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TWO-YEAR CHANGES IN BODY COMPOSITION, PHYSICAL ACTIVITY AND SELECTED METABOLIC RISK FACTORS AMONG ADOLESCENTS LIVING IN TLOKWE MUNICIPALITY AREA, NORTH WEST PROVINCE, SOUTH AFRICA: THE PAHL STUDY

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ABSTRACT

The increase of childhood obesity in low- to middle-income countries is linked to both individual and clustered metabolic risk factors. This study determined the changes, after two years, in body composition, physical activity (PA) and selected metabolic risk factors among adolescents from the Tlokwe Municipality district in the North West Province of South Africa. A total of 289 adolescents (boys=116; girls=173) aged 14 years participated in the study. Body composition was measured according to the ISAK standard procedures. PA level was measured using the International Physical Activity Questionnaire-Short version (IPAQ-S). Abdominal obesity was determined using waist circumference measurements (WC) and resting BP. Overweight increased by 7.6% and was higher among the girls (12.2%) compared to the boys (2.2%), ($p \leq 0.001$). Participation in low physical activity (LPA) increased by 8.2% for the whole group and moderate PA decreased (15.2%). With regard to the metabolic risk factors, boys had significantly higher WC at every measurement point ($p \leq 0.001$) compared to girls. The percentage in the pre-hypertensive/ hypertensive category increased (5%) and was greater for girls than boys ($p \leq 0.001$). The girls were more overweight, obese and less physically active. The boys had greater waist circumference and SBP compared to the girls.

***Keywords*:** Obesity; Body composition; Physical activity; Metabolic risk factors; Adolescents.

INTRODUCTION

Childhood obesity is one of the most serious public health challenges of the 21st Century affecting many low- and middle-income countries, predominantly in urban settings (WHO, 2012). The World Health Organisation (WHO) report noted that in 2012 nearly three-quarters of the non-communicable diseases (NCDs) deaths (28 million) occurred globally (WHO, 2012). In this report, it was stated that the leading cause of these deaths was cardiovascular diseases (CVDs) accounting for 46.2% of the deaths. A global prevalence rate in childhood obesity of 47% was reported from 1980 to 2013 (Ng *et al*., 2014) and the highest prevalence rate was reported in countries mostly from Africa, Latin America, and Asia, that are undergoing economic transition and whose health delivery systems are very weak (Hossain *et al.,* 2007; Monyeki & Kemper, 2008; Ellulu *et al*., 2014). This world-wide prevalence of obesity has resulted in high morbidity and mortality rates. It has become an extra burden especially in the African continent that is also under the threat of communicable and poverty-related diseases, such as malaria, malnutrition, cholera and infant mortality (Adeboye *et al*., 2012)

Obesity co-exists with other metabolic abnormalities, such as high BP, type 2 diabetes, insulin resistance (Eckel *et al.*, 2011), impaired glucose tolerance (Rivers *et al.*, 2014) and dyslipidemia (Reuter *et al*., 2016). These metabolic abnormalities are more closely associated with abdominal (central) obesity than peripheral obesity (Grundy *et al*., 2004). Abdominal adiposity (determined by waist circumference [WC]) is an important metabolic risk factor of CVD (Després, 2012).

Although the aetiology of obesity remains to be multidimensional, it is assumed to be an outcome of several health-risk factors, such as physical inactivity (PI), sedentary lifestyle, as well as uncontrolled nutritional habits during childhood and adolescence stages (Berenson, 2002). Sedentary behaviour, such as watching television (TV) and engaging in computer related activities during childhood, contribute to the epidemic obesity and to the rising prevalence of both individual and clustered metabolic risk factors (Draper *et al.*, 2014; Ellulu *et al*., 2014). It is reported that increased low PA participation and sedentary behaviour at the childhood stage, is positively associated with long term increase in body mass index (BMI), percentage body fat and a cluster of metabolic risk factors (high blood pressure [HBP], WC, high levels of low-density lipoprotein-cholesterol (LDL-C), triglycerides levels and fasting glucose) (Salonen *et al*., 2015).

On the other hand, regular participation in moderate to vigorous physical activity (MVPA) during childhood and adolescence is associated with favourable body composition and metabolic profiles later in life (Ekelund *et al.*, 2012; Bailey *et al*., 2015). The risk of cardiometabolic-related mortality is lower among the obese individuals with high-PA (HPA) levels compared to the normal weight individuals with LPA level (Koolhaas *et al.*, 2017). These results indicate the important role of PA in negating the risk of cardiometabolic-associated illnesses. Knowledge of the changes in body composition, PA, the development of obesity and other metabolic risk factors is essential because it can assist when developing intervention strategies that can prevent or reverse the effects of obesity in children and adolescents. Such knowledge is also important in modifying positively childhood PA behaviour, nutritional habits and leisure time preferences (Moselakgomo *et al*., 2015).

Studies have successively reported a gradual decline in PA and an increased prevalence of overweight and obesity and other metabolic risk factors of CVD among South African children (Toriola & Monyeki, 2012; Moselakgomo *et al*., 2015). However, there is limited data on the longitudinal changes in body composition, PA and selected metabolic risk factors (abdominal obesity and BP) among adolescent learners from the Tlokwe Local Municipality of Potchefstroom. This longitudinal study may promote an understanding of the long-term interaction of these variables, and appropriate intervention strategies to prevent or reduce the prevalence of metabolic risks associated with unhealthy body composition and PI among the adolescent population. Thus, the purpose of this study is to determine longitudinal changes in body composition, PA and selected metabolic risk factors (abdominal obesity and BP) among adolescents living in the North West province of South Africa.

METHODOLOGY

Design

The current study is part of the Physical Activity and Health Longitudinal Study (PAHLS, 2010-2014), where the main objective was to evaluate the development of PA and determinants of health risk factors among 14-year-old high school students in Tlokwe Municipality district in the North West Province, South Africa, over a five-year span (Monyeki *et al.,* 2012). For the purpose of this study, both two-year cross-sectional and longitudinal data collected from 2011 to 2013 was utilised to determine the longitudinal changes in body composition, PA and selected metabolic risk factors (abdominal obesity and BP) among adolescents.

Participants

A total of 289 learners (116 boys and 173 girls) were selected from six out of eight schools. Of the six schools, two schools were from the central business district (CBD) comprising mostly of adolescents from the high socio-economic families and four schools were from the township areas comprising of adolescents from the low socio-economic families.

The selected learners were 14.9±0.76 years in 2011 (at baseline measurement), 15.6±0.77 years in 2012 and 16.4±0.78 years in 2013. School records, as well as the birth clinic cards of the participants were used to establish the age of the participants in the study. The drop-out rate of 21% (2012) and 33% (2013) from 2011 measurements point was observed. The observed drop-out rate was due to participant absenteeism during the day of measurement, drop-out from the school, and transfer from one school to another. These reasons for a drop-out were beyond the control of the study, hence subject attrition did not have a significant effect in the analyses of the objectives of the current study. Detailed information concerning the participants and methods of data collection have been published elsewhere (Monyeki *et al.,* 2012).

Measurement procedures

Before the commencement of the data collection process, permission was granted by the District Manager of the Department of Basic Education in Potchefstroom, North-West Province. Prior to the anthropometric measurements, the International Physical Activity Questionnaire Short version (IPAQ-S) was administered to the participants who were assembled in a classroom, under the supervision of the principal investigator and adequate instructions were provided. Participants completed the questionnaire independently, with no time limit set for completion. All anthropometric sites were measured twice according to standard procedures by Level 2 ISAK certified Anthropometrists.

Anthropometric and body composition measurements

Height, body mass, skinfolds thickness (triceps and subscapular skinfolds), and waist and hip circumferences were measured using the standard procedures described by the International Standard of Advancement of Kinanthropometry (ISAK) (Marfell-Jones *et al.,* 2006). Waist-to-height ratio (WtHR) was calculated as waist (cm)/height (cm). Body mass index (BMI) was calculated as body mass/stature² (kg/m²). Subsequently, age-specific BMI for children was used to determine the following categories: overweight, normal weight and underweight, respectively (Cole *et al.,* 20017). Percentage body fat was calculated from subscapular and triceps skinfolds (mm) measurements using the equation of Slaughter *et al.* (1988).

Measurement of physical activity (PA)

PA was assessed using the short form of the IPAQ (WHO, 2009). IPAQ is considered suitable for use by adolescents at different settings (WHO, 2002) and its short form consists of seven items which identify the frequency and time spent in walking and engaging in other MVPA during the seven days prior to questionnaire administration. In the IPAQ only those sessions which lasted 10 minutes or more were analysed and various types of PA related to transportation, household chores and leisure time activity were included. IPAQ also elicits information about time spent sitting, which is used as an indicator of inactivity. PA was classified into three categories namely: Low activity (METs <3), moderate activity (METs 3-6), and high activity (>6) according to the 2005 guidelines for data processing and analysis of the IPAQ. Total physical activity (TPA) was calculated from all PA components performed within seven days of a week.

Metabolic risk factors

Abdominal obesity

Abdominal obesity was determined using waist circumference (WC) measurements (Grundy *et al.*, 2004). WC was measured at the abdomen at its narrowest point between the lower costal (10^{th} rib) border and the top of the iliac crest, perpendicular to the long axis of the trunk with Lufkin W606PM flexible steel tape according to the International Standard of Advancement of Kinanthropometry (ISAK) (Marfell-Jones *et al.*, 2006). WC values that are age, gender and ethnicity specific and falls within the 75^{th} and 90^{th} percentile are important in the identification and prevention of children and adolescents at risk for various comorbidities, including cardiovascular disease, hyperinsulinemia and type II diabetes (Fernández *et al.*, 2004).

Blood pressure measurement

Measurements were taken on the left arm using the Omron MIT Elite Plus (Omron Healthcare CO., LTD, Japan). Participants were asked to lie down and rest for five minutes before BP measurements were taken, talking was not permitted during the resting period, or when the BP measurement was being taken. The average measurements from two separate measurements at least five minutes apart were used in the analysis. A measurement of SBP >130 millimetre of mercury (mmHg) and DBP >85 mmHg was classified as abnormal according to the IDF cut point, and SBP $\geq 90^{th}$ percentile (Alberti *et al.*, 2006; Jolliffe & Janssen, 2007) for the whole population is considered abnormal according to the National Cholesterol Education Program/Adult Treatment Panel III (NCEP/ATP III) criteria.

Ethical considerations

All procedures followed were in accordance with the ethical standards of the North-West University Ethics Committee and with the Helsinki Declaration. Written informed consent was obtained from the school authorities, the parents and the pupils of the participating schools. Clearance by the Ethics Committee of North-West University, Potchefstroom campus (Ethics number: NWU-0058-01-A1) was granted.

Data analyses

Descriptive (means, standard deviations, and frequencies) statistics were applied to calculate the changes in the body composition, PA and metabolic risk factors (abdominal obesity and BP). Analysis of variance (ANOVA) for repeated measures was calculated for the changes in the body composition, PA and selected metabolic risk factors for 2011, 2012 and 2013 data. In addition, partial Eta-squared (η_p^2) of ANOVA for repeated measures was used to determine the effect sizes of changes in the body composition, PA and selected metabolic risk factors (abdominal obesity and BP), at the 95% confidence interval (CI). Partial Eta-squared of ANOVA are in agreement with Cohen's rules of thumb whereby values of η_p^2 are interpreted as follows, namely 0.01, 0.06 and 0.14 were regarded as small, medium and large effects, respectively. Data analyses for all the variables were calculated using the Statistical Package for Social Sciences (SPSS) version 20.0 programme and the level of significance was set at $p \le 0.05$ (SPSS Inc., 2011).

RESULTS

Figure 1 presents the overall percentage distribution of BMI categories for the total group of learners for the period 2011, 2012 and 2013. The BMI classification of both boys and girls shows that during the period 2011-2012, underweight decreased by 5.7% and increased by 5.1% during the period 2012-2013. A percentage of 70.9% of the group was in the normal weight category during the period 2011, with a 2.2% increase in 2012 (73.1%) and a 9.2 decrease (63.9%) in 2013. In 2011, 12.8% of the group was overweight, the prevalence of overweight increased by 3.5% in 2012, with a further increase of 4.1% in 2013, resulting in an overall increase of 7.6% during the entire period 2011-2013.

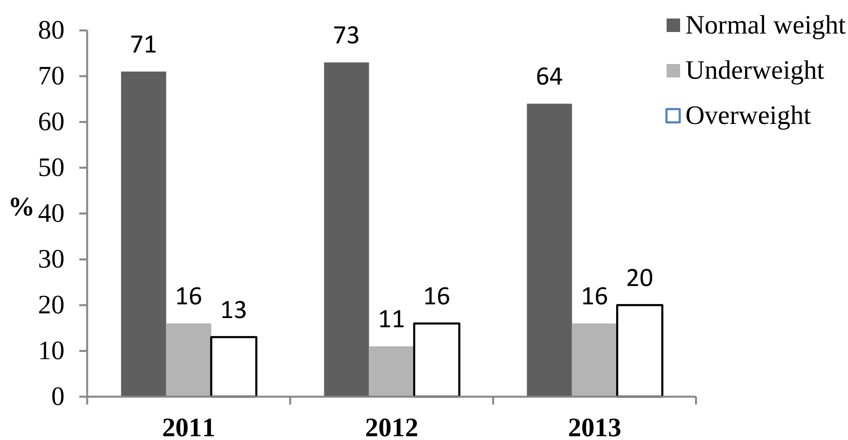

Figure 1. **BODY MASS INDEX DISTRIBUTIONS FOR THREE CATEGORIES OF NORMAL WEIGHT, UNDERWEIGHT AND OVERWEIGHT FOR THE TOTAL GROUP**

Table 1 shows the BMI and the International Obesity Taskforce (IOTF) waist circumference categories of normal weight, underweight and overweight and obese for the total group for three measurement points. The IOTF WC distributions indicate that 6.3% of the adolescents were overweight in 2011 (WC >1.3SD) while 4.9% was obese (WC >2.3SD). In 2012 the number of overweight adolescent boys and girls decreased to 6.1%, while that of obese adolescents increased to 6.1%. In 2013 the number of overweight adolescents increased by 6.5% to 12.6%, while that of obese adolescents decreased by 2.4% to 3.7%.

Table 1. **BMI AND WC DISTRIBUTIONS FOR NORMAL-, UNDER-, OVER-WEIGHT AND OBESE BOYS AND GIRLS**

Variables	2011 Frequency	%	2012 Frequency	%	2013 Frequency	%
BMI classification						
Underweight BMI <17.5	47	16.3	24	10.6	30	15.7
Normal -BMI >17.6 to 24.9	205	70.9	166	73.1	122	63.9
Overweight BMI >25	37	12.8	37	16.3	39	20.4
WC classification (cm)						
Normal WC (<1.3SD) IOTF	257	88.9	199	87.7	160	83.8
Overweight WC (>1.3SD)	18	6.3	14	6.1	24	12.6
Obese WC (>2.3SD) IOTF	14	4.9	14	6.1	7	3.7
Total	289	100	227	100	191	100

BMI=Body Mass Index WC=Waist Circumference IOTF=International Obesity Taskforce

Figure 2 presents data on the percentage distribution of body mass index categories of learners by gender for the period 2011, 2012 and 2013. More boys than girls were in the underweight category at each of the measurement points. The number of overweight adolescents showed a gradual rise for both adolescent boys and girls during the entire measurement period. Among the adolescent boys and girls, overweight increased by 2.2% and 12.2%, respectively. The overall increase in overweight during the entire measurement period was higher among the girls than the boys.

Figure 3 shows the WC distributions for three categories of normal weight, overweight and obese for the adolescent boys and girls for three measurement points in 2011–2013. The distribution shows that in 2011 more girls (7%) than boys (5.2%) were in the overweight category (WC >1.3 SD) according to the IOTF classification. In 2012, the percentage of boys in the overweight category decreased (0.9%) slightly, while that of girls increased (0.3%). In 2013, the percentage of boys and girls in the overweight category substantially increased (9% and 4.7%) respectively. The percentage of adolescent boys in the IOTF obese category (WC >2.3 SD) increased by 1.6% (boys) and 1% (girls) in 2012 and decreased by 2.8% (boys) and 2.3% (girls) in 2013.

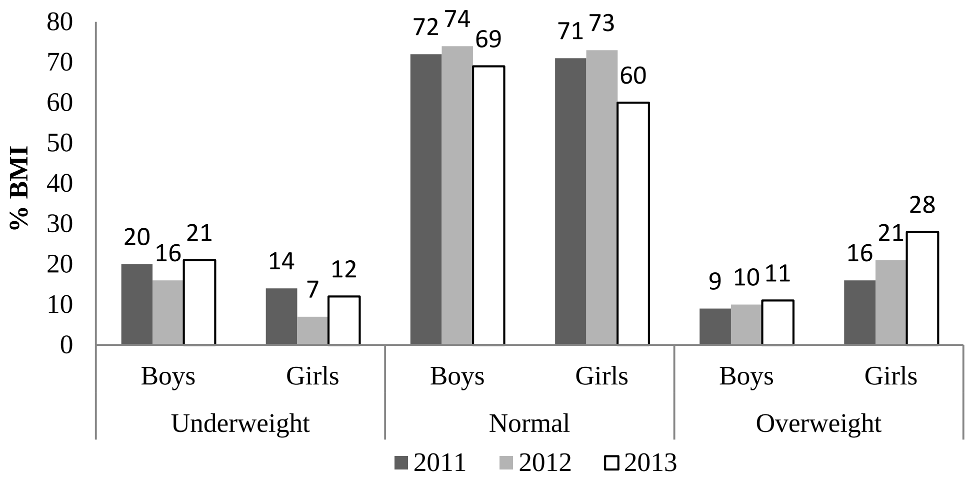

Figure 2. **PERCENTAGE DISTRIBUTION OF BMI CATEGORIES BY GENDER FOR 2011, 2012 AND 2013**

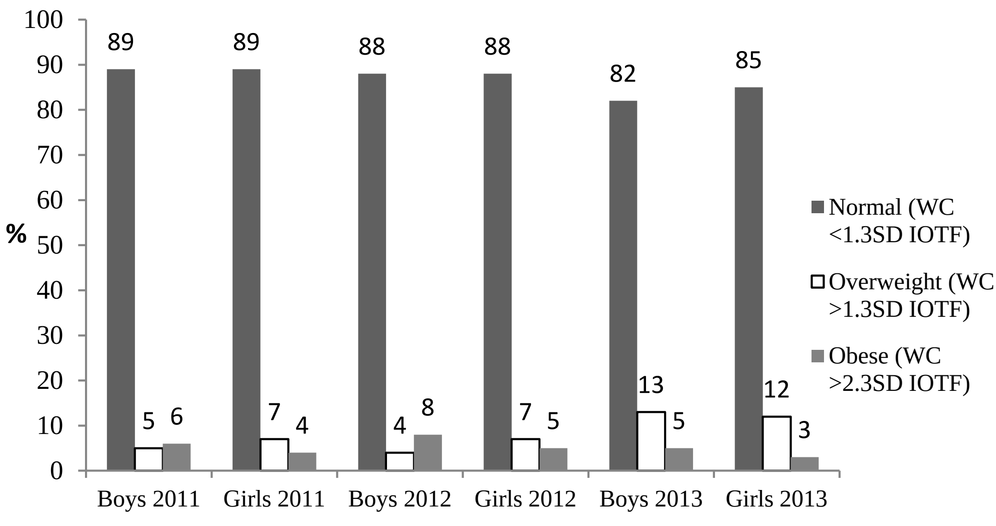

Figure 3. **WC DISTRIBUTIONS FOR NORMAL WEIGHT, OVERWEIGHT AND OBESE FOR THE TOTAL GROUP**

Table 2. PARTICIPANTS: BODY COMPOSITION, METABOLIC RISK FACTORS AND PHYSICAL ACTIVITY CHARACTERISTICS FROM 2011 TO 2013

	2011		**2012**		**2013**			
Variables	**Males** (n=116) Mean±SD	**Females** (n=173) Mean±SD	**Males** (n=92) Mean±SD	**Females** (n=135) Mean±SD	**Males** (n=83) Mean±SD	**Female** (n=108) Mean±SD	η_p^2	p
Body composition								
Stature (cm)	165.29±9.39	157.88±6.94†	168.74±9.06	158.53±7.07†	171.03±8.05	158.97±7.27†	0.53	<0.001
Body mass (kg)	55.24±13.5	53.7±12.8†	59.65±14.95	56.27±12.96††	62.19±13.85	57.63±12.75††	0.57	<0.001
Sum of skinfolds (mm)	19.19±9.65	31.54±13.88†	13.91±7.88	23.42±10.1†	18.69±9.46	30.21±10.40†	0.39	<0.001
% Body fat	13.4±8.21	24.1±10.35†	8.73±7.25	20.11±6.1†	17.01±7.14	25.24±6.37†	0.42	<0.001
BMI (kg/m²)	20.01±3.63	21.43±4.36†	20.75±3.97	22.31±4.43†	21.11±3.61	22.75±4.52††	0.35	<0.001
Metabolic risk factors								
WC (cm)	68.07±8.13	67.61±8.67†	69.82±8.89	68.05±9.2††	71.04±8.54	68.34±8.32††	0.25	<0.001
SBP (mmHg)	105.72±11.19	100.67±8.39†	110.72±12.29	105.24±10.63†	112.11±7.76	106.26±9.93†	0.21	<0.001
DBP (mmHg)	67.67±8.97	67.75±6.93	69.51±9.35	65.89±7.49†	73.08±7.70	70.00±8.49††	0.20	<0.001
Physical Activity								
Vigorous (MET)	213.91±357.47	134.87±295.55	687.51±1780.69	210.27±539.11	268.80±423.94	117.40±308.71†	0.05	0.01
Moderate (MET)	71.20±159.43	57.82±161.49	459.82±1835.93	82.74±196.01	55.80±97.05	21.36±46.43†	0.03	0.01
Total PA (MET)	648.79±525.12	423.68±513.57††	1052.15±2160.15	432.85±695.53†	1257.07±2192.75	637.98±939.95†	0.07	0.001

†=p<0.001 (significant difference: boys vs. girls) ††=p=0.01 (significant difference: boys vs. girls) MET=metabolic equivalents PA=Physical Activity
η_p^2=Partial Eta Square

Table 2 provides descriptive data for gender differences in body composition, selected metabolic risk factors and PA status of both boys and girls for 2011, 2012 and 2013. There was a significant change in height ($p<0.001$ and $\eta_p^2=0.53$) for boys compared to girls during the measurement period. The height of boys increased by 5.74cm compared to the girls (1.09cm) during the period.

The body composition data revealed that during the measurement period the boys recorded a substantial overall increase in body mass of 6.95 kg while among the girls an increase of 3.93kg in body mass was recorded. The increase was also greater in boys than in girls ($p<0.001$ and $\eta_p^2=0.57$). There were inconsistent changes in the skinfold thickness and the percentage body fat with both variables showing a decrease in 2012 and an increase in 2013 for both boys and girls. The change in the sum of skinfolds was significantly higher in girls ($p=0.001$ and $\eta_p^2=0.39$) than in boys while percentage body fat increase was significantly greater in boys (3.61%) than in girls (1.44%) ($p<0.001$ and $\eta_p^2=0.42$).

The data on metabolic risk factors (abdominal obesity and BP) showed that among the boys WC increased by 2.97cm between 2011 and 2013. For girls, the increase in WC was significantly lower (0.73) compared to boys during the same period. Both systolic (SBP) and diastolic (DBP) blood pressure increased (6.39mmHg and 5.41mmHg, respectively) among the boys during the measurement period. For the girls, an overall increase of 5.59mmHg in SBP and 2.25mmHg DBP was noted. The difference of changes in metabolic risk factors between boys and girls were significant ($p<0.001$ and $\eta_p^2=0.25$ WC; 0.21 SBP; 0.20 DBP).

The PA data showed an increase of 608.28 METs among the boys and 214.3 METs among the girls. There were inconsistent changes in the vigorous PA (VPA) and moderate PA (MPA) with both variables decreasing in 2012 and increasing in 2013 for both boys and girls. The changes were higher in boys compared to girls ($p=0.001$ and $\eta_p^2=0.07$) for total PA; ($p=0.01$ and $\eta_p^2=0.5$ for VPA, and ($p=0.01$ and $\eta_p^2=0.03$ for MPA.

Table 3. **PERCENTAGE SCORE (%) FOR PHYSICAL ACTIVITY FOR TOTAL GROUP OF BOYS AND GIRLS**

	2011 (n=184)		**2012** (n=184)		**2013** (n=184)	
Physical activity	**Frequency**	**%**	**Frequency**	**%**	**Frequency**	**%**
Low PA (METS <200)	63	34.2	89	48.4	78	42.4
Moderate PA (METS>200 to <500)	56	30.4	31	16.8	28	15.2
High PA (METS >500)	65	35.3	64	34.8	78	42.4
Total	184	100	184	100	184	100

Table 3 presents the PA percentage scores for the total group of adolescent boys and girls. The percentage of adolescent boys and girls in the LPA category inconsistently increased from 34.2% (2011) to 48.4% (2012) and 42.4% (2013). Overall participation in LPA increased by (8.2%) during the two years of measurement, while participation in the moderate physical activity (MPA) for the whole group gradually declined resulting in a total decline of 15.2% during the entire measurement period. The number of adolescent boys and girls in the HPA category increased inconsistently, 35.3% (2011), 34.8% (2012) and 42.4% (2013) resulting in an overall increase of 7.1% in HPA.

Figure 4 presents the comparisons of PA distributions for three categories of low, moderate and high for the boys and girls for the period 2011–2013. More boys than girls were in the HPA category, while more girls than boys were in the LPA category at each measurement point. HPA overall increased by 3.2% among the boys and 0.9% among the girls. On the other hand, participation in LPA overall increased more among the boys (23.4%) than among the girls (9.2%) during the entire measurement period.

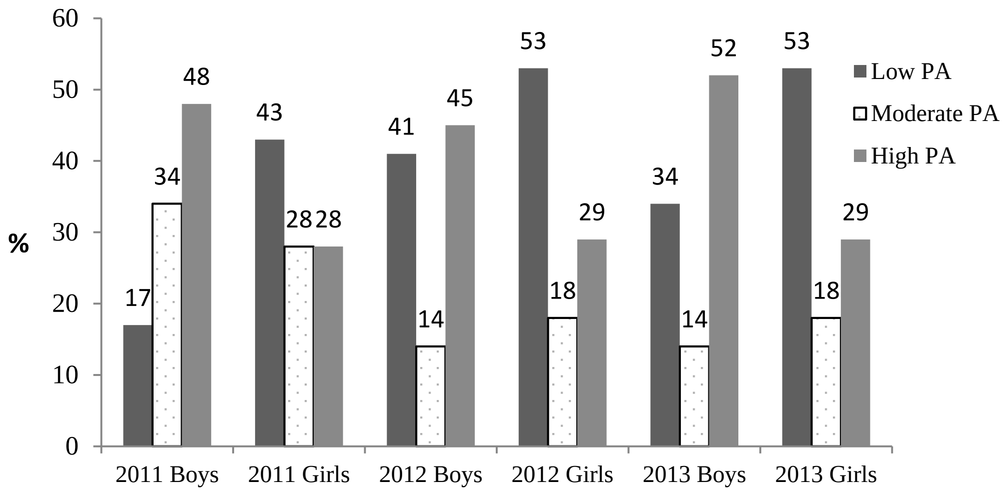

Figure 4. **PA DISTRIBUTIONS OF LOW, MODERATE AND HIGH FOR TOTAL GROUP OF BOYS AND GIRLS**

Table 4 shows the percentage scores (%) of BP for the total group for three measurements point. The adolescent boys and girls (90.3%) were in the normal BP category. The number decreased by 8% in 2012 and then increased by 3% to 85.3% in 2013 giving a 5% total decrease for the entire measurement period. Of the group, 9.7% was in the pre-hypertensive/ hypertensive category with SBP within the 90^{th}, $<95^{th}$ or $> 95^{th}$ percentiles. The number of adolescents in this category increased (8%) to 17.7% in 2012 and decreased by 3% to 14.7 in 2013, with a total increase of 5% for the entire measurement period.

Table 4. **PERCENTAGE SCORES (%) FOR BLOOD PRESSURE FOR TOTAL GROUP**

BMI classification	**2011** (n=227) Frequency	%	**2012** (n=220) Frequency	%	**2013** (n=191) Frequency	%
Normal (Systolic BP <90 percentile	205	90.3	181	82.3	163	85.3
Prehypertension/Hypertension (Systolic BP 90th to <95th/>95th)	22	9.7	39	17.7	28	14.7
Total	227	100	220	100	191	100

Figure 5 presents data on the HBP risk between adolescents by gender of participants during the period 2011 and 2013. In 2011, more boys (15.3%) than girls (5.4%) were in the prehypertension/hypertension category. The number of girls in the prehypertension/ hypertension category increased by 14.3% in 2012 and decreased insignificantly by 0.3% in 2013. The number of boys in the prehypertension/hypertension category decreased gradually resulting in an overall decrease of 6.9% during the entire 2-year period.

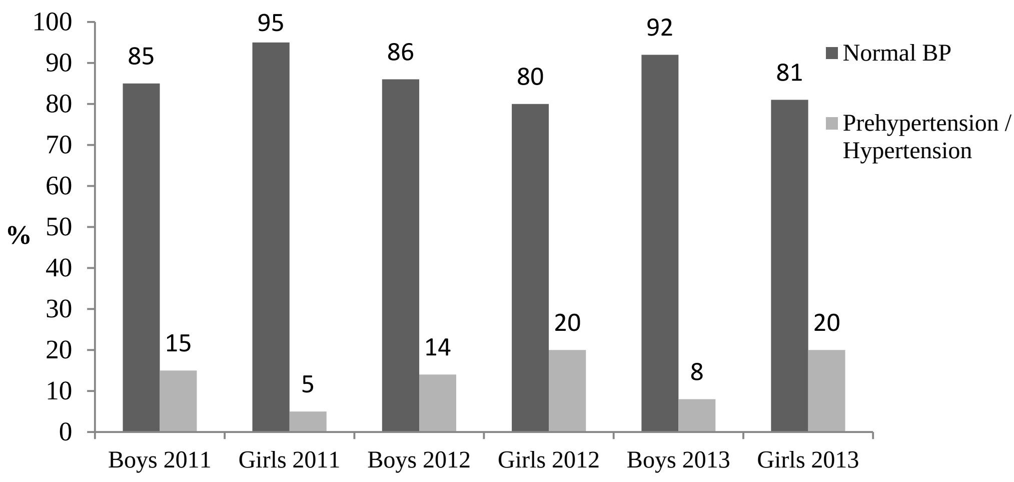

Figure 5. **PERCENTAGE SCORES (%) FOR BP DISTRIBUTIONS FOR NORMAL AND PREHYPERTENSION/HYPERTENSION FOR BOYS AND GIRLS**

DISCUSSION

This present study examines the longitudinal changes in body composition, PA and selected metabolic risk factors (abdominal obesity and BP) among the high school's adolescents from the Tlokwe Local Municipality, Potchefstroom, South Africa.

The results of the study showed that adolescent girls were significantly obese than the boys; with girls having consistently greater BMI, the sum of skinfolds and percentage of body fat. There was a gradual increase in overweight among adolescent boys and girls during the measurements period. At every measurement point, the girls were considerably more overweight than the boys. The greater increase in overweight during the entire measurement period was noted among the girls (12.2%) than the boys (2.2%). In the long term, childhood obesity tends to persist into adulthood, increasing the risk for obesity-related morbidities such as cardiovascular disease, hypertension, type 2 diabetes and some forms of cancer (Bailey *et al.*, 2015; Salonen *et al.*, 2015). This shows that adolescent girls may be at a higher risk of being obese and developing other obesity-associated illnesses.

The prevalence of overweight in the current study was lower than the 25% for girls and 8% for boys (overweight and obesity) from Gauteng Province (Ginsburg *et al*., 2013). However, the findings are in contrast with those of (Thibault *et al.*, 2010) who noted that French adolescent boys were more overweight (obesity included) than girls ($p < 0.01$) as well as those of (Conolly, 2016) who found out that more boys (30%) than girls (26%) sampled in England were overweight and obese. A substantial increase in indices of overweight found among adolescents in this study reflects the extensively documented trend to increased childhood overweight and obesity.

Many studies reported that childhood overweight and obesity is on the rise globally (WHO, 2012; Ng *et al.*, 2014; Wabitsch *et al.*, 2014). The increase in indices of overweight found in this study also confirms the findings from earlier studies that childhood obesity is on the rise among South African children and adolescents (Draper *et al.*, 2014; Moselakgomo *et al*., 2015; Pienaar, 2015). The current study noted that overweight and obesity was prevalent among the adolescent girls compared to the boys. There was a decrease in sum of skinfold thickness and percentage body fat in both boys and girls during the second point of measurement in 2012. The decrease could be due to the corresponding increase in moderate and vigorous PA which was noted during the same period.

Physical inactivity and sedentary behaviour have been noted as some of the main contributors to overweight and obesity that result in the increased risk of developing metabolic-related diseases. Despite the fact that the risks associated with PI and sedentary lifestyle as well as health benefits of regular PA are well known, many children across the world prefer a sedentary lifestyle (Tremblay *et al.*, 2016). Several studies have found out that decreasing the daily PA level can lead to a considerable increase in body mass (Toriola & Monyeki, 2012; Ng *et al.*, 2014; Salonen *et al.*, 2015). The current study shows that participation in LPA was on the increase, from 34.2% (2011) to 48.4% (2012) and then decreased to 42.4% in 2013 while participation in MPA was on the decline. The gradual decline in MPA and the considerably LPA levels found among the adolescent boys and girls in this study support the findings of earlier studies that PA is on the decline among SA children and adolescents (Toriola &

Monyeki, 2012; Draper *et al*., 2014). This also confirms the widely reported assertions that many children and adolescents do not meet the globally recommended daily MVPA (Tremblay *et al.*, 2016).

Participation in PA by gender in this study shows that boys participated in PA more than girls. At any measurement point, more girls were in the LPA category than boys. In the HPA category, there were more boys than girls at each measurements point. Thibault *et al.* (2010) reported that more French boys (80.8%) than girls (66.8%) engaged in PA during leisure time. Similar gender variations in the PA participation was also reported among boys and girls from the US (Caspersen *et al.*, 2000), Canada (Allison *et al.*, 2007) and European Union countries (Armstrong & Welsman, 2006)

Concerning the risk of developing metabolic-related diseases, adolescent boys and girls in this sample are currently at lower risk. In terms of metabolic risk factors, the adolescent boys in this sample have greater waist circumference and SBP at every point of measurements, compared to the girls. DBP for boys was also substantially greater than that of girls for the years 2012 and 2013. Of major interest is the upward trend of these risk factors in both boys and girls particularly WC and SBP. This could mean that if the situation remains unabated the adolescent boys and girls in this sample could be at greater risk of developing chronic diseases such as cardiovascular disease, hypertension, type 2 diabetes mellitus and other metabolic-related diseases later in life.

LIMITATIONS OF STUDY

The study sample consisted of six (6) high schools in the Tlokwe Municipality in Potchefstroom in the North West province of South Africa. Therefore, the findings of this study cannot represent all adolescents in the Tlokwe Municipality, the North West province or the whole of South Africa. The use of IPAQ-S which was based on activity recall may be a limitation to the study. However, the use of IPAQ-S provides information on the frequency and time spent in walking and engaging in other moderate-to-vigorous intensity PA during as well as time spent sitting in the past seven days.

CONCLUSION

Overweight among the 14-year-old high school adolescents living within the Tlokwe Local Municipality of Potchefstroom is gradually increasing; and the increase is high among the adolescent girls as compared to the boys. Increase in metabolic risk factors (systolic BP and WC) is high among the boys than among the girls while participation in moderate MVPA is declining more among the girls compared to the boys. Although the majority of the adolescents were in the normal BP category and currently at less risk of developing metabolic diseases, the upward trend of overweight, percentage body fat, waist circumference and systolic BP and PI could put the adolescents at risk of metabolic illnesses in future if no intervention strategies are instituted.

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REFERENCES

ADEBOYE, B.; BERMANO, G. & ROLLAND, C. (2012). Obesity and its health impact in Africa: A systematic review. *Cardiovascular Journal of Africa*, 23(9): 512-521.

ALBERTI, K.G.; ZIMMET, P. & SHAW, J. (2006). The metabolic syndrome – a new world definition: A consensus statement from the International Diabetic Federation. *Diabetic Medicine*, 23(12): 469-480.

ALLISON, K.R.; ADLAF, E.M.; DWYER, J.J.M.; LYSY, D.C. & IRVING, H.M. (2007). The decline in physical activity among adolescent students. *Canadian Journal of Public Health*, 98(2): 97-100.

ARMSTRONG, N. & WELSMAN, J.R. (2006). The physical activity patterns of European youth with reference to methods of assessment. *Sports Medicine* 36(12): 1067-1086.

BAILEY, D.P.; SAVORY, L.A.; DENTON, S.J. & KERR, C.J. (2015). The association between cardiorespiratory fitness and cardiometabolic risk in children is mediated by abdominal adiposity: The HAPPY study. *Journal of Physical Activity and Health*, 12(8): 1148-1152.

BERENSON, G.S. (2002). Childhood risk factors predict adult risk associated with subclinical cardiovascular disease: The Bogalusa heart study. *American Journal of Cardiology*, 90(10C): 3-7.

CASPERSEN, C.J.; PEREIRA, M.A. & CURRAN. K.M. (2000). Changes in physical activity patterns in the United States, by sex and cross-sectional age. *Medicine and Science in Sports and Exercise*, 32(9): 1601-1609.

COLE, T.J.; FLEGAL, K.M.; NICHOLLS. D. & JACKSON, A.A. (2007). Body mass index cut offs to define thinness in children and adolescents: International survey. *British Medical Journal*, 335(7612): 194 [E-publication].

CONOLLY, A. (2016). "Health Survey for England 2015. Children's body mass index, overweight and obesity". National Health Service. Hyperlink: [www.content.digital.nhs.uk/catalogue/PUB22610/HSE2015-Child-obe.pdf]. Retrieved on 9 June 2017.

DESPRÉS, J.P. (2012). Body fat distribution and risk of cardiovascular disease: An update. *Circulation*, 126(10):1301-1313.

DRAPER, C.; BASSET, S.; DE VILLIERS, E.; LAMBERT, V. & the HASK writing group (2014). Results from South Africa's report card on physical activity for children and youth. *Journal of Physical Activity and Health*, 11(1): 98-104.

ECKEL, R.H.; KAHN, S.E.; FERRANNINI, E.; GOLDFINE, A.B.; NATHAN, D.M.; SCHWARTZ, M.W.; SMITH, R.J. & SMITH, S.R. (2011). Obesity and type 2 diabetes: What can be unified and what needs to be individualized? *Journal of Clinical Metabolism*, 96(6): 1654-1663.

EKELUND, U.; LUAN, J.; SHERAR, L.B.; ESLIGER, D.W.; GRIEW, P. & COOPER, A. (2012). Association of moderate to vigorous physical activity and sedentary time with cardiometabolic risk factors in children and adolescents. *JAMA* (*Journal of the American Medical Association*), 307(7): 704-712.

ELLULU, M.; ABED, Y.; RAHMAT, A.; RANNEH, Y. & ALI, F. (2014). Epidemiology of obesity in developing countries: Challenges and prevention. *Global Epidemic Obesity*, 2(2): 1-6.

FERNÁNDEZ, J.R.; REDDEN, D.T.; PIETROBELLI, A. & ALLISON, D.B. (2004). Waist circumference percentiles in nationally representative samples of African-American, European-American, and Mexican-American children and adolescents. *Journal of Pediatrics,* 145(4): 439-444.

GINSBURG, C.; GRIFFITHS, PL.; RICHTER, L.M. & NORRIS, S.A. (2013). Residential mobility, socioeconomic context and body mass index in a cohort of urban South African adolescents. *Health Place,* 19(January): 99-107.

GRUNDY, S.M.; BREWER, B. Jr.; CLEEMANM J.I.; SMITH, S.C. Jr. & LENFANT, C. (2004). Definition of metabolic syndrome, report of the National Heart, Lung, and Blood Institute/American Heart Association conference on scientific issues related to definition. *Circulation*, 109(3): 433-438.

HOSSAIN, P.; KAWAR, B. & NAHAS, M.E. (2007). Obesity and diabetes in the developing World: A growing challenge. *New England Journal of Medicine,* 356(3): 213-215.

JOLLIFFE, C.J. & JANSSEN, I. (2007). Development of age-specific adolescent metabolic syndrome criteria that are linked to the adult treatment panel III and International Diabetes Federation Criteria. *Journal of the American College of Cardiology*, 49(8): 891-898.

CONOLLY, A. (2016). "Health Survey for England 2015. Children's body mass index, overweight and obesity". National Health Service. Hyperlink: [www.content.digital.nhs.uk/catalogue/PUB22610/HSE2015-Child-obe.pdf]. Retrieved on 9 June 2017.

KOOLHAAS, C.M.; DHANA, K.; SCHOUFOUR, K.D.; IKRAM, M.A.; KAVOUSI, M. & FRANCO, O.H. (2017). Impact of physical activity on the association of overweight and obesity with cardiovascular disease: The Rotterdam Study. *European Journal of Preventive Cardiology*, 24(9): 933-940.

MARFELL-JONES, M.; OLD, T.; STEWARD, A. & CARTER, J.E.L. (2006). *International Standards for Anthropometric Assessment.* Lower Hutt, New Zealand: ISAK (International Society for the Advancement of Kinanthropometry).

MONYEKI, K.D. & KEMPER, H. (2008). The risk factors for elevated blood pressure and how to address cardiovascular risk factors: A review in paediatric populations. *Journal of Human Hypertension,* 22(7): 450-459.

MONYEKI, M.A.; NEETENS, R.; MOSS, S.J. & TWISK, J.W.R. (2012). The relationship between body composition and physical fitness in 14-year-old adolescents residing within the Tlokwe local municipality, South Africa: The PAHL study. *BMC (BioMed Central) Public Health,* 12(374): 1-8.

MOSELAKGOMO, V.K.; MONYEKI, M.A. & TORIOLA, A.L. (2015). Relationship between physical activity and risk factors of body weight disorders among South African primary school children. *Biomedical Research*, 26(4): 730-738.

NG, M.; FLEMING, T.; ROBINSON, M.; THOMSON, B.; GRAETZ, N. (& 100+ authors) (2014). Global, regional, and national prevalence of overweight and obesity in children and adults during 1980-2013: A systematic analysis for the Global Burden of Disease study 2013. *Lancet*, 384(9945): 766-781.

PIENAAR, A. (2015). Prevalence of overweight and obesity among primary school children in a developing country: NW-CHILD longitudinal data of 6-9-yr-old children in South Africa. *BMC (BioMed Central) Obesity,* 2(February): 2. Doi: 10.1186/s40608-014-0030-451.

REUTER, C.P.; DA-SILVA, P.T.; RENNER, J.D.P.; DE-MELLO, E.D.; DE-MOURA-VALIM, A.R.; PASA, L.; DA-SILVA, R. & BURGOS, M.S. (2016). Dyslipidemia is associated with unfit and overweight-obese children and adolescents. *Arquivos Brasileiros de Cardiologia* (trans.: *Brazilian Archives of Cardiology*), 106(3): 188-193.

RIVERS, K.; HANNA-MAHASE, C.; FRANKSON, M.; SMITH, F. & PETER, S. (2014). Association between Obesity and Impaired glucose tolerance in New Providence adolescents as demonstrated by the HbA1c Test. *West Indian Medical Journal,* 62(February): 705-710. Doi:10.4172/2155-6156.1000511.

SALONEN, M.; WASENIUS, N.; KAJANTIE, E.; LANO, A.; LAHTI, J.; HEINONEN, K.; RÄIKKÖNEN, K. & ERIKSSON, J.G. (2015). Physical activity, body composition and metabolic syndrome in young adults. *PLoS One*, 10(5): 1-12.

SLAUGHTER, M.H.; LOHMAN, T.G.; BOILEAU, R.A.; HORSWILL, C.A.; STILLMAN, R.J.; VAN LOAN, M.D. & BEMBEN, D.A. (1988). Skinfold equations for estimates of body fatness in children and youth. *Human Biology,* 60(5): 709-723.

SPSS INC. (2011). *Statistical Package for Social Science Software*. Armonk, NY: IBM Corp.

THIBAULT, H.; CONTRAND, B.; SAUBUSSE, E.; BAINE, M. & MAURICE-TISON, S. (2010). Risk factors for overweight and obesity in French adolescents: Physical activity, sedentary behaviour and parental characteristics. *Nutrition,* 26(2): 192-200.

TORIOLA, O.M. & MONYEKI, M.A. (2012). Health-related fitness, body composition and physical activity status among adolescent learners: The PAHL Study. *African Journal for Physical, Health Education, Recreation and Dance,* 18(4:1): 795-811.

TREMBLAY, M.S.; BARNES, J.D.; GONZÁLEZ, S.A.; KATZMARZYK, P.T.; ONYWERA, V.O.; REILLY, J.J. & TOMKINSON, G.R. (2016). The Global Matrix 2.0 Research Team. Global Matrix 2.0: Report Card Grades on the Physical Activity of Children and Youth Comparing 38 Countries. *Journal of Physical Activity and Health*, 13(2): S343 -S366.

WABITSCH, M.; MOSS, A. & KROMEYER-HAUSCHILD, K. (2014). Unexpected plateauing of childhood obesity rates in developed countries. *BMC (BioMed Central) Medicine,* 12(January):17. Doi: 10.1186/1741-7015-12-17.

WHO (World Health Organization) (2002). "Global strategy on diet, physical activity & health: Reducing risks, promoting healthy life". WHA57.17.38-55. Geneva, Switzerland. Hyperlink: [http://www.who.int/gb/ebwha/pdf_files/WHA57/A57_R17-en.pdf]. Retrieved on 9 June 2017.

WHO (World Health Organization) (2009). "Global health risks: mortality and burden of disease attributable to selected major risks". Geneva, Switzerland. Hyperlink: [http://www.who.int/healthinfo/global_burden_disease/en/]. Retrieved on 1 September 2017.

WHO (World Health Organization) (2012). "Overweight and obesity: Global strategy on diet, physical activity, and health". Geneva, Switzerland. Hyperlink: [http://www.who.int/dietphysicalactivity/strategy/eb11344/strategy_english_web.pdf]. Retrieved on 29 August 2017.

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