

Relationship between sport participation and the physical, motor
performance and anthropometric components of a selected group
of grade 10 adolescents



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FOREWORD

I would like to take this opportunity to express my sincere appreciation to the following special people for all their assistance, guidance and support during the last couple of years:

To my Heavenly Father, thank you for all the talent and opportunities I received. Thank You for blessing me with all your love and forgiveness and for giving me strength when I had none.

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“I can do all things through Christ who strengthens me”

Philippians 4:13

DECLARATION

The co-authors of the two articles, which form part of this dissertation, Dr. Ben Coetzee (Supervisor), Ms. Cindy Pienaar, hereby give permission to the candidate, Ms. Ninette Duvenhage to include the two articles as part of a Master's dissertation. The contribution (advisory and supportive) of the co-author was kept within reasonable limits, thereby enabling the candidate to submit this dissertation for examination purposes. This dissertation, therefore, serves as partial fulfillment of the requirements for the Magister Scientiae degree in Sport Science within Physical Activity, Sport and Recreation in the Faculty of Health Sciences at the North-West University (Potchefstroom Campus).



Dr. Ben Coetzee
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SUMMARY

Sport participation is positively associated with an increase in various physical, motor performance and anthropometric components, however, these benefits are influenced by the gender, race and the type of sport children participate in. Despite this, no researchers have investigated this association and the possible role of gender, race and the nature of sport participation on the possible benefits that can be derived among South African adolescents. It is against this background that the objectives of the study were firstly, to determine the relationship between sport participation and the physical, motor performance and anthropometric components, of a group of grade 10 adolescent learners in the Tlokwe District, North West Province, South Africa. Secondly, it was to determine the significant differences in the physical, motor performance and anthropometric components between a group of grade 10 learners of different genders and races who participated in different types of sport in the Tlokwe District, North West Province, South Africa.

Two hundred and one (156 sport participants and 48 non-sport participants) were purposefully selected to complete a questionnaire among other things to obtain their sport and training habits as well as their maturity status. Furthermore, a total of 28 direct anthropometric measurements were taken as well as tests executed for the determination of flexibility, explosive leg and upper body power, strength, speed and acceleration, agility and the cardiovascular endurance. Of the 156 sport participants, 146 learners' data were separately analysed to investigate the significant differences with regard to the measured variables in boys ($n = 72$) and girls ($n = 71$), black ($n = 105$) and white children ($n = 41$) as well in children who only participated in individual ($n = 17$), team ($n = 82$) or both types of sport ($n = 47$).

The independent t-test results revealed that the sport participants obtained lower values for most of the absolute body and relative body size as well as body composition measurements that showed significant results. Furthermore, the non-sport participants did not perform better in any of the physical and motor performance tests than the sport participants when the significant results were analysed. Lastly, the forward stepwise logistic regression analysis results indicated that body mass, stature, sitting height, sum of six skinfolds, fat percentage, hip circumference, muscle mass and percentage, Vertical Jump Test (VJT) height, VJT Tendo peak power, Horizontal Jump Test distance, 40m speed; right passive shoulder external and internal rotation as well as passive and active straight-leg-raise and the modified Thomas quadriceps

(MTQT) flexibility were identified as adequate and accurate predictors to classify the adolescent learners in sport participant and non-sport participant groups. However, only body mass, sitting height, muscle percentage and muscle mass and the right MTQT flexibility were identified as significant predictors between the two groups of children. Furthermore, the forward stepwise logistic regression analysis revealed that the logistic model of identified physical, motor performance and anthropometric variables was not useful in predicting the different groups.

With regard to the significant results, the study revealed that the boys obtained higher values for most of the absolute and relative body size, body composition and somatotype related variables as well as for all of the tests that were related to lower body explosive power, muscle strength, speed, agility and cardiovascular endurance related variables compared to the girls. The differences with regard to the racial groups showed that black children displayed significantly lower values for most of the absolute and relative body size, body composition as somatotype measurements as well as for all of the upper and lower body explosive power, muscle strength, speed, agility and the cardiovascular endurance related variables which obtained significant differences when compared to the values of white children. Only the flexibility related tests obtained significant differences with regard to the children who participated in different types of sports.

Therefore, although a relationship exists between sport participation and the physical, motor performance and anthropometric benefits that can be derived, factors such as race and gender have a direct influence on this relationship and need to be considered when this population of children is investigated.

OPSOMMING

Sport deelname word positief geassosieer met 'n toename in verskeie fisieke, motories en antropometriese komponente. Hierdie voordele word wel deur ras, geslag en die tipe sport waaraan kinders deelneem beïnvloed. Ten spyte hiervan, is daar nog geen navorsing gedoen aangaan die moontlike rol wat geslag, ras en die tipe sport op die moontlike voordele van sport deelname in Suid Afrikaanse kinders het nie. Gesien teen hierdie agtergrond is die volgende doelwitte vir hierdie studie gestel, eerstens, om vas te stel wat die verhouding tussen sport deelname en die fisiek, motories en antropometriese komponente van 'n groep graad 10 adolosente leerders in die Tlokwe Distrik, Noord Wes Provinsie, Suid Afrika is. Tweedens om te probeer vasstel wat die beduidende verskil in die fisiek, motoriese en antropometriese komponente tussen 'n groep graad 10 leerders van verskillende geslagte, rasse en verskillende sport soorte waaraan deel geneem is in die Tlokwe Distrik, Noord Wes Provinsie, Suid Afrika

Twee-honderd-en-een (156 sport deelnemers en 48 nie deelnemend) was doelgerig gekies om 'n vraelys te beantwoord, aangaande hulle sport en oefen gewoontes asook hulle volwassenheidstatus. Hierna is 'n total van 28 direkte antropometriese metings geneem, gevolg deur toetse om soepelheid, eksplosiewe been en bolyf krag, krag, spoed en versnelling, ratsheid en kardiovaskulêre uithouvermoë te bepaal. Van die 156 sport deelnemers, is 146 leerders se data apart ontleed, om die beduidende verskille tussen seuns ($n = 72$) en dogters ($n = 71$), swart ($n = 105$) en wit kinders ($n = 41$) asook kinders wat in individuele ($n = 17$), span ($n = 82$) of albei sport tipes ($n = 47$) deelneem te ondersoek.

Die onafhanklike t-toes resultate het getoon dat die sport deelnemers beduidende laer waardes vir meeste van die absolute liggaam en relatiewe liggaam groote asook die liggaam samestelling mates wat beduidende verskille getoon het. Verder het die nie sport deelnemende leerders, nie in enige fisieke en motoriese toetse beter as die sport deelnemers gevaar nie. Laastens het die voorwaartse logistiese regressie analise aangedui dat liggaamsmassa, liggaamslengte, sithoogte, som van ses velvoue, vetpersentasie, heupomtrek, spiermassa en persentasie, Vertikale Spring Toets (VJT) hoogte, VJT Tendo piek krag, Horisontale Sprong Toets afstand, 40m spoed, regter passiewe skouer interne en eksterne rotasie asook passiewe en aktiewe reguit-been-oplig en die modified Thomas quadriceps (MTQT) soepelheid voldoende en akurate voorspellers is om hierdie adolosente leerders in sport deelnemende en nie deelnemende groepe te klassifiseer. Net liggaamsmassa,

sithoogte, spier persentasie, spiermassa en die regter MTQT soepelheid is geïdentifiseer as beduidende voorspellers tussen hierdie twee groepe kinders. Verder het die Voorwaartse logistiese regressie analise aangedui dat die logistiese tabel van die geïdentifiseerde fisiek, motories en antropometriesse veranderlikes nie 'van nut was in die voorspelling van die verskillende groepe nie.

Ten opsigte van die beduidende resultate, het die studie aangedui dat seuns hoër waardes het, vir meeste van die absolute en relatiewe liggaams grootte, liggaams samestelling en somatotipering verwante veranderlikes asook al die toetse wat verwant was aan been eksplosiewe krag, spierkrag, spoed, ratsheid, en kardiovaskulêre uithouvermoë verwante veranderlikes in vergelyking met meisies. Die verskille ten opsigte van ras groepe het gewys dat swart kinders beduinde laer waardes vir meeste van die absolute en relatiewe liggaams massa, liggaams samestelling en somatotipering metings asook vir al die been en bo-lyf eksplosiewe krag, spier krag, spoed, ratsheid en kardiovaskulêre uithouvermoë verwante veranderlikes het in vergelyking met die waardes van wit kinders. Net soepelheid verwante toetse het beduidende verskille ten opsigte van die kinders wat in verskillende sportsoorte deelneem, getoon.

Alhoewel daar 'n verhouding tussen sport deelname en die fisiek, motories en antropometriesse voordele bestaan, en faktore soos geslag en ras 'n direkte invloed op hierdie verhouding het, moet dit in ag geneem word wanneer hierdie ouderdomsgroep kinders ondersoek word.

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LIST OF ABBREVIATIONS

1RM	One Repetition Maximum
ADPT	Ankle dorsiflexion and plantar flexion test
ASLRT	Active-straight-leg-raise-test
AST	Abdominal Stage Test
BMD	Bone mineral density
BMI	Body mass index
HJT	Horizontal Jump Test
MTIT	Modified Thomas Iliopsoas Test
MTQT	Modified Thomas Quadriceps Test
PHV	Peak height velocity
PSERT	Passive Shoulder External Rotation Test
PSIRT	Passive Shoulder Internal Rotation Test
PSLRT	Passive-straight-leg-raise-test
SRT	Shuttle run test
VJT	Vertical jump test
$\dot{V}O_{2\max}$	Maximum oxygen uptake

CHAPTER 1



1

INTRODUCTION

-
1. **PROBLEM STATEMENT**
 2. **OBJECTIVES**
 3. **HYPOTHESIS**
 4. **STRUCTURE OF THE DISSERTATION**
 5. **REFERENCES**
-

1. PROBLEM STATEMENT

Research advocates that sport participation is positively associated with an increase in various physical, motor performance and anthropometric components among children. In this regard, several researchers reported an increase in aerobic or cardio respiratory fitness, muscle strength and endurance as well as power (Bergeron, 2007:28; Silvestri, 1997:890); a decrease in body mass index and fat percentage, as well as an increase in fat-free mass (Bergeron, 2007:28; Sirard *et al.*, 2008:209) and bone mineral density (BMD) (Bergeron, 2007:29; Egan *et al.*, 2006:232) among boys and girls who participate in organised sport. The above benefits of sport participation are, however, influenced by the race and gender of the study subjects (Sirard *et al.*, 2008:203, 205). The classification of sport into individual and team sport also seems to have an influence on the benefits of sport participation (Egan *et al.*, 2006:227).

The factors or components that can be categorized as physical components and that will also be the focus point of this study, are muscle and cardiovascular endurance as well as flexibility (Haywood, 1986:203).

Motor performance components can generally be described as factors or components that influence a person's current performance level and allow a person to execute a certain movement skill (Gallahue & Ozman, 1995:73; Gallahue & Ozman, 2006:16). Components such as speed, agility, balance, coordination and explosive power will, therefore, fall under the category of motor performance components (Gallahue & Ozman, 1995:73). The body composition or anthropometric components generally include body sizes that are directly measured which, among other things indicate the shape of the whole body or body segments (Abernethy *et al.*, 2005:33).

According to Silvestri (1997:890), some of the physical and motor performance benefits of sport participation are an increase in muscle strength, flexibility and endurance. However, studies that have measured the direct benefits of sport participation are scarce and have compelled the author of this proposal also to investigate the possible benefits of physical activity and the exercise guidelines that are related to changes in the physical, motor performance and anthropometric components of study subjects. In this regard, a study by Strong *et al.* (2005:736) has, for example, concluded that school age children between the ages of 6 and 18 years should participate in moderate to vigorous exercise for 30 to 45 minutes a day to gain any beneficial changes in skeletal health, aerobic fitness, muscular strength and endurance. To achieve greater beneficial effects it is necessary for children to participate in physical activity of a moderate to vigorous exercise intensity every day for at least 60 minutes or more at a time (Strong *et al.*, 2005:736). With regard to the volume of training or physical activities, a study by Faigenbaum *et al.* (1999:4) showed that greater upper body strength gains are experienced when high volume training programmes are used compared to low volume training programmes, and that different training protocols can enhance children's muscular strength and endurance. Furthermore, longitudinal studies of adolescents also seem to suggest that physical activity has a positive influence on upper body muscular endurance (Strong *et al.*, 2005:735). According to Fletcher *et al.* (1992:340), the cardiovascular system's functional capacity increases and myocardial oxygen demand decreases with participation in physical activity by healthy people. German (2006:566, 567) recommended that children take part in sport and physical activities during the period between the pre-pubertal and pubertal development stages due to the fact that this period provides the most optimal window for increases in peak bone and muscle mass.

Although the above-mentioned research seems to suggest that frequent participation in sport may lead to certain physical, motor performance and anthropometric benefits, researchers have alluded to the fact that various factors may influence the nature and magnitude of the benefits. For example, a study by Tracy *et al.*

(2002:450) on 90,000 adolescents in the United States who had to complete a questionnaire about their sport participation, self esteem and self image, found that African American boys had the highest level of sport participation followed by Caucasian boys and then girls. Tracy *et al.* (2002:456), therefore, hypothesized that the African American boys will probably experience the most benefits due to sport participation because of their higher frequency of participation and concluded that the benefits of sport participation will be dependent on the race and gender of the subjects. In another study, Kimm *et al.* (2002:710) reported that sport participating black girls over all displayed higher body mass index (BMI) than both sport participating and non-participating white girls. Sirard *et al.* (2008:205) also found that physically active African American girls have lower aerobic fitness levels compared to physically active white girls.

With regard to gender, researchers in general found a much higher sport participation rate among boys than among girls (Eitle, 2005:192). Furthermore, Egan *et al.* (2006:227) showed that boys experienced a higher increase in BMD compared to that of girls, due to participation in Rugby Union football. They attributed this to the period of participation that was higher among boys compared to the girls (Egan *et al.*, 2006:227). Bone accretion seems to depend on, among other things, the frequency of the applied force that is experienced during rugby participation (McArdle *et al.*, 2001:63), which may be the physiological mechanism responsible for the differences in BMD increases between the two gender groups because of differences in periods of participation. Ramachandran *et al.* (2009:42) found that sport participating boys and girls showed higher cardio-respiratory and muscular strength values than their peers, but that sport participating boys seemed to display higher cardio-respiratory and muscular strength values than girls. On the other hand both non-participating and participating girls showed significantly higher BMI and flexibility values than those of boys overall. The last-mentioned findings would suggest that the flexibility values of girls are not influenced by sport participation but also by gender specific traits, which allow them to obtain a better range of motion around their joints (Ramachandran *et al.*, 2009:42).

Another factor that needs to be considered when the benefits of sport participation are investigated is the nature of the sport or sport item that adolescents participate in. As mentioned before boys and girls who participate in Rugby Union football for a period of time show increases in BMD (Egan *et al.*, 2006:231, 232). BMD increases are also experienced by participants of netball and athletics although Rugby Union Football seems to have the biggest influence on participant's BMD compared to athletics where participants experienced the lowest BMD (Egan *et al.*, 2006:231, 232). Another benefit that can be derived from sport participation is an increase in aerobic fitness. In this regard, Fletcher *et al.* (1992:341) found that football,

tennis, soccer, basketball and athletics are especially beneficial for an increase in aerobic fitness. According to Gleim and Mc Hugh (1997:296, 297), flexibility patterns are specific to specific sports and even specific positions within the sport. In this regard Church *et al.* (2001:335) stated that specific skills and sport, such as gymnastics, require different speeds and movements that might require more flexibility than other skills and sport types.

Despite the above-mentioned research findings with regard to the possible benefits of sport participation, no research exists with regard to the possible physical, motor performance and anthropometric benefits of sport participation among South African adolescent individual and team sport participants as well as participants of different genders and races. Studies in which South African and especially adolescent boys and girls (10-15 years) of the North West Province were described with regard to various anthropometrical measurements (stature, body mass, relative sitting height and arm span), physical and motor performance components (20-m Shuttle run test, Basket ball throw for distance test, 40 Metre sprint test, 5 Metre agility test, Vertical jump Test and the Throw and Catch for Accuracy Test) do exist, but did not investigate the relationship between sport participation and the different variables among this group of children (Engelbrecht, 2001; Engelbrecht *et al.*, 2002; Van Gent, 2001; Viljoen, 2003; Pienaar & Viljoen, 2010). Furthermore, research suggests that children in South Africa are showing a decrease in physical activity levels which is considered to be the main cause for an increase in the overweight and obesity among this population (Cilliers, 2011). It is against this background of a lack of research concerning the link between physical, motor performance, anthropometric components and sport participation as well as the possible risk of low physical activity and sport participation levels that the following research questions are posed: Firstly, what is the relationship between sport participation and the physical, motor performance and anthropometric components, of a group of grade 10 adolescent learners in the Tlokwe District, North West Province, South Africa? Secondly, what are the significant differences in the physical, motor performance and anthropometric components between a group of grade 10 learners of different genders and races who participated in different types of sport in the Tlokwe District, North West Province, South Africa? Answers to these questions ought to provide coaches, sport scientists and other sport related professionals in the North West Province, South Africa with direction concerning the real benefits of sport participation as well as the possible effects of other factors (such as gender, race and the nature of sport participation) on these benefits.

2. OBJECTIVES

The objectives of this study were to:

- Determine the relationship between sport participation and the physical, motor performance and anthropometric components, of a group of grade 10 adolescent learners in the Tlokwe District, North West Province, South Africa.
- Determine the significant differences in the physical, motor performance and anthropometric components between a group of grade 10 learners, of different genders, in the Tlokwe District, North West Province, South Africa.
- Determine the significant differences in the physical, motor performance and anthropometric components between a group of grade 10 learners, of different racial groups, in the Tlokwe District, North West Province, South Africa.
- Determine the significant differences in the physical, motor performance and anthropometric components between a group of grade 10 learners who participated in different types of sport in the Tlokwe District, North West Province, South Africa

3. HYPOTHESIS

The study is based on the following hypotheses:

- There is a significant positive relationship between sport participation and the physical, motor performance and anthropometric components, of a group of grade 10 adolescent learners in the Tlokwe District, North West Province, South Africa.
- Significant differences will exist in most of the physical, motor performance and anthropometric components between the two gender groups of grade 10 sport participant learners in the Tlokwe District, North West Province, South Africa.
- Significant differences will exist in most of the physical, motor performance and anthropometric components between the two racial groups of grade 10 sport participant learners in the Tlokwe District, North West Province, South Africa.
- No significant differences will exist in most of the physical, motor performance and anthropometric components between groups of grade 10 learners in the Tlokwe District, North West Province, South Africa who participated in different types of sport.

4. STRUCTURE OF DISSERTATION

The dissertation is submitted in article format as approved by the Senate of the North-West University and is structured as follows:

- Chapter 1: Introduction. A bibliography is provided at the end of the chapter in accordance with the guidelines of the North-West University.
- Chapter 2: Literature review: The influence of sport participation on the physical, motor performance and anthropometric components of children. A bibliography is provided at the end of the chapter in accordance with the guidelines of the North-West University.
- Chapter 3: Article 1 - The relationship between adolescent sport participation and the physical, motor performance and anthropometric components of a group of grade 10 learners. The article will be presented to *Pediatric Exercise Science*. A bibliography is presented at the end of the chapter in accordance with the guidelines of the journal. Although not according to the guidelines of the journal, tables will be included within the text so as to make the article easier to read and understand. Furthermore, the line spacing of the article will be set at 1.5 lines instead of the prescribed 2 lines. According to the journal guidelines page numbers must be indicated in the right hand top corner of the page. This guideline was also not met so as to adhere to the format of the dissertation.
- Chapter 4: Article 2 – The effects of gender, race and nature of sport participation on the relationship between adolescent sport participation and the physical, motor performance and anthropometric components of a group of grade 10 adolescents. The article will be presented to the *Journal of Human Kinetics*. Although not according to the guidelines of the journal, line numbers were not inserted in the article itself. Furthermore, tables that were included in the article were supposed to be vertically aligned, but due to space restrictions this guideline was also not met.
- Chapter 5: Summary, conclusions, shortcomings and recommendations.

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CHAPTER 2



2 LITERATURE OVERVIEW: THE INFLUENCE OF SPORT PARTICIPATION ON THE PHYSICAL, MOTOR PERFORMANCE AND ANTHROPOMETRIC COMPONENTS OF CHILDREN

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1. Introduction

According to the Oxford Dictionary of Sports Science and Medicine, physical activity can be defined as “any form of body movement that has a significant metabolic demand” (Kent, 2006:417). Household chores, non-sporting leisure activities can, therefore, all be classified as physical activities (Kent, 2006:417). Only 56.8% of the Australian population was sufficiently physically active in 2000 compared to the 62.2% physically active people in 1997 (Bauman *et al.*, 2001:3). The active people survey of 2008/2009 in England showed that only 16.5% of the English population participated in sport three times per week for 30 minutes at a moderate intensity. The United States Bureau of Labour Statistics (2008) reported a more or less similar sport participation level for the population of the United States of America (USA), with 16% of the population participating in sport. With regard to the activity levels of adolescents, Pate *et al.* (1994:444) reported that two thirds of adolescent boys and one quarter of adolescent girls in the USA participate in moderate to vigorous activities for 20 minutes three times per week.

According to Silvestri (1997:890), some of the benefits that can be derived from physical activity and sport participation include an increase in cardiovascular endurance, strength and flexibility. Boys and girls who participate in organised sport also show a decrease in body mass index and fat percentage, as well as an increase in fat-free mass (Bergeron, 2007:28; Sirard *et al.*, 2008:209) and bone mineral density (BMD) (Egan *et al.*, 2006:232; Bergeron, 2007:29). There are different opinions in the literature about the amount, intensity and type of physical exercise needed to achieve these benefits. Fletcher *et al.* (1992:341) stated that activities must be done at intensities exceeding 50% of a person’s exercise capacity to achieve benefits. Bergeron (2007:30) suggested that adolescents must participate regularly for four to five times per week in moderate to vigorous intensity activities to achieve cardiovascular, musculoskeletal and fitness benefits. Bergeron (2007:31) and Fletcher *et al.* (1992:341) reported that soccer, singles tennis, basketball, field hockey, walking, running, cycling, swimming and touch football are good activities to participate in to attain physical, motor performance and anthropometric benefits.

However, studies that have measured the direct benefits of sport participation are scarce and have compelled the author of this review to also investigate the possible benefits of physical activity and the exercise guidelines that are related to changes in the physical, motor performance and anthropometric components of study subjects. The benefits derived from sport participation are, however, influenced by the race and gender of the participants (Sirard *et al.*, 2008:203, 205). The classification of sport into individual and team sport

also seems to have an influence on the benefits of sport participation (Egan *et al.*, 2006:227). Therefore, this literature review will also include gender, race and the sport of participation as part of the topics for the literature analyses. The possible effects of the last-mentioned components on the relationship between sport participation and the physical, motor performance and anthropometric components of children will also be investigated.

Only literature which included children from the age of seven years and older as well as mid-adolescents (15 to 17 years old) (Dube *et al.*, 2006:444e2) were included in this literature review. The literature searches were narrowed down to include only articles from the past twenty-six years (1986–2012). Furthermore, only studies that focused on the physical, motor performance and anthropometric components of subjects as well as the influence of gender, race, team and individual sports on the last-mentioned components were included in the literature review. The purpose of this chapter was, therefore, to provide a review on the findings with regard to the relationship between sport participation and the physical, motor performance and anthropometric components of children. Furthermore, the review also attempted to establish the effect of gender, race and the nature of sport participation on the physical, motor performance and anthropometric components of children.

In view of the above-mentioned facts, the next section will be dedicated to the possible relationship that exists between sport participation and the physical, motor performance and anthropometric components of children. Each of the last-mentioned components as well as subcomponents which can be categorised under these components will firstly be discussed after which the findings with regard to possible relationships will be presented. This will be followed by a discussion of the possible influence of gender, race and nature of sport participation on the last-mentioned relationship. The section will conclude with a summary of the most relevant literature findings as well as recommendations with regard to the study theme.

2. Relationship between sport participation and the physical, motor performance and anthropometric components of children.

Research advocates that sport participation is positively associated with an increase in various physical, motor performance and anthropometric components among children (Silvestri, 1997:890; Bergeron, 2007:28; Sirard *et al.*, 2008:209). In the next few paragraphs the influence of sport participation on each of these physical, motor performance and anthropometric components will be defined and discussed in detail.

2.1 The influence of sport participation on the physical components of children

The factors or components that can be categorized as physical components are cardiovascular and muscle endurance as well as flexibility (Haywood, 1986:203). In the next section each of the physical components that may possibly be influenced by sport participation among children will firstly be defined after which the possible influence of sport participation and physical activity on each of these components will be discussed.

a) Cardiovascular endurance

Cardiovascular fitness or endurance is “the ability of the heart and blood vessels to supply nutrients and oxygen to tissues, including muscles, during sustained exercise” (Kent, 2006:101). Despite differences between cross-sectional and longitudinal studies, studies overall agree that adolescents and children who are more active have higher cardio respiratory endurance levels (Boreham *et al.*, 1997:792; Ekulund *et al.*, 2001:197; Ara *et al.*, 2004:1588). However, some researchers found that the benefits of aerobic training were small-to-moderate for both boys and girls of 13 years and younger (Payne & Morrow, 1993:311). Furthermore, a significant but weak relationship was found between physical activity and cardiovascular fitness in a study of 1 585 adolescents (Hands *et al.*, 2009:658).

According to Fletcher *et al.* (1992:340), the cardiovascular system’s functional capacity increases and myocardial oxygen demand decreases with participation in physical activity. A study on 114 healthy pre-pubescent boys (Tanner <2) from Gran Canaria (Ara *et al.*, 2004:1586, 1588) confirmed the finding of Fletcher *et al.* (1992:340). They reported significantly better aerobic values for the physically active (completed three hours per week of extracurricular activities) compared to the physically inactive group (who only participated in the compulsory physical education classes of 80-90 minutes per week). Similarly, Ekulund *et al.* (2001:197) and Boreham *et al.* (1997:792) found a significant positive relationship between physical activity and cardiorespiratory fitness for both genders. In a longitudinal study of four years compiled by Baquet *et al.* (2006:54) children from the age of 11 until the age of 15 years who regularly participated in physical activity not only had significant better cardiorespiratory fitness but Baquet *et al.* (2006:54) also found a significant increase in the difference between active and inactive group over these four years. Furthermore, a study by Pfeiffer *et al.* (2007:2237) on girls between grades 8 and 12 showed that girls who participated in moderate to vigorous physical activities had significantly higher fitness levels than girls who were not vigorously active. Ruiz *et al.* (2006:302) also concluded that vigorous physical activities are

associated with higher cardiorespiratory fitness levels compared to light and moderate intensity physical activities. In this regard Fletcher *et al.* (1992:341) stated that football, tennis, soccer, basketball and athletics are especially beneficial to elicit an increase in cardiovascular fitness.

With regard to a comparison between the influence of sport participation and normal physical education classes on the cardiovascular endurance of participants, researchers have for example observed significantly higher aerobic power values in the experimental group of 11-13 year old basketball playing boys compared to the control group who only participated in the school's physical education classes (Vamvakoudis *et al.*, 2007:934). After a period of 18 months during which the experimental group continued with their participation in basketball training, even higher aerobic power values were found compared to the control group whose values stayed more or less the same (Vamvakoudis *et al.*, 2007:934). Another study also indicated that a group of prepubescent football players obtained significantly better results in aerobic power in comparison to the control group who participated in the compulsory physical education classes twice weekly for 45 minutes per session (Vicente-Rodriguez *et al.*, 2003:855). Similarly, 24 girls 14 years of age who played handball showed significantly better aerobic power values than a group of girls ($n = 28$) who only participated in the compulsory physical education classes of a school in Gran Canaria (Vicente-Rodriguez *et al.*, 2004:1210).

Another cardiovascular endurance related component that is also positively influenced by physical activity, is muscle endurance (Silvestri, 1997:890; Bergeron, 2007:28).

b) Muscle endurance

Muscular endurance can be described as the muscle's ability to withstand fatigue (Kent, 2006:366). This is indicated by the capacity of the muscles to "perform repeated actions against a sub-maximal resistance and is determined by the number of repetitions a person can perform at a certain percentage of their one repetition maximum (1RM)" (Kent, 2006:366). Ramsay *et al.* (1990:607) observed increases in the muscular endurance of the bench and leg press exercises after a group of 9 to 11 year old boys followed a circuit training programme for three times per week for 20 weeks. Kruger and Pienaar (2011:364) also found significant improvements in the abdominal muscle endurance values of 19, 10 to 15 year old girls who participated in a sport development programme. This programme consisted of a warm-up, speed, reaction time, speed endurance and plyometric exercises, running drills and a cool-down. Furthermore, longitudinal studies of

adolescents seem to suggest that physical activity has a positive influence on upper body muscular endurance of participants (Strong *et al.*, 2005:735). In contrast to the last-mentioned studies, Hands *et al.* (2009:658) reported no significant difference in the muscle endurance of high (15 053 steps per day) and low (6 898 steps per day) physically active 14 year old adolescents.

According to Faigenbaum *et al.* (1999:4), children's muscular endurance can be enhanced by using different training protocols. In this regard, the effects of medicine ball training (as a resistance training modality) on the fitness of a New England city high school's children were tested by Faigenbaum and Mediate (2006:165). One hundred and eighteen children between the ages of 15 and 16 years participated in this study (Faigenbaum & Mediate, 2006:163). The control group was made up of 35 boys and 14 girls who performed traditional physical education exercises, whereas 42 boys and 27 girls participated in the medicine ball training programme twice per week for six weeks (Faigenbaum & Mediate, 2006:164). Although both groups participated in physical activity during this study, the experimental group showed a significant improvement in upper body muscular endurance compared to the control group who did not show any significant improvements in the named variables (Faigenbaum & Mediate, 2006:163).

Flexibility is also regarded to be an important physical component and results with regard to this component will be discussed in the next section.

c) Flexibility

The sport science handbook defines flexibility as “the range of movement possible around a joint or a series of joints” (Jenkins, 2005:284). According to the Oxford Dictionary of Sport Science, flexibility is “the ability to move a joint smoothly through its complete range of motion” (Kent, 2006:214). Several authors have alluded to the fact that flexibility can be improved by participating in physical activities (Silvestri, 1997:890) or by participating in any organised sport (Bloomfield & Wilson, 1998:240). However, in general girls seem to possess better flexibility than boys of the same age irrespective of differences in activity levels (Thomas & Thomas, 1988:226).

A study of Kruger and Pienaar (2011:3610) compared 19 girls in the rural area of Potchefstroom (South Africa) who followed a sport development programme twice per week, 1.5 hours per session for ten weeks (experimental group) to 18 girls who formed the control group and continued with their normal activities.

They reported significant improvements in the quadriceps, iliopsoas and right leg's plantar and neutral position flexibility values of the experimental group compared to the control group who did not experience any significant improvements. On the other hand, Hoffman *et al.* (2005:159) reported no significant increases in the sit-and-reach flexibility of adolescent boys and girls due to their participation in recreational sports such as basketball, gymnastics, football, baseball, swimming, tennis and soccer. Katzmarzyk *et al.* (1998:713) also found no significant difference between the sit-and-reach test values of 13-18 year old active and inactive boys and girls. According to Baquet *et al.* (2006:54), there is no significant difference in the sit and reach flexibility of sport participating and non-participating boys aged 11-15 years old, but sport participating girls performed significantly better in the sit-and-reach flexibility test compared to inactive girls of the same age.

Surprisingly, Hands *et al.* (2009:660) indicated that low active children showed greater sit-and-reach flexibility measures compared to children who were more active. Most of these low active children spent their time playing video games or watching television, which might have caused increased flexibility for certain joints due to prolonged periods of time that the posture is placed in positions which are at the end of the range of movement (Hands *et al.*, 2009:660). Reduced range of motion may occur when subjects do not stretch regularly while engaged in high intensity repetitive activities (Hands *et al.*, 2009:660).

In the next section the influence of sport participation on the motor performance components of children will be discussed.

2.2 The influence of sport participation on the motor performance components of children

Motor performance components can generally be described as factors or components that influence a person's current performance level and allow a person to execute a certain movement skill (Gallahue & Ozman, 2006:16). Components such as speed, agility, balance, muscle strength and explosive power will, therefore, fall under this category (Gallahue & Ozman, 1995:73). According to Hoffman *et al.* (2005:158), children who participate in sport programmes perform significantly better in anaerobic power and muscular strength tests than non-active children. A study by Okely *et al.* (2001:1900), which examined the relationship between fundamental movement skills and organised physical activity of 180 high school students of New South Wales, Australia, reported a significant relationship between the ability to perform fundamental movement skills and participation in organised physical activities. The results of another study on grades K

to four children (Ulrich, 1987:59) seem to agree with those of Okely *et al.* (2001:1902) by indicating a significant relationship between children's motor performance competence and their participation in organized sport (Ulrich, 1987:61). Dissimilarly, Hands *et al.* (2009:658) found no significant difference in the motor competence of groups of high and low physically active children.

In the next section motor performance components such as speed, agility, balance, muscle strength and explosive power will be defined and the available literature with regard to the influence of sport participation on the last-mentioned variables will be discussed.

a) Speed and agility

Speed is the “distance travelled per unit time and is measured in metres per second” (Kent, 2006:513). The Oxford dictionary of Sport Science and Medicine defines speed as “the ability to perform a movement quickly” (Kent, 2006:513), whereas agility is “the ability to change the body's position rapidly and accurately without losing balance” (Kent, 2006:24). Research shows that active children and adolescents obtain better results in anaerobic capacity and running speed tests compared to non-active children and adolescents (Ara *et al.*, 2004:1588). In an intervention study of Kruger and Pienaar (2011:364) significant improvements in running speed were reported for children who participated in a sport development programme compared to children that did not participate in the programme.

Regarding the type of sport that children participate in, football and handball players seem to obtain better results with regard to speed and agility tests compared to children that do not participate in any sport (Vicente-Rodriguez *et al.*, 2003:855; Vicente-Rodriguez *et al.*, 2004:1210).

b) Balance

Balance, as described by Nashner, (1997:261), is “the process of maintaining the body's centre of gravity over the base of support.” Balance can be divided into two categories, namely: static and dynamic balance (Kent, 2006:66). The Oxford Dictionary of Sport Science and Medicine defines static balance as “the ability to hold a stationary position”, whereas dynamic balance is described as the ability of the body to obtain equilibrium while moving (Kent, 2006:66). To execute smooth and coordinated neuromuscular actions balance relies on continuous feedback from the proprioceptors, vestibular, visual and somatosensory structures (Hrysomallis, 2011:228). Overall studies show that gymnasts perform better than non-gymnasts

when the balance test exceeds 20 seconds (Carrick *et al.*, 2007:1887; Calavalle *et al.*, 2008:647). It has also been proven that balance exercises may lead to improvements in the 20 yard agility run; side hops agility test and vertical jump test values (Simek *et al.*, 2007:136). Yaggie and Campbell (2006:426) also found a significant decrease in the shuttle run time of the experimental group that followed a bosu ball balance training programme three times per week, 20 minutes per session, which consisted of balance exercises on a bosu ball and progressed from the easiest exercise to the most complex exercise.

c) Muscle strength

Muscle strength can be described as the “force or tension that a muscle or muscle group can exert against a resistance in one maximal effort” and is measured by using a dynamometer (Kent, 2006:366). There are several factors, such as the number of muscles needed, the proportion of the muscle fibres and the coordination of the muscle groups that may influence the maximum force that can be generated by a person (Ortega *et al.*, 2008:2). Significant increases in the absolute isokinetic peak torque of the knee extensors and elbow flexors as well as in the isometric strength of the elbow flexors and knee extensors were reported by Ramsay *et al.* (1990:607, 608) for the experimental group (9-11 years old boys) who participated in a circuit training programme three times per week in comparison to a control group who did not participate in weight training but were allowed to continue participating in their sport. However, no significant increases in the cross-sectional areas of the limbs or in motor unit activation were indicated for the group who experienced significant muscle strength improvements (Ramsay *et al.*, 1990:607, 608).

Faigenbaum *et al.* (1993:344) found significant increases in the muscle strength values of the children between the ages of eight and 12 years (ten boys and four girls) who participated in a strength training programme of eight weeks for two times a week, compared to control group (six boys and four girls) who did not participate in any kind of strength training. Ramsay *et al.* (1990:606) also found increases in the 1RM bench and leg press exercise after a group of nine to eleven year old boys followed a circuit training programme three times per week for 20 weeks compared to smaller increase in the 1RM bench press results of the control group who did not participate in the circuit training programme. A study completed by Foo *et al.* (2007:1284) on 283 adolescent girls in Beijing (15 years old) found that girls participating in physical activity had significantly higher hand grip strength than their inactive counterparts. One hundred and eighty three boys between the ages of 12.5 and 17.5 years who participated in vigorous physical activity

(>6 METs) showed a significant positive relationship between physical activity and lower body muscle strength (standing broad jump) compared to the less active boys (Moliner-Urdiales *et al.*, 2010:1122). Moliner-Urdiales *et al.* (2010:1122) also found no significant relationship between physical activity and muscle strength regardless of active and non active girls. In contrast to these studies Baquet *et al.* (2006:54) found no significant difference in the hand grip strength of 11-15 year old active and sedentary boys and girls.

d) Explosive muscle power

Explosive power can be described as “the ability to expend energy in one explosive act or in a series of strong sudden movements as in jumping, or projecting some object (e.g. a javelin) as far as possible” (Kent, 2006:197). With regard to the possible influence of physical activity on jumping height, Ara *et al.* (2004:1588) found that active children and adolescents show significantly better results in jumping height compared to non-active children and adolescents. Adding to this, a study on 44 fifth graders by Hoffman *et al.* (2005:159), showed that recreational or seasonal sport participation by boys and girls can have a significant positive effect on their upper and lower body power scores compared to inactive children (Hoffman *et al.*, 2005:159). Baquet *et al.* (2006:54) also found that boys and girls between the ages of 11 and 15 years old had significant better explosive and functional strength compared to their inactive counterparts.

Sport participation or physical activity level does, however, not only influence the physical and motor performance components of participants but may also have a direct influence on the anthropometric components of participants. The next section will, therefore, be dedicated to the possible influence of sport participation on the anthropometric components of children.

2.3 The influence of sport participation on the anthropometric components of children

Anthropometry can be described as the “measurement of the structure of the human body” (Jenkins, 2005:55). Jenkins, (2005:55) subdivides these measurements into skinfolds and weights (body weight), girths (circumferences) lengths (including stature), diametres. Regular sport participation may benefit the anthropometric components of participants by causing a decrease in body mass index (BMI) and fat percentage, as well as an increase in fat-free mass (Bergeron, 2007:28; Sirard *et al.*, 2008:209) and bone mineral density (BMD) (Egan *et al.*, 2006:232; Bergeron, 2007:29). Vicente-Rodriguez (2006:566, 567) recommended that children take part in sport and physical activities during the period between the pre-

pubertal and pubertal development stages due to the fact that this period provides the most optimal window for increases in peak bone and muscle mass. To gain a better understanding of the role that physical activity or sport participation plays in influencing the different components of children's anthropometric profile, each of the anthropometric components will be discussed under subheadings.

a) Body stature and weight

Body stature is measured from the bottom of one's feet to the highest point of a person's head (Kent, 2006:528). According to the Oxford dictionary of Sport Science and Medicine body weight can be defined as "the gravitational force that the earth exerts on a human body at or near the earth's surface and is the product of body mass (in kilograms) and the acceleration due to gravity (9.81 m.s^2) measured in Newtons (N)" (Kent, 2006:528). The timing of peak height velocity (PHV), rate of growth in stature and attained stature are not influenced by participating in physical activity (Malina, 2004:481). However, a study by Nogueira and Da Costa (2009:95) on 326 adolescents found that Brazilian boys between the ages of 11 and 15 years who exercised for more than one hour per day had significantly higher body weight and stature values in correlation to Brazilian boys who exercised for less than an hour per day. In contrast to these findings, Vicente-Rodriguez *et al.* (2003:855) and Vamvakoudis *et al.* (2007:936) reported that prepubescent boys who participated in football and basketball displayed significantly lower body mass values than their non-participating peers.

b) Body mass index (BMI)

The Oxford Concise Medical Dictionary defines BMI as the body weight divided by the square of the body stature (kg/cm^2) of a person and is more generally used by researchers and medical practitioners to determine whether a person is under or overweight (Kent, 2006:83). BMI is not a good indicator of obesity or being overweight due to the fact that it does not distinguish between body fat and lean body mass (Prentice & Jebb, 2001:144). None the less results from a study by Ara *et al.* (2004:1588) suggested that physical activity and BMI are independently associated with fitness. Ara *et al.* (2004:1587) found that the physically active group (Tanner <2) in their study, who participated in extracurricular activities at least three hours per week, and the non-physically active group, who only participated in the compulsory physical education classes, showed similar body mass and BMI values, although hip and waist circumference were greater in the non-physically active group. Similarly, Hands *et al.* (2009:658) also concluded that no significant difference occurred in the BMI of adolescents that were more physically active compared to those who were less physically active.

c) Fat percentage (Fat mass) and lean body mass

Lean body mass or fat free mass as it is also known, is “the mass of all the non-fat body tissue such as muscles, bone and connective tissue” (Kent, 2006:206). According to the Oxford Concise Medical Dictionary (2006), fat mass is “the absolute amount of body fat” of a person (Kent, 2006:206). A study by Ara *et al.* (2004:1588) concluded that children participating in at least three hours of sport per week display significantly smaller body fat mass and lower fat percentage values than children who do not participate in sports regularly. The skinfold thickness in all areas was smaller and fat mass was 28% lower in the physical active group compared to the non active group (Ara *et al.*, 2004:1588). In addition, Vicente-Rodriguez *et al.* (2003:855) found that prepubescent football players (Tanner <2) have significantly lower fat percentage values than their non-participating counterparts. A study on 11.5 year old prepubescent boys showed similar results with the basketball playing boys who displayed significantly lower fat percentage values compared to non-participating boys (Vamvakoudis *et al.*, 2007:936). In another study, Vicente-Rodriguez *et al.* (2004:1210) reported that girls who played handball showed no difference in body mass and fat percentage, but showed a significantly higher average lean body mass value compared to a control group of non-participating girls. In contrast with the previously mentioned study results, Ekulund *et al.* (2001:198) found no significant relationship between physical activity and body fat in 14 to 15 year old boys and girls. In addition Foo *et al.* (2007:1284) found that 15 year old Chinese girls who participated in physical activity had significantly greater lean body mass compared to their inactive counterparts, but found no significant difference in the fat percentage between sport participants and non participants.

d) Bone mineral density (BMD)

The McGraw-Hill Medical Dictionary for Allied Health defines bone mineral density (BMD) as a “measurement of the amount of calcium in the bone” (Breskin *et al.*, 2008:48). Bergeron (2007:29) stated that running-based and high-volume impact-loading sport such as gymnastics, tennis and soccer should enhance BMD. A study by Foo *et al.* (2007:1285) found no significant differences in the BMD of physically active and non active 15 year old Chinese girls from Beijing. In contrast to Foo *et al.*, Zhu *et al.* (2004:991) found a weak but significant relationship between physical activity and BMD of 10 year old Chinese girls from Beijing. Also, Vicente-Rodriguez *et al.* (2004:1212) found higher BMD and physical fitness values in girls who participated in handball compared to non-active controls. In contrast to the above mentioned, a study by Boot *et al.* (1997:58) reported no significant difference in the BMD of physically active girls compared to

inactive girls, but found that boys who participated in physical activity had significantly higher total body BMD than the boys who did not participate in any sport. In a cross sectional study on adolescent males between the ages of 16 and 18 years, Ginty *et al.* (2005:107) concluded that a positive relationship exists between site-specific bone mineral status, cardio respiratory and muscular fitness.

From the above-mentioned results, it is clear that most studies agree that sport participation has a positive influence on the physical, motor performance and anthropometric components of participants (Ramsay *et al.*, 1990:607; Silvestri, 1997:890; Ara *et al.*, 2004:1588; Hands *et al.*, 2009:658, 660; Kruger & Pienaar, 2011:364). The relationship between sport participation and the physical, motor performance as well as the anthropometric components are, however, influenced by the gender and race of participants as well as the nature of the sport that subjects participate in. These aspects will be the focus of the following section.

3. The possible effect of gender on sport participation and the physical, motor performance and anthropometric components of children.

Gender seems to be a determining factor in the physical, motor performance and anthropometric benefits that will be derived from sport participation or activity levels (Sirard *et al.*, 2008:203, 205). In this regard, researchers reported a much higher sport participation and activity level among boys than among girls (Anderson & Schelin, 1994:15; Boot *et al.*, 1997:58; Sallis *et al.*, 2000:965; Eitle, 2005:192; Ruiz *et al.*, 2006:301; Moliner-Urdiales *et al.*, 2010:1121). Furthermore, the differences in sport participation and activity levels between genders seem to influence the benefits that can be derived from sport or activity participation with adolescent boys who display significantly higher aerobic fitness, muscle strength, muscle endurance, and significantly lower BMI in both sport participating and non-participating groups compared to girls (Hands *et al.*, 2009:658). On the other hand adolescent girls showed significantly higher flexibility values than boys (Hands *et al.*, 2009:659; Dumith *et al.*, 2010:644). Furthermore, sport participating boys and girls seem to display higher cardio-respiratory and muscular strength values than their peers, although the boys in this sport participating population obtained higher cardio-respiratory and muscular strength values compared to the girls (Ramachandran *et al.*, 2009:42).

3.1 The effect of gender on sport participation and the physical components of children

Studies has shown that gender does influence the effect that sport participation has on the physical components of children (Boreham *et al.* 1997:792; Janz *et al.* 2000:1252;; Ruiz *et al.* 2006:301; Evans *et al.*,

2007:453; Msengi *et al.*, 2008:14; Hands *et al.* 2009:659). In the next few paragraphs the effect that gender has on sport participation and the physical components will be discussed in detail.

a) Cardiovascular endurance

With regard to the influence of gender on cardiovascular endurance, Janz *et al.* (2000:1252) found greater peak $\dot{V}O_2$ values in boys than in girls between the ages of seven and eleven years. Boreham *et al.* (1997:792) reported a significant relationship between physical activity and cardiovascular endurance for boys ($p < 0.01$) and sport participation and cardiovascular endurance for girls ($p < 0.01$) in their studies on 1 015 children between the ages of 12 and 15 years. Similarly, studies by Ruiz *et al.* (2006:301) and Hands *et al.* (2009:659) found that 9-10 year and 14 year old girls, respectively had significantly lower cardiovascular endurance levels than their male counterparts. The study results of Katzmarzyk *et al.* (1998:712) and Ekulund *et al.* (2001:197, 198) disagreed with the last-mentioned conclusions, by revealing a significantly better positive relationship between physical activity and aerobic fitness in 14- tot 15-year old girls compared to boys. However, no significant differences were reported between the $\dot{V}O_{2max}$ values of pre-pubertal 10 and 11 year old boys and girls before or after they followed a 13 week aerobic training programme in a study by Mandigout *et al.* (2001:13).

b) Muscle endurance

Research on the muscle endurance of children showed that 14 year old boys achieved better times in the side bridge endurance test than their female counterparts, but for the trunk extensor endurance test both boys and girls achieved similar times (Evans *et al.*, 2007:453). The researchers provided several reasons for these findings. The better results achieved by the boys during the side bridge test might be due to a more beneficial muscle mass distribution, training programme preferences or the difference in the anatomical build of the two gender groups (Evans *et al.*, 2007:453). In a study of 72 grade six and seven students from Midwestern schools in the United States the results showed that non-sport participating and sport participating boys achieved significantly higher scores in the push-up and curl-up endurance tests compared to their female counterparts (Msengi *et al.*, 2008:14). Similarly, studies by Ruiz *et al.* (2006:301) and Hands *et al.* (2009:659) found that 9-10 year and 14 year old girls, respectively had significantly lower muscle endurance levels than their male counterparts.

c) Flexibility

Although boys outperform girls in almost every category of fitness testing the flexibility values of girls tend to be better than those of boys (Hands *et al.*, 2009:657). In this regard Hands *et al.* (2009:657) found significantly better scores in the sit-and-reach and shoulder flexibility test for adolescent girls compared to their male counterparts. Ramachandran *et al.* (2009:42) suggested that the flexibility values of girls are not only influenced by sport participation but also by gender specific traits, which allow them to obtain a better range of motion around their joints. However, when the movement skills of girls are evaluated these skills seem to be stronger related to the time that girls spent in organized physical activities compared to boys where this relationship is not very strong (Okely *et al.*, 2001:1903).

3.2 The effect of gender on sport participation and the motor performance components of children

Overall boys do perform significantly better in motor performance tests, which are related to muscle strength, speed, explosive power, balance and agility (Gallahue & Ozman, 1995:73) compared to girls (Raudsepp & Paasuke, 1995:299; Msengi *et al.*, 2008:14; Hands *et al.*, 2009:657). In this regard, Raudsepp and Paasuke (1995:298) indicated that eight year old boys performed better in motor performance tests such as overhead throw, two hand pushing of the ball, 30 m running and standing long jump compared to girls of the same age. With regard to speed and explosive power, boys tend to have more speed and explosive power than girls even from as early as preschool years (Raudsepp & Paasuke, 1995:301). Janz *et al.* (2003:37) reported a smaller mean ground reaction force for girls, only 3.2 times their body weight, compared to the mean ground reaction force of 3.8 times their body weight for boys. According to Janz *et al.* (2003:37), these differences might be explained by the different jumping strategies that the boys and girls use. Fourteen year old boys outperformed girls in the chest pass, curl ups and motor competence test in a study by Hands *et al.* (2009:657). Furthermore, it was shown that boys between the ages of 14 and 17 years in schools across all the states in Germany have significantly higher strength values than girls of the same age group (Woll *et al.*, 2011:1135). Moliner-Uridiales *et al.* (2010:1121) agrees with Woll *et al.* (2010:1135) and also found that boys perform significantly better in upper (hand grip strength test) and lower body (Broad jump, squat jump test) strength test compared to girls. Overall, studies show that girls perform better in static balance tests (Raudsepp & Paasuke, 1995:301; Woll *et al.*, 2011:1135), but no significant gender differences were found in the scores for the agility tests (Raudsepp & Paasuke, 1995:301; Woll *et al.*, 2011:1135). Dissimilarly, Holm *et al.* (2008:603) found no significant gender differences in the vertical jump height for both sport participating and non-participating children between the ages of seven and eleven years.

3.3 The effect of gender on sport participation and the anthropometric components of children

A study on 376, seven to 12 year old children in the Oslo area found that 11 year old boys had significantly higher body mass index (BMI) values while 12 year old girls were significantly taller and heavier than boys of similar age groups (Holm *et al.*, 2008:603). Results from a study by Baxter-Jones *et al.* (2008:736) found that boys from the age of 9.9 until 17.1 years were taller, heavier and had significantly higher BMD values compared to their peers. In another study, McMurray *et al.* (2003:145) reported that the seven to eleven year old girls in their study were shorter and weighed less than their male counterparts. According to the results from a study compiled by Cheng *et al.* (1999:508), girls at the beginning of their study (first year junior high) were taller and heavier than boys of the same age, but at the end of the study (three years later) girls overall were shorter and lighter than boys. However, in general boys displayed significantly lower body fat values than girls of the same age group (Ruiz *et al.*, 2006:300, 301). According to Ramachandran *et al.* (2009:42), both non-sport participating and sport participating 13 year old girls showed significantly higher body fat and BMI values than 13 year old boys. Baxter-Jones *et al.* (2008:736) also found that boys had significantly greater lean body mass scores compared to girls of the same maturity age. A more recent study by Nogueira and Da Costa (2009:95) found a significant positive relationship between the physical activity levels and BMI of boys, but a significant negative relationship between the physical activity levels and BMI of girls. Egan *et al.* (2006:229) showed that boys experienced a higher increase in BMD compared to that of girls, due to their participation in Rugby Union football. They attributed this to the period of participation that was higher among boys compared to the girls (Egan *et al.*, 2006:227). In contrast to this study Cheng *et al.* (1999:511) found that 87 first year Junior High girls from Hong Kong had significantly higher BMD compared to boys overall. Bone accretion seems to depend on, among other things, the frequency of the applied force that is experienced during rugby participation (McArdle *et al.*, 2001:63), which may be the physiological mechanism responsible for the differences in BMD increases between the two gender groups.

4. The possible effect of race on sport participation and the physical, motor performance and anthropometric components of children

The race of the participants also seems to influence the relationship between sport participation and the physical, motor performance as well as the anthropometric components of these participants. Data from a South African study of children in the greater Johannesburg metropolitan area showed that only 30% of black African children participated in physical education (PE) classes at school compared to 90% of the white

children (McVeigh *et al.*, 2004:986). Tracy and Erkut (2002:450) and McMurray *et al.* (2003:1917) found that black African American boys had the highest level of sport participation followed by the Caucasian boys and then girls when compared to other racial groups. Tracy and Erkut (2002:459) hypothesized that the black African American boys will probably experience the most benefits due to sport participation because of their higher frequency of participation and concluded that the benefits of sport participation are also dependent on the race of subjects.

4.1 The effect of race on sport participation and the physical components of children

During adolescence the cardiorespiratory fitness levels of girls tend to decline (McMurray *et al.*, 2003:1918; Pfeiffer *et al.*, 2007:2234), but this decline seems to be greater in black African American girls than white girls and might be related to the higher body mass and body fat of the black African American girls (McMurray *et al.*, 2003:1917). A variable that has been connected to cardiorespiratory fitness levels of athletes, namely heart rate variability did however not show any significant differences between 62 nine to eleven year old, Canadian, Asian and Caucasian children (Reed *et al.*, 2006:280). Pfeiffer *et al.* (2007:2237) and Lohman *et al.* (2008:1168) both reported that white adolescent girls had significantly higher fitness values and participated more in sport than adolescent black African American girls. In addition, Sirard *et al.* (2008:205) found that physically active black African American girls have lower aerobic fitness levels compared to physically active white girls.

4.2 The effect of race on sport participation and the motor performance components of children

In a study of 113, 12 year old black and white Tunisian football players, white players achieved significantly higher average peak power output values than the black players (Ayed *et al.*, 2011:105). On the other hand the male black football players performed significantly better in the 30 m sprinting test compared to their white counterparts (Ayed *et al.*, 2011:114). This result was also consistent with that of Malina (1988:140), who reported that black African American school boys performed significantly better in the sprint running and the vertical jump tests than the white boys. These research results of Babel *et al.* (2005:800) did, however, not coincide with the results of the last-mentioned studies. These researchers found no difference in the sprint performance test between the 17 eleven year old Caucasian and African- Caribbean boys (Babel *et al.*, 2005:800).

4.3 The effect of race on sport participation and the anthropometric components of children

McArdle *et al.* (2010:763) found that white sprinters and high jump athletes have shorter limbs and wider hips than their black peers. Studies of South African children, between the ages of six and 13 years old, in general revealed that white boys and girls tended to be taller and heavier than black African boys and girls of the same age (Armstrong *et al.*, 2006:441). In accordance with the last-mentioned study results, Roche *et al.* (1994) reported that white boys were overall slightly heavier than their black African counterparts. Similarly Ayed *et al.* (2011:111) also indicated that 12 year old black Tunisian children were significantly smaller and had significantly lower body mass and muscle mass values than white children regardless of the sport of participation. Furthermore, Pesa and Turner (1999:16) revealed that black African American and Native American grade 11 children had the highest body weight compared to Asian American children.

With regard to BMI, Pfeiffer *et al.* (2007:2237) reported a stable BMI over a period of four years as well as no significant differences between white and black African American grade eight girls from South Carolina. Furthermore, Jacobs *et al.* (2010:418) demonstrated that both sport participating and non-participating black African boys had lower BMI and fat percentage values than white boys when they studied 219 boys between the ages of 11 and 13 years living in the rural area of Potchefstroom (South Africa). Data on another South African population of six to 13 year old boys and girls, delivered the same results with the white African boys displaying higher BMI values during all ages, whereas white African girls had higher BMI values up to the age of 11 years where after black African girls displayed higher BMI values than their white peers (Armstrong *et al.*, 2006:442). A study on white and black African girls between the ages of nine and 19 years in the San Francisco and Cincinnati areas showed that sport participating black African girls displayed higher BMI than both sport participating and non-participating white girls (Kimm *et al.*, 2002:710). In a cross-sectional study, Lohman *et al.* (2008:1165) reported that Hispanic girls overall had higher mean fatness and non-Hispanic black girls showed higher fat free mass than the non-Hispanic white groups. Higher fat mass and BMI for non-Hispanic girls were related to lower fitness levels among this population but this relationship was not evident in the other races (Lohman *et al.*, 2008:1168). Freedman *et al.* (2008:1106) found that white boys had a 3.5% higher fat percentage than black African boys and white girls had 2.6% more body fat than black African girls of the same age in New York City. Wagner and Heyward (2000:1396) stated that black African children and adolescents (3 – 18 years old) tend to have significantly higher BMD values than white children. According to a study by Boot *et al.* (1997:58) on 444 Caucasian, 21 Black and 35 Asian children and adolescents aged four to 20 year old Caucasian girls had higher total body BMD in

comparison to girls of Asian ethnicity, while black children did not differ from these groups. They found no significant difference in the BMD of boys across all the various races studied (Boot *et al.*, 1997:58).

From the last-mentioned results it can, therefore, be concluded that the race of sport participants does influence the benefits that can be derived from sport participation. In this next section the possible influence of the nature of sport participation on the different benefits that can be derived will be discussed.

5. The possible effect of the nature of sport participation on the physical, motor performance and anthropometric components of children

Studies which have investigated the differences between the possible influence of team and individual sport participation on the physical, motor performance and anthropometric components of participants are scarce and have compelled the author of this dissertation also to discuss the differences between team and individual sport participation compared to non-sport participation.

5.1 The effect of the nature of sport participation on the physical components of children

Pfeiffer *et al.* (2007:2237) found that girls who participated in team sport had higher absolute fitness levels compared to non-participants. The fact that team sport participants must cover large distances during games may serve as an explanation for the higher aerobic capacity and fitness levels that are observed in team sport participants compared to non-participants (Stone & Kilding, 2009:616). Although all team sport participants need a high aerobic capacity level, differences in the intensity levels of each team sport may influence this component. For example, rugby and soccer players perform most of their activities at low intensities compared to basketball and field hockey players who mostly perform moderate to high intensity activities during their games (Stone & Kilding, 2009:616).

5.2 The effect of the nature of sport participation on the motor performance components of children

A study by Edge *et al.* (2006:228) on young females aged 19 years who participated in team sport, such as hockey, soccer and netball, and individual sport such as cycling, rowing and triathlon found that the team sport group performed significantly better in the repeated sprint test compared to the individual sport group. The females that participated in team sport showed significantly higher absolute total work values and higher blood lactate concentrations immediately after the repeated sprints compared to the individual sport group and the non-sport participation group (Edge *et al.*, 2006:228, 231). According to Bencke *et al.* (2002:176),

the anaerobic power of sport participants is more related to muscle size than to different training modalities due to the finding that anaerobic power differences between participants of different sport disappear when body weight is normalized. With regard to balance, the literature review of Hrysomallis (2011:224) showed that balance ability was best developed in gymnasts followed by soccer players, swimmers and lastly basketball players. In this regard results from the static and dynamic balance ability tests of female gymnasts, soccer and basketball players showed that gymnasts performed the best in the static balance test while basketball players achieved the lowest scores (Bressel *et al.*, 2007:44). Results from the dynamic balance tests showed that soccer players had better dynamic balance ability than basketball players who achieved the lowest scores (Bressel *et al.*, 2007:44).

With regard to flexibility, Gleim and Mc Hugh (1997:296, 297), stated that flexibility patterns were specific to specific sports and even specific positions within the sport. In this regard Church *et al.* (2001:335) concluded that specific skills in a sport, such as gymnastics, require different speeds and movements that might require more flexibility compared to other skills in the same sport or to other sport types. According to Bloomfield and Wilson (1998:279), contact field sport participants such as rugby players as well as Australian and American football players should possess a normal range of motion in most of their joints, except for the joints of the lower body where flexibility will help improve balance and decrease the risk for injuries. In contrast, field hockey and soccer players need high levels of flexibility in the majority of their joints (Bloomfield & Wilson, 1998:278). The ballistic nature of sport such as tennis, squash, cricket and netball accentuates the need for high levels of flexibility in these participants (Bloomfield & Wilson, 1998:271). Gymnasts and jumping field sport need the highest levels of flexibility in the majority of body parts, while swimmers and water polo players need more flexibility in their shoulders, trunks and pelvis. Participants of track and field athletics as well as cycling make use of more static stretching type of exercises compared to ballistic stretching techniques which are focused on the development of explosive power (Bloomfield & Wilson, 1998:272, 273, 276). Research on the possible effect of training on joint mobility did not, however, find any significant differences in the hip and knee joint mobility of a group of players who participated in an 18 month long basketball training programme compared to an inactive control group (Vamvakoudis *et al.*, 2007:935).

5.3 The effect of the nature of sport participation on the anthropometric components of children

Differences between the anthropometric make-up of team and individual sport participants, are a scarce

research topic. Bass *et al.* (1998:502) found that girls 10 years of age who participated in gymnastics were shorter, had 10% more lean mass and 57% less fat mass than girls who participated in other weight bearing sport. Bass *et al.* (1998:501) studied 45 gymnasts and 35 controls from Girls Grammar School. The control subjects participated in sport such as netball, tennis, hockey and ballet for about 1.7 hours per week while the gymnasts participated up to 36 hours per week. Bass *et al.* (1998:502) reported that the 45 gymnasts showed significantly higher whole body BMD compared to the controls. A study by Grimston *et al.* (1993:1204) compared the BMD of 17 children between the ages of 10 and 16 years from the Calgary region in Canada who participated in competitive sport such as running, gymnastics, tumbling and dance to that of children who participate in active loading non-weight bearing activities such as swimming. The results of this study showed that children who were involved in impact loading sport had significantly greater femoral neck BMD measurements compared to children who were involved in active loading sports (Grimston *et al.*, 1993:1205). However, no significant differences were found for the BMD values at the lumbar spine between the two groups (Grimston *et al.*, 1993:1205).

6. Conclusions

In this review, the author attempted to give a thorough overview of the possible relationship between sport participation and the physical, motor performance and anthropometric components of children. However, studies that have measured the direct benefits of sport participation are scarce and have compelled the author to also investigate the possible benefits of physical activity and the exercise guidelines that are related to changes in the physical, motor performance and anthropometric components of study subjects. Furthermore, due to the fact that all of the benefits derived from sport participation are influenced by the race and gender of the participants as well as the nature of the sport of participation the literature review included gender, race and the sport of participation as part of the topics for the literature analyses. The possible effects of the last-mentioned components on the relationship between sport participation and the physical, motor performance and anthropometric components of children were also investigated.

With regard to the possible influence of sport participation and physical activity on the physical components of children the majority of researchers found a positive relationship between physical activity and sport participation levels as well as cardiorespiratory fitness, muscle endurance and flexibility for boys and girls between the ages of 7 and 18 years old. A significant positive relationship was also found between physical activity and sport participation levels and the motor performance components such as speed, agility, balance,

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muscle strength and explosive power of children between the ages of 6 and 16 years old. The literature showed that the anthropometric benefits obtained from regular sport participation are a decrease BMI and fat percentage, as well as an increase in fat-free mass and BMD among sport participating boys and girls.

Overall literature found that boys tend to participate more in physical activity and sport than girls, thus performing better in cardiorespiratory fitness, muscle endurance, speed and agility, muscle strength and explosive power tests while girls tend to perform better in flexibility and balance tests due to gender specific traits. Much controversy exists with regard to the body fat and BMI differences between boys and girls. Some studies found that girls have significantly higher body fat and BMI values while other studies showed that boys had significantly higher body fat and BMI values compared to girls. However, studies showed that boys experienced a higher increase in BMD compared to girls as a result of sport participation.

With regard to possible influence of race on the benefits that can be derived from participation in sport and physical activities, studies of children from areas in South African showed that white boys and girls participate more in sport than their black African counterparts. Studies on populations from other parts of the world found that black African American boys had the highest sport participation levels followed by the Caucasian boys and girls. Regardless of sport participation, black African American girls tend to have the lowest cardiorespiratory fitness levels and the highest BMI levels. Furthermore, research suggests that black African American boys are significantly better in the speed and explosive power tests than their white counterparts. Studies on the anthropometric components of children, demonstrated that white boys and girls tend to be taller and heavier than their black counterparts, and that white boys had higher BMI and fat percentage values than black African boys. Research also suggest that white girls who were younger than 11 years had higher BMI and fat percentage values than black African girls, but that these differences changed over time, and black African girls displayed higher BMI values compared to white girls after the age of 11 years. Literature also found that black African children and adolescents have significantly higher BMD values than their white counterparts.

Research with regard to the influence of the nature of sport participation on the physical, motor performance and anthropometric components of participants, is scarce and a need exists with regard to more research concerning this aspect. Overall literature agrees that team sport participants seem to perform significantly better in speed endurance related tests compared to individual sport participants. Studies also concluded that

flexibility patterns were specific to certain sports and positions within the sport. With regard to balance, the literature revealed that gymnasts achieved the best balance scores followed by soccer players, with basketball players who performed the worst in the balance tests. Studies found no significant difference between the height and body mass values of individual and team sport participants, but showed that children who participated in gymnastics and volleyball had significantly higher BMD values than children who participated in swimming or no sport at all.

In general sport participants showed significantly better benefits with regard to physical, motor performance and anthropometric components. Boys also tend to perform the best in all aspects except flexibility and balance. Black African boys perform better in speed and explosive power while black African girls displayed the highest BMI and fat percentage and lowest sport participation rate. Team sport participants also performed better in speed endurance tests, while flexibility patterns are specific to certain sports and positions.

This knowledge ought to provide coaches, sport scientists and other sport related professionals direction concerning the real benefits of sport participation as well as the possible effects of other factors (such as gender, race and the nature of sport participation) on these benefits. Certain shortcomings or limitations were, however, identified during the literature review, which include the following: At present the literature contains insufficient data with regard to the influence of sport participation on the physical components, such as muscle endurance; the motor performance components, such as speed, agility, balance, muscle strength and power and the anthropometric components, such as the BMD of children. With regard to the possible effect of race on the relationship between sport participation and changes in certain physical, motor performance and anthropometric components of children much research still needs to be done, especially with regard to the African and more closely the South African population. Further research with regard to the possible effects of the nature of sport participation on the last-mentioned relationship can also be recommended.

At present the literature, therefore, contains insufficient data with regard to the possible relationship between sport participation and the physical, motor performance and anthropometric components of children, which makes it imperative that researchers contribute to this field of Human Movement Science in order to provide a wider knowledge base with regard to this theme. The appearance of more sophisticated apparatus such as

the Actiheart (CamNtech Ltd., Cambridge, U.K.) for the measurement of physical activity and the 10 Hz global positioning system (Minimax V2.4, Catapult Sports, Victoria, Australia) that allows researchers to obtain data with regard to the distance, velocity, repeated efforts, accelerations, decelerations and heart rates of children while they are participating in sport and physical activities, can lead to improvements in the data that are sampled and reported. Studies where these type analyses are used must therefore be considered.

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CHAPTER 3



3 THE RELATIONSHIP BETWEEN ADOLESCENT SPORT PARTICIPATION AND THE PHYSICAL, MOTOR PERFORMANCE AND ANTHRO-POMETRIC COMPONENTS OF A GROUP OF GRADE 10 LEARNERS

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THE RELATIONSHIP BETWEEN ADOLESCENT SPORT PARTICIPATION AND THE PHYSICAL, MOTOR PERFORMANCE AND ANTHROPOMETRIC COMPONENTS OF A GROUP OF GRADE 10 LEARNERS

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ABSTRACT

The purpose of this study was to determine the relationship between sport participation and the physical, motor performance and anthropometric components, of a group of grade 10 adolescent learners in the Tlokwe District, North West Province, South Africa. Two-hundred and 10 learners were purposefully selected to complete a questionnaire to obtain among other things their sport and training habits as well as their maturity status after which a total of 28 direct anthropometric measurements were taken as well as tests executed for the determination of flexibility, explosive leg and upper body power, strength, speed and acceleration, agility and the cardiovascular endurance. The independent t-test results revealed that the sport participants obtained lower values for most of the absolute body and relative body size as well as body composition measurements that showed significant results. Furthermore, the non-sport participants did not perform better in any of the physical and motor performance tests than the sport participants when the significant results were analysed. Lastly, the forward stepwise logistic regression analysis results indicated that body mass, stature, sitting height, sum of six skinfolds, fat percentage, hip circumference, muscle mass and percentage, Vertical Jump Test (VJT) height, VJT 10do peak power, Horizontal Jump Test distance, 40m speed; right passive shoulder external and internal rotation as well as passive and active straight-leg-raise and the modified Thomas quadriceps (MTQT) flexibility were identified as adequate and accurate predictors to classify the adolescent learners in sport participant and non-sport participant groups. However, only body mass, sitting height, muscle percentage and muscle mass and the right MTQT flexibility were identified as significant predictors between the two groups of children. Furthermore, the forward stepwise logistic regression analysis revealed that the logistic model of identified physical, motor performance and anthropometric variables was not useful in predicting the different groups.

KEY WORDS adolescent, anthropometry, motor performance, flexibility, endurance

INTRODUCTION

Sport participation is positively associated with an improvement in various physical, motor performance and anthropometric components among children and adolescents (6,60). Even though the relationship between physical activity and fitness is of major interest (36) a small number of publications have investigated the relationship between adolescent sport participation and the physical, motor performance and anthropometric components of these participants. Overall, research suggests that the benefits that can be derived from physical activity and sport participation include an increase in cardiovascular and muscular endurance, muscle strength and flexibility (59), an increase in fat-free mass (6,60) and bone mineral density (BMD) (6,20) and a decrease in body mass index (BMI) and fat percentage (6,60), all factors that may lead to a decrease in health risks (6,8).

More specifically, research with regard to the cardiorespiratory benefits of physical activity and sport participation showed that adolescents and children that are more active have higher cardiorespiratory endurance levels (5,66). Furthermore, Fletcher *et al.* (22), Pfeiffer *et al.* (52) and Ruiz *et al.* (57) concluded that children who participated in moderate to vigorous physical activity achieved the highest cardiorespiratory fitness levels. In contrast, some researchers are of the opinion that the benefits of aerobic training are small-to-moderate for children (27,50). Muscle endurance also seems to be positively influenced by sport participation and physical activity, with children who fell into this category who achieved significantly better results in muscle endurance tests compared to non-active children (19,38). Moreover, longitudinal studies reported a significant positive influence for physical activity on upper body muscle endurance of physically active adolescents (64). Another physical component that showed increases when children participated in organised sport, is flexibility (7). In this regard, Kruger and Pienaar (38) found significant improvements in the quadriceps, iliopsoas and the right leg's plantar and neutral position flexibility of girls who followed a sport development programme compared to girls who did not participate in any sport. On the other hand, Hoffman *et al.* (30) and Katzmarzyk *et al.* (36) observed no significant differences in the flexibility values of sport participating and non-participating children.

Significant positive relationships have also been reported for physical activity, sport participation levels and motor performance components such as speed, agility, balance, muscle strength and explosive power of children between the ages of six and 16 years (2,21,33,38). In this regard, the balance ability of young athletes was found to be superior to that of non-athletes (33). Several studies have also concluded that sport participation led to significant improvements in muscle strength and explosive power (2,30). Participation in organised physical activities also seems to be significantly related to the ability to perform fundamental movement skills (49).

Anthropometric components such as BMI showed no significant difference between sport participants

and non-participants (27) although significant greater hip and waist circumferences were reported for non-sport participants (2). Ara *et al.* (2) found a 28% lower fat percentage in sport participants compared to non-sport participants. These results were also confirmed by Vicente-Rodriguez *et al.* (69) and Vamvakoudis *et al.* (66) who both found sport participating boys and girls to show significantly lower fat percentage values than their non-participating peers. Although sport participating boys and girls showed significantly lower fat percentage values, Vicente-Rodriguez *et al.* (69) and Foo *et al.* (23) reported that sport participants showed significantly greater lean body mass values compared to children who did not participate in sport. Another anthropometric component, namely BMD was also positively influenced by sport participation (25,35,69) with high-volume impact-loading sport such as gymnastics, tennis and soccer leading to the biggest increases in BMD.

Despite the above-mentioned research findings with regard to the possible benefits of sport participation, no research exists with regard to the possible physical, motor performance and anthropometric benefits of sport participation among South African adolescents. Studies in which South African and especially adolescent boys and girls (10-15 years) of the North West Province were described with regard to various anthropometric measurements (stature, body mass, relative sitting height and arm span) as well as physical and motor performance components (20-m Shuttle run test, Basket ball throw for distance test, 40 Meter sprint test, 5 Meter agility test, Vertical jump Test and the Throw and Catch for Accuracy Test) do exist (17,18,53,67,70) but did not investigate the relationship between sport participation and the different variables among this group of children. It is against this background of a lack of research concerning the link between physical, motor performance, anthropometric components and sport participation that the purpose of this study was to determine the relationship between sport participation and the physical, motor performance and anthropometric components, of a group of grade 10 adolescent learners in the Tlokwe District, North West Province, South Africa. Information that arises from this study may provide coaches, sport scientists and other sport related professionals with definite proof of the real benefits of sport participation.

Methods

Subjects

A total of 201 learners (82 boys and 119 girls) in grade 10 at high schools in the Tlokwe local municipality area (Dr Kenneth Kaunda District) of the North West Province of South Africa were purposefully selected from pre-required class lists, from six secondary schools. Two of the selected schools were in the Potchefstroom City area, which predominantly comprised of learners from a high socio-economic status and four from the Ikageng Township area, which predominantly comprised of learners from a low socio-economic background. However, the group of learners cannot be considered to

be representative of the adolescents' population, either of the Tlokwe local municipality area (Dr Kenneth Kaunda District) or of South Africa in general. Only learners who were in grade 10 at the time of measurement (2012) were eligible to participate in the study. Prior to participating in the study, all subjects were informed of the nature of the study, and all potential risks and benefits were explained to them. Informed consent for the investigation was requested from the school authorities, the parents and learners of the participating schools during the weeks prior to the testing period. The study was approved by the Ethics Committee of the institution where the research was conducted (NWU-0058-01-A1) and by the North West Department of Health and the District Director of the Potchefstroom Department of Education. The research data that is use in the study forms part of a larger study - The Physical Activity and Health Longitudinal Study (PAHLS), which is an observational multidisciplinary longitudinal study that started in 2010. Only data that was sampled during 2012 was used in this study.

Procedures

A pilot study during which one school's children were subjected to the anthropometric protocol as well as all the physical and motor performance tests was performed before the main part of the study to determine the reliability of the tests in this population. The average test-retest reliability coefficient for the different physical and motor performance tests of the pilot study was found to be 0.93 (range: 0.89-0.99). For the main part of the study the subjects underwent one day of testing at the testing centre of the institution that was responsible for the research. On arrival the subjects first completed the Demographic, General Information, Sport and Training Habits, Physical Activity and Maturity Determination Questionnaire (not all the results of this questionnaire were used for the purpose of this article) after which the anthropometric measurements, flexibility, explosive leg and upper body power, strength, speed and acceleration, agility and the cardiovascular endurance tests followed. Before the start of the speed and acceleration, agility and the cardiovascular endurance tests the subjects were firstly subjected to a thorough warm-up of more or less 15 min that consisted of aerobic running exercises for more or less 8 min after which a specific warm-up period of shorter, high intensity movements and dynamic stretches followed.

Instruments

Demographic, general information, sport and training habits. A questionnaire in which learners had to provide information with regard to the following was administered during the testing period: Information with regard to demographic and general information of the learner which included the name and address of the learner, his/her ethnic group, his/her school grade at the time of testing and the name of the school which he/she attended; Information with regard to the training habits, which included the type of sport the

learner participated in, his/her main and secondary sport during the last two years, years he/she participated in the main and secondary sport, the frequency of training in the main and secondary sport, the participation level for the main and secondary sport - recreational, school, provincial or national and the best performance/s that has/have been achieved in the main sport; information with regard to maturation which included: menarche age (for the girls only) and age that the voice broke (for the boys only).

Anthropometric components. A total of 28 direct anthropometric measurements was obtained using The International Society for the Advancement of Kinanthropometry (ISAK) protocols (41). It included body mass to the nearest 0.1 kg (using a calibrated Beurer Ps07 Electronic Scale, Ulm, Germany), body stature to the nearest 0.1 cm (using a Harpenden portable stadiometer, Holtain Limited, UK.), sitting height to the nearest 0.1 cm (using a Harpenden portable stadiometer, Holtain Limited, UK.), seven skinfolds (using Harpenden calipers, Holtain Limited, UK.), eight girths (using Lufkin metal tapes, Cooper Industries, USA.), four breadths (using Holtain Bicondylar Calipers, Holtain Limited, UK.), four lengths (using Rosscraft segmometers, Rosscraft Innovations Incorporated, Canada) and selected body composition components. After land marking each participant, he/she was directed to one of four stations where the different anthropometric measurements were taken. All the anthropometric measurements were taken twice by Level 2 ISAK Certified Anthropometrists on the right side of the body. The technical error of measurement (51) revealed values of 1.27% (1.24 mm) for all skinfold measurements, 2.08% (0.56 cm) for all breadth measurements, 0.11% (0.38 cm) for all girth measurements and 1.23% (0.79 cm) for all length measurements. Arm, mid-thigh and calf girth was corrected for the different skinfolds at these sites, by using the following formula: Corrected girth = Girth – ($\pi \times$ skin fold thickness). According to Martin *et al.* (42), corrected girths provide better indicators of musculoskeletal size at each site.

Another eight body composition measures were indirectly calculated, namely: body mass index (body mass/body stature²), sum of the seven skinfolds, body fat mass and body fat percentage, muscle mass and muscle mass percentage as well as the somatotype components. Somatotype was calculated using the formulas of Carter and Heath (10) fat percentage and body density by using the formulas of Slaughter *et al.* (61) and Lohman *et al.* (39) and muscle mass as well as muscle mass percentage by using the formulas of Poortmans *et al.* (55).

Maturational age determination. The anthropometric measures of body stature, sitting height and body mass together with the variables of gender, date of birth and date of measurement were used to calculate peak height velocity (PHV) age. This is the most practical and noninvasive method of identifying maturational age (46). In this regard, Mirwald *et al.*, (46) found the coefficient of determination for the

boys' model to be 0.92 whereas the girls' model showed a value of 0.91 when the equations for determining maturation age were cross-validated on a combined sample of Canadian and Flemish children. Maturity age is calculated by subtracting age at PHV from chronological age at the time of measurement (65). If age at PHV is the same as the chronological age, maturity age equals 0 (65). In cases where chronological age is higher than the age at PHV, maturity age is positive whereas maturity age is negative when age at PHV is higher than chronological age (65). This method is found to be ideal for prediction of PHV in adolescent boys and girls (46). It is important to consider the maturational age of adolescents in order to verify certain trends with regard to their anthropometric, physical and motor performance profile.

Physical and motor performance components. Flexibility was tested by means of the passive-straight-leg-raise-test (PSLRT) according to the method of Maud and Kerr (43); the active-straight-leg-raise-test (ASLRT), the modified Thomas iliopsoas test (MTIT), the modified Thomas quadriceps test (MTQT) and the passive shoulder external (PSERT) and internal rotation test (PSIRT), all according to the methods of Harvey and Mansfield (29); Muscle strength was tested by means of the abdominal stage test (AST) of Ellis *et al.* (16) and the handgrip strength test of Hofman (32); Explosive power was tested by the basketball put (sitting on the floor) test of Ball (4), the horizontal jump test (HJT) of Maulder and Cronin (44) and the vertical jump test (VJT) of Harman *et al.* (2) where power output was measured for each jump with a Tendo™ Power Output Unit (Tendo Sports Machines, Trencin, Slovak Republic). Subsequently, jump velocity was calculated and power was determined. Peak power output was recorded for each jump and used for the subsequent analyses. According to Hoffman *et al.* (31), the test-retest reliability of the Tendo unit is $r \geq 0.90$. Speed and agility were tested by means of the forty metre acceleration and speed test according to the method of Ellis *et al.* (16) and the agility-505-test of Veale *et al.* (68) respectively; Cardiovascular endurance was tested by means of the 20-m Multistage shuttle run test (20-m SRT) according to the procedures described by the Australian Sports Commission (3).

Statistical analysis

The Statistical Data Processing package (62) was used to process the data. The descriptive statistics (averages, standard deviations, minimum and maximum values) for each of the physical, motor performance and anthropometric component were calculated first. Next, independent t-tests were calculated to determine the significant differences between sport participating and non-sport participating groups of children. The level of significance was set at $p \leq 0.05$. This was followed by a cluster analysis of the different physical, motor performance and anthropometric variables, which was used to detect clusters of measures that appear to tap similar abilities. The linkage distance for the detection of different

clusters was set at 200 by the researchers. Next, a binary forward stepwise logistic regression was used to screen for the predictive value of the different physical, motor performance and anthropometric variables (independent variables) in predicting the group classification (sport and non-sport participants) of the learners (dependant variables). The significance of the individual logistic regression coefficients for each independent variable were determined by making use of the Wald statistic. The level of significance was set at $p \leq 0.05$. Next the Hosmer and Lemeshow chi-square goodness-of-fit test tested the adequacy of the sport participation component related logistic model with an adequately fitted logistic model being indicated by a non-significant χ^2 -value ($p > 0.05$). A logistic regression formula was used to predict the probability of being in the sport participation or the non-participation group. The accuracy of the logistic regression model was indicated by a percentage correct-value. The usefulness of the model was calculated by determining the “hit rate” and “chance hit rate” (24). In cases where the “hit rate” was 25% better than the “chance hit rate”, the model was classified as a good model (24). To determine the effect size of the prediction model the “better than chance” index (I) was calculated by comparing the actual or observed “hit rate” with the “chance hit rate” (63). The I -values were categorized as being small ($I < 0.1$), medium ($0.15 < I < 0.25$) and large ($I > 0.3$) according to the guidelines of Huberty and Lowman (34).

Results

Anthropometric components

The descriptive statistics as well as the statistical significance of the differences for the anthropometric components between the sport participation and non-participation group are presented in Table 1.

From the tabulated results it is clear that the sport participants displayed significantly lower values for body mass; BMI; fat mass and percentage; endomorphy and mesomorphy; all the skinfold measurements and sum of skinfolds; flexed and relaxed arm girth; waist and hip circumference; waist to height ratio as well as maximum calf and forearm girth compared to the non-sport participants. However, significant higher values were measured for the sport participant group compared to the non-sport participant group in stature, sitting height, muscle mass percentage, ectomorphy, humerus breadth, midstyliion-dactyliion and foot length. No other significant differences were found for the anthropometric measurements between the sport participant and the non-sport participant group.

Table 1. Descriptive statistics as well as the statistical significance of the differences in the anthropometric components and age related variables between the sport participants and non-sport participants

	Total Group (n = 201)	Sport Participants (n = 153)	Non-Sport Participants (n = 48)
Age (yrs)	15.83 (0.67)	15.87 (0.69)	15.69 (0.57)
Body Mass (kg)	56.99 (14.44)	55.27 (12.56)	62.46 (18.36)*
Stature (cm)	163.58 (8.72)	164.69 (9.03)	160.04 (6.59)*
PHV age (yrs)	14.27 (0.7)	14.3 (0.7)	14 (0.7)
Maturity age	1.8 (0.4)	1.8 (0.4)	1.7 (0.5)
Sitting height (cm)	119.64 (14.87)	120.86 (12.35)	115.75 (20.68)*
BMI (kg.m ⁻²)	21.17 (4.49)	20.19 (3.14)	24.29 (6.40)*
Fat mass percentage (%)	20.07 (9.50)	17.29 (7.52)	28.92 (9.80)*
Fat mass (kg)	12.12 (8.48)	9.88 (5.84)	19.28 (11.26)*
Muscle mass percentage (%)	35.32 (18.95)	37.00 (21.33)	29.94 (4.25)*
Muscle mass (kg)	20.55 (19.70)	21.22 (22.39)	18.41 (4.83)
Endomorphy	3.65 (1.85)	3.10 (1.39)	5.40 (2.04)*
Mesomorphy	3.80 (1.79)	3.61 (1.67)	4.41 (2.02)*
Ectomorphy	3.01 (1.58)	3.35 (1.36)	1.95 (1.76)*
Biceps skinfold (mm)	7.37 (4.37)	6.08 (3.01)	11.49 (5.39)*
Triceps skinfold (mm)	13.38 (6.61)	11.53 (5.10)	19.29 (7.43)*
Subscapular skinfold (mm)	11.69 (7.55)	9.70 (5.45)	18.02 (9.62)*
Supraspinal skinfold (mm)	10.87 (7.34)	8.85 (4.77)	17.31 (10.01)*
Abdominal skinfold (mm)	16.96 (9.23)	14.47 (7.12)	24.93 (10.66)*
Front thigh skinfold (mm)	21.99 (11.74)	18.58 (8.76)	32.88 (13.38)*
Medial calf skinfold (mm)	15.02 (7.56)	13.01 (5.69)	21.44 (9.12)*
Sum of 2 skinfolds (mm)	24.84 (12.79)	20.93 (8.30)	37.32 (16.28)*
Sum of 6 skinfolds (mm)	89.71 (45.85)	75.85 (31.71)	133.89 (55.45)*
Sum of 7 skinfolds (mm)	97.09 (49.73)	81.93 (34.23)	145.38 (60.05)*
Humerus breadth (mm)	6.19 (0.59)	6.27 (0.61)	5.94 (0.46)*
Wrist breadth (mm)	5.16 (2.07)	5.02 (0.40)	5.60 (4.17)
Femur breadth (mm)	8.94 (0.81)	8.92 (0.74)	9.01 (1.00)

Note: BMI = Body mass index; *p ≤ 0.05

Table 1 (cont.). Descriptive statistics as well as the statistical significance of the differences in the anthropometric components and age related variables between the sport participants and non-sport participants

	Total Group (n = 201)	Sport Participants (n = 153)	Non-Sport Participants (n = 48)
Ankle breath (mm)	6.82 (3.59)	6.65 (0.62)	7.36 (7.30)
Head girth (cm)	55.09 (3.72)	55.27 (2.57)	54.51 (6.08)
Relaxed arm girth (cm)	25.33 (4.07)	24.64 (3.50)	27.51 (4.93)*
Flexed arm girth (cm)	27.77 (6.79)	27.20 (6.48)	29.58 (7.50)*
Waist circumference (cm)	68.42 (9.60)	66.99 (7.64)	72.97 (13.25)*
Hip circumference (cm)	90.14 (11.53)	87.85 (9.00)	97.45 (15.25)*
Waist to hip ratio	0.76 (0.12)	0.76 (0.11)	0.75 (0.17)
Waist to height ratio	0.41 (0.05)	0.40 (0.03)	0.45 (0.07)*
Mid-thigh girth (cm)	48.50 (6.67)	47.24 (5.17)	52.50 (9.02)*
Maximum calf girth (cm)	33.04 (3.92)	32.67 (3.39)	34.19 (5.15)*
Fore arm girth (cm)	23.76 (2.62)	23.63 (2.50)	24.21 (2.95)
Acromial-radial length (cm)	31.11 (2.33)	31.28 (2.37)	30.56 (2.12)
Radial-styilion length (cm)	24.57 (1.60)	24.67 (1.52)	24.27 (1.82)
Midstyilion-dactylion length (cm)	19.61 (1.52)	19.85 (1.52)	18.85 (1.25)*
Foot length (cm)	25.13 (1.82)	25.35 (1.88)	24.44 (1.44)*

*p ≤ 0.05

Physical and motor performance components

The descriptive statistics as well as the statistical significance of the differences for the physical and motor performance components between the sport participant and non-participant group are presented in Table 2.

The descriptive statistics in Table 2 show that sport participants performed significantly better in the left and right MTIT and MTQT, the VJT height and Tendo peak speed, HJT distance, left and right handgrip strength, AST (level), 5m and 10m speed, 505 agility from the left and the right foot as well as the last level of the 20-m SRT and the $\dot{V}O_{2max}$ that was reached during execution of 20-m SRT. The non-sport participants did not perform significantly better in any of the physical and motor performance tests than the sport participants.

Table 2. Descriptive statistics as well as the statistical significance of the differences in the physical and motor performance components between the sport participants and non-sport participants

	Total Group (n = 201)	Sport Participants (n = 153)	Non-Sport Participants (n = 48)
Left PSERT flexibility (°)	95.85 (9.60)	96.11 (9.26)	95.04 (10.69)
Right PSERT flexibility (°)	98.13 (8.42)	98.20 (8.22)	97.91 (9.11)
Left PSIRT flexibility (°)	39.72 (15.30)	39.78 (15.18)	39.52 (15.81)
Right PSIRT flexibility (°)	40.02 (14.82)	40.00 (14.86)	40.06 (14.86)
Left PSLRT flexibility (°)	96.48 (16.95)	97.07 (15.23)	94.60 (21.62)
Right PSLRT flexibility (°)	98.97 (17.11)	98.96 (17.17)	99.00 (17.08)
Left ASLRT flexibility (°)	79.18 (15.58)	79.38 (15.44)	78.54 (16.17)
Right ASLRT flexibility (°)	81.06 (18.61)	81.12 (15.30)	80.87 (26.77)
Left MTIT flexibility (°)	6.00 (7.88)	7.09 (6.62)	2.54 (10.32)*
Right MTIT flexibility (°)	4.50 (7.95)	5.51 (6.95)	1.29 (9.96)*
Left MTQT flexibility (°)	64.14 (11.60)	62.41 (11.28)	69.66 (10.97)*
Right MTQT flexibility (°)	65.10 (11.53)	63.50 (10.93)	70.20 (12.00)*
VJT height (cm)	32.73 (12.21)	35.22 (11.41)	24.80 (11.35)*
VJT Tendo peak power (W)	1346.77 (378.50)	1356.33 (375.24)	1316.29 (391.17)
VJT Tendo peak speed (m.s ⁻¹)	2.48 (0.98)	2.57 (1.09)	2.18 (0.28)*
HJT distance (cm)	170.78 (64.46)	179.47 (68.85)	143.08 (36.39)*
Basketball put distance (cm)	4.60 (2.91)	4.79 (3.26)	3.96 (1.05)
Handgrip strength – left (kg)	29.56 (8.08)	30.72 (8.52)	25.87 (4.98)*
Handgrip strength - right (kg)	30.55 (8.17)	31.43 (8.59)	27.74 (5.92)*
AST (level)	2.27 (1.83)	2.46 (1.84)	1.66 (1.66)*
5 m Speed (sec)	1.26 (0.15)	1.22 (0.13)	1.39 (0.12)*
10m Speed (sec)	2.15 (0.23)	2.08 (0.19)	2.36 (0.20)*
40m Speed (sec)	7.15 (3.47)	6.94 (3.92)	7.83 (0.92)

Note: PSERT = Passive shoulder external rotation test; PSIRT = Passive shoulder internal rotation test; PSLRT = Passive straight leg raise test; ASLRT = Active straight leg raise test; MTIT = Modified Thomas iliopsoas test; MTQT = Modified Thomas quadriceps test; VJT = Vertical jump test; HJT = Horizontal jump test; AST = Abdominal stage test; *p ≤ 0.05

Table 2 (cont). Descriptive statistics as well as the statistical significance of the differences in the physical and motor performance components between the sport participants and non-sport participants

	Total Group (n = 201)	Sport Participants (n = 153)	Non-Sport Participants (n = 48)
505 Agility from the left foot (sec)	2.99 (0.25)	2.94 (0.21)	3.16 (0.27)*
505 Agility from the right foot (sec)	3.00 (0.25)	2.93 (0.21)	3.23 (0.24)*
20-m SRT last level	5.84 (2.40)	6.58 (2.14)	3.50 (1.54)*
20-m SRT last shuttle	5.31 (2.72)	5.39 (2.81)	5.06 (2.41)
20-m SRT $\dot{V}O_{2max}$ (ml.kg ⁻¹ .min ⁻¹)	34.41 (8.06)	36.86 (7.24)	26.59 (4.98)*

Note: SRT = Shuttle run test; *p ≤ 0.05

In an attempt to first identify variables that relate to each other and to retain only the relevant variables for the stepwise logistic regression, a cluster analysis was performed. The physical, motor performance and anthropometric components were reduced from 67 to 17 variables by means of the cluster analysis. The physical, motor performance and anthropometric variables that remained were: body mass, stature, sitting height, sum of six skinfolds, fat percentage, hip circumference, muscle mass and percentage, VJT height, VJT Tendo peak power, HJT distance, 40m speed as well as right PSIRT, PSERT, PSLRT, ASLRT and MTQT flexibility.

Binary forward stepwise logistic regression results

Table 3 presents the forward stepwise logistic regression results of the cluster analysis reduced physical, motor performance and anthropometric variables that acted as predictors between the two groups of children.

Table 3: Summary of the forward stepwise logistic regression analysis with sport participants and non-sport participants as the dependant variables and the physical, motor performance and anthropometric variables as the independent variables

Variables	Wald statistics (95% CI)	P-level
Body Mass (kg)	5.80 (0.096-0.93)	0.02*
Stature (cm)	0.22 (-0.08-0.14)	0.64
Sitting height (cm)	5.08 (-0.06- -0.004)	0.02*
Sum of 6 skinfolds (mm)	1.15 (-0.02-0.08)	0.28
Fat percentage (%)	0.72 (-0.12-0.3)	0.40
Hip circumference (cm)	0.20 (-0.1-0.07)	0.66
Muscle percentage (%)	6.42 (-0.2-1.57)	0.01*
Muscle mass (kg)	5.14 (-2.9- -0.2)	0.02*
Right PSERT flexibility (°)	1.25 (-0.09-0.03)	0.26
Right PSIRT flexibility (°)	0.61 (-0.05-0.02)	0.43
Right PSLRT flexibility (°)	0.54 (-0.02-0.05)	0.46
Right ASLRT flexibility (°)	3.18 (-0.002-0.04)	0.08
Right MTQT flexibility (°)	3.89 (0.0003-0.09)	0.05*
VJT height (cm)	0.11 (-0.09-0.07)	0.74
VJT Tendo peak power (W)	1.51 (-0.01-0.002)	0.22
HJT distance (cm)	2.02 (-0.03-0.005)	0.16
40m Speed (sec)	1.09 (-0.06-0.2)	0.30

Note: VJT = Vertical jump test; HJT = Horizontal jump test; PSERT = Passive shoulder external rotation test; PSIRT = Passive shoulder internal rotation test; PSLRT = Passive straight leg raise test; ASLRT = Active straight leg raise test; MTQT = Modified Thomas quadriceps test; * $p \leq 0.05$

As indicated by Table 3, body mass, sitting height, muscle mass and percentage as well as the right MTQT flexibility were the only variables that were identified as significant predictors of the sport participant and non-sport participant groups. The Hosmer and Lemeshow's goodness-of-fit-test was used to assess the significance of the physical, motor performance and anthropometric component related logistic model (which is an indication of the adequacy of the model). A χ^2 value of 11.22 at a p -value of 0.19 was calculated which indicates that the model's estimates fit the data at an acceptable level ($p > 0.05$). Table 4 shows the results of the logistic regression formula which was used to predict the probabilities of being a sport participant or non-sport participant.

Table 4: Classification table of the predicted probabilities of being in the sport participant or non-participant group

Group	Value of the predicted probability		
	Non-sport participant group	Sport participant group	Percentage correct
Non-sport participant group	28	20	58.33
Sport participant group	7	146	95.43
Total	35	166	76.88

The classification table indicates that 76.88% of the children could again be classified into their original groups by making use of the physical, motor performance and anthropometric based logistic regression formula. In order for the researchers to classify the accuracy of the percentage correct-value, the “hit rate” and “chance hit rate” were calculated and found to be 86.57% ($174/201 \times 100$) and 71.24% ($((35/201)^2 * 100) + ((166/201)^2 * 100)$), respectively. The “hit rate” was 15.33% higher than the “chance hit rate” which indicates that the logistic model of identified physical, motor performance and anthropometric variables (Table 4) is not useful (“hit rate” was less than 25% better than the “chance hit rate”) in predicting the different groups. To determine the effect size of the prediction model and to verify the results of the percentage correct-value the “better than chance” index (*I*) was also calculated. An *I*-value of 0.53 was found and shows that the model had a large effect in predicting the classification of the sport participants and the non-sport participants.

Discussion

The purpose of this study was to determine the relationship between sport participation and the physical, motor performance and anthropometric components, of a group of grade 10 adolescent learners in the Tlokwe District, North West Province, South Africa. In terms of the significant differences between the physical, motor performance and anthropometric variables of the sport and non-sport participants, the results showed that most of the absolute and relative body size, the somatotype and body composition related variables obtained lower whereas most of the physical and motor performance tests obtained higher values for the sport participants compared to the non-sport participants. (see Tables 1 and 2).

According to the results sport participants showed significantly higher stature and sitting height values compared to the non-sport participants. The results with regard to the significant differences in stature between the two groups of children are similar to that of Nogueira and Da Costa (48) who also reported significantly higher stature values for Brazilian boys who participated in sport for more than one hour per

day compared to non-sport participating boys. Sitting height, which is an indication of trunk length, was also found to be significantly higher in the sport participant group compared to the non-sport participant group. In another study comparisons between the sitting height values of soccer players, fitness programme participants and sedentary 16 year old boys also showed significant differences with the soccer group that obtained the highest values (54). The more mature body build of the sport participants compared to the non-sport participants (maturity age of 14.3 versus 14.0 years) may provide a possible reason for the differences in stature and sitting height between the two groups of children.

Overall the results also show that sport participating adolescents displayed significantly smaller skinfold and sum of skinfold values together with lower fat mass and percentage as well as lower body mass and BMI values compared to the non-sport participants. Despite the fact that the sport participant group also displayed significant lower values for most of the girth and circumference values, they were the group who also obtained a significant higher average muscle mass percentage. Various authors have referred to the anthropometric benefits that can be derived from regular sport participation with a decrease in body mass index (BMI), fat percentage (6,60) hip- and waist circumference (2) as well as an increase in fat-free mass (6,60). The differences in fat percentage related measurements are probably related to a higher fat oxidation level of the sport participating children (37) compared to non-sport participants. Exercise will normally stimulate fat oxidation due to the fact that this food source will serve as the main source of energy during, especially aerobic exercise of a longer duration (1). In contrast less active children will usually have a higher energy intake with a corresponding lower energy expenditure due to a lower activity level, which would in the long run lead to a positive energy balance and an increase in fat and body mass. In this regard, Maffei *et al.* (40) reported that physical activity may promote fat oxidation in obese children and help them to achieve a negative energy balance which may promote fat oxidation, a reduction in fat mass and an overall reduction in body weight. It is also possible that high levels of adiposity among sport participating children will lead to a reduction in aerobic capacity when expressed relative to body mass, in view of a study by Cureton *et al.* (14) that established a direct negative relationship between the named variables among athletes. This contention was again tested by determining the R of the relationships between average fat mass, fat mass percentage, 20m-SRT level and the 20-m SRT obtained $\dot{V}O_{2max}$ value. Significant R-values were found for the relationships between fat mass and 20m-SRT level ($R = -0.69$) and $\dot{V}O_{2max}$ ($R = -0.70$) as well as for the relationships between fat mass percentage and 20m-SRT level ($R = -0.52$) and $\dot{V}O_{2max}$ ($R = -0.52$). Due to the fact that endomorphy is also related to percentage body fat (11), the researchers did expect the sport participants in this study to display significant lower endomorphy values compared to non-sport participants.

The significantly higher muscle mass percentage among the sport participants were probably caused by the higher level of muscle contractions that occur when these children execute physical activities. The higher frequency of muscle contractions will probably cause a higher activation of muscle fibres which will result in muscle fibre hypertrophy and in the long run an increase in muscle mass percentage (26). Surprisingly, despite the significantly higher muscle mass percentage among the sport participants, this group of children obtained a significantly lower average mesomorphy value. In general, studies suggest that mesomorphy is related to a person's muscle mass and is positively associated with most physical performance tests (9). However, the equation for calculating mesomorphy entails that body stature, humerus and femur breadth as well as corrected arm and calf girth, are entered into the equation (9). The sport participants displayed significantly lower values for corrected arm (flexed arm girth – triceps skinfold) and calf girth (maximum calf girth – calf skinfold) as well as a lower value for femur breadth, which may explain the result with regard to mesomorphy.

The significant higher average ectomorphy value of the sport participants may be an indication of the relative linearity or slenderness of their physique (9). This fact is also emphasized by the significantly lower skinfold, girth and circumference measurements among this population of children. In contrast, the non-sport participant group displayed significantly higher endomorphy and mesomorphy values together with significantly higher skinfold, girth and circumference values which collectively is an indication of a higher level of fatness and relative musculoskeletal robustness (9). Despite of this, comparatively the sport participants displayed significantly longer hand (midstyliion-dactyliion) and foot lengths than the non-sport participants. As mentioned before, the higher maturity age of the sport participants may be an indication of a more mature body build which would also lead to higher extremity lengths compared to the non-sport participants who are less mature.

With regard to the physical and motor performance components, the sport participants obtained significantly better values for the flexibility of the iliopsoas and quadriceps compared to the non-sport participants. Several authors have also alluded to the fact that flexibility can be improved by participating in physical activities (59) or by participating in any organised sport (7). In this regard a study by Kruger and Pienaar (38) reported significant improvements in the quadriceps, iliopsoas and right leg's plantar and neutral position flexibility values of the girls who followed a sport development programme compared to girls who continued with their normal activities. On the other hand, Hoffman *et al.* (30) reported no significant increases in the sit-and-reach flexibility of adolescent boys and girls due to their participation in recreational sports such as basketball, gymnastics, football, baseball, swimming, tennis and soccer. Interestingly, the sport participants in this study also did not show significantly better flexibility scores for the shoulder musculature and the hamstrings. It is, therefore, possible that range of motion is not increased when subjects do not stretch regularly while engaged in high intensity repetitive activities (27).

The lower body explosive power related measurements obtained significant higher values for the sport participants compared to the non-sport participants. Ara *et al.* (2) also found that active children and adolescents show significantly better results in jumping height compared to non-active children and adolescents. Adding to this, a study on 44 fifth graders by Hoffman *et al.* (30), showed that recreational or seasonal sport participation by boys and girls can have a significant positive effect on their lower body power scores compared to inactive children (30). Baquet *et al.* (5) also found that boys and girls between the ages of 11 and 15 years old had significant better explosive and functional strength compared to their inactive counterparts. In sport such as soccer, rugby, hockey and most of the athletic events participants must be able to deliver sudden bursts of power when rapidly changing direction or when a high velocity must be generated (47). This would explain why sport participants will display significantly better values for the lower body explosive power tests. Furthermore, foot length could possibly contribute to an increase in leg explosive power (15). This relationship was again tested by calculating the R-values between foot length and VJT height as well as HJT distance of the children in this study. Significant R-values of 0.69 and 0.23 were respectively found for the last-mentioned relationships.

The sport participants also obtained significantly higher values for all the strength related variables compared to the non-sport participants. In agreement with this study, Foo *et al.* (23) also found that adolescent girls (15 years old) who participated in physical activity had significantly higher hand grip strength than their inactive counterparts. In contrast to this study, Baquet *et al.* (5) found no significant difference in the hand grip strength of 11-15 year old active and sedentary boys and girls. Although research with regard to the importance of handgrip strength in the successful execution of different sport skills is not available, the literature sources have stated that sport such as gymnastics, rugby, badminton, tennis; and combat sport such as boxing, judo and wrestling need a certain level of handgrip strength as a secondary components for success (71). Crawford *et al.* (13) found a direct positive relationship between hand length and grip force. The R-value between the values of the last-mentioned two variables indicate that a significant R of 0.76 existed between the right hand length and right hand grip strength, which verifies the contention that the hand length played a role in the hand grip strength values that the sport participants obtained.

Another muscle strength related test, namely AST which gives the researchers an indication of core muscle strength, displayed significantly higher values for the sport participants. According to Reed *et al.* (56), sport which involves a high level of core activation such as ball sport or sport where the participant needs to hit a ball, will show the greatest improvements due to core strengthening. The repetitive execution of core-based movements will probably lead to an increase in sport participants' core strength which will provide them with more superior core strength compared to non-sport participants. Research further indicated that core strength has a significant effect on sport participants' ability to create and

transfer forces to the extremities (58).

Significant better speed (over very short distances) and agility test times were also achieved by the sport participants compared to the non-sport participant group. Both Kruger and Pienaar (38) as well as Ara *et al.* (2) reported significantly better results in the speed and anaerobic capacity for children who participated in sport compared to the non-sport participants. The significantly higher body and fat mass as well as fat mass percentage and BMI of the non-sport participation group might partially explain the weaker performances in these tests. This group of children will probably be less economical in terms of movement speed because of higher body mass related values compared to the other group who displayed a more slender body build. A study which aimed to determine the sprint performance determinants of Afro-Caribbean adolescents between the ages of 13 and 15 years old indicated that body stature was the main predictive variable of sprint performance (12). The authors of the last-mentioned study contributed the result to the fact that taller individuals usually have longer legs which would allow them to increase their stride lengths while running and sprinting (12). This may also provide a possible reason for the significant higher speed values among the sport participants. To test this contention the correlation coefficients (R) of the relationships between the children's stature as well as 5m and 10m speed times were calculated and revealed significant R-values of -0.34 and -0.40, respectively for the last mentioned relationships. Interestingly Milvi and Jürimäe (45) found that sitting height had a significant contribution of between 13.41% and 52.35% to the prediction of different physical and motor performance test results which were related to speed and speed endurance, lower and upper body explosive power, strength, dribbling and throwing accuracy among 14 to 15 year old male basketball and handball players. These relationships may be related to the fact that children with higher sitting heights are usually more mature which may have a beneficial effect on the muscle strength, explosive power, speed of movement and hand-eye-coordination among this group of children.

According to Fletcher *et al.* (22), the cardiovascular system's functional capacity increases and myocardial oxygen demand decreases with participation in physical activity. In view of this finding, the researchers therefore expected the sport participants to obtain higher values for the 20m SRT level and $\dot{V}O_{2max}$. These results are also similar to the study results of Pfeiffer *et al.* (52) who indicated that girls (grade eight to twelve) who participated in moderate to vigorous physical activities had significantly higher fitness levels than girls who were not vigorously active. Ruiz *et al.* (57) also concluded that vigorous physical activities are associated with higher cardiorespiratory fitness levels compared to light and moderate intensity physical activities. In this regard Fletcher *et al.* (22) stated that football, tennis, soccer, basketball and athletics are especially beneficial to elicit an increase in cardiovascular fitness.

To the researchers' knowledge, this is the first study to investigate the predictive value of a forward

stepwise logistic regression, physical, motor performance and anthropometric component-related model to classify sport and non-sport participating children in their respective groups (see Tables 3 and 4). This made it difficult to compare the results of this study directly to similar studies. Nevertheless, body mass, sitting height, muscle mass and percentage as well as the right MTQT flexibility were the only variables that were identified as significant predictors of the sport participant and non-sport participant groups.

Explanations for the identification of the last-mentioned variables as possible predictors of sport and non-sport participants were already provided in the afore-mentioned text. However, the identification of MTQT flexibility as a group predictor, needs further discussion. It is possible that the continuous elongation and contraction of the quadriceps muscle group during especially dynamic eccentric movements which occurs during sport participation, may give rise to a more flexible muscle. Furthermore, it can probably be assumed that sport participants will also stretch more regularly during especially warm ups and cool downs in order to avoid injuries.

Further analyses revealed that the physical, motor performance and anthropometric component related logistic model could be regarded as an adequate ($\chi^2 = 11.22$, $p = 0.19$) and accurate model ($I = 0.53$). This contention was further substantiated by the fact that 76.88% of the children could again be classified into their respective original groups by making use of the logistic regression formula. However, the “hit rate” was found to be 15.33% higher than the “chance hit rate” which indicated that the logistic model of identified physical, motor performance and anthropometric variables was not useful in predicting the different groups.

In conclusion, the findings of this study provide insight into an area of research where uncertainty still reigns and ought to provide coaches, sport scientists and other sport related professionals direction concerning the real benefits of sport participation. However, the results of the present study must be interpreted with caution since the prediction model was developed specifically for adolescent learners in the Tlokwe local municipality area, which means that the results cannot be generalized to all adolescent learners. It is also important to test logistic models of identified physical, motor performance and anthropometric variables through longitudinal studies to evaluate its significance, adequacy, accurateness and usefulness among different populations of sport and non-sport participant adolescents.

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CHAPTER 4



4 THE EFFECT OF GENDER, RACE AND NATURE OF SPORT PARTICIPATION ON THE RELATIONSHIP BETWEEN ADOLESCENT SPORT PARTICIPATION AND THE PHYSICAL, MOTOR PERFORMANCE AND ANTHROPOMETRIC COMPONENTS OF A GROUP OF GRADE 10 LEARNERS

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Anthropometric components

Maturational age determination

Physical and motor performance components

Statistical analysis

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TITLE: THE EFFECTS OF GENDER, RACE, AND NATURE OF SPORT PARTICIPATION ON THE RELATIONSHIP BETWEEN ADOLECENT SPORT PARTICIPATION AND THE PHYSICAL, MOTOR PERFORMANCE AND ANTHROPOMETRIC COMPONENTS OF A GROUP OF GRADE 10 LEARNERS

RUNNING HEAD: THE EFFECTS OF GENDER, RACE AND NATURE OF SPORT ON THE RELATIONSHIP BETWEEN SPORT PARTICIPATION AND CERTAIN COMPONENTS

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THE EFFECTS OF GENDER, RACE, AND NATURE OF SPORT PARTICIPATION ON THE RELATIONSHIP BETWEEN ADOLESCENT SPORT PARTICIPATION AND THE PHYSICAL, MOTOR PERFORMANCE AND ANTHROPOMETRIC COMPONENTS OF A GROUP OF GRADE 10 LEARNERS

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ABSTRACT

The purpose of this study was to determine the significant differences in the physical, motor performance and anthropometric components between a group of grade 10 learners of different genders and races who participated in different types of sport in the Tlokwe District, North West Province, South Africa. One hundred and forty six learners were purposefully selected to complete a questionnaire to obtain among other things their sport and training habits as well as their maturity status after which a total of 28 direct anthropometric measurements were taken as well as tests executed for the determination of flexibility, explosive leg and upper body power, strength, speed and acceleration, agility and the cardiovascular endurance. With regard to the significant results, the study revealed that the boys ($n = 72$) obtained higher values for most of the absolute and relative body size, body composition and somatotype related variables as well as for all of the tests that were related to lower body explosive power, muscle strength, speed, agility and cardiovascular endurance related variables compared to the girls ($n = 74$). The differences with regard to the racial groups showed that black children ($n = 105$) displayed significantly lower values for most of the absolute and relative body size, body composition as somatotype measurements as well as for all of the upper and lower body explosive power, muscle strength, speed, agility and the cardiovascular endurance related variables which obtained significant differences when compared to the values of white children ($n = 41$). Only the flexibility related tests obtained significant differences with regard to the children who participated in different types of sports. Therefore, although a relationship exists between sport participation and the physical, motor performance and anthropometric benefits that can be derived, factors such as race and gender have a direct influence on this relationship and need to be considered when this population of children are investigated.

KEY WORDS adolescent, race, gender, individual, team

INTRODUCTION

Although the research seems to suggest that frequent participation in sport may lead to certain physical, motor performance and anthropometric benefits (Bergeron, 2007; Sirard et al., 2008), researchers have alluded to the fact that various factors may influence the nature and magnitude of the benefits. In this regard the gender and race (Sirard et al., 2008) of the sport participants as well as the nature of sport participation (team or individual) (Egan et al., 2006) may all have a direct influence on the named benefits that sport participants can obtain. Despite proof that the last-mentioned factors may influence the sport participation benefits, only a small number of researchers have investigated this influence.

With regard to the possible effect of gender, research demonstrated that boys in general maintained a significantly higher sport participation and activity level than girls (Eitle, 2005; Ruiz et al., 2006; Moliner-Urdiales et al., 2010). Gender differences also seem to influence the physical and motor performance benefits that can be derived directly from sport participation with adolescent boys who displayed significantly higher aerobic fitness, muscle strength, muscle endurance, speed, explosive power and balance values in both sport participating and non-participating groups compared to girls (Raudsepp and Paasuke, 1995; Evans et al., 2007; Msengi et al., 2008; Hands et al., 2009). On the other hand adolescent girls showed significantly higher flexibility values than boys (Hands et al., 2009; Ramachandran et al., 2009; Dumith et al., 2010). With regard to the physical components, Janz et al. (2000) found that boys between the ages of 7 and 11 years had significantly greater peak $\dot{V}O_2$ values than girls of the same age group. In contrast, some researchers found a significantly better positive relationship between physical activity and aerobic fitness in 14 to 15 year old girls compared to boys (Katzmarzyk et al., 1998; Ekulund et al., 2001). Baxter-Jones et al. (2008) and McMurray et al. (2003) also concluded that boys between the ages of 7 and 17 years were taller, heavier and had significantly higher bone mineral density (BMD) values compared to girls of the same age group. The same researchers also reported significantly higher fat percentages and BMI values for both sport participating and non-participating girls compared to their male counterparts (Baxter-Jones et al., 2008; McMurray et al., 2003).

A study that focused on South African children of different race groups reported a higher frequency of sport participation for white boys and girls compared to black African children of both gender groups (McVeigh et al., 2004). Studies on populations from other parts of the world found that black African American boys had the highest sport participation levels followed by the Caucasian boys and girls (Tracy and Erkut, 2002; McMurray et al., 2003). Also, regardless of sport participation level black African American girls displayed significantly lower aerobic fitness levels compared to Caucasian girls of the

same age group (Pfeiffer et al., 2007; Lohman et al., 2008; Sirard et al., 2008). In a study of 12 year old black and white Tunisian football players, white players achieved significantly higher average peak power output values than the black players (Ayed et al., 2011). On the other hand black African American school boys performed significantly better in the sprint running and the vertical jump tests than the white boys in a study by Malina (1988). Another study by Ayed et al. (2011) also found that male black football players performed significantly better in the 30m sprinting test compared to the white players. With regard to the anthropometric characteristics of different races of children, Armstrong et al. (2006) revealed that white South African boys and girls were taller and heavier than black African boys and girls of the same age group. These researchers (Armstrong et al., 2006) together with Jacobs et al. (2010) also both reported lower BMI and fat percentage values in black African boys compared to white boys, whilst white African girls had higher BMI values up to 11 years of age where after black African girls displayed higher BMI values than their white counterparts. Furthermore, Boot et al. (1997) concluded that black African children and adolescents have significantly higher BMD than white children and adolescents.

Research with regard to the influence of the nature of sport participation on the physical, motor performance and anthropometric components of participants, is scarce. The research that does exist indicated that team sport participants performed significantly better in the repeated sprint test and obtained higher absolute total work and blood lactate concentration values immediately after the test compared to the individual sport group (Edge et al., 2006). Gleim and Mc Hugh (1997) also stated that flexibility patterns were specific to specific sports and even specific positions within the sport. In this regard Church et al. (2001) concluded that specific skills in a sport, such as gymnastics, require different speeds and movements that might require more flexibility compared to other skills in the same sport or to other sport types. With regard to balance, Hrysomallis (2011) and Bressels et al. (2007) showed that gymnasts tend to have the best developed balance ability followed by soccer players, swimmers and basketball players. Gymnasts and volleyball players were also the group of children who displayed significantly higher BMD values than children who participated in swimming or no sport at all (Grimston et al., 1993).

It is against this background of a lack of research concerning the effect of gender, race and the nature of sport participation on the relationship between the physical, motor performance, anthropometric components and sport participation of South African children that the purpose of this study was to determine the significant differences in the physical, motor performance and anthropometric components between a group of grade 10 learners of different genders and races who participated in different types of sport in the Tlokwe District, North West Province, South Africa. Information that may arise from this study may provide coaches, sport scientists and other sport related professionals with definite proof of the

real effect that gender, race and nature of sport participation have on these components.

Material and Methods

Subjects

A total of 201 learners (82 boys and 119 girls) in grade 10 at high schools in the Tlokwe local municipality area (Dr Kenneth Kaunda District) of the North West Province of South Africa were purposefully selected from pre-required class lists, from six secondary schools. Two of the selected schools were in the Potchefstroom City area, which predominantly comprised of learners from a high socio-economic status and four from the Ikageng Township area, which predominantly comprised of learners from a low socio-economic background. However, the group of learners cannot be considered to be representative of the adolescents' population, either of the Tlokwe local municipality area (Dr Kenneth Kaunda District) or of South Africa in general. Only learners who were in grade 10 at the time of measurement (2012) were eligible to participate in the study. However, only the data of 146 children (74 girls and 72 boys) who were identified to be sport participants were used for the purpose of this study. Prior to participating in the study, all subjects were informed of the nature of the study, and all potential risks and benefits were explained to them. Informed consent for the investigation was requested from the school authorities, the parents and learners of the participating schools during the weeks prior to the testing period. The study was approved by the Ethics Committee of the institution where the research was conducted (NWU-0058-01-A1) and by the North West Department of Health and the District Director of the Potchefstroom Department of Education. The research data that is used in the study forms part of a larger study - The Physical Activity and Health Longitudinal Study (PAHLS), which is an observational multidisciplinary longitudinal study that started in 2010. Only data that was sampled during 2012 was used for this study.

A pilot study during which one school's children were subjected to the anthropometric protocol as well as all the physical and motor performance tests was performed before the main part of the study to determine the reliability of the tests in this population. The average test-retest reliability coefficient for the different physical and motor performance tests of the pilot study was found to be 0.93 (range: 0.89-0.99). For the main part of the study the subjects underwent one day of testing at the testing centre of the institution that was responsible for the research. On arrival the subjects first completed the Demographic, General Information, Sport and Training Habits, Physical Activity and Maturity Determination Questionnaire (not all the results of this questionnaire were used for the purpose of this article) after which the anthropometric measurements, flexibility, explosive leg and upper body power, strength, speed and acceleration, agility and the cardiovascular endurance tests followed. Before the start of the speed and

acceleration, agility and the cardiovascular endurance tests the subjects were firstly subjected to a thorough warm-up of more or less 15 min that consisted of aerobic running exercises for more or less 8 min after which a specific warm-up period of shorter, high intensity movements and dynamic stretches followed.

Demographic, general information, sport and training habits determination questionnaire

A questionnaire in which learners had to provide information with regard to the following was also administered during the testing period: Information with regard to demographic and general information of the learner which included the name and address of the learner, his/her ethnic group, his/her school grade at the time of testing and the name of the school which he/she attended; Information with regard to the training habits, which included the type of sport the learner participated in, his/her main and secondary sport during the last two years, years he/she participated in the main and secondary sport, the frequency of training in the main and secondary sport, the participation level for the main and secondary sport - recreational, school, provincial or national, the best performance/s that has/have been achieved in the main sport; Information with regard to their physical activity such as the amount of days and hours the learners spent doing high, moderate and low intensity exercises during the last 7 days.

Anthropometric components

A total of 28 direct anthropometric measurements were obtained using The International Society for the Advancement of Kinanthropometry (ISAK) protocols (Marfell-Jones et al., 2006). It included body mass to the nearest 0.1 kg (using a calibrated Beurer Ps07 Electronic Scale, Ulm, Germany), body stature to the nearest 0.1 cm (using a Harpenden portable stadiometer, Holtain Limited, UK.), sitting height to the nearest 0.1 cm (using a Harpenden portable stadiometer, Holtain Limited, UK.), seven skinfolds (using Harpenden calipers, Holtain Limited, UK.), eight girths (using Lufkin metal tapes, Cooper Industries, USA.), four breadths (using Holtain Bicondylar Calipers, Holtain Limited, UK.), four lengths (using Rosscraft segmometers, Rosscraft Innovations Incorporated, Canada) and selected body composition components. After land marking each participant, he/she was directed to one of four stations where the different anthropometric measurements were taken. All the anthropometric measurements were taken twice by Level 2 ISAK Certified Anthropometrists on the right side of the body. The technical error of measurement (Pederson & Gore, 1996) was 3.11% for all skinfold measurements, 0.54% for all limb girth measurements and 1.97% for all bone breadth measurements. Arm, mid-thigh and calf girth was corrected for the different skinfolds at these sites, by using the following formula: Corrected girth = Girth – (π x skin fold thickness). According to Martin et al., (1990), corrected girths provide better indicators of musculoskeletal size at each site.

Maturational age determination.

The anthropometric measures of body stature, sitting height, leg length and body mass together with the variables of gender, date of birth and date of measurement were used to calculate peak height velocity (PHV). This is the most practical and non-invasive method of identifying maturational age (Mirwald et al. 2002). In this regard, Mirwald et al., (2002) found the coefficient of determination for the boys' model to be 0.92 whereas the girls' model showed a value of 0.91 when the equations for determining maturation age were cross-validated on a combined sample of Canadian and Flemish children. Maturity age is calculated by subtracting age at PHV from chronological age at the time of measurement (Thompson et al., 2002). If age at PHV is the same as the chronological age, maturity age equals 0 (Thompson et al., 2002). In cases where chronological age is higher than the age at PHV, maturity age is positive whereas maturity age is negative when age at PHV is higher than chronological age (Thompson et al., 2002:). This method is found to be ideal for prediction of PHV in adolescent boys and girls (Mirwald et al., 2002). It is important to correct for maturational age during the statistical analysis in order to eliminate the influence of growth when the true relationship between adolescent sport participation and the physical, motor performance and anthropometric components is to be determined.

Physical and motor performance components

Flexibility was tested by means of the passive-straight-leg-raise-test (PSLRT) according to the method of Maud and Kerr (2006); the active-straight-leg-raise-test (ASLRT), the modified Thomas iliopsoas test (MTIT), the modified Thomas quadriceps test (MTQT) and the passive shoulder external and internal rotation test (PSEIRT), all according to the methods of Harvey and Mansfield (2000); Muscle strength was tested by means of the abdominal stage test (AST) of Ellis et al. (2000) and the handgrip strength test of Hofman (2006); Explosive power through the basketball put (sitting on the floor) test of Ball (1991), the horizontal jump test (HJT) of Maulder and Cronin (2005) and the vertical jump test (VJT) of Harman et al. (2000) where power output was measured for each jump with a Tendo™ Power Output Unit (Tendo Sports Machines, Trencin, Slovak Republic). Subsequently, jump velocity was calculated and power was determined. Peak power output was recorded for each jump and used for the subsequent analyses. According to Hoffman et al. (2009), the test-retest reliability of the Tendo unit is $r \geq 0.90$; Speed and agility were tested through the forty metre acceleration and speed test according to the method of Ellis et al. (2000) and the agility-505-test of Veale et al. (2010), respectively; Cardiovascular endurance was tested by means of the 20-m Multistage shuttle run test (20-m SRT) according to the procedures described by the Australian Sports Commission (1998).

Statistical Analysis

The Statistical Data Processing package (Statsoft Inc., 2011) was used to process the data. Firstly, the

descriptive statistics (averages, standard deviations, minimum and maximum values) of each physical, motor performance and anthropometric component were calculated. Secondly, an independent t-test was used to determine the significance of differences between each of the physical, motor performance and anthropometric components of sport participating children of different gender and racial groups. Lastly, a one-way analysis of variance (ANOVA) was performed to determine the significant differences between each of the physical, motor performance and anthropometric components in children who participated in different types of sports (team, individual and both type of sports). The level of significance was set at $p \leq 0.05$.

Results

Anthropometric components

The descriptive statistics as well as the statistical significance of the differences for the anthropometric, physical and motor performance components between each of the gender and racial groups as well as between the children who participated in different types of sport are presented in Tables 1 and 2.

From the results in Table 1, which only presents the anthropometric variables, it is clear that the boys displayed significantly higher body mass; stature; muscle mass and percentage, mesomorphy; ectomorphy; humerus, wrist, femur and ankle breadth; relaxed arm, maximum calf and forearm girth; waist circumference; waist to hip ratio; acromial-radial, radial-stylian, midstylian-dactylian and foot length compared to girls. However significant lower fat mass and percentage, endomorphy, skinfold measurements and sum of skinfold values were displayed by the boys compared to the girls.

With regard to race, black children showed significantly lower body mass; stature; sitting height; BMI; fat mass; muscle mass; mesomorphy; supraspinal and abdominal skinfolds; humerus, wrist and femur breadth; relaxed arm, flexed arm, mid thigh, maximum calf and forearm girth; waist and hip circumference; waist to height ratio; acromial-radial, radial-stylian, midstylian-dactylian and foot length compared to their white counterparts. However, black children displayed significantly higher ectomorphy values compared to white children.

No significant differences were found between the anthropometric components of team, individual and combined sport participation.

Physical and motor performance components

Descriptive statistics as well as the statistical significance of the differences between the physical and motor performance components in sport participating children of different gender and racial groups and who participated in different types of sports are presented in Table 2. From the tabulated results it is clear

that boys performed significantly better in VJT height and Tendo peak power and speed, horizontal jump distance, left and right handgrip strength, AST, 5m and 10m speed, 505 agility from the left and the right foot as well as the last level of the 20-m SRT and the $\dot{V}O_{2max}$ that was reached during execution of 20-m SRT compared to the girls. In contrast, the girls performed significantly better in the right and left PSERT, right PSLRT, left and right ASLRT and left MTQT flexibility compared to boys.

White children performed significantly better in the VJT height and Tendo peak power, basketball put distance, left and right hand grip strength, AST, 5m and 10m speed, 505 agility from the left and the right foot as well as the last level of the 20-m SRT and the $\dot{V}O_{2max}$ that was reached during execution of 20-m SRT compared to their black counterparts. With regard to flexibility black children performed significantly better in the left and right PSIRT, PSLRT and MTQT compared to the white children.

Results from the one way ANOVA (Table 2) showed that children who participated in both team and individual (combined) sport performed significantly better in the left PSLRT compared to children who only participated in team or individual sports. Combined sport participants also performed significantly better in the right PSLRT compared to children who only participated in individual sport. Furthermore, children who participated in team sport showed significant better results in the left ASLRT compared to children who participated in both team and individual sport.

The effect of gender, race and nature of sport participation on the relationship between adolescent sport participation and the physical, motor performance and anthropometric components of a group of grade 10 learners

Table 1. Descriptive statistics as well as the statistical significance of the differences between the anthropometric components and age related variables in sport participating children of different gender and racial groups and who participated in different types of sport

	Total Group (n = 146)	Girls (n = 74)	Boys (n = 72)	White (n = 41)	Black (n = 105)	Team sport (n = 82)	Individual sport (n = 17)	Combined sport (n = 47)
Age (yrs)	15.9 ± 0.7	15.8 ± 0.8	15.9 ± 0.6	15.8 ± 0.6	15.9 ± 0.7	15.9 ± 0.7	15.7 ± 0.7	15.9 ± 0.7
Body mass (kg)	55.2 ± 12.6	51.3 ± 8	58.6 ± 14.3 *	67.5 ± 14.2	50.4 ± 7.7 *	55.4 ± 12.9	54.6 ± 7.5	55.1 ± 13.7
Stature (cm)	164.6 ± 9	160 ± 6	169.1 ± 9.2 *	172.4 ± 9.7	161.5 ± 6.7 *	164.4 ± 8.2	166.7 ± 9	164.2 ± 10.5
PHV Age (yrs)	14.27 ± 0.7	14.33 ± 0.6	14.21 ± 0.7	14.24 ± 0.6	14.28 ± 0.7	14.21 ± 0.7	14.05 ± 0.7	14.43 ± 0.6
Maturity Age	1.8 ± 0.4	1.8 ± 0.4	1.8 ± 0.4	1.8 ± 0.5	1.8 ± 0.4	1.8 ± 0.4	1.9 ± 0.3	1.8 ± 0.4
Sitting height (cm)	120.7 ± 12.6	120.3 ± 5	121 ± 17.3	125.3 ± 15.5	119 ± 10.8 *	120.7 ± 12.7	117.8 ± 22.5	121.9 ± 5.9
BMI (kg.m ⁻²)	20.2 ± 3.1	20.0 ± 3.0	20.3 ± 3.5	22.6 ± 3.5	19.3 ± 2.5 *	20.3 ± 3.4	19.6 ± 2.1	20.2 ± 3.1
Fat mass percentage (%)	17.4 ± 7.6	22.08 ± 4.6	12.3 ± 6.6 *	20.3 ± 8.3	16.3 ± 7	17.02 ± 7.5	15.4 ± 7.7	18.8 ± 7.6
Fat mass (kg)	9.9 ± 5.9	11.6 ± 3.9	7.9 ± 6.5 *	14.05 ± 7.6	8.3 ± 4.1 *	9.9 ± 6.1	8.4 ± 4.2	10.6 ± 6
Muscle mass percentage (%)	37 ± 21.8	30.7 ± 2.7	40 ± 3 *	41.3 ± 40.2	35.3 ± 5.7	38.8 ± 28.6	37.3 ± 5.4	33.7 ± 5.7
Muscle mass (kg)	21.2 ± 23	15.7 ± 2.6	23.2 ± 4.5 *	29.9 ± 41.8	17.8 ± 4.1 *	22.8 ± 30.1	20.4 ± 4.5	18.7 ± 6.1
Endomorphy	3.1 ± 1.4	3.8 ± 1.1	2.4 ± 1.2 *	3.6 ± 1.6	2.9 ± 1.3	3.07 ± 1.3	2.7 ± 1.3	3.4 ± 1.6
Mesomorphy	3.6 ± 1.7	3.3 ± 1.9	3.9 ± 1.3 *	4.5 ± 2	3.3 ± 1.4 *	3.7 ± 1.7	3.6 ± 0.9	3.5 ± 1.8
Ectomorphy	3.3 ± 1.3	3.1 ± 1.3	3.6 ± 1.4 *	2.7 ± 1.3	3.6 ± 1.2 *	3.3 ± 1.4	3.7 ± 1.3	3.3 ± 1.3
Biceps skinfold (mm)	6.1 ± 3.1	7.9 ± 3	4.2 ± 1.8 *	7.03 ± 3.7	5.8 ± 2.7	6.2 ± 3.3	5.7 ± 3.5	6.06 ± 2.3
Triceps skinfold (mm)	11.6 ± 5.2	14.5 ± 4.3	8.4 ± 4 *	13.7 ± 6	10.8 ± 4.6	11.5 ± 5	10.5 ± 5.3	12.2 ± 5.4
Subscapular skinfold (mm)	9.8 ± 5.5	10.9 ± 6.2	8.4 ± 4.2 *	11.03 ± 5.1	9.3 ± 5.6	9.5 ± 4	8.6 ± 2.6	10.8 ± 8
Supraspinal skinfold (mm)	8.9 ± 4.8	9.9 ± 3.5	7.6 ± 5.5 *	11.9 ± 6.4	7.7 ± 3.4 *	8.9 ± 4.9	7.7 ± 3.4	9.2 ± 5.2
Abdominal skinfold (mm)	14.4 ± 7.2	16.8 ± 6	11.7 ± 7.2 *	18.7 ± 8.6	12.7 ± 5.7 *	14.6 ± 7.2	12.9 ± 6.5	14.7 ± 7.2

Note: BMI = Body mass index, PHV = Peak height velocity; *p ≤ 0.05

The effect of gender, race and nature of sport participation on the relationship between adolescent sport participation and the physical, motor performance and anthropometric components of a group of grade 10 learners

Table 1 (cont.). Descriptive statistics as well as the statistical significance of the differences between the anthropometric components and age related variables in sport participating children of different gender and racial groups and who participated in different types of sport

	Total Group (n = 146)	Girls (n = 74)	Boys (n = 72)	White (n = 41)	Black (n = 105)	Team sport (n = 82)	Individual sport (n = 17)	Combined sport (n = 47)
Front thigh skinfold (mm)	18.7 ± 8/9	24 ± 7	12.9 ± 6.6 *	20.6 ± 9.6	17.9 ± 8.5	18.3 ± 8.6	16.05 ± 8	20.2 ± 9.5
Medial calf skinfold (mm)	13.01 ± 5.8	16.02 ± 4.8	9.7 ± 4.6 *	14.7 ± 6.5	12.4 ± 5.3	13.2 ± 5.9	11.1 ± 4.6	13.5 ± 5.9
Sum of 2 skinfolds (mm)	21.04 ± 8.4	24.8 ± 6.76.7	16.8 ± 7.6 *	24.7 ± 10.2	19.6 ± 7.1	21 ± 8.4	19.07 ± 7.5	21.9 ± 8.6
Sum of 6 skinfolds (mm)	76.02 ± 32	91.6 ± 23.3	58.7 ± 30 *	90.6 ± 39.3	70.3 ± 26.9	75.9 ± 32.3	66.9 ± 28.3	79.5 ± 32.9
Sum of 7 skinfolds (mm)	82.4 ± 34.6	99.4 ± 25.5	62.9 ± 31.7 *	97.6 ± 42.3	76.1 ± 29.1	82.2 ± 35.2	72.6 ± 31.5	85.6 ± 34.7
Humerus breadth (mm)	6.3 ± 0.6	5.8 ± 0.4	6.7 ± 0.5 *	6.7 ± 0.6	6.1 ± 0.5 *	6.3 ± 0.6	6.4 ± 0.6	6.2 ± 0.7
Wrist breadth (mm)	5.02 ± 0.4	4.8 ± 0.3	5.2 ± 0.4 *	5.3 ± 0.4	4.9 ± 0.3 *	5.01 ± 0.4	5.09 ± 0.3	5.02 ± 0.5
Femur breadth (mm)	8.9 ± 0.7	8.5 ± 0.5	9.3 ± 0.7 *	9.5 ± 0.8	8.7 ± 0.5 *	9 ± 0.8	9 ± 0.5	8.8 ± 0.8
Ankle breath (mm)	6.6 ± 0.6	6.2 ± 0.4	7.06 ± 0.5 *	7.2 ± 0.6	6.4 ± 0.5	6.7 ± 0.6	6.8 ± 0.6	6.6 ± 0.7
Head girth (cm)	55.2 ± 2.6	55.1 ± 1.6	55.3 ± 3.3	55.6 ± 1.7	55.1 ± 2.9	55.6 ± 1.5	54.9 ± 1.5	54.9 ± 4.05
Relaxed arm girth (cm)	24.6 ± 3.5	23.9 ± 2.6	25.2 ± 3.9 *	28.09 ± 3.5	23.3 ± 2.3 *	24.6 ± 3.6	25.3 ± 2.3	24.5 ± 3.7
Flexed arm girth (cm)	27.2 ± 6.6	26.5 ± 8.2	27.8 ± 4	31.2 ± 8.5	25.6 ± 4.9 *	27.1 ± 6.8	27.4 ± 2.7	27.3 ± 7.2
Waist circumference (cm)	66.9 ± 7.7	64.2 ± 5.4	69.3 ± 8.1 *	73.1 ± 8.9	64.5 ± 5.6 *	67.1 ± 8	66.8 ± 3.8	66.7 ± 8.2
Hip circumference (cm)	87.8 ± 9.1	89 ± 8.5	86.3 ± 9.1	95 ± 8	85.04 ± 7.9 *	88.2 ± 9	86.7 ± 5.9	87.6 ± 10.2
Waist to hip ratio	0.8 ± 0.1	0.7 ± 0.1	0.8 ± 0.03 *	0.8 ± 0.05	0.8 ± 0.1	0.8 ± 0.06	0.7 ± 0.04	0.8 ± 0.2
Waist to height ratio	0.4 ± 0.04	0.4 ± 0.03	0.4 ± 0.04	0.4 ± 0.04	0.4 ± 0.03 *	0.4 ± 0.04	0.4 ± 0.02	0.4 ± 0.04
Mid thigh girth (cm)	47.2 ± 5.1	46.7 ± 4.7	47.6 ± 5.4	50.9 ± 5.2	45.8 ± 4.4 *	47.5 ± 5.1	46.4 ± 3.7	47 ± 5.7
Maximum calf girth (cm)	32.7 ± 3.4	32.02 ± 2.8	33.2 ± 3.6 *	35.8 ± 2.8	31.4 ± 2.7 *	32.7 ± 3.6	32.4 ± 2.8	32.7 ± 3.2

Note: BMI = Body mass index, PHV = Peak height velocity

*p ≤ 0.05

The effect of gender, race and nature of sport participation on the relationship between adolescent sport participation and the physical, motor performance and anthropometric components of a group of grade 10 learners

Table 1 (cont.). Descriptive statistics as well as the statistical significance of the differences between the anthropometric components and age in sport participating children of different gender and racial groups and who participated in different types of sport

	Total Group (n = 146)	Girls (n = 74)	Boys (n = 72)	White (n = 41)	Black (n = 105)	Team sport (n = 82)	Individual sport (n = 17)	Combined sport (n = 47)
Forearm girth (cm)	23.6 ± 2.5	22.4 ± 1.6	24.8 ± 2.6 *	25.8 ± 2.6	22.7 ± 1.8 *	23.7 ± 2.5	24.02 ± 1.7	23.4 ± 2.8
Acromial-radial length (cm)	31.2 ± 2.3	30.1 ± 2.1	32.3 ± 2 *	32.8 ± 2.4	30.6 ± 2.1 *	31.4 ± 2	31.7 ± 2.5	30.8 ± 2.9
Radial-styilion length (cm)	24.7 ± 1.5	23.9 ± 1.3	25.4 ± 1.4 *	25.1 ± 1.5	24.5 ± 1.5 *	24.7 ± 1.6	24.7 ± 1.5	24.5 ± 1.5
Midstyilion-dactyilion length (cm)	19.8 ± 1.5	18.7 ± 0.9	20.9 ± 1.2 *	20.5 ± 1.7	19.6 ± 1.4 *	19.8 ± 1.5	20.1 ± 1.4	19.7 ± 1.6
Foot length (cm)	25.3 ± 1.9	24.03 ± 1.1	26.6 ± 1.4 *	26.4 ± 2	24.9 ± 1.7 *	25.5 ± 1.9	25.3 ± 1.6	25.06 ± 1.9

Note: BMI = Body mass index, PHV = Peak height velocity

*p ≤ 0.05

The effect of gender, race and nature of sport participation on the relationship between adolescent sport participation and the physical, motor performance and anthropometric components of a group of grade 10 learners

Table 2. Descriptive statistics as well as the statistical significance of the differences between the physical and motor performance components in sport participating children of different gender and racial groups and who participated in different types of sport

	Total Group (n = 146)	Girls (n = 74)	Boys (n = 72)	White (n = 41)	Black (n = 105)	Team sport (n = 82)	Individual sport (n = 17)	Combined (n = 47)
Left PSERT flexibility (°)	98 ± 8.9	98.5 ± 8.5	97.6 ± 9.4	97.5 ± 10.1	96.3 ± 8.8	98.07 ± 8.1	99.5 ± 10.4	97.340 ± 9.9
Right PSERT flexibility (°)	100.3 ± 8.6	102.3 ± 7.8	98.2 ± 9 *	101.3 ± 9.3	98.3 ± 8.1	99.8 ± 8.6	100.1 ± 7.7	101.319 ± 9
Left PSIRT flexibility (°)	41.6 ± 15.4	42.9 ± 16.5	40.4 ± 14.2	34 ± 9.4	42.6 ± 16.3 *	40.8 ± 14.5	35.9 ± 14.7	44.936 ± 16.8
Right PSIRT flexibility (°)	41.4 ± 15.1	41.7 ± 15.1	41.3 ± 15.4	33.2 ± 9.8	43.05 ± 15.7 *	40.6 ± 14.6	37.6 ± 14.3	44.213 ± 16.2
Left PSLRT flexibility (°)	98.6 ± 15.7	101.6 ± 14.4	95.9 ± 16.3 *	93.02 ± 15.9	99. ± 14.9 *	99.6 ± 14.1 ^a	88.4 ± 18 ^b	100.553 ± 6.5 ^{ab}
Right PSLRT flexibility (°)	100.6 ± 15.9	104.3 ± 13	97.2 ± 17.6 *	94.8 ± 17	100.9 ± 17.3 *	100.9 ± 15.6	91.2 ± 16.8 ^b	103.489 ± 15.2 ^b
Left ASLRT flexibility (°)	80.9 ±	84.3 ± 16.2	77.5 ± 13.8 *	80.3 ± 13.4	79.4 ± 16.4	83.7 ± 16.1 ^a	74.2 ± 13.6	78.426 ± 13.7 ^a
Right ASLRT flexibility (°)	82.6 ± 15.6	87.1 ± 14.4	78.3 ± 15.6 *	81 ± 16.2	81.8 ± 15.1	82.9 ± 16.8	76.5 ± 13.4	84.404 ± 13.8
Left MTIT flexibility (°)	6.5 ± 6.6	6 ± 6.9	7.1 ± 6.3	7.3 ± 5.4	7 ± 7	6.2 ± 6.5	7.7 ± 6.9	6.702 ± 6.9
Right MTIT flexibility (°)	5 ± 6.8	4.6 ± 7.6	5.4 ± 6.1	5.7 ± 4.5	5.5 ± 7.6	4.3 ± 6.9	5.3 ± 4.2	6.043 ± 7.6
Left MTQT flexibility (°)	63.3 ± 11.3	65.5 ± 11.1	61 ± 11.2 *	59 ± 10	63.8 ± 11.5 *	63.8 ± 11.4	58.8 ± 11.7	64.149 ± 10.8
Right MTQT flexibility (°)	64.4 ± 11	65.8 ± 10.8	63 ± 11.3	61.2 ± 10	64.7 ± 11.2 *	65.6 ± 10.6	60.5 ± 13.4	63.638 ± 10.8
VJT height (cm)	35.07 ± 11.4	28.2 ± 8.9	42.1 ± 9.2 *	41.7 ± 8.7	32.5 ± 11.4 *	35.6 ± 11.2	38.4 ± 11.7	33 ± 11.6
VJT Tendo peak power (W)	1353.6 ± 70.6	1176.1 ± 98.1	1521.4 ± 400.6 *	1697.4 ± 420	1219.3 ± 242.6 *	1349.5 ± 350.6	1380.4 ± 243.5	1351.1 ± 442.2
VJT Tendo peak speed (m.s⁻¹)	2.6 ± 1.1	2.3 ± 0.2	2.8 ± 1.6 *	2.6 ± 0.3	2.6 ± 1.3	2.6 ± 1.5	2.6 ± 0.2	2.477 ± 0.3
HJT distance (cm)	180.7 ± 69.7	160 ± 25.1	202.3 ± 92.1 *	190.3 ± 63.6	177 ± 72	181.7 ± 79.8	178.3 ± 34.7	179.847 ± 60.6
Basketball put distance (cm)	4.8 ± 3.3	4.6 ± 4.6	5 ± 1	6.2 ± 6	4.2 ± 0.9 *	5.04 ± 4.3	5 ± 0.9	4.301 ± 1.3
Handgrip strength – left (kg)	30.6 ± 8.4	25 ± 4.4	36.1 ± 7.7 *	35.3 ± 10	28.7 ± 6.9 *	30.2 ± 8.5	32.6 ± 7.7	30.464 ± 8.6

Note: PSERT = Passive shoulder external rotation test; PSIRT = Passive shoulder internal rotation test; PSLRT = Passive straight leg raise test; ASLRT = Active straight leg raise test; MTIT = Modified Thomas iliopsoas test; MTQT = Modified Thomas quadriceps test; VJT = Vertical jump test; HJT = Horizontal jump test; AST = Abdominal stage test; SRT = Shuttle run test. When the same letter appears above one or more values under the different types of sports category, a significant difference ($p \leq 0.05$) was present. * $p \leq 0.05$

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Table 2 (cont.). Descriptive statistics as well as the statistical significance of the differences physical and motor performance components between gender, race and

	Total Group (n = 146)	Girls (n = 74)	Boys (n = 72)	White (n = 41)	Black (n = 105)	Team sport (n = 82)	Individual sport (n = 17)	Combined (n = 47)
Handgrip strength - right (kg)	31.3 ± 8.5	25.8 ± 4.9	36.8 ± 7.8 *	37.5 ± 9.1	28.9 ± 6.9 *	30.9 ± 8.4	34.9 ± 8.2	30.623 ± 8.7
AST (level)	2.5 ± 1.8	2.1 ± 1.8	2.9 ± 1.8 *	3.8 ± 1.7	2.04 ± 1.7*	2.4 ± 1.8	2.9 ± 1.7	2.553 ± 1.9
5 m Speed (sec)	1.2 ± 0.1	1.3 ± 0.1	1.1 ± 0.1 *	1.2 ± 0.09	1.2 ± 0.2 *	1.2 ± 0.2	1.2 ± 0.1	1.235 ± 0.1
10m Speed (sec)	2.08 ± 0.2	2.2 ± 0.1	1.9 ± 0.1 *	2.03 ± 0.1	2.1 ± 0.2*	2.09 ± 0.2	2 ± 0.1	2.107 ± 0.2
40m Speed (sec)	7 ± 4	7.1 ± 0.6	6.8 ± 5.7	6.3 ± 0.5	7.2 ± 4.7	7.2 ± 5.3	6.2 ± 0.5	6.735 ± 0.8
505 Agility from the left foot (sec)	2.9 ± 0.2	3.05 ± 0.2	2.8 ± 0.2 *	2.9 ± 0.2	3 ± 0.2 *	2.9 ± 0.2	2.9 ± 0.2	2.979 ± 0.2
505 Agility from the right foot (sec)	2.9 ± 0.2	3.04 ± 0.2	2.8 ± 0.2 *	2.8 ± 0.2	3 ± 0.2 *	2.9 ± 0.2	2.8 ± 0.2	2.948 ± 0.2
20-m SRT last level	6.6 ± 2.1	5.1 ± 1.4	8.1 ± 1.7 *	7.1 ± 1.7	6.4 ± 2.3*	6.5 ± 2	6.8 ± 1.9	6.532 ± 2.5
20-m SRT last shuttle	5.4 ± 2.8	5.1 ± 2.7	5.7 ± 2.9	5.04 ± 3	5.6 ± 2.8	5.3 ± 3	5.2 ± 2.8	5.745 ± 2.6
20-m SRT $\dot{V}O_{2max}$ (ml.kg⁻¹.min⁻¹)	36.9 ± 7.2	31.9 ± 4.8	42 ± 5.7 *	38.6 ± 5.7	36.2 ± 7.7 *	36.7 ± 7	37.6 ± 6.4	36.831 ± 8.1

Note: PSERT = Passive shoulder external rotation test; PSIRT = Passive shoulder internal rotation test; PSLRT = Passive straight leg raise test; ASLRT = Active straight leg raise test; MTIT = Modified Thomas iliopsoas test; MTQT = Modified Thomas quadriceps test; VJT = Vertical jump test; HJT = Horizontal jump test; AST = Abdominal stage test; SRT = Shuttle run test. When the same letter appears above one or more nature of sport, a significant difference ($P \leq 0.05$) was present

* $p \leq 0.05$

Discussion

The purpose of this study was to determine the effect of gender, race and the nature of sport participation on the relationship between adolescent sport participation and the physical, motor performance and anthropometric components of a group of grade 10 learners in the Tlokwe District, North West Province, South Africa. In terms of the differences between the anthropometric variables of boys and girls, the results showed that the boys obtained significant higher values for most of the absolute and relative body size, body composition and somatotype related variables compared to the girls. Only the skinfold and sum of skinfold values as well as fat mass, fat mass percentage and endomorphy displayed significantly higher values for the girls compared to the boys (see Tables 1 and 2).

Previous research by McMurray *et al.* (2003), Cheng *et al.* (1999) and Baxter-Jones *et al.* (2008) also reported significantly higher body mass and stature values for boys (between the ages of 9 and 17) compared to girls, although a study of 12 year old children from Oslo found significantly higher values for the last-mentioned variables in girls compared to boys (Holm *et al.*, 2008). However, despite of boys' significantly higher body mass values, they were also the gender group who displayed significantly lower skinfold and sum of skinfold, fat mass and percentage values. Due to the fact that endomorphy is also related to percentage body fat (Coetzee, 2002), a lower endomorphy value for the boys was therefore expected. Baxter-Jones *et al.* (2008) also found that boys had significantly greater lean body mass scores compared to girls of the same maturity age. Furthermore, Ruiz *et al.* (2006) and Ramachandran *et al.* (2009) reported significantly lower body fat values in sport participating boys compared to their female counterparts.

The significantly higher body mass value of the boys are probably related to the significantly higher muscle mass and percentage that they displayed. In view of the fact that relaxed arm, maximum calf and forearm girth are related to the peripheral muscle size, it is not unexpected that the boys will obtain significantly higher values for these measurements, compared to the girls. Mesomorphy is related to a person's muscle mass (Carter & Ackland, 2009), which would also explain the significantly higher average mesomorphy values in boys compared to girls. All of these last-mentioned differences will give rise to a more slender or linear body build in boys compared to girls who will display a more plump type of body build. Ectomorphy, which is an indication of the relative linearity or slenderness of a person's physique will, therefore, obtain a significantly higher value for boys compared to girls. Research suggested that boys experience an almost 10 fold increase in testosterone production during puberty, which causes most of the muscle gain in this gender group (Kenney *et al.*, 2012). According to McArdle *et al.* (2010), testosterone is

the main contributor to the male-female differences in muscle mass between the boys and girls. However, the secretion of estradiol, especially during the early teens in girls will stimulate fat deposition in the hips, thighs, buttocks and breasts (Saladin, 2007) and will lead to the significantly higher skinfold, sum of skinfold, fat mass, fat mass percentage and endomorphy values for this gender group compared to the boys. In general girls grow faster during adolescence than boys and attain their adult stature earlier because of the effects of estradiol (estrogen) (Saladin, 2007). Boys do however grow for a longer period of time, which will lead to a taller body stature and longer extremity lengths compared to girls (Saladin, 2007).

Another factor that needs consideration when explaining the gender differences in muscle mass, is boys' preference for more vigorous physical activities during sport participation, compared to girls (Deere et al., 2012). The execution of more vigorous physical activities will probably lead to a higher activation of muscle fibres which will result in muscle fibre hypertrophy and in the long run to an increase in muscle mass percentage (Guyton & Hall, 2006).

With regard to the physical and motor performance components, boys performed significantly better in all of the tests that were related to lower body explosive power, muscle strength, speed, agility and cardiovascular endurance. The only tests in which the girls performed significantly better than the boys, were the flexibility related tests. The last-mentioned results are similar to what previous researchers also found. In this regard, researchers have collectively shown that sport participating boys tend to have significantly more explosive power, speed, muscle strength and cardiovascular endurance than sport participating girls (Raudsepp and Paasuke, 1995; Janz et al., 2000:1252; Janz et al., 2003:37; Ruiz et al., 2006:301; Hands et al., 2009:657; Moliner-Uridiales et al., 2010:1121; Woll et al., 2011:1135). Studies that have reported no significant gender differences between the agility and lower body explosive power scores of sport participating children, were all performed on younger children (5-11 years of age) (Raudsepp & Paasuke, 1995; Holm et al., 2008) than the children who tested in this study. According to Janz et al. (2003), the differences between the jumping tests scores (lower body explosive power) might be explained by the different jumping strategies that boys and girls use. In this regard Janz et al. (2003) reported a smaller mean ground reaction force for girls (3.2 times their body weight), compared to the mean ground reaction force for boys (3.8 times their body weight). Significant relationships exist between the body stature, HJT distance, speed and stride length of children (Raudsepp & Paasuke, 1995; Copaver, 2012), which may also help to explain the differences in HJT distance, speed and agility values in this group of children. To test this contention the correlation coefficients (R) of the relationships between the children's stature as well as HJT

distance; 5m and 10m speed times as well as 505 agility from the left and right foot times were calculated and revealed significant R-values of 0.27, -0.34, -0.41, -0.09, -0.25, -0.31, respectively for the last mentioned relationships. These results indicate that a taller body stature will usually be an advantage for the execution of explosive power jumping, speed and agility tests. This benefit is probably due to a longer leg length that will allow the participants to maintain longer stride lengths during the execution of the tests.

Research also suggests that direct positive relationships exist between grip strength and hand length (Crawford et al. 2002) as well as between foot length and leg explosive power (Davis et al., 2006), which may also help to explain the significant gender differences between the handgrip strength and the jumping related tests (VJT and HJT). Significant R-values of 0.76, 0.72 and 0.20 exist between the last-mentioned variables, which verifies this contention. The significantly higher fat mass as well as fat mass percentage of the girls group might also partially explain the weaker performances in the speed, agility and cardiovascular endurance related tests. This group of children will probably be less economical in terms of movement speed because of a relative higher body fat compared to a lower muscle mass ratio compared to the boys who displayed a more slender body build with relative lower body fat compared to a higher muscle mass ratio. Boys performed significantly better in last level of the 20-m SRT and the $\dot{V}O_{2max}$ that was reached during execution of 20-m SRT compared to girls. These differences may also be attributed to the significantly higher muscle mass values of the boys compared to the girls. In this regard McArdle et al. (2010) stated that the size of the muscle mass which is contracted during the execution of exercise will largely account for the gender differences in cardiovascular endurance.

With regard to the differences between the flexibility scores of girls and boys, Hands et al., (2009) found significantly better scores in the sit-and-reach and shoulder flexibility test for adolescent girls compared to their male counterparts. Ramachandran et al. (2009) suggested that the flexibility values of girls are not only influenced by sport participation but also by gender specific traits, which allow them to obtain a better range of motion around their joints.

The differences with regard to the racial groups showed that black children displayed lower values for most of the absolute and relative body size, body composition and somatotype related variables which obtained significant differences when compared to the values of white children. Ectomorphy was the only anthropometric variable that obtained a significant lower value for the black children compared to the white children. Overall research also found similar results with regard to the significant differences and the direction of differences between the anthropometric measurements of sport participating children of different

racial groups. In this regard research has collectively showed that white boys and girls tended to be taller, heavier and have greater fat percentage values than black African boys and girls of the same age (6-13 years) (Armstrong et al., 2006). Several studies have only investigated the racial differences in boys and indicated that white American and Tunisian children were overall heavier and shorter than their black counterparts (Roche et al., 1994; Ayed et al., 2011). Jacobs et al. (2010) studied 219 boys between the ages of 11 and 13 years living in the rural area of Potchefstroom (South Africa) and found that sport participating black African boys had lower BMI and fat percentage values than white boys. Armstrong et al. (2006) showed that white African boys displayed higher BMI values during all ages, whereas white African girls had higher BMI values up to the age of 11 years where after black African girls displayed higher BMI values than their white peers. Pfeiffer et al. (2007) reported a stable BMI over a period of four years as well as no significant differences between white and black African American grade eight girls from South Carolina. A study by Pesa and Turner (1999) also indicated that black African American and Native American grade 11 children had the highest body weight compared to Asian American children.

Most of the black children (95%) that formed part of the sport participating group in this study comprised of learners from a rural area which falls into the low socio-economic status category. It is therefore possible that the black children's nutritional intake was not optimal in terms of the nutritional and energy requirements for growth and development. These children will then be characterised by smaller body dimensions, lower body mass and stature values despite of a higher maturity age than the white children. This notion was also accentuated through the significant lower average ectomorphy value of the black children. Ectomorphy is an indication of the relative linearity or slenderness of children's physique (Carter & Ackland, 2009). In contrast the white children displayed significantly higher endomorphy and mesomorphy values together with significantly higher skinfold, girth and circumference values which collectively is an indication of a higher level of fatness and relative musculoskeletal robustness (Carter & Ackland, 2009).

With regard to significant differences in the physical and motor performance components between racial groups, white children performed significantly better in all of the upper and lower body explosive power, all of the muscle strength, most of the speed, all of the agility and the cardiovascular endurance related tests compared to the black children. In contrast, the black children performed better in all the flexibility related tests which showed significant differences compared to the white children. Previous research results with regard to the differences between white and black children, are contradicting. For example, in a study of one hundred and thirteen 12 year old black and white Tunisian football players, white players achieved

significantly higher average peak power output values than the black players (Ayed et al., 2011). On the other hand the male black football players performed significantly better in the 30 m sprinting test compared to their white counterparts (Ayed et al., 2011). This result was also consistent with that of Malina (1988), who reported that black African American school boys performed significantly better in the sprint running and the vertical jump tests than white boys. The research results of Babel et al. (2005) did, however, not coincide with the results of the last-mentioned studies. These researchers found no difference in the sprint performance test between the 17 eleven year old Caucasian and African-Caribbean boys (Babel et al., 2005). With regard to cardiovascular endurance Pfeiffer et al. (2007) and Lohman et al. (2008) reported that white adolescent girls had significantly higher fitness values and participated more in sport than adolescent black African American girls. In addition, Sirard et al. (2008) found that physically active black African American girls have lower aerobic fitness levels compared to physically active white girls.

As been discussed before, it is possible that the differences in body stature, hand and foot length may be partly responsible for the significant differences that was found between the lower body explosive power, speed, hand grip strength and agility of the two racial groups. Furthermore, research suggested that muscle mass may act as a predictor of maximal short-term performances in young sport participants (14-16 years of age) (Carvalho et al., 2011). The same type of conclusion with regard to the role of muscle mass to performance in cardiovascular endurance type of tests, was also made by McArdle et al. (2010) who pointed out that the mass of the contracting muscles which are activated during exercises will largely account for difference in the aerobic capacity measures between individuals. Despite of these conclusions, the muscle mass and muscle mass percentage of this children in this study were only significantly related to VJT height ($R = 0.24$ and 0.20) and Tendo peak power output ($R = 0.46$ and 0.32). Only non-significant R -values were calculated for the relationships between muscle mass and muscle mass percentage as well as the last level of the 20-m SRT and the $\dot{V}O_{2max}$ that was reached during the 20-m SRT ($R = 0.09$ and 0.10 as well as $R = 0.14$ and 0.16). What this means is that neurological factors were probably more responsible for the differences between the anaerobic and aerobic test values of the different racial groups, than peripheral factors.

White children in general obtained significantly poorer scores for the left and right PSIRT, PSLRT and MTQT compared to their black counterparts. According to Alter (2004), there is a time variable between the growth of bones and soft tissue during the growth acceleration and peak height velocity (PHV) phase which could result in greater tension and tightness in the connective tissues. This disproportioned relative growth of the bones and connective tissues can, therefore, serve as a partial explanation for the decreased flexibility that

the white children experienced compared to the black children. From the results with regard the PHV of the two groups of children, it is clear that the black children are further past their PHV age (14.28 years) compared to the white children (14.24 years). The fact that the black children have experienced the growth acceleration and PHV phase and have subsequently moved into the flexibility-improvement period, may explain the better flexibility scores that they obtained compared to the other group of children.

With regard to the types of sport (team, individual and combined), no significant differences were found between the anthropometric components of the three groups of sport participants. The flexibility related tests were the only physical and motor performance tests that obtained significant differences with regard to the children who participated in different types of sport. Overall we have seen that children who participate in both team and individual sport performed significantly better in the left PSLRT compared to children who only participate in team or individual sports. Combined sport participants (team and individual) also performed significantly better in the right PSLRT compared to children who only participate in individual sport. Participants who participate in team as well as individual sport are more exposed to stretching and might have more regular stretching sessions compared to children who only participate in either team or individual sports. Children participating in team sport showed significant better results in the left ASLRT compared to children who participate in both team and individual sport. Outliers for some of the flexibility scores of the children in the different groups could have influenced the ANOVA analysis results in such a way that significant differences were observed. The reason for this is that children who were categorized into the individual sport category were very few ($n = 17$) and outliers in the groups of children may have “pulled” the ANOVA analysis results skew.

In conclusion, the study revealed that gender differences accounted for the majority of significant differences between the anthropometric, physical and motor performance components of the sport participation children that were tested, with only the fat and flexibility related variables that displayed higher values for the girls compared to the boys. Racial differences accounted for the second most significant differences between the anthropometric, physical and motor performance components of the sport participation children that were tested, with only the flexibility related variables that displayed better values for the black compared to the white children. However, very few significant differences were observed for differences between the groups of children who participated in different types of sport. The flexibility related variables were the only variables that displayed significant differences between the last-mentioned groups. Therefore, although a relationship exists between sport participation and the physical, motor performance and

anthropometric benefits that can be derived, factors such as race and gender have a direct influence on this relationship and need to be considered when this population of children are investigated. Several shortcomings and recommendations should, however, be considered when interpreting the results of this study. Small group sizes of especially the groups of children who participated in different types of sport could have caused outliers to have influenced the mean values of the respective anthropometric, physical and motor performance components more than would have been the case with larger group sizes. A much bigger sample size that also includes more children who participate in individual sports would, therefore, be advisable. Apart from this, only data of players distributed over a small geographical area in South Africa were utilized. Generalization of the results to the whole of South Africa would, therefore, not be accurate. Due to the fact that maturity status may also play a crucial role in the differences that children of various racial and gender groups display with regard to their anthropometric, physical and motor performance profiles, it is important to use more direct methods for the determination of maturity status in future studies of this nature. Lastly, in view of the possible negating effect that socio-economic status may have on the nutritional status and the anthropometric, physical and motor performance of children who come from low socio-economic households, this is also an important factor to consider in future studies.

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CHAPTER 5



5 SUMMARY, CONCLUSIONS LIMITATIONS AND RECOMMENDATIONS

-
- 1. SUMMARY**
 - 2. CONCLUSIONS**
 - 3. LIMITATIONS AND RECOMMENDATIONS**
-

1. SUMMARY

The purposes of this study were firstly, to determine the relationship between sport participation and the physical, motor performance and anthropometric components of a group of grade 10 adolescent learners in the Tlokwe District, North West Province, South Africa. Secondly, it was to determine the significant differences in the physical, motor performance and anthropometric components between a group of grade 10 learners of different genders and races who participated in different types of sport in the Tlokwe District, North West Province, South Africa. Chapter 1 provided a brief problem statement that culminated into the research questions, objectives and the related hypotheses of the study as well as the structure of this dissertation.

Chapter 2 consisted of a literature review titled: “The influence of sport participation on the physical, motor performance and anthropometric components of children”. In this chapter, the author attempted to give a thorough overview of the possible relationship between sport participation and the physical, motor performance and anthropometric components of children. However, studies that have measured the direct benefits of sport participation are scarce and have compelled the author to also investigate the possible

benefits of physical activity and the exercise guidelines that are related to changes in the physical, motor performance and anthropometric components of study subjects. Furthermore, due to the fact that all of the benefits derived from sport participation are influenced by the race and gender of the participants as well as the nature of the sport of participation, the literature review included gender, race and the sport of participation as part of the topics for the literature analyses. The possible effects of the last-mentioned components on the relationship between sport participation and the physical, motor performance and anthropometric components of children were also investigated.

With regard to the possible influence of sport participation and physical activity on the physical components of children the majority of researchers found a positive relationship between physical activity and sport participation levels as well as cardiorespiratory fitness, muscle endurance and flexibility for boys and girls between the ages of 7 and 18 years old. A significant positive relationship was also found between physical activity and sport participation levels and the motor performance components such as speed, agility, balance, muscle strength and explosive power of children between the ages of 6 and 16 years old. The literature showed that the anthropometric benefits obtained from regular sport participation are a decreased BMI and fat percentage, as well as an increase in fat-free mass and BMD among sport participating boys and girls. Overall gender specific studies found that boys tend to participate more in physical activity and sport than girls, thus performing better in cardiorespiratory fitness, muscle endurance, speed and agility, muscle strength and explosive power tests while girls tend to perform better in flexibility and balance tests due to gender specific traits. Much controversy exists with regard to the body fat and BMI differences between boys and girls. Some studies found that girls have significantly higher body fat and BMI values while other studies showed that boys had significantly higher body fat and BMI values compared to girls. However, studies showed that boys experienced a higher increase in BMD compared to girls as a result of sport participation. In terms of race differences, studies of children from areas in South African showed that white boys and girls participate more in sport than their black African counterparts. Studies on populations from other parts of the world found that black African American boys had the highest sport participation levels followed by the Caucasian boys and girls. Regardless of sport participation, black African American girls tend to have the lowest cardiorespiratory fitness levels and the highest BMI levels. Furthermore, research suggested that black African American boys were significantly better in the speed and explosive power tests than their white counterparts. Studies on the anthropometric components of children, demonstrated that white boys and girls tend to be taller and heavier than their black counterparts, and that white boys had higher BMI and fat percentage values than black African boys. Research also suggest that white girls who were younger than 11

years had higher BMI and fat percentage values than black African girls, but that these differences changed over time. The literature also found that black African children and adolescents have significantly higher BMD values than their white counterparts.

Research with regard to the influence of the nature of sport participation on the physical, motor performance and anthropometric components of participants, agrees that team sport participants seem to perform significantly better in speed endurance related tests compared to individual sport participants. Studies also concluded that flexibility patterns were specific to certain sport and positions within the sport. With regard to balance, the literature revealed that gymnasts achieved the best balance scores followed by soccer players, with basketball players who performed the worst in the balance tests. Studies found no significant difference between the height and body mass values of individual and team sport participants, but showed that children who participated in gymnastics and volleyball had significantly higher BMD values than children who participated in swimming or no sport at all.

However, at present the literature contains insufficient data with regard to the influence of sport participation on the physical components, such as muscle endurance; the motor performance components, such as speed, agility, balance, muscle strength and power and the anthropometric components, such as the BMD of children. With regard to the possible effect of race on the relationship between sport participation and changes in certain physical, motor performance and anthropometric components of children much research still needs to be done, especially with regard to the African and more closely the South African population. Further research with regard to the possible effects of the nature of sport participation on the last-mentioned relationship can also be recommended.

Chapter 3 comprises of the first article, titled: “The relationship between adolescent sport participation and the physical, motor performance and anthropometric components of a group of grade 10 learners”, and was compiled according to the guidelines of Pediatric Exercise Science. The purpose of this article was to determine the relationship between sport participation and the physical, motor performance and anthropometric components, of a group of grade 10 adolescent learners in the Tlokwe District, North West Province, South Africa. In terms of the differences between the anthropometric variables of the sport and non-sport participants, the results showed that body mass, stature, sitting height, BMI, fat mass percentage, fat mass, muscle mass percentage, endomorphy, mesomorphy, ectomorphy, all the skinfold and the sum of skinfold measurements, humerus breadth, relaxed and flexed arm girth, waist and hip circumference, waist to

height ratio, mid thigh girth, maximum calf girth, midstyliion-dactyliion length and foot length obtained statistical significant results. The physical and motor performance components that also displayed significant differences between the two named groups of children were: left and right MTIT and MTQT flexibility, the VJT height as well as VJT Tendo peak speed, HJT distance, left and right handgrip strength, AST level, five and ten metre speed, 505 agility from the left and the right foot, the last level of the 20-m SRT and the $\dot{V}O_{2max}$ that was obtained during the SRT. The forward stepwise logistic regression analysis results indicated that body mass, stature, sitting height, sum of six skinfolds, fat percentage, hip circumference, muscle percentage, muscle mass, VJT height, VJT Tendo peak power, HJT distance, 40m speed, right PSERT, right PSIRT, right PSLRT, right ASLRT and the right MTQT flexibility were the physical, motor performance and anthropometric variables that were identified as adequate and accurate predictors to classify the adolescent learners in sport participant and non-sport participant groups. However, only body mass, sitting height, muscle percentage and muscle mass and the right MTQT flexibility were identified as significant predictors between the two groups of children. Furthermore, the forward stepwise logistic regression analysis revealed that the logistic model of identified physical, motor performance and anthropometric variables was not useful in predicting the different groups.

Chapter 4 comprised of the second article, titled: “The effects of gender, race and nature of sport participation on the relationship between adolescent sport participation and the physical, motor performance and anthropometric components of a group of grade 10 learners”, and was compiled according the guidelines of the Journal of Human Kinetics. The purpose of this article was to determine the significant differences in the physical, motor performance and anthropometric components between a group of grade 10 learners of different genders and races who participated in different types of sport in the Tlokwe District, North West Province, South Africa. With regard to the gender differences between the anthropometric components of the sport participating children, the results showed that boys displayed significantly higher body mass; stature; muscle mass percentage as well as muscle mass; mesomorphy; ectomorphy; humerus, wrist, femur and ankle breadth; relaxed arm, maximum calf and forearm girth; waist circumference; waist to hip ratio; acromial-radial, radial-styliion, midstyliion-dactyliion and foot length compared to girls. However a significant lower average values for fat mass and fat mass percentage, endomorphy, all skinfold measurements and sum of skinfold values were seen for boys compared to girls. Boys also performed significantly better than girls in the VJT height and Tendo peak power, speed, horizontal jump distance, left and right handgrip strength, AST, 5m and 10m speed, 505 agility from the left and the right foot as well as the last level of the 20-m SRT and

the $\dot{V}O_{2\max}$ that was reached during execution of 20-m SRT. In contrast, the girls performed significantly better in the right and left PSERT, right PSLRT, left and right ASLRT and left MTQT flexibility compared to boys.

Black children showed a significantly lower average body mass; stature; sitting height; BMI; fat mass; muscle mass; mesomorphy; supraspinal and abdominal skinfolds; humerus, wrist and femur breadths; relaxed arm, flexed arm, mid thigh, maximum calf and forearm girths; waist and hip circumference; waist to height ratio; acromial-radial, radial-styilion, midstyilion-dactylion and foot length compared to their white counterparts. However, black children did show significantly higher ectomorphy values compared to white children. Comparisons between the black and white children's physical and motor performance test values revealed that white children performed significantly better in the VJT height and Tendo peak power, basketball put distance, left and right hand grip strength, AST, 5m and 10m speed, 505 agility from the left and the right foot as well as the last level of the 20-m SRT and the $\dot{V}O_{2\max}$ that was reached during execution of 20-m SRT. The flexibility related tests (PSIRT and PSLRT) were the only tests in which the black children significantly outperformed the white children.

Comparisons between the physical, motor performance and anthropometric components of children who participated in different type of sport showed that children who participated in both team and individual sport performed significantly better in the left PSLRT compared to children who only participate in team or individual sport. Combined sport participants (team and individual) also performed significantly better in the right PSLRT and left ASLRT compared to children who participated in individual and team sport, respectively. No significant differences between the anthropometric components of children who participated in team, individual or both type of sports, were found.

2. CONCLUSIONS

The conclusions drawn from this research are presented in accordance with the set hypotheses (Chapter 1):

Hypotheses 1:

There is a significant positive relationship between sport participation and the physical, motor performance and anthropometric components, of a group of grade 10 adolescent learners in the Tlokwe District, North West Province, South Africa. Despite the fact that the study results indicated that body mass, stature, sitting

height, sum of six skinfolds, fat percentage, hip circumference, muscle percentage, muscle mass, VJT height, VJT Tendo peak power, HJT distance, 40m speed, right PSERT, right PSIRT, right PSLRT, right ASLRT and the right MTQT flexibility were the physical, motor performance and anthropometric variables that were identified as adequate and accurate predictors to classify the adolescent learners in sport participant and non-sport participant groups, only body mass, sitting height, muscle percentage and muscle mass and the right MTQT flexibility were identified as significant predictors between the two groups of children. Furthermore, the forward stepwise logistic regression analysis revealed that the logistic model of identified physical, motor performance and anthropometric variables was not useful in predicting the different groups. The last-mentioned finding together with the view that a hypothesis is accepted or rejected based on the “majority approach”, the hypothesis is rejected.

Hypothesis 2:

Significant differences will exist in most of the physical, motor performance and anthropometric components between the two gender groups of grade 10 sport participant learners in the Tlokwe District, North West Province, South Africa. Fifty-one out of a possible sixty-eight physical, motor performance and anthropometric components showed significant differences between the two gender groups of grade 10 sport participant learners. These findings led the researcher to accept the set hypothesis.

Hypothesis 3:

Significant differences will exist in most of the physical, motor performance and anthropometric components between the two racial groups of grade 10 sport participant learners in the Tlokwe District, North West Province, South Africa. Forty-three out of a possible sixty-eight physical, motor performance and anthropometric components showed significant differences between the two racial groups of grade 10 sport participant learners. Therefore, in view of the fact that the majority of variables displayed significant differences between the groups of children, the set hypothesis is accepted.

Hypothesis 4:

No significant differences will exist in most of the physical, motor performance and anthropometric components between groups of grade 10 learners in the Tlokwe District, North West Province, South Africa who participated in different types of sport. Sixty-five out of a possible sixty-eight physical, motor performance and anthropometric components showed no significant differences between the groups of children who participated in different types of sports. Due to the fact that the majority of variables displayed

no significant differences between the groups of children, the set hypothesis is accepted.

3. LIMITATIONS AND RECOMMENDATIONS

To the researcher's knowledge, this is the first study to investigate the predictive value of a forward stepwise logistic regression, physical, motor performance and anthropometric component-related model to classify sport and non-sport participating children in their respective groups. The findings of this study provide insight into an area of research where uncertainty still reigns and ought to provide coaches, sport scientists and other sport related professionals direction concerning the real benefits of sport participation. Despite these facts, several shortcomings of this study should, however, be considered together with recommendations for future researchers who want to work in this area of research:

- At present the literature contains insufficient data with regard to the possible relationship between sport participation and the physical, motor performance and anthropometric components of children, which makes it imperative that researchers contribute to this field of Human Movement Science in order to provide a wider knowledge base with regard to this theme. The appearance of more sophisticated apparatus such as the Actiheart (CamNtech Ltd., Cambridge, U.K.) for the measurement of physical activity and the 10 Hz global positioning system (Minimax V2.4, Catapult Sports, Victoria, Australia) that allows researchers to obtain data with regard to the distance, velocity, repeated efforts, accelerations, decelerations and heart rates of children while they are participating in sports and physical activities, can lead to improvements in the data that are sampled and reported. Studies where these types of analyses are used must therefore be considered.
- The prediction model was developed specifically for adolescent learners in the Tlokwe local municipality area, which means that the results cannot be generalized to all adolescent learners. For generalization purposes it would, therefore, be advisable to include children who are situated over a larger geographical area
- It is important to test logistic model of identified physical, motor performance and anthropometric variables through longitudinal studies to evaluate its significance, adequacy, accurateness and usefulness among different populations of sport and non-sport participant adolescents.
- A much bigger sample size that also includes more children who participate in individual sports would, therefore, be advisable
- It is important to use more direct methods for the determination of maturity status in future studies of this nature.

APPENDIX



APPENDIX A, B AND C

TITLE PAGE

APPENDIX A **ETHICS FORM, INFORMED CONSENT FORM,
DEMOGRAPHIC, GENERAL INFORMATION, SPORT AND
TRAINING HABITS, PHYSICAL ACTIVITY AND MATURITY
DETERMINATION QUESTIONNAIRE**

**ANTHROPOMETRIC, PHYSICAL AND MOTOR PERFORMANCE
DATA COLLECTION FORMS**

APPENDIX B **SUBMISSION GUIDELINES FOR AUTHORS**

APPENDIX C **EXAMPLE OF AN ARTICLE: PEDIATRIC EXERCISE SCIENCE
EXAMPLE OF AN ARTICLE: JOURNAL OF HUMAN KINETICS**

APPENDIX A

**ETHICS FORM, INFORMED CONSENT
FORM, DEMOGRAPHIC, GENERAL
INFORMATION, SPORT AND TRAINING
HABITS, PHYSICAL ACTIVITY AND
MATURITY DETERMINATION
QUESTIONNAIRE, ANTHROPOMETRIC,
PHYSICAL AND MOTOR PERFORMANCE
DATA COLLECTION FORMS**



Appendix A:

Ethics form, Informed consent forms, General information questionnaire and anthropometric, physical and motor performance data collection forms



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Prof A Monyeki

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ETHICS APPROVAL OF PROJECT

The North-West University Ethics Committee (NWU-EC) hereby approves your project as indicated below. This implies that the NWU-EC grants its permission that, provided the special conditions specified below are met and pending any other authorisation that may be necessary, the project may be initiated, using the ethics number below.

Project title: Five year Longitudinal Study of Physical Activity status and the Determinants of Health in Adolescents attending high school in Potchefstroom areas of South Africa (PAHLS-Study)

Ethics number:

N	W	U	-	0	0	5	8	-	1	0	-	A	1
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Institution Project Number Year Status
Ethics: S = Submission, R = Re-Submission, P = Provisional Authorisation, A = Authorisation

Approval date: 2010/07/19

Expiry date: 2015/07/18

Special conditions of the approval (if any): None

General conditions:

While this ethics approval is subject to all declarations, undertakings and agreements incorporated and signed in the application form, please note the following:

- The project leader (principle investigator) must report in the prescribed format to the NWU-EC:
 - annually (or as otherwise requested) on the progress of the project,
 - without any delay in case of any adverse event (or any matter that interrupts sound ethical principles) during the course of the project.
- The approval applies strictly to the protocol as stipulated in the application form. Would any changes to the protocol be deemed necessary during the course of the project, the project leader must apply for approval of these changes at the NWU-EC. Would there be deviation from the project protocol without the necessary approval of such changes, the ethics approval is immediately and automatically forfeited.
- The date of approval indicates the first date that the project may be started. Would the project have to continue after the expiry date, a new application must be made to the NWU-EC and new approval received before or on the expiry date.
- In the interest of ethical responsibility the NWU-EC retains the right to:
 - request access to any information or data at any time during the course or after completion of the project;
 - withdraw or postpone approval if:
 - any unethical principles or practices of the project are revealed or suspected,
 - it becomes apparent that any relevant information was withheld from the NWU-EC or that information has been false or misrepresented,
 - the required annual report and reporting of adverse events was not done timely and accurately,
 - new institutional rules, national legislation or international conventions deem it necessary.

The Ethics Committee would like to remain at your service as scientist and researcher, and wishes you well with your project. Please do not hesitate to contact the Ethics Committee for any further enquiries or requests for assistance.

Yours sincerely

Prof MMJ Lowes
(chair NWU Ethics Committee)



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INFORMATION LETTER TO THE PARENTS AND CONSENT FORMS: PAHLS STUDY

Dear Parent or Guardian,

Your child is been invited to participate in a study entitled – Five year Longitudinal Study of Physical Activity status and the Determinants of Health in Adolescents attending high school in Potchefstroom areas of South Africa (*PAHLS-Study, 2010–2014*).

My name is Professor Makama Andries Monyeki (from Potchefstroom Campus of the North-West University) principal investigator in the project together with the research team would like to ask your permission to allow your child (or a child under your care) to participate in our study. To give the background of the study, research revealed that physical activity in adolescents is drastically declining. The decline in the level of physical activity of human populations has been observed, and such decline is been associated with increased mechanization, reliance on technology and urbanization, and the high rate of crime in South Africa. Physical inactivity is thought to be one of the main risk factors for the development of obesity, diabetes, cardiovascular disease, osteoporosis and psychological constraints or risks of behavioral health. Therefore, the purpose of this study is to gather information about physical activity (i.e. by questionnaire & ActiHeart rate monitor) and health determinants (i.e. through measurements of anthropometry, maturation, blood pressure measurement, health-related physical fitness, social and self-efficacy questionnaire, resting metabolic rate, oxygen consumption (by the use of a portable gas analyser apparatus), blood sampling, leisure and recreation constraint questionnaires, nutritional intake questionnaire as questionnaire on risk factors of life) over a period of five years (2010–2014).

Participation in this study is not part of the child's regular classroom work; it is an optional activity in which the learner can choose to participate. The study will assess and test the following variables: anthropometric measurements, maturation, blood pressure measurement, health-related physical fitness, social and self-efficacy questionnaire, resting metabolic rate, oxygen consumption, blood sampling, leisure and recreation constraint questionnaires, nutritional intake questionnaire as questionnaire on risk factors of life. Blood samples will be collected by a registered professional nurse who will be obliged to health profession practices at all times.

The data of the study will be used for research purpose only. The measurements will not be shared with your child classmates or teacher. All information collected in this study will be kept confidential. Your child's participation is important because the information that shall be gathered on him/her will help him/her with knowledge for personal development and life skills.

Your child participation in the project is very important, but it is entirely your choice. If your child chooses to refuse to participate in any part of the study or withdraw from the study at any time, for any reason, this will not cause anyone to be upset or angry, and this will not result in any type of penalty.

There are no costs required from your child (or a child under your care) to participate in the study. Further, no payment will be granted to your child (or a child under your care) for participating in the study.

If you have any question regarding this study, please feel free to call me at (018) 2991790 / e-mail:andries.monyeki@nwu.ac.za or the PHASrec Niche Area Leader Dr Hanlie Moss at (018) 2991821 / e-mail:hanlie.moss@nwu.ac.za. If you have any questions regarding your rights or your child's rights as participants in this study you can call Ms Hannekie Botha at (018) 299 4850 from Potchefstroom Campus of the North-West University Research Ethics Office.

Thank you, in advance, for considering your child participation in this study. Should you choose that your child participate, please read and sign the attached consent form. Keep one consent form for your records and return the other copy. All received consent form will be kept locked during the entire period of the study. In addition, your child is requested to bring along his/her birth clinic card. The card will be given back to the

child immediately after collecting information on birth date and birth weight. A child who shall have returned a completed and signed consent form will participate in the study.

Sincerely,

Prof. Makama Andries Monyeke

Principal Investigator – PAHLS Study

CONSENT FORM

(Parent/Guardian Copy)

FIVE YEAR LONGITUDINAL STUDY OF PHYSICAL ACTIVITY STATUS AND THE DETERMINANTS OF HEALTH IN ADOLESCENTS ATTENDING HIGH SCHOOL IN POTCHEFSTROOM AREAS OF SOUTH AFRICA (PAHLS-STUDY, 2010–2014).

I,, father/mother/guardian of

agree to permit my child to provide the information on physical activity (i.e. by questionnaire & ActiHeart rate monitor) and health determinants (i.e. through measurements of anthropometry, maturation, blood pressure measurement, health-related physical fitness, social and self-efficacy questionnaire, resting metabolic rate, oxygen consumption (by the use of a portable gas analyser apparatus), blood sampling, leisure and recreation constraint questionnaires, nutritional intake questionnaire as questionnaire on risk factors of life), by the researchers at my child school. I understand that the results of this study of Five year longitudinal study of physical activity status and the determinants of health in adolescents attending high school in Potchefstroom areas of South Africa (*PAHLS-STUDY NWP*) will be used for research purpose and nothing else. I am aware that if I have any question or concerns about the study I can contact the researcher at (018) 299 1790 or the PHASRec Niche Area Leader at (018) 299 1821. Any questions or concerns regarding my child rights as a participant in this study can be addressed to Ms Hannekie Botha at (018) 299 4850 from Potchefstroom Campus of the North-West University Research Ethics Office. I understand that there will be no discomfort or foreseeable risks for my child to participate in the study. I understand that all information my child provide will remain strictly confidential. I have read and understand the information provided above and in the information letter. I have been provided with the opportunity to ask questions and my questions have been answered satisfactorily. I consent to have my child participate in the study described above, understanding that he/she may refuse to participate in any part of the study and can withdraw from the study at any time. I have kept one copy of this consent for my records and will return the second copy with the **clinic birth card**. I am aware that by giving consent my child can participate in the study. The return consent form will be kept locked during the entire period of the study.

Appendix A:
Ethics form, Informed consent forms, General information questionnaire and anthropometric,
physical and motor performance data collection forms

Child's Age:.....

Grade:.....

Teacher:.....

School Name:.....

Name of Child:.....

Name of Parent/Guardian:.....

.....

(Signature of Child)

.....

(Signature of Parent/Guardian)

.....

(Date)

.....

(Date)

PHYSICAL ACTIVITY QUESTIONNAIRE (PAHLS-IPAQ)

A: GENERAL INFORMATION ABOUT YOU

School:									
Grade:									
School number:									
Name of the participant:									
Subject number:									
Address:									
Date of Survey			Grade	Sex (mark with a X)		Date of birth			Age
dd	mm	yy		F	M	dd	mm	yy	

In the next few question cross out the answers that are applicable to you!!

Ethnic group

White	Coloured	Black	Indian
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Do you participate in sport or have you been participating in sport during the last two years?

☐

YES

☐

NO

If your answer is **YES**, answer the next questions, and **IF** your answer is **NO** go to the next section.

Appendix A:
Ethics form, Informed consent forms, General information questionnaire and anthropometric,
physical and motor performance data collection forms

INFORMATION REGARDING SPORT AND TRAINING HABITS

1. **Type of sport** that you are participating in or did participate in during the last two years – **main sport**.

Soccer	Rugby	Netball	Hockey	Volleyball	Athletics Javelin/ Shot pot/ Discus	Athletics Long jump/High jump
Athletics 100m/ 200m	Athletics 400m	Athletics 800m	Athletics 1500m	Athletics Cross country	Tennis	Squash
Badminton	Cricket	Golf	Wrestling	Boxing	Karate	Swimming
Cycling	Triathlon	Biathlon	Duathlon	Ballet	Artistic gymnastics	Rhythmic gymnastics

Other: _____

2. **Type of sport** that you are participating in or did participate in during the last two years – **secondary sport**.

Soccer	Rugby	Netball	Hockey	Volleyball	Athletics Javelin/ Shot pot/ Discus	Athletics Long jump/High jump
Athletics 100m/ 200m	Athletics 400m	Athletics 800m	Athletics 1500m	Athletics Cross country	Tennis	Squash
Badminton	Cricket	Golf	Wrestling	Boxing	Karate	Swimming
Cycling	Triathlon	Biathlon	Du-athlon	Ballet	Artistic gymnastics	Rhythmic gymnastics

Other: _____

Appendix A:
Ethics form, Informed consent forms, General information questionnaire and anthropometric, physical and motor performance data collection forms

3. Years you've been participating in your main sport.

<1 year	1-2 years	3-4 years	5-6 years	7-8 years	8-9 years	>9 years
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4. Years you've been participating in your secondary sport.

<1 year	1-2 years	3-4 years	5-6 years	7-8 years	8-9 years	>9 years
---------	-----------	-----------	-----------	-----------	-----------	----------

5. Frequency of training - how many days per week do/did you normally train for your main sport?

1 day	2 days	3 days	4 days	5 days	6 days	7 days
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6. Frequency of training - how many days per week do/did you normally train for your secondary sport?

1 day	2 days	3 days	4 days	5 days	6 days	7 days
-------	--------	--------	--------	--------	--------	--------

7. Frequencies of training - how many days per week do/did you normally do weight training?

1 day	2 days	3 days	4 days	5 days	6 days	7 days
-------	--------	--------	--------	--------	--------	--------

8. Frequencies of training - how many days per week do/did you normally do training on the field/track/court or in the pool/ring?

1 day	2 days	3 days	4 days	5 days	6 days	7 days
-------	--------	--------	--------	--------	--------	--------

9. How many hours per day do/did you normally train?

1 hour	2 hours	3 hours	4 hours	5 hours	6 hours	7 or more
--------	---------	---------	---------	---------	---------	-----------

10. On what level do/did you compete in your main sport?

Recreational	School	Provincial	National
--------------	--------	------------	----------

11. On what level do/did you compete in your secondary sport?

Recreational	School	Provincial	National
--------------	--------	------------	----------

Appendix A:
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12. What is the best performance/s that you achieved in your main sport:

Year	Sport	Distance/Height/Time/ Team/Achievement

INFORMATION REGARDING MATURITY

1. FOR GIRLS ONLY: At what age did you experience menarche?

9 years	10 years	11 years	12 years	13 years	14 years	Not yet
---------	----------	----------	----------	----------	----------	---------

2. FOR BOYS ONLY: At what age did your voice break?

11 years	12 years	13 years	14 years	Not yet
----------	----------	----------	----------	---------

SECTION B: PHYSICAL ACTIVITY QUESTIONNAIRE

IT IS IMPORTANT TO ANSWER **ALL QUESTIONS**, AND **BE HONEST** WITH YOUR ANSWERS

1. During the **last 7 days**, on how many days did you do **very hard** physical activities like heavy lifting, digging, aerobics, or fast bicycling?

_____ **days per week**

☐

No very hard physical activities



Skip to question 3

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physical and motor performance data collection forms

2. How much time did you usually spend doing **very hard** physical activities on one of those days?
- _____ **hours per day**
- _____ **minutes per day**
- ☐ Don't know/Not sure
3. During the **last 7 days**, on how many days did you do **moderate** physical activities like carrying light loads, bicycling at a regular pace, or doubles tennis? Do not include walking.
- _____ **days per week**
- ☐ No moderate physical activities → **Skip to question 5**
4. How much time did you usually spend doing **moderate** physical activities on one of those days?
- _____ **hours per day**
- _____ **minutes per day**
- ☐ Don't know/Not sure
5. During the **last 7 days**, on how many days did you **walk** for at least **10 minutes** at a time?
- _____ **days per week**
- ☐ No walking → **Skip to question 7**
6. How much time did you usually spend **walking** on one of those days?
- _____ **hours per day**
- _____ **minutes per day**
- ☐ Don't know/Not sure

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7. During the **last 7 days**, how much time did you spend **sitting** on a **week day**? (watching TV, Videogames/Internet, Listening to music, reading)

_____ **hours per day**

_____ **minutes per day**

☐

Don't know/Not sure

B: SOCIAL SUPPORT FOR PHYSICAL ACTIVITY

This section asks you about the social support for participation in physical activity. Answer all questions.

Answer these questions by putting a **Tick (√)** or **Cross (X)** in an appropriate box.

For an example:

During a typical week, how often	NEVER	SOMETIMES	EVERY DAY
do my friend play soccer with me		√	

Now is your term **ANSWER THESE QUESTIONS, and Remember no answer is WRONG**

DURING A TYPICAL WEEK, HOW OFTEN	NEVER	SOMETIMES	EVERY DAY
do you encourage your friends to do physical activities or play sports?			
do your friends encourage you to do physical activities or play sports?			
do your friends do physical activities or play sports with you?			
do your friends tell you that you are doing a good job at physical activity?			
has someone encouraged you to do physical activities or sports?			
has someone done a physical activity or played sports with you?			

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DURING A TYPICAL WEEK, HOW OFTEN	NEVER	SOMETIMES	EVERY DAY
has someone provided transportation to a place where you can do physical activities or play sports?			
has someone watched you participate in physical activities or sports?			
has someone told you that you are doing well in physical activity?			

RAW DATA FOR PAHLS (Anthropometry)

NAME OF LEARNER: _____ **SUBJECT NO.** _____

TEST COMPONENT	1ST READING		
BOX HEIGHT (CM)			
TEST COMPONENT	1ST READING	2ND READING	MEAN
BODY MASS (KG)			
BODY STATURE (CM)			
SITTING HEIGHT (CM)			
TEST COMPONENT	1ST READING	2ND READING	MEAN
L: BICEPS SKINFOLD (MM)			
R: BICEPS SKINFOLD (MM)			
L: TRICEPS SKINFOLD (MM)			
R: TRICEPS SKINFOLD (MM)			
L: SUBSCAPULAR SKINFOLD (MM)			
R: SUBSCAPULAR SKINFOLD (MM)			
L: SUPRASPINALE SKINFOLD (MM)			
R: SUPRASPINALE SKINFOLD (MM)			
ABDOMINAL SKINFOLD (MM)			
L: FRONT THIGH SKINFOLD (MM)			
R: FRONT THIGH SKINFOLD (MM)			

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TEST COMPONENT	1 ST READING	2 ND READING	MEAN
L: MEDIAL CALF SKINFOLD (MM)			
R: MEDIAL CALF SKINFOLD (MM)			
TEST COMPONENT	1 ST READING	2 ND READING	MEAN
L: HUMERUS BREADTH (CM)			
R: HUMERUS BREADTH (CM)			
L: WRIST BREADTH (CM)			
R: WRIST BREADTH (CM)			
L: FEMUR BREADTH (CM)			
R: FEMUR BREADTH (CM)			
L: ANKLE BREADTH (CM)			
R: ANKLE BREADTH (CM)			
TEST COMPONENT	1 ST READING	2 ND READING	MEAN
HEAD GIRTH (CM)			
L: RELAXED ARM GIRTH (CM)			
R: RELAXED ARM GIRTH (CM)			
L: FLEXED ARM GIRTH (CM)			
R: FLEXED ARM GIRTH (CM)			
WAIST (MINIMUM) GIRTH (CM)			
GLUTEAL (HIP) GIRTH (CM)			
L: MID THIGH GIRTH (CM)			
R: MID THIGH GIRTH (CM)			
L: MAXIMUM CALF GIRTH (CM)			
R: MAXIMUM CALF GIRTH (CM)			
L: FOREARM GIRTH (CM)			
R: FOREARM GIRTH (CM)			

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TEST COMPONENT	1 ST READING	2 ND READING	MEAN
L: ACROMIALE-RADIALE LENGTH (CM)			
R: ACROMIALE-RADIALE LENGTH (CM)			
L: RADIALE-STYLION RADIALE LENGTH (CM)			
R: RADIALE-STYLION RADIALE LENGTH (CM)			
L: MIDSTYLION-DACTYLION (CM)			
R: MIDSTYLION-DACTYLION (CM)			
L: FOOT LENGTH (CM)			
R: FOOT LENGTH (CM)			

RAW DATA FOR PAHLS (Flexibility tests)

NAME OF LEARNER: _____ **SUBJECT NO.** _____

TEST COMPONENT	1 ST READING	2 ND READING	BEST
L: SHOULDER EXTERNAL ROTATION TEST (°)			
R: SHOULDER EXTERNAL ROTATION TEST (°)			
L: SHOULDER INTERNAL ROTATION TEST (°)			
R: SHOULDER INTERNAL ROTATION TEST (°)			
L: PASSIVE KNEE EXTENSION TEST (°)			
R: PASSIVE KNEE EXTENSION TEST (°)			
L: ACTIVE KNEE EXTENSION TEST (°)			
R: ACTIVE KNEE EXTENSION TEST (°)			
L: MODIFIED THOMAS ILIOPSOAS TEST (°)			
R: MODIFIED THOMAS ILIOPSOAS TEST (°)			
L: MODIFIED THOMAS QUADS TEST (°)			
R: MODIFIED THOMAS QUADS TEST (°)			

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RAW DATA FOR PAHLS (Fitness tests)

NAME OF LEARNER: _____

SUBJECT NO. _____

TEST COMPONENT	1 ST TIME							
POLE HEIGHT (CM)								
VERTICAL JUMP REACHING HEIGHT (CM)	A							
FINAL VERTICAL JUMP HEIGHT A-B (CM)								
TEST COMPONENT	1 ST READING		2 ND READING		HIGHEST			
VERTICAL JUMP HEIGHT (CM)					B			
TENDO PEAK POWER (W)								
TENDO SPEED (M/SEC)								
TEST COMPONENT	1 ST READING		2 ND READING		HIGHEST			
HORIZONTAL JUMP DISTANCE (CM)								
TEST COMPONENT	1 ST READING		2 ND READING		HIGHEST			
BASKETBAL THROW DISTANCE (M)								
TEST COMPONENT	1 ST READING		2 ND READING		HIGHEST			
L: HAND GRIP STRENGTH (KG)								
R: HAND GRIP STRENGTH (KG)								
TEST COMPONENT	1 ST READING							
ABDOMINAL STRENGTH TEST (LEVEL)	0	1	2	3	4	5	6	7
TEST COMPONENT	1 ST READING		2 ND READING		LOWEST			
5M SPEED (SEC)								
10M SPEED (SEC)								
40M SPEED (SEC)								

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TEST COMPONENT					1 ST READING	2 ND READING	LOWEST																									
L: AGILITY 505-TEST (SEC)																																
R: AGILITY 505-TEST (SEC)																																
TEST COMPONENT					1 ST READING																											
GENDER					M / F																											
BIRTH DATE					year / month / day																											
20M SHUTTLE RUN																																
LEVEL	SHUTTLE NUMBER AND HEART RATES																															
1	1		2		3		4		5		6		7																			
2	1		2		3		4		5		6		7		8																	
3	1		2		3		4		5		6		7		8																	
4	1		2		3		4		5		6		7		8		9															
5	1		2		3		4		5		6		7		8		9															
6	1		2		3		4		5		6		7		8		9		10													
7	1		2		3		4		5		6		7		8		9		10													
8	1		2		3		4		5		6		7		8		9		10		11											
9	1		2		3		4		5		6		7		8		9		10		11											
10	1		2		3		4		5		6		7		8		9		10		11											
11	1		2		3		4		5		6		7		8		9		10		11		12									
12	1		2		3		4		5		6		7		8		9		10		11		12									
13	1		2		3		4		5		6		7		8		9		10		11		12		13							
14	1		2		3		4		5		6		7		8		9		10		11		12		13							
15	1		2		3		4		5		6		7		8		9		10		11		12		13							
16	1		2		3		4		5		6		7		8		9		10		11		12		13		14					
17	1		2		3		4		5		6		7		8		9		10		11		12		13		14					
18	1		2		3		4		5		6		7		8		9		10		11		12		13		14		15			
19	1		2		3		4		5		6		7		8		9		10		11		12		13		14		15			
20	1		2		3		4		5		6		7		8		9		10		11		12		13		14		15		16	
VO ₂ MAX (ML/KG/MIN) - INDIRECT																																

APPENDIX B

SUBMISSION

GUIDELINES FOR

AUTHORS



ARTICLE ONE

PEDEATRIC EXERCISE SCIENCE

Authorship Guidelines

The Journals Division at Human Kinetics limits the number of authors for each published manuscript to six. Only individuals, who have made a substantial contribution to the manuscript, as described below, should be credited as coauthors, and the inclusion of additional authors will only be considered if all meet the following requirements:

The Journals Division at Human Kinetics adheres to the criteria for authorship as outlined by the International Committee of Medical Journal Editors*:

Each author should have participated sufficiently in the work to take public responsibility for the content. Authorship credit should be based only on substantial contributions to:

- a. Conception and design, or analysis and interpretation of data; and
- b. Drafting the article or revising it critically for important intellectual content; and
- c. Final approval of the version to be published.

Conditions a, b, and c must *all* be met.

Individuals who do not meet the above criteria may be listed in the acknowledgements section of the manuscript.

*Uniform requirements for manuscripts submitted to biomedical journals. *New England Journal of Medicine*, 1991, 324, 424–428.

Submission Guidelines for PES

Pediatric Exercise Science welcomes submissions of original research, topical reviews, commentaries, and letters-to-the editor which address issues surrounding the science of exercise in subjects less than 18 years old. In general, *Pediatric Exercise Science* does not publish material related to physical education curricula or pedagogy, sports medicine (including athletic injuries), or motor development.

The instructions below (revised September 2011) are intended to help authors prepare high-quality and

readable manuscripts. Authors are encouraged to refer to a recent issue of the journal to ascertain the preferred layout, format, style, and appearance.

The manuscript should be double-spaced, including the abstract, references, and any block quotations. Manuscripts are subject to editing to eliminate sexist and biased language.

Manuscripts must be submitted electronically via *Manuscript Central* (http://mc.manuscriptcentral.com/hk_pes). Authors of manuscripts accepted for publication will be required to transfer copyright to Human Kinetics, Inc. *Manuscript Central* manages the electronic transfer of manuscripts throughout the article review process while providing step-by-step instructions and a user-friendly design. Please access the site and follow the directions for authors submitting manuscripts. Any problems that may be encountered can be resolved easily by selecting “Get Help Now” in the upper-right corner of any *Manuscript Central* screen. Please note that a blind review process is used to evaluate manuscripts. As such, any clues to the author’s identity should be eliminated from the manuscript. The first page of the manuscript must not include author names or affiliations, but it should include the title of the paper and a preferred running head.

It is expected that the length of the body of the manuscript, including title page, abstract, text, and references, will be 15 to 20 double-spaced pages. Number the pages in the upper right corner beginning with the title page. Authors credited should be limited to fewer than seven except in certain cases at the discretion of the journal editor. Limit the abstract 200 words. A statement regarding institutional review board approval as well as obtaining informed consent/assent from parents/child subjects should be included in the Methods section. Figures and tables should be limited to a combined total of 5 and should not duplicate material in the text. Captions for the figures should be included at the end of the file with the full text.

The corresponding author is required to nominate two potential reviewers for the manuscript with suitable expertise in the area addressed by the manuscript. The journal is under no obligation to use any of the nominated reviewers.

Writing style should be concise and direct. Avoid using unnecessary jargon and abbreviations, but use an acronym or abbreviation if it is more commonly recognized than the spelled-out version of a term. Formats of numbers and units *should follow the AMA Manual of Style*, 10th edition. Measurements of length, height, mass, and volume should be reported in metric units (meter, kilogram). Only standard physiological abbreviations should be used. Avoid abbreviations in the title. The full wording should precede the first use of an abbreviation.

The reference style for Pediatric Exercise Science should follow the Vancouver style guidelines set by the International Committee of Medical Journal Editors (<http://www.icmje.org/about.html>), as they appear in the committee's Uniform Requirements for Manuscripts Submitted to Biomedical Journals publication (http://www.icmje.org/urm_main.html). In the reference list, the citations should be listed in alphabetical order (rather than in the order of citation). In the text, references are identified by Arabic numerals in parentheses (1). Assure that that all entries in the reference list are cited in the text and that all those in the text are included in the reference list. References should be limited to previously published works or those which are in press (accepted for publication). Usually the number of references should not exceed 50. An abstract properly identified may be cited only when it is the sole source. *The reference list should be double-spaced. When the number of authors of a reference exceed seven, use the first three, followed by "et al."*. The reference style should be:

Journal article:

Soldin OP, Mattison DR. Sex differences in pharmacokinetics and pharmacodynamics. Clin Pharmacokinet. 2009;48(3):143-57.

Book:

Heyward VH, Stolarczyk LM. Applied Body Composition Assessment. Champaign, IL: Human Kinetics, 1996.

Chapter in Edited Book:

Young LR, Altose MD. Respiratory responses to ventilatory loading. In: Hornbein TF, editor. Regulation of Breathing. New York: Dekker, 1981, pp. 905-964.

Authors are encouraged to consult the following website for more detailed examples:
http://www.nlm.nih.gov/bsd/uniform_requirements.html

International Committee of Medical Journal Editors (ICMJE) Uniform Requirements for Manuscripts Submitted to Biomedical Journals: Sample References

The International Committee of Medical Journal Editors offers guidance to authors in its Uniform Requirements for Manuscripts Submitted to Biomedical Journals publication. The recommended style for references is based on the National Information Standards Organization NISO Z39.29-2005 (R2010) Bibliographic References as adapted by the National Library of Medicine for its databases. Details are in

Citing Medicine. (Note Appendix F which covers how citations in MEDLINE/PubMed differ from the advice in *Citing Medicine.*) Sample references typically used by authors of journal articles are provided below.

Articles in Journals (see also #36. *Journal article on the Internet*)

1. Standard journal article

List the first six authors followed by et al. (Note: NLM now lists all authors.)

Halpern SD, Ubel PA, Caplan AL. Solid-organ transplantation in HIV-infected patients. *N Engl J Med.* 2002 Jul 25;347(4):284-7.

As an option, if a journal carries continuous pagination throughout a volume (as many medical journals do) the month and issue number may be omitted.

Halpern SD, Ubel PA, Caplan AL. Solid-organ transplantation in HIV-infected patients. *N Engl J Med.* 2002;347:284-7.

More than six authors:

Rose ME, Huerbin MB, Melick J, Marion DW, Palmer AM, Schiding JK, et al. Regulation of interstitial excitatory amino acid concentrations after cortical contusion injury. *Brain Res.* 2002;935(1-2):40-6.

Optional addition of a database's unique identifier for the citation: **[Edited 12 May 2009]**

Halpern SD, Ubel PA, Caplan AL. Solid-organ transplantation in HIV-infected patients. *N Engl J Med.* 2002 Jul 25;347(4):284-7. PubMed PMID: 12140307.

Forooghian F, Yeh S, Faia LJ, Nussenblatt RB. Uveitic foveal atrophy: clinical features and associations. *Arch Ophthalmol.* 2009 Feb;127(2):179-86. PubMed PMID: 19204236; PubMed Central PMCID: PMC2653214.

Optional addition of a clinical trial registration number: **[Added 12 May 2009]**

Trachtenberg F, Maserejian NN, Soncini JA, Hayes C, Tavares M. Does fluoride in compomers prevent future caries in children? *J Dent Res.* 2009 Mar;88(3):276-9. PubMed PMID: 19329464. ClinicalTrials.gov registration number: NCT00065988.

2. Organization as author

Diabetes Prevention Program Research Group. Hypertension, insulin, and proinsulin in participants with impaired glucose tolerance. *Hypertension.* 2002;40(5):679-86.

3. *Both personal authors and organization as author* (List all as they appear in the byline.) [Edited 12 May 2009]

Vallancien G, Emberton M, Harving N, van Moorselaar RJ; Alf-One Study Group. Sexual dysfunction in 1,274 European men suffering from lower urinary tract symptoms. *J Urol*. 2003;169(6):2257-61.

Margulies EH, Blanchette M; NISC Comparative Sequencing Program, Haussler D, Green ED. Identification and characterization of multi-species conserved sequences. *Genome Res*. 2003 Dec;13(12):2507-18.

4. *No author given*

21st century heart solution may have a sting in the tail. *BMJ*. 2002;325(7357):184.

5. *Article not in English* [Edited 12 May 2009]

Ellingsen AE, Wilhelmsen I. Sykdomsangst blant medisins- og jusstudenter. *Tidsskr Nor Lægeforen*. 2002;122(8):785-7. Norwegian.

Optional translation of article title (MEDLINE/PubMed practice):

Ellingsen AE, Wilhelmsen I. [Disease anxiety among medical students and law students]. *Tidsskr Nor Lægeforen*. 2002 Mar 20;122(8):785-7. Norwegian.

6. *Volume with supplement*

Geraud G, Spierings EL, Keywood C. Tolerability and safety of frovatriptan with short- and long-term use for treatment of migraine and in comparison with sumatriptan. *Headache*. 2002;42 Suppl 2:S93-9.

7. *Issue with supplement*

Glauser TA. Integrating clinical trial data into clinical practice. *Neurology*. 2002;58(12 Suppl 7):S6-12.

8. *Volume with part*

Abend SM, Kulish N. The psychoanalytic method from an epistemological viewpoint. *Int J Psychoanal*. 2002;83(Pt 2):491-5.

9. *Issue with part*

Ahrar K, Madoff DC, Gupta S, Wallace MJ, Price RE, Wright KC. Development of a large animal model for lung tumors. *J Vasc Interv Radiol*. 2002;13(9 Pt 1):923-8.

10. *Issue with no volume*

Banit DM, Kaufer H, Hartford JM. Intraoperative frozen section analysis in revision total joint arthroplasty. Clin Orthop. 2002;(401):230-8.

11. *No volume or issue*

Outreach: bringing HIV-positive individuals into care. HRSA Careaction. 2002 Jun:1-6.

12. *Pagination in roman numerals*

Chadwick R, Schuklenk U. The politics of ethical consensus finding. Bioethics. 2002;16(2):iii-v.

13. *Type of article indicated as needed*

Tor M, Turker H. International approaches to the prescription of long-term oxygen therapy [letter]. Eur Respir J. 2002;20(1):242.

Lofwall MR, Strain EC, Brooner RK, Kindbom KA, Bigelow GE. Characteristics of older methadone maintenance (MM) patients [abstract]. Drug Alcohol Depend. 2002;66 Suppl 1:S105.

14. *Article containing retraction*

Feifel D, Moutier CY, Perry W. Safety and tolerability of a rapidly escalating dose-loading regimen for risperidone. J Clin Psychiatry. 2002;63(2):169. Retraction of: Feifel D, Moutier CY, Perry W. J Clin Psychiatry. 2000;61(12):909-11.

Article containing a partial retraction: [Added 12 May 2009]

Starkman JS, Wolder CE, Gomelsky A, Scarpero HM, Dmochowski RR. Voiding dysfunction after removal of eroded slings. J Urol. 2006 Dec;176(6 Pt 1):2749. Partial retraction of: Starkman JS, Wolter C, Gomelsky A, Scarpero HM, Dmochowski RR. J Urol. 2006 Sep;176(3):1040-4.

15. *Article retracted*

Feifel D, Moutier CY, Perry W. Safety and tolerability of a rapidly escalating dose-loading regimen for risperidone. J Clin Psychiatry. 2000;61(12):909-11. Retraction in: Feifel D, Moutier CY, Perry W. J Clin Psychiatry. 2002;63(2):169.

Article partially retracted: [Added 12 May 2009]

Starkman JS, Wolter C, Gomelsky A, Scarpero HM, Dmochowski RR. Voiding dysfunction following removal of eroded synthetic mid urethral slings. J Urol. 2006 Sep;176(3):1040-4. Partial retraction in: Starkman JS, Wolder CE, Gomelsky A, Scarpero HM, Dmochowski RR. J Urol. 2006 Dec;176(6 Pt 1):2749.

16. *Article republished with corrections*

Mansharamani M, Chilton BS. The reproductive importance of P-type ATPases. *Mol Cell Endocrinol.* 2002;188(1-2):22-5. Corrected and republished from: *Mol Cell Endocrinol.* 2001;183(1-2):123-6.

17. *Article with published erratum*

Malinowski JM, Bolesta S. Rosiglitazone in the treatment of type 2 diabetes mellitus: a critical review. *Clin Ther.* 2000;22(10):1151-68; discussion 1149-50. Erratum in: *Clin Ther.* 2001;23(2):309.

18. *Article published electronically ahead of the print version*

Yu WM, Hawley TS, Hawley RG, Qu CK. Immortalization of yolk sac-derived precursor cells. *Blood.* 2002 Nov 15;100(10):3828-31. Epub 2002 Jul 5.

Books and Other Monographs

19. *Personal author(s)*

Murray PR, Rosenthal KS, Kobayashi GS, Pfaller MA. *Medical microbiology.* 4th ed. St. Louis: Mosby; 2002.

20. *Editor(s), compiler(s) as author*

Gilstrap LC 3rd, Cunningham FG, VanDorsten JP, editors. *Operative obstetrics.* 2nd ed. New York: McGraw-Hill; 2002.

21. *Author(s) and editor(s)*

Breedlove GK, Schorfheide AM. *Adolescent pregnancy.* 2nd ed. Wiecezorek RR, editor. White Plains (NY): March of Dimes Education Services; 2001.

22. *Organization(s) as author* [Edited 12 May 2009]

Advanced Life Support Group. *Acute medical emergencies: the practical approach.* London: BMJ Books; 2001. 454 p.

American Occupational Therapy Association, Ad Hoc Committee on Occupational Therapy Manpower. *Occupational therapy manpower: a plan for progress.* Rockville (MD): The Association; 1985 Apr. 84 p.

National Lawyer's Guild AIDS Network (US); National Gay Rights Advocates (US). *AIDS practice manual: a legal and educational guide.* 2nd ed. San Francisco: The Network; 1988.

23. *Chapter in a book*

Meltzer PS, Kallioniemi A, Trent JM. Chromosome alterations in human solid tumors. In: Vogelstein B, Kinzler KW, editors. The genetic basis of human cancer. New York: McGraw-Hill; 2002. p. 93-113.

24. Conference proceedings

Harnden P, Joffe JK, Jones WG, editors. Germ cell tumours V. Proceedings of the 5th Germ Cell Tumour Conference; 2001 Sep 13-15; Leeds, UK. New York: Springer; 2002.

25. Conference paper

Christensen S, Oppacher F. An analysis of Koza's computational effort statistic for genetic programming. In: Foster JA, Lutton E, Miller J, Ryan C, Tettamanzi AG, editors. Genetic programming. EuroGP 2002: Proceedings of the 5th European Conference on Genetic Programming; 2002 Apr 3-5; Kinsdale, Ireland. Berlin: Springer; 2002. p. 182-91.

26. Scientific or technical report

Issued by funding/sponsoring agency:

Yen GG (Oklahoma State University, School of Electrical and Computer Engineering, Stillwater, OK). Health monitoring on vibration signatures. Final report. Arlington (VA): Air Force Office of Scientific Research (US), Air Force Research Laboratory; 2002 Feb. Report No.: AFRLSRBLTR020123. Contract No.: F496209810049.

Issued by performing agency:

Russell ML, Goth-Goldstein R, Apte MG, Fisk WJ. Method for measuring the size distribution of airborne Rhinovirus. Berkeley (CA): Lawrence Berkeley National Laboratory, Environmental Energy Technologies Division; 2002 Jan. Report No.: LBNL49574. Contract No.: DEAC0376SF00098. Sponsored by the Department of Energy.

27. Dissertation

Borkowski MM. Infant sleep and feeding: a telephone survey of Hispanic Americans [dissertation]. Mount Pleasant (MI): Central Michigan University; 2002.

28. Patent

Pagedas AC, inventor; Ancel Surgical R&D Inc., assignee. Flexible endoscopic grasping and cutting device and positioning tool assembly. United States patent US 20020103498. 2002 Aug 1.

Other Published Material

29. Newspaper article

Tynan T. Medical improvements lower homicide rate: study sees drop in assault rate. The Washington Post. 2002 Aug 12;Sect. A:2 (col. 4).

30. Audiovisual material

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31. Legal Material

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Optional presentation (omits bracketed phrase that qualifies the journal title abbreviation):

Aboud S. Quality improvement initiative in nursing homes: the ANA acts in an advisory role. Am J Nurs. 2002 Jun [cited 2002 Aug 12];102(6):[about 1 p.]. Available from:
<http://www.nursingworld.org/AJN/2002/june/Wawatch.htmArticle>

Article published on the Internet ahead of the print version:

See # 18.

Optional formats used by NLM in MEDLINE/PubMed:

Article with document number in place of traditional pagination:

Williams JS, Brown SM, Conlin PR. Videos in clinical medicine. Blood-pressure measurement. N Engl J Med. 2009 Jan 29;360(5):e6. PubMed PMID: 19179309.

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Artwork Instructions for PES

Figures and Tables: Figures, not larger than 8 in. x 10 in., should be professional in appearance and have clean, crisp lines. Hand drawings and hand lettering are not acceptable. Submit one print of each figure and include photocopies in each copy of the manuscript. Identify each figure by marking lightly on the back or on a gummed label affixed to the back, indicating figure number, author's name, top side, and abbreviated title of manuscript. Tables should be double-spaced on separate sheets and include a brief title. However, authors are encouraged to submit illustrations rather than tables. When tabular material is necessary, the information should not duplicate that in the text.

Reviewer Guidelines for PES

Does the paper report important findings that add to the body of scientific knowledge and have useful practical application in sport?

Have the main findings or applications been published previously?

Is the purpose of the study stated clearly and an adequate justification for the study provided?

Is the experimental design sound and appropriate for the stated purpose of the study?

Are the methods and analysis appropriate and sufficiently clear to be readily repeated by other scientists?

Are the conclusions justified and logically consistent?

Are the practical applications of the study clear and concise?

Are the references to existing studies pertinent and complete?

Presentation

Is the paper concise, consistent in format, and clearly written? Is the quality of the grammar, usage, and English at a high level?

Are all the figures and tables relevant? Are there unnecessary duplications of results among figures, tables, and the text?

Are the figures and tables properly prepared in accordance with the Submission Guidelines?

Do the title and abstract accurately reflect the contents and findings of the study?

Is the written text clear and unambiguous? Without rewriting the manuscript or imposing your own style, identify text that is verbose and/or ambiguous. Please identify text that should be expanded or condensed by specific reference to sentences and/or paragraph as appropriate.

Statistical Considerations

Have the authors clearly identified the experimental design and statistical methods?

Are there any concerns with sampling bias or measurement bias?

Have the authors quantified measurement imprecision with details on the typical or technical error of

measurement?

Has the sample variability been reported with standard deviation and uncertainty (or precision) of estimates indicated using confidence intervals?

Have magnitudes of effects been reported and interpreted with established criteria? Reporting the clinical or practical significance in a sport setting will help readers determine the real-world value or application of the main findings.

Is the use of standard and nonstandard statistical terms, abbreviations, and symbols defined appropriately and are the details of computer software packages cited?

Is there any notion of a reporting bias where underpowered studies and/or statistically nonsignificant results have been neglected or underemphasized? These results might have some practical (clinical) importance and could be useful for generating research questions and for researchers conducting meta-analyses.

ARTICLE TWO

JOURNAL OF HUMAN KINETICS

Guidelines for the Journal of Human Kinetics

JHK brings the latest research results in the area of kinesiology, exercise physiology & nutrition as well as valuable data in physical education, sports training and recreation

General structure

- MS Word editor
- font - Times New Roman
- 12-point type
- all margins - 2 cm
- interline - 1,5
- adjusting - left to right
- pages numbered
- do insert line numbers in the body of the manuscript to facilitate the reviewing and editing processes
- words division turned off
- standard division into paragraphs (each new paragraph should be indented)
- type only one space following the end of a sentence

Articles content:

- the maximum number of pages is 16 (including Tables, Figures and References), please note that only one file including the title page, abstract page, main text, references, tables and figures should be submitted; do not number the sections of the paper

Title page

- consists of the title, authors' names, affiliations, corresponding author data, acknowledgments

Title:

- bold, 16-point type, adjusting - centered, do not use upper-case letters

Authors name:

- first name (not initials) and last name must be provided - italics, adjusting - to the left, full affiliation in footer

Corresponding author:

- corresponding author should be presented with affiliation, address, phone number, fax number and e-mail address (in English)

Acknowledgments:

- reference to prior publication of the results in abstract form or in proceedings, addresses of authors other than the laboratory acknowledged for the work should be provided; financial support should be stated; thanks may be expressed

Affiliation:

- in a footnote; italics; shall contain full information about each author

Abstract page

- at the top of the abstract page, the title should be provided (bold, 16-point type, adjusting-centered, do not use upper-case letters)
- the JHK does not accept structured abstracts, type the abstract in one paragraph; the structure of the abstract should be similar to the full text; the abstract should be informative and self explanatory without reference to the text of the manuscript; it should state concisely the research question that was asked, the methods used, the results of the research and the answer to the research question
- abbreviations should not be used in the abstract
- the abstract must be limited to 240 words
- adjusting - left to right

Key words:

- at the end of the abstract, three to six key words not used in the title should be provided; adjusting - to the left

Main Text

- titles of the following sections - bold print, font's size 1 point larger than in the text; adjusting - to the left

Introduction

- should be comprehensible to the general reader; give a clear statement of the purpose of the paper and provide relevant context to support the basis for the paper and the significance of the work; do not exhaustively review the literature.

Material and Methods

- in the Material & Methods' section, give a clear description of the study and how it was carried out; specifically describe the procedures and materials used, so the study can be replicated; the subsections, with brief content descriptions, in order, are:

Participants

- describe the sample: how many participants, how they were recruited. Provide basic demographics (age and SD, sex distribution, etc.).

Measures

- each subsection here should describe one questionnaire or interview or objective observation. Include details of the origin of the measure, the number of items and subscales, format of responses, scoring and known psychometric qualities.

Procedures

- explain how the experiment was carried out. Who tested participants, where were they tested or observed, etc.; if submitted papers contain clinical and animal research, approval of a local ethics committee is required; please note that authors should follow the principles outlines in the Declaration of Helsinki

Statistical Aalysis

- describe the analyses applied to the data. It is helpful if you arrange this section to be coherent with the hypotheses

Results

- results should be presented precisely and should not contain material that is appropriate in the discussion; units, quantities, and formulas should be expressed according to the International System (SI units); all measurements should be given in metric units.

Discussion

- emphasize the new and important aspects of the study and conclusions derived from the study

References cited in the text

references should be cited in the text by author and year of the publication e.g. (Jaric, 1989). In case there are more than one author, the rule is as follows:

citing a reference with two authors:

Smith and Jones (2007) stated that...

or (Smith and Jones, 2007)

citing a reference with three authors or more :

Smith et al. (2007) stated that...

or (Smith et al., 2007)

References

- should be compiled alphabetically at the end of the article

Entries in the reference list should be styled as follows:

- references to standard journal articles:

Jaric S, Ristanovic D, Corcos DM. The relationship between muscle kinetic parameters and kinematic variables in a complex movement. *Eur J Appl Physiol Occup Physiol*, 1989; 59: 370-376

- titles of journals should be abbreviated according to the latest edition of ISI Journal Title Abbreviations. (<http://www.efm.leeds.ac.uk/~mark/ISIabbr/>).

- references to books:

Costill D, Maglischo E, Richardson A. *Swimming*. Oxford: Blackwell Scientific Publications, 61-86; 1992

- references to websites:

Sanders R, Bonnar S. *Start Technique - Recent Findings*, 2008. Available at: ; accessed on 01.12.2011

- references to conference presentations:

references to unpublished papers presented at conferences will not be accepted

- references to master / doctoral thesis:

references to master / doctoral thesis will not be accepted

- published abstracts must not be used as references; the use of a large number of abstracts or non peer reviewed articles in the reference section will be grounds for rejection of the submission without review
- all references listed must be cited in the manuscript and referred to by author. References must be limited to 30 entries.
- non-English papers may be included in the references, yet only if the publication has an English abstract; the title of the original paper must be translated into English.
- authors bear complete responsibility for the accuracy of the references

Tables and Figures

- do not place Tables and Figures in the text of the paper, but present them on separate pages at the end of the manuscript following the References; in the text of the paper, indicate approximately where Tables and Figures should appear (e.g. insert Table 1 here)

- the article may contain up to 3 Tables, 3 Figures and 3 Pictures; they all need to be positioned vertically
- Tables, Figures and Pictures should be consecutively numbered (e.g. Table 1, Figure 1, Picture 1)
- the Table/Figure/Picture's title - bold, adjusting - to the right
- all descriptions should be placed below Table/Figure/Photo, font - italics, adjusting - centered
- the maximal size of original Tables, Photos and Figures is 14 x 20 cm, minimum 8-point type; edging lines marked
- Tables, Photos and Figures - only vertically positioned

Language

- only English
- before submitting your article, you may want to have it edited for correct usage of the English language, particularly if English is not your first language. Please note that this step is not mandatory and moreover, language editing does not guarantee that your manuscript will be accepted for publication. The Journal of Human Kinetics recommends: American Journal Experts for correcting scientific manuscripts in the area of sport sciences. Authors are liable for all costs associated with such services.

EXAMPLE OF AN ARTICLE:
PEDIATRIC EXERCISE
APPENDIX C **SCIENCE,**
JOURNAL OF HUMAN
KINETICS



Inter-Relationships Among Physical Activity, Body Fat, and Motor Performance in 6- to 8-Year-Old Danish Children

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University of Southern Denmark

Joey C. Eisenmann

Helen DeVos Children's Hospital Healthy Weight Center

Karsten Froberg

University of Southern Denmark

Karin A. Pfeiffer

Michigan State University

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University of Southern Denmark

This study examined the interrelationships among physical activity (PA), percent body fat (%BF), and motor performance (MP) in 498 6- to 8-year-old Danish children. PA was assessed by accelerometer, %BF was calculated from skinfolds, and the Koordinations Test für Kinder along with a throwing accuracy test was used to assess MP. PA was not correlated with %BF, but was significantly correlated with MP. The strongest correlations existed between %BF and MP. Low %BF/High PA had higher MP scores compared with High %BF/Low PA, and within the High %BF groups MP was higher in the High PA versus Low PA group. When comparing PA by %BF and MP groups, boys in the Low %BF/High MP had higher PA than both the Low %BF/Low MP and High %BF/Low MP groups. In girls, PA was highest in the High %BF/High MP group. This study highlights the complex interrelationships among PA, %BF, and MP in children and the need to develop fundamental motor skills during childhood.

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Childhood obesity is a critical public health issue in most developed countries (14). Although obesity is now recognized as a complex multifactorial trait (5,12), lack of physical activity is considered one of the leading contributors to its development (17). In the U.S. less than half of 6–11 year old children meet the recommendation for physical activity (27).

So why are a majority of children not engaging in the recommended amount of physical activity? Several factors including age, sex, socioeconomic status, body mass index, ethnicity, parental support, and geographical location have been shown to contribute to the interindividual variation in physical activity levels among children (21). Another possible but often overlooked factor that may influence physical activity in children is motor skill performance. Given that fundamental motor skill development is one hypothesized impetus for participation in habitual physical activity, it seems essential to develop a wide base of fundamental motor skills during early to middle childhood to enhance the ability to participate in physical activity, particularly recreational sports settings (3,10,11,18,25). Even though the patterns of physical activity in childhood and adolescence are moderately predictive of lifelong physical activity patterns (26), skill-based activities contribute a large portion of children's physical activity and may develop the impetus for future physical activity behaviors (11).

The interrelationships between physical activity, adiposity, and motor performance in children have previously been examined using bivariate relationships between either motor performance and adiposity (7,8,15,19) or motor performance and physical activity (6,8,18,20). Further, two studies (29,30) have examined the bivariate relationship between motor performance and physical activity and controlled for weight status (e.g., body mass index). In general, children with higher levels of adiposity display lower motor performance scores, and children with lower motor performance scores participate in less physical activity than peers with higher motor performance abilities. However, there is considerable variation in motor performance levels and physical activity among individuals with similar levels of adiposity.

In their conceptual model, Stodden and colleagues (24) suggest a “reciprocal and developmentally dynamic relationship between motor skill competence and physical activity.” This could be stated as an improvement in one causing an improvement in the other. However, in the Stodden model “unhealthy weight/obesity” is recognized as a potential outcome of poor motor skill competence and low physical activity levels, but this model fails to hypothesize if weight status modifies the relationship. Two studies (8,16) have investigated if weight status influences the association between physical activity and motor performance. Hume and colleagues (8) found those children with higher motor proficiency scores performed more physical activity; weight status did not significantly change this trend. More noteworthy, Morgan and colleagues (16) found correlations between 0.26 and 0.49 for gross motor quotient and physical activity levels of obese 5–9 year old boys and girls.

It seems reasonable to investigate both the joint association of adiposity and physical activity on motor performance as well as the joint association of adiposity and motor performance on physical activity in children. This analysis may provide further evidence to how the relationship between motor performance and physical activity is modified by weight status (e.g., level of adiposity). Thus, the purpose of

this investigation was threefold: 1) to determine the interrelationships (i.e., bivariate correlations) among physical activity, % body fat, and motor performance in 6- to 8-year-old Danish children, 2) to determine the joint association of % body fat and physical activity on motor performance, and 3) to determine the joint association of motor performance and % body fat on the level of physical activity.

Methods

Subjects

Subjects included in this analysis were tested during baseline data collection of the Copenhagen School-Child Intervention Study (4) from all 18 schools in 2 communities (Ballerup and Tårnby) within the Copenhagen area with similar sociodemographic characteristics. The local ethical committee at the University of Copenhagen approved the study. Written informed consent from the parents or guardian was mandatory before participation in the study. Of the 369 boys and 327 girls that originally provided parental consent to participate in the study, 498 children (265 boys, 233 girls, mean age 6.7 years) possessed complete data on all variables needed for the proposed research questions. There were no significant differences in age or other demographics between those subjects with complete or incomplete data. Data collection occurred between December 2001 and June 2002, which was before the initiation of the intervention.

Habitual Physical Activity

Habitual physical activity was assessed over four days (two weekdays, two weekend days) using the Actigraph (7164) accelerometer (ActiGraph LLC, Pensacola, FL). Due to the age of the participants and their potential to engage in spontaneous, short duration bouts of activity, a 10-s epoch was used. The participants were instructed to begin wearing the Actigraph one day before the actual beginning of recording to become accustomed to the device and prevent reactivity. Monitors were to be worn near the center of gravity on the lower back secured with an elastic belt. Participants were instructed to wear the Actigraph at all times except while sleeping and during activities involving water. Periods with zero counts lasting 10 min or longer were considered times that the Actigraph was not worn and were removed from the data file. For data to be used, a participant needed to accumulate a minimum of 8 hr of recorded activity on at least 3 of the 4 testing days. The average counts per 10-s epoch over the assessment period were calculated for each participant and used as the outcome variable in the data analysis. All units were calibrated in a motor driven vertical acceleration machine before use.

Anthropometry

Standing height was measured by a portable Harpenden stadiometer to the nearest 0.5 cm in bare feet using standard methodology. Body mass was measured to the nearest 0.1 kg using an electronic scale (Seca model 882, Hamburg, Germany) with the subjects lightly dressed. Assessments were conducted by experienced personnel following standard procedures. Interrater reliability ranged from 0.83

to 0.99. Body mass index (BMI, kg/m^2) was calculated for each subject. Skinfold thickness was assessed at the triceps and subscapular skinfolds in triplicate on the nondominant side of the body using a Harpenden caliper. The average of the three values was taken from each site and converted to percent (%) body fat using the Slaughter equation (23).

Motor Performance

Motor performance was assessed by the Koordinations Test für Kinder (KTK; 22) as well as a test of throwing accuracy. The KTK is a product-oriented motor performance battery which consists of four age-adjusted movement ability tests: 1) a single-legged hop over obstacles, 2) a balance test on three different width beams, 3) a sideward jumping (ski jumping) test lasting 15 s, and 4) a lateral movement test lasting 20 s where the participant moves from one 6 × 6 inch footstool to another as many times as possible. A motor quotient for each participant was derived from the sum of the KTK age-adjusted scores from the four test items. In addition, a throwing accuracy test was performed by having participants stand three meters from a 35 cm wide square target. The target was placed 1.5 m above the floor. Subjects threw a tennis ball at the target ten consecutive times. The center (10 cm wide), middle (20 cm wide), and outer (35 cm wide) squares received three, two, and one points, respectively. The highest attainable score was thirty points. The test was first described in the Allgemeiner sportmotorischer Test für Kinder (AST) test battery (2). The throwing accuracy scores and KTK tests were added together to derive an overall motor performance score.

Statistical Analysis

Descriptive statistics were calculated for all variables, and independent samples *t* tests were used to examine gender differences. Pearson correlation coefficients were used to examine the associations among physical activity, % body fat, and motor performance for boys and girls separately. Gender-specific median splits were performed for each of the variables to examine purposes 2 and 3 of this study (i.e., joint association). Median values for the variables were: physical activity (boys = 125.0 counts/epoch, girls = 114.9 counts/epoch), % body fat (boys = 12.6%, girls = 14.8%), and motor performance score (boys = 115.5, girls = 113.5). To examine the joint association of % body fat and physical activity on motor performance—the following groups were created based on values equal to or above the median and those below the median: Low body fat/High physical activity, Low body fat/Low physical activity, High body fat/High physical activity, High body fat/Low physical activity. To examine the joint association of motor performance and % body fat on the level of physical activity—the following groups were created based on values equal to or above the median and those below the median: Low body fat/High motor performance, Low body fat/Low motor performance, High body fat/High motor performance, High body fat/Low motor performance. Gender-specific analyses of covariance (ANCOVA), controlling for age, were performed to test for differences among the four groups described above for purposes 2 and 3 (e.g., combined influence). All statistical analyses were performed using the Statistical Package for Social Sciences (SPSS, Inc., Chicago, Ill.; version 16.0).

Results

Descriptive characteristics of the sample by gender are shown in Table 1. The mean stature, weight, and BMI for boys and girls fell between the 50th and 75th centiles of the CDC growth chart (9). Significant differences ($p < .05$) existed between genders for age, height, weight, % body fat, and physical activity. Motor performance did not differ between boys and girls.

The interrelationships among physical activity, % body fat, and motor performance are shown in Table 2. Overall, correlations were low to moderate at best ($r < .36$, $p < .001$). Physical activity was not significantly correlated with % body fat and approximated zero ($r = .01$ to -0.06 , $p > .05$). Physical activity was significantly correlated with motor performance in boys ($r = .20$, boys; $p < .001$), but not girls ($r = .10$, $p > .05$). Further, when controlling for % body fat, the correlations between physical activity and motor performance were significant in both boys and girls ($r = .21$ and 0.14 , respectively; $p < .05$), although coefficients remain comparable to when adiposity was not statistically controlled. The correlations between % body fat and motor performance were the highest among the three relationships examined ($r = -0.35$, boys, $p < .01$; $r = -0.23$, girls, $p < .001$), and remained similar when controlling for physical activity.

Figure 1 shows the joint association of % body fat and physical activity on motor performance scores in boys and girls, respectively. Boys and girls with lower % body fat had significantly higher motor performance than boys and girls with higher % body fat [(122 ± 2 v. 110 ± 2 ; $p = .0001$) and (115 ± 2 v. 110 ± 2 ; $p = .05$), respectively] Further, boys and girls with higher physical activity had significantly higher motor performance than boys and girls with lower physical activity [(120 ± 2 v. 112 ± 2 ; $p = .006$) and (117 ± 2 v. 108 ± 2 ; $p = .003$), respectively]. Overall, there was a significant difference in motor performance across the four % body fat/physical activity groups in both boys and girls ($p < .001$). Boys and girls with higher % body fat and low levels of physical activity (i.e., high fat/low PA) had significantly lower motor performance scores than subjects in the other three groups ($p < .05$). It should be emphasized that within the high fat groups for both genders, those with higher level of physical activity had a significantly higher motor performance score; however, this was not shown within the low fat groups.

Table 1 Descriptive Characteristics of the Sample by Gender

	Boys ($n = 265$)	Girls ($n = 233$)
Age (yrs)	6.8 (0.4)*	6.7 (0.4)
Ht (cm)	123.8 (4.9)*	122.0 (4.8)
Weight (kg)	24.5 (3.6)*	24.0 (3.6)
BMI (kg/m ²)	16.0 (1.7)	16.0 (1.8)
Body fat (%)	13.6 (4.1)*	15.7 (4.1)
Physical Activity (counts/10-s epoch)	129.8 (36.9)*	116.2 (26.6)
Motor Performance Score	115.7 (24.2)	113.0 (22.8)

* $p < .05$ between sexes

Table 2 Partial Correlations Between Physical Activity, Body Fat and Motor Performance Among 6- to 8-Year-Old Danish Children

	Boys (n = 265)		Girls (n = 233)	
	r ^a	r ^b	r ^a	r ^b
Physical activity & % body fat	-.06	.04	.01	.05
Physical activity & motor performance	.20***	.21***	.10	.14*
% body fat & motor performance	-.35**	-.36***	-.23***	-.25***

* p-value <.05 ** p-value <.01 *** p-value£.001

r^a partial correlations controlling for age, r^b partial correlations controlling for age as well as the third dependent variable within the original correlation matrix.

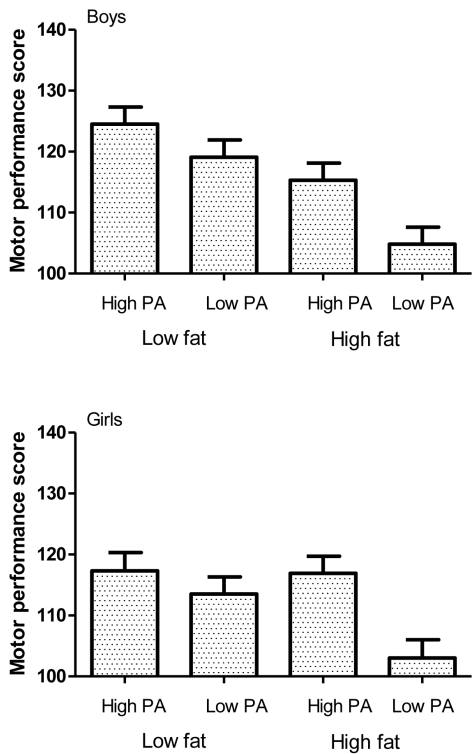


Figure 1 — Differences in motor performance score by fat-physical activity groups. See results section for group differences.

Boys with lower body fat and high physical activity (low fat/high PA) showed significantly higher motor performance scores than their high activity peers with high body fat ($p < .05$).

Figure 2 shows the joint association of % body fat and motor performance on physical activity in boys and girls, respectively. There was no difference in physical activity between low and high % body fat groups for boys and girls (130 ± 3 v. 129 ± 3 ; $p > .05$) and (113 ± 2 v. 119 ± 2 ; $p = .09$), respectively. However, boys and girls with higher motor performance had higher physical activity than boys and girls with lower motor performance (136 ± 3 v. 123 ± 3 ; $p = .005$) and (119 ± 2 v. 113 ± 2 ; $p = .07$), respectively. Significant differences in physical activity were found between all % fat/motor performance groups in both boys ($p < .03$) and girls ($p < .003$); however, specific group differences were inconsistent between the sexes. In boys, within a body fat category those with higher motor performance scores showed higher levels of physical activity. Although significant in the low body fat groups ($p < .05$), there was only a nonsignificant trend between the 2 groups classified as high body fat ($p = .10$). In addition, there was a trend ($p = .09$) for boys with low fat/low MP to have lower physical activity compared with boys with high fat/high MP. This same group comparison (low fat/low MP v. high fat/high MP) was statistically significant ($p = .016$) in girls, and was the only significant group difference in girls (Figure 2).

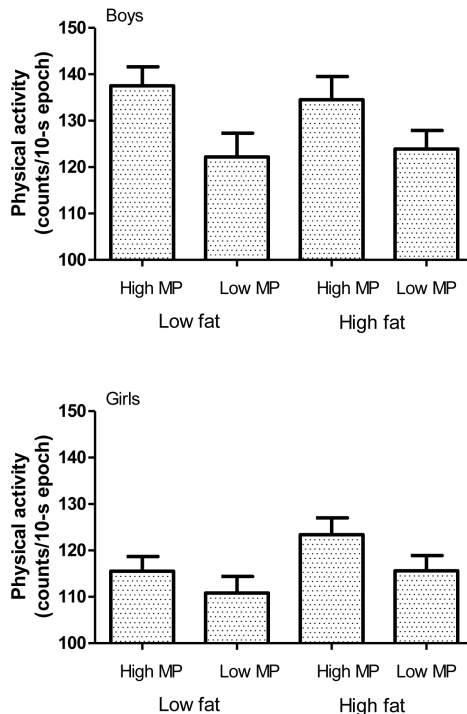


Figure 2 — Differences in physical activity by fat-motor performance groups. See results section for group differences.

Discussion

The present study is unique in that it examined the joint association of physical activity and body fatness on motor performance and the joint association of motor performance and body fatness on physical activity. In addition, we controlled for the concomitant variable in correlation analyses (e.g., controlling for physical activity when examining correlation between body fat and motor performance). These approaches are important to better understand the complex interrelationships among these variables. The results indicate low to moderate associations between physical activity and motor performance and body fatness and motor performance. Furthermore, motor performance is associated with physical activity regardless of the level of body fatness. Among boys and girls classified as high fat in this sample those with higher levels of physical activity performed better on the motor performance tasks.

In general, the positive correlations between physical activity and motor performance in this study are similar in magnitude to previous papers (6,8,18,20,29,30). As shown here, others have also reported either correlations or group differences (active v. inactive). In the current study, we grouped subjects by the median split and showed significant differences. Previously, Graf et al. (7) showed a significant graded relationship across five leisure behavior groups classified by parental questionnaire (no sport, irregular sport, regular sport, club sport, or club sport and regular sport) and KTK- motor performance quotient score among 668 German first graders.

A limitation of this study is the cross-sectional design that does not allow for the establishment of time-order between physical activity and motor performance. To our knowledge, there are only two longitudinal studies published on this topic (1,13). One study (1) identified that object control proficiency during childhood was positively associated with time spent in moderate to vigorous physical activity during adolescence, accounting for 12.7% of the variance in a group of Australian students. However, the results of a study by McKenzie and colleagues (13) indicated that motor performance between the ages of 4–6 years of age was not a significant predictor of adolescent physical activity in a sample of 207 Mexican American and Anglo American children. However, these studies used self-reported recall instruments to assess physical activity instead of an objective instrument such as accelerometry.

Several of the papers (1,8,16,20,29) that examined the bivariate relationship between motor performance and physical activity generally reported that a greater percentage of the explained variance in physical activity was due to object-control skills than locomotor skills, but this trend varied by gender. Therefore, another limitation of this study is that the overall motor performance score is not comprehensive in nature, relying primarily on balance and coordination skills, as well as one accuracy based object-control test to represent each subject's motor abilities. Future research examining this topic using a longitudinal approach and a more comprehensive motor performance battery is warranted.

Compared with the literature on physical activity and motor skill performance, fewer papers have examined the relationship between adiposity and motor performance. Our findings are consistent with previous studies (7,15,19) in that youth with higher levels of adiposity possess lower motor performance scores. In a study that

also used the KTK to assess motor performance among 668 (341 boys, 327 girls) German first graders, Graf et al. (7) found a low correlation ($r = -0.16$) between motor performance quotient and BMI. We found a partial correlation (controlling for age and physical activity) of -0.35 in boys and -0.25 in girls between % body fat calculated from skinfold thickness and KTK motor performance. Others have shown the motor performance abilities of overweight youth were significantly lower when compared with normal weight youth from Bavaria (15) and Australia (19). Wearing and colleagues (28) have suggested that overweight children display poorer motor performance due to poor postural balance and insufficient muscular strength. Future studies exploring the neuro-mechanical mechanisms of this relationship would add to our understanding of this observation.

A primary aim and unique aspect of this paper was to examine the joint associations of % body fat and physical activity on motor performance and motor performance and % body fat on the level of physical activity. The premise of this research question stems from the recognition that not all children with higher levels of fatness display poor motor skills and/or are physically inactive. The results indicate that for boys and girls within the high fat groups, those with higher level of physical activity had a significantly higher motor performance score. However, it is important to highlight that the median split was 13% body fat in boys and 15% body fat in girls; thus, the “high fat” group was still relatively lean compared with cutpoints used for overfatness (e.g., FITNESSGRAM, 32% girls and 25% boys). A previous study (16) sheds some light onto extending these results to overweight and obese children. Morgan et al. (16) showed that motor skill proficiency was significantly correlated ($r = .24-0.53$) with moderate and vigorous physical activity in obese 5–9 year old boys and girls. Object-control skill proficiency explained 10% of the variance in vigorous intensity physical activity and 25% of the activity counts per minute performed by boys; these values are some of the highest currently presented in the literature on this topic.

In summary, this study expands our knowledge of the joint association of adiposity on motor skill performance and also demonstrates a difference in physical activity patterns of children classified as “high fat” with low and high motor performance abilities. Although this study needs to be replicated in a sample of overweight and obese children, the results provide some insight into the inclusion of motor skill training as a component of a physical activity intervention for overweight children. Although physical activity is a key component of childhood obesity programs, the child must possess the requisite motor skills to successfully enjoy participation in most forms of physical activity and sport. Furthermore, it provides evidence for the necessity of a strong foundation of motor skill performance in relation to a physically active lifestyle for all children. However, this study and previous studies on this topic have been limited by its cross-sectional design. Future studies need to employ a longitudinal design to fully understand the complex interactions of physical activity, adiposity, and motor skill performance in children.

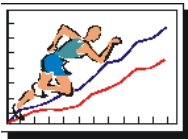
Acknowledgments

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Sprint Performance Changes and Determinants in Afro-Caribbean Adolescents Between 13 and 15 Years Old

by

Karine Babel Copaver¹, Claude Hertogh¹, Olivier Hue¹

Afro-Caribbean sprinters often reach high performance levels at an early age. Adolescence is a time of morphological and physiological changes. This study was designed to analyze the evolution in parameters of short sprint performance during adolescence in Afro-Caribbean boys, especially the stride number/body height ratio (SN/BH), which is at the interface of technical and morphological factors. Seventy-one 13-year-old boys performed vertical jumps and short sprint races. The races were filmed with a view to determine stride variables. Anthropometric parameters were also measured. The same tests were performed two years later. Body height and SN/BH were the main predictors of sprint performance. The delta of performance was principally explained by stride length and stride number. Although deterioration in technical parameters was expected, the parameters related to body size and stride length were the main sprint performance predictors rather than explosive force. These results could be useful in developing tests to detect sprint potential in youth.

Key words: puberty, stride characteristics, sprinting, Afro-Caribbean youth

Introduction

African-Americans and West Indian athletes have long dominated international sprint events and this was evident in the 2009 and 2011 World Track and Field Championships. A few studies have focused on the influence of ethnicity on sprint performances. Most of them demonstrated that black boys and girls performed better than their white counterparts of the same age in 30 to 50 m dashes (Milne et al., 1976), although others showed no differences (Babel et al., 2005). Concerning physiological factors, although some studies demonstrated that bone density was higher (Schutte, 1984; Wang et al., 1999) and fat content lower in blacks (Himes, 1988), it seems that muscular architecture is not influenced by ethnic origin (Abe et al., 1999). Still other studies have demonstrated a more advanced puberty for black boys than white (Morisson et al., 2000). In sprint running, several

elite Afro-Caribbean athletes have performed exceptionally well at an early age (Usain Bolt, the fastest man in the world, had already run the 200 m in 21.73 s in 2001 at the age of 14). In 2005, Babel et al. demonstrated that ethnicity did not influence sprint performance in prepubertal boys, but the predictive variables of performance were better for Afro-Caribbean boys versus Caucasians. We thus wondered how sprint performance and its variables changed in Afro-Caribbean boys during adolescence.

Children's physical resources are transformed in both qualitative and quantitative ways during development, and physical performance varies with age and sex (Weineck, 1996). During the first pubertal stage (from 12-13 to 14-15 years for boys), the abrupt body changes and hormonal instability cause a decline in specific coordination (Weineck, 1996), a decrease

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in the precision of body control, and excessive movement. The release of specific sexual hormones also causes significant morphological changes (Thiebaud, 1997).

In addition to morphological factors, muscle strength also undergoes change during puberty (Round, 1999; Jones et al., 2004), what affects physical performance. Indeed, pubertal development and muscle strength are closely related. Malina et al. (2004) tested 69 young football players (13 and 15 years old) and showed that both biological maturity (stages of puberty) and training significantly influenced their functional capacities. Moreover, their study indicated that, although training contributed to an increase in aerobic capacity, sprint and jump performances were more related to anthropometric variables (notably body mass and body size). Chandler and Brown (2007) showed that improvement in sprint performance was due to an increase in stride frequency followed by an increase in stride length. The morphological changes induced by development and maturation most likely influenced sprint performance.

In 2005, Babel et al. demonstrated that the stride number/body height ratio (SN/BH) could be used to predict sprint performance in Afro-Caribbean children. This ratio is interesting because it includes both technical (stride frequency and length) and anthropometric variables. The study showed that the fastest runners were those with the lowest SN/BH ratio, meaning that those with the smallest number of strides in relative values had the best results in short sprint performance. We thus raised the question of how maturation would influence this last variable.

We were specifically interested in how the SN/BH ratio would change so we decided to test its persistence as a predictive variable of sprint performance during adolescence. Great changes in anthropometric variables occur during adolescence, notably an increase in body size. These changes can lead to instability in coordination (Weineck, 1996) and might reduce the importance of the SN/BH ratio as a predictive variable of sprint performance. It can thus be hypothesized that changes in anthropometric variables will perturb coordination and have a negative influence on sprint performance. Greater maximal leg strength has been demonstrated to be

strongly correlated with sprint performance (Kumagai et al., 2000; Bret et al., 2002). The literature shows that leg strength is correlated with jump tests, particularly vertical jump height (Sleivert and Taingahue, 2004). As strength increases during puberty and is closely related to sprint performance, we assumed that vertical jump height would show greater predictive power regarding sprint performance. We also assumed that over the course of adolescence, sprint performance would be greater due to the increase in leg strength. We therefore tested the hypothesis that between 13 and 15 years, vertical jump height would become a better predictor of sprint performance than the SN/BH ratio.

Material and Methods

Subjects

Two hundred youths participated in the first part of this study. At least 70 performed all the tests in Years 1 and 3. Subjects were lost to analysis for many reasons, mainly school changes, involvement in sports competition, or injuries. The average age of the subjects at the start of the study was 13.24 ± 1.05 years. The ethics committee of the University of the French West Indies approved the study, and parental consent was obtained for all subjects who participated in the study. All measurements and tests were conducted within the confines of the school, during physical education classes. Authorization was first obtained from the headmaster.

All tests were conducted twice, two years apart. During the interval, none of the subjects was involved in athletic practice and/or competition. The only physical activities were the official physical education classes for up to 3 hours per week, depending on the class. The conditions for the testing procedures and the equipment were the same in the two testing periods.

Anthropometric variables and puberty ratings

Body height and leg length were measured with a wall meter and body mass was measured with a calibrated scale. Leg length was measured in a lateral position, from the anterior superior spine of the ilium to foot contact with the ground (Mak et al., 2006). The dominant leg was measured. For right-handed individuals, the dominant leg is generally the left one, but we considered the leg spontaneously used by subjects

to jump as dominant. The subjects stood with the feet placed shoulder-width apart. They were asked to stand straight and look straight ahead. The percentage of body fat was obtained from skinfold thickness measured at four sites (biceps, triceps, supra iliac and subscapular) with a caliper (Caliper Holtain Ltd, Crymych, UK), as described by Durnin and Rahaman (1967).

Sexual maturation was evaluated by the pubertal stages of Tanner (1989). To determine the stage, five illustrations were shown to the children as described by Taylor et al. (2001).

Physical tests

The subjects took part in a standardized protocol consisting of a vertical jump test and a 30 m sprint test.

Jump test

The jump test was performed using Abalakov apparatus (Jump-MD, Takei, Japan). Performance was assessed by the unwinding of a thin cord tethered at the waist. The amount of cord unwound automatically appeared on a digital screen fixed to the belt. The jump height was given with a precision of 1 cm. The participants were asked to perform a countermovement jump in which they began in a standing position, dropped into a semi-squat position, and immediately jumped as high as possible. Knee flexion was monitored by an experimenter in order to prevent excessive or insufficient flexion. The jumps were performed without the help of the arms, which remained on the hips. Each subject performed three jumps separated by 4 minutes of rest to allow for ATP/PC resynthesis. The vertical jump measure retained was the best of the three jumps.

Sprint performance

The sprint tests were performed individually in one lane of a synthetic track. The distance was delimited by two markers at the start line and two others at the finish line. Before beginning the test, the subjects warmed up for about 20 minutes with a slow run, dynamic stretching and some specific exercises. The subjects performed the same warm-up at both testing periods. Every 30-m sprint was filmed with a digital video camera (VL-WD250S, Sharp, Malaysia; speed, 1/1000 to 1/10000 s) positioned at a 14° angle to the sprint start. The camera was located about 20 m from the start line with a lateral distance of 5 m from the lane. The film

analysis consisted of counting the number of strides during the sprints using the camera view-by-view function. A stride was defined as a bound between the right and left contact with the ground and was identified at each foot contact with the ground. The performance time was assessed using photoelectric cells (Globus Tecnica e Sport, Italy) placed at the start and finish lines. The subject stood 1 m behind the line. When he was ready, he began to run. All children were vocally encouraged during the sprints. Each participant performed only one sprint. All wore their usual sports shoes. Cells were placed at 1 m in year 1, then at 110 cm in year 3.

Statistics

Paired Student tests were conducted to determine the differences between the performances during the two years of research. To determine the variables predictive of sprint performance, multiple correlations were also performed on the overall performance and the performance deltas between the two years.

Results

Anthropometric and performance differences between Year 1 and Year 3

The age of participants increased from 13.24 to 15.24 years. The anthropometric parameters showed that body height and mass had increased significantly by year 3, respectively 157 versus 170 cm ($p < 0.01$) and 47 versus 64 kg ($p < 0.01$). There was no significant difference in fat content (19.85 versus 18.29 %).

The physical fitness tests showed a significant improvement in running speed and vertical jump height. Stride frequency was the only variable that did not change. Stride length increased significantly, and the SN/BH ratio showed a significant decline.

Predicting sprint performance

A system of stepwise regressions revealed four predictors of performance in the following equation:

$$\text{Perf} = 0.016 \text{ BH} + 22.086 \text{ SN/BH} - 1.236 \text{ SF} - 1.451 \text{ SL} + 6.817$$

$$r^2 = 0.995, p = 0.001$$

BH: body height, SN/BH: stride number/body height ratio; SF: stride frequency; SL: stride length

Variables related to sprint performance

Table 1 shows the correlations between the measured variables and sprint performance.

All the parameters were correlated with the 30-m sprint performance.

Variables correlated with sprint performance

Except for body mass, the changes in all

parameters were significantly, but weakly correlated with performance.

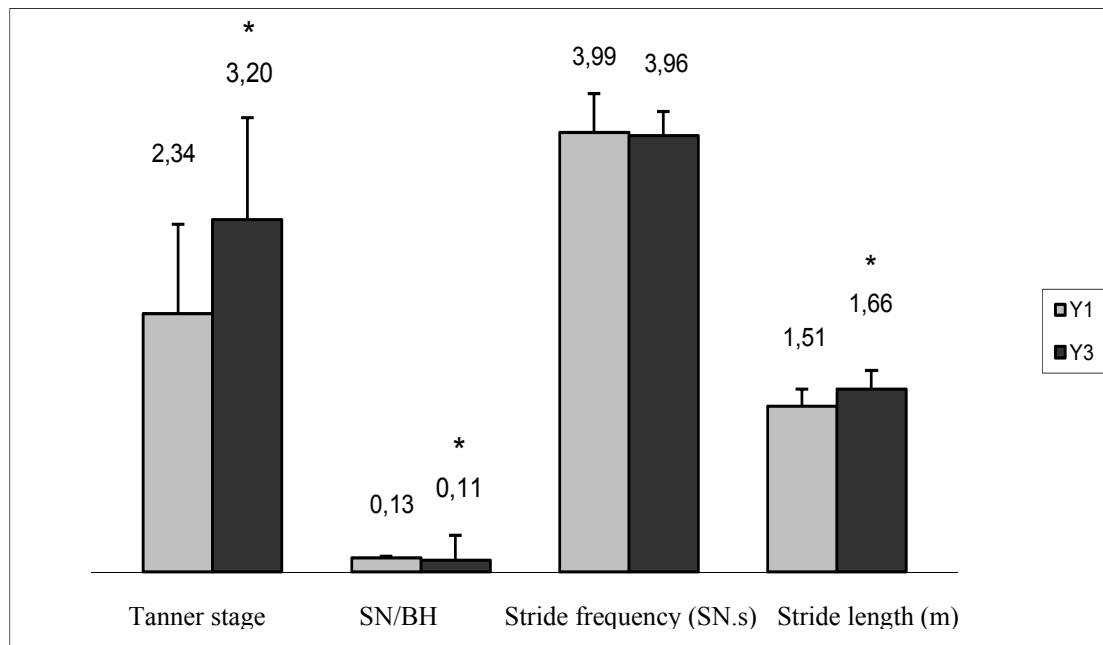


Figure 1

Changes in pubertal stage, SN/BH ratio, and stride characteristics.

SN/BH: stride number/body height ratio. Stride frequency in stride number per second (SN.s). Stride length in meters (m). Y: Year. *p<.001

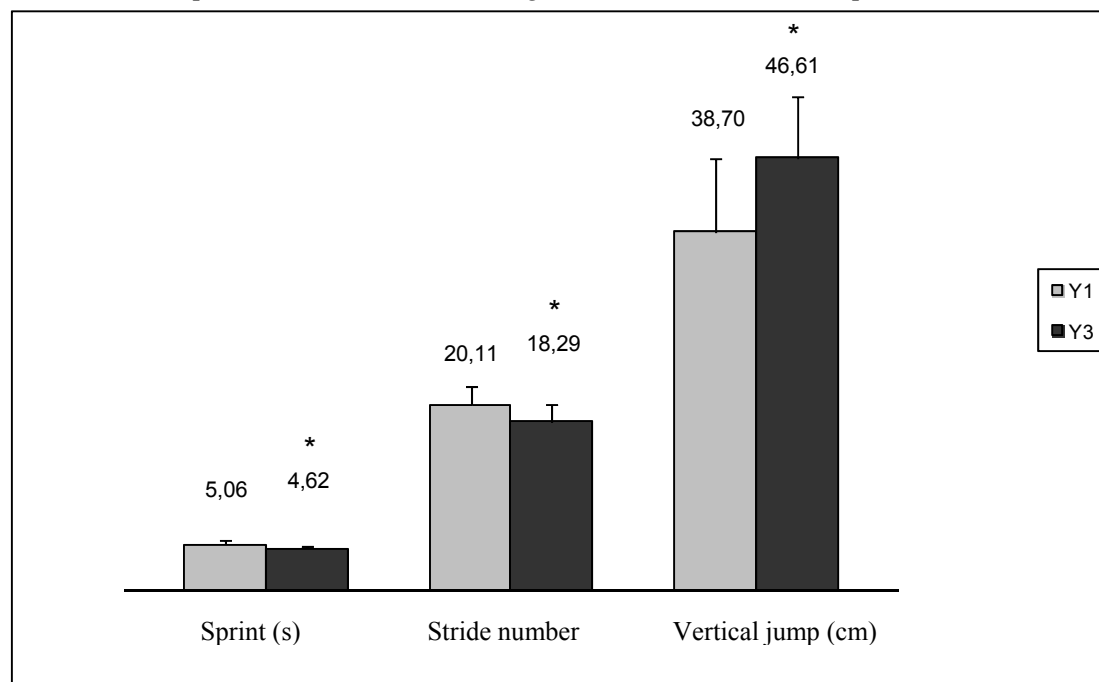


Figure 2

Changes in sprint performance, stride number and vertical jump height.

*p<.001. Sprint in seconds (s), vertical jump in centimetres (cm)

Table 1

Relationships between sprint performance (30 m) and anthropometric variables as well as chosen fitness tests

	Age	Tan	BH	BM	FM %	SN	VJ	SN/BH	SF	SL
r²	.255	.575	.385	.030	.221	.561	.561	.643	.031	.565
p	<.001	<.001	<.001	<.05	<.001	<.001	<.001	<.001	<.05	<.001

Tan: Tanner stage, BH: body height, BM: body mass, FM%: fat mass percentage, SN: stride number, VJ: vertical jump, SN/BH: stride number/body height ratio, SF: stride frequency, SL: stride length

Table 2

Relationships between the deltas in sprint performance of boys aged 11 – 13 and anthropometric variables as well as chosen fitness tests

	BH	BM	SN	FM %	VJ	SN/BH	SF	Stride length
r²	.073	.031	.209	.074	.114	.266	.054	.197
p	<.05	.144	<.001	<.05	<.01	<.001	<.05	<.001

BH: body height, BM: body mass, SN: stride number, FM%: fat mass percentage, VJ: vertical jump, SN/BH: stride number/body height ratio, SF: stride frequency.

Predictive parameters of the difference in performance

No anthropometric variable emerged as predictive in the equation from the regression step. The performance predictors were stride length, the number of strides, and stride frequency.

$$\text{Delta Perf} = -0.453 \text{ SL} + 0.217 \text{ SN} - 1.252 \text{ F} - 0.009.$$

$$r^2 = 0.989, p = 0.001$$

SL: stride length, SN: stride number, SF: stride frequency

Stride frequency did not change over the two years, and it remained one of the predictive variables of performance.

Discussion

The most important results of this study were as follows: 1) the lack of correlation when simple regressions were used, whereas 2) step-by-

step regression revealed a change in the determinants of performance and confirmed the importance of stride length in sprint running.

Changes in anthropometric, physical and technical variables

Afro-Caribbean boys distinguish themselves in sprint track running even at an early age. The literature is controversial concerning the influence of ethnic origin on sprint performance. To our knowledge, no study has demonstrated that the factors that determine performance differ with ethnic origin. In 2005, Babel et al. showed that the factors of performance were the same for Afro-Caribbean and Caucasian prepubertal boys (vertical jump and stride number/height ratio). However, they also showed that Afro-Caribbeans had better results concerning these factors.

The vertical jump significantly improved

over the two-year period. We did not evaluate hormonal concentrations and can only assume that this improvement was due to the rise in testosterone production, which influences muscle growth, strength and vertical jump height (Cardinale and Stone, 2006). Moreover, age rather than pubertal stage seems to be correlated with a testosterone level (Srinivasan, 1986). The literature is controversial in regard to the influence of ethnicity on testosterone and growth hormones. Some authors showed that prepubertal and young black boys had higher testosterone levels (Ross et al., 1986; Winters et al., 2001; Abdelrahmane et al., 2005) and higher insulin growth factor (IGF-1) (Higgins et al., 2005). However, other authors demonstrated that ethnicity did not have any effect on a testosterone level during childhood and puberty (Lee et al., 2010; Morisson et al., 2000; Richards et al., 1992).

The results of the present study are consistent with the literature on the development of motor skills: boys and girls improve during the first 18 years (Costill and Wilmore, 2006), although the improvement in physical fitness is not linear during development (Philipaerts et al., 2006). Body fat content was the only anthropometric variable that did not vary significantly. We observed only a trend ($p < 0.06$), whereas a significant reduction based on earlier findings of a 4% decrease in body fat between the age of 13 and 15 was expected (Wabtsish, 1997). In addition to the improved sprint performance and the increase in anthropometric indices, stride length increased and the stride number and SN/BH ratio decreased, what was probably related to the increase in body size. Stride frequency apparently stabilized as it showed little difference between the initial and final evaluations. Concerning the stride frequency/length factor, the speed improvement was mainly due to longer strides. These results are therefore consistent with the literature (Chandler and Brown, 2007).

The determinants of performance

The main predictive variables of performance were body height and the SN/BH ratio, underlining the importance of anthropometric characteristics. The literature nevertheless shows controversial findings. Some authors showed that changes in some of the anthropometric parameters (body size, body

mass) improved physical performance (Van Praagh and Dore, 2002). Other studies reported that the standard anthropometric factors were low performance predictors (Kukolj et al., 1999), and low stride length predictors for distance running (Cavanagh and Williams, 1982).

The finding that body size was the main predictor of performance may suggest that the taller an individual is, the longer his legs are likely to be and thus the longer the strides will be, as well. Usain Bolt (1.96 m), the current world record holder for the 100 m (9.58 s), illustrates these characteristics, although tallness is not characteristic of all elite sprinters (Greene 1.75 m, 9.79 s; Nesta Carter 1.78 m, 9.78 s; Ato Boldon 1.75 m, 9.86 s; Tyson Gay 1.83 m, 9.69 s).

One of our objectives was to test the SN/BH ratio. The results of the stepwise regression confirmed its relevance in predicting sprint performance as it was the second most important predictive parameter, after body size. This parameter shows the adaptation of stride length to a morphological variable, body size, during sprint racing. This interaction is necessary and indicates a feedback relationship and not simply a one-way relationship. Thus, the SN/BH ratio can be used as an index of coordination and efficiency specific to sprint racing in children and adolescents.

Determinants of change in performance

Regression analysis was performed on the delta of performance between the first and third year of the experiment. The results showed that sprint performance changed significantly, because stride length increased, the stride number slightly decreased, and the stride rate did not change. It thus seems that the variables related to stride length determine the change in sprint performance during adolescence. In the fastest sprinters, stride length increased while a stride number decreased.

Stride length is an important performance variable in sprint races of elite athletes (Summers, 1997). The results of the present study showed that this variable also determines performance in the sprints of sedentary children and adolescents, indicating that the running technique of elite sprinters (Morin et al., 2003) optimizes the same variables that determine sprint performance in non-athletes.

Of course, elite performance includes

many factors that cannot be summarized in one or two variables. In 1996, Krantz studied and compared the stride patterns of Michael Johnson (MJ) and Marie-Jose Perec (MJP) at the 1996 Atlanta Olympic Games. Whereas MJ had a racing pattern showing more grasp than push, MJP showed greater push than traction. This difference may be explained by the specificity of their anthropometric features and the need to adapt their stride to achieve cost-effective performance. Despite their differences in racing pattern, both have been the best in their respective disciplines.

The results of this study show that performance improved with the increase in stride length. Many authors have demonstrated the relationships between stride length, sprint performance and ground contact time (Derrick et al., 1998; Mercer et al., 2002; Coh et al., 2001). Ground contact time was not measured in our study. However it raises the question of the relationship between strength and coordination. Indeed, better ground support could be interpreted as a better use of lower limb strength or simply as the result of stronger lower limbs.

Many authors have shown the relationship between physical fitness test results and pubertal stages. Pineau (1991) demonstrated that during puberty, explosive strength and vertical jump height changed in parallel with statural characteristics between Tanner stages 1 and 3. Bucheit (2008) demonstrated a significant correlation between short sprint test results and pubertal stage, from stage 2. In sprint running, since technical factors are so important, the role of coordination also needs to be addressed. Stride frequency and stride length must be in correct proportions to be efficient (Mero et al., 1992), but the variables representing stride length are widely used in predicting performance in sprint racing. Stride length reflects power, coordination, and the adaptation to morphological constraints. From 12 to 15 years for boys, the abrupt body changes and hormonal instability lead to a decrease in specific coordination (Cardinale and Stone, 2006). In the present study, we expected that disturbances in coordination would affect the stride pattern, with stride frequency and amplitude becoming unstable performance variables. This was not the case. Thus, our results indicated that the sprint

coordination patterns were not affected by the strong morphological changes associated with maturation. Indeed, it seems that not all types of motor function are affected by changes in body proportion (Weineck, 1996). In the present study, the increases in body size and muscle strength probably contributed more to increasing stride length, rather than affecting the race pattern.

Contrary to our hypothesis, the stepwise regression did not identify vertical jump height as a predictive variable of performance. According to findings on the relationship between lower limb strength and sprint performance (Morin and Belli, 2003; Sleivert and Taingahue, 2004), we can assume that the change in explosive power of the lower limbs would match changes in sprint running performance. One explanation is that during adolescence, the ability to run fast is not simply related to great ground forces, but also to a better impact of strength on stride length. Thus, better results on strength tests do not inevitably lead to greater sprint performance, which probably explains why strength tests are not systematically correlated with running velocity (Morin and Belli, 2003).

In conclusion, this study shows that although vertical jump height is most often described as the strongest predictor of sprint performance with increasing maturity, we found that it remained strongly correlated with sprint performance, but less so than stride length, which was a predictive variable for adolescents between 12 and 15 years old. Furthermore, it appears that with greater maturity, the subjects of this study spontaneously adopted a style of running similar to the current techniques of sprint racing. The stride number/height ratio seems to be a valid predictor of sprint performance, but this finding should be confirmed up to the last stage of puberty. In order to detect sprint potential, coaches should use a larger battery of tests that includes the assessment of stride length, which should be put into relation with body size. Further research is needed to confirm these results up to the last stage of puberty and to study the variables of stride length, particularly ground contact during sprinting.

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