder, HM 200P Portstad, Germany) was used to measure the height of the child. This measurement was taken without shoes. The child's heels, buttocks and upper back were aligned and touching the stadiometer. Further, the head of the child was positioned in the Frankfort plane before the height was measured. The reading on the stadiometer was taken to the nearest 0.1 centimetre (cm).

### Body Weight

The child's body weight was measured with a calibrated electronic scale (Masscot UC-321, A&D personal precision scale, Tokyo, Japan). The scale was calibrated every time before testing. The measurement was done without shoes. The children were asked to stand on the scale with both of their feet shoulder width apart and weight evenly distributed between their legs, while looking straight ahead. The reading on the scale was taken to the nearest 0.1 kilogram (kg).

### Standing Long Jump (SLJ)

The SLJ station was set-up as indicated by **Figure 3.1**. The take-off point was from a hard non-slippery surface and the landing zone was on the softer gymnastic mats. The children lined up, toes behind the starting line and feet shoulder width apart. The children performed a countermovement jump (flexed knees and hips, trunk brought forward and arms swung backwards) as shown by **Figure 3.2**. Once the children were ready they could perform the jump in their own time. The purpose was to jump as far as possible. Six trials were executed: three barefoot and three with training shoes. Al Haddad *et al.* (2015) suggested that a series of jumps (two to five jumps) need to be performed, and because school children were tested three trials were picked to gain a better mean value. The footwear condition was randomly allocated. At least a one minute rest was given between trials. Research studies showed that in a school setting that SLJ is a valid and reliable test to measure lower body power (Castro-Piñero, Artero, Espana-Romero, Ortega, Sjöström, Suni & Ruiz, 2010; Hammami *et al.*, 2015) The distance was measured with a metal measuring tape to the nearest 0.5 cm (Hoffman, 2006). The average score of the three trials, in each footwear condition, was used for statistical analysis. The reason for using average scores are the distance was measured by hand and measuring error is therefor higher, according to Al Haddad, Simpson & Buchheit (2015) to reduce the effect of measuring error it is better to use mean values rather than the best score.

**Figure 3.1:** The set-up of the SLJ (Photo by Schalk van Wyk).

**Figure 3.2:** The jumping sequence of SLJ (www.google.co.za/search?q=standing+long+jump+clipart&espv=2&biw=1280&bih=899&tbm=isch&tbo=u&source=univ&sa=X&ved=0ahUKEwi8l4PK9vTMAhVICcAKHSzHAsUQsAQIGQ&dpr=1#imgrc=Zbs4FqvtDDj7eM%3A).

### 20 m Sprinting Speed

**Figure 3.3** demonstrates the set-up of the speed testing station at each school. The Brower Timing System speed cells (Salt Lake City, UT, USA) were placed at the start, 2.5m, 5m, 10m and 20m marks. Various research studies used 2.5m, 5m, 10m and 20m to determine sprinting speed and acceleration in athletes (Kukolj *et al.*, 1999; Cronin & Hansen, 2005; Vescovi & McGuigan, 2008; Hammami *et al.*, 2015) The 2.5m, 5m, 10m and 20m times were measured automatically during the same trial with the Brower Timing System with the accuracy of 0.01 seconds (s) (Hammami *et al.*, 2015), (**Figure 3.4)**. Speed cells are a reliable source to use for measuring sprinting speed (Hammami *et al.*, 2015). The sprinting time was measured from a standing start. The children started in an upright position with their left or right foot behind the starting line and could start on their own time, once they were ready. Four trials were performed: two barefoot and two with training shoes. Al Haddad *et al.* (2015) recommend that two trails are taken during speed testing. The footwear condition was randomly allocated. Between one and two minutes of rest was given between trials depending on the amount of children at the testing station. The average times of 2.5m, 5m, 10m and 20m of the two trials, with the different footwear condition, were used for statistical analysis. The reason behind using the average time was, because single beam speed lights were used for testing and not double beam speed lights (Yeadon, Katot & Kerwin, 1999).

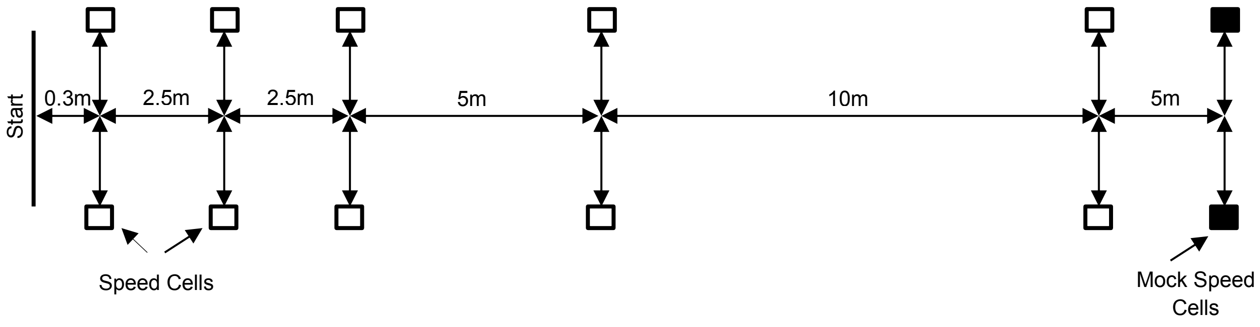


**Figure 3.3:** Layout of 20m speed set-up (Diagram by Schalk van Wyk).


**Figure 3.4:** Photo of the Brower Timing System (Photo by Schalk van Wyk).

**Handgrip Strength**

The handgrip test was used to measure the upper body strength of the children. The handgrip test is cost-effective and easy to use (Milliken *et al.*, 2008). The other benefit of the handgrip test, is that a child is not likely to score zero (Milliken *et al.*, 2008), as might be the case with the push-up or bench press test for example. During the pilot study we found in the younger children they struggled to identify their dominant side, for example they will write left handed, but throws a ball right handed.

To keep it consistent for data collection everyone had to do the handgrip strength test with both hands. Various research studies found that the handgrip test is a valid and reliable test to use in testing the upper body strength of children (Milliken *et al.*, 2008; Jenkins, Buckner, Bergstrom, Cochrane, Goldsmith, Housh, Johnson, Schmidt & Cramer, 2014). **Figure 3.5** indicates how the test was conducted by the researcher. The test was performed in a standing position. The child's arms were kept at their sides, shoulders flexed at $0^0$ (arms straight) and the elbows in full extension at $180^0$ (Innes, 1999). The handgrip dynamometer, seen in **Figure 3.6**, was squeezed as hard as possible for 3-4 seconds (Jenkins *et al.*, 2014) and measured to the nearest 0.5 kg (Milliken *et al.*, 2008). Four trials were taken, two with the left hand and two with the right hand (Innes, 1999). The best trial with the left or right hand were retained and used for statistical analysis.

**Figure 3.5:** Testing position for handgrip test (Photo by Schalk van Wyk)


**Figure 3.6:** Example of handgrip dynamometer (Photo by Schalk van Wyk)

## G Statistical Analysis

The statistical analysis calculations were done with SPSS 23.0 (SPSS inc, Chicago, IL) and Microsoft Excel (Windows, 2010). Data were normally distributed. For the Barefoot LIFE project the sample size based on the SLJ should be n=18 (μ=152.9; SD=31.5) and for 20m sprint n=12 (μ=3.81; SD=0.64). With a two-sided significance level of 0.05, and assuming a power of 0.8, a minimum of 16 participants per age group, had to be included for this study (Hollander *et al.*, 2016). The descriptive data for continuous measurements were presented by the means and standard deviations. A within-/between-group comparison was done between the barefoot and shod footwear condition to determine if results of both groups could be used interchangeable with each other. There were, however, a difference between performance in the barefoot and shod conditions and the two footwear conditions were analysed separately. The general linear model, univariate and multivariate, ANOVA were used to compare the sprinting speeds (2.5m, 5m, 10m and 20m), SLJ distance and handgrip strength within the various age groups. The significant level was set at $p<0.05$. The independent unpaired T-test was used to compare the sprinting speeds and SLJ distance for a specific age between boys and girls. The Pearson correlation was used to determine the correlation between the sprinting speeds, SLJ distance and handgrip strength of the children. The R values used for the Pearson correlation were as follows: no correlation (0.00 - 0.25), fair correlation (0.26 - 0.50), moderate to good correlation (0.51 - 0.75) and good to excellent correlation (> 0.75) (Landis & Koch, 1977; Hopkins, 2010).

# CHAPTER FOUR

# RESULTS

## A Introduction

This chapter will focus on the analysis of data according to the aims and objectives set out for the study. The primary aim was to determine the relationships between sprinting speed, at 2.5m, 5m, 10m and 20m, standing long jump (SLJ) and handgrip strength. The secondary aim of the study was to compare performance on biomotor abilities (speed, power and strength) with the windows of opportunity as suggested by LTAD models. Boys and girls were divided into age group categories (**Table 4.1**). Results will be presented according to the objectives set out for the research project.

**Table 4.1:** The age group categories for boys and girls, according to Balyi (2001) and Rumpf *et al.* (2012).

| Boys | Girls |
|---|---|
| 6-9 | 6-8 |
| 10-12 | 9-10 |
| 13-16 | 11-13 |
| 17 | 14-17 |

## B Participants Characteristics

A total of 550 children, 275 boys and 275 girls, took part in the study. In **Table 4.2** the anthropometric data is displayed for boys and girls age 6-11, while for boys and girls age 12-17 is shown in **Table 4.3**.

**Table 4.2:** The anthropometric data for boys and girls between the ages 6 and 11 years old (data are presented as means ± SD).

| **Age** | **6** n=25 | | **7** n=27 | | **8** n=49 | | **9** n=46 | | **10** n=44 | | **11** n=35 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Gender** | **Boys** | **Girls** | **Boys** | **Girls** | **Boys** | **Girls** | **Boys** | **Girls** | **Boys** | **Girls** | **Boys** | **Girls** |
| **n** | 12 | 13 | 15 | 12 | 17 | 32 | 20 | 26 | 29 | 15 | 15 | 20 |
| **Height** (m) | 1.22 ± 0.07 | 1.21 ± 0.07 | 1.29 ± 0.04 | 1.25 ± 0.05 | 1.35 ± 0.05 | 1.31 ± 0.06 | 1.39 ± 0.07 | 1.39 ± 0.04 | 1.44 ± 0.08 | 1.43 ± 0.05 | 1.52 ± 0.05 | 1.5 ± 0.09 |
| **Mass** (kg) | 26.42 ± 10.1 | 24.29 ± 5.50 | 27.25 ± 3.50 | 24.92 ± 3.60 | 31.06 ± 5.40 | 30.81 ± 5.90 | 35.22 ± 8.40 | 35.40 ± 6.50 | 40.20 ± 11.7 | 36.23 ± 5.60 | 46.02 ± 8.30 | 43.65 ± 10.0 |
| **BMI** (kg/$m^2$) | 17.74 ± 4.51 | 16.35 ± 2.08 | 16.35 ± 1.54 | 15.98 ± 2.08 | 16.93 ± 1.82 | 17.70 ± 2.23 | 18.12 ± 2.91 | 18.19 ± 3.07 | 19.21 ± 3.99 | 17.62 ± 2.71 | 19.87 ± 3.03 | 19.20 ± 3.17 |

**Table 4.3:** The anthropometric data for boys and girls between the ages 12 and 17 years old (data are presented as means ± SD).

| **Age** | **12** n=61 | | **13** n=69 | | **14** n=38 | | **15** n=49 | | **16** n=62 | | **17** n=35 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Gender** | **Boys** | **Girls** | **Boys** | **Girls** | **Boys** | **Girls** | **Boys** | **Girls** | **Boys** | **Girls** | **Boys** | **Girls** |
| **n** | 34 | 27 | 28 | 41 | 18 | 20 | 32 | 17 | 27 | 35 | 28 | 17 |
| **Height** (m) | 1.54 ± 0.07 | 1.59 ± 0.06 | 1.63 ± 0.09 | 1.60 ± 0.08 | 1.74 ± 0.10 | 1.59 ± 0.24 | 1.75 ± 0.08 | 1.65 ± 0.07 | 1.77 ± 0.07 | 1.64 ± 0.06 | 1.79 ± 0.07 | 1.63 ± 0.07 |
| **Mass** (kg) | 48.81 ± 13.0 | 52.28 ± 11.6 | 53.72 ± 10.9 | 53.49 ± 13.8 | 66.13 ± 16.3 | 62.08 ± 13.0 | 64.53 ± 10.1 | 58.39 ± 10.2 | 71.84 ± 8.30 | 59.57 ± 8.90 | 80.03 ± 12.6 | 61.01 ± 14.6 |
| **BMI** (kg/$m^2$) | 20.31 ± 4.51 | 20.50 ± 4.09 | 20.04 ± 2.97 | 20.72 ± 4.29 | 21.60 ± 3.99 | 23.02 ± 4.04 | 21.14 ± 2.64 | 21.33 ± 3.10 | 22.82 ± 2.18 | 22.16 ± 3.04 | 24.95 ± 3.78 | 22.76 ± 4.35 |

# C Acceleration and Sprinting Speed

## Girls barefoot sprinting

In the table below, is the barefoot sprinting data for girls in the four different age group categories (**Table 4.4**).

**Table 4.4:** The barefoot sprinting data for girls in age group categories (data are presented as means ± SD).

| Age groups | 6-8 | 9-10 | 11-13 | 14-17 |
|---|---|---|---|---|
| **n per age group** | 57 | 49 | 88 | 89 |
| **2.5m** (s) | 0.84 ± 0.09 | 0.81 ± 0.09 | 0.77 ± 0.08 | 0.73 ± 0.09 |
| **5m** (s) | 1.44 ± 0.10 | 1.37 ± 0.11 | 1.31 ± 0.11 | 1.24 ± 0.12 |
| **10m** (s) | 2.47 ± 0.18 | 2.33 ± 0.18 | 2.21 ± 0.18 | 2.06 ± 0.21 |
| **20m** (s) | 4.44 ± 0.37 | 4.11 ± 0.35 | 3.86 ± 0.34 | 3.55 ± 0.41 |

In the 2.5m barefoot sprinting tests for girls were no statistical significant differences ($p>0.05$) between the age groups.

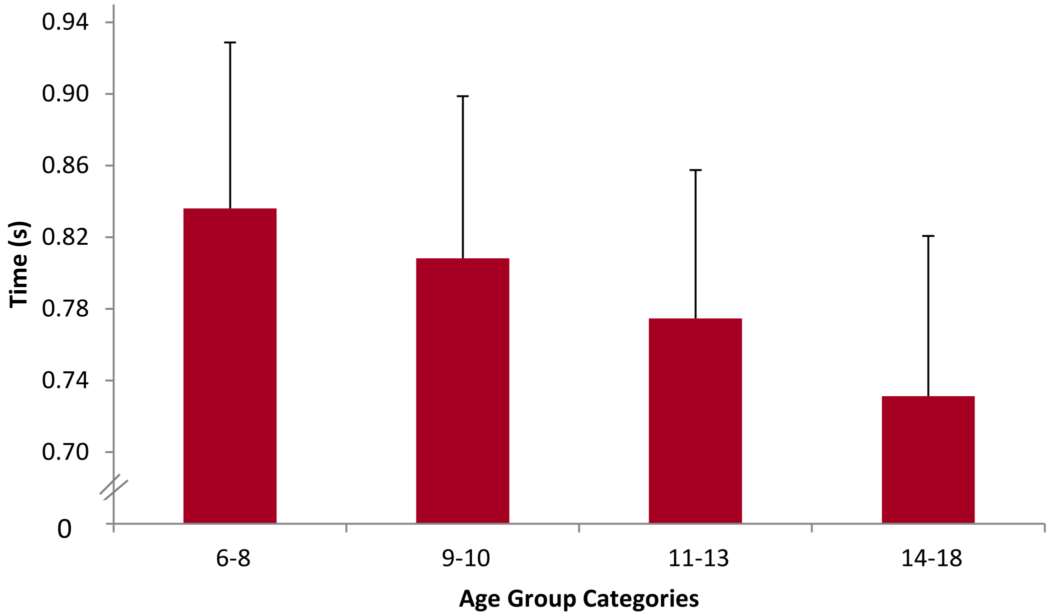


**Figure 4.1:** The average 2.5m barefoot sprinting time (s) in age group categories for girls (data are presented as means and SD).

With the 5m barefoot sprinting test, the age group 6-8 was significant ($p<0.05$) slower than age group 9-10, age group 11-13 and age group 14-17. There was not significant differences ($p>0.05$) between the other age groups.

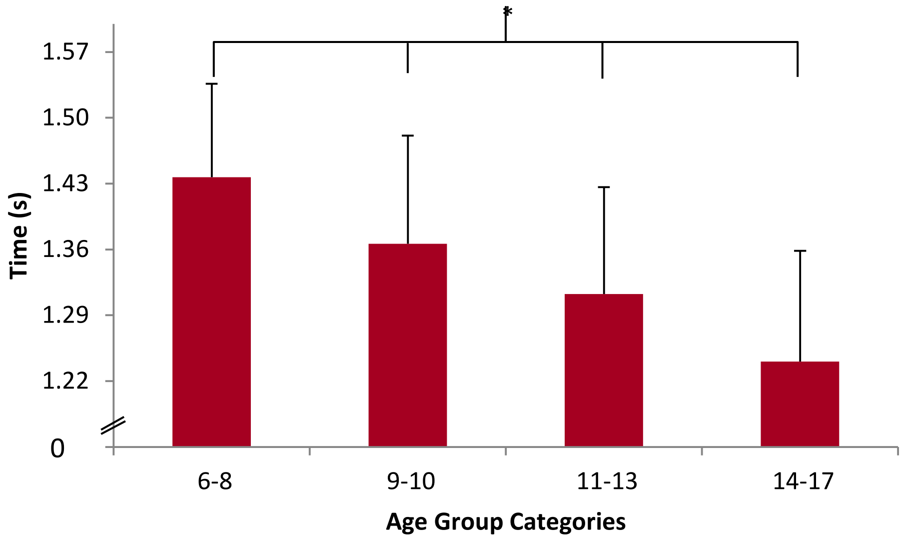


**Figure 4.2:** The average 5m barefoot sprinting time (s) in age group categories for girls (data are presented as means and SD).

* $p<0.05$ statistical significant difference between age group 6-8 and the other three age groups

In the 10m barefoot sprinting for girls the age group 6-8 was significantly ($p<0.05$) slower compared to age group 9-10, age group 11-13 and age group 14-17. The age group 9-10 was also significantly ($p<0.05$) slower than age group 11-13. There was not a significant differences ($p>0.05$) between age group 9-10 with age group 14-17, as well as between age group 11-13 with age group 14-17.

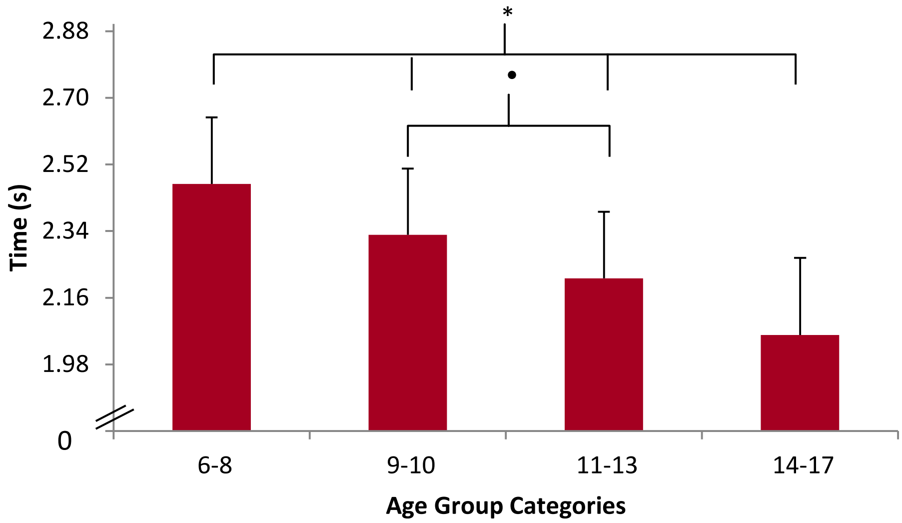


**Figure 4.3:** The average 10m barefoot sprinting time (s) in age group categories (years) for girls (data are presented as means ± SD).

* p<0.05 statistical significant difference between age group 6-8 and the other three age groups

• p<0.05 statistical significant difference between age group 9-10 and age group 11-13

For the 20m barefoot sprinting test with girls, the age group 6-8 was significantly (p<0.05) slower compared to age group 9-10, age group 11-13 and age group 14-17. The 9-10 age group was also significantly (p<0.05) slower compared to age group 11-13 and age group 14-17 (p=0.05). There was not a significant difference (p>0.05) between age group 11-13 with age group 14-17.

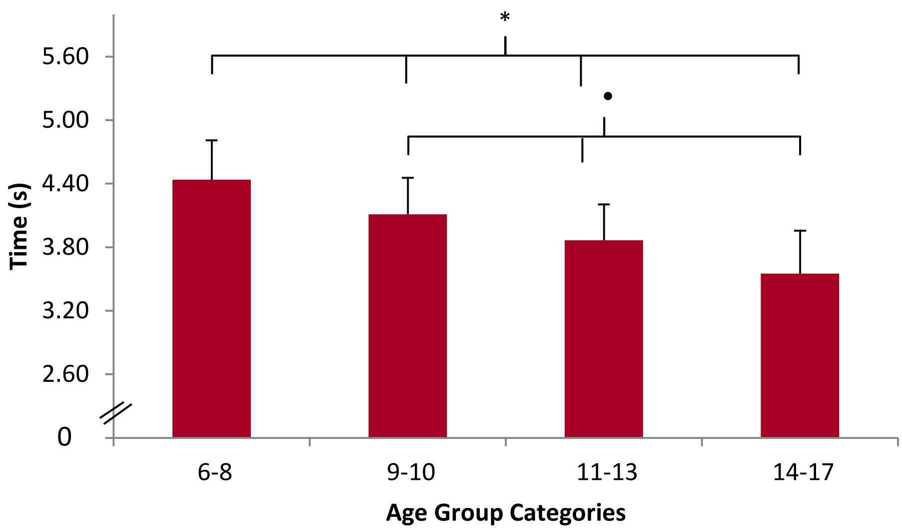


**Figure 4.4:** The average 20m barefoot sprinting time (s) in age group categories (years) for girls (data are presented as means ± SD).

* p<0.05 statistical significant difference between age group 6-8 and the other three age groups

• p<0.05 statistical significant difference between age group 9-10, age group 11-13 and age group 14-17

**Boys barefoot sprinting**

The barefoot sprinting data for boys in the four different age group categories can be found in **Table 4.5**.

**Table 4.5:** The barefoot sprinting data for boys in age group categories (data are presented as means ± SD).

| Age groups | 6-9 | 10-12 | 13-16 | 17 |
|---|---|---|---|---|
| **n per age group** | 64 | 78 | 105 | 28 |
| **2.5 m** (s) | 0.83 ± 0.10 | 0.79 ± 0.08 | 0.74 ± 0.08 | 0.72 ± 0.10 |
| **5 m** (s) | 1.42 ± 0.11 | 1.34 ± 0.11 | 1.26 ± 0.11 | 1.23 ± 0.13 |
| **10 m** (s) | 2.44 ± 0.19 | 2.27 ± 0.16 | 2.09 ± 0.19 | 2.04 ± 0.24 |
| **20 m** (s) | 4.36 ± 0.39 | 3.97 ± 0.32 | 3.62 ± 0.38 | 3.54 ± 0.44 |

As indicated by **Figure 4.5** to **Figure 4.8** the barefoot sprinting test for boys at 2.5m, 5m, 10m and 20m respectively, the age group 6-9 was significantly ($p<0.05$) slower than age group 10-12, age group 13-16 and age group 17. Furthermore age group 10-12 was significantly ($p<0.05$) slower than age group 13-16 and age group 17. There was not a significant difference ($p>0.05$) between age group 13-16 with age group 17.

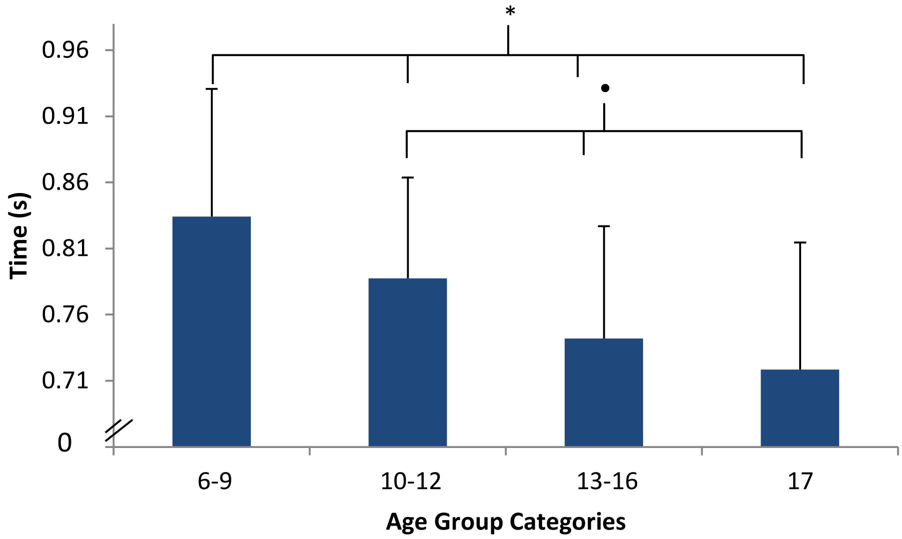


**Figure 4.5:** The average 2.5m barefoot sprinting time (s) in age group categories (years) for boys (data are presented as means ± SD).

* $p<0.05$ statistical significant difference between age group 6-9 and the other three age groups

• $p<0.05$ statistical significant difference between age group 10-12, age group 13-16 and age group 17

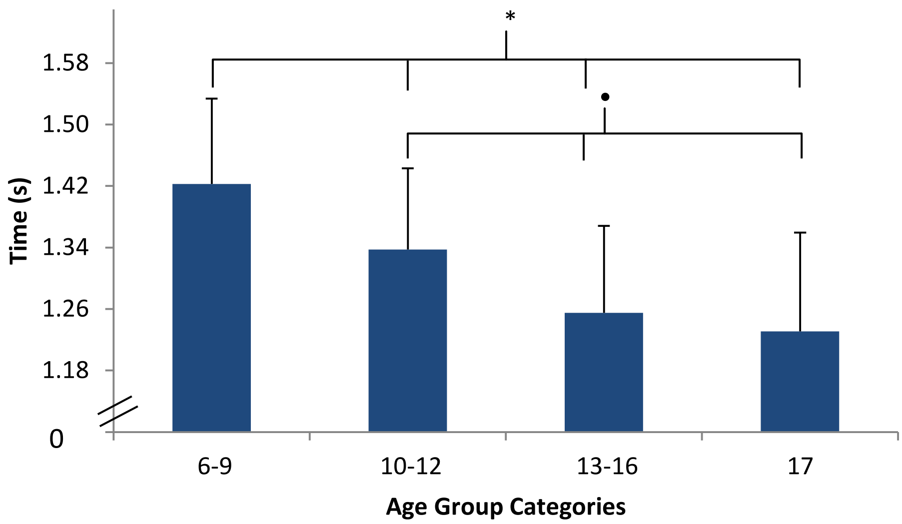


**Figure 4.6:** The average 5m barefoot sprinting time (s) in age group categories (years) for boys (data are presented as means ± SD).

* $p<0.05$ statistical significant difference between age group 6-9 and the other three age groups

• $p<0.05$ statistical significant difference between age group 10-12, age group 13-16 and age group 17

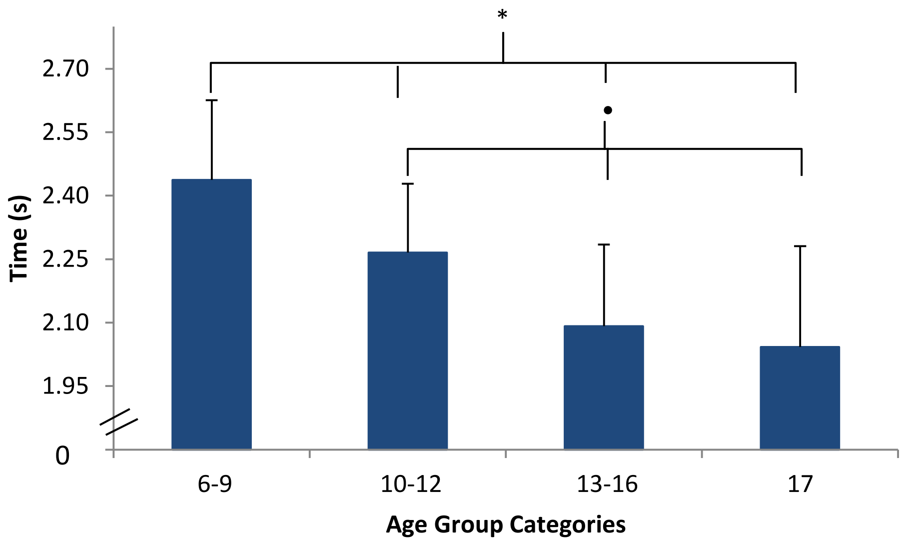


**Figure 4.7:** The average 10m barefoot sprinting time (s) in age group categories (years) for boys (data are presented as means ± SD).

* $p<0.05$ statistical significant difference between age group 6-9 and the other three age groups

• $p<0.05$ statistical significant difference between age group 10-12, age group 13-16 and age group 17

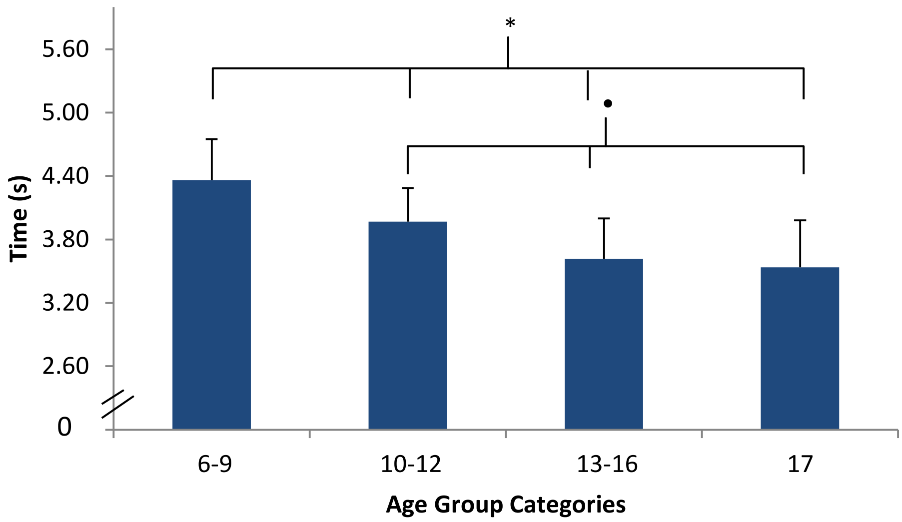


**Figure 4.8:** The average 20m barefoot sprinting time (s) in age group categories (years) for boys (data are presented as means ± SD).

* p<0.05 statistical significant difference between age group 6-9 and the other three age groups

• p<0.05 statistical significant difference between age group 10-12, age group 13-16 and age group 17

## Barefoot sprinting speed comparison between boys and girls

**Table 4.6** and **Table 4.7** represent the means and standard deviations of the sprinting times at 2.5m, 5m, 10m and 20m for the age categories and gender groups.

**Table 4.6:** The barefoot average sprinting times (s) for boys and girls between the ages 6 and 11 years old (data are presented as means ± SD).

| **Age** | **6** n=25 | | **7** n=27 | | **8** n=49 | | **9** n=46 | | **10** n=44 | | **11** n=35 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Gender** | **Boys** | **Girls** | **Boys** | **Girls** | **Boys** | **Girls** | **Boys** | **Girls** | **Boys** | **Girls** | **Boys** | **Girls** |
| **n** | 12 | 13 | 15 | 12 | 17 | 32 | 20 | 26 | 29 | 15 | 15 | 20 |
| **2.5m** (s) | 0.87 ± 0.09 | 0.87 ± 0.14 | 0.82 ± 0.06 | 0.87 ± 0.05 | 0.80 ± 0.08 | 0.82 ± 0.09 | 0.81 ± 0.11 | 0.85 ± 0.10 | 0.77 ± 0.07 | 0.80 ± 0.05 | 0.79 ± 0.08 | 0.84 ± 0.06 |
| **5m** (s) | 1.46 ± 0.15 | 1.52 ± 0.08 | 1.41 ± 0.07 | 1.49 ± 0.07 | 1.36 ± 0.09 | 1.42 ± 0.08 | 1.36 ± 0.13 | 1.42 ± 0.13 | 1.33 ± 0.11 | 1.34 ± 0.05 | 1.33 ± 0.12 | 1.40 ± 0.10 |
| **10m** (s) | 2.56 ± 0.27 | 2.60 ± 0.15 | 2.40 ± 0.12 | 2.56 ± 0.14 | 2.34 ± 0.17 | 2.44 ± 0.13 | 2.31 ± 0.17 | 2.42 ± 0.20 | 2.26 ± 0.18 | 2.32 ± 0.07 | 2.25 ± 0.18 | 2.37 ± 0.15 |
| **20m** (s) | 4.65 ± 0.51 | 4.71 ± 0.37 | 4.26 ± 0.24 | 4.68 ± 0.26 | 4.16 ± 0.33 | 4.37 ± 0.26 | 4.10 ± 0.40 | 4.28 ± 0.34 | 3.96 ± 0.33 | 4.12 ± 0.16 | 3.91 ± 0.34 | 4.17 ± 0.34 |

**Table 4.7:** The barefoot average sprinting times (s) for boys and girls between the ages 12 and 17 years old (data are presented as means ± SD).

| **Age** | **12** n=61 | | **13** n=69 | | **14** n=38 | | **15** n=39 | | **16** n=62 | | **17** n=45 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Gender** | **Boys** | **Girls** | **Boys** | **Girls** | **Boys** | **Girls** | **Boys** | **Girls** | **Boys** | **Girls** | **Boys** | **Girls** |
| **n** | 34 | 27 | 28 | 41 | 18 | 20 | 32 | 17 | 27 | 35 | 28 | 17 |
| **2.5m** (s) | 0.75 ± 0.07 | 0.80 ± 0.09 | 0.72 ± 0.07 | 0.78 ± 0.08 | 0.74 ± 0.07 | 0.80 ± 0.10 | 0.69 ± 0.07 | 0.77 ± 0.06 | 0.67 ± 0.06 | 0.78 ± 0.06 | 0.68 ± 0.06 | 0.79 ± 0.07 |
| **5m** (s) | 1.29 ± 0.10 | 1.35 ± 0.11 | 1.22 ± 0.09 | 1.31 ± 0.11 | 1.24 ± 0.08 | 1.33 ± 0.11 | 1.17 ± 0.09 | 1.29 ± 0.09 | 1.15 ± 0.08 | 1.31 ± 0.08 | 1.17 ± 0.08 | 1.32 ± 0.09 |
| **10m** (s) | 2.19 ± 0.16 | 2.27 ± 0.14 | 2.05 ± 0.14 | 2.21 ± 0.17 | 2.01 ± 0.16 | 2.25 ± 0.19 | 1.91 ± 0.12 | 2.17 ± 0.15 | 1.93 ± 0.11 | 2.19 ± 0.14 | 1.92 ± 0.13 | 2.25 ± 0.18 |
| **20m** (s) | 3.83 ± 0.31 | 3.96 ± 0.24 | 3.59 ± 0.26 | 3.86 ± 0.32 | 3.43 ± 0.50 | 3.92 ± 0.39 | 3.30 ± 0.20 | 3.77 ± 0.35 | 3.27 ± 0.20 | 3.77 ± 0.25 | 3.32 ± 0.23 | 3.89 ± 0.41 |

**Figure 4.9** to **Figure 4.12** represent the barefoot sprinting speeds for each age category of the boys compared to the girls. **Figure 4.9** indicated for the sprinting speed at 2.5m there was a significant difference (p<0.05) at ages 7, 12, 13, 14, 15, 16 and 17, with the boys running faster times in all the mentioned ages.

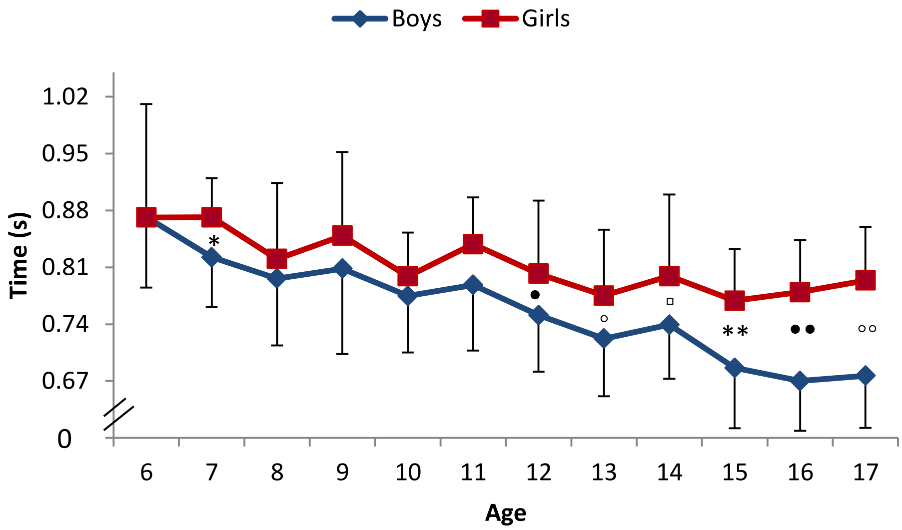


**Figure 4.9:** The average 2.5m barefoot sprinting time (s) for boys vs girls at different ages (years) (data are presented as means ± SD).

* p<0.05 statistical significant difference between boys and girls at age 7

• p<0.05 statistical significant difference between boys and girls at age 12

◦ p<0.05 statistical significant difference between boys and girls at age 13

▫ p<0.05 statistical significant difference between boys and girls at age 14

** p<0.05 statistical significant difference between boys and girls at age 15

•• p<0.05 statistical significant difference between boys and girls at age 16

◦◦ p<0.05 statistical significant difference between boys and girls at age 17

There was a statistical significant difference ($p<0.05$) for 5m sprinting speeds between boys and girls at age 7, 8, 12, 13, 14, 15, 16 and 17, with boys running faster times in the mentioned ages (**Figure 4.10**).

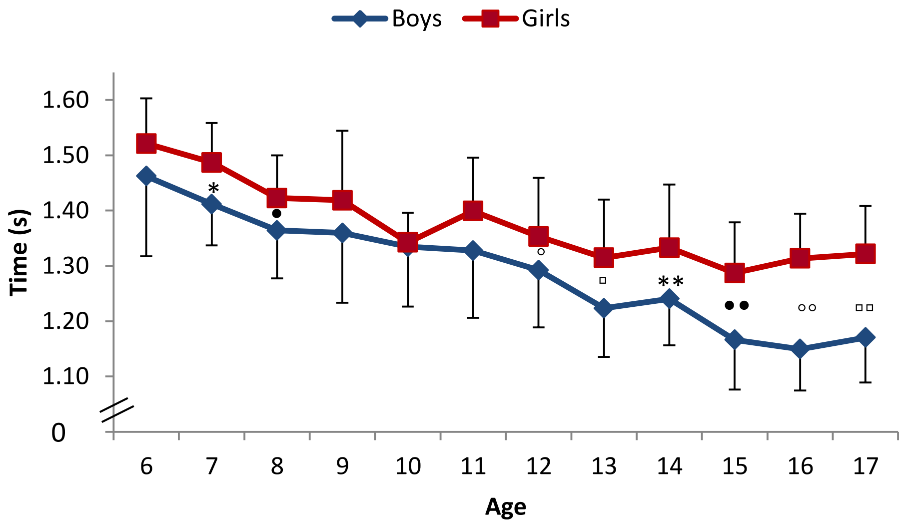


**Figure 4.10:** The average 5m barefoot sprinting time (s) for boys vs girls at different ages (years) (data are presented as means ± SD).

* $p<0.05$ statistical significant difference between boys and girls at age 7

• $p<0.05$ statistical significant difference between boys and girls at age 8

◦ $p<0.05$ statistical significant difference between boys and girls at age 12

▫ $p<0.05$ statistical significant difference between boys and girls at age 13

** $p<0.05$ statistical significant difference between boys and girls at age 14

•• $p<0.05$ statistical significant difference between boys and girls at age 15

◦◦ $p<0.05$ statistical significant difference between boys and girls at age 16

▫▫ $p<0.05$ statistical significant difference between boys and girls at age 17

At the 10m sprinting speed times for boys compered to girls shown in **Figure 4.11** found a statistical significant difference ($p<0.05$) at the ages of 7, 8, 11, 13, 14, 15, 16 and 17 was found. Boys run faster than girls throughout.

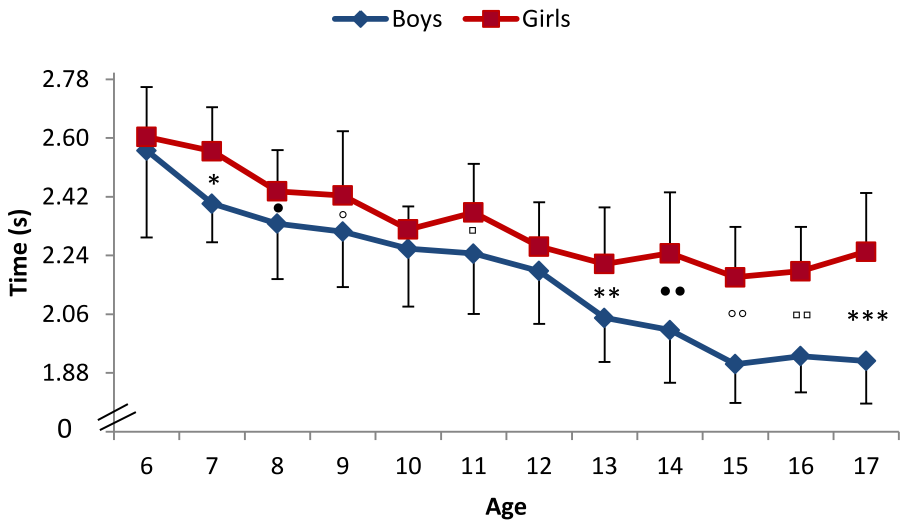


**Figure 4.11:** The average 10m barefoot sprinting time (s) for boys vs girls at different ages (years) (data are presented as means ± SD).

* p<0.05 statistical significant difference between boys and girls at age 8

• p<0.05 statistical significant difference between boys and girls at age 9

◦ p<0.05 statistical significant difference between boys and girls at age 11

▫ p<0.05 statistical significant difference between boys and girls at age 12

** p<0.05 statistical significant difference between boys and girls at age 13

•• p<0.05 statistical significant difference between boys and girls at age 14

◦◦ p<0.05 statistical significant difference between boys and girls at age 15

▫▫ p<0.05 statistical significant difference between boys and girls at age 16

*** p<0.05 statistical significant difference between boys and girls at age 17

The 20m sprinting times found in **Table 4.12** there were significant differences ($p<0.05$) at the ages of 7, 8, 10, 11, 13, 14, 15, 16 and 17 for the boys compared to the girls, boys with quicker times than the girls.

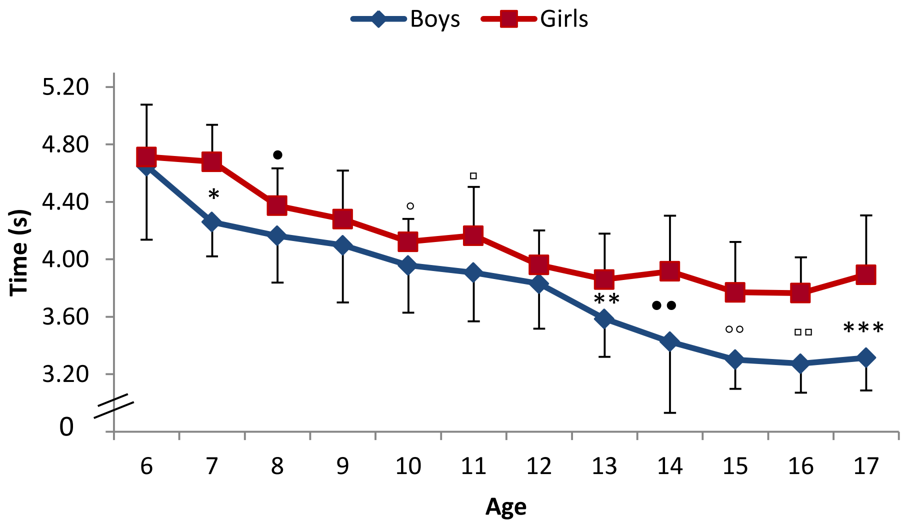


**Figure 4.12:** The average 20m barefoot sprinting time (s) for boys vs girls at different ages (years) (data are presented as means ± SD).

* $p<0.05$ statistical significant difference between boys and girls at age 8

• $p<0.05$ statistical significant difference between boys and girls at age 9

◦ $p<0.05$ statistical significant difference between boys and girls at age 11

▫ $p<0.05$ statistical significant difference between boys and girls at age 12

** $p<0.05$ statistical significant difference between boys and girls at age 13

•• $p<0.05$ statistical significant difference between boys and girls at age 14

◦◦ $p<0.05$ statistical significant difference between boys and girls at age 15

▫▫ $p<0.05$ statistical significant difference between boys and girls at age 16

*** $p<0.05$ statistical significant difference between boys and girls at age 17

### Girls shod sprinting

The shod sprinting (child's running shoes) data for girls in the various age group categories are represented in **Table 4.8**.

**Table 4.8:** The barefoot sprinting data for girls in age group categories (data are presented as means ± SD).

| Age groups | 6-8 | 9-10 | 11-13 | 14-17 |
|---|---|---|---|---|
| **n per age group** | 35 | 29 | 63 | 75 |
| **2.5m** (s) | 0.88 ± 0.10 | 0.84 ± 0.08 | 0.78 ± 0.10 | 0.74 ± 0.11 |
| **5m** (s) | 1.50 ± 0.13 | 1.41 ± 0.12 | 1.33 ± 0.12 | 1.26 ± 0.13 |
| **10m** (s) | 2.44 ± 0.19 | 2.27 ± 0.16 | 2.09 ± 0.19 | 2.04 ± 0.24 |
| **20m** (s) | 4.36 ± 0.39 | 3.97 ± 0.32 | 3.62 ± 0.38 | 3.54 ± 0.44 |

With the 2.5m shod sprinting test for girls, the age group 6-8 was significantly ($p<0.05$) slower than age group 11-13. There were not any significant differences ($p>0.05$) between the other age groups.

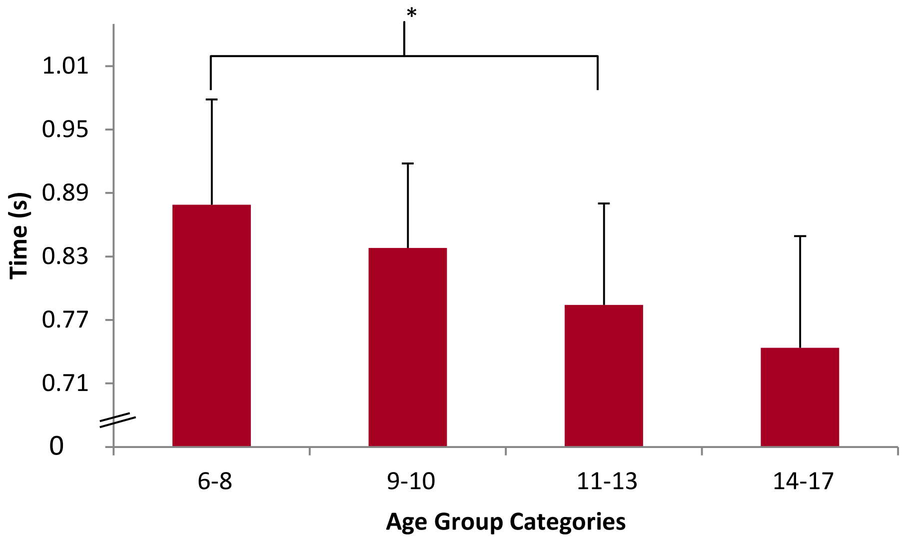


**Figure 4.13:** The average 2.5m shod sprinting time (s) in age group categories (years) for girls (data are presented as means ± SD).

* $p<0.05$ statistical significant difference between age group 6-9 and age group 11-13

The 5m shod sprinting test, shown in **Figure 4.14**, the age group 6-8 was significantly ($p<0.05$) slower than age group 11-13 and age group 14-17. No significant differences ($p>0.05$) could be found between the other age groups.

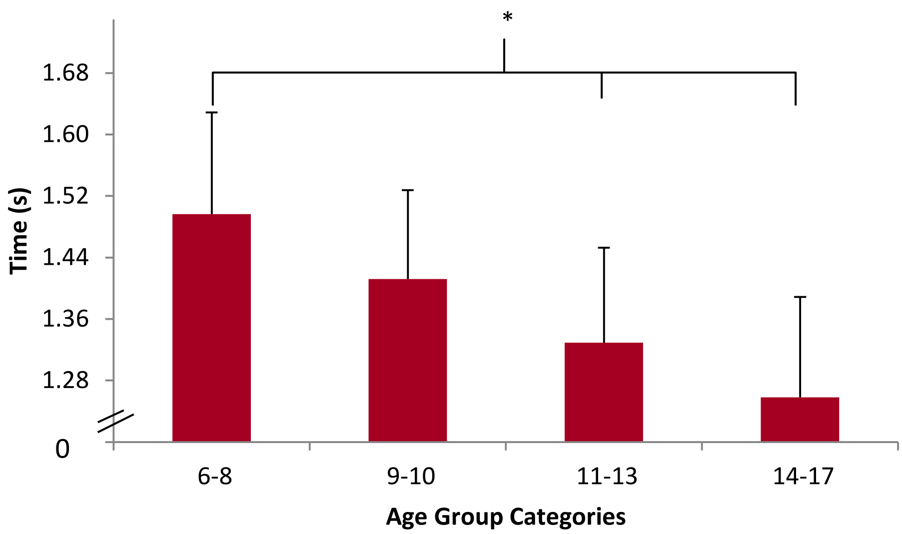


**Figure 4.14:** The average 5m shod sprinting time (s) in age group categories (years) for girls (data are presented as means ± SD).

* p<0.05 statistical significant difference between age group 6-9, age group 11-13 and age group 14-17

As indicated by **Figure 4.15** and **Figure 4.16**, the 10m and 20m shod sprinting tests for girls respectively showed that age group 6-8 were statistical significant (p<0.05) slower than age group 9-10, age group 11-13 and age group 14-17. For the rest of the age groups no significant difference (p>0.05) could be found between them.

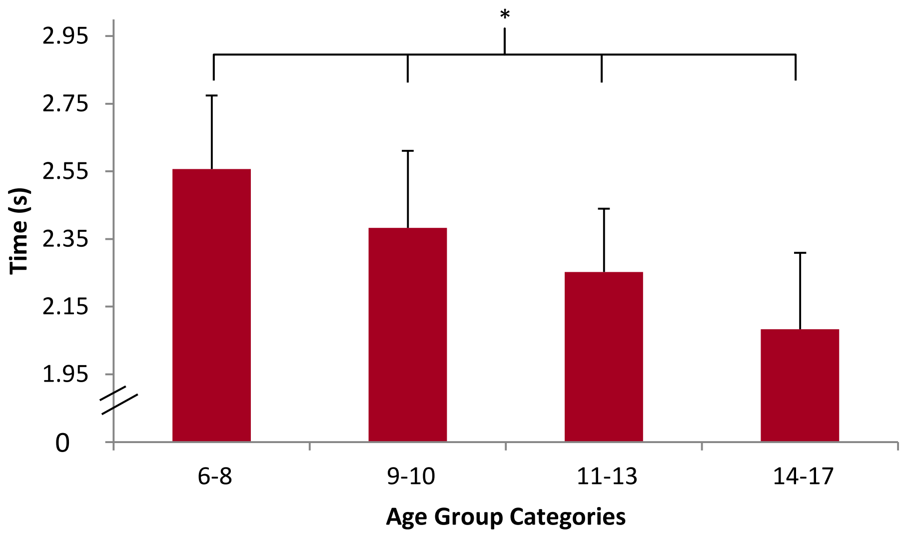


**Figure 4.15:** The average 10m shod sprinting time (s) in age group categories (years) for girls (data are presented as means ± SD).

* p<0.05 statistical significant difference between age group 6-9 and all three of the other age groups

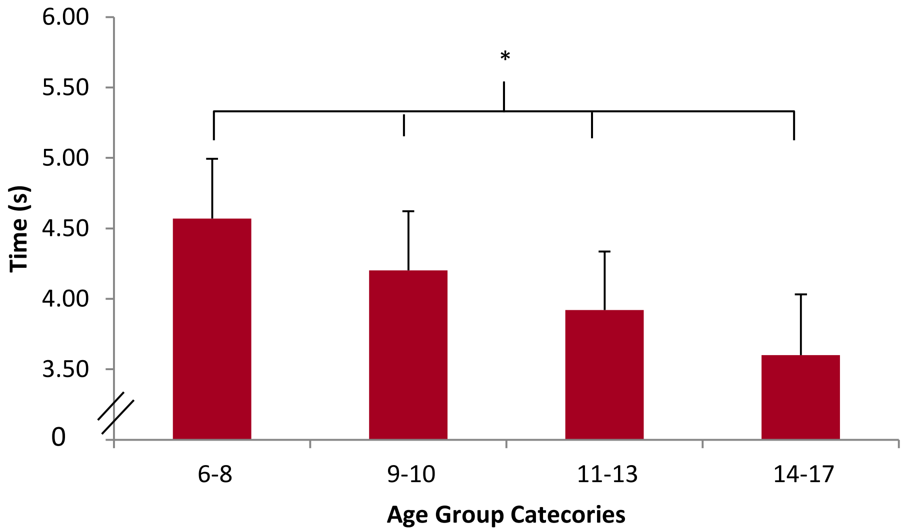


**Figure 4.16:** The average 20m shod sprinting time (s) in age group categories (years) for girls (data are presented as means ± SD).

* p<0.05 statistical significant difference between age group 6-9 and all three of the other age groups

**Boys shod sprinting**

**Table 4.9** shows the shod sprinting data for boys according to the four age group categories.

**Table 4.9:** The shod sprinting data for boys in age group categories (data are presented as means ± SD).

| Age groups | 6-9 | 10-12 | 13-16 | 17 |
|---|---|---|---|---|
| **n per age group** | 42 | 62 | 67 | 18 |
| **2.5m** (s) | 0.87 ± 0.09 | 0.80 ± 0.09 | 0.75 ± 0.10 | 0.74 ± 0.11 |
| **5m** (s) | 1.48 ± 0.13 | 1.36 ± 0.12 | 1.26 ± 0.13 | 1.26 ± 0.13 |
| **10m** (s) | 2.50 ± 0.25 | 2.31 ± 0.17 | 2.12 ± 0.21 | 2.05 ± 0.23 |
| **20m** (s) | 4.46 ± 0.46 | 4.05 ± 0.35 | 3.66 ± 0.41 | 3.54 ± 0.51 |

The age group 6-9 were significantly ($p<0.05$) slower than age group 10-12, age group 13-16 and age group 17 in the 2.5m shod sprinting for boys (**Figure 4.17**). There were not any significant differences ($p>0.05$) between the other age groups.

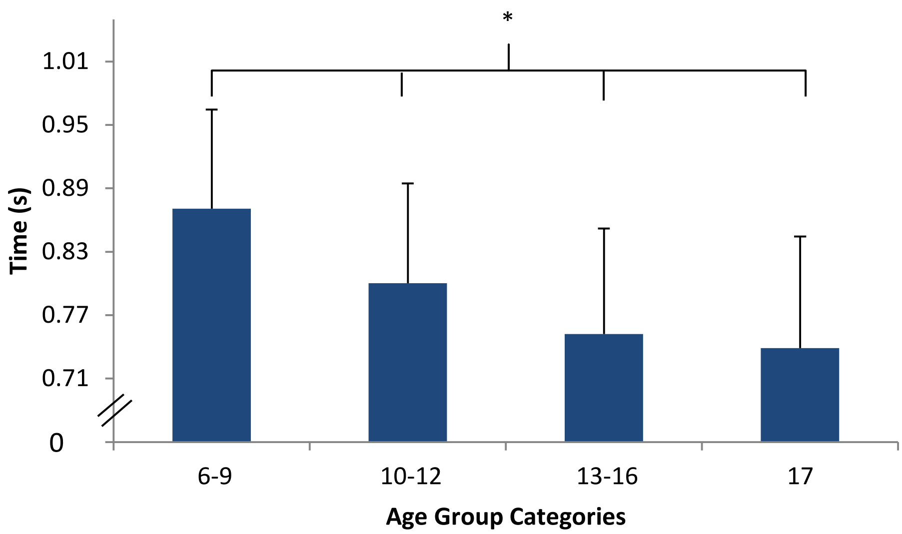


**Figure 4.17:** The average 2.5m shod sprinting time (s) in age group categories (years) for boys (data are presented as means ± SD).

* p<0.05 statistical significant difference between age group 6-9 and the other three age groups

**Figure 4.18**, **Figure 4.19** and **Figure 4.20** respectively have shown that during the shod sprinting for 5m, 10m and 20m for boys, the 6-9 age group run significantly (p<0.05) slower than age group 10-12, age group 13-16 and age group 17. Age group 10-12 were also significantly (p<0.05) slower than the boys in age group 13-16 and age group 17. No significant difference (p>0.05) could be found for age group 13-16 with age group 17.

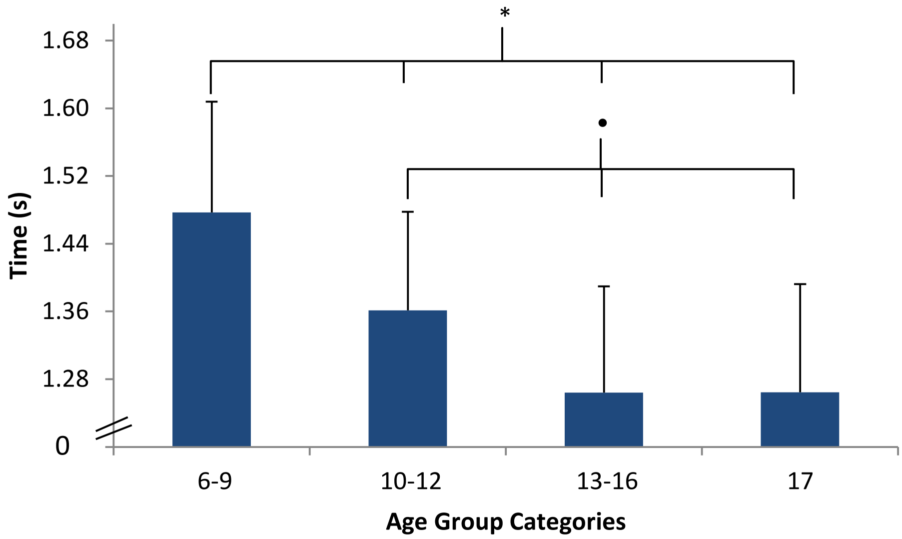


**Figure 4.18:** The average 5m shod sprinting time (s) in age group categories (years) for boys (data are presented as means ± SD).

* $p<0.05$ statistical significant difference between age group 6-9 and the other three age groups

• $p<0.05$ statistical significant difference between age group 10-12, age group 13-16 and age group 17

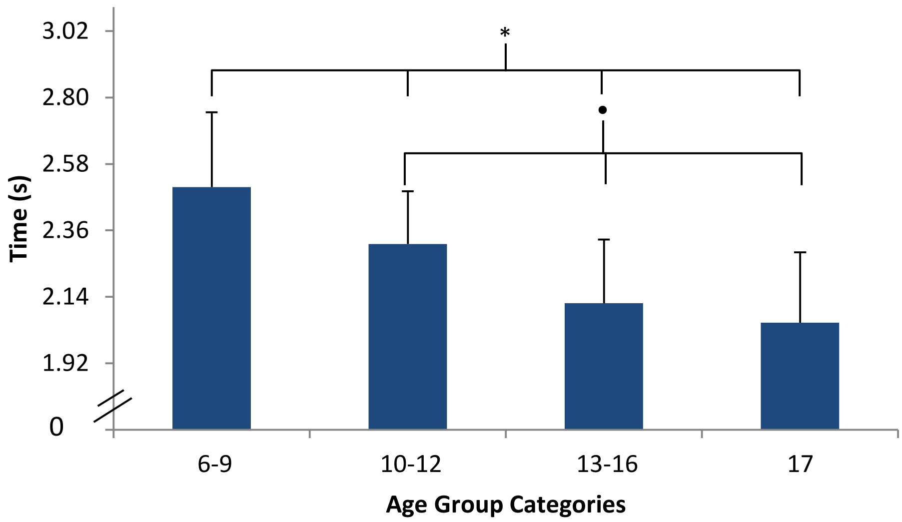


**Figure 4.19:** The average 10m shod sprinting time (s) in age group categories (years) for boys (data are presented as means ± SD).

* $p<0.05$ statistical significant difference between age group 6-9 and the other three age groups

• $p<0.05$ statistical significant difference between age group 10-12, age group 13-16 and age group 17

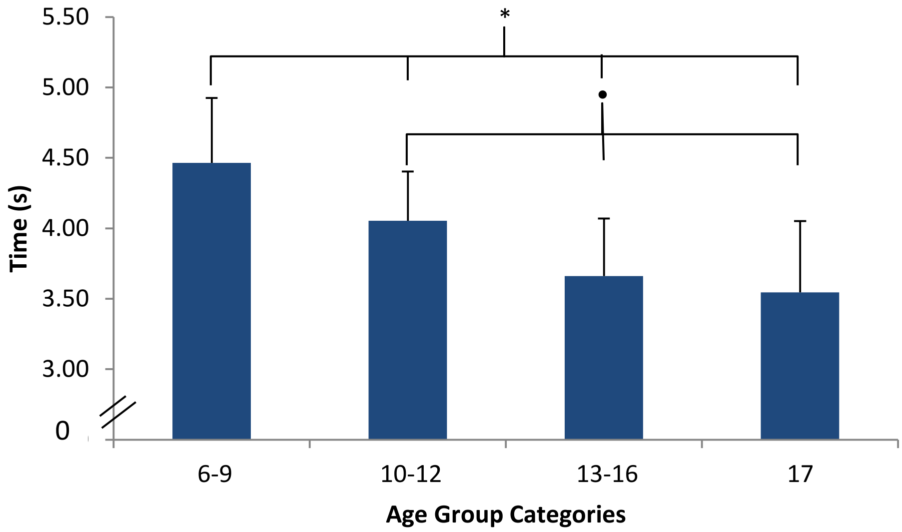


**Figure 4.20:** The average 20m shod sprinting time (s) in age group categories (years) for boys (data are presented as means ± SD).

* p<0.05 statistical significant difference between age group 6-9 and the other three age groups

• p<0.05 statistical significant difference between age group 10-12, age group 13-16 and age group 17

**Shod sprinting speed comparison between boys and girls**

**Table 4.10** and **table 4.11** represent the means and standard deviations of the sprinting times at 2.5m, 5m, 10m and 20m for the age groups and gender groups.

**Table 4.10:** The shod average sprinting times (s) for boys and girls between the ages 6 and 11 years old (data are presented as means ± SD).

| **Age** | **6** n=13 | | **7** n=14 | | **8** n=33 | | **9** n=37 | | **10** n=30 | | **11** n=29 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Gender** | **Boys** | **Girls** | **Boys** | **Girls** | **Boys** | **Girls** | **Boys** | **Girls** | **Boys** | **Girls** | **Boys** | **Girls** |
| **n** | 5 | 8 | 9 | 5 | 11 | 22 | 17 | 20 | 21 | 9 | 14 | 15 |
| **2.5m** (s) | 0.95 ± 0.07 | 0.95 ± 0.10 | 0.90 ± 0.06 | 0.98 ± 0.12 | 0.81 ± 0.05 | 0.84 ± 0.10 | 0.84 ± 0.10 | 0.87 ± 0.07 | 0.80 ± 0.07 | 0.84 ± 0.06 | 0.77 ± 0.08 | 0.84 ± 0.14 |
| **5m** (s) | 1.61 ± 0.13 | 1.57 ± 0.14 | 1.49 ± 0.08 | 1.66 ± 0.15 | 1.42 ± 0.08 | 1.45 ± 0.11 | 1.42 ± 0.14 | 1.47 ± 0.10 | 1.35 ± 0.10 | 1.41 ± 0.08 | 1.32 ± 0.12 | 1.44 ± 0.09 |
| **10m** (s) | 2.77 ± 0.24 | 2.69 ± 0.20 | 2.54 ± 0.13 | 2.82 ± 0.22 | 2.40 ± 0.14 | 2.48 ± 0.18 | 2.42 ± 0.20 | 2.42 ± 0.32 | 2.31 ± 0.18 | 2.41 ± 0.10 | 2.26 ± 0.17 | 2.42 ± 0.15 |
| **20m** (s) | 5.07 ± 0.55 | 4.84 ± 0.36 | 4.45 ± 0.27 | 5.07 ± 0.36 | 4.26 ± 0.32 | 4.45 ± 0.30 | 4.27 ± 0.31 | 4.31 ± 0.58 | 4.03 ± 0.35 | 4.24 ± 0.17 | 3.99 ± 0.41 | 4.25 ± 0.33 |

**Table 4.11:** The shod average sprinting times (s) for boys and girls between the ages 12 and 17 years old (data are presented as means ± SD).

| **Age** | 12 n=46 | | 13 n=47 | | 14 n= 32 | | 15 n=37 | | 16 n=40 | | 17 n=33 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Gender** | **Boys** | **Girls** | **Boys** | **Girls** | **Boys** | **Girls** | **Boys** | **Girls** | **Boys** | **Girls** | **Boys** | **Girls** |
| **n** | 27 | 19 | 18 | 29 | 14 | 18 | 22 | 15 | 13 | 27 | 18 | 15 |
| **2.5m** (s) | 0.76 ± 0.08 | 0.83 ± 0.09 | 0.74 ± 0.07 | 0.78 ± 0.09 | 0.69 ± 0.12 | 0.82 ± 0.09 | 0.69 ± 0.09 | 0.78 ± 0.10 | 0.68 ± 0.04 | 0.79 ± 0.09 | 0.69 ± 0.09 | 0.80 ± 0.09 |
| **5m** (s) | 1.31 ± 0.13 | 1.39 ± 0.12 | 1.25 ± 0.08 | 1.30 ± 0.12 | 1.22 ± 0.08 | 1.35 ± 0.13 | 1.15 ± 0.09 | 1.31 ± 0.14 | 1.15 ± 0.05 | 1.32 ± 0.11 | 1.20 ± 0.09 | 1.33 ± 0.11 |
| **10m** (s) | 2.25 ± 0.19 | 2.32 ± 0.16 | 2.13 ± 0.15 | 2.20 ± 0.18 | 2.03 ± 0.13 | 2.29 ± 0.22 | 1.91 ± 0.15 | 2.20 ± 0.19 | 1.91 ± 0.14 | 2.21 ± 0.16 | 1.92 ± 0.13 | 2.24 ± 0.17 |
| **20m** (s) | 3.95 ± 0.35 | 4.03 ± 0.31 | 3.59 ± 0.50 | 3.85 ± 0.35 | 3.54 ± 0.20 | 4.02 ± 0.47 | 3.29 ± 0.22 | 3.81 ± 0.41 | 3.32 ± 0.19 | 3.77 ± 0.24 | 3.36 ± 0.23 | 3.93 ± 0.36 |

**Figure 4.21** to **Figure 4.24** represent the shod sprinting times of the boys compared to the girls at the different ages. **Figure 4.21** indicates that at the 2.5m sprinting times there were significant differences ($p<0.05$) at the ages 12, 14, 15, 16 and 17.

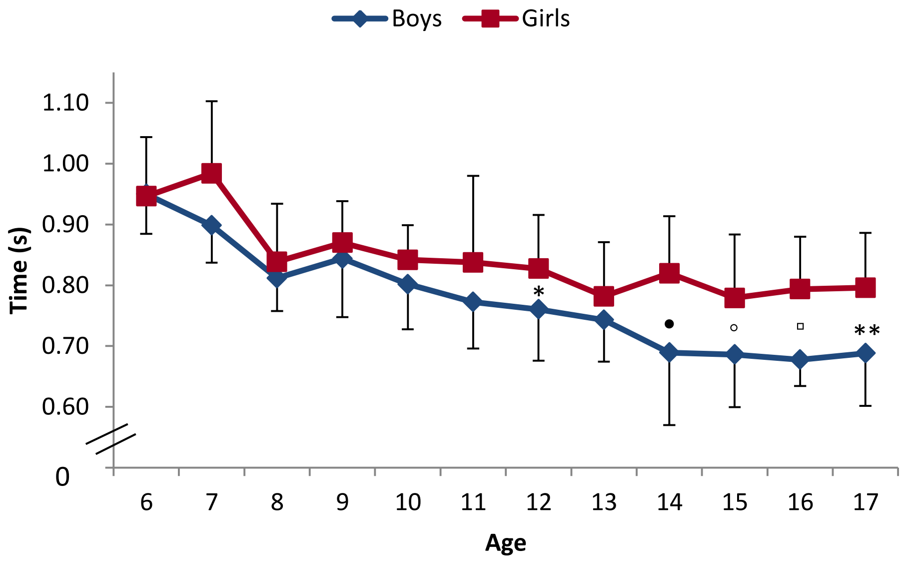


**Figure 4.21:** The average 2.5m shod sprinting time (s) for boys vs girls at different ages (years) (data are presented as means ± SD).

* $p<0.05$ statistical significant difference between boys and girls at age 12

• $p<0.05$ statistical significant difference between boys and girls at age 14

◦ $p<0.05$ statistical significant difference between boys and girls at age 15

▫ $p<0.05$ statistical significant difference between boys and girls at age 16

** $p<0.05$ statistical significant difference between boys and girls at age 17

In **Figure 4.22** there were significant differences (p<0.05) found at the age of 11, 12, 14, 15, 16 and 17 for the 5m sprinting times between boys and girls.

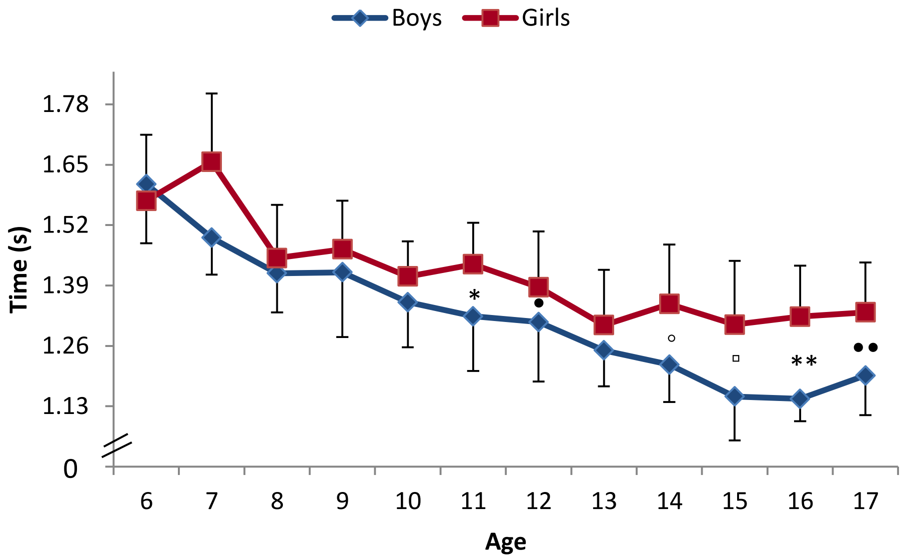


**Figure 4.22:** The average 5m shod sprinting time (s) for boys vs girls at different ages (years) (data are presented as means ± SD).

* p<0.05 statistical significant difference between boys and girls at age 11

• p<0.05 statistical significant difference between boys and girls at age 12

◦ p<0.05 statistical significant difference between boys and girls at age 14

▫ p<0.05 statistical significant difference between boys and girls at age 15

** p<0.05 statistical significant difference between boys and girls at age 16

•• p<0.05 statistical significant difference between boys and girls at age 17

**Figure 4.23** shows significant differences ($p<0.05$) between boys and girls for the 10m sprinting times at ages 11, 14, 15, 16 and 17.

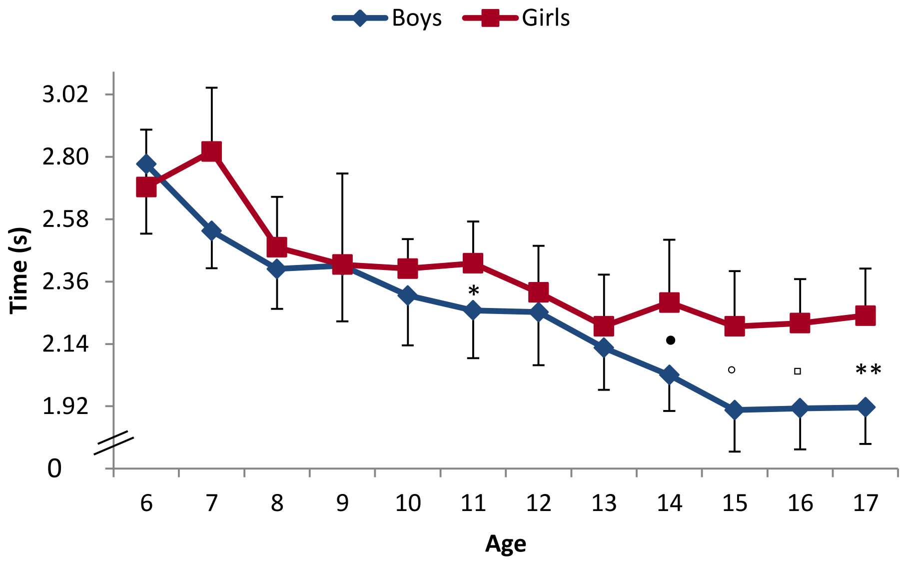


**Figure 4.23:** The average 10m shod sprinting time (s) for boys vs girls at different ages (years) (data are presented as means ± SD).

* $p<0.05$ statistical significant difference between boys and girls at age 11

• $p<0.05$ statistical significant difference between boys and girls at age 14

◦ $p<0.05$ statistical significant difference between boys and girls at age 15

▫ $p<0.05$ statistical significant difference between boys and girls at age 16

** $p<0.05$ statistical significant difference between boys and girls at age 17

In **Figure 4.24** there are significant differences ($p<0.05$) at ages 6, 7, 14, 15, 16 and 17 for the 20m sprinting times for boys compared to the girls.

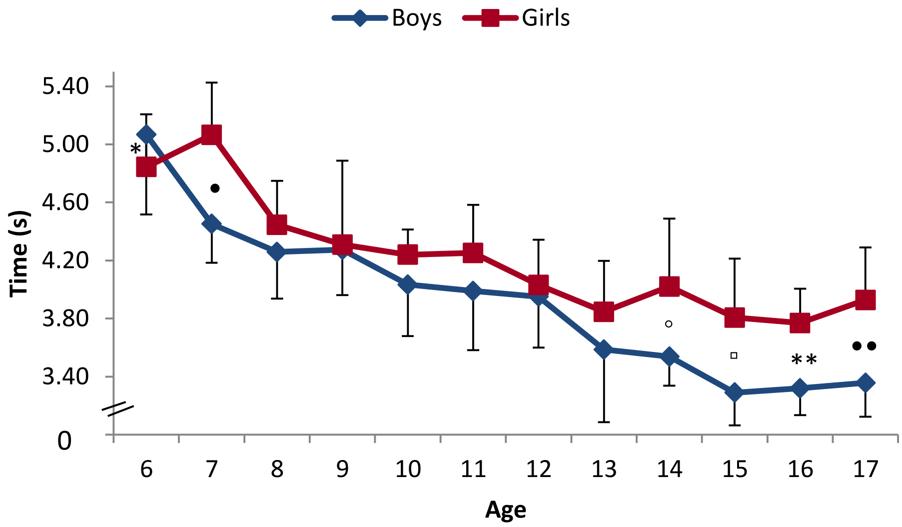


**Figure 4.24:** The average 20m shod sprinting time (s) for boys vs girls at different ages (years) (data are presented as means ± SD).

* $p<0.05$ statistical significant difference between boys and girls at age 6

• $p<0.05$ statistical significant difference between boys and girls at age 7

◦ $p<0.05$ statistical significant difference between boys and girls at age 14

▫ $p<0.05$ statistical significant difference between boys and girls at age 15

** $p<0.05$ statistical significant difference between boys and girls at age 16

•• $p<0.05$ statistical significant difference between boys and girls at age 17

### Barefoot and shod SLJ data for girls

The SLJ data for girls performed barefoot and shod conditions in the various age group categories are presented in age **Table 4.12**.

**Table 4.12:** The barefoot (BF) and shod (SH) SLJ distance (m) data for girls in age group categories (data are presented as means ± SD).

| Age groups | 6-8 | 9-10 | 11-13 | 14-17 |
|---|---|---|---|---|
| **n** | 57 | 41 | 88 | 89 |
| **BF SLJ** (m) | 1.16 ± 0.16 | 1.29 ± 0.18 | 1.45 ± 0.24 | 1.57 ± 0.25 |
| **n** | 34 | 29 | 83 | 89 |
| **SH SLJ** (m) | 1.16 ± 0.17 | 1.30 ± 0.20 | 1.45 ± 0.24 | 1.54 ± 0.27 |

When girls performed the SLJ test barefoot the following were observed. The age group 6-8 jumped significantly ($p<0.05$) shorter than age group 9-10, age group 11-13 and age group 14-17. Age group 9-10 also jumped significantly ($p<0.05$) shorter than age group 14-17. There was not a significant difference ($p>0.05$) among the other age groups.

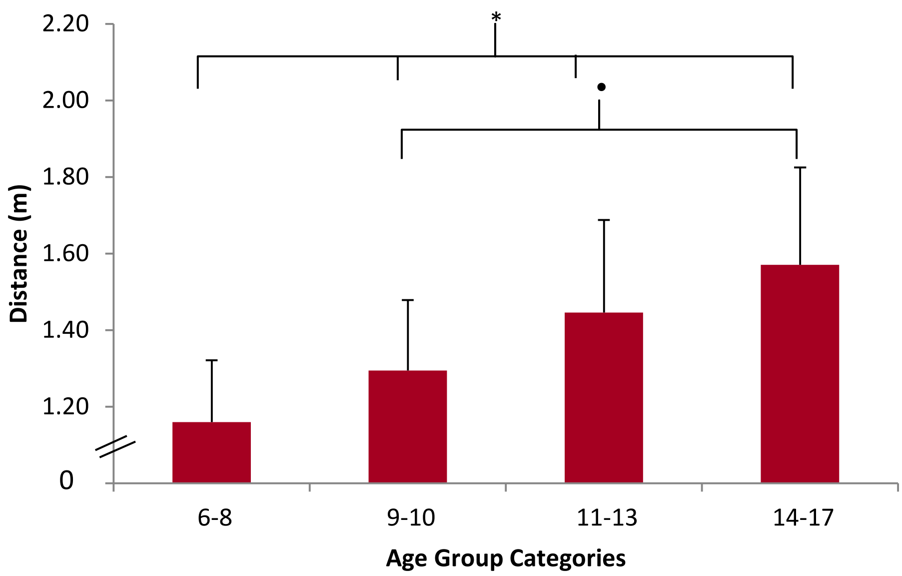


**Figure 4.25:** The average barefoot SLJ distance (m) for girls at different age group categories (years) (data are presented as means ± SD).

* $p<0.05$ statistical significant difference between age group 6-8 and the other three age groups

• $p<0.05$ statistical significant difference between age group 9-10 and age group 14-17

During the shod testing condition for girls the following observations were made: The age group 6-8 jumped significantly ($p<0.05$) shorter than age group 11-13 and age group 14-17. No significant difference ($p>0.05$) could be found between the rest of the age groups.

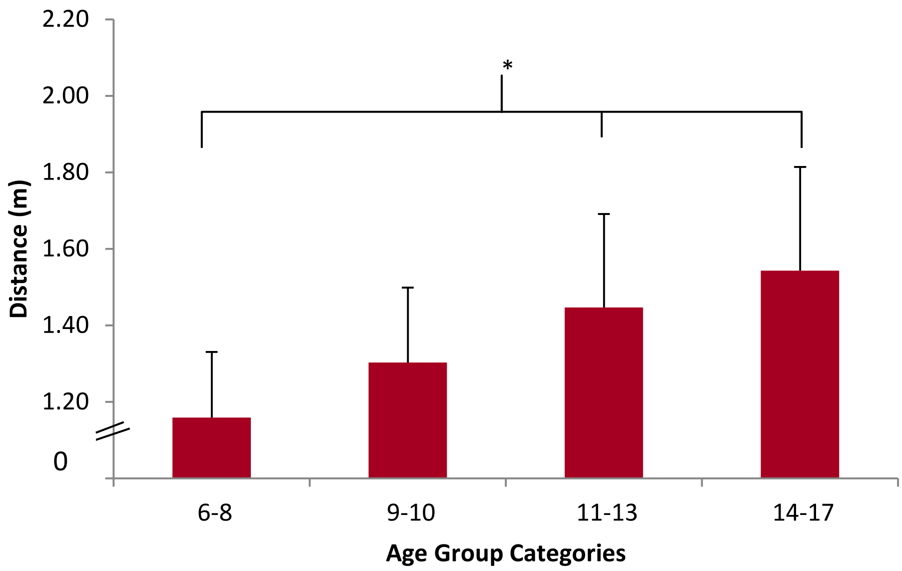


**Figure 4.26:** The average shod SLJ distance (m) for girls at different age group categories (years) (data are presented as means ± SD).

* $p<0.05$ statistical significant difference between age group 6-8 and the other three age groups

**Barefoot and shod SLJ data for boys**

In **Table 4.13**, the data of the SLJ for boy are represented for the various age group categories as well as for the barefoot and shod conditions.

**Table 4.13:** The barefoot (BF) and shod (SH) SLJ distance (m) data for boys in age group categories (data are presented as means ± SD).

| Age groups | 6-9 | 10-12 | 13-16 | 17 |
|---|---|---|---|---|
| **n** | 64 | 78 | 105 | 28 |
| **BF SLJ** (m) | 1.32 ± 0.20 | 1.50 ± 0.22 | 1.93 ± 0.25 | 2.11 ± 0.24 |
| **n** | 41 | 63 | 74 | 21 |
| **SH SLJ** (m) | 1.30 ± 0.21 | 1.44 ± 0.24 | 1.92 ± 0.26 | 2.14 ± 0.24 |

In the SLJ test for the boys that between the age groups and the two different footwear conditions, barefoot (**Figure 4.27**) and shod (**Figure 4.28**) respectively, the following results were observed. The age group 6-9 jumped significantly ($p<0.05$) shorter than age group 10-12, age group 13-16 and age group 17. Further the age group 10-12 jumped significantly ($p<0.05$) shorter than age group 13-16 and age group 17. Lastly the age group 13-16 also jumped significantly ($p<0.05$) shorter than age group 17.

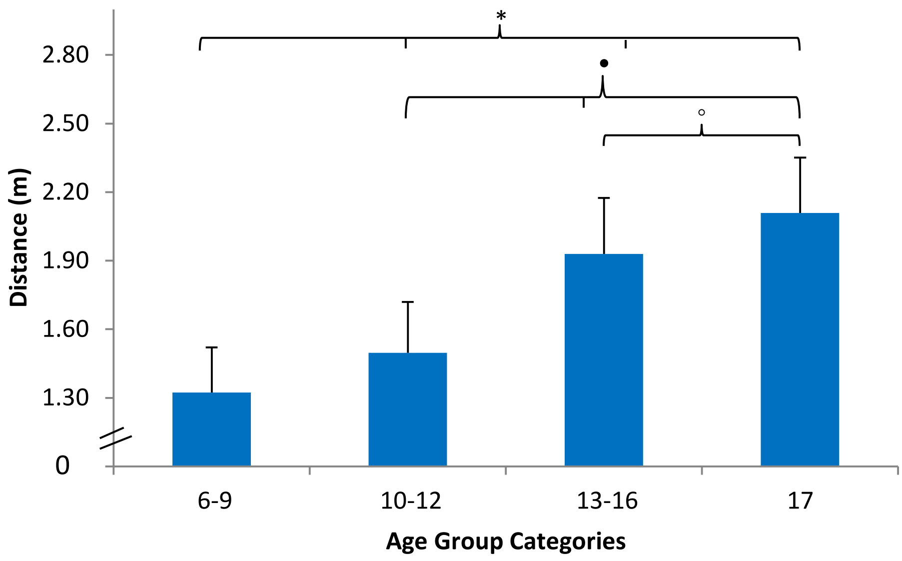


**Figure 4.27:** The average barefoot SLJ distance (m) for boys at different age group categories (years) (data are presented as means ± SD).

* $p<0.05$ statistical significant difference between age group 6-9 and the other three age groups

• $p<0.05$ statistical significant difference between age group 10-12, age group 13-16 and age group 17

◦ $p<0.05$ statistical significant difference between age group 13-16 and age group 17

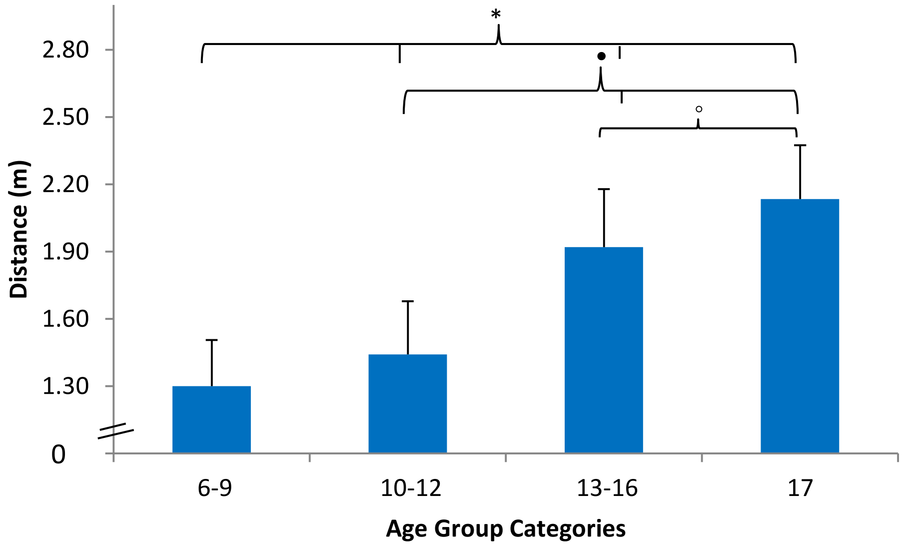


**Figure 4.28:** The average shod SLJ distance (m) for boys at different age group categories (years) (data are presented as means ± SD).

* $p<0.05$ statistical significant difference between age group 6-9 and the other three age groups

• $p<0.05$ statistical significant difference between age group 10-12, age group 13-16 and age group 17

◦ $p<0.05$ statistical significant difference between age group 13-16 and age group 17

### Barefoot and shod SLJ comparison between boys and girls

**Table 4.14**, **Table 4.15**, **Table 4.16** and **Table 4.17** represent the means and standard deviations of the SLJ distance jumped for the age groups and gender groups.

**Table 4.14:** Barefoot (BF) average SLJ distance (m) for boys and girls between the ages 6 and 11 years old (data are presented as means ± SD).

| **Age** | **6** n=15 | | **7** n=27 | | **8** n=49 | | **9** n=46 | | **10** n=44 | | **11** n=35 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Gender** | **Boys** | **Girls** | **Boys** | **Girls** | **Boys** | **Girls** | **Boys** | **Girls** | **Boys** | **Girls** | **Boys** | **Girls** |
| **n** | 12 | 13 | 15 | 12 | 17 | 32 | 20 | 26 | 29 | 15 | 15 | 20 |
| **BF SLJ** (m) | 1.13 ± 0.18 | 1.10 ± 0.18 | 1.36 ± 0.16 | 1.08 ± 0.13 | 1.36 ± 0.19 | 1.22 ± 0.14 | 1.38 ± 0.18 | 1.27 ± 0.18 | 1.47 ± 0.25 | 1.34 ± 0.19 | 1.47 ± 0.22 | 1.35 ± 0.19 |

**Table 4.15:** Barefoot (BF) average SLJ distance (m) for boys and girls between the ages 12 and 17 years old (data are presented as means ± SD).

| **Age** | **12** n=61 | | **13** n=69 | | **14** n=38 | | **15** n=49 | | **16** n=62 | | **17** n=45 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Gender** | **Boys** | **Girls** | **Boys** | **Girls** | **Boys** | **Girls** | **Boys** | **Girls** | **Boys** | **Girls** | **Boys** | **Girls** |
| **n** | 34 | 27 | 28 | 41 | 18 | 20 | 32 | 17 | 27 | 35 | 28 | 17 |
| **BF SLJ** (m) | 1.53 ± 0.19 | 1.43 ± 0.22 | 1.73 ± 0.21 | 1.50 ± 0.26 | 1.88 ± 0.23 | 1.50 ± 0.28 | 2.04 ± 0.21 | 1.60 ± 0.27 | 2.03 ± 0.20 | 1.63 ± 0.19 | 2.09 ± 0.21 | 1.57 ± 0.27 |

**Table 4.16:** Shod (SH) average SLJ distance (m) for boys and girls between the ages 6 and 11 years old (data are presented as means ± SD).

| **Age** | **6** n=13 | | **7** n=14 | | **8** n=33 | | **9** n=36 | | **10** n=31 | | **11** n=29 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Gender** | **Boys** | **Girls** | **Boys** | **Girls** | **Boys** | **Girls** | **Boys** | **Girls** | **Boys** | **Girls** | **Boys** | **Girls** |
| **n** | 5 | 8 | 9 | 5 | 11 | 21 | 16 | 20 | 22 | 9 | 14 | 15 |
| **SH SLJ** (m) | 1.09 ± 0.27 | 1.12 ± 0.18 | 1.29 ± 0.19 | 1.03 ± 0.09 | 1.34 ± 0.21 | 1.22 ± 0.15 | 1.35 ± 0.16 | 1.27 ± 0.20 | 1.45 ± 0.26 | 1.38 ± 0.16 | 1.38 ± 0.23 | 1.33 ± 0.20 |

**Table 4.17:** Shod (SH) average SLJ distance (m) for boys and girls between the ages 12 and 17 years old (data are presented as means ± SD).

| **Age** | **12** n=46 | | **13** n=50 | | **14** n=34 | | **15** n=39 | | **16** n=42 | | **17** n=36 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Gender** | **Boys** | **Girls** | **Boys** | **Girls** | **Boys** | **Girls** | **Boys** | **Girls** | **Boys** | **Girls** | **Boys** | **Girls** |
| **n** | 27 | 19 | 20 | 30 | 15 | 19 | 24 | 15 | 15 | 27 | 21 | 15 |
| SH SLJ (m) | 1.47 ± 0.23 | 1.42 ± 0.23 | 1.73 ± 0.21 | 1.52 ± 0.25 | 1.85 ± 0.24 | 1.45 ± 0.31 | 2.03 ± 0.24 | 1.58 ± 0.26 | 2.07 ± 0.19 | 1.63 ± 0.20 | 2.12 ± 0.23 | 1.53 ± 0.29 |

**Figure 4.29** and **Figure 4.30** represent the distance for barefoot and shod jumping respectively at the different ages for the boys compared to the girls. **Figure 4.29** showed that there were significant differences (p<0.05) at ages 7, 8, 9, 13, 14, 15, 16 and 17.

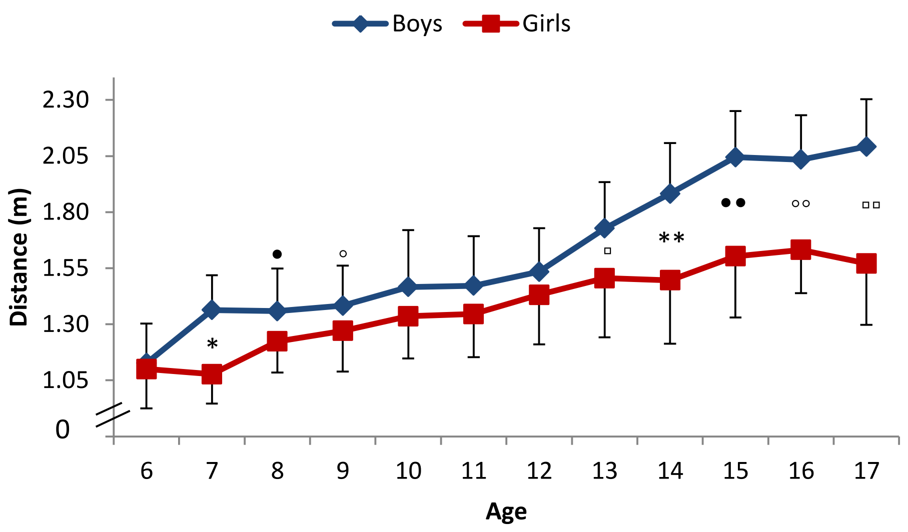


**Figure 4.29:** The average barefoot SLJ distance (m) for boys vs girls at different ages (years) (data are presented as means ± SD).

* p<0.05 statistical significant difference between boys and girls at age 7

• p<0.05 statistical significant difference between boys and girls at age 8

◦ p<0.05 statistical significant difference between boys and girls at age 9

▫ p<0.05 statistical significant difference between boys and girls at age 13

** p<0.05 statistical significant difference between boys and girls at age 14

•• p<0.05 statistical significant difference between boys and girls at age 15

◦◦ p<0.05 statistical significant difference between boys and girls at age 16

▫▫ p<0.05 statistical significant difference between boys and girls at age 17

There were significant differences (p<0.05) between the boys and girls at the ages of 7, 13, 14, 15, 16 and 17 (**Figure 4.30**).

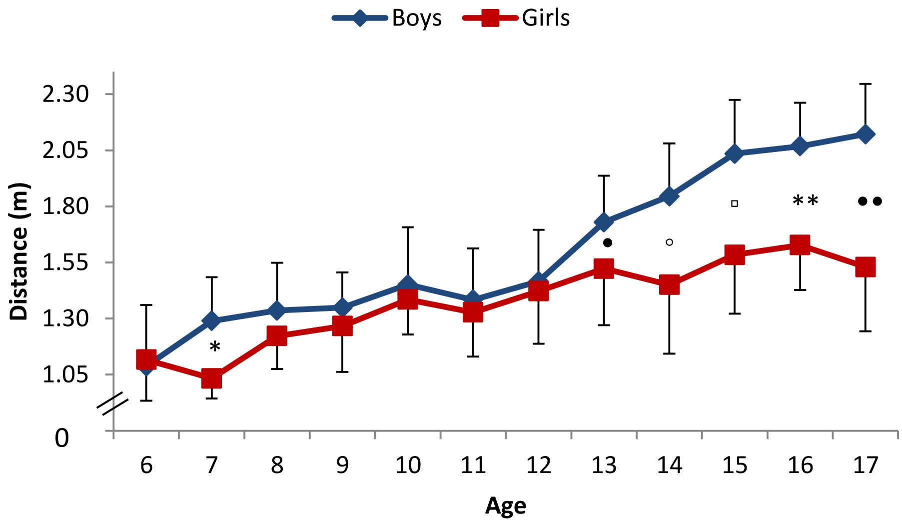


**Figure 4.30:** The average shod SLJ distance (m) for boys vs girls at different ages (years) (data are presented as means ± SD).

* p<0.05 statistical significant difference between boys and girls at age 7

• p<0.05 statistical significant difference between boys and girls at age 8

◦ p<0.05 statistical significant difference between boys and girls at age 9

▫ p<0.05 statistical significant difference between boys and girls at age 13

** p<0.05 statistical significant difference between boys and girls at age 14

•• p<0.05 statistical significant difference between boys and girls at age 15

### The handgrip strength of boys and girls

The two tables below provide the handgrip strength data for the left and right hands' for boys and girls in the various age group categories (**Table 4.18** and **Table 4.19**).

**Table 4.18:** The handgrip strength data for girls in age group categories (data are presented as means ± SD).

| Age groups | 6-8 | 9-10 | 11-13 | 14-17 |
|---|---|---|---|---|
| **n** | 54 | 41 | 88 | 88 |
| **Left hand** (kg) | 11.50 ± 3.95 | 15.04 ± 3.98 | 21.58 ± 5.10 | 27.22 ± 5.39 |
| **Right hand** (kg) | 12.10 ± 3.11 | 15.92 ± 2.69 | 22.91 ± 4.97 | 28.67 ± 5.46 |

**Table 4.19:** The handgrip strength data for boys in age group categories (data are presented as means ± SD).

| Age groups | 6-9 | 10-12 | 13-16 | 17 |
|---|---|---|---|---|
| **n** | 57 | 77 | 104 | 28 |
| **Left hand** (kg) | 14.43 ± 4.10 | 20.72 ± 4.57 | 37.64 ± 9.42 | 48.87 ± 8.37 |
| **Right hand** (kg) | 15.00 ± 4.48 | 21.45 ± 4.62 | 38.71 ± 9.61 | 48.40 ± 7.62 |

The grip strength for girls in the age group 6-8 were significantly ($p<0.05$) less than for age group 9-10, age group 11-13 and age group 14-17. For the age group 9-10 grip strength were significantly ($p<0.05$) less than for age group 11-13 and age group 14-17. Lastly the grip strength for age group 11-13 was also significantly ($p<0.05$) less than for age group 14-17 (**Table 4.18**).

The grip strength for in boys age group 6-9 were significantly (p<0.05) less than for age group 10-12, age group 13-16 and age group 17. In age group 10-12 the grip strength were also significantly (p<0.05) less than for age group 13-16 and age group 17. Lastly, the grip strength for age group 13-16 was also significantly (p<0.05) less than age group 17 (**Table 4.19**).

**Table 4.20 and Table 4.21** indicate that the handgrip strength for girls and boys increases with age for both left and right hand.

**Table 4.20:** The average left and right hand, handgrip strength for boys and girls between the ages 6 and 11 years old (data are presented as means ± SD).

| **Age** | **6** n=22 | | **7** n=26 | | **8** n=44 | | **9** n=46 | | **10** n=44 | | **11** n=34 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Gender** | **Boys** | **Girls** | **Boys** | **Girls** | **Boys** | **Girls** | **Boys** | **Girls** | **Boys** | **Girls** | **Boys** | **Girls** |
| **n** | 11 | 11 | 14 | 12 | 12 | 31 | 20 | 26 | 29 | 15 | 14 | 20 |
| **Left** (kg) | 10.3 ± 2.36 | 10.1 ± 2.88 | 12.5 ± 2.31 | 10.0 ± 2.19 | 15.0 ± 2.29 | 12.6 ± 2.89 | 17.7 ± 3.95 | 14.4 ± 3.26 | 18.8 ± 3.48 | 16.2 ± 2.07 | 19.9 ± 3.54 | 16.6 ± 3.42 |
| **Right** (kg) | 10.5 ± 2.53 | 10.6 ± 2.53 | 12.8 ± 2.05 | 10.5 ± 2.17 | 16.5 ± 3.76 | 13.3 ± 3.21 | 18.1 ± 4.19 | 15.7 ± 2.99 | 19.7 ± 3.77 | 16.4 ± 2.11 | 21.2 ± 3.58 | 18.6 ± 3.84 |

**Table 4.21:** The average left and right hand, handgrip strength for boys and girls between the ages 12 and 17 years old (data are presented as means ± SD).

| **Age** | 12 n=61 | | 13 n=68 | | 14 n=38 | | 15 n=49 | | 16 n=62 | | 17 n=44 | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Gender** | **Boys** | **Girls** | **Boys** | **Girls** | **Boys** | **Girls** | **Boys** | **Girls** | **Boys** | **Girls** | **Boys** | **Girls** |
| **n** | 34 | 27 | 27 | 41 | 18 | 20 | 32 | 17 | 27 | 35 | 28 | 16 |
| **Left** (kg) | 22.7 5.03 | 22.8 4.10 | 29.6 8.35 | 23.3 4.85 | 35.9 7.92 | 28.4 5.07 | 40.2 6.99 | 26.1 6.21 | 43.7 8.21 | 26.8 5.78 | 48.3 6.29 | 28.4 4.03 |
| **Right** (kg) | 23.2 5.15 | 23.9 4.23 | 29.4 7.88 | 24.3 4.81 | 38.9 8.34 | 29.2 4.05 | 41.5 7.53 | 27.4 6.77 | 44.9 7.02 | 28.2 5.48 | 49.2 6.41 | 31.0 5.29 |

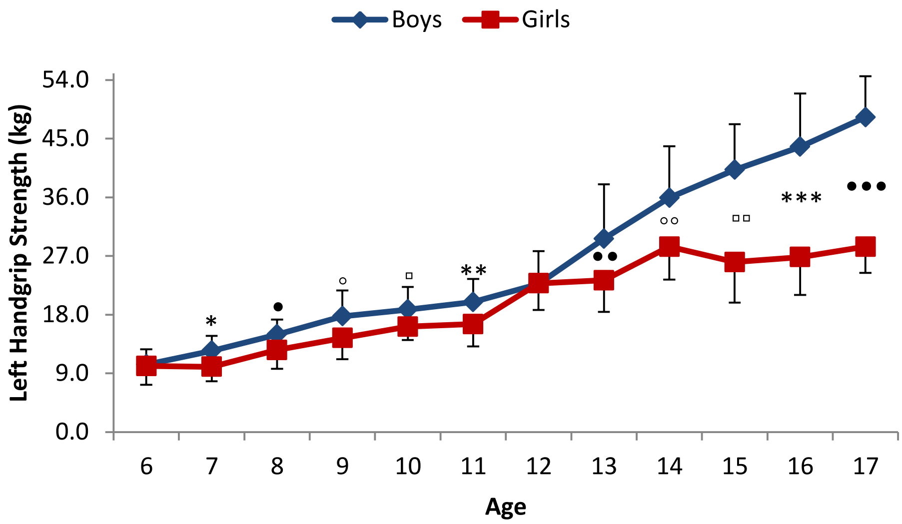


**Figure 4.31**: The handgrip strength of the left hand for boys vs girls at different ages (years) (data are presented as means ± SD).

* $p<0.05$ statistical significant difference between boys and girls at age 7

• $p<0.05$ statistical significant difference between boys and girls at age 8

◦ $p<0.05$ statistical significant difference between boys and girls at age 9

▫ $p<0.05$ statistical significant difference between boys and girls at age 10

** $p<0.05$ statistical significant difference between boys and girls at age 11

•• $p<0.05$ statistical significant difference between boys and girls at age 13

◦◦ $p<0.05$ statistical significant difference between boys and girls at age 14

▫▫ $p<0.05$ statistical significant difference between boys and girls at age 15

*** $p<0.05$ statistical significant difference between boys and girls at age 16

••• $p<0.05$ statistical significant difference between boys and girls at age 17

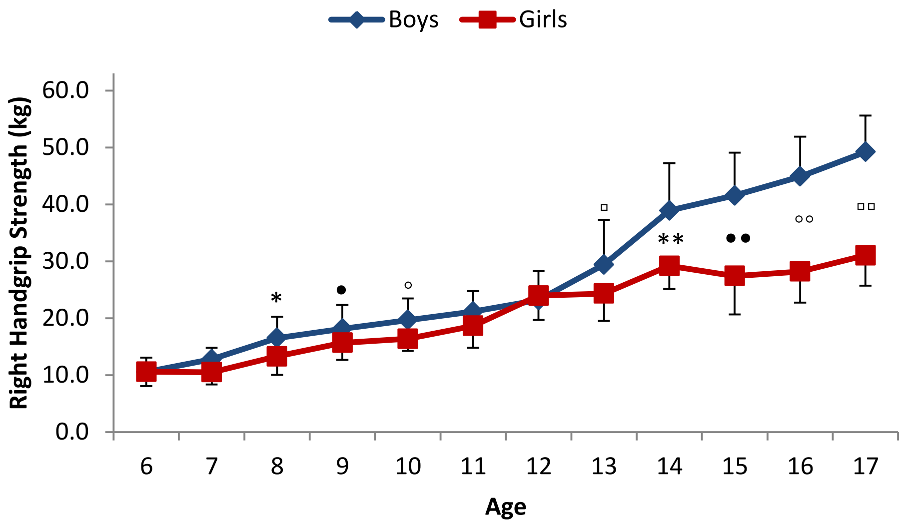


**Figure 4.32**: The handgrip strength of the right hand for boys vs girls at different ages (years) (data are presented as means ± SD).

* p<0.05 statistical significant difference between boys and girls at age 8

• p<0.05 statistical significant difference between boys and girls at age 9

◦ p<0.05 statistical significant difference between boys and girls at age 10

▫ p<0.05 statistical significant difference between boys and girls at age 13

** p<0.05 statistical significant difference between boys and girls at age 14

•• p<0.05 statistical significant difference between boys and girls at age 15

◦◦ p<0.05 statistical significant difference between boys and girls at age 16

▫▫ p<0.05 statistical significant difference between boys and girls at age 17

### The correlations between sprinting speed, SLJ, handgrip strength and age group categories

### The correlations for girls when barefoot

**Table 4.22:** Correlation between running performance, SLJ and handgrip (HG) strength for girls, aged 6-8 when barefoot.

| | 2.5m | 5m | 10m | 20m | HG L | HG R | SLJ |
|---|---|---|---|---|---|---|---|
| **HG L** | -0.29 | -0.21 | -0.25 | -0.31 | 1.00 | 0.85 | 0.32 |
| **HG R** | -0.33 | -0.32 | -0.33 | -0.35 | 0.85 | 1.00 | 0.38 |
| **SLJ** | -0.50 | -0.63 | -0.75 | -0.71 | 0.32 | 0.38 | 1.00 |

**Table 4.22** showed, for girls age 6-8, the correlations between running performance, SLJ and handgrip strength for the left and right hand were the following, according to the correlation categories of Pearson (Landis & Koch, 1977; Hopkins, 2010). There were a moderate to good correlation between the SLJ and 2.5m, 5m and 20m sprinting performance. Between the 10m sprinting performance and SLJ an excellent correlation was recorded. The left and right hand showed a fair correlation between handgrip strength and sprinting performance at 2.5m, 10m and 20m. At the 5m the left hand showed no correlation, but the right hand still had a fair correlation. The correlation between SLJ and handgrip strength for both left and right hand was a fair correlation.

**Table 4.23:** Correlation between running performance, SLJ and handgrip (HG) strength for girls, aged 9-10 when barefoot.

| | 2.5m | 5m | 10m | 20m | HG L | HG R | SLJ |
|---|---|---|---|---|---|---|---|
| **HG L** | -0.20 | -0.42 | -0.51 | -0.60 | 1.00 | 0.79 | 0.42 |
| **HG R** | -0.23 | -0.37 | -0.45 | -0.50 | 0.79 | 1.00 | 0.21 |
| **SLJ** | -0.28 | -0.40 | -0.42 | -0.54 | 0.42 | 0.21 | 1.00 |

In age group 9-10 (**Table 4.23**), there was a fair correlation between SLJ and the 2.5m, 5m and 10m sprinting performance, but with the 20m sprinting performance a moderate to good correlation was found with SLJ. There was no correlation between handgrip strength and running performance at 2.5m, a fair correlation at 5m and a moderate to good correlation at 10m and 20m for the left hand. With the right hand there was also no correlation between handgrip strength at 2.5m, a fair correlation at 5m and 10m and a moderate to good correlation for 20m. No correlation was found between SLJ and the right hand's handgrip strength. While the left hand's handgrip strength showed a fair correlation.

**Table 4.24:** Correlation between running performance, SLJ and handgrip (HG) strength for girls, aged 11-13 when barefoot.

| | 2.5m | 5m | 10m | 20m | HG L | HG R | SLJ |
|---|---|---|---|---|---|---|---|
| **HG L** | -0.13 | -0.15 | -0.23 | -0.24 | 1.00 | 0.89 | 0.30 |
| **HG R** | -0.09 | -0.14 | -0.21 | -0.28 | 0.89 | 1.00 | 0.31 |
| **SLJ** | -0.40 | -0.50 | -0.62 | -0.68 | 0.30 | 0.31 | 1.00 |

The barefoot correlation data for girls in the age group 11-13 is represented in **Table 4.24**. A fair correlation between SLJ and 2.5m sprinting performance was found. There was a moderate to good correlation for 5m, 10m and 20m sprinting performance and SLJ. There was no correlation between the handgrip strength and 2.5m, 5m, 10m. At 20m the right hand had a fair correlation between handgrip strength and sprinting performance, but the left hand still had no correlation. The left and right hand's handgrip strength had a fair correlation with SLJ.

**Table 4.25:** Correlation between running performance, SLJ and handgrip (HG) strength for girls, aged 14-17 when barefoot.

| | 2.5m | 5m | 10m | 20m | HG L | HG R | SLJ |
|---|---|---|---|---|---|---|---|
| **HG L** | -0.17 | -0.16 | -0.17 | -0.20 | 1.00 | 0.83 | 0.28 |
| **HG R** | -0.15 | -0.18 | -0.19 | -0.21 | 0.83 | 1.00 | 0.24 |
| **SLJ** | -0.44 | -0.58 | -0.65 | -0.70 | 0.28 | 0.24 | 1.00 |

For girls in age group 14-17 in the barefoot condition, **Table 4.25**, showed the following results: A fair correlation between SLJ and sprinting performance at 2.5m. Furthermore, between SLJ and sprinting performance at 5m, 10m and 20m there was a moderate to good correlation. No correlation could be found between handgrip strength and sprinting performance at 2.5m, 5m, 10m and 20m between the left and right hand. SLJ had fair correlation with the left hand's handgrip strength and no correlation with the right hand's handgrip strength.

**The correlations for boys when barefoot**

**Table 4.26:** Correlation between running performance, SLJ and handgrip (HG) strength for boys, aged 6-9 when barefoot.

| | 2.5m | 5m | 10m | 20m | HG L | HG R | SLJ |
|---|---|---|---|---|---|---|---|
| **HG L** | -0.22 | -0.30 | -0.40 | -0.42 | 1.00 | 0.86 | 0.29 |
| **HG R** | -0.15 | -0.25 | -0.37 | -0.34 | 0.86 | 1.00 | 0.30 |
| **SLJ** | -0.60 | -0.67 | -0.73 | -0.77 | 0.29 | 0.30 | 1.00 |

In age group 6-9 (**Table 4.26**), a moderate to good correlation was found between SLJ and sprinting performance at 2.5m, 5m, 10m and an excellent correlation for the 20m. Handgrip strength showed no correlation at 2.5m and a fair correlation at 5m, 10m and 20m sprinting performance for both the left and right hand. The handgrip strength between both left and right hand had a fair correlation with SLJ.

**Table 4.27:** Correlation between running performance, SLJ and handgrip (HG) strength for boys, aged 10-12 when barefoot.

| | 2.5m | 5m | 10m | 20m | HG L | HG R | SLJ |
|---|---|---|---|---|---|---|---|
| **HG L** | -0.17 | -0.09 | -0.05 | -0.07 | 1.00 | 0.90 | 0.08 |
| **HG R** | -0.14 | -0.08 | -0.07 | -0.13 | 0.90 | 1.00 | 0.11 |
| **SLJ** | -0.46 | -0.51 | -0.61 | -0.68 | 0.08 | 0.11 | 1.00 |

For boys in age group 10-12 in the barefoot condition, **Table 4.27**, showed the following results. The correlation between SLJ and 2.5m sprinting performance had a fair correlation, but the correlation at 5m, 10m and 20m changed to a moderate to good correlation. There was no correlation between, left and right hand, handgrip strength, SLJ and 2.5m, 5m, 10m and 20m sprinting performance.

**Table 4.28:** Correlation between running performance, SLJ and handgrip (HG) strength for boys, aged 13-16 when barefoot.

| | 2.5m | 5m | 10m | 20m | HG L | HG R | SLJ |
|---|---|---|---|---|---|---|---|
| **HG L** | -0.23 | -0.32 | -0.36 | -0.38 | 1.00 | 0.92 | 0.49 |
| **HG R** | -0.26 | -0.34 | -0.39 | -0.37 | 0.92 | 1.00 | 0.49 |
| **SLJ** | -0.47 | -0.58 | -0.66 | -0.66 | 0.49 | 0.49 | 1.00 |

**Table 4.28** showed a fair correlation between SLJ and 2.5m sprinting performance. With the 5m, 10m and 20m sprinting performance a moderate to good correlation was found SLJ. No correlation could be found between the handgrip strength for the left and right hand in the 2.5m sprinting performance. For the 5m, 10m and 20m sprinting performance the correlation was fair. There was a fair correlation between the SLJ and handgrip strength for both hands.

**Table 4.29:** Correlation between running performance, SLJ and handgrip (HG) strength for boys, aged 17 when barefoot.

| | 2.5m | 5m | 10m | 20m | HG L | HG R | SLJ |
|---|---|---|---|---|---|---|---|
| **HG L** | -0.16 | -0.19 | -0.36 | -0.49 | 1.00 | 0.84 | 0.41 |
| **HG R** | -0.13 | -0.17 | -0.41 | -0.48 | 0.84 | 1.00 | 0.42 |
| **SLJ** | -0.38 | -0.39 | -0.58 | -0.45 | 0.41 | 0.42 | 1.00 |

The barefoot correlation data for boys in the age group 17 is represented in **Table 4.29**. A fair correlation was established between SLJ and barefoot 2.5m, 5m and 20m sprinting performance. For the 10m the correlation was moderate to good between sprinting performance and SLJ. There was no correlation between handgrip strength for the left and right hand and 2.5m and 5m sprinting performance. For 10m and 20m the correlation was fair. The correlation between SLJ handgrip strength for both hand's was fair.

### The correlations for girls in shod condition

**Table 4.30:** Correlation between running performance, SLJ and handgrip (HG) strength for girls, aged 6-8, in shod condition.

| | 2.5m | 5m | 10m | 20m | HG L | HG R | SLJ |
|---|---|---|---|---|---|---|---|
| **HG L** | -0.27 | -0.27 | -0.25 | -0.23 | 1.00 | 0.86 | 0.32 |
| **HG R** | -0.33 | -0.37 | -0.36 | -0.36 | 0.86 | 1.00 | 0.42 |
| **SLJ** | -0.77 | -0.78 | -0.81 | -0.82 | 0.32 | 0.42 | 1.00 |

For girls in age group 6-8 in the shod condition, **Table 4.30**, showed the following results. The 2.5m, 5m, 10m and 20m sprinting performance and SLJ results indicated an excellent correlation. There was a fair correlation at 2.5m, 5m and 10m sprinting performance for the left and right hand's handgrip strength. No correlation could be found for the left hand at 20m, but there was still a fair correlation for the right hand between handgrip strength and sprinting performance. The correlation between the SLJ and handgrip strength showed fair correlations for both the left and the right hand.

**Table 4.31:** Correlation between running performance, SLJ and handgrip (HG) strength for girls, aged 9-10, in shod condition.

| | 2.5m | 5m | 10m | 20m | HG L | HG R | SLJ |
|---|---|---|---|---|---|---|---|
| **HG L** | -0.40 | -0.49 | -0.41 | -0.48 | 1.00 | 0.82 | 0.48 |
| **HG R** | -0.16 | -0.20 | -0.29 | -0.34 | 0.82 | 1.00 | 0.25 |
| **SLJ** | -0.39 | -0.47 | -0.23 | -0.24 | 0.48 | 0.25 | 1.00 |

**Table 4.31** revealed that the 2.5m and 5m sprinting performance had a fair correlation with SLJ. However, the 10m and 20m sprinting performance hand no correlation with SLJ. A fair correlation were found between handgrip strength and sprinting performance at 2.5m, 5m, 10m and 20m for the left hand, but for the right hand there was no correlation at 2.5m and 5m and a fair correlation at 10m and 20m. Handgrip strength showed no correlation between the right hand's handgrip strength and SLJ, but for the left hand the correlation was fair.

**Table 4.32:** Correlation between running speed, SLJ and handgrip (HG) strength for girls, aged 11-13, in shod condition.

| | 2.5m | 5m | 10m | 20m | HG L | HG R | SLJ |
|---|---|---|---|---|---|---|---|
| **HG L** | -0.19 | -0.18 | -0.20 | -0.23 | 1.00 | 0.87 | 0.22 |
| **HG R** | -0.19 | -0.13 | -0.15 | -0.19 | 0.87 | 1.00 | 0.19 |
| **SLJ** | -0.47 | -0.66 | -0.75 | -0.77 | 0.22 | 0.19 | 1.00 |

The shod correlation data for girls in the age group 11-13 is represented in **Table 4.32**. A fair correlation at 2.5m and a moderate to good correlation at 5m sprinting performance and SLJ were found. An excellent correlation was found between SLJ and the 10m and 20m sprinting performance. There was no correlation between handgrip strength and sprinting performance at 2.5m, 5m, 10m, or 20m as well as for SLJ for either the left or right hand.

**Table 4.33:** Correlation between running performance, SLJ and handgrip (HG) strength for girls, aged 14-17, in shod condition.

| | 2.5m | 5m | 10m | 20m | HG L | HG R | SLJ |
|---|---|---|---|---|---|---|---|
| **HG L** | -0.10 | -0.11 | -0.15 | -0.20 | 1.00 | 0.89 | 0.30 |
| **HG R** | -0.07 | -0.07 | -0.11 | -0.18 | 0.89 | 1.00 | 0.28 |
| **SLJ** | -0.46 | -0.60 | -0.73 | -0.75 | 0.30 | 0.28 | 1.00 |

In age group 14-17 (**Table 4.33**) results indicated a fair correlation at 2.5m and a moderate to good correlation for 5m and 10m between SLJ and speed performance. The 20m sprinting performance had an excellent correlation with SLJ. No correlation could be found between handgrip strength and sprinting performance at 2.5m, 5m, 10m and 20m between the left and right hand. SLJ and handgrip strength indicated a fair correlation between both left and right hand.

**The correlations for boys in shod condition**

**Table 4.34:** Correlation between running performance, SLJ and handgrip (HG) strength for boys aged 6-9, in shod condition.

| | 2.5m | 5m | 10m | 20m | HG L | HG R | SLJ |
|---|---|---|---|---|---|---|---|
| **HG L** | -0.20 | -0.19 | -0.28 | -0.31 | 1.00 | 0.90 | 0.21 |
| **HG R** | -0.11 | -0.16 | -0.26 | -0.31 | 0.90 | 1.00 | 0.22 |
| **SLJ** | -0.60 | -0.75 | -0.80 | -0.84 | 0.21 | 0.22 | 1.00 |

The shod correlation data for boys in the age group 6-9 is represented in **Table 4.34**. There was a moderate to good correlation between SLJ and 2.5m sprinting performance and an excellent correlation was found between SLJ and 5m, 10m and 20m sprinting performance. No correlation could be found between the handgrip strength, left and right hand, SLJ and sprinting performance at 2.5m and 5m. For the 10m and 20m the correlation was fair between sprinting performance and handgrip strength.

**Table 4.35:** Correlation between running performance, SLJ and handgrip (HG) strength for boys aged 10-12, in shod condition.

| | 2.5m | 5m | 10m | 20m | HG L | HG R | SLJ |
|---|---|---|---|---|---|---|---|
| **HG L** | -0.04 | -0.04 | -0.03 | -0.03 | 1.00 | 0.88 | 0.05 |
| **HG R** | -0.07 | -0.07 | -0.10 | -0.15 | 0.88 | 1.00 | 0.11 |
| **SLJ** | -0.47 | -0.56 | -0.68 | -0.70 | 0.05 | 0.11 | 1.00 |

Boys in age group 10-12 in the shod condition, **Table 4.35**, showed the following results: The correlation between SLJ and 2.5m sprinting performance had a fair correlation, but the correlation at 5m, 10m and 20m changed to a moderate to good correlation. There was no correlation between, left and right hand, handgrip strength between SLJ and 2.5m, 5m, 10m and 20m sprinting performance.

**Table 4.36:** Correlation between running performance, SLJ and handgrip (HG) strength for boys aged 13-16, in shod condition.

| | 2.5m | 5m | 10m | 20m | HG L | HG R | SLJ |
|---|---|---|---|---|---|---|---|
| **HG L** | -0.19 | -0.41 | -0.48 | -0.32 | 1.00 | 0.91 | 0.43 |
| **HG R** | -0.18 | -0.40 | -0.51 | -0.31 | 0.91 | 1.00 | 0.41 |
| **SLJ** | -0.09 | -0.51 | -0.62 | -0.54 | 0.43 | 0.41 | 1.00 |

In age group 13-16 (**Table 4.36**) a fair correlation between SLJ and 2.5m sprinting performance. With the 5m, 10m and 20m sprinting performance a moderate to good correlation was found SLJ. For the 2.5m there was no correlation between handgrip strength for both hands and the sprinting performance. The 5m and 20m sprinting performance had a fair correlation between left and right hand's handgrip strength and sprinting performance. The right hand had an excellent correlation with the 10m sprinting performance, while the left hand had a fair correlation.  There was a fair correlation between the left and right hands and SLJ.

**Table 4.37:** Correlation between running performance, SLJ and handgrip (HG) strength for boys aged 17 in shod condition.

| | 2.5m | 5m | 10m | 20m | HG L | HG R | SLJ |
|---|---|---|---|---|---|---|---|
| **HG L** | -0.08 | -0.20 | -0.18 | -0.08 | 1.00 | 0.85 | 0.44 |
| **HG R** | -0.07 | -0.06 | -0.34 | -0.02 | 0.85 | 1.00 | 0.41 |
| **SLJ** | -0.25 | -0.06 | -0.52 | -0.06 | 0.44 | 0.41 | 1.00 |

**Table 4.37** showed no correlation could be found between the SLJ and 5m and 20m sprinting performance, but the 2.5m and 10m sprinting performance showed a fair correlation with SLJ. No correlation could be found for handgrip strength for both hand's and 2.5m, 5m and 20m sprinting performance. At 10m the right hand showed

a fair correlation, but the left hand still had no correlation. There was a fair correlation between SLJ and handgrip strength for the left and right hand.

## D Summary of Results

The results revealed that the boys performed better than girls in both footwear conditions in the sprinting, SLJ and handgrip strength. Furthermore, the girls showed a plateau in performance after the age of 14. Where the boys showed increase in performance from especially form age 13. These findings will be discussed and explained in more detail in chapter five.

# CHAPTER FIVE

# DISCUSSION AND CONCLUSION

## A Introduction

The primary aim of the study was to determine if there was a relationship between standing long jump (SLJ), sprinting performance and handgrip strength of school children, aged 6-17, as well as the footwear condition on performance. The secondary aim was to compare performance on biomotor abilities, at certain ages, as suggested by the long term athlete development (LTAD) models. The results will be discussed with regard to these stated objectives.

## B Performance Tests

Tomkinson and Olds (2007) did not show that boys consistently outperformed girls during early childhood during anaerobic performances. However the peak power in males increases around 120% and for females around 66% between the ages of 12 and 17 years old (Tomkinson & Olds, 2007). Findings from the current study supported the results from the mentioned study. Between the ages 6-12 no differences were found, but after the age 13 years, boys in the current study significantly improved their performance in SLJ, sprinting performance and handgrip strength. Pienaar, Kruger, Monyeki and van der Walt (2015) showed that 15 to 16 year old boys (n=214 of which boys=88 and girls=126) outperformed girls in the SLJ. In the present study, similar results were found.

Significant differences were found in SLJ performance between children in some ages, as well as between boys and girls. In the current study, boys had significant better scores than girls in all the performance tests from age of 13. Although not significant, boys outperformed girls in all the tests. The study by Castro-Pinero *et al.* (2010) reported similar findings for the SLJ in their study among 1513 boys and 1265 girls aged 6 to17.9 years in Spain. However studies done by Ranson, Stratton and Taylor (2015) and Catley and Tomkinson (2013) found that boys performed significantly better than girls in speed, and power (SLJ) assessment tests.

The HELENA study emphasised the need to collect data in various countries to develop normative values (Ortega, Artero, Ruiz, España-Romero, Jiménez-Pavón, Vicente-Rodriguez, Moreno, Manios, Béghin, Ottevaere, Ciarapica, Sarri, Dietrich, Blair, Kersting, Molnar, González-Gross, Gutiérrez, Sjöström & Castillo, 2011). In the HELENA study (Ortega *et al.*, 2011) 3428 adolescents (1845 girls) between the ages 12.5 and 17.49 years from 10 European cities were tested. Children in the current study scored better than their European counterparts in the SLJ and handgrip tests, according to the data provided by Ortega *et al.* (2011).

## C Relationships between Tests

Nimphuis, McGuigan and Newton (2010) reported that the strength of the correlations between the VJ and sprinting speed differ for pre-, during and post-season testing in female softball players. It is important to keep this finding in mind when looking at the current study because data was collected over a six-month period from the various schools. There is a possibility that not all the children were in the same training phase when testing was conducted and this may influence the results.

In a study in track athletes and soccer female players in high school (aged 14-16) and college students (aged 18-20) to determine a correlation between vertical jump (VJ) and speed performance, an excellent correlation was shown between vertical jump (VJ) and speed performance in the college students and a moderate to good correlation in high school players (Nimphius, McGuigan & Newton, 2010). Another study conducted by Vescovi and McGuigan (2008) discovered that the correlation between sprinting speed and countermovement jump (CMJ) for female college (aged 18-20) soccer and lacrosse players was excellent and for the high school players (aged 14-16) it was moderate to good.

The results of Pienaar et al. (2015) correspond with the Boyle (2011) study that was conducted on u/15 and u/17 year old soccer boys. The lower body explosive power measured with SLJ can explain 29% of the variance in the 10m speed times and 20% of 5m speed times. Furthermore, Hammami et al. (2015) found a strong correlation between SLJ and 5m and 20m sprinting speed in 13-15 year old boys. A study done on 22 male (age 20-22) 100m sprinting athletes (11 high performance sprinters and 11 physical education students) indicated a good to moderate correlation with SLJ and 10m and 30m  sprinting speed (Maćkała et al., 2015).

The squat exercise is used in the gym to measure lower leg power directly, where SLJ is a field-based exercise to measure lower body power indirectly, without the use of specialised testing equipment. In two more studies the following correlations where found between leg power and speed. A study done on 20 year old rugby league and rugby union players indicated that the concentric power of a squat exercise correlated moderately to good with 5m with sprinting speed (Sleivert & Taingahue, 2004). These findings were in line with Young, Mclean and Ardagna (1995) who found an excellent correlation between the concentric squat jump and 2.5m. The correlations of these the above mentioned studies are also in line with what was found in the current study.

In the following two studies that focus on lower body strength, the strength did not influence the sprinting speed. Harris, Cronin, Hopkins and Hansen (2008) found no correlation between 10m (r=-0.06) and 40m (r=-0.19) sprinting speeds and three rep max squat strength for professional rugby league players. Another study done by Cronin and Hansen (2005) on 26 male rugby league players found similar results for three rep max squat and 10m (r=-0.01) and 30m (r=-0.29) sprinting speeds.

A study done on 1776 Welsh children, boys 917 and girls 814, between the ages of 8-12 years-old found similar findings as in the current study that there was no correlation between their sprinting speed at 20m, 30m, 40m and 50m and handgrip strength (Ranson et al., 2015).

Contrary to the findings of the current study, a few research studies reported different results. A study on 94 children (45 girls and 49 boys) (aged 6 to 17) to compare upper and lower body test with each other found an excellent correlation between SLJ and the basketball chest past that measures upper body strength (Castro-Piñero, Ortega, *et al.*, 2010). According to Milliken *et al.* (2008) was there an excellent correlation between the handgrip strength and 1 repetition leg press.

However, these two studies contradict the findings of the current study. A number of factors could contribute to the contrasting findings. Firstly, different tests to measure the upper body strength and leg power were uses in the various studies. Secondly, not all the ages from 6 to 17 year old is tested in the various studies. In the current study, 550 children were tested, while, for example, Castro- Piñero, Ortega, et al. (2010) only tested 94 children.

## D Athlete Development Models

According to Tomkinson and Olds (2007) there is one critical period (trigger point) in a child's life normally during puberty where certain biomotor abilities needed to be train. A study done by Ranson, Stratton and Taylor (2015) found that boys performed significantly better than girls in speed, strength (handgrip) and power (SLJ). Catley and Tomkinson (2013) found the same results in their study. The current study also found that the boys outperformed the girls. These findings can be contributed to the following factors: difference in body fat percentage, amount of physical activity and different hormone levels like testosterone (Marta, Marinho, Barbosa, Izquierdo & Marques, 2012).

## Acceleration and Speed

The 2.5m sprinting speeds for girls while being barefoot indicated no significant differences between the age group categories as was suggested to be the case with speed windows of opportunity according to the LTAD models (Balyi, 2001; "Planning for Long Term Success", 2005, "Long-Term participant development programme: From grassroots to Proteas", 2011; Norris, 2010). Although there were no significant differences, as the girls grew older, they ran slower than the boys. During the shod condition, the sprinting speed showed that there is a significant difference between the age group 6-8 years and the 11-13 years group. This finding was expected according to the LTAD model, because girls reach their growth spurt or peak height velocity (PHV) during age group 11-13 years (Balyi, 2001; "Planning for Long Term Success", 2005, "Long-Term participant development programme: From grassroots to Proteas", 2011; Norris, 2010). The growth spurt is an important factor because the increase in body size means that an increase in limb size occurs, and this leads to an increase in step length and step length is one of the important factors for increasing speed (Sander *et al.*, 2013). For both the barefoot and shod condition no significant discernible difference between age group 11-13 years and age group 14-17 years was expected. The reason for this assumption is when girls reach the end of their growth spurt their sport performance tends to plateau (Castro-Piñero, González-Montesinos, Keating, Mora, Sjöström & Ruiz, 2010).

The results for the boys 2.5m on the other hand, look vastly different compared to the results of the girls. For the barefoot condition, the 2.5m sprinting speed showed a significant difference between all the age groups except between age group 13-16 and age group 17, but this was expected. However, there was no distinct window for a specific age group where 2.5m speed needs to be trained as suggested by the

LTAD models (Balyi, 2001; “Planning for Long Term Success”, 2005, “Long-Term participant development programme: From grassroots to Proteas”, 2011; Norris, 2010). The findings were more in correspondence with the Youth Physical Development (YPD) model and the FTEM framework that states speed is trainable throughout childhood from 6-16 years of age (Lloyd & Oliver, 2012). It is possible that there may be two reasons why there is no significant difference between age group 13-16 and age group 17. Firstly, boys reach the end of their growth spurt at the age of 13-16 years (Balyi, 2001; Lloyd & Oliver, 2012). Secondly, the sample size of the 17 year-olds was too small and not diverse enough. During the 2.5m shod condition there were no significant differences between age group 6-9 and all three other age groups. Again this was no surprise because the YPD model and FTEM framework suggests speed is trainable throughout childhood (Lloyd & Oliver, 2012). The main reason for not seeing a significant difference in the other age groups is most probably due to the small sample size.

During the 5m sprinting speeds barefoot and shod for girls the same results were found. There was a significant difference with all the age groups if it was compared to the 6-8 years old age group. These results differ from what was expected from the LTAD models because age 6-8 was the first window of opportunity for speed training (Balyi, 2001; “Planning for Long Term Success”, 2005, “Long-Term participant development programme: From grassroots to Proteas”, 2011; Norris, 2010). These results are more in agreement with the newer athlete development models like the YPD model that suggested, speed can be trained from age 5-15 years of age for girls (Lloyd & Oliver, 2012). Once again no statistical significant difference was anticipated between age group 11-13 and age group 14-17 because both the all the athlete development models report that there is a plateau in the girls’ sprinting development after reaching the end of their growth spurt (Balyi, 2001; “Planning for Long Term Success”, 2005, “Long-Term participant development programme: From grassroots to Proteas”, 2011; Norris, 2010; Lloyd & Oliver, 2012).

The research on the boys’ barefoot and shod 5m, 10m and 20m sprinting speeds reflected the following: The results for boys also once again tend to favour the later athlete development models like the YPD model and FTEM framework theory that speed is trainable from age 6-16 years old (Lloyd & Oliver, 2012) instead of only through the two windows of opportunity at age group 6-9 and age group 13-16 as suggested by the LTAD models (Balyi, 2001; “Planning for Long Term Success”, 2005, “Long-Term participant development programme: From grassroots to Proteas”, 2011; Norris, 2010). The motivation behind this observation is that there was a significant difference between age group 6-9 and the three older groups as well as between age group 10-12 and the two older age groups. Once again the same two reasons that were mentioned previously can be the cause of no significant difference between age group 13-16 and age group 17. Firstly, boys reach the end of their growth spurt at age group 13-16 years (Balyi, 2001; Lloyd & Oliver, 2012). Secondly, the sample size of the 17 year-olds was too small and not diverse enough.

For the girls the 10m and 20m sprinting speeds during the shod condition were the same as for 5m as was already discussed. For the 10m sprinting speed while being barefoot the following results were found: There were statistical significant differences between age group 6-8 and the three older age groups, but also between age group 9-10 and age group 11-13 years old. For the 20m sprinting speed the same was found except that there was also a significant difference between age group 9-10 and age group 14-17 years old. These results also support the claims of the YPD model and the FTEM framework namely, that speed is trainable throughout childhood instead of just during the two windows of opportunity at ages 6-8 and 11-13 years old as suggested by the LTAD models (Balyi, 2001; “Planning for Long Term Success”, 2005, “Long-Term participant development programme: From grassroots to Proteas”, 2011; Norris, 2010; Lloyd & Oliver, 2012). A most interesting finding was that as the distance of the speed increased the clearer the pattern became that the sprinting times improve with age.

For all four sprinting distances, namely 2.5m, 5m, 10m and 20m, the speeds were the same at age 6 for boys and girls, but with increased age, the boys were faster than the girls at all ages for all speeds. From age 14 there was a statistical significant difference between the boys and girls for both footwear conditions. Studies done by Ranson, Stratton and Taylor (2015) and Catley and Tomkinson (2013) also found that the boys had outperformed the girls. These findings correspond with what was suggested by athlete development models say will happen. The reason for this is that girls mature earlier than boys. The girls reach maturity at age group 11-13 years of age, while the boys’ growth spurt start at age group 13-16 years of age and reach maturity only at age 16 (Balyi, 2001; “Planning for Long Term Success”, 2005, “Long-Term participant development programme: From grassroots to Proteas”, 2011; Norris, 2010; Lloyd & Oliver, 2012). The LTAD models and the YPD model even suggest that before puberty the girls may outperform the boys, but this was not the case with speed in the current study.

The results of the current studies correspond more with the YPD model that suggests speed is trainable over a period from more less 5 years old to 15 years old. This means right through these years and not only in the two distinct speed windows of opportunities at age groups 6-9 and 13-16 for boys and age groups 6-8 and 11-13 for girls. A variety of research studies indicate linear increase of speed with age, as well as an improvement in speed with training in training programmes at different ages. A study done by Malina *et al.* (2004) found no distinct spurt of speed improvement and suggests boys can improve running speed linearly from age 5 up to age 17. Pienaar and Viljoen (2010) conducted a study on boys between the ages of 10-15 years old that also support a linear improvement in the speed of the boys.

Furthermore research done by Sander *et al.* (2013) on elite soccer players in age groups 13, 15 and 17 years old over a two year period found that their speed performance (5m, 10m, 15m, 20m, 25m and 30m) had increased with 5.8%. Another study done by Comfort, Haigh and Matthews (2012) on 19 professional rugby players over a 8 week period indicated a 5.9-7.6% improvement in sprinting speed (5 m, 10 m and 20 m).

However, Sander *et al.* (2013) could not find the same significant improvements in the 17 year old age group that they found in the 13 and 15 year old age groups due to maturation in these two age groups. Body size is an important factor for sprinting performance because it influences the step length of the athlete and in the 17 year old age group the growth process was largely completed (Sander *et al.*, 2013). Caldwell and Peters (2009) is of the opinion that sprinting improvements with regular soccer training cannot be expected in one season. The reason for this statement is because the trainer needs a period of time longer than a season to improve the speed of the players.

### Jumping performance (ability)

The power in the lower limb extremities was indirectly measured by the SLJ test for girls and boys. It was done in two different footwear conditions, barefoot and shod.

During the barefoot condition there were statistical significant differences between age group 6-8 years old and the other three older age groups, but also between age group 9-10 and age group 14-17 years old. The LTAD models do not include any windows of opportunity for training power. The YPD model on the other hand, identifies power as a key component for succeeding in sport. Although the key period to develop power is only at the onset of adolescence (age 14+), they do suggest starting with power training already at pre-pubertal phase (age group 6-8) (Lloyd & Oliver, 2012). Lloyd and Oliver (2012) propose that the real power burst really starts after adolescence and only then. With girls this cannot be seen so clearly in the results, only some of it can be discerned in barefoot condition where there is a statistical significant difference between age group 9-10 and age group 14-17 years of age.

The findings of Lloyd and Oliver (2012) confirm the results found with the boys in barefoot as well as in shod condition with SLJ. There were statistical significant differences between all four age group categories with age group 17 performing best of all. The pre-pubertal phase with boys starts at age 6-9 and adolescence from age 17+ ("Long-Term participant development programme: From grassroots to Proteas", 2011; Lloyd, Oliver, *et al.*, 2014).

Once again the boys outperformed the girls in jumping at the different ages. From the age of 14 years there is a statistical significant difference between boys and girls. Studies done by Ranson, Stratton and Taylor (2015) and Catley and Tomkinson (2013) also found that the boys had outperformed the girls. The reason is again that the boys mature at a later stage than the girls, as was found with speed performance. The statistical significant difference that is noted during the puberty phase may be due to a too small and not diverse enough sample size in the studies mentioned above.

**Handgrip strength**

Both the left and right hand for boys and girls had a gradual increase in strength every year. The handgrip strength for boys and girls were the same at age six. After that the boys performed statistical significantly better up to age 12. At the age of 12, there was no difference in handgrip strength between the boys and girls. Findings from the current study are contradictory with Faigenbaum *et al.* (2009). The study done by Faigenbaum *et al.* (2009) did not find any differences in strength before puberty between boys and girls. It could be that groups for boys and girls were not diverse enough. After age 12 the boys' strength increased significantly more than that of girls and the girls' handgrip strength started to plateau. The current study is in coherence with studies done by Newman *et al.* (1984) and Innes (1999), as well as studies done by Ranson, Stratton and Taylor (2015) and Catley and Tomkinson (2013) where the boys had outperformed the girls.

These results support the theory of the YPD model more that strength is an important component that needs to be trained from puberty into adulthood (Lloyd & Oliver, 2012). The LTAD models believe the key window of opportunity to train strength is 12-18 months after a child has reached Peak Height Velocity (PHV), and this means for girls at the age of 11-13 and for boys when 13-16 years old (Balyi, 2001; "Planning for Long Term Success", 2005, "Long-Term participant development programme: From grassroots to Proteas", 2011; Norris, 2010). It is during this age that we see the significant and sudden increase in the boys' strength that supports the theory of the LTAD models.

## E Conclusion

The primary finding of the current study is the correlation between SLJ and sprinting performance in children. Secondly, results from the current study challenges the claims of the LTAD model about specific windows of opportunity for developing specific biomotor abilities.

The results showed a strong correlation between SLJ (measuring power) and sprinting performance at 2.5m, 5m, 10m and 20m. It is therefore suggested that children who have fast sprinting times, should be able to also perform better in the standing long jump. Sprinting (running) is regarded as a fundamental movement skill. It could therefore be possible to screen large numbers of children for explosive power abilities, by administering a sprint test, especially in younger populations. SLJ could be an added measure for older children or those selected in teams.

Furthermore, results did correspond with the YPD model that states that a child's speed, power and strength is trainable and can be developed over an extended period throughout childhood and need not have only specific windows of opportunities for training as suggested by the LTAD model.

It is important to remember that the tests used in the current study also have important implications on the health related tests in children and adolescences and not only their sport performance (Ruiz *et al.*, 2006). In many European countries the field-based tests of SLJ, sprinting performance and handgrip strength is part of their curriculum (Ruiz *et al.*, 2006). The AVENA study that was conducted found that SLJ has a negative correlation with cholesterol in adolescents (Ortega, Ruiz, Gutiérrez, Moreno, Tresaco, Martínez, González-Lamuño, Wärnberg, Castillo & Group, 2004). The study done by Ruitz *et al.* (2011) also supporting the fact that physical fitness can be used as good future predictor for diseases or better health statuses in children and adolescences.

The last most beneficial aspect to these field-based testing is that it is easy to conduct on large population groups at once and it is time and cost effective (Castro-Piñero, Artero, *et al.*, 2010; Hammami *et al.*, 2015).

## F Study Limitations

In the current study one of the limitations was that not all the children had brought their running shoes to school on testing days and for this reason the shod group was smaller than the barefoot group. The children's sporting abilities was not taken into consideration to ensure that the testing group stayed a diverse group. Lastly, the SLJ was measured by hand instead of an electronic SLJ matt.

## G Recommendations for Future Research Studies

There could be bias with regard to the children that participated in the study. It could be possible that mostly active children of athletes volunteered to participate because of the physical challenge the tests might have presented. Also ensure that more or less the same amount of children is tested from each grade at that particular school. Test all winter sport teams during winter and all summer sports during the summer. In this way all tests will be carried out during the competitive phase.

Create more normative values for South African population to identify childhood and adolescence for major public and health diseases (Ruiz, Castro-Pinero, Espana-Romero, Artero, Ortega, Cuenca, Jimenez-Pavon, Chillon, Girela-Rejon, Mora, Gutierrez, Suni, Sjostrom & Castillo, 2011). The reasoning behind the statement is that many changes in development of children occur during childhood and adolescence.

Lastly, there are very few studies that have looked into the relationship between upper and lower body strength. It might be a good idea to investigate this matter more comprehensively to discover if there is a correlation between upper and lower body strength and how it may influence the different biomotor abilities in a sport setting.

To conclude, to the researcher’s knowledge this is a novelty of the current study that testing was done in a barefoot as well as in shod condition. In a future research, the effect of the footwear condition can be investigated in habitually barefoot cultures.

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# APPENDICES

## Appendix 1

UNIVERSITEIT·STELLENBOSCH·UNIVERSITY
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### Approval Notice

Stipulated documents/requirements

18-Feb-2015

De Villiers, Johanna JE

**Proposal #: HS1153/2014**

**Title:** **Moving Feet – A Comparative Study between Habitually Barefoot And Shod School-Aged Children.**

Dear Ms. Johanna De Villiers,

Your **Stipulated documents/requirements** received on **18-Feb-2015**, was reviewed by members of the **Research Ethics Committee: Human Research (Humanities)** via Expedited review procedures on **17-Feb-2015** and was approved.

Sincerely,

Clarissa Graham REC Coordinator

Research Ethics Committee: Human Research (Humanities)

# Appendix 2

Western Cape Government
Education

Directorate: Research

Audrey.wyngaard@westerncape.gov.za
tel: +27 021 467 9272
Fax: 0865902282
Private Bag x9114, Cape Town, 8000
wced.wcape.gov.za

**REFERENCE:** 20141023-38716
**ENQUIRIES:** Dr A T Wyngaard

Mrs Johanna De Villiers
PO Box 1551
Stellenbosch
7599

**Dear Mrs Johanna De Villiers**

**RESEARCH PROPOSAL: MOVING FEET – A COMPARATIVE STUDY BETWEEN HABITUALLY BAREFOOT AND SHOD SCHOOL-AGED CHILDREN**

Your application to conduct the above-mentioned research in schools 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 and schools 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 Study is to be conducted from **02 February 2015 till 30 September 2015**
6. No research can be conducted during the fourth term as schools are preparing and finalizing syllabi for examinations (October to December).
7. Should you wish to extend the period of your survey, please contact Dr A.T Wyngaard at the contact numbers above quoting the reference number?
8. A photocopy of this letter is submitted to the principal where the intended research is to be conducted.
9. Your research will be limited to the list of schools as forwarded to the Western Cape Education Department.
10. A brief summary of the content, findings and recommendations is provided to the Director: Research Services.
11. The Department receives a copy of the completed report/dissertation/thesis addressed to:
    **The Director: Research Services**
    **Western Cape Education Department**
    **Private Bag X9114**
    **CAPE TOWN**
    **8000**

We wish you success in your research.

Kind regards.
Signed: Dr Audrey T Wyngaard
**Directorate: Research**
**DATE: 24 October 2014**

# Appendix 3

Western Cape Government
Education

Directorate: Research

Audrey.wyngaard@westerncape.gov.za
tel: +27 021 467 9272
Fax: 0865902282
Private Bag x9114, Cape Town, 8000
wced.wcape.gov.za

**REFERENCE:** 20160128-7123
**ENQUIRIES:** Dr A T Wyngaard

Mrs Johanna De Villiers
PO Box 1551
Stellenbosch
7599

**Dear Mrs Johanna De Villiers**

**RESEARCH PROPOSAL: MOVING FEET – A COMPARATIVE STUDY BETWEEN HABITUALLY BAREFOOT AND SHOD SCHOOL-AGED CHILDREN**

Your application to conduct the above-mentioned research in schools 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 and schools 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 Study is to be conducted from **01 February 2016 till 24 June 2016**
6. No research can be conducted during the fourth term as schools are preparing and finalizing syllabi for examinations (October to December).
7. Should you wish to extend the period of your survey, please contact Dr A.T Wyngaard at the contact numbers above quoting the reference number?
8. A photocopy of this letter is submitted to the principal where the intended research is to be conducted.
9. Your research will be limited to the list of schools as forwarded to the Western Cape Education Department.
10. A brief summary of the content, findings and recommendations is provided to the Director: Research Services.
11. The Department receives a copy of the completed report/dissertation/thesis addressed to:

    **The Director: Research Services**
    **Western Cape Education Department**
    **Private Bag X9114**
    **CAPE TOWN**
    **8000**

We wish you success in your research.

Kind regards.
Signed: Dr Audrey T Wyngaard
**Directorate: Research**
**DATE: 28 January 2016**

Lower Parliament Street, Cape Town, 8001
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Safe Schools: 0800 45 46 47

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Employment and salary enquiries: 0861 92 33 22
www.westerncape.gov.za

# Appendix 4

UNIVERSITEIT•STELLENBOSCH•UNIVERSITY
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**STELLENBOSCH UNIVERSITY**
**CONSENT TO PARTICIPATE IN RESEARCH**

**Moving feet – a comparative study of school children who normally wear shoes and those who normally walk barefoot**

I am Elbé de Villiers (a PhD student in Sport Science) of the Department of Sport Science at Stellenbosch University. I would like to invite your child to participate in my research study. The results of the study will form part of the thesis for my doctoral degree in Sport Science. Your child has been chosen as a possible participant in the study because he/she is in one of the participant schools and also is of the right age.

## 1. PURPOSE OF THE STUDY

The main purpose of this study is to determine the effect that shoes have on the developing foot. I will also determine whether shoes influence children's ability to move.

## 2. PROCEDURES

If you agree that your child may take part in this study, your child will have to undergo the following tests and measurements:

*Anthropometric measurement:* Your child's length and weight will be measured.

*Complete a questionnaire on physical activity:* This is done to determine how active your child is.

*Jogging and running for 20 metres:* While your child runs, he/she will be recorded on a video camera. The child will be asked to do this three times with and without shoes. The video is just to determine how your child lands with his feet while running.

*Balance tests*: Your child will be asked to walk backwards on three different sized bars. This will be done twice on each bar with and without shoes.

*Jumps:* Your child will be asked to jump as far as he/she can with both feet together. The distance will be measured. Your child will do this jump three times with and without shoes.
Next your child will be asked to jump sideways as many times as possible in 15 seconds. They will do it twice with and without shoes.

*Foot shape:* Your child will be asked to walk over a platform with a pressure plate embedded in it. They will also have to stand on a foot measuring platform, which then will determine the child's foot length and breadth as well as the height of his/her foot bridge while standing and seated.

*Grip strength:* Your child's grip strength will be determined by using a hand grip calliper.

**3. POTENTIAL RISKS AND DISCOMFORT**

Although some of the tests might be unknown to your child, they are simple tests. They should not make your child exceptionally tired or cause any discomfort.

**4. POTENTIAL BENEFITS FOR STUDY PARTICIPANTS AND/OR SOCIETY**

Your child will gain no direct benefit from the study.

The study does hold benefits for knowledge in the field of sport science, however, and specifically on the effect of shoes on children's feet and their ability to move. The results could possibly also provide shoe manufacturers with the necessary knowledge in the future to design shoes that are beneficial for the development of children's feet.

**5. REMUNERATION FOR PARTICIPATION**

Your child will not be paid for participation in this study.

**6. CONFIDENTIALITY**

Any information that is obtained in connection with this study and that could reveal your child's identity will remain confidential and will only be revealed with your consent or if required by law. Confidentiality will be maintained by storing the data on a personal computer with a password. Only the researcher and the supervisor will be able to look at the data. The data will be dealt with anonymously at all times.

If the research should be published, the data will be discussed in general – in other words for the group as a whole.

**7. PARTICIPATION AND WITHDRAWAL**

You can decide whether or not your child may participate in this study. If you offer that your child may participate, you may still withdraw him/her from the study at any stage without this holding any negative consequences for your child. The researcher could also decide to remove your child from the study should circumstances require this.

**8. DETAILS OF RESEARCHERS**

If you have any questions on the research or if anything about it bothers you, you are welcome to contact us:

Elbé de Villiers (cell phone 084 515 7642; e-mail edup@sun.ac.za) or Dr Ranel Venter (cell phone 083 309 2894; e-mail rev@sun.ac.za)

**9. RIGHTS OF RESEARCH PARTICIPANTS**

You may withdraw your consent at any stage and discontinue your child's participation, without any negative consequences. Your child will not waive any legal claims or rights by taking part in this research study. For any questions about your child's rights as a study participant, contact Ms Maléne Fouché at the Stellenbosch University Division for Research Development [mfouche@sun.ac.za; 021 808 4622].

**SIGNATURE OF PARENT / GUARDIAN**

I was given a copy of the letter with information.
I was given the opportunity to ask questions, and they were answered satisfactorily.

I consent that ________________________________ may participate in this study. I have received a copy of this form.

________________________________________
**Name of parent/guardian**

___________________________________                    _______________
**Signature of parent/guardian**                    **Date**

**Physical Address:**

Street number and name:_______________________________________________

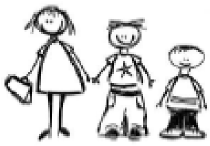
Area / Suburb: _______________________________________________________

Town / City: _________________________________________________________

Appendix 5

STELLENBOSCH UNIVERSITY

## PARTICIPANT INFORMATION LEAFLET AND ASSENT FORM



**TITLE OF THE RESEARCH PROJECT:**
Moving Feet – A Study where we compare school-aged children who normally walks barefoot to those who normally wear shoes.

**RESEARCHER'S NAME:** Elbé de Villiers

**ADDRESS:** Department of Sport Science, Stellenbosch University

**CONTACT NUMBER:** 021 808 4735 / 021 808 4735

**What is RESEARCH?**
Research is something we do to find **NEW KNOWLEDGE** about the way things (and people) work. We use research projects or studies to help us find out more about children and teenagers and the things that affect their lives, their schools, their families and their health. We do this to try and make the world a better place!

**What is this research project all about?**
During this project we want to see what effect your everyday shoes have on:
The way you walk
The shape of your feet
Your balance
The distance that you can jump

**Why have I been invited to take part in this research project?**
You were invited because you are a pupil in one of the schools that was chosen for the study. You are healthy, do not have an injury and you are the right age.

**Who is doing the research?**
My name is Elbé de Villiers. I am a Biokineticist working at Stellenbosch University. My job is to help people get better after they had an injury, where in an accident or where very ill. We help them by doing specific exercises.

**What will happen to me in this study?**
During the study we will do a few tests.
First of all we will measure your height and weight.
Then we will do a warm-up (light jogging and stretches) to get you ready for the other tests.
We will ask you to walk a few metres over a platform. We will take measurements of your foot while you are standing and sitting
The balance test is next. You will need to walk backwards on three different sized plank, 3 times.
You will be asked to jump forward as far as you can 3 times and jump sideways as many times as possible in 15 seconds. You will do this twice.
Next you will jog and run 20 metres while being recorded by a video camera. We want to see how you put your foot down while running. Only the running will be done twice and the time it takes you to complete this will be taken.
Lastly we will measure your hand grip strength.

**Can anything bad happen to me?**
Nothing bad can happen to you during the study. You will only run short distances and jump three times. The only thing that might happen is that your muscles might feel uncomfortable.
We will show you how to do everything.

**Will anyone know I am in the study?**
Nobody have to know that you are part of the study. Your specific results will only be known by Elbé.

**Who can I talk to about the study?**
If you have questions or want to speak to someone about the study you can contact: Elbé de Villiers (cell phone: 084 515 7642; email: edup@sun.ac.za) or Dr Ranel Venter (cell phone: 083 309 2894; email: rev@sun.ac.za).

**What if I do not want to do this?**
No one can force you to be part of the study. If you do not want to do this, you do not have to. Even if your parents allowed you and signed the form, you still do not have to do it.
If you said that you want to be part of the study and decide later on that you do not want to do it any more, nothing will happen to you and you can just stop being part of it.

Do you understand this research study and are you willing to take part in it?

YES NO

Has the researcher answered all your questions?

YES NO

Do you understand that you can STOP being in the study at any time?

YES NO

______________________ ______________________

Signature of Child Date

# Appendix 6

UNIVERSITEIT•STELLENBOSCH•UNIVERSITY
jou kennisvennoot • your knowledge partner

**STELLENBOSCH UNIVERSITY**
**CONSENT TO PARTICIPATE IN RESEARCH**

**Moving feet – a comparative study of school children who normally wear shoes and those who normally walk barefoot**

I am Elbé de Villiers (a PhD student in Sport Science) of the Department of Sport Science at Stellenbosch University. I would like to invite you to participate in my research study. The results of the study will form part of the thesis for my doctoral degree in Sport Science. You have been chosen as a possible participant in the study because you are in one of the participant schools and also are of the right age.

## 1. PURPOSE OF THE STUDY

The main purpose of this study is to determine the effect that shoes have on the developing foot. I will also determine whether shoes influence children's ability to move.

## 2. PROCEDURES

If you agree to take part in this study, you will have to undergo the following tests and measurements:

*Anthropometric measurement:* Your length and weight will be measured.

*Complete a questionnaire on physical activity:* This is done to determine how active you are.

*Questionnaire on being barefoot:* This will be done to determine how often you are barefoot.

*Jogging and running for 20 metres:* First you will jog and then sprint for 20 metres. While doing this, you will be recorded on a video camera. You will be asked to do the sprinting twice with and without shoes. The video is just to determine how you land with your feet while running.

*Balance tests:* You will be asked to walk backwards on three different sized bars. This will be done twice on each bar with and without shoes.

*Jumping:* You will be asked to jump as far as you can with both feet together. The distance will be measured. You will do this jump three times with and without shoes.
With the next jump, you will have to jump sideways as many times as possible in 15 seconds. The jumps will be counted and you will do it twice with and without shoes.

*Foot shape:* You will be asked to walk over a platform with a pressure plate embedded in it.
You would also have to stand with both legs on a foot measuring platform and your arch height, foot length and foot width will be measured by a calliper while you are standing and being seated.

*Grip strength:* Your grip strength will be determined by using a hand grip calliper.

### 3. POTENTIAL RISKS AND DISCOMFORT

Although some of the tests might be unknown to you, they are simple tests. They should not make you exceptionally tired or cause any discomfort.

### 4. POTENTIAL BENEFITS FOR STUDY PARTICIPANTS AND/OR SOCIETY

You will gain no direct benefit from the study.

The study does hold benefits for knowledge in the field of sport science, however, and specifically on the effect of shoes on children's feet and their ability to move. The results could possibly also provide shoe manufacturers with the necessary knowledge in the future to design shoes that are beneficial for the development of children's feet.

### 5. REMUNERATION FOR PARTICIPATION

You will not be paid for participation in this study.

### 6. CONFIDENTIALITY

Any information that is obtained in connection with this study and that could reveal your identity will remain confidential and will only be revealed with your consent or if required by law. Confidentiality will be maintained by storing the data on a personal computer with a password. Only the researcher and the supervisor will be able to look at the data. The data will be dealt with anonymously at all times.

If the research should be published, the data will be discussed in general – in other words for the group as a whole.

### 7. PARTICIPATION AND WITHDRAWAL

You can decide whether or not you want to participate in this study. If you offer that you will participate, you may still withdraw from the study at any stage without this holding any negative consequences for you. The researcher could also decide to remove you from the study should circumstances require this.

### 8. DETAILS OF RESEARCHERS

If you have any questions on the research or if anything about it bothers you, you are welcome to contact us:

Elbé de Villiers (cell phone 084 515 7642; e-mail edup@sun.ac.za) or Dr Ranel Venter (cell phone 083 309 2894; e-mail rev@sun.ac.za)

### 9. RIGHTS OF RESEARCH PARTICIPANTS

You may withdraw your consent at any stage and discontinue your participation, without any negative consequences. You will not waive any legal claims or rights by taking part in this research study. For any questions about your rights as a study participant, contact Ms Maléne Fouché at the Stellenbosch University Division for Research Development [mfouche@sun.ac.za; 021 808 4622].

**SIGNATURE OF PARTICIPANT**

I was given a copy of the letter with information.
I was given the opportunity to ask questions, and they were answered satisfactorily.

I consent that I, ______________________________ will participate in this study. I have received a copy of this form.

______________________________
**Name of participant**

______________________________ ______________
**Signature of participant** **Date**

# Appendix 7

UNIVERSITEIT•STELLENBOSCH•UNIVERSITY
jou kennisvennoot • your knowledge partner

**UNIVERSITEIT STELLENBOSCH**
**TOESTEMMING TOT DEELNAME AAN NAVORSING**

**Bewegende voete – 'n vergelykende studie van skoolkinders wat gewoonlik skoene dra teenoor dié wat gewoonlik kaalvoet loop**

Ek is Elbé de Villiers ('n PhD-student in Sportwetenskap) van die Departement Sportwetenskap aan die Universiteit Stellenbosch. Ek nooi u kind om deel te neem aan my navorsingstudie. Die resultate van die studie sal deel uitmaak van die tesis vir my doktorsgraad in Sportwetenskap. U kind is as 'n moontlike studiedeelnemer gekies omdat hy/sy in een van die deelnemerskole is en ook die regte ouderdom is.

## 1. DOEL VAN DIE STUDIE

Die hoofdoel van hierdie studie is om te bepaal watter effek skoene op die ontwikkelende voet het. Ek sal ook vasstel of skoene kinders se bewegingsvermoë beïnvloed.

## 2. PROSEDURES

Indien u instem dat u kind aan hierdie studie kan deelneem, sal u kind die volgende toetse en metings ondergaan:

*Antropometriese meting:* U kind se lengte en gewig sal gemeet word.

*Invul van 'n vraelys oor fisiese aktiwiteit:* Dit word gedoen om te bepaal hoe aktief u kind is.

*Invul van 'n vraelys oor kaalvoetgewoontes:* Hiermee wil ons agterkom hoe gereeld u kind kaalvoet is.

*Draf en hardloop oor 20 meter:* Terwyl u kind draf en hardloop sal hy/sy met 'n videokamera afgeneem word. Die video word geneem om te kyk hoe u kind se voet neergesit word tydens die verskillende situasies. Die tyd wat dit u kind neem om die 20 meter te hardloop sal geneem word en hy/sy sal gevra word om dit twee keer te doen met en sonder skoene.

*Balanstoetse:* Die kind sal gevra word om agteruit te loop op drie verskillende plankies, elkeen met 'n ander breedte. Dit moet twee keer elk gedoen word met en sonder skoene.

*Spronge:* U kind sal gevra word om so ver as moontlik met albei voete tegelyk te spring. Die afstand sal gemeet word. U kind sal die sprong drie keer doen, met en sonder skoene.
Na die verspring sal u kind gevra word om so veel keer as moontlik in 15 sekondes sywaarts te spring. Dit sal twee keer herhaal word en die beste een sal gebruik word, met en sonder skoene.

*Handgreep:* Die krag van albei u kind se hande sal gemeet word met 'n handgreepkaliper.

*Voetvorm:* U kind sal gevra word om kaalvoet op 'n voetmetingsapparaat te staan waar u kind se voetlengte en -breedte sowel as die hoogte van sy/haar voetbrug bepaal sal word.

## 3. MOONTLIKE RISIKO'S EN ONGEMAK

Hoewel van die toetse dalk onbekend sal wees vir u kind, is dit eenvoudige toetse. Dit behoort nie u kind buitengewoon moeg te maak of ongemak te veroorsaak nie.

## 4. MOONTLIKE VOORDELE VIR STUDIEDEELNEMERS EN/OF DIE SAMELEWING

U kind sal geen direkte voordeel uit die studie trek nie.

Die studie hou egter wel voordele in vir kennis op die gebied van sportwetenskap en veral oor die uitwerking van skoene op kinders se voete en bewegingsvermoë. Die resultate kan skoenvervaardigers ook moontlik in die toekoms die nodige kennis gee om skoene te ontwerp wat voordelig is vir die ontwikkeling van kinders se voete.

## 5. VERGOEDING VIR DEELNAME

U kind sal nie vir deelname aan hierdie studie betaal word nie.

## 6. VERTROULIKHEID

Enige inligting wat in verband met hierdie studie bekom word en u kind se identiteit verklap, sal vertroulik bly en slegs met u toestemming of ingevolge wetsvereistes bekend gemaak word. Vertroulikheid sal gehandhaaf word deur die data op 'n persoonlike rekenaar met 'n wagwoord te berg. Slegs die navorser en die studieleier sal na die data kan kyk. Die data sal te alle tye anoniem hanteer word.

Indien die navorsing gepubliseer word, sal die data in die algemeen – met ander woorde vir die groep in die geheel – bespreek word.

## 7. DEELNAME EN ONTTREKKING

U kan kies of u kind aan hierdie studie mag deelneem of nie. Indien u aanbied dat u kind kan deelneem, kan u hom/haar steeds in enige stadium onttrek sonder dat dit enige gevolge vir u kind sal inhou. Die navorser kan ook besluit om u kind aan die studie te onttrek indien omstandighede dit vereis.

## 8. BESONDERHEDE VAN NAVORSERS

As u enige vrae oor die navorsing het of as enigiets daarvan u pla, kontak ons gerus:

Elbé de Villiers (selfoon 084 515 7642; e-pos edup@sun.ac.za) of dr Ranel Venter (selfoon 083 309 2894; e-pos rev@sun.ac.za)

## 9. REGTE VAN NAVORSINGSDEELNEMERS

U kan in enige stadium u toestemming terugtrek en u kind se deelname staak, sonder enige nadelige gevolge. U kind doen nie afstand van enige wettige aansprake of regte deur aan hierdie navorsingstudie deel te neem nie. Vir enige vrae oor u kind se regte as studiedeelnemer, skakel met me Maléne Fouché in die Universiteit Stellenbosch se Afdeling Navorsingsontwikkeling [mfouche@sun.ac.za; 021 808 4622].

**HANDTEKENING VAN OUER / VOOG**

Ek het geleentheid gekry om vrae te vra, en dit is bevredigend beantwoord.

Ek stem in dat ________________________________ aan hierdie studie kan deelneem. Ek het 'n afskrif van hierdie vorm ontvang.

________________________________________

**Naam van ouer/voog**

___________________________________ ______________

**Handtekening van ouer/voog** **Datum**

**<u>Woonadres:</u>**

Straatnaam en nommer: ________________________________________________________

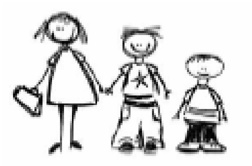
Voorstad / area: ______________________________________________________________

Stad / Dorp: _________________________________________________________________

# Appendix 8

UNIVERSITEIT STELLENBOSCH

## INLIGTINGSTUK EN TOESTEMMINGSVORM VIR DEELNEMERS



**NAAM VAN DIE NAVORSINGSPROJEK:** Bewegende voete – 'n studie waar ons skoolkinders wat gewoonlik skoene dra vergelyk met dié wat gewoonlik kaalvoet loop

**NAVORSER(S) SE NAAM:** Elbé de Villiers

**ADRES:** Departement Sportwetenskap, Universiteit Stellenbosch

**KONTAKNOMMER:** 021 808 4735 / 084 515 7642

**Wat is NAVORSING?**
Navorsing is iets wat ons doen om MEER TE LEER oor hoe dinge (en mense) werk. Ons gebruik navorsingsprojekte of -ondersoeke om meer uit te vind oor kinders en tieners en die dinge wat hulle lewe beïnvloed, soos hulle skool, hulle gesin en hulle gesondheid. Ons doen dit omdat ons die wêreld 'n beter plek probeer maak.

**Waaroor gaan hierdie navorsingsprojek?**
Met hierdie navorsing wil ons kyk of die skoene wat jy dra, die volgende doen:
Die manier waarop jy loop verander
Die vorm van jou voet verander
Jou balans beter maak
Jou verder laat spring

**Hoekom vra julle my om aan hierdie navorsingsprojek deel te neem?**
Ons wil graag hê dat jy moet deelneem aan die projek, omdat jy in die skool is wat ons gekies het om deel te wees, jy gesond is, jy nie enige beserings het nie, en jy die regte ouderdom is.

**Wie doen die navorsing?**
My naam is Elbé de Villiers en ek werk by die Universiteit Stellenbosch. Ek is 'n Biokinetikus. Ek gebruik oefening om mense sterker te maak nadat hulle seergekry het of as hulle baie siek was.

**Wat sal ek moet doen as ek aan die studie deelneem?**
Ons gaan eers kyk hoe lank en hoe swaar jy is.
Daarna gaan ons jou laat opwarm deur liggies te draf en bietjie strekke te doen om jou reg te kry vir die toetse.
Jy gaan 20 meter moet hardloop terwyl jy met 'n videokamera afgeneem word en jou tyd geneem word.
Dan gaan jy 'n op 'n meetapparaat moet staan vir 'n paar sekondes, sodat ons jou voet kan meet.
Ons gaan ook jou balans toets. Jy sal agteruit moet loop op drie verskillende plankies. Dit gaan jy twee keer moet doen.
Volgende gaan ons kyk hoe ver jy met altwee bene gelyktydig kan spring.
Daarna gaan ons kyk hoeveel keer jy sywaarts kan spring in 15 sekondes. Dit moet ook twee keer gedoen word.
Laastens gaan ons ook kyk hoe sterk jou handgreep is.

**Is daar enigiets wat kan verkeerd gaan?**
Jy gaan kort ente hardloop en driekeer spring en jou spiere kan dalk vreemd voel, maar niks kan jou seermaak of niks kan verkeerd gaan nie.
Ons sal ook vir jou mooi wys hoe om alles te doen.

**Sal ander mense weet ek neem aan die projek deel?**
Niemand hoef te weet dat jy aan die studie deelneem nie en niemand anders, behalwe Elbé, sal weet hoe jy met die toetse gevaar het nie.

**Met wie kan ek oor die projek gesels?**
As jy enige vrae het oor die projek of as jy met iemand wil gesels kan jy vir Elbé de Villiers (selfoon: 084 515 7642; e-pos: edup@sun.ac.za) of Dr Ranel Venter (selfoon: 083 309 2894; e-pos: rev@sun.ac.za) kontak.

**Wat gebeur as ek nie wil deelneem nie?**
Jy hoef net deel te neem aan die projek as jy wil. Jy gaan nie gedwing word nie en dit maak nie saak as jou ouers gesê het jy mag nie, en as jy nie wil nie, hoef jy nie.

As jy wel gesê het jy wil deelneem en jy sien later jy is nie lus nie, kan jy enige tyd vir my sê en dan kan jy ophou deelneem aan die projek.

Verstaan jy waaroor hierdie navorsing gaan, en sal jy aan die projek deelneem?

| JA | NEE |
|---|---|

Het die navorser ál jou vrae beantwoord?

| JA | NEE |
|---|---|

Verstaan jy dat jy kan OPHOU deelneem net wanneer jy wil?

| JA | NEE |
|---|---|

____________________________ ________________________

Kind se handtekening Datum

Appendix 9

UNIVERSITEIT•STELLENBOSCH•UNIVERSITY
jou kennisvennoot • your knowledge partner

**UNIVERSITEIT STELLENBOSCH**
**TOESTEMMING TOT DEELNAME AAN NAVORSING**

**Bewegende voete – 'n vergelykende studie van skoolkinders wat gewoonlik skoene dra teenoor dié wat gewoonlik kaalvoet loop**

Ek is Elbé de Villiers ('n PhD-student in Sportwetenskap) van die Departement Sportwetenskap aan die Universiteit Stellenbosch. Ek nooi jou om deel te neem aan my navorsingstudie. Die resultate van die studie sal deel uitmaak van die tesis vir my doktorsgraad in Sportwetenskap. Jy is as 'n moontlike studiedeelnemer gekies omdat jy in een van die deelnemerskole is en ook die regte ouderdom is.

**1. DOEL VAN DIE STUDIE**

Die hoofdoel van hierdie studie is om te bepaal watter effek skoene op die ontwikkelende voet het. Ek sal ook vasstel of skoene kinders se bewegingsvermoë beïnvloed.

**2. PROSEDURES**

Indien jy instem om aan hierdie studie deel te neem, sal jy die volgende toetse en metings ondergaan:

*Antropometriese meting:* Jou lengte en gewig sal gemeet word.

*Invul van 'n vraelys oor fisiese aktiwiteit:* Dít word gedoen om te bepaal hoe aktief jy is.

*Invul van 'n vraelys oor kaalvoetgewoontes:* Hiermee wil ons agterkom hoe gereeld jy kaalvoet is.

*Draf en hardloop oor 20 meter:* Terwyl jy draf en hardloop sal jy met 'n videokamera afgeneem word. Die video word geneem om te kyk hoe jy jou voet neersit tydens die verskillende situasies. Die tyd wat dit jou neem om die 20 meter te hardloop sal geneem word en jy sal gevra word om dit twee keer te doen, met en sonder skoene.

*Balanstoetse*: Jy sal gevra word om agteruit te loop op drie verskillende plankies, elkeen met 'n ander breedte. Dít moet ook twee keer elk gedoen word, met en sonder skoene.

*Spronge:* Jy sal so ver as moontlik met albei voete tegelyk probeer spring. Die afstand sal gemeet word. Jy sal die sprong drie keer doen, met en sonder skoene.
Na die verspring sal jy gevra word om so veel keer as moontlik in 15 sekondes sywaarts te spring. Dit sal twee keer herhaal word en die beste een van die twee sal gebruik word, met en sonder skoene.

*Handgreep:* Die krag van albei jou hande sal gemeet word met 'n handgreepkaliper.

*Voetvorm:* Jy sal gevra word om kaalvoet op 'n voetmetingsapparaat te staan terwyl jou voetlengte en -breedte sowel as die hoogte van jou voetbrug bepaal sal word.

**3. MOONTLIKE RISIKO'S EN ONGEMAK**

Hoewel van die toetse dalk onbekend sal wees vir jou, is dit eenvoudige toetse. Dit behoort jou nie buitengewoon moeg te maak of ongemak te veroorsaak nie.

**4. MOONTLIKE VOORDELE VIR STUDIEDEELNEMERS EN/OF DIE SAMELEWING**

Jy sal geen direkte voordeel uit die studie trek nie.

Die studie hou egter wel voordele in vir kennis op die gebied van sportwetenskap en veral oor die uitwerking van skoene op kinders se voete en bewegingsvermoë. Die resultate kan skoenvervaardigers ook moontlik in die toekoms die nodige kennis gee om skoene te ontwerp wat voordelig is vir die ontwikkeling van kinders se voete.

**5. VERGOEDING VIR DEELNAME**

Jy sal nie vir deelname aan hierdie studie betaal word nie.

**6. VERTROULIKHEID**

Enige inligting wat in verband met hierdie studie bekom word en jou identiteit kan verklap, sal vertroulik bly en slegs met jou toestemming of ingevolge wetsvereistes bekend gemaak word. Vertroulikheid sal gehandhaaf word deur die data op 'n persoonlike rekenaar met 'n wagwoord te berg. Slegs die navorser en die studieleier sal na die data kan kyk. Die data sal te alle tye anoniem hanteer word.

Indien die navorsing gepubliseer word, sal die data in die algemeen – met ander woorde vir die groep in die geheel – bespreek word.

**7. DEELNAME EN ONTTREKKING**

Jy kan kies of jy aan hierdie studie wil deelneem of nie. Indien jy aanbied dat jy kan deelneem, kan jy steeds in enige stadium onttrek sonder dat dit enige gevolge vir jou sal inhou. Die navorser kan ook besluit om jou aan die studie te onttrek indien omstandighede dit vereis.

**8. BESONDERHEDE VAN NAVORSERS**

As jy enige vrae oor die navorsing het of as enigiets daarvan jou pla, kontak ons gerus:

Elbé de Villiers (selfoon 084 515 7642; e-pos edup@sun.ac.za) of dr Ranel Venter (selfoon 083 309 2894; e-pos rev@sun.ac.za)

## 9. REGTE VAN NAVORSINGSDEELNEMERS

Jy kan in enige stadium jou toestemming terugtrek en jou deelname staak, sonder enige nadelige gevolge. Jy doen nie afstand van enige wettige aansprake of regte deur aan hierdie navorsingstudie deel te neem nie. Vir enige vrae oor jou regte as studiedeelnemer, skakel met me Maléne Fouché in die Universiteit Stellenbosch se Afdeling Navorsingsontwikkeling [mfouche@sun.ac.za; 021 808 4622].

**HANDTEKENING VAN DEELNEMER**

Ek het geleentheid gekry om vrae te vra, en dit is bevredigend beantwoord.

Ek ______________________________stem in om aan hierdie studie deel te neem. Ek het 'n afskrif van hierdie vorm ontvang.

__________________________________________
**Naam van deelnemer**

_____________________________________ _______________
**Handtekening van deelnemer** **Datum**