

The effect of a physical activity intervention on selective markers of the metabolic syndrome in adolescents with low socio-economic status

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Innovation through diversity



NORTH-WEST UNIVERSITY
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Preface

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Declaration

The co-authors of the articles of this dissertation, Dr. Hanlie Moss (promoter), Prof. Salome Kruger (co-promoter) and Prof. Johannes van Rooyen, hereby give permission to the candidate, Mrs. Annemarié Zeelie to include the 4 articles as part of a PhD thesis. The contribution (advisory and supportive) of these co-authors was kept within reasonable limits, thereby enabling the candidate to submit this thesis for examination purposes. This thesis, therefore serves as fulfilment of the requirements for the PhD degree in Human Movement Science within the School of Biokinetics, Recreation and Sport Science in the Faculty of Health Sciences at the North-West University, Potchefstroom Campus.

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Summary

Background

Physical inactivity causes obesity, a condition which is related to insulin resistance, hypertension, diabetes mellitus, dyslipidemia and the metabolic syndrome (MS). MS is the collective description of lifestyle diseases associated with significant morbidity and premature mortality. MS has recently been observed in youth, and if left untreated could lead to cardiovascular diseases. Regular physical activity (PA) and exercise training appear to modify the independent risk factors for MS and cardiovascular diseases, and has a positive effect on waist circumference, blood pressure, body fat percentage, insulin sensitivity and arterial compliance.

Aims

The aim of this study was to determine the relationship between body composition and selective markers of the MS, and the extent to which a PA intervention programme will influence selective markers of the MS, body composition and markers of vascular function in black adolescents.

Methods

Grade 9 classes from two high schools, in a low socio-economic status area near Potchefstroom, participated as the experimental and control group respectively. The experimental group consisted of 194 participants and the control group of 57 participants. The experimental group participated in a 10-week PA intervention. Body mass index, stature, body mass, waist-hip ratio, waist circumference, hip circumference, body fat percentage, fasting serum insulin, fasting plasma glucose, plasma leptin, homeostasis model assessment of insulin resistance (HOMA-IR), systolic blood pressure (SBP), diastolic blood pressure (DBP), Windkessel arterial compliance (C_w), total peripheral resistance, Tanner-stage and habitual physical activity were measured.

The data were analysed by means of descriptive statistics, Mann-Whitney U-tests, analysis of covariance (ANCOVA), Pearson's correlation analyses and multiple regression models. HOMA-IR and leptin were log transformed before analyses because of the skewed distribution. The Statistica for Windows and SAS computer programmes were used to analyse the data according to the above-mentioned aims of the study.

Results and conclusions

Firstly, a significant positive association was found between body fat percentage and both SBP ($p=0.02$) and HOMA-IR ($p=0.02$) respectively. Girls with a high body fat percentage had higher SBP ($p=0.004$), DBP ($p=0.03$), plasma insulin ($p=0.004$) and HOMA-IR ($p=0.004$) than girls with normal body fat percentage. Secondly, a 10-week PA intervention led to a significant decrease in SBP ($p=0.000061$), a trend of decreasing HOMA-IR, and a trend of increasing C_w in black adolescents. Lastly, no significant differences were found in body composition and vascular function variables for the normal- and over-fat group in this study after the 10-week PA intervention.

In conclusion, the results of this study showed firstly, that there was a positive association between body fat percentage and SBP and HOMA-IR respectively; and secondly, that PA had a positive effect on some MS markers, namely: SBP and HOMA-IR. Further research regarding PA intervention's influence on the MS in black adolescents should be conducted, as there is clearly a shortage of literature that focuses on this research theme within this South African ethnic group.

Key words: Obesity, metabolic syndrome, physical activity, adolescents

Opsomming

Agtergrond

Fisieke onaktiwiteit veroorsaak obesiteit, 'n toestand wat verwant is aan insulienweerstandigheid, hipertensie, diabetes mellitus, dislipidemie en die metaboliese-sindroom (MS). Die MS is die saamgevatte beskrywing van leefstylsiektes geassosieer met betekenisvolle morbiditeit en premature mortaliteit. MS is onlangs waargeneem by die jeug, en indien dit nie behandel sou word nie, kan dit tot kardiovaskulêre siektes lei. Gereelde fisieke aktiwiteit (PA) en oefening dien voorts om die onafhanklike risikofaktore van kardiovaskulêre siektes te wysig, en het 'n positiewe effek op die middelomtrek, bloeddruk, persentasie liggaamsvet, insulien-sensitiwiteit en arteriële meegewendheid.

Doelstellings

Die doelwitte vir hierdie studie was om die verhouding tussen liggaamsamestelling en selektiewe merkers van die MS, asook die invloed van 'n PA-intervensieprogram op die selektiewe merkers van die MS, liggaamsamestelling en merkers van vaskulêre funksie in swart adolessente te bepaal.

Metodes

Graad 9-klasse van twee hoërskole in 'n gebied met 'n lae sosio-ekonomiese status naby Potchefstroom het deelgeneem aan die studie, respektiewelik as die eksperimentele en kontrolegroep. Die eksperimentele groep het uit 194 deelnemers bestaan, en die kontrole groep uit 57 deelnemers. Die eksperimentele groep het deelgeneem aan 'n 10-week PA-intervensie. Die liggaamsmassa-indeks, liggaamslengte, liggaamsmassa, middel-heup ratio, middelomtrek, heupomtrek, persentasie liggaamsvet, vastende seruminsulien, vastende plasma-glukose, plasma-leptien, insulienweerstandigheid (HOMA-IR), sistoliese bloeddruk (SBP), diastoliese bloeddruk (DBP), Windkessel arteriële meegewendheid (C_w), totale perifere weerstandigheid, demografiese inligting, Tanner-vlak en gebruiklike fisieke aktiwiteit (PDPAR) is gemeet.

Beskrywende statistiek, Mann-Whitney U-toetse, analises van kovariansie (ANCOVA), Pearson se korrelasie-analises en veelvuldige regressie-modelle is gebruik om die data te ontleed. HOMA-IR en leptien is voor die analises log-getransformeer as gevolg van die

skewe dataverspreiding. Die Statistica vir Windows en SAS-rekenaarprogramme is gebruik om die data volgens die bogenoemde doelstellings te analiseer.

Resultate en gevolgtrekkings

Eerstens is 'n betekenisvolle positiewe verwantskap tussen persentasie liggaamsvet met respektiewelik SBP ($p=0.02$) en HOMA-IR ($p=0.02$) gevind. Meisies met 'n hoër persentasie liggaamsvet het hoër SBP ($p=0.004$), DBP ($p=0.03$), plasma-insulien (0.004) en HOMA-IR ($p=0.004$) as die meisies met 'n normale persentasie liggaamsvet gehad. Tweedens het 'n 10-week PA intervensie tot 'n betekenisvolle afname in SBP ($p=0.000061$), 'n neiging tot die afname in HOMA-IR en 'n neiging tot 'n verhoging in C_w by swart adolessente gelei. Laastens is geen betekenisvolle verskille in liggaamsamestelling en die veranderlikes van vaskulêre funksie in die normaal- en oorvet groep waargeneem na 'n 10-week PA-intervensieprogram nie.

Ten slotte, die resultate van die studie het eerstens getoon daar 'n positiewe verwantskap tussen persentasie liggaamsvet met respektiewelik SBP en HOMA-IR bestaan. Tweedens dat PA 'n positiewe effek op sekere MS-merkers het, naamlik SBP en HOMA-IR. Verdere navorsing oor die invloed van 'n PA-intervensie op die MS by swart kinders moet gedoen word omdat daar duidelik 'n tekort van soortgelyke studies op dié Suid Afrikaanse etniese groep in the literatuur bestaan.

Sleutel terme: Obesiteit, metabooliese-sindroom, fisieke aktiwiteit, adolessente

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List of Abbreviations

A

ACSM American College of Sports Medicine

B

BF Body fat

BMI Body Mass Index

BP Blood pressure

C

CDC Centre for disease control

cm Centimetre

C_w Windkessel Arterial Compliance

D

d/w days per week

DBP Diastolic blood pressure

E

et al. And others

F

F Fisher's F-distribution

Fe Females

H

HDL-C High-density lipoprotein cholesterol

HOMA-IR Homeostasis model assessment of insulin resistance

HR Heart rate

I

ISAK International Society for the Advancement of Kinanthropometry

K

kg Kilogram

kg/m² Kilogram per meter squared

L

LDL-C Low-density lipoprotein cholesterol

M

M Males

m² Meter squared

MET Metabolic Equivalent

min Minutes

ml Millilitre

mmHg Millimetres of mercury

mmHg/ml Millimetres of mercury per millilitre

mmol/dL Millimol per decilitre

mmol/L Millimol per litre

MRC Medical Research Council

MS Metabolic syndrome

N

n Number of participants

NRF National Research Foundation

NS Non significant

P

p p-value (significant differences, $p < 0.05$)

PA Physical activity

PDPAR Previous day physical activity recall

PLAY Physical Activity in the Young

S

SBP Systolic blood pressure

SD Standard deviation

T

TC Total cholesterol

U

USA United States of America

V

$\dot{V}O_{2\max}$ Maximal oxygen uptake

W

WC Waist circumference

WHO World Health Organization

WHR Waist-hip-ratio

Y

y Year/ years

All abbreviations are indicated and explained where they first appear in the text, after which only the abbreviations are used.

List of Symbols

%	Percentage
[]	Concentration
μU	Micro unit(s)

CHAPTER 1

Introduction

1.1 INTRODUCTION

Obesity has become a global epidemic, and it is not only seen in adults but also in children and adolescents (Bullo *et al.*, 2003:525; Dedoussis *et al.*, 2004:1037). Obesity is related to insulin resistance, hypertension, diabetes mellitus, dyslipidaemia and coronary heart disease (Karasalihoglu *et al.*, 2003:452, Romon *et al.*, 2004:1227; Weiss *et al.*, 2004:2362). Obesity has also been found to be a key factor in the development of the metabolic syndrome (MS) (Klein-Platat *et al.*, 2005:1182). MS is the collective description of lifestyle diseases associated with significant morbidity and premature mortality (Ascott-Evans, 2002:187). The black adult population of South-Africa is disproportionately affected, with obesity rates being two to three times higher in the black population compared to the white population (Mollentze *et al.*, 1995:93). Therefore, black South African adolescents appear to be a group that is particularly vulnerable to obesity and thus MS.

The escalated incidence of obesity among adolescents proves to be a result of a combination of various lifestyle factors, most notable an increase in sedentary lifestyles (Epstein *et al.*, 2005:200), and high-energy diets which are rich in saturated fats. Paradoxically, the quantity of food provision in communities has increased, but the nutrient quality has lowered (Ritenbaugh *et al.*, 2003:317). It would therefore be necessary to take in more food in order to reach adequate nutrient levels. These changes with regard to food intake and lack of physical activity (PA), when combined, would result in obesity (Ritenbaugh *et al.*, 2003:317). Furthermore, an increase in age has been shown to be related to a decrease in PA participation (MRC, 2002:63), which further underlines the importance of instilling the value of PA in children and adolescents.

1.2 PROBLEM STATEMENT

Long considered a condition affecting only the developed world, obesity has now joined the ranks of underweight, malnutrition, and infectious diseases as a major health problem of the developing world (Haslam & James, 2005:1197). Globally, childhood obesity has reached epidemic proportions with 155 million school-aged children being either obese or

overweight (Noakes, 2004). In South Africa, more than 17% of adolescents are overweight and more than 4% are obese, according to the Youth Risk Behaviour Survey of 2002 (MRC, 2002:58). This is of serious concern as it has been found that obesity is a key factor in the development of diabetes and hypertension (Haslam & James, 2005:1197). About 18 million people die every year from cardiovascular diseases worldwide, for which diabetes and hypertension are major predisposing factors (Haslam & James, 2005:1197).

Even though clinical symptoms of cardiovascular risk factors appear only later in life, it is documented that risk-related behaviour patterns for coronary heart disease have their origins in childhood and adolescence (Froberg & Anderson, 2005:S34). One of the reasons for the increase in obesity is the fact that adolescents are no longer as physically active as they used to be a few decades ago (Epstein *et al.*, 2005:200). The Youth Risk Behaviour Survey of 2002 noted that a contributing factor to adolescent inactivity is the fact that 29% of South African adolescents have no physical education classes at school (MRC, 2002:66). Adolescents need to partake in PA regularly to reduce their risk of developing Type 2 diabetes and cardiovascular diseases such as hypertension (Ritenbaugh *et al.*, 2003:317). The benefits of regular PA are substantial as it plays a crucial role in the regulation and maintenance of an adolescent's body weight by decreasing the percentage body fat (ACSM, 2006:245). Regular PA also increases insulin sensitivity (Schmitz *et al.*, 2002:1310), slows down the normal loss of elasticity and compliance in the human cardiovascular system and can reverse some of the age-related declines in arterial stiffness (Tanaka *et al.*, 2000:1273). PA also has a significant negative relationship with blood lipids and blood pressure (McMurray *et al.*, 2002:125; Ritenbaugh *et al.*, 2003:309; Nassis *et al.*, 2005:1472; Nemet *et al.*, 2005:E443).

Studies designed to explore the influence of PA on the components of the MS in black South African adolescents are lacking. The vast majority of studies in African children focus on undernutrition (Bhutta, 2009:94) with precious few considering the alarming prevalence of increasing obesity. Therefore, the purpose of this study is to determine the relationship between body composition and markers of the metabolic syndrome as well as the effect of a 10-week physical activity intervention on the markers of the metabolic syndrome, body composition and vascular function.

The contribution of this research will be the exploration of the influence of a PA intervention on selective markers of the MS in black adolescents. The results will explore the relationship between body composition and fitness and markers of the metabolic syndrome and vascular function. These findings will contribute to the body of knowledge that is needed to influence policymakers in addressing physical activity levels in adolescents.

1.3 OBJECTIVES

The specific objectives of this study are to investigate:

- The relationship between body composition and selective markers of the MS in black adolescents.
- The influence of a 10-week PA intervention programme on selective markers of the MS in black adolescents.
- The influence of a 10-week PA intervention programme on body composition and vascular function in black adolescents.

1.4 HYPOTHESES

This study is based on the following hypotheses:

- There is a positive relationship between body composition components and selective markers of the MS in black adolescents.
- A 10-week PA intervention programme will significantly improve selective markers of the MS in black adolescents.
- A 10-week PA intervention programme will significantly improve body composition and vascular function in black adolescents.

1.5 STRUCTURE OF THE THESIS

This thesis is submitted in article format, as approved by the senate of the North-West University (Potchefstroom Campus). The articles have been submitted for publication in peer-reviewed journals. Chapters 1 and 6 are presented and referenced according to the guidelines of the North-West University (Harvard format). Chapters 2, 3, 4 and 5 are

presented according to the author's instructions for each journal. The guidelines to the authors are placed in the list of appendices.

This thesis is presented in five main parts, namely an introduction (Chapter 1), a narrative review article (Chapter 2), three research articles (Chapter 3, 4, 5) and finally a summary with conclusions and recommendations (Chapter 6). The introduction presents the problem statement, objectives and hypotheses of the study. The narrative review article considers the influence of PA on components of the MS and vascular function in children and adolescents. The research article 1 (Chapter 3), investigates the association between body composition and selective MS markers in black adolescents. The research article 2 (Chapter 4) investigates the impact of a 10-week PA intervention programme on selective MS markers in black adolescents. The research article 3 (Chapter 5) investigates the impact of a 10-week PA intervention programme on body composition and markers of vascular function in normal- and over-fat black adolescents. The results of the studies in Chapter 2, 3, 4 and 5 are presented and interpreted in each chapter respectively and then summarised in Chapter 6, together with the conclusions and recommendations. Chapter 6 is followed by a list of appendices.

Chapter 1: Introduction

Chapter 2: Article 1: The influence of PA on components of the MS and vascular function in adolescents (A narrative review) (*African Journal for Physical, Health Education, Recreation and Dance*)

Chapter 3: Article 2: The relationship between body composition and selective MS markers in black adolescents in South Africa: PLAY study (*International Journal of Applied and Basic Nutritional Sciences*)

Chapter 4: Article 3: The impact of a 10-week PA intervention programme on selective MS markers in black adolescents: PLAY study (*The South African Journal for Research in Sport, Physical Education and Recreation*)

Chapter 5: Article 4: The impact of a 10-week PA intervention programme on body composition and markers of vascular function in over-fat black adolescents:

PLAY study (*African Journal for Physical, Health Education, Recreation and Dance*)

Chapter 6: Summary, conclusions and recommendations

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CHAPTER 2

The influence of physical activity on components of the metabolic syndrome and vascular function in adolescents: a narrative review

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Submitted to the African Journal for Physical, Health Education, Recreation and Dance

ABSTRACT

Adolescents are no longer as physically active as a few decades ago. Inactivity causes obesity which is related to insulin resistance, hypertension, diabetes mellitus, dyslipidaemia, poor vascular health and the metabolic syndrome (MS). The MS has recently been observed in youth, and if left untreated it can lead to cardiovascular diseases. The aim of this research was to determine the influence of physical activity (PA) on the MS components and vascular function in children and adolescents by means of a narrative review of available studies (26 studies) focusing on habitual PA and physical interventions related to the MS and vascular function. The literature review was extensive, employing NEXUS, Science Direct, PubMed and Medline. The available evidence from studies suggested that increased PA and decreased sedentary behaviour may protect against the development of arterial stiffening, high blood pressure, -triglyceride levels, -glucose levels, -waist circumference and low high-density lipoprotein cholesterol values, all of which are associated with components of the MS.

Key words: Physical activity; metabolic syndrome; adolescents

INTRODUCTION

Adolescents are no longer as physically active as a few decades ago, with their lifestyle having become more sedentary (Deckelbaum & Williams, 2001). In South Africa, as in many other parts of the world, decreasing physical activity (PA) levels are contributing to the escalating trend in obesity (Kruger, Puoane, Senekal & Van Der Merwe, 2005), which in turn is a major risk factor for the development of many chronic diseases. Obesity plays a central role in the metabolic syndrome (MS), which includes hyperinsulinemia, hypertension, hyperlipidemia, Type 2 diabetes mellitus and atherosclerotic cardiovascular disease (Kelishadi, 2007). Conversely, research has shown that regular PA assists in lowering the chances of developing Type 2 diabetes and preventing cardiovascular diseases, hypertension and obesity (Ritenbaugh, Teufel-Shone, Aickin, Joe, Poirier, Dillingham, Johnson, Henning, Cole & Cockerham, 2003).

The purpose of this literature review was to determine the influence of PA on components of the MS and vascular function in children and adolescents by means of a narrative review of available studies (26 studies), focusing on habitual PA and PA interventions.

MATERIALS AND METHODS

Literature review

In order to ensure a comprehensive literature review, a computer-assisted search was conducted to identify all relevant studies published between 1990 and January 2009. The following databases were utilised: NEXUS, Science Direct, PubMed and Medline. Keyword filters related to PA (exercise, fitness, training), MS (insulin resistance syndrome, syndrome X), obesity (abdominal obesity, overweight), MS components (blood pressure, high-density lipoprotein cholesterol (HDL-C), triglyceride, abdominal obesity, fasting glucose, glucose intolerance, blood lipids, fasting insulin and waist circumference) and markers of vascular function (systolic blood pressure, diastolic blood pressure, arterial compliance and total peripheral resistance) were used to search. Additional information was obtained through literature-to-literature referencing, and each identified study was thoroughly investigated to ascertain any relevance to the topic. Randomised control trials and cross-sectional studies that considered the markers of MS and arterial compliance were included in this review.

RESULTS

The literature review focused on the topics of PA and associated MS markers and vascular function. Special attention was paid to studies pertaining to children and adolescents. A total of 26 randomised controlled trials as well as cross-sectional studies were used. Adolescents and children were classified as suffering from the MS if they met three or more of the criteria outlined by the National Cholesterol Education Programme Adult Treatment Panel III, which employs adapted cut-offs. Table 1 sets out these criteria.

Table 1: Assessing the metabolic syndrome: the national cholesterol education programme adult treatment panel III criteria, with adapted cut-offs for children

Criteria for the metabolic syndrome	Adapted cut-offs
Serum Triacylglycerol concentration	>90 th percentile
Serum HDL-C concentration	<5 th percentile
Systolic or diastolic blood pressure	>90 th percentile
Fasting plasma glucose	>6.1 mmol/L
Waist circumference	> 95 th percentile

[] = concentration; HDL = high-density lipoprotein cholesterol

(Jessup & Harrell, 2005:26)

Summaries of published studies about the influence of habitual PA and PA intervention studies on the markers of the MS and vascular function in children, adolescents and young adults are presented in Table 2 and Table 3 respectively. Information on the exercise intensity of physical activity interventions was not included in Table 3, due to the fact that the overwhelming majority of the studies did not report it.

Table 2: A summary of cross-sectional studies on the influence of habitual physical activity on the markers of the metabolic syndrome and vascular function in children, adolescents and young adults

Study	Number of Participants	Age (year)	Fitness or PA Assessment Method	Main finding
Kwee & Wilmore, 1990	399 M	8 - 15	$\dot{V}O_2$ max was determined by means of a treadmill test	Significant differences were found between fitness and body fat, plasma triglycerides, systolic and diastolic blood pressure respectively, with the higher fitness groups exhibiting significantly lower values
Armstrong, Williams, Balding, Gentle & Kirby, 1991	363 (164 Fe, 199 M)	11 - 16	$\dot{V}O_2$ max was determined by means of a treadmill test. Habitual PA was determined during three week days using self-contained computerised telemetry system	Skin fold thickness had a significant negative relationship with peak $\dot{V}O_2$ max. No significant relationship between PA, BP and TC
Bazzono, Cunningham, Varrassi, & Falconio, 1992	164 (84 Fe, 80 M)	10 - 17	Fitness was tested with the 1-mile (1.6 km) run, pull-ups and sit-ups	The sum of skin folds had a significant negative relationship with DBP in boys and with SBP in girls. Sit-ups were significantly associated with SBP for boys. No significant relationship between 1.6 km run performance and resting BP
Suter & Hawes, 1993	97 (58 Fe, 39 M)	10 - 15	Fitness was evaluated by a sub maximal exercise test, and habitual PA was assessed using a questionnaire	Significant negative relationship between PA and blood lipid profile
De Visser, Van Hooft, Van Doornen, Hofman, Orlebeke & Grobbee, 1994	154 Fe & M	7 - 32	Fitness was evaluated by a maximal exercise test, and habitual PA was assessed using a questionnaire	No significant relationship between PA and BP
Dwyer & Gibbons, 1994	2400 (1200 Fe, 1200 M)	11 - 15	Endurance fitness was measured as physical work capacity on a Monark bicycle ergometer	Significant negative relationship between aerobic fitness and SBP. This relationship was only partly accounted for by the compounding effect of lower body fatness in fitter children.

Table 2: A summary of cross-sectional studies on the influence of habitual physical activity on the markers of the metabolic syndrome and vascular function in children, adolescents and young adults (continued)

Study	Number of Participants	Age (year)	Fitness or PA Assessment Method	Main finding
Raitakari, Porkka, Taimela, Telama, Räsänen & Viikari, 1994	2358 (1244 Fe, 1114 M)	11 - 24	PA was assessed with a standardised questionnaire and a sum index was derived from the product of intensity, frequency, and duration of leisure time PA	Serum insulin and serum triglyceride concentrations were significantly lower in active young men, who also reported a lower TC:HDL-C than their sedentary counterparts. Among young women, significant differences were observed in adiposity and in serum triglyceride concentration
Hager, Tucker, & Seljaas, 1995	262 (100 Fe, 162 M)	9.79 ± 0.48	The 1-mile run was used to estimate fitness	Significant relationship between 1.6km run/walk performance and body fatness. Fit children had significantly lower TC, LDL-C and triglyceride levels and significantly higher HDL-C levels than unfit children, except after adjustment for body fat and/or abdominal fat
Raitakari, Taimela, Porkka, Telama, Välimäki, Åkerblom & Viikari, 1997	2358 (1244 Fe, 1114 M)	11 - 24	Original survey in 1980, with follow-ups in 1983 and 1986. PA was assessed with a standardised questionnaire, and a sum index was derived from the product of intensity, frequency and duration of leisure time PA	Significant positive relationship between PA and HDL-C in males. Significant negative relationship between PA and triglyceride in males and females
Twisk, Kemper, Van Mechelen, & Post, 1997	181 (98 Fe, 83 M)	13 - 27	$\dot{V}O_2$ max was determined by means of a treadmill test, and habitual PA was assessed using a questionnaire	No significant relationship between PA and TC
Reed, Warburton, Lewanczuk, Haykowsky, Scott, Whitney, McGavock & McKay, 2005	99 Fe & M	9 - 11	PA was assessed with a 7-day questionnaire	There was a significant association between high aerobic fitness levels and lower arterial stiffness

Table 2: A summary of cross-sectional studies on the influence of habitual physical activity on the markers of the metabolic syndrome and vascular function in children, adolescents and young adults (continued)

Study	Number of Participants	Age (year)	Fitness or PA Assessment Method	Main finding
Brunet, Chaput, & Tremblay, 2007	1140 (549 Fe & 591 M)	7, 8 & 10	Physical fitness was measured by speed shuttle run	BMI and WC had a significant negative relationship with physical fitness. These associations were more pronounced in older children
Krekoukia, Nassis, Psarra, Skenderi, Chrousos & Sidossis, 2007	27 obese and 27 lean Fe & M	9 - 11.5	Habitual PA was measured by a 4-day triaxial accelerometer, cardiorespiratory fitness was measured by a sub maximal bicycle ergometer test	Total and central adiposity had a significant positive relationship, and PA had a significant negative relationship with insulin resistance in children
Thomas, Greene, Ard, Oster, Darnell & Gower, 2009	32 Fe & M	12 - 18	PA was assessed over 8 days using accelerometer (counts per min)	PA had a significant positive relationship with both glucose tolerance and resting energy expenditure

BMI = body mass index; BP = blood pressure; DBP = diastolic blood pressure; d/w = days per week; Fe = females; HDL-C = high-density lipoprotein cholesterol; LDL-C = low density lipoprotein cholesterol; M = males; min = minutes; PA = physical activity; SBP = systolic blood pressure; TC = total cholesterol; $\dot{V}O_2$ Max = maximal oxygen uptake; WC = waist circumference; % = percent/ percentage

Table 3: A summary of published studies on the influence of physical activity interventions on the markers of the metabolic syndrome and vascular function in children and adolescents

Study	Number of Participants	Age (years)	Study Design	PA intervention	Main finding
Al-Hazzaa, Sulaiman, Al-Matar & Al-Mobaireek, 1994	91 M	7 - 12	Randomised trial	7 weeks, daily PA was assessed using heart rate telemetry. The heart rate monitor was attached to each boy for a period of 8 hours at the end of a school day	Significant negative relationship between PA and body fat percentage, SBP and DBP respectively, but no significant relationship between PA and blood lipids
Webber, Osganian, Feldman, Wu, McKenzie, Nichaman, Lytle, Edmundson, Cutler, Nader & Luepker, 1996	4019 Fe & M	8 - 9	Randomised trial	2½ year diet and PA intervention. Increasing moderate to vigorous activity in physical education class to 40% of class period	No significant changes in blood lipid status
Rimmer & Looney, 1997	25 Fe & M	14 - 17	Quasi-experimental design	15 weeks; 4d/w; 40 min; aerobic activities	Significant reduction in TC but not in HDL-C or TC: HDL-C
Ewart, Young, & Hagberg, 1998	99 Fe	9th grade	Randomised trial	18 weeks; 50 min; aerobic exercises	Experimental group had significantly greater decrease in SBP compared with control group
Owens, Gutin, Allison, Riggs, Ferguson & Thompson, 1999	74 Fe & M	7 - 11	Randomised trial	4 months; 5d/w; 40 min; aerobic exercises	Significant decrease in visceral adipose tissue
McMurray, Harrell, Bangdiwala, Bradley, Deng & Levine, 2002	1140 (630 Fe, 510 M)	11 - 14	Randomised trial	8 weeks; 3d/w; 30 min; aerobic exercises	SBP and DBP increased significantly more in the control group, independent of body weight loss. The BMI did not change significantly in the experimental group
Watts, Beye, Siafarikas, Davis, Jones, O'Driscoll & Green, 2004.	19 Fe & M	14 ± 2	Randomised trial	8 weeks; 3d/w; 60 min; circuit weight training	Aerobic activity restored endothelial reactivity to levels seen in lean participants

Table 3: A summary of published studies on the influence of physical activity interventions on the markers of the metabolic syndrome and vascular function in children and adolescents (continued)

Study	Number of Participants	Age (years)	Study Design	PA intervention	Main finding
Carrel, Clark, Peterson, Nemeth, Sullivan & Allen, 2005	50 Fe & M	12.5 ± 0.5	Randomised trial	9 months; 5 days every 2 weeks; 45 min	Significant decrease in body fat and fasting insulin and an increase in cardiovascular fitness
Nassis, Papantakou, Skenderi, Triandafilopoulou, Kavouras, Yannakoulia, Chrousos & Sidossis, 2005	19 Fe	13.1 ± 1.8	Observational study	12 weeks; 3d/w; 40 min; aerobic training	Significant increase in insulin sensitivity in overweight and obese girls without change in body weight and percentage body fat
Nemet, Barkan, Epstein, Friedland, Kowen & Eliakim, 2005	46 Fe & M	6 - 16	Randomised trial	3 month; 2d/w, 60min; aerobic exercises	Significant decrease in body weight, BMI, body fat percentage, TC, LDL-C and an increase in fitness
Reed, Warburton, Macdonald, Naylor & McKay, 2008	268 Fe & M	9 - 11	Randomised trial	12 months; 2d/w; 40 min; physical education classes and 5d/w; 15 min activities (e.g. skipping, dancing)	Experimental group had a significant increase in fitness and a smaller increase in blood pressure compared to the control group
Wong, Chia, Tsou, Wansaicheong, Tan, Wang, Tan, Kim, Boh & Lim, 2008	24 M	13 - 14	Randomised trial	12 weeks; 2d/w; 45-60 min; circuit-based resistance training and aerobic exercises	Exercise training significantly increase lean muscle mass and fitness and significantly decrease BMI, resting HR, SBP and triglycerides in obese boys

BP = blood pressure; BMI = body mass index; DBP = diastolic blood pressure; d/w = days per week; Fe = females; HDL-C = high-density lipoprotein cholesterol; HR = heart rate; LDL-C = low density lipoprotein cholesterol; M = males; min = minutes; PA = physical activity; SBP = systolic blood pressure; TC = total cholesterol; % = percent/ percentage

The results of the studies summarised in Tables 2 and 3 indicate some beneficial association, as well as non-significant relationships, between PA and components of the MS and vascular function. The available evidence from the studies suggests that increased PA and higher fitness levels are mostly protective against high blood pressure, increased arterial stiffness, -triglyceride levels, -glucose concentrations and -waist circumference and low HDL-C values, all of which are associated with cardiovascular heart disease and components of the MS.

DISCUSSION

The influence of habitual PA and PA interventions on the markers of the MS and vascular function in children, adolescents and young adults, as presented in Tables 2 and 3, are as follows:

Physical activity and markers of vascular function

PA intervention studies have suggested that PA or fitness decreases blood pressure in hypertensive adults (Dengel, Galecki, Hagberg & Pratley, 1998). Whether the same benefits can be seen in adolescents remain inconclusive (Thomas, Baker & Davies, 2003). While some studies indicate that decreased blood pressure levels are associated with increased levels of habitual PA (Kwee & Wilmore, 1990; Dwyer & Gibbons, 1994), other studies show no significant relationship between blood pressure and PA (Armstrong *et al.*, 1991; Bazzano *et al.*, 1992; de Visser *et al.*, 1994). It should be noted, however, that five of the PA intervention studies found a significant negative relationship between PA and blood pressure (Al-Hazzaa *et al.*, 1994; Ewart *et al.*, 1998; McMurray *et al.*, 2002; Reed *et al.*, 2008; Wong *et al.*, 2008). Furthermore, in one study blood pressure was significantly decreased after only a 7-week PA intervention (Al-Hazzaa *et al.*, 1994). The significant negative association between fitness and blood pressure was found to be either independent of body weight loss (Al-Hazzaa *et al.*, 1994; McMurray *et al.*, 2002), or only partly accounted for by lower body fatness (Dwyer & Gibbons., 1994). Similar to adults, obese children appear to be characterized by poor vascular health, which may contribute to this population's tendency towards high blood pressure (Watts *et al.*, 2004). In the study by Reed *et al.* (2005), aerobic fitness was associated with arterial compliance, supporting the concept that physical fitness may exert a protective effect on the cardiovascular system. In a study by Watts *et al.* (2004) exercise training normalized endothelial-dependent dilatation to levels seen in lean controls after an 8-week PA intervention programme. However, arterial reactivity returned to pre-

training levels within eight weeks following cessation from exercise, suggesting that vascular improvements from exercise training are transient and sensitive to the negative effects of obesity if children return to sedentary habits.

Physical activity and blood lipids

As shown in Tables 2 and 3, there is some controversy regarding the association between PA and the blood lipid profile. While some studies indicate that healthy blood lipid profiles are associated with increased levels of PA (Raitakari *et al.*, 1994; Hager *et al.*, 1995; Raitakari *et al.*, 1997; Suter & Hawes, 2003; Nemet *et al.*, 2005; Wong *et al.*, 2008), other studies have shown that there is no significant relationship between blood lipids and PA (Armstrong *et al.*, 1991; Al-Hazzaa *et al.*, 1994; Webber *et al.*, 1996; Twisk *et al.*, 1997). In one study, a 2½ year diet and PA intervention resulted in no significant change in blood lipid status (Webber *et al.*, 1996). However, another study showed that total cholesterol and LDL-cholesterol decreased after a mere 3-month PA intervention that only consisted of 60 minutes of aerobic exercises 2 days per week (Nemet *et al.*, 2005). A possible explanation for this controversy can be that blood lipids are affected by hormonal levels which can vary through the pubertal stage in adolescents (Jessup & Harrell, 2005). Total cholesterol decreases in mid-puberty and increases to adult levels at the end of puberty (Jessup & Harrell, 2005).

Physical activity and body composition

There is a significant negative relationship between cardiovascular fitness in adolescents and each of the following indicators respectively: body weight, BMI, and body fat percentage (Hager *et al.*, 1995; Carrel *et al.*, 2005; Nemet *et al.*, 2005; Wong *et al.*, 2008). Abdominal obesity/ central obesity, which has been indicated as a key component of the MS, (Klein-Platat, Draï, Oujaa, Schlienger & Simon, 2005) is negatively associated with PA levels (Owens *et al.*, 1999; Brunet *et al.*, 2007; Krekoukia *et al.*, 2007). As shown in Table 3, body weight, BMI and body fat percentages were significantly reduced after a 3-month PA intervention that consisted of 60 minutes of aerobic exercises, 2 days per week (Nemet *et al.*, 2005). However, in another study, adolescents' BMI, body weight and body fat percentage did not change significantly in the experimental group after an 8- or a 12-week PA intervention (McMurray *et al.*, 2002; Nassis *et al.*, 2005). A possible explanation for these different results can be that the 8-week PA intervention (McMurray *et al.*, 2002) was too short a time period to observe a change in body composition and that the 12-week PA

intervention (Nassis *et al.*, 2005) involved only 19 participants, forming a rather small group for determining a significant outcome.

Physical activity, fasting blood glucose and -insulin

A significant improvement of glucose metabolism and a significant decrease in fasting glucose and fasting insulin levels was found in adults who participated in PA interventions (Dengel *et al.*, 1998; Brekke, Lenner, Taskinen, Månson, Funahashi, Matsuzawa & Jansson, 2005; Thomas *et al.*, 2009). It must be remembered that insulin secretion and insulin resistance increase during puberty (Jessup & Harrell, 2005). Such increased insulin secretion may be caused by an increased amount of circulating growth hormones and changes in body composition (Jessup & Harrell, 2005). However, some PA intervention studies show a significant improvement in insulin sensitivity (Carrel *et al.*, 2005; Nassis *et al.*, 2005), e.g. one study consisting of a PA intervention that was only 12 weeks in duration and only consisted of aerobic exercises 3 days per week for 40 minutes per day (Nassis *et al.*, 2005). In the studies by Carrel *et al.* (2005) and Nassis *et al.* (2005), aerobic exercise training improved insulin sensitivity, independent of changes in body weight or body fat.

SUMMARY

As noted from the studies that constitute this literature review, PA has a positive effect on the components of the MS and vascular function. Blood pressure decreased after a 7-week PA intervention, arterial compliance increased after a 8-week PA intervention, insulin sensitivity increased and blood lipids, body weight and body fat decreased after a 12-week PA intervention. However, PA intervention studies similar to those described in Table 3 have not yet been performed with regard to black adolescents in African countries. Further research is necessary to determine whether PA would have similar effects on markers of the MS and vascular function in children, especially black children in developing countries. A regular PA routine is essential for long-term weight management and may have significant positive effects on cardiovascular risk factors.

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CHAPTER 3

The relationship between body composition and selective metabolic syndrome markers in black adolescents in South Africa: PLAY study

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ABSTRACT

Objective: The purpose of this study was to determine the relationship between body composition and selective markers of the metabolic syndrome in black adolescents. *Research Methods & Procedures:* The group consisted of 232 adolescent boys and girls aged 15-19 years attending two secondary schools in a low socio-economic status area of Potchefstroom, South Africa. Body mass (kg), stature (cm), waist- (WC) and hip circumferences were measured using standard methods. Body mass index (BMI) and waist:hip ratio (WHR) were calculated. Percentage body fat and lean body mass were measured by air displacement plethysmography. Fasting plasma insulin, fasting glucose, homeostasis model assessment of insulin resistance (HOMA-IR), systolic blood pressure (SBP) and diastolic blood pressure (DBP), were measured using standard methods. *Results:* Children with a high body fat percentage (boys > 20%, girls >25%) had significantly higher serum leptin concentration than children with normal body fat percentage (boys $p=0.005$, girls $p<0.0001$). Girls with a high body fat percentage also reported significantly higher SBP ($p=0.004$), DBP ($p=0.03$), plasma insulin ($p=0.004$) and HOMA-IR ($p=0.004$) than girls with normal body fat percentage. Body fat percentage had a significant positive association with HOMA-IR ($p=0.02$) and SBP ($p=0.02$), respectively. A significant positive correlation was also found between plasma leptin concentration and BMI ($p<0.0001$), WC ($p<0.0001$), body fat percentage ($p<0.0001$) and fat:height index ($p<0.001$). *Conclusion(s):* A significant positive association was found between body fat percentage and both SBP and HOMA-IR respectively. Girls with a high body fat percentage had significantly higher BP, plasma insulin and HOMA-IR than girls with normal body fat percentage, indicating risk of non-communicable diseases.

Key words: Body composition; systolic blood pressure; insulin resistance; metabolic syndrome; adolescents

INTRODUCTION

The prevalence of obesity amongst adults and children in both developed and developing countries has reached epidemic proportions [1-3]. Of greatest concern is the fact that the increase in overweight and obesity is related to insulin resistance (HOMA-IR), hypertension, diabetes mellitus, dyslipidaemia, coronary disease and increased serum leptin levels [4-7]. Increases in the severity of obesity have also been shown to be related to the prevalence of the metabolic syndrome (MS) among children and adolescents [4]. Therefore, early identification of adolescents at risk of developing obesity is essential for the prevention of premature mortality [8].

Children in Africa are generally regarded to be predominantly underweight and the focus of recent research has been on undernutrition [9]. South Africa, however, has a low prevalence of underweight children (which may be due in part to the country's positive economic growth) [10]. Indeed, the Youth Risk Behaviour Survey (n = 9 054), conducted in 2002, found that more than 17% of South African adolescents were overweight, and 4.2% obese [11]. This trend is set to continue: based on the results of a regional school-based health and fitness survey of almost 5 000 children aged 12-18 years. It is estimated that the future prevalence of obesity in 18 year old girls will be 37% for black girls, 10% for caucasian girls and 20% for girls of mixed ancestry [10]. The factors that are causing this trend include sedentary behaviour and passive overeating, as well as socio-cultural and economic influences and an obesogenic environment [3].

Even though this trend has been identified, studies designed to explore the relationship between body composition and selective metabolic markers in black African adolescents are lacking [12;13] as the focus in developing countries is still on treating undernutrition [14]. Limited information is also available regarding the metabolic consequences of black adolescents in particular being overweight [15]. This being the case, the purpose of this investigation is to determine the relationship between body composition and selective metabolic syndrome markers in black South African adolescents.

MATERIALS AND METHODS

Sample and study design

This cross-sectional study formed part of the **Physical Activity in the Young Study (PLAY)** and was conducted in a low socio-economic area in the North-West Province of South Africa. The setting and design of the study is described by Mamabolo *et al.* [12] and Swanepoel *et al.* [13]. All available adolescents, 251 boys and girls, in the grade 9 class (15-19 years) attending two secondary schools, were recruited and informed consent was obtained from 232 children, of whom 180 received parental consent to give blood samples. The adolescents came from two schools where the situations were similar with regard to growth phase, socio-economic status, diet and physical activity profiles [12]. The schools were selected according to the advice of the district nutrition advisor, who identified the schools that were most at risk of undernutrition. The main focus of the PLAY-study was to investigate children at risk of undernutrition, as earlier studies in the North-West Province of South Africa had found that undernourished children have a unique body composition, with a relatively low proportion of lean body mass and a relatively higher proportion of body fat [16].

Ethical considerations

The PLAY study was approved by the Ethics Committee of the North-West University, Potchefstroom Campus (no. 04M01) as well as by the principals of the participating schools. Informed consent was obtained from both the adolescents and their parents or guardians for participation in the study and the collection of blood samples.

Measurements

Participants were measured in a controlled environment in groups of between 40-50 participants per day over a period of one week. Upon arrival fasting blood samples were taken after which body fat percentage, lean body mass, blood pressure (BP) and anthropometric measurements were performed. The participants were then presented with light refreshments, after which the habitual physical activity (PDPAR), demographic information and Tanner stage questionnaires were completed.

Body composition

BMI was determined from the stature (cm) of participants by a vertical stadiometer using the stretch-method to the nearest 0.1 cm and body mass by means of a calibrated electronic

scale (Precision, A&D Company, Saitama, Japan) to the nearest 0.1 kg [17]. The circumferences were measured with a flexible steel tape (Lufkin, Cooper Tools, Apex, NC) to the nearest 0.1 cm of the waist at the narrowest part between the lower rib and the iliac crest and the hips across the broadest part over the buttocks. The waist-hip ratio (WHR) was calculated by dividing the waist circumference (WC) by the hip measurement [17]. Fat mass, body fat percentage and lean body mass were measured by means of air displacement plethysmography (ADP, BOD-POD, Life measurement Inc, Concord, CA) according to standard guidelines [18]. Fat:height index was calculated as the ratio of fat mass (kg) divided by height in meters squared. Girls with a body fat percentage larger than 25% and boys with a body fat percentage larger than 20% were classified as having a high body fat percentage [19].

Biochemical analysis

An over-night (12 hours) fasting sample of 20 ml blood was taken from each participant for all biochemical analyses of the study. Blood samples for plasma were collected in ethylenediamine tetra-acetate-(EDTA)-coated venepuncture tubes. The plasma and serum were immediately separated and stored in Eppendorff tubes at -80°C until the analyses were performed. Fasting serum insulin was measured according to the microparticle enzyme immunoassay (MEIA) AxSYM-method, (Abbott, Wiesbaden, Germany). The inter-assay coefficient of variation (CV) for insulin was 5.7% and the intra-assay CV was 3.8%. Insulin sensitivity was measured by means of the Quantitative Insulin sensitivity Check Index (QUICKI) [20]. HOMA-IR was calculated according to the equation proposed by Matthews *et al.* [21]. For blood glucose concentrations, blood was sampled in sodium fluoride and calcium oxalate tubes. Plasma glucose was measured by means of Vitros DT60 II Chemistry Analyser (Ortho-Clinical Diagnostics, Rochester, NY, USA) with VITROS reagents and control. The inter-assay CV for plasma glucose was 2.1% and the intra-assay CV was 1.2%. Plasma leptin concentrations were determined by using an immunoradiometric assay (Active Human Leptin IRMA, DSL-23100, Diagnostic System Laboratories Inc., Webster, TX, USA). The inter-assay CV for plasma leptin was 5.1% and the intra-assay CV was 3.2%. All plasma or serum samples were run in the same assay for each test in an accredited laboratory (Ampath, Pretoria, South Africa).

Blood pressure

A continuous BP measurement was recorded for a period of at least 5 minutes by means of the Finometer apparatus (FMS, The Netherlands) to obtain both systolic blood pressure (SBP) (mmHg) and diastolic blood pressure (DBP) [22].

Tanner

The Tanner-stage questionnaires were used to determine the level of physical maturity in boys and girls. Trained adults of the same gender as the child administered the questionnaire in a private room. Classification for Tanner 1 was PH1 (no pubic hair) to PH5 (adult stage). Classification for Tanner 2 is MA1 (no breasts) to MA5 (adult stage) for girls. Genital development in boys is classified from level 1 (no enlargement) to level 5 (adult stage). A sketch with descriptions of the five stages of development in boys and girls was shown to the participants, who then indicated their own development level [23].

The Previous Day Physical Activity Recall (PDPAR)

Trained field workers were employed to collect information from respondents regarding their level of physical activity on one given weekday and one given weekend day. This method of classifying PA, called the PDPAR, developed by Trost *et al.* [24], uses a 24 hour recall list to classify respondents as vigorously, moderately active or inactive. According to this method respondents were asked to list their PA of the given day in 30 minute time frames, on an activity list. Using a difficulty factor, the type as well as intensity of activity was classified as high, medium or low. The metabolic equivalent (MET) values of PA were taken from *The Compendium of physical activities*, and the energy usage list was taken from the PDPAR [25]. The number of 30-minute periods with a MET value of 3 METs or more, as well as 30-minute periods with a MET value of 6 METs or more, was aggregated. Respondents were classified as vigorously active if two or more 30-minute periods had been coded as 6 METs or more, moderately active if two or more 30-minute periods had been coded as 3-5 METS and inactive if a respondent failed to meet the criteria for high or medium PA [26].

Statistical analysis

Statistical computer software (Statistica 2007, Stat Soft, Inc. for Windows, Tulsa, OK) was used for the analysis of the collected data [27]. Data are presented as means \pm standard deviations. Children were divided into two groups based on body fat percentage.

Comparisons between the groups with different body fat percentage were made using Mann-Whitney U-tests. Associations between body composition and metabolic variables were assessed using Pearson's correlation analyses, with adjustment for gender and Tanner stage. The relationships between variables were then analysed using multiple regression models. Interactions between body fat percentage and the different metabolic marker variables (HOMA-IR, SBP, leptin) were tested, with covariates gender, Tanner stage and habitual physical activity (PDPAR score), as well as height in the model, and SBP as the dependent variable. Because no interaction was observed with sex, all the results are presented with both sexes pooled. HOMA-IR and leptin were log transformed before analyses because of the skewed distribution of the data.

RESULTS

Anthropometric and biochemical characteristics of the normal- and high body fat percentage participants are presented in Table 1. In contrast to these categories based on % BF, only 4.1% of the boys and 9.9% of the girls had a BMI above the cut-off points proposed by Cole *et al.* [28] for overweight and obesity. It is evident that the boys with a high body fat percentage had a significantly higher BMI, hip circumference and serum leptin concentrations than the boys with normal body fat percentage. Similarly, the girls with high body fat percentage had significantly higher BMI, WC, hip circumference and leptin, as well as higher SBP, DBP, fasting insulin concentrations, and HOMA-IR than the girls with a normal body fat percentage.

Table 1
Age, anthropometric and biochemical characteristics of participants with normal body fat % and high body fat % (mean ± SD)

Variables	Body fat % $\leq 20\%$	Body fat % $> 20\%$	p-value†	Body fat % $\leq 25\%$	Body fat % $> 25\%$	p-value†
	Boys (n= 72)*	Boys (n= 27)*		Girls (n= 29)*	Girls (n= 104)*	
Age (y)	15.8 ± 1.3	15.5 ± 1.3	NS	15.2 ± 0.8	15.5 ± 1.4	NS
BMI (kg/m ²)	18.1 ± 1.9	19.8 ± 3.3	0.03	18.0 ± 2.2	21.3 ± 3.1	<0.0001
Waist circumference (cm)	64.9 ± 4.5	67.4 ± 6.4	NS	60.2 ± 4.4	65.8 ± 5.8	<0.0001
Hip circumference (cm)	77.9 ± 5.4	81.7 ± 7.8	0.04	80.2 ± 5.6	87.3 ± 7.4	<0.0001
Waist-to-hip ratio	0.84 ± 0.06	0.83 ± 0.04	NS	0.75 ± 0.05	0.75 ± 0.04	NS
Body fat (%)	14.3 ± 2.8	26.0 ± 5.0	<0.0001	20.3 ± 4.6	31.8 ± 4.8	<0.0001
Systolic blood pressure (mm Hg)	98 ± 11	103 ± 13	NS	94 ± 12	99 ± 10	0.004
Diastolic blood pressure (mm Hg)	61 ± 11	61 ± 10	NS	60 ± 8	64 ± 8	0.03
	Boys (n= 50)*	Boys (n= 18)*		Girls (n= 25)*	Girls (n= 87)*	
Fasting serum insulin (pmol/L)#	8.8 ± 6.7	8.9 ± 7.8	NS	7.4 ± 4.3	10.9 ± 6.8	0.004
Fasting plasma Glucose (mmol/L)	5.3 ± 0.6	5.3 ± 0.3	NS	4.8 ± 0.3	5.0 ± 0.4	NS
HOMA-IR#	2.1 ± 1.6	2.2 ± 2.1	NS	1.6 ± 1.0	2.5 ± 1.8	0.004
Plasma Leptin (ng/ml)#	2.38 ± 0.8	6.5 ± 5.0	0.005	10.6 ± 6.6	21.9 ± 11.9	<0.0001
Participants with one or more markers of the metabolic syndrome † (n, %)	8 (16%)	12 (66.7%)		2 (8%)	14 (16.1%)	

BMI, Body mass index; HOMA-IR, homeostasis model assessment of insulin resistance; SD, standard deviation; NS, non significant; n, number; %, percentage

Tested with log transformed values, HOMA-IR= [(fasting insulin (μU/ml)) × (fasting venous glucose (mmol/L))/22.5]

*Participant number varied due to missing variables, †Difference between groups tested using Mann-Whitney U-test

†Waist circumference above the 95th percentile for age and gender, blood pressure above the 90th percentile for gender and height, or fasting blood glucose >6.1mmol/L

Among the anthropometric variables there was a strong correlation between BMI and WC ($r=0.84$, $p<0.001$), fat:height index ($r=0.75$, $p<0.001$) and body fat percentage ($r=0.60$, $p<0.001$), but no significant correlation between BMI and WHR ($r=0.12$, $p=0.11$). Of all anthropometric variables fat:height index ($r=0.75$, $p<0.001$) showed the strongest correlation with body fat percentage, compared to the correlation between BMI and body fat percentage of $r=0.60$. Table 2 presents the partial correlation between body composition and selective MS markers and plasma leptin in all participants. It is important to note that even though some p-values are smaller than 0.05, correlation was generally weak as most of the r-values are below 0.5. A significant positive correlation was found between body fat percentage and SBP ($p=0.02$), fasting plasma insulin ($p=0.02$), HOMA-IR ($p=0.02$) and plasma leptin ($p<0.0001$) respectively. A significant positive correlation was found between WC and SBP ($p<0.0001$), DBP ($p<0.0001$) and plasma leptin ($p<0.0001$), respectively. A significant positive correlation was found between all the selective MS markers and BMI. A significant positive correlation was also found between BMI ($p<0.0001$), WC ($p<0.0001$), body fat percentage ($p<0.0001$) and fat:height index ($p<0.001$) with plasma leptin concentration.

Table 2

Partial correlation between body composition and selective metabolic syndrome markers and leptin in all participants (adjusted for gender and Tanner stage)¹

Selective metabolic syndrome markers	Body Composition (n=232)				
	BMI (kg/m ²)	WC (cm)	WHR	Fat:height index	Body fat (%)
Systolic blood pressure (mm Hg) (n=228)	r= 0.27 p< 0.0001*	r= 0.37 p< 0.0001*	r= 0.04 p= NS	r=0.14 p= NS	r= 0.17 p= 0.02*
Diastolic blood pressure (mm Hg) (n=228)	r= 0.22 p= 0.001*	r= 0.26 p< 0.0001*	r= 0.12 p= NS	r= 0.07 p= NS	r= 0.05 p= NS
Fasting plasma insulin (pmol/L) [#] (n=180)	r= 0.20 p= 0.01*	r= 0.15 p= 0.057(NS)	r= 0.004 p= NS	r=0.14 p= 0.08(NS)	r= 0.19 p= 0.02*
Fasting plasma glucose (mmol/L) (n=180)	r= 0.16 p= 0.04*	r= 0.09 p= NS	r= 0.06 p= NS	r= 0.06 p= NS	r= 0.10 p= NS
HOMA-IR [#] (n=180)	r= 0.21 p= 0.007*	r= 0.16 p= 0.05	r= 0.01 p= NS	r= 0.14 p= 0.08(NS)	r= 0.19 p= 0.02*
Plasma leptin (ng/ml) [#] (n=180)	r= 0.59 p< 0.0001*	r= 0.65 p< 0.0001*	r= 0.16 p< 0.059 (NS)	r= 0.64 p< 0.001*	r= 0.66 p< 0.0001*

¹ All values are β estimates \pm Ses. BMI, Body mass index; HOMA-IR, homeostasis model assessment; WC, waist circumference; WHR, waist-hip ratio

[#] Tested with log transformed values, HOMA-IR= [(fasting insulin (μ U/ml)) \times (fasting venous glucose (mmol/L))/22.5]

* Significant difference between participants with normal and high body fat % (p<0.05)

Tables 3 and 4 display the multiple regression analyses of the association between body fat percentage and HOMA-IR, and body composition and SBP with gender, Tanner stage and physical activity as covariates. Body fat percentage and Tanner stage had a significant association with HOMA-IR, and there was a trend of a negative association between physical activity and HOMA-IR.

As shown in Table 4, even with the statistically significant positive association between SBP and stature in the model, body fat percentage had a significant association with SBP. Gender and Tanner stage did not have a significant association with SBP. The r^2 for the associations were both small (0.07 and 0.14 respectively) indicating the factors in the model explained only 7% and 14% of the variation in HOMA-IR and SBP, respectively.

Table 3

Multiple regression for the association between body fat percentage and HOMA-IR

Co-variates	T	p
Gender (1=male, 2= female)	-0.34	ns
Body fat %	2.31	0.02*
Tanner stage	2.62	0.009*
Habitual physical activity (PDPAR score)	-0.8	ns

Whole model $F=3.89$; $p=0.005$

Adjusted $r^2=0.07$

PDPAR = previous day physical activity recall

Table 4

Multiple regression for the association between body composition and systolic blood pressure

Co-variates	T	P
Gender (1=male, 2= female)	-1.7	0.09
Height	4.8	<0.0001*
Body fat %	3.0	0.003*
Tanner stage	0.2	ns
Habitual physical activity (PDPAR score)	-0.19	ns

Whole model $F=7.1$; $p<0.0001$

Adjusted $r^2=0.14$

PDPAR = previous day physical activity recall

DISCUSSION

Undernutrition is a large problem in developing countries [9]. Paradoxically, the rise of obesity among children in such countries has now also become a cause for concern, with the associated condition of heart disease projected to become the leading cause of death in developing countries by 2010, according to the World Health Organisation [29]. As obesity is now recognised as a public health epidemic, the WHO and others have started advocating public health promotion through both legislation and community level programs recommending exercise and better nutrition [29].

The increase in obesity is related to insulin resistance, hypertension, diabetes mellitus, dyslipidaemia, coronary heart disease and increased leptin levels, culminating in the MS [4-7]. The MS is characterised by the linking of hyperinsulinemia/insulin resistance, dyslipidaemia and obesity to hypertension through a shared association with hyperinsulinemia/insulin resistance [5]. However, there is limited data on the prevalence of the MS in the pediatric populations of developing countries available [15]. In the limited number of studies on this subject, it was shown that overweight was more prevalent in urban girls than in rural girls and more prevalent in girls with a higher socio-economic status than in those with a lower socio-economic status. Participants recruited for the present study were living in a low socio-economic township in the North-West Province, South Africa.

The purpose of this investigation was to determine the relationship between body composition and selective markers of the metabolic syndrome in black adolescents in South Africa. The results of the study indicate that there is a significant positive association between body fat percentage and SBP and HOMA-IR respectively. It is evident that the boys with a high body fat percentage had a significant higher BMI, hip circumference and serum leptin concentrations than the boys with normal body fat percentage. Similarly, the girls with high body fat percentage had significantly higher BMI, WC, hip circumference, serum leptin concentration, and also SBP, DBP, fasting insulin concentrations and HOMA-IR than the girls with a normal body fat percentage. BMI, WC, body fat percentage and fat:height index showed a significant correlation with plasma leptin concentration in the adolescents.

There were signs of high BP among the children and most girls had a high percentage body fat. In a study by Wilson *et al.* [30], adolescents in low socioeconomic status environments were more susceptible to illnesses such as hypertension and cardiovascular diseases. It was

hypothesised that a higher level of parental education and/or income would reduce the elevated BP reactivity associated with living in poorer neighbourhoods [30]. Environmental stressors such as noise, overcrowding, and violence, or economic stressors such as chronic poverty, may abound in urban neighbourhoods, which may in turn have an effect on essential hypertension and related health outcomes in children and youth [31]. The exposure to chronic stressors interacts with biological, behavioral and psychological risk factors to increase sympathetic nervous system activity [32]. The repeated stressor-induced episodes of vascular reactivity from chronic stress may lead to structural changes in the vascular wall, which in turn elevate BP responses which may not be related to body composition [32].

However, Wilks *et al.* [33] reported the association of BP with both weight and height. In consensus with the findings reported in the literature, this study (Table 4) indicated that SBP was positively associated with height (see Table 4) [34;35]. The findings emphasize that height offers more precision in calculating high BP in children and adolescents and support the recommendations of the updated American Task Force Report [36]. For this reason height of the children was introduced as a covariate in the regression model with SBP as the dependent variable. Tanner stage and gender was not significantly associated with SBP (Table 4), but there was a positive association between body fat percentage and SBP. In a study by Jaddou *et al.* [37], SBP and DBP values for both male and female students increased as they grew older, but the pattern of increase was somewhat different among various age-sex categories as the SBP values were significantly higher among males. De Cesaris *et al.* [38] reported that an increase in BP was positively related to menarche. Elevated BMI in childhood predicted risk of hypertension in young adulthood [39]. Because of the long-term health implications of chronic environmental stressors, understanding how community and family factors may affect children's BP responses should be a major focus of future research.

In Table 1 it is noted that the girls with high body fat percentage had a significantly higher SBP, DBP, HOMA-IR and serum leptin concentration than the girls with normal body fat percentage. A possible explanation for this may be the fact that the relationship between fasting insulin and BP is partially confounded by differences in body size expressed as BMI or body weight [40]. Insulin resistance and hyperinsulinemia appear to develop in obese children at an early age [41]. Insulin resistance plays a role in the development of hypertension [42]. In a study by Cruz *et al.* [40], it was found that insulin resistance was a

more important determinant of SBP in children than body fat. Furthermore it was found that black ethnicity and decreased insulin sensitivity were independently related to elevated BP even at an early age [40].

In Table 2 a medium strength significant positive correlation between BMI, WC and body fat percentage with plasma leptin concentrations were observed. In this study, a significant positive correlation was found between plasma leptin concentration and BMI, WC, body fat percentage, fat:height index, respectively. Leptin concentrations increase directly proportional to an individual's fat mass or body fat percentage [7]. Overweight and obese individuals therefore have higher serum leptin levels than their lean counterparts [43]. Furthermore, a direct effect of increased plasma leptin in skeletal muscle may play a major role in the development of insulin resistance and obesity [44].

HOMA-IR was significantly associated with Tanner stage and body fat percentage in this study. Body fat mass and insulin sensitivity changed markedly during periods of growth and maturation [5;45]. Insulin resistance increases during puberty, as insulin sensitivity is reduced in both non-diabetic and diabetic children, and therefore the body produces more insulin [45]. This increased insulin secretion can be caused by an increase in circulating growth hormones and changes in body composition [45]. These changes in insulin sensitivity during puberty are sex-dependent and relates to changes in body composition [45].

LIMITATIONS

A limitation of this study was the small number of participants who consented to blood sampling, which made the sample size relatively small.

CONCLUSION

A significant positive association was found between body fat percentage and both SBP and HOMA-IR respectively. Girls with a high body fat percentage had higher BP, plasma insulin and HOMA-IR than girls with normal body fat percentage, indicating risk of non-communicable diseases.

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CHAPTER 4

The impact of a 10-week physical activity intervention programme on selective metabolic syndrome markers in black adolescents: PLAY study

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ABSTRACT

The purpose of this study was to determine the effects of a 10-week physical activity (PA) intervention on selective metabolic syndrome markers in black adolescents. All available adolescents (194 participants), boys and girls, in the grade 9 class (15-19 years) attending a secondary school were recruited for the experimental group. A control group consisting of 57 adolescents from grade 9 of another secondary school in the same area was also recruited. The experimental group participated in a 10-week PA intervention. Body mass index (BMI), fasting insulin, fasting glucose, homeostasis model assessment of insulin resistance (HOMA-IR), systolic blood pressure (SBP), diastolic blood pressure (DBP), windkessel arterial compliance (C_w), total peripheral resistance (TPR) and waist circumference were measured. After the 10-week PA intervention, adolescents from the control group had a significantly lower DBP compared to the experimental group ($p=0.00005$) and adolescents from the experimental group had a significantly lower SBP compared to the control group ($p=0.000061$). There was also a tendency towards a higher C_w and lower HOMA-IR in the experimental group compared to the control group. The findings of this study suggest that the experimental group had significantly lower SBP and lower HOMA-IR compared to the control group after a 10-week PA intervention.

Key words: Physical activity; metabolic syndrome; adolescents

INTRODUCTION

Adolescents are no longer as physically active as a few decades ago (Deckelbaum & Williams, 2001; Dwyer *et al.*, 2009). Low levels of physical activity (PA) are widely assumed to be involved in the etiology of obesity and underlie public health messages globally (Must & Tybor, 2005). In South Africa the occurrence of obesity is two to three times higher in the black population than in the white population (Punyadeera, 2000). This significantly higher rate of obesity in the black population is of serious concern, because the metabolic syndrome (MS) is high among obese children and adolescents (Weiss *et al.*, 2004). The MS is defined by the clustering of metabolic abnormalities, primarily overweight and more specifically central obesity, insulin resistance, dyslipidaemia and hypertension (Klein-Platat *et al.*, 2005; Jennings *et al.*, 2009). The MS affects a great number of adolescents (Jessup & Harrell, 2005; Day *et al.*, 2009) and is related to cardiovascular risk (Klein-Platat *et al.*, 2005; Day *et al.*, 2009; Leite *et al.*, 2009). However, studies designed to explore the influence of a PA intervention on the components of the MS in black South African adolescents are lacking. This is a significant shortcoming in the study of the MS in South Africa, especially as previous studies in the US have found that black children, as compared to their white counterparts, had a higher prevalence of obesity (Schuster *et al.*, 1998; Deckelbaum & Williams, 2001), were more insulin resistant (Schuster *et al.*, 1998) and had higher blood pressure, independent of adiposity (Cruz *et al.*, 2002).

Adolescents require monitoring, as risk-related behaviour patterns for coronary heart disease have their origin in childhood and adolescence (Day *et al.*, 2009). Adolescents need to partake in PA on a regular basis to reduce their risk of developing Type 2 diabetes and cardiovascular diseases like hypertension (Ritenbaugh *et al.*, 2003). The benefits of regular PA are substantial as PA plays a crucial role in the regulation and maintenance of an adolescent's body weight by decreasing the percentage body fat (ACSM, 2006). Regular PA also increases insulin sensitivity (Schmitz *et al.*, 2002), slows down the normal loss of elasticity and compliance in the human cardiovascular system and can reverse some of the age-related declines in arterial stiffness (Tanaka *et al.*, 2000). PA also has a significant negative relationship with blood lipids and blood pressure (McMurray *et al.*, 2002; Ritenbaugh *et al.*, 2003; Nassis *et al.*, 2005; Nemet *et al.*, 2005).

Studies of PA interventions on American adolescents have indicated a positive effect on MS markers (McMurray *et al.*, 2002; Ritenbaugh *et al.*, 2003; Nassis *et al.*, 2005; Nemet *et al.*,

2005), but no such study has been conducted on black adolescents in a South African setting. This exploratory study sought to address this undesirable state of affairs by analysing the effects of a 10-week PA intervention on selective markers of the MS in black boys and girls aged 15 to 19 years.

METHODS

Sample and study design

The Physical Activity in the Young (PLAY) study was a pre-test, intervention, post-test study design that included an experimental group and a control group. The experimental group was subjected to a PA intervention programme while the control group received health information only on a single health promotion day at the school. The setting and design of the study were described by Mamabolo *et al.* (2007) and Swanepoel *et al.* (2007). All available adolescents, boys and girls, in the grade 9 class (15-19 years) attending a secondary school in the low socio-economic status (SES) area of Ikageng township (North West Province, South Africa) were recruited for the experimental group. A total of 194 adolescents were in the experimental group (96 boys and 98 girls). Another 57 adolescents (16 boys and 41 girls) from grade 9 of another secondary school in the same low SES area were recruited for the control group. These schools were selected from a total of five high schools in the low socio-economic township, because they were attended only by adolescents from the surrounding neighbourhoods. The adolescents' status was similar with regard to growth phase, SES, diet and PA profiles.

Ethical considerations

The PLAY study was approved by the Ethics Committee of the North-West University, Potchefstroom Campus (no. 04M01) as well as the school principals. Consent was obtained from the adolescents' parents and from the adolescents for participation in the study and the collection of blood samples.

Measurements

The adolescents were transported to the university in groups of 20-30 per day for baseline- and end measurements before and after the PA intervention programme. Data were collected over a period of one week at baseline and after the intervention, respectively. The measuring sequence was as follows: Fasting blood samples were taken upon arrival in the morning. The participants were then taken to the remaining workstations, namely air displacement

plethysmography (BOD-POD), blood pressure and anthropometry workstations. The participants were provided with light refreshments before being guided to the demographic, PA and Tanner-stage questionnaire workstations.

Body composition

Body composition was compiled by determining the body mass index (BMI), waist-hip ratio (WHR) and percentage body fat. BMI was determined from the height (cm) by a vertical stadiometer using the stretch-method (ISAK, 2001) to the nearest 0.1 cm and body mass by means of a calibrated electronic scale (Precision, A&D Company, Saitama, Japan) to the nearest 0.1 kg. The circumferences were measured with a flexible steel tape (Lufkin, Cooper Tools, Apex, NC) to the nearest 0.1 cm. The measures of the abdomen (across the smallest or leanest area of the abdomen) and the hips (across the broadest part over the buttocks) were recorded. Body fat percentage was measured by means of air displacement plethysmography (BOD-POD, Life Measurement Inc, Concord, CA) according to standard guidelines (Fields *et al.*, 2000). When the body density is known, relative ratios of fat-containing and fat-free mass can be calculated. This technique is based on Boyle's law of pressure-volume ratios (Fields *et al.*, 2000).

Biochemical analysis

The participants fasted overnight (12 hours). A fasting sample of 20 ml blood was taken from each participant for all biochemical analyses of the study. Blood samples for plasma were collected in ethylenediamine tetra-acetate-(EDTA)-coated venepuncture tubes. The plasma and serum were immediately separated and stored in Eppendorff tubes at -80°C until the analyses were performed. Fasting serum insulin was measured according to the ELISA method by means of the Immulite 2000 Analyzer. Insulin resistance was calculated according to the formula used by Matthews *et al.* (1985). For blood glucose concentrations blood was sampled in tubes with sodium fluoride and calcium oxalate. A total of 4.5 ml blood was mixed with the calcium oxalate and sodium fluoride (glucolite inhibitor) by turning the tube around carefully (not shaking). It was then placed on ice and centrifuged within 15 minutes. Plasma was immediately deposited into plastic micro tubes for analysis of glucose and frozen on dry ice. Plasma glucose was measured by means of Vitros DT60 II Chemistry Analyser (Ortho-Clinical Diagnostics, Rochester, NY, USA) with VITROS reagents (catalogue number 1532316) and control (catalogue numbers 8420317, 1448042).

Blood pressure

A continuous blood pressure measurement was recorded for a period of at least 5 minutes by means of the Finometer apparatus (FMS, The Netherlands). The Finometer computed all cardiovascular variables online, the Beatscope 1.1 software programme integrated the subject's gender, age, height and weight and this information was further integrated to obtain systolic blood pressure (SBP) (mmHg), diastolic blood pressure (DBP) (mmHg), total peripheral resistance (TPR) (mmHg/ml) and Windkessel arterial compliance (C_w) (ml/mmHg). The mean values of all the cardiovascular function variables were estimated in the last 2 minutes of the 5 minutes measuring time. The vascular unloading technique of Penáz together with the Physioal criteria of Wesseling provided reliable, non-invasive and continuous estimations of the cardiovascular function variables (Schutte *et al.*, 2004).

Tanner

The Tanner-stage questionnaires were used to determine the level of physical maturity in boys and girls and were administered by trained individuals in private rooms. Classification for Tanner 1 was PH1 (no pubic hair) to PH5 (adult stage). Classification for Tanner 2 is MA1 (no breasts) to MA5 (adult stage). Genital development in boys is classified from level 1 (no enlargement) to level 5 (adult stage). A sketch with descriptions of the five stages of development in boys and girls was shown to respondents, who then indicated their own development level (Tanner & Whitehouse, 1982).

The Previous Day Physical Activity Recall (PDPAR)

Trained field workers were employed to collect information from respondents regarding their level of PA on one given weekday and one given weekend day. This method of classifying PA, called the PDPAR, developed by Trost *et al.* (1999), uses a 24 hour recall list to classify respondents' PA levels as low (1), moderate (2) or high (3). According to this method respondents were asked to list their PA of a given day in 30 minute time frames, on an activity list. Using a difficulty factor, the type as well as intensity of activity was classified as high, medium or low. The metabolic equivalent (MET) values of PA were taken from *The Compendium of physical activities*, and the energy usage list was taken from the PDPAR (Ainsworth *et al.*, 1993; Weston *et al.*, 1997). The number of 30-minute periods with a MET value of 3 METs or more, as well as 30-minute periods with a MET value of 6 METs or more, was aggregated. Respondents were classified as vigorously active if two or more 30-minute periods had been coded as more than 6 METs, moderately active if two or

more 30-minute periods had been coded as 3 to 6 METS, and inactive if a respondent failed to meet the criteria for high or medium PA (Pate *et al.*, 1997). This questionnaire has been validated and used in the assessment of PA of children and adolescents from various ethnic groups (Weston *et al.*, 1997).

Physical activity intervention and compliance

The intervention programme was performed three days a week for ten weeks and presented by 12 post-graduate Human Movement Science students. No activity periods were scheduled during school hours, therefore the programme had to be done directly after school hours. Although the adolescents were encouraged to participate in the programme their participation was voluntary. The 10-week period was selected to conform to a school term, the assumption being that adolescents would be more willing to partake in the intervention at school on school days than at school during a holiday. Each intervention session lasted one hour, consisting of aerobic activity (aerobic exercises, dancing, kata boxing) for 20 minutes, sport-specific activity (mini-soccer, ball skills) lasting 20 minutes, and strength and flexibility exercises (push-ups, lunges, stretching exercises) for 20 minutes. Compliance with exercise intensity was performed by determining the heart rates of the adolescents manually at random by the post-graduate Human Movement Science students. Heart rates between 136 and 155 (beats per minute) were the required intensity for this population as determined according to their age (Lamb, 1984). The intensity of this intervention was also monitored through accelerometers (Actical, Minimitter, Bend, Oregon), where learners were selected according to group lists to wear them at every session. The mean duration of the activity sessions was 69 minutes. Girls spent a mean of 28 minutes on vigorous activity and boys spent a mean of 29.5 minutes on vigorous activity. The frequency of participation was monitored through the use of an attendance register.

Statistical analysis

Statistical computer software (Statistica 2007, Stat Soft, Inc. for Windows, Tulsa, OK) was used for the analysis of the collected data. The SAS programme was used individually for each adolescent to calculate height-for-age z-scores, according to the Centres for Disease Control database (CDC, 2000). Descriptive statistics and the Mann-Whitney U-test were used to compare groups. Analysis of covariance (ANCOVA) was used to compare the data of the groups after the intervention (Thomas & Nelson, 2001).

RESULTS

Baseline characteristics of the adolescents

Baseline characteristics of participants by gender and group are presented in Table 1. It should be noted that although the control- and the experimental groups included participants from the same grade (Grade 9), the boys in the experimental group were significantly older than the boys of the control group. The majority of all the participants in both the intervention- and control groups reported to be in Tanner-stage 4 of physical development. The baseline data indicated that the boys of the experimental group had a higher mean muscle mass, than the boys of the control group. In subsequent statistical analyses age, body fat percentage and muscle mass, as well as the baseline variable corresponding to the dependent variable were included as covariates. The habitual PA levels in the intervention- and control group are presented in Figure 1. The girls' PA levels were on average low when compared to those of the boys.

TABLE 1: BASELINE CHARACTERISTICS (MEAN ± SD, OR MEDIAN [INTERQUARTILE RANGE]) OF THE BOYS AND GIRLS OF THE EXPERIMENTAL- AND CONTROL GROUPS

Characteristic	Experimental group (n=194) Mean ± SD		Control group (n=57) Mean ± SD	
	Boys (n=96)	Girls (n=98)	Boys (n=16)	Girls (n=41)
Age (years)	15.8 ± 1.2 ^a	15.5 ± 1.1 ^a	14.7 ± 0.8 ^a	14.8 ± 1.0 ^a
Tanner stage: 1	0	0	0	1 (2.4%)
Tanner stage: 2	10 (10.4%)	7 (7.1%)	0	3 (7.1%)
Tanner stage: 3	17 (17.7%)	36 (36.7%)	7 (43.8%)	19 (45.2%)
Tanner stage: 4	53 (55.2%)	45 (45.9%)	9 (56.2%)	15 (35.7%)
Tanner stage: 5	16 (16.7%)	10 (10.1%)	0	4 (9.4%)
Body fat percentage (%)	18.1 ± 6.0 ^b	29.1 ± 6.2	21.4 ± 9.2 ^b	29.4 ± 7.5
Muscle mass (kg)	40.5 ± 8.2 ^c	34.4 ± 4.4	34.0 ± 5.7 ^c	33.8 ± 6.8
BMI (kg/m ²)	18.9 ± 2.6	20.3 ± 3.0	18.0 ± 1.5	20.7 ± 3.2
Height-for-age z-score	-1.26 ± 0.9	-1.12 ± 0.9	-1.29 ± 1.1	-0.89 ± 1.1
Waist circumference (cm)	66.3 ± 5.5	64.3 ± 5.5	64.0 ± 3.3	64.3 ± 6.0
Fasting plasma glucose (mmol/dL)	5.3 ± 0.6	5.0 ± 0.4	5.0 ± 0.4	4.8 ± 0.4
Systolic blood pressure (mm Hg)	105.8 ± 12.0	105.8 ± 10.8	102.8 ± 7.0	110.8 ± 13.3
Diastolic blood pressure (mm Hg)	72.7 ± 7.5	70.8 ± 6.7	68.7 ± 6.6	68.9 ± 9.3
Total Peripheral Resistance (mmHg/ml)	1.52 ± 0.37	1.72 ± 0.3	1.57 ± 0.23	1.39 ± 0.25
Windkessel arterial compliance (mmHg/ml)	1.70 ± 0.34	1.39 ± 0.2	1.55 ± 0.16	1.30 ± 0.09
Fasting plasma insulin (μU/ml) (median, 25%, 75%)	6.4 [4.8,10.2]	8.8 [6.3,12.6]	5.1 [4.7,6.6]	8.0 [6.1,12.6]
¹ Homeostasis Model Assessment insulin resistance (HOMA-IR)	1.56 [1.1,2.8]	1.94 [1.3,2.9]	1.64 [1.0,1.4]	1.75 [1.2,2.8]
¹ HOMA-IR = [(fasting insulin (μU/ml)) x (fasting venous glucose (mmol/L))/22.5]				
^{a-c} Similar letters indicate significant differences between variables for intervention and control adolescents, p < 0.05; t-test and Mann-Whitney U-test				

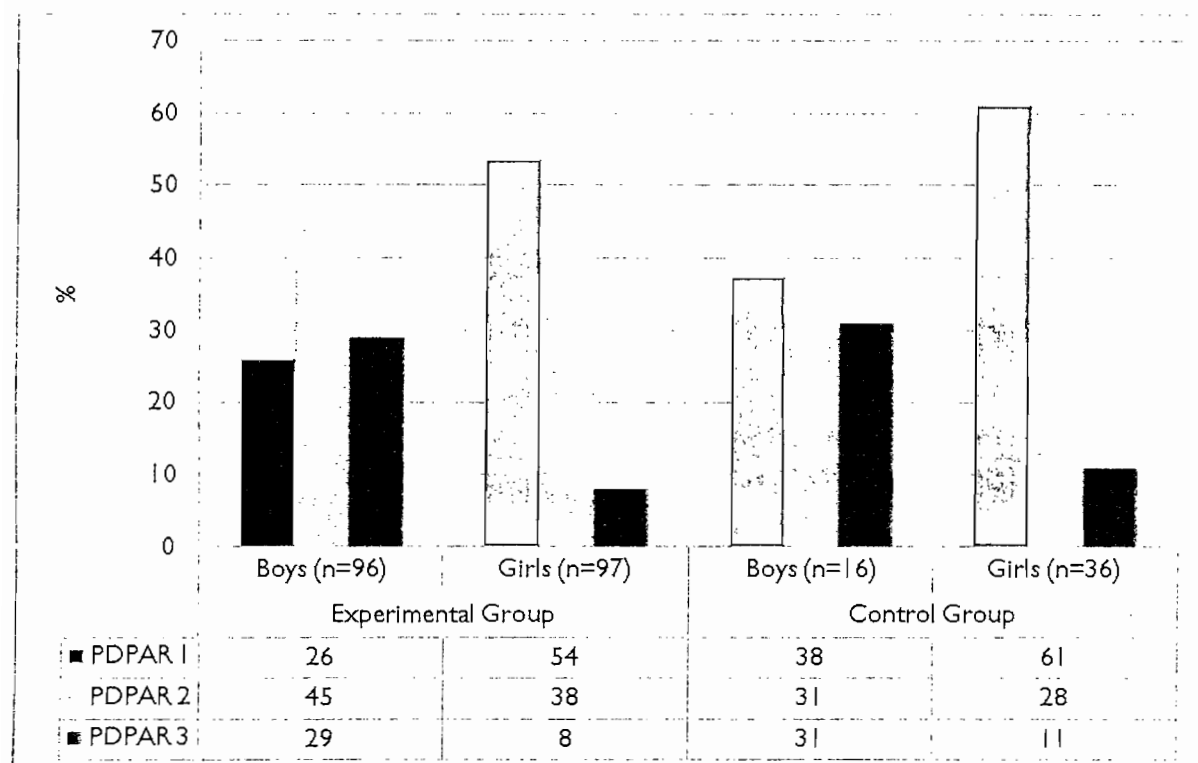


FIGURE 1: HABITUAL PHYSICAL ACTIVITY LEVELS IN THE EXPERIMENTAL- AND CONTROL GROUP AT BASELINE AS MEASURED WITH PREVIOUS DAY PHYSICAL ACTIVITY RECALL

Adolescents identified with markers of the metabolic syndrome

Six (two girls, four boys) out of the 156 participants who consented to blood samples had a fasting blood glucose > 6.1 mmol/L. Not one of the 6 above-mentioned participants had high blood pressure, although only one had a waist circumference $> 95^{\text{th}}$ percentile of the British reference (McCarthy *et al.*, 2001). Both girls had a body fat percentage $> 25\%$ and both were inactive (PDPAR = 1). The four boys had a body fat percentage $> 20\%$ and were moderately active (PDPAR = 2). All six adolescents had a HOMA-IR reading above 2.8 (75^{th} percentile in the present study).

Ten (six girls, four boys) out of the 214 adolescents measured had a waist circumference above the 95^{th} percentile of the British reference (McCarthy *et al.*, 2001). Only one of the ten participants had high blood pressure and one had high fasting plasma glucose. All ten had a body fat percentage $> 25\%$ for girls and $> 20\%$ for boys. Six were inactive and four

moderately active. Six out of these ten adolescents consented to blood samples and four had a HOMA-IR reading > 2.8 .

Twenty-two (9 girls, 13 boys) out of the 216 measured, had blood pressure $> 90^{\text{th}}$ percentile (Jessup & Harrell, 2005). None of the 22 participants had high fasting glucose, but one had a waist circumference $> 95^{\text{th}}$ percentile. Eleven participants out of the 22 were inactive and 11 moderately active. Eleven had a body fat percentage $> 25\%$ (for girls) and $> 20\%$ (for boys). Fifteen out of 22 consented to blood samples and three had a HOMA-IR reading > 2.8 .

Triacylglycerol and high-density lipoprotein cholesterol (HDL-C) were not determined in this study, therefore only blood pressure larger than the 90^{th} percentile based on US age and sex reference curves (National High Blood Pressure Education Program, 2005), glucose concentrations > 6.1 mmol/L and waist circumference $> 95^{\text{th}}$ percentile based on British reference curves (McCarthy *et al.*, 2001) were used as markers of the MS. The British reference was used because there is currently no reference curve or cut-off point for waist circumference of South African adolescents. In this study there was no participant that met all three the criteria for the MS, as defined in this study. Only two participants met two of the three MS criteria (McCarthy *et al.*, 2001).

Compliance with the physical activity intervention

Only 31.4% of the adolescents attended 40% or more of the PA sessions. The most important reasons for not attending were household chores and living far from school. Attendance ranged between 0-100 % with only five adolescents attending no sessions and the rest of the group attending some sessions. The low compliance adolescents were not excluded from this study.

Figure 2 presents the percentage change from baseline to end for different variables of the intervention- and control group after the PA intervention as a percentage change of median variables. In the experimental group there was an increase in the percentage change in C_w (3%), fasting plasma insulin (3%) and SBP (2%). There was also a decrease in the participants' glucose (-4%), HOMA-IR (-10%) and TPR (-12%). No difference in the participants' DBP was found. The control group showed increases in the percentage change in C_w (2%), fasting plasma glucose (1%), HOMA-IR (6%), SBP (20%), and TPR (10%). There was also a decrease in their fasting plasma insulin (-1%) and DBP (-14%).

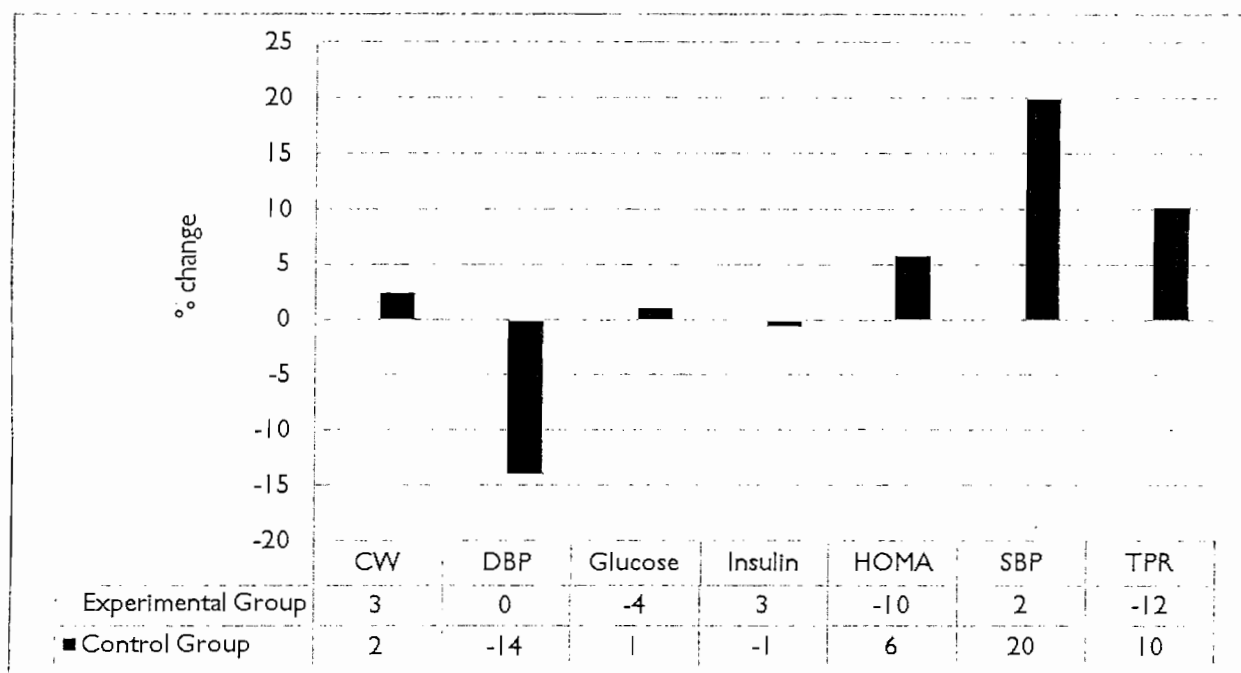


FIGURE 2: UNADJUSTED PERCENTAGE CHANGE FROM BASELINE TO END FOR DIFFERENT VARIABLES IN THE EXPERIMENTAL- AND CONTROL GROUP AFTER THE PHYSICAL ACTIVITY INTERVENTION (% CHANGE OF MEDIAN VARIABLES)

Changes in metabolic syndrome markers after the physical activity intervention

Table 2 gives the least squares means, 95% confidence intervals and level of significance for the difference in metabolic markers between the experimental group and the control group (ANCOVA with adjustment for age, gender, Tanner-stage, habitual PA, body fat percentage, muscle mass and baseline values of the relevant variable). Significant differences were found between DBP and SBP, respectively of the two groups. Adolescents from the control group had a lower DBP compared to the experimental group and adolescents from the experimental group had a lower SBP compared to adolescents from the control group.

TABLE 2: LEAST SQUARES MEANS, 95% CONFIDENCE INTERVALS AND LEVEL OF SIGNIFICANCE FOR THE DIFFERENCE IN METABOLIC MARKERS BETWEEN THE EXPERIMENTAL- AND THE CONTROL GROUP

Variable	Level of significance	n	Experimental group	n	Control Group
Model 1*					
Fasting plasma glucose (mmol/dL)	NS	50	4.84 [4.7, 4.9]	11	5.0 [4.7, 5.3]
Homeostasis Model Assessment insulin resistance (HOMA-IR)	NS	48	0.61 [0.43, 0.78]	11	0.74 [0.35, 1.13]
Systolic blood pressure (mm Hg)	p=0.00061	59	100 [97, 102]	20	110 [105, 114]
Diastolic blood pressure (mm Hg)	p=0.00005	59	63 [61, 66]	20	52 [48, 57]
Total Peripheral Resistance (mmHg/ml)	NS	53	1.54 [1.45, 1.63]	11	1.54 [1.33, 1.75]
Windkessel arterial compliance (mmHg/ml)	NS	53	1.51 [1.47, 1.55]	11	1.50 [1.41, 1.59]
Model 2**					
Fasting plasma glucose (mmol/dL)	NS	50	4.81 [4.7, 4.9]	11	5.1 [4.7, 5.5]
Homeostasis Model Assessment insulin resistance (HOMA-IR)	NS	48	0.55 [0.35, 0.75]	11	0.99 [0.41, 1.58]
Systolic blood pressure (mm Hg)	p=0.00061	59	100 [96, 103]	20	110 [101, 118]
Diastolic blood pressure (mm Hg)	p=0.00005	59	63 [60, 66]	20	53 [46, 60]
Total Peripheral Resistance (mmHg/ml)	NS	53	1.57 [1.47, 1.67]	11	1.39 [1.08, 1.71]
Windkessel arterial compliance (mmHg/ml)	NS	53	1.51 [1.46, 1.55]	11	1.49 [1.35, 1.63]

* Ancova with adjustment for gender, tanner-stage, habitual pa, body fat percentage, muscle mass and baseline values of the relevant variable

** Model 1 + percentage attendance in the PA intervention

As noted in Table 2, after an additional adjustment for percentage attendance in the PA intervention (Model 2), there were still significant differences between DBP and SBP of adolescents from the two groups. There was also a trend of a difference between HOMA-IR of the two groups.

DISCUSSION

The purpose of this study was to determine the effects of a 10-week PA intervention on selective markers of the MS in black adolescents. One of the main reasons for conducting a PA intervention was that atherosclerosis has been found in children and young adults and is associated with cardiovascular disease risk factors such as obesity, abnormal plasma lipoprotein levels, elevated blood pressure, insulin resistance (Day *et al.*, 2009) and diabetes mellitus type 2 due to a lack of PA (Ritenbaugh *et al.*, 2003). The reason for this inactivity can in turn be attributed to a range of factors: urbanisation, lack of interest in PA, technology, unsafe neighbourhoods and schools that cannot afford hosting physical activities (Bar-or *et al.*, 1998; WHO, 1998).

There was a significant difference in PA participation between black and white adolescents in the USA (Kimm *et al.*, 2002), and it became more apparent with an increase in age (Jago *et al.*, 2008). In South Africa, significantly more males (57.1% [95%CI 54.6 – 59.6]) participated in vigorous- and moderate physical activities than females (34.7% [95% CI 31.7 – 37.6]), and a decrease in participation was apparent with an increase in age. Significantly more black females than black males were inactive, or showed low PA participation levels (MRC, 2002). The same tendency is seen in this study (Figure 1) as the girls from both the intervention and control groups' habitual PA levels were on average low when compared to the boys (PDPAR 1: Girls intervention = 54%, Girls control = 61%). On average, the boys were classified as being more moderately- and vigorously active, compared to the girls (Figure 1). In this study only 31.4% of the adolescents attended 40% or more of the PA sessions. Despite their low level of PA, none of the study participants presented with all three of the MS markers.

Insulin resistance and consequently fasting plasma insulin of the adolescents from the experimental group did not show a significant improvement after the 10-week PA intervention. As presented in Figure 2, the experimental group had a small increase in the percentage change in fasting insulin (3%) but a decrease in HOMA-IR (-10%). Changes in fasting plasma insulin were, however, small in both groups. Insulin resistance increases during puberty, as insulin sensitivity is reduced in both non-diabetic and diabetic children, and therefore the body produces more insulin (Jessup & Harrell, 2005). This increased insulin secretion may be caused by an increased amount of circulating growth hormones and changes in body composition (Jessup & Harrell, 2005). African Americans' fasting insulin

and acute insulin responses are significantly higher than in white children (Deckelbaum & Williams, 2001; Gower *et al.*, 2001; Cruz *et al.*, 2002), and it can be explained by black adolescents' altered rates of hepatic insulin extraction when compared to white adolescents, which contribute significantly to their peripheral hyperinsulinemia (Schuster *et al.*, 1998).

After the 10-week PA intervention, adolescents from the control group had a significantly lower DBP compared to the experimental group ($p=0.00005$) and adolescents from the experimental group had a significantly lower SBP compared to the control group ($p=0.000061$). The higher DBP encountered in the experimental group was attributed to the higher vascular TPR found in the adolescents from the experimental group. Even after an additional adjustment for percentage attendance in the PA intervention, there were still significant differences between DBP and SBP when the adolescents from the two groups were compared. As presented in Figure 2, the experimental group had a small increase in SBP (2%), but no change in DBP. The control group showed an increase in SBP (20%) and a decrease in DBP (-14%). These results can be due to the increase in muscle mass in the experimental group which in turn may possibly elevate resting blood pressure (AAOP 1997). While some studies indicated that decreased blood pressure levels were associated with increased levels of PA (Ewart *et al.*, 1998; McMurray *et al.*, 2002), a study by De Visser *et al.* (1994) indicated a non-significant relationship between blood pressure and PA in adolescents. In a study by Fu and Hao (2002) on Hong Kong adolescents, SBP and DBP were related to sexual maturation, and increased with age. Insulin sensitivity did not improve significantly in this study. Insulin resistance and hyperinsulinemia alter blood pressure through several mechanisms (Cruz *et al.*, 2002), including the insulin-mediated effects on the sympathetic nervous system and renal sodium reabsorption (Cruz *et al.*, 2002). In a study by Cruz *et al.* (2002), it was found that insulin resistance was a more important determinant of SBP in children than body fat. Furthermore it was found that black ethnicity and decreased insulin sensitivity were independently related to elevated blood pressure even at an early age (Cruz *et al.*, 2002).

After the PA intervention, the experimental group had an increase in the percentage change in C_w (3%) and a decrease in TPR (-12%) (Figure 2). In a study by Otsuki *et al.* (2007) it was suggested that endurance training in school-age youths decreased arterial stiffness or increased C_w and continued endurance training would maintain this decrease. Because arterial pressure is determined by cardiac output and TPR, reductions in arterial pressure

after endurance exercise training must be mediated by decreases in one or both of these variables. Reductions in resting cardiac output do not typically occur after chronic exercise; thus, decreased TPR appears to be the primary mechanism by which resting BP is reduced after exercise training.

LIMITATIONS

This study has several limitations. This study is firstly limited by the relatively small number of participants who consented to blood sampling pre- and post test. This small sample size makes it difficult to detect statistically significant changes with a great deal of accuracy. It is important to note that participants enrolled in this study voluntarily, which could also lead to potential bias. The second limitation was the duration of the study. School terms are, however, relatively short and it is almost impossible to maintain school-based interventions over school holidays. The third limitation was that triacylglycerol and HDL-C were not measured due to budget constraints. However, this study has provided valuable information for future studies on South African adolescents.

CONCLUSION

The findings of this study suggest that the experimental group had significantly lower SBP ($p=0.000061$) and lower HOMA-IR compared to the control group after a 10-week PA intervention. The implications of the results are that adolescents should be encouraged to increase their PA levels, which may result in significant improvements in selective markers of the MS. The present study is, however, limited by the small subject sample size and the small number of adolescents who gave consent for blood sampling after the intervention.

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CHAPTER 5

The impact of a 10-week physical activity intervention programme on body composition and markers of vascular function in normal- and over-fat black adolescents: PLAY study

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ABSTRACT

The purpose of this study was to determine the effects of a 10-week physical activity (PA) intervention on the body composition and vascular function in normal- and over-fat black adolescents. A total of 251 black adolescents (194 in the experimental and 57 in the control group), aged 15 - 19 years from two schools in the North West Province were recruited for this study. Body mass index (BMI), waist circumference (WC), waist-hip ratio (WHR), body fat percentage, muscle mass, fasting insulin and -glucose, homeostasis model assessment of insulin resistance (HOMA-IR), systolic and diastolic blood pressure (SBP & DBP), windkessel arterial compliance (C_w) and total peripheral resistance (TPR) were measured at baseline and after a 10-week PA intervention programme. The results of the least square means analyses indicated changes in HOMA-IR ($F=2.5$; $p=0.09$), muscle mass ($F=2.3$; $p=0.10$) and SBP ($F=2.7$; $p=0.08$) in the experimental group. Changes in HOMA-IR was also observed in the over-fat experimental group ($F=2.6$; $p=0.09$). However, none of the changes in body composition and vascular function of the normal- and over-fat adolescents were significant.

Key words: Blood pressure, insulin resistance, body composition, adolescents, Africa

INTRODUCTION

Obesity that has long been considered as a condition affecting only developed countries, has now joined the ranks of underweight, malnutrition, and infectious diseases as a major health problem of the developing world (Haslam & James, 2005). Globally, childhood obesity has reached epidemic proportions with 155 million school-aged children being either obese or overweight (Noakes, 2004). In South Africa, 17% of adolescents were overweight and 4% were obese, according to the Youth Risk Behaviour Survey of 2002 (MRC, 2002). The black adult population of South-Africa is disproportionately affected, with obesity rates being two to three times higher compared to the white population (Mollentze, Moore, Steyn, Joubert, Steyn, Oosthuizen & Weich, 1995). This high prevalence of obesity is of serious concern, as it has been found to be a key factor in the development of diabetes and hypertension (Haslam & James, 2005). About 18 million people die every year from cardiovascular diseases worldwide, for which diabetes and hypertension are major predisposing factors (Haslam & James, 2005).

Even though clinical symptoms of cardiovascular risk factors appear only later in life, it is documented that risk-related behaviour patterns for coronary heart disease have their origins in childhood and adolescence (Froberg & Anderson, 2005). One of the reasons for the increase in obesity is the fact that adolescents are no longer physically active as they used to be a few decades ago (Epstein, Roemmich & Paluch, 2005). Low levels of physical activity (PA) have been shown to be related to the development of obesity (Must & Tybor, 2005). The World Health Organisation estimates that physical inactivity causes almost 2 million deaths worldwide each year (WHO, 2005). These statistics underline the importance of instilling the value of PA in children and adolescents. The Youth Risk Behaviour Survey of 2002 noted that a contributing factor to adolescents' inactivity is the fact that 29% of South African adolescents have no physical education classes at school (MRC, 2002). Regular PA assists in decreasing the risk of developing Type 2 diabetes and in preventing cardiovascular diseases like hypertension (Ritenbaugh, Teufel-Shone, Aickin, Joe, Poirier, Dillingham, Johnson, Henning, Cole & Cockerham, 2003). Furthermore, PA has been shown to have a positive effect on waist circumference (Klein-Platat, Draï, Oujaa, Schlienger & Simon, 2005), blood pressure (Ritenbaugh *et al.*, 2003), insulin sensitivity (Schmitz Jacobs, Hong, Steinberger, Moran & Sinaiko, 2002) and arterial compliance (Tanaka, Dinunno, Monahan, Clevenger, Desouza & Seals, 2000). Tanaka *et al.* (2000) demonstrated that regular PA slows down the normal loss of elasticity and compliance in the human vascular system.

Acute exercise intervention can reverse some of the age-related declines in arterial stiffness (Tanaka *et al.*, 2000). PA and exercise training appear to modify these independent risk factors for cardiovascular disease.

The vast majority of studies in African children focus on undernutrition (Bhutta, 2009) with precious few considering the alarming trend of increasing obesity prevalence. This study seeks to address this lacuna. The aim of this study is to examine the effects of a 10-week PA intervention on body composition and vascular function in 12-19 year old black adolescents, with separate analysis for normal- and over-fat black adolescents.

MATERIALS AND METHODS

Sample and study design

The **Physical Activity in the Young (PLAY)** study was a pre-test post-test intervention study design that included an experimental group and a control group. The experimental group was subjected to a PA intervention programme while the control group received health information only during a single health promotion day at the school. The setting and design of the study was described by Swanepoel, Moss, Kruger and Schutte (2007). All available adolescents, boys and girls, in the grade 9 class (15-19 years) attending a secondary school in the low socio-economic status (SES) area of Ikageng township (North West Province, South Africa) were recruited for the experimental group. A total of 194 adolescents were in the experimental group (96 boys and 98 girls). Another 57 adolescents (16 boys and 41 girls) from grade 9 of a secondary school in the same low SES area were recruited for the control group. At the pre-intervention tests, 142 participants in the experimental group and 37 participants in the control group consented to blood sampling. The number of participants consented to post intervention blood sample tests declined to only 78 participants in the experimental group and 23 participants in the control group. These schools were selected from a total of five high schools in the low socio-economic township because they were attended by adolescents only from the surrounding neighbourhoods. The adolescents in the control and experimental groups' status were similar with regard to growth phase, SES, diet and PA profiles.

Ethical considerations

The PLAY study was approved by the Ethics Committee of the North-West University, Potchefstroom Campus (no. 04M01) as well as the school principals. Consent was obtained

from the adolescents' parents and from the adolescents themselves for participation in the study and the collection of blood samples.

Measurements

Participants were measured in a controlled environment in groups of between 40-50 participants per day for baseline- and end measurements before and after the 10-week PA intervention programme. Upon arrival fasting blood samples were taken after which body fat percentage, blood pressure (BP) and anthropometric measurements were performed using standard procedures. The participants were then presented with light refreshments, after which the habitual physical activity (The previous day physical activity recall (PDPAR)), demographic information and Tanner stage questionnaires were completed.

Body composition

Body composition was compiled by determining the body mass index (BMI), waist circumference (WC), waist-hip ratio (WHR) and percentage body fat. BMI was determined from height (cm) measured by a vertical stadiometer using the stretch-method (ISAK, 2001) to the nearest 0.1 cm and body mass by means of a calibrated electronic scale (Precision, A&D Company, Saitama, Japan) to the nearest 0.1 kg. The circumferences were measured with a flexible steel tape (Lufkin, Cooper Tools, Apex, NC) to the nearest 0.1 cm. The measures of the waist (at the narrowest part between the lower rib and the iliac crest) and the hips (across the broadest part over the buttocks) were recorded. Body fat percentage and lean body mass were measured by means of air displacement plethysmography (BOD-POD, Life Measurement Inc, Concord, CA) according to standard guidelines (Fields, Hunter & Goran, 2000). When the body density is known, relative ratios of fat-containing and fat-free mass can be calculated. This technique is based on Boyle's law of pressure-volume ratios (Fields *et al.*, 2000). Children were categorised according to body fat percentage into groups with a normal body fat percentage, <20% for boys and <25% for girls, and overfat if they had a body fat percentage above these cut-off points (Lohman, 1981).

Biochemical analysis

The participants fasted overnight (12 hours). A fasting sample of 20 ml blood was taken from each participant for all biochemical analyses of the study. Blood samples for plasma were collected in ethylenediamine tetra-acetate-(EDTA)-coated venepuncture tubes. The plasma and serum were immediately separated and stored in Eppendorff tubes at -80°C until

the analyses were performed. Fasting serum insulin was measured according to the ELISA method by means of the Immulite 2000 Analyzer. Insulin resistance (HOMA-IR) was calculated according to the formula used by Matthews, Hosker, Rudenski, Naylor, Treacher and Turner (1985). For blood glucose concentrations blood was sampled in tubes with sodium fluoride and calcium oxalate. A total of 4.5 ml blood was mixed with the calcium oxalate and sodium fluoride (glucolite inhibitor) by turning the tube around carefully (not shaking). It was then placed on ice and centrifuged within 15 minutes. Plasma was immediately deposited into plastic micro tubes for analysis of glucose and frozen on dry ice. Plasma glucose was measured by means of Vitros DT60 II Chemistry Analyser (Ortho-Clinical Diagnostics, Rochester, NY, USA) with VITROS reagents (catalogue number 1532316) and control (catalogue numbers 8420317, 1448042).

Cardiovascular variables

A continuous blood pressure measurement was recorded for a period of at least 5 minutes by means of the Finometer apparatus (FMS, The Netherlands). The Finometer computed all cardiovascular variables online, the Beatscope 1.1 software programme integrated the subject's gender, age, height and weight and this information was further integrated to obtain systolic blood pressure (SBP) (mmHg), diastolic blood pressure (DBP) (mm Hg), total peripheral resistance (TPR) (mmHg/ml) and Windkessel arterial compliance (C_w) (ml/mmHg). The mean values of all the cardiovascular function variables were estimated in the last 2 minutes of the 5 minutes measuring time. The vascular unloading technique of Penáz together with the Physiocal criteria of Wesseling provided reliable, non-invasive and continuous estimations of the cardiovascular function variables (Schutte, Huisman, van Rooyen, Malan & Schutte, 2004).

Tanner

The Tanner-stage questionnaires were used to determine the level of physical maturity in boys and girls and were administered by trained individuals in private rooms. Classification for Tanner 1 was PH1 (no pubic hair) to PH5 (adult stage). Classification for Tanner 2 is MA1 (no breasts) to MA5 (adult stage). Genital development in boys is classified from level 1 (no enlargement) to level 5 (adult stage). A sketch with descriptions of the five stages of development in boys and girls was shown to respondents, who then indicated their own development level (Tanner & Whitehouse, 1982).

The Previous Day Physical Activity Recall (PDPAR)

Trained field workers were employed to collect information from respondents regarding their level of PA on one given weekday and one given weekend day. This method of classifying PA, called the PDPAR, developed by Trost, Pate, Ward, Saunders and Riner (1999), uses a 24-hour recall list to classify respondents PA levels as low (1), moderate (2) or high (3). According to this method respondents were asked to list their PA of a given day in 30 minute time frames, on an activity list. Using a difficulty factor, the type as well as intensity of activity was classified as high, medium or low. The metabolic equivalent (MET) values of PA were taken from *The Compendium of physical activities*, and the energy usage list was taken from the PDPAR (Ainsworth, Haskell, Leon, Jacobs, Montoye, Sallis & Paffenbarger, 1993; Weston, Petosa & Pate, 1997). The number of 30-minute periods with a MET value of 3 METs or more, as well as 30-minute periods with a MET value of 6 METs or more, was aggregated. Respondents were classified as vigorously active if two or more 30-minute periods had been coded as more than 6 METs, moderately active if two or more 30-minute periods had been coded as 3 to 6 METS, and inactive if a respondent failed to meet the criteria for high or medium PA (Pate, Trost, Felton, Ward, Dowda & Saunders, 1997). This questionnaire has been validated and used in the assessment of PA of children and adolescents from various ethnic groups (Weston *et al.*, 1997).

Physical activity intervention and compliance

The intervention programme was performed three days a week for ten weeks and presented by 12 post-graduate Human Movement Science students. No activity periods were scheduled during school hours, therefore the programme had to be followed directly after school hours. Although the adolescents were encouraged to participate in the programme their participation was voluntary. The 10-week period was selected to conform to a school term, the assumption a higher compliance to exercise on school days than during school holiday. Each intervention session lasted one hour, consisting of aerobic activity (aerobic exercises, dancing, kata boxing) for 20 minutes, sport-specific activity (mini-soccer, ball skills) lasting 20 minutes, and strength and flexibility exercises (push-ups, lunges, stretching exercises) for 20 minutes. Exercise intensity was monitored by having post-graduate Human Movement Science students manually take the heart rate of the adolescents at random. Heart rates between 136 and 155 (beats per minute) were the required intensity for this population to achieve physiological adaptation as determined according to their age (Lamb, 1984). The intensity of this intervention was also monitored through accelerometers (Actical,

Minimitter, Bend, Oregon), where learners were selected according to group lists to wear accelerometers at every session. The mean duration of the activity sessions was 69 minutes. Girls spent a mean of 28 minutes in vigorous activity and boys spent a mean of 29.5 minutes in vigorous activity. The frequency of participation was monitored through the use of an attendance register. The statistical analyses for this study were conducted according to the participants' attendance level in the physical activity intervention. Adolescents were placed in the low attendance sub-group if they participated in less than 40% of the PA intervention sessions; and placed in the higher attendance sub-group if they participated in more than 40% of the PA intervention sessions.

Statistical analysis

Statistical computer software (Statistica 2007, Stat Soft, Inc. for Windows, Tulsa, OK) was used for the analysis of the collected data. Descriptive statistics and the Mann-Whitney U-test were used to compare adolescents of the two schools, as well as adolescents with normal body fat percentage with over-fat adolescents at baseline. Analysis of covariance (ANCOVA) was used to compare the data of the groups after the intervention (Thomas & Nelson, 2001), with adjustment for gender, Tanner stage, habitual physical activity, age, waist circumference, WHR and baseline values of the relevant variable.

RESULTS

Baseline measurements, as presented in Table 1, of normal- and over-fat adolescents (body fat percentage >25% in girls, >20% in boys) show that the over-fat groups had higher body fat percentage, BMI, waist circumference, HOMA-IR, SBP and DBP and a lower muscle mass, than the normal-fat groups. At baseline, there were significant differences in age and WHR between experimental- and control groups of both the normal- and over-fat groups respectively. The experimental group were on average, one year older than the control group (Normal-fat $p=0.0019$; Over-fat $p<0.0001$) and had a greater WHR (Normal-fat $p=0.0018$; Over-fat $p<0.0001$). WC was only statistically different between the normal-fat experimental- and control groups, with the experimental group having a WC of an average of 3 cm greater than the control group ($p=0.04$).

Only 31.4% of the adolescents attended 40% or more of the PA sessions. The most important reasons for not attending were household chores and living far from school. Attendance ranged between 0-100 % with only five adolescents attending no sessions. As

the analyses considered participants' attendance in the physical activity intervention, the low attendance participants were not excluded from this study.

At baseline 142 participants in the experimental- and 37 participants in the control group consented to blood sampling (Table 1). The number of participants consented to end measurement blood samples declined to only 78 participants in the experimental- and 23 participants in the control group (Table 2).

TABLE 1: Baseline measurements of normal- and over-fat adolescents, mean \pm standard deviation

Variable	Adolescents with normal fat (%BF) ¹				Over-fat adolescents (%BF>25% in girls, >20% in boys)			
	Experimental Group	n	Control Group	n	Experimental Group	n	Control Group	n
	Age (years)	15.8 \pm 1.2 ^a	90	14.7 \pm 0.9 ^a	18	15.7 \pm 1.4 ^b	103	14.8 \pm 1 ^b
Body fat percentage (%)	16.5 \pm 4.5	72	15.5 \pm 4.4	11	30.3 \pm 5.5	94	31.4 \pm 5.1	37
Muscle mass (kg)	39.4 \pm 7.5	72	33.1 \pm 7.5	11	35.6 \pm 6.3	94	34.0 \pm 6.2	37
Body mass (kg)	47.4 \pm 7.5	87	44.3 \pm 7.4	18	51.1 \pm 9.8	102	51.1 \pm 8.9	37
Height (cm)	161.2 \pm 8	87	158.1 \pm 9.8	18	155.9 \pm 7.5	102	155.7 \pm 7	37
Body mass index (kg/m ²)	18.2 \pm 2.1	87	17.6 \pm 1.5	18	20.9 \pm 3.3	102	21.0 \pm 3.1	37
Waist circumference (cm)	64.0 \pm 5.1 ^c	84	61.3 \pm 3.9 ^c	18	66.4 \pm 6.1	100	65.6 \pm 5.6	37
WHR	0.82 \pm 0.07 ^d	84	0.77 \pm 0.06 ^d	18	0.78 \pm 0.04 ^c	98	0.73 \pm 0.05 ^c	37
HOMA-IR ¹	1.99 \pm 1.5	62	1.71 \pm 1.3	13	2.47 \pm 1.9	79	2.24 \pm 1.6	24
Quantitative insulin check index	0.36 \pm 0.03	63	0.37 \pm 0.04	13	0.35 \pm 0.03	79	0.35 \pm 0.03	24
Systolic blood pressure (mm Hg)	105 \pm 12	52	106 \pm 14	11	107 \pm 11	68	110 \pm 12	19
Diastolic blood pressure (mm Hg)	72 \pm 7	52	68 \pm 8	11	72 \pm 7	68	70 \pm 9	19
Total peripheral resistance (mmHg/ml)	1.58 \pm 0.38	52	1.46 \pm 0.22	11	1.54 \pm 0.29	68	1.41 \pm 0.25	16
Arterial compliance (mmHg/ml)	1.63 \pm 0.34	52	1.48 \pm 0.12	11	1.48 \pm 0.22	68	1.47 \pm 0.21	16

¹[Homeostasis model for insulin resistance = (fasting insulin (μ U/ml)) x (fasting venous glucose (mmol/L))/22.5]

^{a-c} Significant difference between normal- and over-fat adolescents

WHR= Waist: hip-ratio

A large number of participants in this study had a high body fat percentage, 94 participants in the experimental- and 37 in the control group. For this reason a separate analysis was conducted to compare the results of the over-fat participants to those of the total group participants, categorising them into sub-groups according to their attendance level in the physical activity intervention: low- (<40%) and higher attendance ($\geq 40\%$). The analysis was adjusted for gender, Tanner stage, habitual physical activity, age and WHR.

Table 2 shows the least squares mean and level of significance for the difference in body composition and markers of vascular function between the experimental group and the control group after the PA intervention. The insulin resistance of the total experimental group ($F=2.5$; $p=0.09$) as well as the over-fat group ($F=2.6$; $p=0.09$) was lower after the intervention than that of the control group. The muscle mass of the total experimental group ($F=2.3$; $p=0.10$) as well as the over-fat group ($F=0.84$; $p=NS$) was higher after the intervention than that of the control group. The percentage body fat of the total experimental group ($F=0.82$; $p=NS$) as well as in the over-fat group was lower than that of the control group ($F=1.49$; $p=NS$) after the intervention. This finding was repeated in the changes observed in the total peripheral resistance of the total experimental group ($F=1.4$; $p=NS$) and the over-fat group ($F=0.66$; $p=NS$).

The systolic- and the diastolic blood pressure were higher after the intervention in both the total experimental group (SBP – $F=2.7$; $p=0.08$; DBP – $F=0.6$; $p=NS$) and over-fat group (SBP – $F=0.85$; $p=NS$; DBP – $F=0.72$; $p=NS$) compared to the control group. These differences were however not significant. .

TABLE 2: Least squares means and level of significance for the difference in body composition and markers of vascular function between the experimental groups with low (<40%) and higher attendance (>=40%) and the control group

Variable	MODEL 1				MODEL 2			
	All adolescents *			F and p-values	Over-fat adolescents *			F and p-values
	Low Attendance group	Higher Attendance group	Control group		Low Attendance group	Higher Attendance group	Control group	
Body fat (%)	21.0±0.4 (n=79)	20.0±0.7 (n=31)	21.0±0.8 (n=24)	F=0.82 NS	25.7±0.6 (n=36)	24.0±0.8 (n=22)	24.3±0.9 (n=19)	F=1.49 NS
Muscle mass (kg)	40.1±0.3 (n=80)	40.4±0.4 (n=31)	38.9±0.6 (n=25)	F=2.3 NS p=0.10	38.6±0.4 (n=36)	39.2±0.4 (n=22)	38.2±0.5 (n=19)	F=0.84 NS
Body mass index (kg/m ²)	19.8±0.2 (n=91)	20.0±0.3 (n=39)	19.2±0.3 (n=32)	F=1.4 NS	20.8±0.20 (n=41)	20.8±0.15 (n=24)	20.4±0.16 (n=20)	F=1.45 NS
#HOMA-IR	2.1±0.7 (n=25)	1.8±0.7 (n=25)	5.0±1.2 (n=13)	F=2.5 NS p=0.09	1.83±1.4 (n=9)	1.55±1.0 (n=19)	6.15±1.6 (n=10)	F=2.6 NS p=0.09
Arterial compliance (mmHg/ml)	1.53±0.03 (n=26)	1.53±0.02 (n=28)	1.49±0.04 (n=15)	F=0.98 NS	1.45±0.03 (n=13)	1.47±0.03 (n=19)	1.42±0.05 (n=9)	F=0.3 NS
Total peripheral resistance (mmHg/ml)	1.59±0.1 (n=26)	1.46±0.1 (n=28)	1.56±0.1 (n=15)	F=1.4 NS	1.65±0.09 (n=13)	1.51±0.07 (n=19)	1.60±0.13 (n=9)	F=0.66 NS
Systolic blood pressure (mmHg)	110±2 (n=26)	115±2 (n=28)	109±3 (n=15)	F=2.7 NS p=0.08	111±3 (n=13)	116±2 (n=19)	113±4 (n=9)	F=0.85 NS
Diastolic blood pressure (mmHg)	72±1 (n=26)	74±1 (n=28)	74±2 (n=15)	F=0.6 NS	73±2 (n=13)	75±2 (n=19)	78±3 (n=9)	F=0.72 NS

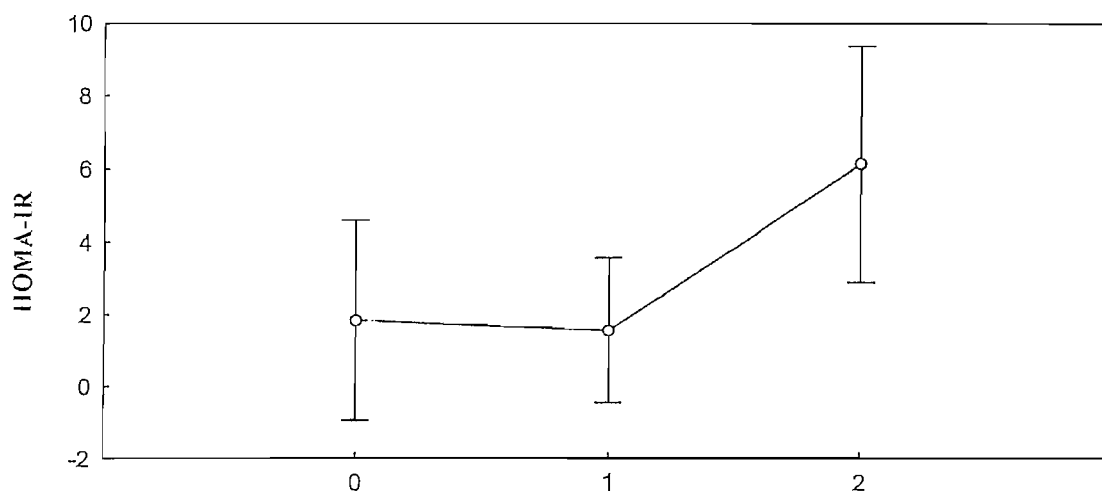
ANCOVA with adjustment for gender, Tanner stage, habitual physical activity, age, waist circumference, WHR and baseline values of the relevant variable

Number of participants vary due to missing values and not all adolescents agreeing to give blood samples

Analyses done with logarithmically transformed data %= percentage WHR= Waist: hip-ratio

HOMA-IR= Homeostasis model assessment-estimated insulin resistance NS= Non-significant

Figure 1 is a graphic illustration of the analysis of covariance for HOMA-IR for the over-fat control group and low- and high attendance sub-groups after the PA intervention. Lower HOMA-IR were observed after the intervention for both the low attendance and higher attendance groups compared to the control group ($F=2.56$; $p=0.1$). These differences were however not significant.



Attendance groups: 0 = Low attendance, 1 = High attendance, 2 = Control ($F= 2.56$; $p= 0.095$)

Covariate means: Gender: 1.82; Age: 15.30; Waist: 64.23; WHR: 0.766; Tanner 1: 3.42;

HOMA-IR base: 2.23; PDPAR: 1.42

Include condition: Body fat % > 20% Males/ 25% Females. Exclude condition: Age > 19

Figure 1: Analyses of covariance for HOMA-IR for the over-fat control group and the low- and high attendance over-fat sub-groups after the physical activity intervention programme

DISCUSSION

The baseline measurements of the study confirmed that over-fat adolescents had a higher body fat percentage, BMI, waist circumference, abdominal skin fold, HOMA-IR, SBP and DBP and a lower muscle mass, than the normal-fat group (see Table 1). These parameters form part of the insulin resistance syndrome and are related to vascular function (De Fronzo & Ferranini, 1991). Adolescents require monitoring, as risk-related behaviour patterns for coronary heart disease have their origin in childhood and adolescence (Day, Fulton, Dai, Mihalopoulos & Barradas, 2009). Obesity in childhood, especially in adolescence, is a key predictor of obesity in adulthood (Schuster, Kien, & Osei, 1998; Deckelbaum & Williams, 2001). Hyperinsulinemia, insulin resistance (Schuster *et al.*, 1998), elevated blood pressure,

dyslipidaemia and Type 2 diabetes mellitus appear frequently in the overweight and obese pediatric population (Chen, Srinivasan, Elkasabany, Berenson, 1999; Deckelbaum & Williams, 2001).

Contrary to the expectation, no significant changes were found for the over-fat group in this study. A possible reason for this lack of result could be the short duration of the study. In a physical activity intervention study by Owens, Gutin, Allison, Riggs, Ferguson and Thompson (1999) which consisted of aerobic exercises for 16-weeks, 5 days per week for 40 minutes, obese children showed a significant decrease in visceral adipose tissue. Another PA intervention showed a significant increase in insulin sensitivity in overweight and obese girls, but without change in body weight and percentage body fat after 12-weeks of aerobic training for 3 days per week, 40 minutes per session (Nassis, Papantakou, Skenderi, Triandafilopoulou, Kavouras, Yannakoulia, Chrousos & Sidossis, 2005). Wong, Chia, Tsou, Wansaicheong, Tan, Wang, Tan, Kim, Boh and Lim (2008), also found that exercise training significantly increased lean muscle mass and fitness and significantly decreased BMI and SBP in obese boys after 12 weeks' circuit-based resistance training and aerobic exercises for 2 days per week, 45-60 minutes per session. In a study by Nemet, Barkan, Epstein, Friedland, Kowen and Eliakim (2005), body weight, BMI and body fat percentage were significantly reduced after a 12-week physical activity intervention which consisted of 60 minutes of aerobic exercises, 2 days per week. However, in another study, adolescents' BMI, body weight and body fat percentage did not change significantly in the experimental group after an 8- and 12-week PA intervention (McMurray, Harrell, Bangdiwala, Bradley, Deng & Levine, 2002; Nassis *et al.*, 2005). A possible explanation for these different results can be that the 8-week physical activity intervention (McMurray *et al.*, 2002) was too short in duration for a change in body composition to be observed. Also, the 12-week PA intervention (Nassis *et al.*, 2005) involved only 19 subjects, forming a rather small group for determining a significant outcome. Our study was 10-weeks in duration and attendance levels were low. Furthermore, the small sample size of this study makes it difficult to detect statistically significant changes with a great deal of accuracy. A point to note is that the most important reasons for participants not attending were household chores and living far from school.

Another reason why this study may not have shown that a PA intervention improves body composition could be the fact that the study did not consider the diet of participants. The

escalated incidence of obesity among adolescents is the result of a combination of lifestyle factors: most notable an increase in sedentary lifestyles, but to significant extent also high-energy diets rich in saturated fats (Deckelbaum & Williams, 2001). This is now also the case in developing countries, where the quantity of food consumed has increased, whilst the nutritional value of food has decreased (Ritenbaugh *et al.*, 2003).

Waist circumference, which has been shown to predict coronary artery disease risk in young people (Janssen, Katzmarzyk, Srinivasan, Chen, Malina, Bouchard & Berenson, 2005), was employed as a proxy indicator for visceral obesity. Contrary to expectations, WC in the group of all adolescents was significantly higher in the experimental group at baseline, but the difference persisted after the intervention ($p=0.002$). This was the case in both low- and higher attendance sub-groups. No difference was noted for BMI and body fat percentage.

The Cw, TPR, SBP and DBP measurements of the experimental group also did not show any significant changes after the PA intervention compared to the control group. Although there was a higher SBP in the higher attendance experimental sub-group this change was not significant. These results can be due to the increase in muscle mass in the total experimental group, as higher muscle mass may have elevated resting blood pressure (AAOP, 1997). While some studies indicate that decreased blood pressure levels are associated with increased levels of PA (Dwyer & Gibbons, 1994; Ewart, Young & Hagberg, 1998; McMurray *et al.*, 2002), other studies have indicated a non-significant relationship between blood pressure and PA (Bazzano, Cunningham, Varrassi & Falconio, 1992; de Visser, van Hooft, van Doornen, Hofman, Orlebeke & Grobbee, 1994). Alpert and Wilmore (1994) described the defining of hypertension in children and adolescents as difficult, given the increases in blood pressure that occurs as a result of increasing body size. Furthermore, the distinction between normotension and hypertension is difficult to make because of the continuous increase in BP with age in children and adolescents as well as the different upper limit of each age category (Pescatello, Franklin, Fagard, Farquhar, Kelley & Ray, 2004).

Insulin resistance also did not show a significant change in the experimental group after the PA intervention compared to the control group. The reason for insulin resistance not being significantly lower may be the smaller sample size of adolescents who were willing to give blood samples after the intervention. Also, it is important to note that body fat mass, blood pressure, lipids and insulin sensitivity change markedly during periods of growth and

maturation (Chen *et al.*, 1999; Jessup & Harrell, 2005). Insulin resistance increases during puberty, as insulin sensitivity is reduced in both non-diabetic and diabetic children, requiring the body to produce more insulin (Jessup & Harrell, 2005). This increased insulin secretion can be caused by an increased amount of circulating growth hormones and changes in body composition (Jessup & Harrell, 2005). However, some PA intervention studies show a significant improvement in insulin sensitivity (Carrel, Clark, Peterson, Nemeth, Sullivan & Allen, 2005; Nassis *et al.*, 2005), one study consisting of a PA intervention that was only 12 weeks in duration and only consisted of aerobic exercises 3 days per week for 40 minutes per day (Nassis *et al.*, 2005).

In conclusion, the results of this study indicate a change in body composition and vascular function in normal- and over-fat adolescents. However, these changes were not significant. To ensure better results in future intervention studies, a longer time period should be employed - at least 12 to 16 weeks. Compliance issues should be stressed in future studies, particularly in low socio-economic areas.

LIMITATIONS

This study has several limitations. It is firstly limited by the relatively smaller sample size of adolescents who were willing to give blood samples in pre- and post intervention tests. This small sample size makes it difficult to detect statistically significant changes with high accuracy. It is important to note that participants enrolled in this study voluntarily, which could also lead to a potential bias. The second limitation was the duration of the study, which stretched from the start to the end of a school term. School terms are relatively short, but it is almost impossible to maintain school-based interventions over school holidays. However, this study has provided valuable information for future studies on South African adolescents.

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CHAPTER 6

Summary, Conclusions and Recommendations

6.1 SUMMARY

The aims of this study were firstly to determine the relationship between body composition and selective metabolic syndrome (MS) markers in black adolescents; secondly to determine the influence of a 10-week physical activity (PA) intervention programme on selective MS markers in black adolescents; and thirdly to determine the influence of a 10-week PA intervention on body composition and vascular function in normal- and over-fat black adolescents. This thesis is submitted in article format, as approved by the senate of the North-West University (Potchefstroom Campus). Chapter 1 provides a brief introduction and outline of the problem statement that underlies the research questions, aims and hypotheses of this study. This thesis includes one narrative review article (Chapter 2) and three research articles (Chapter 3, 4 and 5 respectively), for presentation to appropriate and accredited journals.

Chapter 2: A narrative review article titled: “The influence of PA on components of the MS and vascular function in adolescents” by Zeelie, A., Moss, S.J. and Kruger, H.S. This article has been submitted to the African Journal for Physical, Health Education, Recreation and Dance (AJPHERD). Available studies on the topic from 1990 to January 2009 were analysed for the review. Specific attention was given to the influence of PA interventions and habitual PA on components of the MS and vascular function in children and adolescents. The narrative review concludes that increased PA and decreased sedentary behaviour are protective against high blood pressure, -triglyceride levels, -glucose levels, -waist circumference (WC) and low arterial compliance and high-density lipoprotein cholesterol (HDL-C) values. In conclusion, PA improves components of the MS and vascular function.

Chapter 3: The first research article titled “The relationship between body composition and selective MS markers in black adolescents in South Africa: PLAY study” by Zeelie, A., Moss, S.J. and Kruger, H.S. This article has been accepted for publication in the International Journal of Applied and Basic Nutritional Sciences. The main purpose of this

study was to determine whether significant associations exist between body composition and selective MS markers. Various body composition variables were analysed, and the results showed that there was a significant positive association between body fat percentage with both systolic blood pressure (SBP) ($p=0.02$) and homeostasis model assessment of insulin resistance (HOMA-IR) ($p=0.02$) respectively. Girls with a high body fat percentage also had higher SBP ($p=0.004$), diastolic blood pressure (DBP) ($p=0.03$), plasma insulin ($p=0.004$) and HOMA-IR ($p=0.004$) than girls with normal body fat percentage.

Chapter 4: The second article titled “The impact of a 10-week PA intervention programme on selective MS markers in black adolescents: PLAY study”, by Zeelie, A., Moss, S.J., Kruger, H.S. and van Rooyen, J.M. This article has been accepted for publication in the South African Journal for Research in Sport, Physical Education and Recreation (SAJRSPER) (2010. 32(1):147-162). The aim of this study was to determine the effects of a 10-week PA intervention on selective markers of the MS in black adolescents. The results of the study indicated that adolescents from the control group had a significantly lower DBP compared to the experimental group ($p=0.00005$) and adolescents from the experimental group had a significantly lower SBP compared to the control group ($p=0.000061$) after the 10-week PA intervention. There was also a tendency towards a higher arterial compliance and lower HOMA-IR in the experimental group compared to the control group. The findings of this study suggest that the experimental group had significantly lower SBP and lower HOMA-IR compared to the control group after a 10-week PA intervention.

Chapter 5: The third article titled “The impact of a 10-week PA intervention programme on body composition and markers of vascular function in normal- and over-fat black adolescents: PLAY study”, by Zeelie, A., Moss, S.J., Kruger, H.S and van Rooyen, J.M. This article will be presented for publication to the African Journal for Physical, Health Education, Recreation and Dance (AJPHERD). The aim of this study was to determine the effects of a PA intervention on body composition and the markers of vascular function in both normal- and over-fat adolescents. The results of this study indicated a lower HOMA-IR ($F=2.5$; $p=0.09$) and a higher muscle mass ($F=2.3$; $p=0.10$) and SBP ($F=2.7$; $p=0.08$) in the experimental group overall. In the over-fat group, a similar tendency towards a lower HOMA-IR ($F=2.6$; $p=0.09$) was found after the PA intervention compared to the control group. No significant differences were found between body composition and vascular

function variables at baseline and after the intervention for the normal- and over-fat group in this study.

All the above mentioned articles have been written according to the guidelines of the specific journals and consist of an introduction, problem statement and the resulting research questions and purposes of the study. The research methods (participants, measurement procedures and data analysis) were described, after which the results were presented and discussed. Each article ends with a research conclusion.

6.2 CONCLUSIONS

The conclusions that are drawn from this research are presented in accordance with the set hypothesis (Chapter 1).

6.2.1 Hypothesis 1: *There is a positive relationship between body composition components and selective markers of the MS in black adolescents.*

The purpose of chapter 3 was to determine the relationship between body composition and selective MS markers in black adolescents in the North West Province of South Africa. The selective MS markers analysed in this study were fasting insulin, fasting glucose, HOMA-IR, SBP and DBP together with the following body composition markers; WC, BMI, body fat percentage, height, weight and waist-hip ratio.

The results showed that there was a significant positive association between body fat percentage with both SBP ($p=0.02$) and homeostasis model assessment of insulin resistance (HOMA-IR) ($p=0.02$) respectively. Girls with a high body fat percentage also had higher SBP ($p=0.004$), DBP ($p=0.03$), plasma insulin ($p=0.004$) and HOMA-IR ($p=0.004$) than girls with normal body fat percentage.

Hypothesis 1 is therefore accepted based on the research findings. To conclude from the results: the maintenance of ideal body weight and body fat percentage is recommended to prevent cardiovascular disease, as a high body fat percentage is positively associated with SBP and HOMA-IR. The girls with a high body fat percentage in this study not only had higher SBP and HOMA-IR, but also DBP and plasma insulin, compared to the girls with normal body fat percentage. Girls in this study (both in the intervention and in the control

group) recorded habitual PA levels that were on average low when compared to the boys. Thus, it is recommended that girls in particular be encouraged to participate in physical activities in order to reduce their body fat percentage.

6.2.2 Hypothesis 2: *A 10-week PA intervention programme will significantly improve selective markers of the MS in black adolescents.*

The aim of chapter 4 was to determine the effects of a 10-week PA intervention on selective markers of the MS in black adolescents. The results of the study indicated that adolescents from the control group had a significantly lower DBP compared to the experimental group ($p=0.00005$) and adolescents from the experimental group had a significantly lower SBP compared to the control group ($p=0.000061$) after the 10-week PA intervention. The results of this study found a 2% increase in SBP in the experimental group and a 20% increase in SBP in the control group. This study also reported a decrease in HOMA-IR and an increase in Cw in the experimental group compared to the control group after the 10-week PA intervention programme.

Hypothesis 2 is therefore only partially accepted, as although HOMA-IR decreased in the experimental group after the 10-week PA intervention, SBP increased. It should however be noted that the difference in the level of increase in SBP in the experimental group (2% increase) and the control group (20% increase) was statistically significant, which provides some support to the assumption that a 10-week PA intervention programme had a protective role in preventing a higher increase in SBP in the experimental group.

6.2.3 Hypothesis 3: *A 10-week PA intervention programme will significantly improve body composition and vascular function in black adolescents.*

The purpose of chapter 5 was to determine the effects of a PA intervention on body composition and vascular function in both normal- and over-fat adolescents. The results indicated lower insulin resistance ($F=2.5$; $p=0.09$) and an increase in muscle mass ($F=2.3$; $p=0.10$) and SBP ($F=2.7$; $p=0.08$) in the experimental group overall. In the over-fat group, a similar lower insulin resistance was found after the PA intervention ($F=2.6$; $p=0.09$) compared to the control group. No significant differences were found between body

composition and vascular function variables at baseline and after the intervention for the normal- and over-fat group in this study.

Hypothesis 3 is therefore rejected based on the research findings. A reason for the rejection of this hypothesis could lie in the issue of compliance. Compliance issues should be stressed in future studies, particularly when conducted in low socio-economic areas.

6.3 RECOMMENDATIONS

- 6.3.1 One of the reasons for the results in hypothesis two and three may be that participation levels in the PA intervention after school was very low. It is therefore recommended that such PA intervention programmes be implemented during school hours where all the children and adolescents can be exposed to PA and also be educated on the benefits of being physically active and fit.
- 6.3.2 The results of this study showed that PA had a positive effect on some MS markers, namely: SBP and HOMA-IR. Further research regarding PA intervention's influence on the MS in black adolescents should be conducted, as there is clearly a shortage of literature that focuses on this research theme within this South African ethnic group.
- 6.3.3 Similar studies can also be conducted on other ethnic groups in South Africa in order to assess the role of ethnicity in the occurrence of the MS.

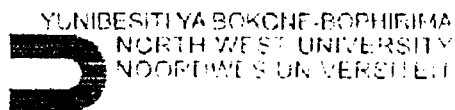
Although the study was carefully planned, some limitations were evident and should be addressed in future similar studies. The following recommendations are made in this regard:

- 6.3.4 This study is firstly limited by the relatively small sample size of adolescents who were willing to give blood samples in pre- and post intervention tests. This small sample size makes it difficult to detect statistically significant changes with high accuracy. It is important to note that participants enrolled in this study voluntarily, which could also lead to a potential bias.
- 6.3.5 A further shortcoming was the duration of the study, which stretched from the start to the end of a school term. School terms are relatively short, and it is almost impossible to maintain school-based interventions over school holidays. Successful school intervention programmes rely on the full participation of all the players in the school system, particularly teachers and parents, in order to promote the

sustainability of the programmes. Negotiating the sustainability strategy with the communities at the onset of the programme will contribute significantly to its success. For example discussions should be on the importance

- 6.3.6 Another limitation was that a small percentage of participants who participated regularly in the programme, something that was beyond the control of the researchers. It is therefore recommended that similar research studies be conducted during school hours in order to prevent this compliance problem.
- 6.3.7 There was also a very small number of participants with MS and/ or with MS markers, making the analysis and generalising of these results difficult. However, the results indicated a positive relationship between PA and selective MS markers, and further research in this regard is therefore recommended. In future studies researchers should make sure that they identify and select sufficient number adolescents who have the MS.
- 6.3.8 Triacylglycerol and HDL-C, both markers of the MS, were not measured due to budget constraints. It is recommended that all MS markers should be tested to strengthen the research outcome.
- 6.3.9 Although the study focused on grade 9 learners, large age differences were observed (15 – 19 years). It is recommended that the researchers should select their participants according to age and not grade, as this will improve data analysis and interpretation.

Appendix A: Approval of the PLAY-Study by the NWU ethics committee



Etiëkkomitee

Tel (018) 299 2558

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E-Posdiivealr@puk.ac.za

11 Februarie 2004

Prof HH Vorster

Bussie 594

NWU (Potchefstroomkampus)

Geagte prof Vorster

GOEDKEURING VIR EKSPERIMENTERING MET MENSE

Hiermee wens ek u in kennis te stel dat u projek getiteld

Physical Activity in the Young (PLAY-project)

op 11 Februarie 2004 goedgekeur is met nommer 04M01. Gebruik asseblief laasgenoemde nommer in alle korrespondensie rakende bogenoemde projek en let daarop dat daar van projekteers verwag word om jaarliks in Junie op die voorgeskrawe vorm (wat voorsien sal word) aan die Etiëkkomitee verslag te doen insake etiese aspekte van hulle projekte asook van publikasies wat daaruit voortgespruit het. Goedkeuring van die Etiëkkomitee is vir 'n termyn van hoogstens 5 jaar geldig (volgens Senaatsbesluit van 4 November 1992, art 9.13.2). Vir die voortsetting van projekte na verstryking van hierdie tydperk moet opnuut goedkeuring verkry word.

Die Etiëkkomitee wens u alle voorspoed met u werk toe.

Vriendelike groete

ESTELLE LE ROUX

NAMENS SEKRETARIAAT

APPENDIX B: Informed consent: Experimental group**PLAY PROJECT: INFORMATION ON THE STUDY**

THE PROJECT HAS BEEN APPROVED BY THE ETHICS COMMITTEE OF THE NORTH WEST UNIVERSITY (Potchefstroom Campus), project number 04M01

I CONFIRM THAT:

It has been explained to me, that:

1. The purpose of the research study is to collect information on growth and activity among Grade 9 schoolchildren in Boitshoko Secondary School, North West Province.
2. I have been told that the researchers will measure me. The participant will be weighed and his/her height as well as circumferences and skinfolds of his/her arm will be measured without causing any pain to the child. For those measurements boys and girls in separate groups will be asked to undress in the privacy of a class-room, because some measurements must be taken with the children dressed in underwear only, or a light shirt and pants/skirt. The researchers will also ask me to indicate my own level of physical maturation from pictures. The different age groups will be measured separately. The researchers and fieldworkers will work in a professional way, not to embarrass the children.
3. I will also be measured in an instrument, called the BODPOD to measure amount of muscle, bone and fat. These measurements will be done at the North West University and children will be transported to the laboratory and back.
4. Fitness testing will be done and blood pressure will be tested.
5. Blood samples will be taken during basal and final measurements. Blood will be collected by qualified personnel by using a thin needle (20ml blood per each sample) to minimize pain and discomfort. Blood samples will not be tested for HIV.
6. The measurements will be done twice, March and September, to assess growth and health.
7. The researchers will ask me about my home environment, the food that I usually eat and activities that I do. None of these questions will be to see if I am clever, or know correct answers. I can just tell them what I usually do.
8. Guidelines for appropriate, culture sensitive, practical and sustainable intervention programmes for children will be developed.
9. The information I will give shall be kept confidential, only to be used anonymously for making known the findings to other scientists.
10. It was also clearly explained to me that I can refuse to participate in this research study or I can stop answering the questions at any time during the interviews, or refuse to give a blood sample if it hurts.

The information in this consent form was explained to me by Mrs Susan Leqoete (interviewer) in _____ (language) and I confirm that I have a good command in this language and understood the explanations, OR it was translated to me by _____ (Name of translator) in my language _____. I was also given the opportunity to ask questions on things I did not understand clearly.

I the participant (child) hereby agree voluntarily to take part in this research survey.

Signed/confirmed _____ at _____ on _____ 2015

Witness _____

Representative of participant (parent/guardian) _____

APPENDIX C: Informed consent: Control group

PLAY PROJECT: INFORMATION ON THE STUDY

THE PROJECT HAS BEEN APPROVED BY THE ETHICS COMMITTEE OF THE NORTH WEST UNIVERSITY (Potchefstroom Campus).

I CONFIRM THAT:

It has been explained to me, that:

1. The purpose of the research study is to collect information on growth and activity among Grade 9 schoolchildren in Seiphemelo Secondary School, North West Province.
2. I have been told that the researchers will measure me. The participant will be weighed and his/her height as well as circumferences and skinfolds of his/her arm will be measured without causing any pain to the child. For those measurements boys and girls in separate groups will be asked to undress in privacy of a class-room, because some measurements must be taken with the children dressed in underwear only, or a light shirt and pants/skirt. The researchers will also ask me to indicate my own level of physical maturation from pictures. The different age groups will be measured separately. The researchers and fieldworkers will work in a professional way, not to embarrass the children.
3. I will also be measured in an instrument, called the BODPOD to measure amount of muscle, bone and fat. These measurements will be done at the North West University and children will be transported to the laboratory and back.
4. Fitness testing will be done.
5. Blood samples will be taken during basal and final measurements. Blood will be collected by qualified personnel using a thin needle (20ml blood per each sample) to minimize pain and discomfort. Blood samples will not be tested for HIV.
6. The measurements will be done at the beginning and end of the study. After the first measurements, an activity programme, based on fun games for children will be presented for three days per week at the school. The programme will run from about March to September during the school terms. The purpose of the measurements at the end of the study is to see if the participants improve physically after the activity programme. On at least one day I will be asked to wear a little measuring instrument on a waistband to measure my physical activity. The instrument cannot harm me in any way, all it does is to measure movement.
7. The researchers will ask me about my home environment, the food that I usually eat and activities that I do. None of these questions will be to see if I am clever, or know correct answers. I can just tell them what I usually do.
8. Guidelines for appropriate, culture sensitive, practical and sustainable intervention programmes for children will be developed.
9. The information I will give shall be kept confidential, only to be used anonymously for making known the findings to other scientists.
10. It was also clearly explained to me that I can refuse to participate in this research study or I can stop answering the questions at any time during the interviews, or I can refuse to give a blood sample if it hurts.

The information in this consent form was explained to me by _____ (name of interviewer) in _____ (language) and I confirm that I have a good command in this language and understood the explanations, OR it was translated to me by _____ (Name of translator) in my language _____. I was also given the opportunity to ask questions on things I did not understand clearly.

I the participant (child) hereby agree voluntarily to take part in this research survey.

Signed/confirmed at _____ on _____ 2005

Witness _____

Representative of participant (parent/guardian) _____

APPENDIX D: PLAY-Study data sheet

PLAY-STUDY DATASHEET 2006

PLAY – DATA sheet	Subject no		
Name:			
Age:		Gender	M F
Birth date:		Grade	
Test date:		Arm span	
		Sitting height	

ANTROPOMETRIC MEASUREMENTS

Stature		Calf circumference	
Body mass		Abdominal circumference	
Sub scapular circumference		BMI	
Triceps circumference		% Body fat	

FITNESSGRAM

Bleep-test (Levels)		Pacer-test (Laps)	
Aerobic capacity		Trunk lift	
Curl Up		Standing long jump	
Push Up		Step up test	
Sit and reach			
Modified sit and reach			
Bent arm hang (girls)		Pull-ups (boys)	
Handgrip strength			

TID TESTS

Basketball throw (m)	1	40 m sprint (sec)	1
	2		2
Vertical jump (cm)	1	Agility (sec)	1
	2		2

APPENDIX E: PLAY-Study anthropometric data sheet

PLAY-PROJECT
ANTHROPOMETRIC DATA SHEET

Name: _____ Surname: _____

DOB: ____/____/____ Age: _____ Gender: _____

Subject number: _____ RHT: _____ Test date: ____/____/200__

			Measurement 1	Measurement 2	Measurement 3
1	Weight	kg			
2	Height	cm			
3	Arm span	cm			
4	Sitting Height	Cm			
Circumference					
5	Upper arm relaxed	cm			
6	Upper arm tensed	cm			
7	Waist	cm			
8	Hip	cm			
9	Calf	cm			
Skin folds:					
10	Triceps	mm			
11	Sub scapular	mm			
12	Calf	mm			
13	Supra spinal	mm			
14	Abdominal	mm			
Bod-Pod:					
13	Mass	kg			
14	Body fat %	%			
15	Fat mass	kg			
16	% Lean tissue	%			
17	Lung volume	L			

APPENDIX F: Female self assessment of maturity characteristics (Tanner)

FEMALE SELF-ASSESSMENT OF MATURITY CHARACTERISTICS

Name:	Gender:	F	Age:
Subject number:			

1. Have your menstrual cycle (periods) started already? Tick in the appropriate box.
 Yes No

2. When was your last period? (Indicate the number of days, weeks, months).

3. If you have started menstruating, circle the age and the grade when you did.

Primary school				Secondary school				
10 years Grade 4	11 years Grade 5	12 years Grade 6	13 years Grade 7	14 years Grade 8	15 years Grade 9	16 years Grade 10	17 years Grade 11	18 years Grade 12


4. Do you think you started menstruating at the same time, earlier or later than friends or girls with a similar age than you? Tick in the appropriate box.
 EARLIER LATER SAME TIME

5. If possible, try to recall the exact date when you started menstruating (year, month)
 Year:
 Month:

6. As you keep growing over the next few years, you will see changes in your body. These changes happen at different ages for different children and you may already be seeing some changes. Doctors use the set of drawings of pubic hair development which is shown to you to determine stage of growth. These changes can be identified in 5 different phases. We want to determine how well you can select your stage of growth from the set of drawings. All you need to do is pick the drawing and description that looks like you do know. Make a tick above the drawing that is closest to your stage of development, then put the sheet in the envelope and seal it so your answer will be kept in private.

The following drawings show different amounts of female pubic hair development. Please look at each of the drawings and read the sentences under the drawings. Then tick the drawing that is closest to your hair development.

Figure 1 Figure 2 Figure 3 Figure 4 Figure 5



There is no pubic hair at all.

There is small amount of long lightly coloured hair. This hair may be straight or a little curly

There is darker hair, curlier and thinly spread out to cover a somewhat larger area than in stage 2.











The hair is thicker and more spread out covering a larger area than in stage 3

The hair now is widely spread covering a large area, like that of an adult female

7. In comparison to other girls your age, how would you describe your development with regard to pubic hair development.

Much earlier	Somewhat earlier	About the same	Somewhat later	Much later
--------------	------------------	----------------	----------------	------------

8. The following drawings show the amount of breast development. Please look at each of the drawings and read the sentences under the drawings. Then tick the drawing that is closest to your breast development.

Picture 1	Picture 2	Picture 3	Picture 4	Picture 5
				
				
The nipple is raised a little in this stage. The rest of the breast is still fat	This is the breast bud stage. In this stage the nipple is raised more than in stage 1. The breast is a small mound. The areola is larger than in stage 1	The areola and the breast are both larger than in stage 2. The areola does not stick out away from the breast	The areola and the nipple make up a mound that sticks above the shape of the breast	This is the mature adult stage. The breasts are fully grown. Only the nipple sticks out in this stage. The areola has moved back to the general shape of breast

9. In comparison to other girls your age, how would you describe your development with regard to breast development.

Much earlier	Somewhat earlier	About the same	Somewhat later	Much later
--------------	------------------	----------------	----------------	------------

Thank you for your time!

APPENDIX G: Male self assessment of maturity characteristics (Tanner)

MALE SELF-ASSESSMENT OF MATURITY CHARACTERISTICS

Subject nr:	Name:	Age:
--------------------	--------------	-------------

1. Have you already experienced a voice change? Tick in the appropriate box.

No <input type="checkbox"/>	<input type="checkbox"/>	Yes <input type="checkbox"/>
Unbroken	Signs of breaking	Definitely broken adult quality

2. If applicable, circle the age/grade in which you experienced signs of breaking of your voice.

Primary school				Secondary school				
10 years Grade 4	11 years Grade 5	12 years Grade 6	13 years Grade 7	14 years Grade 8	15 years Grade 9	16 years Grade 10	17 years Grade 11	18 years Grade 12

3. If applicable, circle the age/grade in which you experienced YOUR VOICE DEFINITELY BROKEN.

Primary school				Secondary school				
10 years Grade 4	11 years Grade 5	12 years Grade 6	13 years Grade 7	14 years Grade 8	15 years Grade 9	16 years Grade 10	17 years Grade 11	18 years Grade 12

4. Do you think your voice broke at the same time, earlier or later than friends or boys of a similar age than you? Tick in the appropriate box?

EARLIER <input type="checkbox"/>	LATER <input type="checkbox"/>	SAME TIME <input type="checkbox"/>
----------------------------------	--------------------------------	------------------------------------

5. If you have started shaving, in which grade did it happen?

Grade:
Not Yet:

6. Do you think you started shaving at the same time, earlier or later than friends or boys with a similar age than you? Tick in the appropriate box?

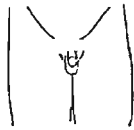
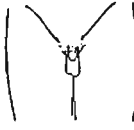
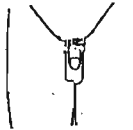
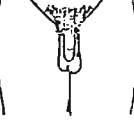
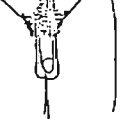
EARLIER <input type="checkbox"/>	LATER <input type="checkbox"/>	SAME TIME <input type="checkbox"/>
----------------------------------	--------------------------------	------------------------------------

7. The description on this page describes different amounts of male facial hair. Please read each of the descriptions. Then tick the appropriate box that describes your stage of facial hair development best.

None	Increase in length, with pigmentation (darkening) at corners of upper lip, spreading medially to complete moustache.	Hair on the upper part of the cheeks and in the midline just below the lower lip.	Hair on the sides and lower border of the chin.
------	----------------------------------------------------------------------------------------------------------------------	-----------------------------------------------------------------------------------	-------------------------------------------------

8. As you keep growing over the next few years, you will see changes in your body. These changes happen at different ages for different children and you may already be seeing some changes. Doctors use the set of drawings which is shown to you to determine stages of growth. These changes can be identified in 5 different phases. We want to determine how well you can select your stage of growth from the set of drawings. All you need to do is to pick the drawing and description that looks like you do now. Make a tick above the drawing that is closest to your stage of development, then put the sheet in the envelope and seal it so your answer will be kept in private.






The drawings on this page show different amounts of male pubic hair. Please look at each of the drawings and read the sentences under the drawings. Then tick the drawing that is closest to your stage of hair development

Picture 1 <input type="checkbox"/>	Picture 2 <input type="checkbox"/>	Picture 3 <input type="checkbox"/>	Picture 4 <input type="checkbox"/>	Picture 5 <input type="checkbox"/>
				
There is no pubic hair at all.	There is small amount of long, lightly coloured hair. This hair may be straight or a little curly.	There is darker hair, curlier and thinner, spread out to cover a somewhat larger area than in stage 2.	The hair is thicker and more spread out, covering a larger area than in stage 3.	The hair now is widely spread, covering a large area, like that of an adult male.

9. In comparison to other boys of your age, how would you describe your development with regard to pubic hair development.

Much earlier	Somewhat earlier	About the same	Somewhat later	Much later
--------------	------------------	----------------	----------------	------------

10. The drawings on this page show different stages of growth of the testes, scrotum and penis. A boy goes through each of the 5 stages shown. Please look at each of the drawings and read the sentences under the drawings. Then tick the drawing that is closest to your stage of growth

Picture 1 <input type="checkbox"/>	Picture 2 <input type="checkbox"/>	Picture 3 <input type="checkbox"/>	Picture 4 <input type="checkbox"/>	Picture 5 <input type="checkbox"/>
				
The testes, scrotum and penis are about the same size and shape as they were when you were a child.	The testes and scrotum are bigger. The skin of the scrotum has changed. The scrotum (the sack holding the testes) has gotten lower. The penis has gotten only a little bigger.	The penis has grown in length. The testes and scrotum have grown and dropped lower than in picture 2.	The penis has gotten even bigger. It is wider. The head of the penis is bigger. The scrotum is darker than before. It is bigger because the testes are bigger.	The penis, scrotum, and testes are the size and shape of that of an adult man.

11. In comparison to other boys of your age, how would you describe your development with regard to growth of the penis, testes and scrotum.

Much earlier	Somewhat earlier	About the same	Somewhat later	Much later
--------------	------------------	----------------	----------------	------------

THANK YOU FOR YOUR TIME!

APPENDIX H: Previous day physical activity recall: PDPAR script

Previous Day Physical Activity Recall: PDPAR Script

"Good morning! I'm _____ and I've brought _____ with me today. We're from the University of South Carolina and are here to measure your recent physical activity. We are going to assist you with recalling the main activities you did yesterday after school. There are a couple of things we need to know. They include what the activity was, how physically hard it was, and how long the activity lasted.

[HAND-OUT PDPAR WORKSHEETS TO THE STUDENTS. WHILE YOU TALK, HOLD UP A PDPAR WORKSHEET FOR EVERYONE TO SEE.]

"First, lets look at the top page of the recall sheet. This page has drawings of activities of different intensities. The lowest level is called very light activities. Activities such as watching television and studying are considered very light. Medium physical activities increase heart and breathing rates. Looking at the drawings we can see that such activities as jogging and playing basketball are moderate activities. Hard activities are those that cause you to be tired in just a few minutes. They include activities such as running very fast and biking very fast."

"Did anyone notice that some activities can be done so that they are either physically hard or sort of easy? [Let them respond.] What did you notice about basketball and running?" [Let them respond.] "It should be clear that basketball, running, and other activities can be done easy or hard, depending on how they are played or done."

"You will be asked to recall the main activities you did yesterday after school. You will also be asked to report the main activity you engaged in each half-hour. Can anyone think of an activity that lasts a half-hour? [Pause. **Hopefully, someone will say watching a TV show; if they don't, mention it yourself.**]

"Now flip to the middle pages of your worksheet. On the left side is a list of 33 Common activities. From this list you will choose yesterday's after school activities. Let's look at the list. The first 3 items have to do with eating. Notice each item is assigned a number. For example, # 1 is *eating a meal* and # 2 is *eating a snack*."

"Let's look down the list...continue reading the whole list... # 33 is "other." Some activities are listed twice. For example, # 8 and # 21 both list *walking*. The difference is that # 8 walking is walking for transportation... such as walking to a friend's house because you have no other way to get there. If someone went for a walk to get some fresh air, walk the dog or to get some exercise we would record # 21."

"The difference between # 30 – "organized" sport and # 31 – "individual" sport is that # 30 has a coach."

"In some cases an activity you participate in may not be listed. For example, let's say you read a book for fun. Reading is not listed so you would pick # 20 or # 33 "other" and write the word "reading" on the line.

[HOLD UP ENLARGED VERSION OF RECALL SHEET. ASK STUDENTS TO PUT THEIR PENCILS/PENS DOWN & INSTRUCT THEM NOT TO WRITE ON THEIR WORKSHEET YET.]

"Before we actually fill one out, let's look at this chart...it is similar to the one on the right hand page you have in front of you. In order to show you how to record your activity, we will go through a make-believe 7th grader's activity recall. Notice the chart has spaces to mark the main activity which our 7th grader did and how physically hard it was."

1. Let's say yesterday from 3:00 until 3:30 the main activity of this student was riding home on a school bus. What number activity is riding on a school bus? [Pause and wait for the correct answer.]

"Correct. He or she would write a 7 in the first box. Please remember that only ONE activity can be put in each block." [Record a "7" in the correct box on the sample sheet.]

"How hard do you believe it is to *ride a school bus*?" [Pause.] *Riding a school bus* is physically easy, that is: "done while sitting down." So, we would put a check in the very light column." [Record a ✓ mark in the VERY LIGHT column.]

2. "Let's say the person got home at 3:30 and had a *snack*. What number is snacking? [Pause.] We will put the # 2 here. [Record a "2" in the correct box.] "How physically hard is *snacking*?" [Pause.] Because it is not very physically hard, we would choose very light." [Record a ✓ mark in the VERY LIGHT column.]

3. "From 4:00 until 5:00 the person decided to *shoot baskets*. What number activity would that be? The correct number is 31. Because he or she was just *shooting baskets* and not working hard he or she would put a check in either the light or medium column." [Put a check ✓ in one of those columns.]

4. "From 5:00 until 6:00 our 7th grader *ate dinner*. What number is *dinner*? [Pause.] Correct, it is number: 1. How physically hard is *eating*? Because it is not very physically hard we would choose very light." [Record # 1 and ✓ VERY LIGHT.]

5. "From 6:00 until 7:30 this person *did homework*. What number is *homework*? [Pause.] Correct # 11. [Record # 11 in the 3 corresponding boxes.] How physically hard is *homework*? [Pause.] Because *homework* is not physically hard we would choose very light. [✓ VERY LIGHT.] What if the *homework* subject was math and was very hard? [Pause.] We would still mark very light because it is physically very light.

6. "From 7:30 until 9:30 this person *watched television*. What number is *television*? It's # 13 so we will write 13 in the next four blocks. [Record #13 in the corresponding boxes.] Because *television* viewing is not physically hard and is done while sitting, we would choose very light." [✓ VERY LIGHT.]

7. "At 9:30 our friend *went to bed*. What number is *sleeping*? [Pause.] Right, #4. [Record # 4 in the corresponding box.] Because *sleeping* is not physically hard we would choose very light. [✓ VERY LIGHT.] What if our friend was *sleeping* hard? [Pause.] We would still mark very light because it is physically light. [✓ VERY LIGHT.]

[BEGIN THE ACTUAL ADMINISTRATION. ASK THE STUDENTS TO PICK-UP THEIR PENCILS/PENS AND BEGIN THE RECALL WORKSHEET.]

"Okay, let's recall YOUR activity. Try your best to remember! Please be honest! First remember to circle the day of the week being recalled. [Point to it on the sample sheet.] Since today is _____, yesterday was _____.

"At 3:00 yesterday afternoon, remember what you were doing. Three o'clock is right after school, so many of you were probably on your way home. Some of you may have been walking and some of you riding in a bus or car." [Pause.]

"Now, find the number of the activity YOU participated in and write it in the proper box. Remember, only ONE activity per box. How physically hard was that activity? Write in how physically hard you thought the activity was."

"At 3:30 many of you probably arrived at home. Try to remember what you did. Many people have a snack at this time but, you may have been doing something else."

[Give them time to mark their responses.]

"Do you remember what you were doing from 4:00 until you ate dinner? Did you help prepare dinner? Did you go outside and play? Please find the number of the activity you participated in and record it."
[Pause and let them record responses.]

"Somewhere between 5:00 and 7:30 most people eat dinner. Please do not forget to put down when you ate. What did you do after dinner? Did you help with dishes? Did you watch television, do homework, go to a store, hang around with friends, or talk on the phone? Please complete the recall to 8:00."

[Walk around the room and see how the students are doing.]

"You can finish the worksheet at your own pace. I will be walking around the room if you have any questions. Does anyone have any questions?"

[Walk around the room and look over students' shoulders to make sure that they are not forgetting to mark intensities and are filling-in the specific activity when necessary.]

[As the students complete their recalls, collect them one-by-one. BE SURE TO INSPECT EACH RECALL SHEET FOR MISSING OR INCORRECT INFORMATION. Ask the student to make the necessary corrections. Collect each recall from each student.]

[Remember to thank the students and the teach for their cooperation and effort!]

APPENDIX I: Physical activity questionnaire of the previous weekend day (PDPAR)

Physical activity questionnaire of the previous weekend day

Subject no:

Name:

Age: Gender: M V

School: Race: W B C I

Date: Teacher:

Classification:

Grade:

Think back about the weekend. For each of the 30 minute periods, select a primary activity that you performed and write the type of activity in the type of activity column.

Mark the day of the weekend that you fill in this form:

Saturday Sunday

Time	Activity	METS		Intensity			
		Very light	Light	Medium	Hard	Very Hard	Very Very Hard
7:00	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>
7:30	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>
8:00	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>
8:30	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>
9:00	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>
9:30	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>
10:00	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>
10:30	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>
11:00	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>
11:30	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>
12:00	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>
12:30	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>
13:00	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>
13:30	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>
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16:00	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>
16:30	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>
17:00	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>
17:30	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>
18:00	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>
18:30	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>
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19:30	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>
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21:30	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>
22:00	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>

APPENDIX J: Physical activity questionnaire of the previous week day (PDPAR)

Physical activity questionnaire of the previous week day

Subject nr

Name:

Race: W B G I

Age:

Gender: M F

Grade:

School:

Teacher:

Date:

Classification

Think back about yesterday. For each of the 30 minutes periods, select a primary activity that you performed and write the type of activity in the type of activity column.

Mark the day of the week that you fill in this form

Monday Tuesday Wed Thursday Friday

Time	Activity	METS		•	Very light	Light	Med	Hard
7:00	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>
7:30	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>
8:00	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>
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11:30	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>
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21:00	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>
21:30	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>
22:00	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>	<input type="text"/>

APPENDIX K: Author guidelines: The African Journal for Physical, Health Education, Recreation and Dance (Chapter 2 & Chapter 5)

GUIDELINES FOR AUTHORS

The African Journal for Physical, Health Education, Recreation and Dance (AJPHERD) is a peer-reviewed journal established to:

- i) provide a forum for physical educators, health educators, specialists in human movement studies and dance, as well as other sport-related professionals in Africa, the opportunity to report their research findings based on African settings and experiences, and also to exchange ideas among themselves.
- ii) afford the professionals and other interested individuals in these disciplines the opportunity to learn more about the practice of the disciplines in different parts of the continent.
- iii) create an awareness in the rest of the world about the professional practice in the disciplines in Africa.

GENERAL POLICY

AJPHERD publishes research papers that contribute to knowledge and practice, and also develops theory either as new information, reviews, confirmation of previous findings, application of new teaching/coaching techniques and research notes. Letters to the editor relating to the materials previously published in AJPHERD could be submitted within 3 months after publication of the article in question. Such letter will be referred to the corresponding author and both the letter and response will be published concurrently in a subsequent issue of the journal.

Manuscripts are considered for publication in AJPHERD based on the understanding that they have not been published or submitted for publication in any other journal. In submitting papers for publication, corresponding authors should make such declarations. Where part of a paper has been published or presented at congresses, seminars or symposia, reference to that publication should be made in the acknowledgement section of the manuscript.

AJPHERD is published quarterly, i.e. in March, June, September and December. Supplements/Special editions are also published periodically.

SUBMISSION OF MANUSCRIPT

Three copies of original manuscript and all correspondence should be addressed to the Editor-in-Chief:

Professor L. O. Amusa	Tel: +27 15 9628076
Centre for Biokinetics, Recreation and Sport Science, University of Venda for Science and Technology, P. Bag X5050, Tlohozyandou 0950 Republic of South Africa	Fax: +27 15 9628647 9628055 E-mail: amusalhw@yahoo.com

Articles can also be submitted electronically, i.e. via e-mail attachment. However, the corresponding author should ensure that such articles are virus free. AJPHERD reviewing process normally takes 4-6 weeks and authors will be advised about the decision on submitted manuscripts within 60 days. In order to ensure anonymity during the reviewing process authors are requested to avoid self-referencing or keep it to the barest minimum.

PREPARATION OF MANUSCRIPT

Manuscripts should be type written in fluent English (using 12-point Times New Roman font and 1" line-spacing) on one side of white A4-sized paper justified fully with 3cm margin on all sides. In preparing manuscripts, MS-Word, Office 98 or Office 2000 for Windows should be used. Length of manuscripts should not normally exceed 12 printed pages (including tables, figures, references, etc.). For articles exceeding 12 typed pages US\$ 10.0 is charged per every extra page. Longer manuscripts may be accepted for publication as supplements or special research reviews. Authors will be requested to pay a publication charge of US\$ 150.0 to defray the very high cost of publication.

Title page:

The title page of the manuscript should contain the following information:

Concise and informative title.

Author(s)' name(s) with first and middle initials. Authors' highest qualifications and main area of research specialisation should be provided.

Author(s)' institutional addresses, including telephone and fax numbers.

Corresponding author's contact details, including e-mail address

A short running title of not more than 6 words.

Abstract

An abstract of 200-250 words is required with up to a maximum of 5 words provided below the abstract. Abstract must be typed on a separate page using single line spacing, with the purpose of the study, methods, major results and conclusions concisely presented. Abbreviations should either be defined or excluded.

Text

Text should carry the following designated headings: Introduction, materials and methods, results, discussion, acknowledgement, references and appendices (if appropriate).

Introduction

The introduction should start on a new page and in addition to comprehensively giving the background of the study should clearly state the problem and purpose of the study. Authors should cite relevant references to support the basis of the study. A concise but informative and critical literature review is required.

Materials and Methods

This section should provide sufficient and relevant information regarding study participants, instrumentation, research design, validity and reliability estimates, data collection procedures, statistical methods and data analysis techniques used. Qualitative research techniques are also acceptable.

Results

Findings should be presented precisely and clearly. Tables and figures must be presented separately or at the end of the manuscript and their appropriate locations in the text indicated. The results section should not contain materials that are appropriate for presentation under the discussion section. Formulas, units and quantities should be expressed in the *SI* (International System of Units) units. Colour printing of figures and tables is expensive and could be done upon request authors' expense.

Discussion

The discussion section should reflect only important aspects of the study and its major conclusions. Information presented in the results section should not be repeated under the discussion. Relevant references should be cited in order to justify the findings of the study. Overall, the discussion should be critical and tactfully written.

References

The American Psychological Association (APA) format should be used for referencing. Only references cited in the text should be alphabetically listed in the reference section at the end of the article. References should not be numbered either in the text or in the reference list.

Authors are advised to consider the following examples in referencing:

Examples of citations in body of the text:

117 GUIDELINES FOR AUTHORS

For one or two authors: Kruger (2003) and Travill and Lloyd (1998). These references should be cited as follows when indicated at the end of a statement: (Kruger, 2003); (Travill & Lloyd, 1998).

For three or more authors cited for the first time in the text: Monyeki, Brits, Mantsera and Toriola (2002) or when cited at the end of a statement as in the preceding example: (Monyeki, Brits, Mantsera & Toriola, 2002). For subsequent citations of the same reference it suffices to cite the particular reference as: Monyeki et al. (2002).

Multiple references: when cited in the body of the text should be listed chronologically in ascending order, i.e. starting with the oldest reference. These should be separated with semi colons. For example: (Tom, 1982; McDaniels & Jooste, 1999; van Heerden, 2001; de Ridder et al., 2003).

Reference List

In compiling the reference list at the end of the text the following examples for journal references, chapter from a book, book publication and electronic citations should be considered:

Examples of journal references:

Journal references should include the surname and initials of the author(s), year of publication, title of paper, name of the journal in which the paper has been published, volume and number of journal issue and page numbers.

For one author: McDonald, A.K. (1999). Youth sports in Africa: A review of programmes in selected countries. *International Journal of Youth Sports*, 1(4), 102-117.

For two authors: Johnson, A.G. & C'Kefee, L.M. (2002). Analysis of performance factors in provincial table tennis players. *Journal of Sport Performance*, 2(3), 12-31.

For multiple authors: Kemper, G.A., McPherson, A.B., Toledo, I. & Abdullah, L. (1996). Kinematic analysis of forehand smash in badminton. *Science of Racket Sports*, 2(2), 99-112.

Examples of book references:

Book references should specify the surname and initials of the author(s), year of publication of the book, title, edition, page numbers written in brackets, city where book was published and name of publishers. Chapter references should include the name(s) of the editor(s) and other specific information provided in the third example below.

For authored references: Amusa, L.O. & Toriola, A.L. (2003). *Foundations of Sport Science* (1st ed.) (pp. 39-45). Mokopane, South Africa: Dynasty Printers.

For edited references: Amusa, L.O. and Toriola, A.L. (Eds.) (2003). *Contemporary Issues in Physical Education and Sports* (2nd ed.) (pp. 20-24). Mokopane, South Africa: Dynasty Printers.

For chapter references in a book: Adams, L.L. & Neveling, I.A. (2004). Body fat characteristics of sumo wrestlers. In J.K. Manny and F.O. Boyd (Eds.), *Advances in Kinesiology* (pp. 21-29). Johannesburg, South Africa: The Publishers Company Ltd.

Example of electronic references:

Electronic sources should be easily accessible. Details of Internet website links should also be provided fully. Consider the following example:

Wilson, G.A. (1997). Does sport sponsorship have a direct effect on product sales? *The Cyber-Journal of Sport Marketing Online*, October, 1(4), at <http://www.cad.gu.au/cjsm/wilson.html>, February 1997.

PROOFREADING

Manuscript accepted for publication may be returned to the author(s) for final correction and proofreading. Corrected proofs should be returned to the Editor-in-Chief within one week of receipt. Minor editorial corrections are handled by AJPHERD.

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APPENDIX L: Author guidelines: The International Journal of Applied and Basic Nutritional Sciences (Chapter 3).

Nutrition provides an international forum for professionals interested in the **applied and basic** biomedical **nutritional sciences, and publishes papers both of clinical interest and of scientific import**. Investigators are encouraged to submit papers in the disciplines of nutritionally related biochemistry, genetics, immunology, metabolism, molecular and cell biology, neurobiology, physiology, and pharmacology. Papers on nutrition-related plant or animal sciences which are not of direct relevance to man, whereas occasionally of interest are not the main focus of the Journal.

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- ii) Publication in another source by the same author(s) without acknowledgement or permission from the publisher, or
- iii) Plagerism or self-plagiarism (publication of material without acknowledging original author source).
- iv) Fabrication of data, not substantiable via review of research records.

Should such publications occur, editorial action would be taken. In certain cases, secondary publication is justifiable and even beneficial; however, such circumstances should be prospectively discussed with and agreed upon by the Editor-In-Chief.

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Authorship

Corresponding Author: One author is designated the corresponding author (not necessarily the senior author)

who will be approached to clarify any issues, such as those pertaining to materials and methods, or technical comments. If *Nutrition* receives feedback from its readers concerning the published paper, the corresponding author will be contacted. It is this author's responsibility to inform all coauthors of such matters to ensure they are dealt with promptly.

The corresponding author must affirm in the cover letter at the time of submission that:

1. None of the material in the manuscript is included in another manuscript, has been published previously, or is currently under consideration for publication elsewhere. This includes symposia proceedings, transactions, books, articles published by invitation, and preliminary publications of any kind except an abstract of less than 250 words. If there is any question concerning potential overlap, the related material must be included for evaluation.
2. Ethical guidelines were followed by the investigator in performing studies on humans or animals and should be described in the paper. The approval of the institutional review board of either animal or human ethics committee must be cited in the Methods.
3. Each author must have participated sufficiently in the work to take public responsibility for the content of the paper and must approve of the final version of the manuscript. Authorship should be based on substantive contributions to each of the following: conception and design of the study; generation, collection, assembly, analysis and/or interpretation of data; and drafting or revision of the manuscript; approval of the final version of the manuscript. Authors are required to include a statement in the Acknowledgements to specify the actual contribution of each coauthor under the above headings.
4. If requested, the authors will provide the data or will cooperate fully in obtaining and providing the data on which the manuscript is based for examination by the editors or their assignees

Conflict of Interest

Conflict of interest regarding a manuscript exists when a participant in the peer review and publication process—author, reviewer, or editor—has ties to activities that could inappropriately influence his or her impartial judgment, whether or not judgment is in fact affected. Financial relationships with industry are usually considered to be the most important conflicts of interest. However, conflicts can occur for other reasons, such as personal relationships or academic competition. See [Competing Interest Form](#) for instructions about the competing interests statement.

CATEGORIES OF MANUSCRIPTS

Nutrition publishes a wide range of articles, which includes original investigations, review articles, rapid communications, research letters, case reports and special category manuscripts. Manuscripts must be prepared

in accordance with the "Uniform Requirements for Manuscripts Submitted to Biomedical Journals" developed by the International Committee of Medical Journal Editors (*N Engl J Med* 1991;324:424-428). All submissions are peer reviewed.

Original Investigations (4,000-6000 words)

Original investigations are considered full-length applied (human) or basic (bench work) research reports. They cover topics relevant to clinical and basic studies relevant to man in the following areas nutritionally related biochemistry, genetics, immunology, metabolism, molecular and cell biology, neurobiology, physiology, and pharmacology. Studies in adult and pediatric populations are welcome. The work presented in the manuscript must be original; studies confirming previous observations will be considered. Other considerations of a paper's publishability are its importance to the science, the soundness of the experimental design, the validity of methods, the appropriateness of the conclusions and the quality of presentation.

Rapid Communications: (3000 words including tables, figures, and references)

Papers representing concise and original studies of scientific importance are considered. In the cover letter the author should justify the request for Rapid Communication. The review process is 10 days, authors are allowed one revision if accepted, and the final version of the paper appears in the next available issue of the journal.

Research Letters: (1000 words, up to 10 references and 1 figure or table)

A Research Letter contains new data or a clinical observation, in a format that allows for rapid publication.

Review articles (6000 words)

In-depth, comprehensive state of the art reviews on a nutritional topic are welcomed. Reviews may be invited by the Editor or may be unsolicited viewpoints.

Case Reports (2,500 words)

Case Reports include case studies of 4 or fewer patients that describe a novel situation or add important insights into mechanisms, diagnosis or treatment of a disease.

Editorials

Editorials express opinions on current topics of interest, or provide comments on papers published in *Nutrition* or other journals. Editorials are generally solicited by one of the Editors.

Correspondence (Letters to the Editor) (1000 words including references)

Opinion pieces concerning papers published in *Nutrition* are particularly welcomed and all submissions are subject to editing. Letters commenting on past-published papers are sent to the corresponding author for a response. Letters are selected for their relevance and originality; not all letters submitted can be published.

Reports of meetings (2700 words)

Reports of meeting proceedings are synopses of scientific meetings of interest to *Nutrition's* audience. Authors

should e-mail the Editor to solicit potential interest 8 weeks prior to conference.

Collections of abstracts, representing the proceedings of organizational meetings are not subjected to customary peer review. It is the view of the editorial board that it is of service to the nutrition community to present such material as promptly as possible.

PREPARATION OF MANUSCRIPT

Manuscripts must be written in English. Prior to submission, it is mandatory that authors have the manuscript evaluated and edited by a native English speaker. The layout and style should adhere strictly to the instructions given under **PREPARATION OF MANUSCRIPT**.

Cover Letter (see AUTHORSHIP)

The cover letter should make it clear that the final manuscript has been seen and approved by all authors and that they have taken due care to ensure the integrity of their work and their personal scientific reputation. Any potential conflicts of interest should be declared, in addition to any information on prior or duplicate publication (see **Ethical and Legal Considerations**).

Authors must recommend five potential referees, at least three of whom should be from outside the country of the principal author, together with their e-mail addresses. While *Nutrition* does not guarantee these reviewers will be called upon, these suggestions may facilitate the editorial decision. It is Nutrition's experience that friends are the harshest critics while investigators in the same field are the most objective. Also include any person(s) who should not be considered a potential reviewer.

SUBMISSION PROCEDURE - PREPARING ELECTRONIC MANUSCRIPTS

As of 15 March 2005 all new manuscripts must be submitted through Nutrition's online submission and review Web site (⇒ <http://ees.elsevier.com/nut/>). Use the following guidelines to prepare your submission. Via the "[Author Gateway](#)" page of this journal you will be guided stepwise through the creation and uploading of various files. Once the uploading is done, the system automatically generates an electronic (PDF) proof (which is then used for reviewing). The corresponding author will be informed via e-mail that a PDF of the submission has been created and that approval is required from the corresponding author to begin the review process. Be sure to keep a backup copy of your paper for reference and safety. All correspondence should be with the Regional Editorial Offices. If a paper is accepted, the Production Office will correspond with the author via e-mail.

For online submission authors are requested to submit the text, tables and artwork in separate documents in electronic form to ⇒ <http://ees.elsevier.com/nut/>. In an accompanying cover letter, authors should state that the manuscript, or parts of it, have not been and will not be submitted elsewhere for publication.

Text files should be supplied in one of the following formats: Microsoft Word Windows or Macintosh

formatted. Format your paper (tabs, indents, etc.) consistently. Once a manuscript has been accepted, most formatting codes will be removed or replaced so there is no need to use excessive layout styling. Do not use options such as automatic word breaking, justified layout, double columns or automatic paragraph numbering. However, do use bold face, italic, subscripts, and superscripts for scientific nomenclature.

When preparing tables, if you are using a table grid, please use only one grid for each separate table and not a grid for each row. If no grid is being used, use tabs to align columns, not spaces.

Graphic files: see Artwork Instructions under [Instructions for Authors](#) on *Nutrition's* website within Science Direct for guidelines for preparing electronic artwork: (Note: Only TIFF, EPS, or PDF formats are acceptable formats). Each figure should be a separate file and not be embedded in the text. All graphic files must be submitted in sufficiently high resolution (300dpi for grayscale or color images and 600-1000 dpi for line art) to allow for printing.

PREPARATION OF MANUSCRIPT

Manuscripts should be typewritten, using DOUBLE SPACING and 1-inch margins. Pages should be numbered consecutively starting with the title page.

Title Page

This should include 1) title of paper (use no abbreviations, limit: 120 characters with spaces), 2) running head of fewer than 55 characters with spaces, 3) full names of all authors with highest academic degree(s); 4) affiliations of all authors; 4) role of each author in the work (see Authorship); 5) a word count for the entire manuscript (including figures and tables), and the number of figures and tables, 4) the complete mailing address (including telephone, fax, and e-mail address of the corresponding author for e-mailing of proofs and reprint requests).

Acknowledgments

Acknowledge only persons who have made substantive contributions to the study. Authors are responsible for obtaining permission of everyone acknowledged by name. If the name of the individual performing statistical consultation is not included with authors, acknowledgment must include name and degree of statistician. Acknowledge all funding and material support, both direct and indirect for the work represented by the manuscript; include commercial, institutional, and other forms of support.

Abstract

Abstracts should be no more than 250 words, in accordance with Medline limitations. The structured abstract for an original investigation should be organized as follows:

Objective. The abstract should begin with a clear statement of the precise objective or question addressed in the

paper. If a hypothesis was tested, it should be stated.

Research Methods & Procedures. The basic design of the study and its duration should be described. The methods used should be stated, the statistical data/methods provided and referenced.

Results: The main results of the study should be given in narrative form. Measurements or other information that may require explanation should be defined. Levels of statistical significance should be indicated, including other factors crucial to the outcome of the study.

Conclusion(s) State only conclusions that are directly supported by the evidence and the implications of the findings.

Key Words: 5—7 key words or phrases should be provided which should be selected from the body of the text and not duplicate title words.

Structure of Text

Introduction: Context of study.

Materials and Methods: Provide sufficient detail to allow the work to be reproduced. Methods already published should be indicated by a reference; only relevant modification should be described.

Results: These should be clear and concise and not duplicate data in Tables.

Discussion: This should be relevant to the results and placed in context of the current literature.

Conclusion: (no longer than 50 words) Summarize your findings.

References

References are numbered sequentially in the order in which they first appear in the text in square brackets. All references cited in the text should be listed at the end of the manuscript on a separate page. All items in the reference list should be cited in the text and conversely, all references cited in the text must be presented in the list. The Journal has adopted the Vancouver style, citing the first six authors and then adding et al. and uses page ranges.

References to periodicals should be as follows: name and initials of authors, title of paper, abbreviated journal title (conforming to those used in *Index Medicus*), year, and first and last pages of the article.

Book references should be as follows: author, initials, title of book, title of series and volume number (if applicable), publisher and city, and year.

Multi-author books or to proceedings printed in book form should be similar to those for monograph books.

Article

Folch J, Lees M, Sloane-Stanley GH. A simple method for the isolation and purification of total lipids from animal tissues. *J Biol Chem* 1957;266:497-509.

Article in Book

Johnson RK. Energy. In: Mahan LK, Escott-Stump S, editors. *Krause's food, nutrition & diet therapy*. 10th ed. Philadelphia: W.B. Saunders; 2000, p. 19-30.

Book

Kline P. *The handbook of psychological testing*. London: Routledge; 1993.

The authors are responsible for the accuracy, relevance, and completeness of each reference.

For references to articles in press, supply the name of the journal. References to unpublished material, including written (not verbal) personal communications, should be included parenthetically in the text with investigators' names and initials.

Figures

Legends to Figures: Figure legends should be concise and clear and should not duplicate the body of the text. Each illustration must have a title and an explanatory legend. The title should be part of the legend and not be reproduced on the figure itself. The legends should be placed on a separate page at the end of the manuscript and begin with the number of the illustration they refer to. All symbols and abbreviations used in the figure including statistical information must be explained.

Figures and other graphic material: May be formatted in any common file format, such as TIFF, GIF, JPG, or BMP as long as quality and resolution are borne in mind.

All material submitted must have been originally produced with proportions that will remain legible when reduced to the width of a one-half page column in the final publication (Column width: 20 picas, 3½", 8.3 cm). Text font size should be consistent both within each figure and among all figures in the document.

Authors are responsible for applying for permission for both print and electronic rights for all borrowed materials and are responsible for paying any fees related to the applications of these permissions.

Color Reproduction: If a manuscript containing color figures undergoes peer review and acceptance, it must be published with color figures. Authors are required to pay for the printing of color figures (\$650 for the first

figure in an article, \$100 for every additional figure in the article).. If the author does not wish to pay for printing color figures, then the manuscript's figures must be in black and white at the time of submission and during the review process.

Tables

These should be typed double-spaced with each table on a separate page. Legends should contain sufficient information to provide an adequate understanding of the table by the reader without reference to the text.

Copyright

Publications are made subject to copyright for the protection of the authors and the publisher. A Transfer of Copyright Agreement will be sent to the corresponding author along with the page proof. The form must be completed and returned to the publisher before the article can be published.

MANUSCRIPT PROCESSING AND REVIEW

Review Process: All contributions selected for peer review are sent to at least two, independent reviewers, designated by the editors. Authors are required to suggest suitable independent referees and may also request that *Nutrition* excludes one or two (but no more) individuals or laboratories if there is a specific, declared conflict of interest.

Nutrition's editors may seek advice about submitted papers from technical and statistical referees on any aspect of a paper that raises concerns. These may include ethical issues or issues of data or materials access. As in all publishing decisions, the ultimate decision whether to publish is the responsibility of the Editor of the journal concerned.

Decisions: The single most important criterion for acceptance is the originality of the work. However, a decision to accept is not solely based on the scientific validity of the paper's content. Other factors affecting decisions include the extent and importance of new information in the paper compared with papers previously published or under consideration; the Journal's need to represent a wide range of topics and the overall suitability for *Nutrition*. Decision letters usually, but not always convey all factors considered for a particular decision. Occasionally the comments to the author may appear to be inconsistent with the editorial decision, which takes into consideration confidential reviewers' comments to the Editor as well as the above factors.

Author Checklist for Manuscript Submission 1) Double-spaced manuscript in PDF or MS Word-compatible format; with structured abstract, pages numbered, running head, key words, author(s)' full names, degrees and affiliations.

2) Photos, legends, tables, and/or figures numbered sequentially (see Color Reproduction).

3) Cover letter including statement regarding declaration of authorship, of scientific integrity, and of any

potential conflict of interest (See Competing Interest Form).

4) Address, e-mail, phone number and FAX number of corresponding author.

5) Names and e-mail addresses of 5 potential referees.

PUBLISHING AND REPRINT INFORMATION

Accepted papers are sent to the publisher, Elsevier, upon acceptance. They will be immediately copyedited, typeset, and sent to authors for review. Articles will be uploaded to *Nutrition* online under the heading 'Articles in Press' for preprint viewing by subscribers as soon as author corrections are implemented.

Reprints: Forms for ordering article reprints are e-mailed to each contributor with the page proof and should be returned with the correct proofs. Authors do not receive free reprints and therefore are responsible for ordering their own reprints from the publisher. Prospective ordering of reprints is less expensive than retrospective. Bulk reprints are arranged via Elsevier.

Manuscripts from outside of North America should be directed to the appropriate Regional Editor.

African Office

Demetre Labadarios, MD

Department of Nutrition

University of Stellenbosch

Tygerberg 7505 South Africa

APPENDIX M: Author guidelines: The South African Journal for Research in Sport, Physical Education and Recreation (Chapter 4)

The *South African Journal for Research in Sport, Physical Education and Recreation* is published by the Stellenbosch University. Contributions from the fields of Sport Science, Movement Education, Recreation/Leisure Studies, Exercise Science and Dance Studies will be considered for publication. The articles submitted will be administered by the appropriate Subject Review Editor and evaluated by two or more referees. The decision as to whether a particular article is to be published or not, rests with the Editorial Board.

SUBMISSION

Manuscripts should be typed with one and a half spacing in 12-point Times New Roman letter size and printed on A4-size white paper in laser quality. The original manuscript (clearly indicated) and three copies of the manuscript must be submitted. Length must not exceed 20 pages (tables, figures, references, etc. included). Original manuscripts may be submitted in English or Afrikaans and should be sent to:

The Editor

S.A. Journal for Research in Sport, Physical Education and Recreation

Department of Sport Science

Private Bag X1

7602 Matieland, STELLENBOSCH

Republic of South Africa

Editorial Office

Tel: 021-808 4915 / 4724

Fax: 021-808 4817

E-mail: floris@sun.ac.za

NB. Articles can also be submitted by e-mail.

CONDITIONS

A signed declaration in respect of the originality must accompany each manuscript. On submission of the manuscript, the author shall present a written statement that the article has not been published or is not being presented for publication elsewhere. Should the article be taken from a Master's thesis or Doctoral dissertation, academic ethic requires that the student will be the first author. The author should also ensure that the LANGUAGE of the manuscript has been thoroughly edited at the time of submission. The name, address and telephone number of the person who has done the language editing must be provided. On receiving a written notification from the Managing Editor that the article has been accepted, a final hard copy of the manuscript and a diskette (virus checked) should be submitted using MS WORD, Office 97 or 2000 as a DOC-file (see Figures). It can also be send per e-mail as an attached file.

PREPARATION OF MANUSCRIPT

Title page

The first page of each manuscript should indicate the title in English and Afrikaans (will be translated for foreign authors), the names (title, first name and other initials, surname) of the author(s), the telephone numbers (work & home), facsimile number, e-mail address (if available) and the field of study. The mailing address of the first named author and the

institution where the work was conducted should be provided in full. A short title of not more than 45 characters, including the spaces, should be provided for use as a running head.

Abstract

Each manuscript must be accompanied by an abstract of approximately 150-200 words in English and should be set on a separate page as a SINGLE paragraph (one and a half spacing). Articles in Afrikaans must include an additional extended summary (500-1000 words) in English. This summary must start on a new page (following the list of sources) providing the English title of the article at the beginning. A list of three to seven key words in English is required for indexing purposes and should be typed below the abstract.

Text

Start the text on a new page with the title of the article (centred and without the names of the authors). Follow the style of the most recent issue of the journal regarding the use of headings and subheadings.

Tables and figures: Tables and figures should be numbered in Arabic numerals (1, 2, etc.) and each be prepared on a SEPARATE page (also on the diskette). Tables require a heading at the top and figures a legend below and separate from the figure. For figures, kindly supply the values of the co-ordinates of line or bar graphs in a separate MS EXCEL (.xls) or WORD file (.doc) while also including the actual figures in the same file. Only original and high-resolution laser quality copies of figures and drawings and original photographs can be accepted (photocopies or negatives are unacceptable) for scanning. Indicate where the tables or figures must feature in the text. The names of the authors must be indicated clearly on the back of the copy of each table and figure. Note: Use the decimal POINT (not the decimal comma).

References: In the text the Harvard method must be adopted by providing the author's surname and the date placed in parentheses. For example: Daly (1970); King and Loathes (1985); McGuines et al. (1986) or (Daly, 1970: 80) when Daly is not part of the sentence. More than one reference must be arranged chronologically. Note that et al. is used in the body of the text when there are more than two authors, but never in the list of references.

List of references

Only the references cited in the text should be listed alphabetically according to surname (last name) of authors (capitals) after the body of text under the heading, References (capitals) starting on a new page. In the case of articles published in JOURNALS, references listed should include the surnames and initials (capitals) of all authors, the date of the publication in parentheses, the full title of the article, the full title of the journal (*italics*), the volume number, the serial number in parentheses (omitted only if the said journal does not use issue numbers), followed by a colon and the first and last page numbers separated by a hyphen.

Example:

VAN WYK, G.J. & AMOORE, J.N. (1995). A practical solution for calculating instantaneous values of tension in the extensor muscles of the knee joint during extension and flexion. *South African Journal for Research in Sport, Physical Education and Recreation*, 18(1): 77-97.

If the reference is a BOOK, the surname (last name) and initials of the author or editor (Ed.) must be given, followed by the date of publication in parentheses, the title of the book (*italics*) as given on the title page, the number of the edition (ed.) in parentheses, the city (and abbreviation for the state in the case of the USA) where published, followed by a colon and the name of the publisher.

Example:

JEWETT, A.E.; BAIN, L.L. & ENNIS, C.E. (1995). *The curriculum process in physical education* (2nd ed.). Madison, WI: WCB Brown & Benchmark.

For a CHAPTER from a book, the page numbers of the chapter cited must be provided in parentheses (not italics) after the title of the book. For further details, authors should consult the most recent publication of this Journal for other examples.

Example:

DE RIDDER, J.H. (1999). Kinanthropometry in exercise and sport. In L.O. Amusa; A.L. Toriola & I.U. Onyewadume (Eds.), *Physical education and sport in Africa* (235-263). Ibadan (Nigeria): LAP Publications.

For ELECTRONIC SOURCES all references start with the same information that would be provided for a printed source (if available). The web page information follows the reference. It will usually contain the name of the author(s) (if known), year of publication or last revision, title of complete work in inverted commas, title of web page in italics, Uniform Resource Locator (URL) or access path in text brackets (do not end the path statement with a fullstop) and date of access. See "How to cite information from the internet and the world wide web" at

<http://www.apa.org/journals/webref.html> for specific examples. When citing a web site in the text, merely give the address. Note that personal communications such as e-mail are cited only in the text and are not included in the list of references.

Example of Web Page:

ACKERMANN, E. (1996). "Writing your own Web Pages." *Creating Web Pages*. Hyperlink [<http://www.mwc.edu/ernie/writeweb/writeweb.html>]. Retrieved 22 October 1999.

ADMINISTRATION

If authors honour the rules and specifications for the submission of manuscripts, unnecessary delays will be avoided. A manuscript that does not meet the requirements as set out above, will be returned to the author without being evaluated. Requesting copying rights concerning figures or photographs is the responsibility of the authors.

The first-named author will receive five reprints of the article free of charge. The original manuscripts and illustrations will be discarded one month after publication unless a request is received to return the original to the first-named author. Page charges of R80 per page are payable on receipt of an account issued by the editor.

APPENDIX N: Proof of submission of Chapter 2 to the African Journal for Physical, Health Education, Recreation and Dance.

from Hanlie Moss <Hanlie.Moss@nwu.ac.za>
to amusalbw@yahoo.com
date Wed, Mar 17, 2010 at 9:14 PM
subject Corrections to manuscript
mailed-by nwu.ac.za

Dear Prof Amusa

Please find the manuscript with the requested corrections attached.

Please inform me should you have any further questions.

Kind regards

Hanlie

APPENDIX O: Proof of acceptance of Chapter 3 by the International Journal of Applied and Basic Nutritional Sciences

From: "Marietjie Herselman" <mgh@sun.ac.za>

To: hanlie.moss@nwu.ac.za

Date: 4 Mar 2010 18:59:22 +0000

Subject: Your Submission NUT-D-09-00415R2

Ms. Ref. No.: NUT-D-09-00415R2

Title: The relationship between body composition and selected metabolic syndrome markers in black adolescents in South Africa: The Play-study
Nutrition

Dear Dr moss,

I am delighted to inform you that your paper The relationship between body composition and selected metabolic syndrome markers in black adolescents in South Africa: The Play-study has been accepted for publication in Nutrition.

We look forward to publishing your paper and thank you for your contribution and interest in Nutrition.

Kind regards,

Marietjie Herselman, PhD (Nutritional Sciences)
Co-Regional Editor
Nutrition

APPENDIX P: Proof of acceptance of Chapter 4 by the South African Journal for Research in Sport, Physical Education and Recreation

>>> "Van der Merwe, FJG, Prof <floris@sun.ac.za>" <FLORIS@sun.ac.za>
2009/11/24 01:55 PM >>>

Beste Hanlie. Die artikel (MS 701) sal in vol. 32(1) verskyn.
Groetend, Floris

From: Barnard, Biokinetika <jgb@sun.ac.za>
Sent: Monday, November 23, 2009 11:35 AM
To: Van der Merwe, FJG, Prof <floris@sun.ac.za>
Subject: FW: Manuskrip 701 (Zeelie et al.)

Dagsê

Ek reken die artikel is nou reg.

Sthinus

-----Original Message-----

From: Hanlie Moss [mailto:Hanlie.Moss@nwu.ac.za]
Sent: 29 September 2009 12:22
To: Barnard, Biokinetika <jgb@sunac.za>
Cc: annemarie.zeelie@gmail.com; Johannes van Rooyen; Salome Kruger
Subject: Manuskrip 701 (Zeelie et al.)

Beste Prof Barnard

Vind asb aangeheg:

1. Hersiende manuskrip
2. Referent brief met kommentaar op die korreksies wat aangebring is.

Ek vertrou dat dit in orde is vir die eerste uitgawe van 2010. Laat weet asb as daar nog wysigings benodig word.

Groete
Hanlie

Dr S.J.Moss (PhD-Biokinetics)
Research Leader: Physical activity, Sport and Recreation (PhASRec)
North-West University
Potchefstroom Campus
Potchefstroom
Tel & Fax: (018) 299 1821