

Liggaamsamestelling, groeivertraging en fisieke aktiwiteit van swart adolessente in 'n dorpsgemeenskap: PLAY studie

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SAMEVATTING

LIGGAAMSAMESTELLING, GROEIVERTRAGING EN
FISIEKE AKTIWITEIT BY SWART ADOLESSENTE IN 'N
DORPSGEMEENSKAP: PLAY STUDIE

In Suid-Afrika word 'n aansienlike gewigstoename by swart adolessente meisies tydens mid-adolessensie gevind, wat nie noodwendig by seuns die geval is nie (Kalk, 2001:577). Antropometrie is een van die mees basiese metodes vir die bepaling van oorvoeding-en ondervoedingstatus. 'n Groot hoeveelheid navorsing word wel oor obesiteit uitgevoer, en heelwat word gedoen oor groeivertraging (GV), maar min intervensies bestaan om GV te voorkom en te behandel (Marcus *et al.*, 2006). Die Wêreld Gesondheidsorganisasie (WGO) het bepaal dat ongeveer 230 miljoen kinders is wêreldwyd GV (WHO working group, 1986). Fisieke aktiwiteit (FA) by kinders word geraak deur gemiddelde of ernstige wanvoeding en het 'n invloed op adolessente se liggaamsbou en liggaamsamestelling (LS) aangesien hulle 'n tydperk van ontwikkeling beleef. Hoffman *et al.* (2006), Mantsena *et al.* (2005) en Monyeki *et al.* (2005) het bevind dat GV-kinders/adolessente korter in lengte en ligter in massa is as adolessente wat normaal groei. Maar meeste GV-adolessente het 'n hoër velvoutepersentasie getoon sowel as 'n hoër liggaamsmassa indeks (LMI). Intra-abdominale vetstoring kom ook voor by GV adolessente en kinders wat 'n gesondheidsrisiko is. Dwarsdeursnit studies toon dat fisieke aktiwiteit (FA) met tot 50% tydens adolessensie afneem wat 'n invloed op liggaamsamestelling het. Navorsing toon dat 'n FA-deelnamepiek bereik word tussen die ouderdomme 13 en 14 jaar, wanneer seuns meer aktief is as meisies. Wat minder duidelik is, is hoe die patroon van adolessente obesiteit verskil in term van ras, geslag en ouderdom (Popkin & Udry, 1998:701).

Die doel van hierdie studie was eerstens om deur middel van 'n literatuurstudie vas te stel wat die aard is van die navorsing wat oor liggaamsamestelling (LS) van GV en wangevoede adolessente in Afrika en Suid-Amerika gedoen is. Die tweede doel was om te bepaal watter LS-veranderlikes veranderinge in LS by adolessente (13 tot 18 jaar) na deelname aan 'n fisiekeaktiwiteitsintervensie die beste beskryf. Derdens is

bepaal watter LS- -verhoudings- en rypingsverskille tussen GV en nie-groeivertraagde (NGV) adolessente tussen die ouderdomme 13 en 18 jaar voorkom. Laastens was die doel om te bepaal of die fisiekeaktiwiteitsvlakke en fisiekeaktiwiteitspatrone van adolessente (13 tot 18 jaar) ooreenkomstig toename in ouderdom verander.

Die studie is deur middel van 'n beskikbaarheid-steekproef saamgestel deur gebruik te maak van twee sekondêre swart skole in Ikageng (Potchefstroom) in die Noordwes-Provinsie. Die beskikbaarheid-steekproef bestaan uit 'n kontrole- en eksperimentele groep swart leerlinge. Die studie is van 'n longitudinale studie-ontwerp wat strek van Maart 2004 tot September 2006. Adolessente (N=309) in die Noordwes-Provinsie (Potchefstroom), Suid-Afrika, (158 seuns, 211 meisies) tussen die ouderdomme 13-18 jaar is in hierdie studie gebruik. Al die leerlinge was met die aanvang van die studie in 2004 in graad 8. Die proefpersone van die eksperimentele groep (N=222) het deelgeneem aan 'n fisiekeaktiwiteit-intervensieprogram ongeveer een uur lank, twee dae per week na skoolure, drie en twintig weke lank in 2004, en in 2005 het hulle driemaal per week geoefen, negentien weke lank (die Julie skoolvakansie uitgesluit). Bywoningspersentasie van die FA program is volgens presensielyste aangeteken en by die eksperimentele groep in drie kategorieë ingedeel, naamlik laag (0%-30% bygewoon), matig (30%-60%) en hoog (60% en hoër). Die kontrolegroep (N=87) het aan geen intervenisieprogram deelgeneem nie. LS, middel-tot-heup-ratio (MHR), liggaamsmassa-indeks(LMI), persentasie liggaamsvet (%LV) en velvoue is gemeet vir basislyn en weer na afloop van die intervenisieprogram. Fase van ryping is bepaal deur middel van twee geslagspesifieke vraelyste (Tanner-vraelyste). Die *Previous Day Physical Activity Recall* (PDPAR), wat saamgestel is deur Trost *et al.* (1999), is vir die studie gebruik om die FA vlakke te ontleed. Lengte-vir-ouderdom z-telling (LOZ) is bereken vir elke adolessent ooreenstemmend met die geslag-spesifieke lengte vir ouderdompersentiel van die Centre for Disease Control (CDC). Deelnemers met 'n HOZ < -2 is geklassifiseer as GV (CDC, 2000).

Die Statistica (Statsoft Inc 9) en SAS (SAS Institute Inc, uitgawe 8, Cary NC) rekenaarverwerkingspakkette is aangewend om die ingesamelde data te verwerk. Beskrywende statistiek is gebruik om LS komponente van die deelnemers voor te stel. 'n Herhaaldemetings-kovariansieanalise (ANCOVA) (gekorregeer vir bywoningspersentasie en geslag) is gebruik om verskille tussen die eksperimentele en kontrole

groepe aan te toon, en variansie analise (ANOVA) oor tyd, met 'n *Bonferroni post hoc*-analise om te bepaal hoe die verskeie veranderlikes oor die verskeie toetsingsperiodes in maande van mekaar verskil. Die betekenisvolheid van verskille wat gevind is, is gestel op $p < 0.05$. Vervolgens is die Mann-Whitney U-toets gebruik om die betekenisvolle verskille van sekere veranderlikes tussen die GV- en NGV-adolescente te bereken. Die Chi-kwadraat toets is ook gebruik om die kategorieëse veranderlikes, naamlik verskille in die verspreiding binne die vyf Tanner-fases, asook die verskille tussen die GV- en NGV-meisies en -seuns afsonderlik, t.o.v. die verspreiding te bepaal tussen die groepe met 'n liggaamsvetpersentasie laer of hoër as die mediaan. Vir die ontleding van die verandering in FA-data oor tyd is gebruik gemaak van die tegniek van multivlak-modellering. Een van die doelstellings is deur middel van 'n literatuuroorsig ontleed.

Die resultate verkry uit die literatuuroorsig wat uitgevoer is, dui duidelik daarop dat GV algemeen by adolessente en kinders in ontwikkelende lande voorkom. Daar is ook gevind dat FA voordelig is vir die adolessente met betrekking tot LS – veral vir die seuns. Volgens die liggaamsmassaindeks-waardes (LMI-waardes) is 'n klein persentasie kinders as oorgewig geklassifiseer, terwyl met metodes soos die som-van-die-velvouberekening van velvou-vetpersentasie en persentasie LV gemeet deur middel van lugverplasing *pletismografie* (ADP), 'n groter persentasie kinders as “oorgewig” geklassifiseer het. Daar is ook gevind dat beduidende verskille tussen die massa, lengte, lengte-vir-ouderdom-z-telling, armspan, MO, heupomtrek en skraalliggaamsmassa van die GV-(28 meisies en 28 seuns) en NGV-(113 meisies en 90 seuns) groepe voorgekom het. Die resultate het aan die lig gebring dat die FA-vlakke van seuns in die eksperimentele en die kontrolegroep verskil het na deelname aan die FA program. Met toename in ouderdom en oor tyd was daar 'n afname in naweek fisiekeaktiwiteitspatrone by albei groepe (eksperimenteel en kontrole) vir albei geslagte. Die eksperimentele groep het op 'n hoër FA vlak as dié van die kontrole groep seuns oor die 30.75 maande tydperk geëindig. Hierteenoor het die meisies (152 en 59 proefpersone onderskeidelik) wel met die basislynmetings statisties betekenisvolle verskille tydens die week sowel as naweek getoon, waar die eksperimentele groep aanvanklik hoër FA vlakke getoon het. Hierdie verskille was egter nie meer betekenisvol tydens eindmetings nie. Albei groepe meisies het verder 'n laer kurwe van FA as dié van die seuns getoon. Die eksperimentele groep seuns en meisies, sowel as die kontrole groepe het 'n neiging tot afname in FA oor die 30.75-maande tydperk getoon. Met toename in ouderdom en oor tyd was daar 'n afname in naweek FA patrone by albei groepe vir albei geslagte, alhoewel die laaste twee

metings 'n effense opwaartse neiging toon, veral by die eksperimentele groep seuns. Die resultate het 'n verskil in FA patrone by die seuns in die eksperimentele en kontrolegroep aangetoon, wat aan die FA intervensie toegeskryf kan word.

Uit die literatuuroorsig kan die gevolgtrekking gemaak word dat Afrikalande en ander ontwikkelende lande, waar voedselnood meer algemeen is, 'n groter mate van probleme met GV ondervind. Die voorkomssyfer van GV in Suid-Afrika is matig. Daar kan gevolglik afgelei word dat groei en ontwikkeling in ag geneem moet word wanneer LS by adolessente bepaal word. Vetpersentasie is 'n sensitiewer maatstaf van obesiteit as LMI na deelname aan 'n FA-intervensieprogram by adolessente uit 'n dorpsgemeenskap. Die bepaling van LV-persentasie deur middel van velvoue en lugverplasing *pletismografie* (ADP) is akkurater as LMI by hierdie spesifieke groep proefpersone. Uit hierdie studie kan tot die gevolgtrekking geraak word dat daar verskille tussen GV-en NGV-adolessente van beide geslagte in sekere LS- en liggaamproporsie-komponente voorkom, sonder 'n verskil in seksuele ontwikkeling. Wat die meisies betref met betrekking tot FA-vlakke, het dit 'n ander effek as by die seuns met die intervensie getoon. Die eksperimentele groep seuns het na 3 jaar (waarvan hulle vir 2 jaar lank 'n FA-intervensie ondergaan het) 'n hoër FA-vlak as die kontrolegroep se seuns, wat nie aan 'n FA-intervensie blootgestel is nie, getoon. Hieruit kan afgelei word dat dié intervensie wel kan bydra tot verskille in FA van seuns wat aan fisieke aktiwiteitsprogramme deelneem in gedepriveerde omgewings, terwyl andersoortige strategieë ontwikkel sal moet word vir meisies vanuit hierdie gemeenskappe.

Sleutel woorde: Adolessente, Fisieke aktiwiteit, Groeivertraging, Fisiekeaktiwiteitsintervensie, Liggaamsamestelling.

ABSTRACT

BODY COMPOSITION AND PHYSICAL ACTIVITY IN BLACK ADOLESCENTS IN A TOWN COMMUNITY: PLAY STUDY

In South Africa a remarkable weight gain is found in black adolescent girls during mid-adolescence, which is not necessarily the case among boys (Kalk, 2001:577). Anthropometry is one of the most basic methods for determining over-nutrition and malnutrition status. A considerable amount of research is indeed done on obesity, and quite an amount on growth stunting (GS), but few interventions exist for prevention and treatment of GS. The World Health Organization (WHO) has determined that approximately 230 million children world wide are growth stunted (GS) (WHO working group, 1986). Physical activity in children is affected by average or serious malnutrition and influences adolescents' body build and body composition (BC) because they are in a period of development. Hoffman *et al.* (2006), Mantsena *et al.* (2005) and Monyeki *et al.* (2005) have all found that GS children/adolescents are shorter in length and lighter in mass than adolescents that grow normally. But most GS adolescents have shown a higher skin fold-fat percentage as well as a higher body mass index (BMI). Intra-abdominal fat storage is also found in GS adolescents and children, which is a health risk. Cross sectional studies show that physical activity (PA) decrease with up to 50% during adolescence, which influences body composition. Research has indicated that a PA participation peak is reached between aged 13 and 14 years, when boys are more active than girls. What is less clear is how the pattern of adolescent obesity differs in terms of race, gender and age (Popkin & Udry, 1998).

Firstly, the aim of this study was to determine what the nature of research is that has been undertaken regarding body composition (BC) of GS and malnourished adolescents in Africa and South America, by means of a literature study. The second aim was to determine which body composition variables best describe changes in BC in adolescents (13-18 years) after participation in a physical activity intervention. Thirdly, the aim was to determine which BC, relations and maturation differences are found between GS and non growth stunted (NGS) adolescents between ages 13 and 18 years. Finally, the aim was to establish whether the physical activity levels and

physical activity patterns of adolescents (13 to 18 years) change congruent to age increase.

The study was compiled by means of an availability sample by making use of two secondary black schools in Ikageng (Potchefstroom) in the North West Province. The availability sample comprised a control group and an experimental group of black learners each. The study was of a longitudinal study design nature which stretched from March 2004 to September 2006. Adolescents (N=309) in the North West Province (Potchefstroom), South Africa (158 boys, 211 girls) between ages 13 and 18 years were used in this study. All the learners were in grade 8 at the onset of the study in 2004. The experimental group participated in a physical activity intervention programme for practically one hour, two days per week after school hours for twenty-three weeks in 2004, and in 2005 they practised three times per week for nineteen weeks (July school holiday excluded). Attendance percentage of the PA programme was noted according to attendance registers with the experimental group split into three categories, namely low (0%-30% attended), average (30%-60%) and high (60% and higher). The control group (N=87) attended no intervention program. BC, middle-to-hip ratio (MHR), body mass index (BMI), percentage body fat (% LV) and skin folds were measured for baseline and again after completion of the intervention programme. Maturation phase was determined by means of two gender specific questionnaires (Tanner Questionnaires). The *Previous Day Physical Activity Recall* (PDPAR), compiled by Trost *et al.* (1999), was used for the study to analyse the PA levels.

Statistica (Statsoft Inc 9) and SAS (SAS Institute Inc, edition 8, Cary NC) computer processing packages were used to process the data collected. Descriptive statistics were used to represent BC components and participants. A Repeated measurements co-variance analysis (ANCOVA) (corrected for attendance percentage and gender) was used to indicate differences between the experimental and control groups, and variance analysis (ANOVA) over time, with a *Bonferroni post hoc* analysis to establish how the different variables differ from each other over the various test periods in months. The significance of differences found was set on $p < 0.05$. Next the Mann-Whitney U test was applied to calculate the significant differences of certain variables between the GS and non-growth stunted (NGS) adolescents. The Chi-

square test was also used to determine the categorical variables, namely differences in the distribution within the five Tanner phases, as well as the differences between the GS and NGS girls and boys separately, with regard to the distribution between the groups with a body fat percentage lower or higher than the median. The technique of multilevel modelling was used for analysing the change in PA data over time.

The result gained from the literature clearly indicates that GS generally occurs in adolescents and children in developing countries. It was also found that physical activity is beneficial to the adolescents in terms of body composition, especially for the boys. According to the body mass index (BMI) values, a small percentage of children are classified as overweight, whilst with methods such as the sum of skin folds calculation of skin fold fat percentage and %BF measured by means of air transfer *pletismografie* (ADP), a larger percentage of children was classified as “over fat”. It has also been found that significant differences occurred between the mass, length, length-for-age-z-score (LOZ), arm span, middle circumference, hip circumference and lean body mass of the GS (28 girls and 28 boys) and NGS (113 girls and 90 boys) groups. The results also indicated a difference in PA levels of boys in the experimental and control groups after participation in the PA programme. With increase in age and over time there was a decrease in weekend physical activity patterns in both groups (experimental and control) for both genders. The experimental group ended at higher PA level than that of the control group of boys over the 30.75 months period. Opposed to this the girls (152 and 59 subjects respectively) did indeed show significant differences during the week as well as during the weekend with the baseline measurements, whereas the experimental group initially showed higher PA levels. These differences were, however, not more significant during end measurements. Both groups of girls further showed a lower curve of PA than that of the boys. The experimental group of boys and girls, as well as the control groups displayed a decrease in PA over the 30.75 months period. With increase in age and over time, a decrease was observed in PA patterns in both groups for both genders, although the last two measurements showed a slight upward inclination, especially in the experimental group of boys. The results showed a difference in PA patterns in the boys in the experimental and control groups, which can be attributed to the PA intervention.

From the literature overview the conclusion can be drawn that African countries and other developing countries, where food scarcity is more common, experience a larger extent of problems with GS. The occurrence of GS in South Africa is average. Hence

it can be deduced that growth and development need to be taken into consideration when BC is determined in adolescents. Fat percentage is more sensitive measure of obesity than BMI following participation in a PA intervention programme in town community adolescents. Determining BF percentage by means of skin folds and air replacement *pletismografie* (ADP) is more accurate than BMI in this specific group of experimental subjects. From this study the conclusion can be drawn that differences occur between GS and NGS adolescents of both genders in certain BC and body proportion components, without a difference in sexual development. With regard to the girls in terms of PA levels, it had another effect as with the boys with the intervention. The experimental group of boys, after 3 years (of which they underwent a PA intervention for 2 years) showed a higher PA level than the control group of boys that did not participate in a PA intervention. From this it can be deduced that this intervention did indeed contribute to differences in PA of boys that participate in physical activity programmes in deprived environments, while strategies different from these will need to be developed for girls from these communities.

Key words: Adolescents, physical activity, growth stunting, physical activity intervention, body composition

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LYS VAN AFKORTINGS

ADP	Lugverplasing <i>pletismografie</i>
ANCOVA	Ko-variantsie analise
ANOVA	Variantsie analise
BMI	<i>Body mass index</i>
CDC	<i>Centre of Disease Control</i>
Cm	Sentimeter
DXA	X-straal absorpsiometrie
FA	Fisieke aktiwiteit
Gem	Gemiddeld
GV	Groeivertraag
HOZ	Lengte-vir-ouderdom z-telling
Jr	Jaar
Kg	Kilogram
Kkal	Kilokalorie
LMI	Liggaamsmassa indeks
LO	Liggaamlike opvoeding
LS	Liggaamsamestelling
MET	Metaboliese ekwivalent
MHR	Middel-heup ratio
MHtR	Middel-tot-lengte ratio
Min	Minuut
ml	Mililiter
mm	Milimeter
MO	Middelomtrek

N	Steekproef grootte
NGV	Nie-groeivertraag
NWU	Noordwes Universiteit
O₂	Suurstof
PDPAR	Previous Day Physical Activity Recall
PLAY	PhysicaL Activity in Youth
RSA	Republiek van Suid-Afrika
SA	Standaardafwyking
TV	Televisie
Vet%	Vetpersentasie
VV	Velvou
WGO	Wêreld Gesondheidsorganisasie
WHO	World Health Organisation

HOOFSTUK 1

PROBLEEMSTELLING EN DOEL VAN DIE STUDIE

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1.1 INLEIDING

Volgens Potera (2004:A802) toon navorsing dat oorvoeding en die gevolge van obesiteit 'n groeiende gesondheidsprobleem vir kinders en adolessente in industriële lande en selfs in sommige ontwikkelende lande is. Volgens Kumanyika *et al.* (2002:429) is die liggaam ontwerp om vet te stoor vir tye van nood en is 'n probleem in hedendaagse tye as gevolg van 'n ongesonde leefstyl. Dit blyk dat die voorkoms van obesiteit by volwassenes sowel as kinders wêreldwyd geleidelik besig is om te verhoog (Adams *et al.*, 2005:146). Obesiteit sal gevolglik in die volgende millenium aanhou toeneem indien dieet of fisieke aktiwiteitspatrone nie verander nie (Kumanyika *et al.*, 2002:429). Die meeste populasies verander hul dieet en fisieke aktiwiteitspatrone om by die samelewing aan te pas (Uauy *et al.*, 2001:S985).

1.2 PROBLEEMSTELLING

Adolessensie is 'n tydperk van verandering in elke mens se lewe (Spear, 2002:S23). Daar bestaan ook verskeie mites oor ryping wat tieners en hul ouers kan verwar met betrekking tot die effek van ryping (Nakamoto, 2000:182). Volgens Spear (2002:S23) word adolessensie ook as 'n sensitiewe tydperk ten opsigte van voeding om verskeie redes beskou. Daar ontstaan onder andere 'n groter behoefte na nutriënte wat vir fisieke groei en ontwikkeling nodig word, en verandering in leefstyl en eetgewoontes van adolessente is dikwels ook redes vir verandering in nutriëntinname (Spear, 2002:S23).

Obesiteit is een van die gevolge van onaktiwiteit en het die potensiaal om chroniese siektetoestande, byvoorbeeld hipertensie, diabetes en koronêre arteriële toestande te verhoog (Leupker, 1999:S16). Oefening verlaag nie net die risiko vir obesiteit nie, maar hou ook voordele vir gesondheid in (Deheeger *et al.*, 1997:372). Obesiteit by kinders is wêreldwyd 'n ernstige publieke gesondheidsprobleem en verskeie kliniese programme is ontwerp vir die behandeling van obese kinders (Cole *et al.*, 2005:419). Dit is gevolglik duidelik dat kinderobesiteit al reeds in die kinderjare aangespreek moet word (Dietz & Gortmaker, 2001:337). Fisieke aktiwiteit (FA) neem af en sedentêre gedrag neem toe gedurende adolessensie (Brodersen *et al.*, 2007), veral by meisies (Pearson *et al.*, 2009; Kimm *et al.*, 2002). Vlakke van sedentêre gedrag is ook grootter by adolessente met 'n laer sosio-ekonomiese agtergrond en begin al so vroeg as op 11-jarige ouderdom te verskein (Brodersen *et al.*, 2007).

Die toename van navorsing oor obesiteit oor die afgelope dekade kan egter die beeld skep dat hongersnood iets van die verlede is, alhoewel baie kinders in ontwikkelende lande steeds honger ly (Potera, 2004:A802). Cameron *et al.* (1998:495) verwys na verskeie Suid-Afrikaanse studies oor groeivertraging wat rapporteer dat kinders progressief meer groeivertraging ondergaan tydens die pre-adolessente jare. Gorstein *et al.* (1994:280) klassifiseer minder as 20% voorkoms in groeivertraging as laag, 20-29% as matig, en meer as 30% as hoog. Volgens Mantsena *et al.* (2003:227) is groeivertraging en wanvoeding by kinders in Suid-Afrika steeds 'n belangrike probleem wat siekte en swak

gesondheid tot gevolg het. Potera (2004:A802) rapporteer in dié verband dat 'n gebrek aan optimale voeding die effek van infeksies en siektes vererger, wat tot die helfte van kindersterftes regoor die wêreld kan bydra.

Die effek van voedingstatus op liggaamsamestelling (oorvoeding of ondervoeding) word meestal bepaal deur van antropometriese metodes gebruik te maak (Mei *et al.*, 2002:978). Verskeie metodes bestaan vir die bepaling van liggaamsamestelling en elke metode het voor- en nadele (Stewart, 2001:694). Velvouformules en metodes is oor jare ontwikkel vir die voorspelling van vetpersentasie, vetmassa en vetvryemassa by kinders, sowel as volwassenes (Boye *et al.*, 2002:628). Aangesien ras, geslag en ouderdomsverskille 'n invloed op velvoudiktes het, is dit belangrik dat daar oor verskillende areas van die liggaam gemeet moet word om 'n totale oorsig van vetweefsel by die verskillende groepe te bepaal (Freedman & Perry, 2000:S40). Obesiteit word meestal deur liggaamsmassa indeks (LMI) of metings vir onderhuidse vet bepaal (Cameron & Getz, 1997:776). Daar bestaan nog baie kontroversie oor watter metode mees geskik is om obesiteit en groeivertraging by adolessente te bepaal (Stewart, 2001:694). Die probleem is in hierdie studie ondersoek deur van verskeie antropometriese metings en indekse gebruik gemaak.

Dit is nie net leefstyl, byvoorbeeld televisie-kyk en rekenaarspeletjies speel, wat lei tot gebrek aan fisieke aktiwiteit nie, maar ook faktore soos die wegneem van Liggaamlikeopvoeding (LO) uit skoolprogramme in Suid-Afrika en ander lande (Leupker, 1999:S12; Van Mil *et al.*, 1999:S42; Bar-Or *et al.*, 1998:4; Van Deventer, 1998:93). Puberteit vereis energie, en mag daartoe bydra dat daar 'n afname in FA by meisies sowel as by seuns plaasvind (Van Mil *et al.*, 1999:S43). Van Deventer (2000:60) dui voorts aan dat adolessente minder aktief word met 'n toename in ouderdom tot en met volwassenheid, moontlik as gevolg van gebrek aan belangstelling in sport, groepsdruk en huislike omstandighede (sosio-ekonomiese druk).

Die navorsingsvrae wat derhalwe in hierdie studie gestel word, is eerstens watter navorsing al uitgevoer is oor groeivertraagde en wangevoede adolessente in Suid-Afrika, Afrika en Suid-Amerika en die bevindinge daarvan. Die tweede vraag is, watter

liggaamsamestelling veranderlikes beskryf liggaamsamestellingsveranderinge die beste by adolessente na 'n FA intervensie. Derdens word gevra of daar verskille bestaan tussen groeivertraagde en nie-groeivertraagde adolessente, met betrekking tot liggaamsamestelling, liggaamsproporsies in verskillende tydperke van ryping. Laastens word gevra hoe die FA patrone en FA vlakke van adolessente oor 'n tydperk van 3 jaar sal verander na deelname aan 'n FA intervensie program.

Beantwoording van hierdie navorsingsvrae kan lig werp op groeibeperking by adolessente en die rol van fisieke aktiwiteit daarin. Hierdie resultate kan moontlik bydra dat fisieke aktiwiteits-intervensieprogramme, wat gesondheidsprobleme kan aanspreek, met groter effektiwiteit ontwikkel en geïmplimenteer kan word. Die mees geskikte antropometrieëse metodes wat gebruik kan word om liggaamsamestelling te bepaal word ook ondersoek. 'n Beter begrip kan verkry word oor adolessente in terme van liggaamlike veranderlike, fisieke aktiwiteitsgewoontes en fisieke aktiwiteitsvlakke in die tydperk van 3 jaar.

1.2 DOELSTELLINGS

Hierdie studie is gegrond op die volgende doelstellings:

- 1.2.1 Om die omvang en resultate van navorsing gedoen oor die liggaamsamestelling van groeivertraagde en wangevoede adolessente in Suid-Afrika, Afrika en Suid Amerika te ondersoek : Literatuuroorsig.
- 1.2.2 Om te bepaal watter liggaamsamestelling veranderlikes veranderinge in liggaamsamestelling by adolessente die beste beskryf na 'n fisieke aktiwiteitsintervensie.
- 1.2.3 Om vas te stel watter liggaamsamestelling-; -verhoudinge- en rypingsverskille tussen groeivertraagde en nie-groeivertraagde adolessente voorkom.

- 1.2.4 Om te bepaal of die fisieke aktiwiteitsvlakke en fisieke aktiwiteitspatrone van adolessente seuns en meisies oor 'n tydperk van 3 jaar betekenis beïnvloed sal word na deelname aan 'n FA intervensieprogram.

1.3 HIPOTEESES

Hierdie studie is op die volgende hipoteses gegrond:

- 1.3.1 Navorsing oor groeivertraging by adolessente en kinders in Suid-Afrika toon 'n matige voorkomssyfer.
- 1.3.2 Vetpersentasie is 'n meer sensitiewe maatstaf van obesiteit as liggaamsmassa indeks na deelname aan 'n fisieke aktiwiteits-intervensieprogram by dorpsgemeenskap-adolessente.
- 1.3.3 Liggaamsamestelling, liggaamsverhoudings en ryping van groeivertraagde en nie-groeivertraagde adolessente toon betekenisvolle verskille.
- 1.3.4 Deelname aan 'n FA intervensieprogram sal die FA vlakke en patrone van adolessente seuns en meisies oor 'n tydperk van 3 jaar betekenisvol beïnvloed.

1.4 STRUKTUUR VAN PROEFSKRIF

Hierdie proefskrif word in artikelformaat aangebied.

- 1.4.1 **Hoofstuk 1:** Probleemstelling en doel van die studie. Soos voorgeskryf deur die Noordwes Universiteit (NWU) is van die Harvard verwysingstyl gebruik gemaak vir dié hoofstuk sowel as bronaanhalings, wat direk daarna volg.

- 1.4.2 Hoofstuk 2:** 'n Literatuuroorsig oor puberteit, liggaamsamestelling, antropometrie en fisieke aktiwiteit by adolessente. Bronaanhalinge wat in hierdie hoofstuk voorkom, volg direk na die hoofstuk. Hierdie hoofstuk en sy bronaanhalinge is volgens die Harvard verwysingstyl aangebied soos voorgeskryf deur die NWU.
- 1.4.3 Hoofstuk 3:** Literatuuroorsig: Die omvang en resultate van navorsing gedoen oor groeivertraagde en wangevoede adolessente in Afrika. Hierdie hoofstuk is in artikel formaat aangebied en sal aangebied word vir die *“Human Biology”* joernaal.
- 1.4.4 Hoofstuk 4:** Artikel 1: Afname in liggaamsvet maar nie in liggaamsmassa indeks by swart Suid-Afrikaanse adolessente na 'n fisieke aktiwiteits-intervensie program: PLAY studie. Hierdie artikel is gepubliseer in die *“African Journal for Physical, Health Education, Recreation and Dance”*.
- 1.4.5 Hoofstuk 5:** Artikel 2: Verskille in liggaamsamestelling, liggaamsproporsies en tydsberekening van puberteit tussen groeivertraagde en nie-groeivertraagde adolessente. Hierdie artikel is gepubliseer in die *“African Journal for Physical, Health Education, Recreation and Dance”*. Soos met hoofstuk 4 is daar sekere aanpassings in die uitleg van die hoofstuk gemaak vir tegniese doeleindes om eenvormigheid aan die proefskrif te gee.
- 1.4.6 Hoofstuk 6:** Artikel 3: Verandering in fisieke aktiwiteitsvlakke en fisieke aktiwiteitspatrone by swart adolessente tussen 14 en 16 jaar: PLAY-studie. Hierdie artikel sal aangebied word vir die *“Journal of Tropical Pediatrics”*. Riglyne aan outeurs kom in bylaag E voor. Vir tegniese doeleindes en eenvormigheid van die proefskrif is daar enkele wysigings aan die riglyne van die tydskrif aangebring.
- 1.4.7 Hoofstuk 7:** Samevatting, gevolgtrekkings en aanbevelings. In hierdie hoofstuk word 'n samevatting van die totale proefskrif gegee.

Gevolgtrekkings van elke hoofstuk word bespreek waar aanbevelings aangedui word.

- 1.4.8 Bylae:** Die riglyne vir outeurs vir elke artikel in hierdie proefskrif is in bylaag E geplaas. Vir tegniese doeleindes en eenvormigheid van die proefskrif is daar enkele wysigings aan die riglyne van die tydskrif aangebring. Die artikel se kantlyne is soos die res van die proefskrif uiteengesit. Tabelle is in die teks geplaas en nie aan die einde van die artikel nie. Bogenoemde wysigings maak die proefskrif makliker leesbaar en pas in by die res van die proefskrif se struktuur. Die joernaal vereis ook dat die artikel in Engels geplaas word en die oorspronklike artikels word aan die einde van hoofstuk 3 en 4 geplaas. Tanner vraelyste wat gebruik is in hoofstukke 4, 5 en 6, is in bylaag A beskikbaar. Demografiese vraelyste wat gebruik is vir hoofstukke 4, 5 en 6 word as bylaag B aangeheg. Die Previous Day Physical Activity Recall (PDPAR) vraelyste is in bylaag C geplaas. Bylaag D bevat die antropometriese datakaar. Hoofstuk 4 en 5 wat reeds gepubliseer is is in bylaag F beskikbaar.

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HOOFSTUK 2

'N LITERATUUROORSIG OOR RYPING, LIGGAAMSAMESTELLING, ANTROPOMETRIE EN FISIEKE AKTIWITEIT BY ADOLESSENTE

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2.1 INLEIDING

Suid-Afrika ervaar oor die afgelope jare 'n spoedige verstedeliking, veral by swart mense wat in onderontwikkelde areas in en om stede woon en na 'n beter leefstyl streef (Underhay *et al.*, 2003:78). Moontlike oorsake vir die toename in obesiteit

by kinders en adolessente is modernisasie, vinnige verstedeliking in ontwikkelende lande en onveilige omgewings wat almal lei tot 'n meer onaktiewe leefstyl (Leupker, 1999:S13, Van Mill *et al.*, 1999:S42). Die hedendaagse leefstyl lei daartoe dat minder tyd en aandag aan fisieke aktiwiteit (FA) en liggaamlike opvoeding (LO) in die skool bestee word en meer aan populêre aktiwiteite soos TV-kyk en rekenaarspeletjies speel, wat minimale fisieke inspanning verg (Leupker, 1999:S12; Van Mill *et al.*, 1999:S42; Bar-Or *et al.*, 1998:4; Van Deventer, 1998:63).

Kinder-obesiteit is nou 'n ernstige publieke gesondheidsprobleem wêreldwyd en baie verskeie kliniese programme is ontwerp vir die behandeling van obese kinders (Cole *et al.*, 2005:419). FA is egter belangrik vir almal, nie net vir obese persone nie (Van Mill *et al.*, 1999:S42). Gereelde FA is ook belangrik met betrekking tot die regulering van liggaamsgewig en word geassosieer met 'n afname in vetmassa en selfs 'n toename en of instandhouding van vetvrye massa (Galbis-Reig & Conzaes, 2003:17).

'n Groot hoeveelheid navorsing toon ook dat oorvoeding en die gevolge van obesiteit 'n groeiende gesondheidsprobleem in industriële lande en selfs party ontwikkelende lande is (Potera, 2004:A802). Hierdie toename in navorsing kan die beeld skep dat hongersnood tot die verlede behoort, maar baie kinders in ontwikkelende lande ly steeds honger (Potera, 2004:A802). Die voorkoms van groeivertraging of wanvoeding in Suid-Afrika is tussen 22.9% en 30.2% (Steyn & Walker, 2000:1). Groeivertraging vind plaas as gevolg van 'n tekort aan belangrike nutriënte wat deur wanvoeding veroorsaak word (Post & Victora, 2001:1290). Adolessensie word veral beskou as 'n voedingskwesbare periode van lewe waar 'n groter nutriëntbehoefte ontstaan vir groei en ontwikkeling (Spear, 2002:S23; Mukuddem-Peterson & Kruger, 2004:843).

Daar vind nie net fisieke verandering plaas nie, maar ook 'n verandering in eetgewoontes en leefstyl wat langtermyn gesondheid beïnvloed (Mukuddem-

Petersen & Kruger, 2004:848). Kinders se groei hang ook van ander faktore af soos onder andere genetica, sowel as omgewingsfaktore en nodige nutriënte (Muzzo *et al.*, 2004:867). Baie mites bestaan oor ryping wat tieners en hul ouers kan verwar (Nakamoto, 2000:182). Wat ook minder duidelik is, is hoe die patroon van obesiteit by adolessente verskil in terme van ras, geslag en ouderdom (Popkin & Udry, 1998:701).

Die patrone van verandering by oorgewig en wangevoede kinders verskil in terme van ouderdom, geslag en woonarea in verskillende lande (Wang *et al.*, 2002:971). Inligting oor liggaamsamestelling (LS) van sekere populasies is belangrik vir baie kliniese en voedingsverwante navorsing (Goran, 1998:505; Mantsena *et al.*, 2003:225). Intra-abdominale vet is direk in verskeie studies gemeet, maar die belangrikheid van vetverspreiding tydens die kinderjare is steeds onduidelik (Freedman & Perry, 2000:S48). Antropometrie is een van die mees basiese metodes vir die bepaling van oorvoeding en ondervoeding status (Mei *et al.*, 2002:978; Houtkooper *et al.*, 2000:401). Met die meet van LS word grootliks van velvolumetodes gebruik gemaak of van gekompliseerde en duur tegnieke soos dubbel X-straal absorpsiometrie (DXA) (Huang *et al.*, 2003:1192).

Hierdie studie fokus op die LS-komponente, FA en ryping by swart adolessente in 'n dorpsgemeenskap naamlik Ikageng in die Noordwes-Provinsie, Suid-Afrika. Hierdie hoofstuk sal hoofsaaklik fokus op literatuur rakende die aspekte van LS, antropometriese metodes, FA en ryping by adolessente. Terminologie wat met die studie verband hou, sal ook kortliks toegelig word. Verder word ander komponente wat LS, FA en ryping beïnvloed, bespreek. Hierdie hoofstuk kan meer duidelikheid gee oor obesiteit, adolessente, groeivertaging, LS en fisieke aktiwiteit.

2.2 TERMINOLOGIE

Terminologie wat die kern van hierdie studie vorm word in Tabel 2.1 opgesom in die vorm van definisies volgens Dirckx (2001) se mediese woordeboek.

Tabel 2.1 Definiering en beskrywing van kern terme

TERM	DEFINISIE/BESKRYWING
Adolescent/ <i>Adolescent</i>	'n Individu wat in 'n stadium van ontwikkeling tot volwassenheid is.
Antropometrie/ <i>Anthropometry</i>	'n Wetenskaplike studie van die menslike liggaam, deur vergelyking van mates van die liggaam.
Fisieke aktiwiteit/ <i>Physical activity</i>	Enige liggaamlike beweging wat aangedryf word deur spierkontraksies wat tot energieverbruik lei.
Liggaamsmassa indeks (LMI) / <i>Body mass index (BMI)</i>	'n Ruwe metode vir die bepaling van voedingstatus gemeet as massa gedeel deur die kwadraat van lengte in meter (kg/m^2) indeks korreleer met mortaliteits- of sieklikeidsmerkers as gevolg van assosiasie met obesiteit.
Middel-heup-ratio/ <i>Waist-to-hip ratio</i>	Middelomtrek gedeel deur heupomtrek; aanduider van abdominale (ingewandsvet) obestiteit en voorspeller van gesondheidsrisiko onafhanklik van totale persentasie liggaamsvet. Gesondheidsrisiko: vroue > 0.80 en mans > 0.95.
Obesiteit/ <i>Obesity</i>	'n Abnormale vermeerdering van vet in die subkutaneuse weefsel.
Ryping/ <i>Maturation</i>	Ontwikkeling en groei wat lei tot volwassenheid.
Velvou meting/ <i>Skinfold measurement</i>	Bepaling van die dikte van 'n velvou en onderliggende subkutaneuse vet deur gebruik te maak van 'n kaliper.

2.3 LIGGAAMSAMESTELLING (LS)

Inligting oor LS van sekere populasies is belangrik in terme van kliniese en voedingsverwante studies of navorsing (Mantsena *et al.*, 2003:225). LS is 'n integrale komponent van totale gesondheid en fisieke fiksheid, en help om te bepaal wat die werklike graad van vetheid of skraalheid by 'n persoon is (Kravitz & Heyward, 1997:25). Verskeie metodes bestaan waarvolgens die liggaam in sekere fundamentele komponente ingedeel kan word (De Ridder, 2005:85). 'n Tweekomponent-model is aanvaarbaar, naamlik skraalliggaamsmassa en vetmassa (De Ridder, 2005:85; Kravitz & Heyward, 1997:19; Houtkooper *et al.*, 2000:401).

Aangesien chemiese analise van liggaamsvet slegs moontlik is op kadawers, is verskeie indirekte metodes ontwikkel vir die meet van LS en meeste metodes is gebaseer op die aanname dat die liggaam uit die tweekomponent-model bestaan (Freedman & Perry, 2000:S36). Die twee algemene prosedures om LS te bepaal is die direkte (*in vivo*) en indirekte (*in vitro*) analyses (De Ridder, 2005:85). Direkte metodes (chemiese analise en anatomiese disseksie) verskaf geldigheid aan indirekte metodes (onderwaterweging, lugverplasing, DXA, LMI, velvoue en bio-elektriese impedansie-analise) (De Ridder, 2005:86). Antropometrie is een van die mees basiese metodes vir die bepaling van oorvoeding en ondervoeding status (Mei *et al.*, 2002:978).

2.3.1 Faktore wat liggaamsamestelling beïnvloed

Geslagshormone oefen 'n invloed uit op vetverspreiding tydens adolessensie (Freedman & Perry, 2000:S48). Boreham *et al.* (2004:9) het bevind dat meer tieners bewus geraak het van hul liggaamsamestellingsveranderinge, wat die gevolg het dat hulle eetgewoontes drasties verander het. Fisieke aktiwiteit het 'n invloed op adolessente se liggaamsbou en liggaamsamestelling aangesien hulle in 'n tydperk van ontwikkeling is (Boreham *et al.*, 2004:10). Swart kinders is meer

geneig om 'n sentrale vetpatroon te hê met minder vetdeponering by die ledemate (Malina, 1996:217) en dus speel ras ook 'n rol by vetverspreiding. Sportlui het minder liggaamsvet (ongeag geslag) as sedentêre persone (De Ridder, 2005:82). 'n Studie onderneem deur De Ridder (2005:85) het gevind dat verskillende sportsoorte 'n invloed uitoefen op die hoeveelheid liggaamsvet waaroor die sportman of -vrou beskik.

2.3.2 Antropometrie

Indirekte metodes, byvoorbeeld antropometrie word deur biokinetici, sportwetenskaplikes, sportdieetkundiges en afrigters gebruik om LS te bepaal (De Ridder, 2005:86). Eenvoudige indirekte antropometriese metings en indekse soos die LMI, abdomen-omtrek en velvoue bly die mees algemene metodes vir die bepaling van LS, aangesien dit die eenvoudigste en goedkoopste is (De Onis & Habicht, 1996:650). Bogenoemde metodes word ook gebruik vir die bepaling van metaboliese risikofaktore by volwassenes (Lean *et al.*, 1998:853) en kinders (Zannolli & Morgese, 1996:1368). Hierdie metodes is goeie voorspellers van totale liggaamsvetpersentasie by seuns en manlike adolessente (Sarría *et al.*, 2001:387).

Die belangrikheid van inligting oor LS kan moontlik toegeskryf word aan die verhoogde voorkoms van obesiteit wêreldwyd (Mantsena *et al.*, 2003:225). Antropometriese metodes (byvoorbeeld velvoue) voorsien akkurate waardes by gewig-stabiele persone wie se vetvrye-massa samestelling min of meer dieselfde is as 'n vasgestelde verwysingsraamwerk (Houtkooper *et al.*, 2000:401).

Om maer te wees verwys eenvoudig na 'n laer liggaamsgewig vir voorgestelde waardes vir ouderdom-lengte-massa tabelle (Kravitz & Heyward, 1997:19). Skraalheid verwys weer na spier-, skelet- en vetsamestelling van liggaamsgewig (Kravitz & Heyward, 1997:19). Die liggaam bestaan uit water, proteïene, minerale en vet (De Ridder, 2005:85; Kavitz & Heyward, 1997:19).

Totale liggaamsvet bestaan uit essensiële- en stoorvet. Vet in die murg van bene, in die hart, longe, lewer, milt, niere, ingewande, spiere en vetryke weefsel in die senuweestelsel is noodsaaklike vet, terwyl vet wat in vetweefsel gestoor is, as gestoorde vet bekend staan (Kravitz & Heyward, 1997:20). Noodsaaklike vet is nodig vir normale liggaamlike funksionering. Vroue het meer noodsaaklike vet as mans as gevolg van geslagseienskappe en ook om vir swangerskap voorsiening te maak (Kravitz & Heyward, 1997:20).

Die akkumulasie van vet in die liggaam is 'n sigbare manifestasie dat meer energie gestoor word as wat verbruik word (Bray, 1990:497). Gestoorde vet kom voor rondom organe en onder die vel en help met beskerming (skokabsorbering) en isolasie (hitteregulering) (Kravitz & Heyward, 1997:21). Dit is dus belangrik om “skraalheid” en nie “maerheid” aan te moedig om fisieke en geestelike welstand te bevorder in die gemeenskap (Kravitz & Heyward, 1997:19).

2.3.2.1 Velvoumetode

Oor die jare is velvou-formules en -metodes ontwikkel vir die voorspelling van vetpersentasie, vetmassa en vetvrye massa vir kinders, adolessente en volwassenes (Boye *et al.*, 2002:630). Velvoue verteenwoordig 40%-60% van die totale liggaamsvet in die subkutane area van die liggaam en kan direk gemeet word met behulp van 'n velvou-tang (Moreno *et al.*, 2002:1210). Velvoumetings word aan die regterkant van die liggaam geneem behalwe wanneer die persoon 'n gebrek of 'n besering aan die regterkant van sy liggaam het. Aangesien velvoumetodes so maklik is om te gebruik word dit wêreldwyd gebruik vir die bepaling van vetheid en voedingstatus vir kliniese doeleindes (Boye *et al.*, 2002:631).

Die velvoumetode het meer as 'n honderd-en-vyftig formules vir die bepaling van liggaamsvetpersentasie en liggaamsdigtheid (LD) (De Ridder, 2005:101). Die meeste metodes is ontwikkel uit laboratoriumprosedures soos onderwaterweging

en lugverplasing (Bod Pod[®]) (De Ridder, 2005:101). Met toename in ouderdom tydens puberteit neem die velvoudikte toe (Jürimäe *et al.*, 2004:68). Velvouformules is populasie-spesifiek en die regte formule moet dan ook gebruik word (De Ridder, 2005:105). Volgens Freedman en Perry (soos aangehaal deur Lohman, 1981:181) word daar dikwels aangeneem dat velvoue 'n direkte meting van liggaamsvet verskaf, maar hierdie metings reflekteer slegs subkutaneuse vet by 'n spesifieke area.

Aangesien ras, geslag en ouderdomsverskille 'n invloed op velvoudiktes het is dit belangrik dat daar oor verkillende liggaamsareas gemeet moet word om 'n totale oorsig van vetweefsel by die verskillende subgroepe te bepaal (Freedman & Perry, 2000:S40). In 'n studie deur Monyeki *et al.* (2005:254) is gevind dat velvoudiktes en die som van nege velvoue hoër was by normaal-gewig-meisies as dié van groeivertraagde meisies vir dieselfde ouderdom. So ook het Cameron en Getz (1997:775-782) met behulp van velvoue bevind dat meer adolessente meisies as seuns geneig is om obees of "oorvet" te wees. In Suid-Afrika kom 'n aansienlike gewigstoename by swart adolessente meisies tydens mid-adolessensie voor, wat nie noodwendig by seuns waargeneem word nie (Kalk, 2001:577).

Freedman en Perry (2000:S39-S40) het bevind dat die trisepdikte afneem by seuns na ryping, maar toeneem by meisies. Hulle het ook bevind dat die trisepvelvou by blankes dikker is as by swart persone, maar dat die verskil by die subskapulêre velvou kleiner was.

2.3.2.2 Liggaamsmassa-indeks (LMI)

Obesiteit word meestal bepaal deur velvoumetodes of liggaamsmassa-indeks (kg/m^2) (Cameron & Getz, 1997:776). LMI is die mees algemene metode wat gebruik word vir klassifisering van voedingstatus by volwassenes en ook vir bepaling van vetheid en obesiteit by adolessente (Mei *et al.*, 2002:978). Martorell

(1994:1134) beskryf egter LMI as 'n swak metode om te gebruik vir die bepaling van vetheid by groeivertraagde individue.

Een van die probleme met die interpretasie van obesiteit deur LMI is om te onderskei of 'n persoon "oorvet" of "oorgewig" is (Cameron & Getz, 1997:776). Hierdie twee terme word dikwels as sinonieme gebruik om oormatige gewig te beskryf (Cameron & Getz, 1997:776). Wanneer van LMI gebruik gemaak word om die lengte-massa (kg) ratio te bepaal, kan gepraat word van "oorgewig". Wanneer 'n oormaat vet as subkutaneuse vet (velvoue) gevind word kan gepraat word van "oorvet" (Cameron & Getz, 1997:776). Interpretasies van obesiteit moet gevolglik volgens die metode van meting gebruik word.

Die gewildheid van die gebruik van LMI sal egter voortbestaan aangesien dit herhaalbaar, eenvoudig en goedkoop is en groot hoeveelhede ingesamelde data daarmee vergelyk kan word (Freedman & Perry, 2000:S42). Alhoewel LMI as meting gewild is, kan LMI misleidend wees as dit alleen gebruik word (Maddalozzo *et al.*, 2002:1677). So byvoorbeeld sal 'n atleet met groot spiermassa en 12 persent liggaamsvet geklassifiseer kan word as oorgewig in terme van sy LMI, waar 'n tweede persoon met 'n ideale LMI en klein spiermassa in werklikheid klinies oorgewig of obees mag wees (Maddalozzo *et al.*, 2002:1679).

Die verwantskap tussen liggaamsvet, tydens kinderjare en volwasse obesiteit het aanleiding gegee tot afsnypunte vir LMI by kinders (2 – 18 jaar) om te klassifiseer of kinders obees of oorgewig is ter voorspelling vir toekomstige obesiteit tydens volwassenheid (Cole *et al.*, 2000:1245). Deur die afsnypunte te gebruik het Monyeki *et al.* (2002:285) bevind dat die voorkoms van obesiteit by stadsmeisies van 0.8% – 21.1% wissel en by seuns van 0.8% - 12.1% vir die ouderdomme 6 – 13 jaar. LMI neem toe tydens adolessensie (Bonora *et al.*, 1992:1271).

2.3.2.3 Middel-heup ratio (MHR)

Die middelomtrek is 'n goeie aanduider van intra-abdominale vet by volwassenes (Lean *et al.*, 1998:854). Volgens Maffeis *et al.* (2001:978) is die middelomtrek die beste bepaler vir oorgewig by kinders. Nog 'n potensiële meting van gesondheidsrisiko is middel-heup ratio (MHR – middelomtrek (cm) gedeel deur die heupomtrek (cm) en hierdie indeks verskaf 'n vergelykende risiko van totale liggaamsvet by volwassenes, maar nie noodwendig by kinders of adolessente nie (Dietz, 1995:156). Individue wat vet om die middel akkumuleer die sogenaamde appel figuur het 'n groter gesondheidsrisiko as die individue wat vet om die heupe en gluteale area versamel as die sogenaamde peerfiguur (Kravitz & Heyward, 1997:22).

Daar is verskeie meganismes waarvolgens vetverspreiding metabolisme en kliniese komplikasies kan beïnvloed, maar die aandag het verskuif na intra-abdominale vet as gevolg van die nabyheid aan die lewerpoortaar en die sensitiwiteit tot lipolitiese stimuli (Björntorp, 1990:493). Intra-abdominale vet is direk in verskeie studies gemeet, maar die belangrikheid van vetverspreiding tydens die kinderjare is steeds onduidelik (Freedman & Perry, 2000:S48).

2.3.3 Obesiteit

Kinder-obesiteit is nou 'n ernstige publieke gesondheidsprobleem wêreldwyd en verskeie kliniese programme is ontwerp vir die behandeling van obese kinders (Cole *et al.*, 2005:419; Underhay *et al.*, 2003:78). Die liggaam is ontwerp om vet te stoor vir tye van nood en dit is 'n probleem in moderne tye (Kumanyika *et al.*, 2002:429). Dit geld vir alle populasies, ongeag watter nasie, dus gaan obesiteit aanhou toeneem in die volgende millennium as huidige dieet- en FA-patrone nie verander word nie (Kumanyika *et al.*, 2002:429).

Obesiteit is 'n siekte, gekarakteriseer deur 'n toename in liggaamsvetmassa en lei tot 'n toename in mortaliteit en sieklikheid (Lara-Castro *et al.*, 2002:868). Medici stem universeel saam dat te veel liggaamsvet 'n groot gesondheidsrisiko inhou (Kravitz & Heyward, 1997:22). Obesiteit is 'n chroniese siektetoestand wat geassosieer kan word met verskeie obesiteit-verwante siektes soos koronêre arteriële siektes, kanker, tipe 2 diabetes, galblaassiekte, gewrigsiektes en psigologiese probleme (Bar-Or *et al.*, 1998:2). Ander gesondheidsrisiko's wat gekoppel word aan obesiteit is verhoogde bloeddruk, verhoogde serum cholesterol en respiratoriese probleme (Kravitz & Heyward, 1997:22).

Om maer te wees verlaag nie noodwendig gesondheidsrisiko's nie, intendeel kan die obsessie om maer te wees soms lei tot ernstige eetversteurings soos anorexia en bulimie (Kravitz & Heyward, 1997:19). Oorgewig in kinders en adolessente kan ook geassosieer word met hoë lipiedvlakke, bloeddruk, insulien en ander risikofaktore wat gesondheiduitkomst tydens volwassenheid voorspel (Power *et al.*, 1997:511; Must *et al.*, 1992:1350; Nieto *et al.*, 1992:201). Tussen 70-90% van obese kinders en adolessente word in hul latere lewe obese volwassenes (Bar-Or *et al.*, 1998:2).

Die voorkoms van obesiteit by dorpsgemeenskap Suid-Afrikaanse kinders in die Limpopo provinsie (3-10 jaar) wissel van 0-4.3% vir meisies en 0-2.5% by seuns (Monyeki *et al.*, 2005:287). In 'n studie deur Monyeki *et al.* (2008:1616) is gevind dat oorgewig en obesiteit by laerskool- sowel as hoërskoolmeisies eerder as by seuns voorkom. Die hedendaagse leefstyl lei daartoe dat minder tyd en aandag aan liggaamlike opvoeding in die skool bestee word en meer aan populêre aktiwiteite soos TV-kyk en rekenaarspeletjies speel, wat minimale fisieke inspanning verg (Leupker, 1999:S12; Van Mill *et al.*, 1999:S42; Bar-Or *et al.*, 1998:4; Van Deventer, 1998:63). Kinders wat liggaamlike opvoeding op skool ontvang, stel meer belang in FA as kinders wat geen onderrig daarin ontvang nie (Van Mill *et al.*, 1999:S43). Die lae vlakke van motivering by oorgewig adolessente

om aan 'n oefenprogram deel te neem, is dan ook 'n groot uitdaging vir medici (Bar-Or & Baranowski, 1994:357).

2.3.3.1 Intra-abdominale vetweefsel

Daar is verskeie meganismes hoe vetverspreiding metabolisme en kliniese komplikasies kan beïnvloed, maar die aandag het verskuif na intra-abdominale vet as gevolg van die nabyheid aan die lewerpoortaar en die sensitiwiteit tot lipolitiese stimuli (Björntorp, 1990:494). Intra-abdominale vetstoring speel 'n belangrike rol in die negatiewe effekte van oormaat liggaamsvet soos verhoogde bloeddruk, insulienweerstandigheid en hoë cholesterol (Lara-Castro *et al.*, 2002:869). Volgens Lara-Castro *et al.* (2002:869) geld hierdie negatiewe effekte vir beide blankes en swartmense selfs al is ras of etniese verskille in vetverspreiding al waargeneem (Freedman & Perry, 2000:S48).

Baie faktore beïnvloed intra-abdominale vet, naamlik geslagshormone, veroudering, oormaat suikrose-inname, gewigstoename, genetiese samestelling en leefstylgewoontes, byvoorbeeld onaktiwiteit, alkoholgebruik en sigareetrook (Lara-Castro *et al.*, 2002:869). Aangesien geslagshormone bekend is vir hul invloed op area-vetverspreiding is dit moontlik dat die hormonale omgewing bydra tot vet-herverspreiding (Freedman & Perry, 2000:S48). Blanke adolessente kinders het meer intra-abdominale vet as swart adolessente (Göran *et al.*, 1997:1073).

2.3.4 Groeivertraging

Die "World Health Organization (WHO)" het bepaal dat ongeveer 230 miljoen kinders wêreldwyd groeivertraag is (Monyeki *et al.*, 2005:251). Die voorkoms van groeivertraging in Suid-Afrikaanse kinders 1-9 jaar oud was 19% in 1999 (Steyn *et al.*, 2005:4). Volgens Leenstra *et al.* (2005:42) is ongeveer 35% en 29% van voorskoolse kinders (suid van die Sahara in Afrika) onderskeidelik groeivertraag en ondergewig. Die wêreldwye probleem van groeivertraging of wanvoeding kan 'n

gevolg wees van sosiale, ekonomiese en kulturele probleme, veral in ontwikkelende lande (Mukuddem-Petersen & Kruger, 2004:842). Voorskoolse kinders, veral in Afrika populasies, word blootgestel aan wanvoeding en dit het 'n groot impak op groei en ontwikkeling (Bènéfice *et al.*, 2001:50). Moontlike oorsake van groeivertraging in Suid-Afrika kan werkloosheid en armoede wees (Erik & Gericke, 2000:126; Napier & Albertse, 2000:121).

Weens die groot hoeveelheid navorsing oor obesiteit kan 'n wanindruk geskep word oor die voorkomssyfer van hongersnood, alhoewel baie kinders in ontwikkelende lande honger ly (Potera, 2004:A802). Groeivertraging vind juis plaas as gevolg van 'n tekort aan belangrike nutriënte deur wanvoeding (Post & Victora, 2001:1291). Die voedingstatus van skoolkinders en voorskoolse kinders in ontwikkelende lande ontvang min aandag (Lwambo *et al.*, 2000:36). Die gebrek aan voedingstowwe en kalorië (wanvoeding) kan die effek van infeksies vererger, wat lei tot die helfte van kindersterftes reg oor die wêreld (Potera, 2004:A802).

Verskeie studies het bevind dat daar 'n toename in groeivertraging is met 'n toename in ouderdom en dui ook aan dat groeivertraging tydens die voorskoolse jare reeds begin ontwikkel (Lwambo *et al.*, 2000:36 soos aangehaal deur Cameron & Getz, 1997; Partnership for child development, 1999:280; Simondon *et al.*, 1998:412; Stoltzfus *et al.*, 1997a:1100). Verder vind hulle ook 'n afname in groeivertraging by ouer meisies by 'n sekere ouderdom, terwyl groeivertraging progressief vererger by seuns (Lwambo *et al.*, 2000:36).

In die verlede was daar duidelike onderskeid tussen groeivertraging en toegang tot voedsel; hoe meer voedsel beskikbaar, hoe minder was die voorkoms van wanvoeding (Mukuddem-Petersen & Kruger, 2004:842). Mukuddem-Petersen en Kruger (2004:842) stel ook verder dat bogenoemde verband nie meer so duidelik is nie en dat wanvoeding meer aandag nodig, veral in Suid-Afrika. Verder het hulle bevind dat daar geen verwantskap tussen groeivertraging en

oorgewig/obesiteit in kinders tussen die ouderdomme 10-15 jaar in die Noordwes-Provinsie, Suid-Afrika is nie.

Fisieke fiksheid by kinders word geraak deur gemiddelde of ernstige wanvoeding (Bar-Or *et al.*, 1998:7). Kinders wat wangevoed (of groeivertraag) is, toon 'n laer maksimale suurstofopname as kinders met 'n beter voedingstatus (Bar-Or *et al.*, 1998:7). 'n Wanvoedingsprobleem is 'n chroniese eerder as 'n akute toestand (Napier & Albertse, 2000:122). Beskikbare data toon aan dat groeivertraging 'n baie komplekse en 'n meervoudige-oorsaakverskynsel van wanvoeding is (Kolsten, 1996:59). Die begeerte van die Suid-Afrikaanse regering om die gesondheid te bevorder in dorpsgemeenskappe vereis dat genoegsame basislyndata beskikbaar moet wees vir evaluering van die status van verbeterde voedings- en gesondheidsorg (Mantsena *et al.*, 2002:445).

2.3.4.1 Liggaamsamestelling by wanvoeding

Groeivertraging in lengte lei tot 'n afname in finale lengte of te wel, dwerggroei (Bènéfice *et al.*, 2001:50). Die kleiner liggaamsgrootte van chronies ondervoede kinders beperk hul maksimale aërobiese krag (Bar-Or *et al.*, 1998:7). Wanvoeding kan ook geassosieer word met 'n kleiner moontlikheid om moeilike fisieke werk te verrig (Bar-Or *et al.*, 1998:7). Verskille in lengte-vir-ouderdom beïnvloed die interpretering van resultate vanaf eenvoudige metodes om oorgewig en obesiteit (byvoorbeeld met behulp van LMI) te bepaal (Hoffman *et al.*, 2006:e730).

Groeivertraagde adolessente ly aan negatiewe faktore soos 'n lae LMI en 'n gebrek aan vitamien en minerale, wat 'n groot uitwerking op die ontwikkeling van maksimale skeletvolwassenheid het (Ibrahim *et al.*, 2003:93). LMI moet egter versigtig gebruik word vir die voorspelling van persentasie liggaamsvet, ongeag of daar gewerk word met normale of groeivertraagde adolessente (Hoffman *et al.*, 2006:e731). Mukuddem-Petersen en Kruger (2004:850) het ook bevind dat meisies wat groeivertraag is meer vet stoor om die naeltjie-area as meisies wat nie

groeivertraag is nie. LS, veral vetmassa, kan 'n belangrike komponent wees vir die bepaling van langtermyn ontwikkeling van groeivertraging (Bènéfice *et al.*, 2001:51).

Adolessente meisies wat groeivertraag was tydens die kinderjare blyk om korter te wees tydens ryping in vergelyking met meisies van normale lengte (Bènéfice *et al.*, 2001:56). Dié groeivertraagde meisies is geneig om meer subkutane vet om die borsarea te akkumuleer. Die komplekse aanpassing in totale vetheid en vetverspreiding tydens adolessensie kan as gevolg van hormone wees (Bènéfice *et al.*, 2001:57). Adolessensie is die kritieke laaste periode om groei-afwykings te probeer voorkom en die kennis van risikofaktore en risikogroepe is belangrik om 'n geskikte intervensie te kan ontwerp (Leenstra *et al.*, 2005:42).

2.3.4.2 Risiko's van wanvoeding/groeivertraging

Die langtermyn effek van wanvoeding wat tot groeivertraging lei wek groot kommer (Bènéfice *et al.*, 2001:51). In 'n studie deur Ibrahim *et al.* (2003:93) is gevind dat beenmineraal-digtheid by die groeivertraagde groep laer was as by die kontrolegroep. Serumvlakke van kalsium en magnesium was ook laer by die groeivertraagde groep (Ibrahim *et al.*, 2003:93). 'n Beperkte inname van noodsaaklike skeletale beenvormingsvoedingstowwe het 'n groot impak op beenmassa (Ibrahim *et al.*, 2003:99). Osteoporose is 'n siektetoestand as gevolg van 'n afname in die totale beendigtheid wat tot been broosheid en 'n verhoogde risiko vir frakture lei (Ibrahim *et al.*, 2003:93). Groeivertraging kom ook soms voor by tienermoeders wat self nog nie tot vollengte gegroei het nie (Leenstra *et al.*, 2005:42). Sulke tieners het 'n hoë risiko om anemies te wees en kan probleme met geboorteskenking ervaar (Leenstra *et al.*, 2005:42).

2.4 FISIEKE AKTIWITEIT (FA)

FA is 'n liggaamlike beweging wat meegebring word deur skeletspiere wat verhoogde energieverbruik tot gevolg het (Bar-Or & Malina, 1995:79). Bar-Or en Baranowski (1994:348) beskryf FA as 'n natuurlike liggaamsbeweging. Oefening vind plaas wanneer persone 'n beplande stel oefeninge (gewoonlik onder toesig) oor weke of maande heen uitvoer (Bar-Or & Baranowski, 1994:348). FA is belangrik vir normale groei en ontwikkeling vir kinders deur te help met morfologiese, funksionele en metaboliese ontwikkeling (Monyeki *et al.*, 2005:979).

FA is belangrik vir almal, nie net vir obese persone nie (Van Mill *et al.*, 1999:S42). Verskeie studies het bewys dat FA 'n belangrike rol speel in die behoud van skraalliggaamsmassa by kinders (Obarzanek *et al.*, 1994:15; Bar-Or, 1993:323). Gereelde FA is ook belangrik met betrekking tot die regulering van liggaamsgewig en word geassosieer met 'n afname in vetmassa en selfs 'n toename in of instandhouding van vetvrye massa (Galbis-Reig & Gonzales, 2003:17; Parizkova, 1996:320). FA alleen kan egter nie maklik gewigsverlies by obese persone laat plaasvind nie (Garfinkel & Cosina, 1990:514). Die kritieke tydperk vir deelname aan FA is die adolessensie periode (Van Mill *et al.*, 1999:S42).

Navorsing toon dat 'n FA-deelnamepiek bereik word tussen die ouderdomme 13 en 14 jaar, wanneer seuns meer aktief is as meisies (Van Mil *et al.*, 1999:S41). Gepaste FA word gedefinieer as oefening wat groot spiergroepe insluit, ten minste 20 minute duur, drie dae per week plaasvind, en teen 60% of meer van 'n individu se maksimale aërobiese kapasiteit uitgevoer word (Bar-Or & Malina, 1995:94). Galbis-Reig en Gonzales (2003:17) en Schwellnus en Derman (2003:13) beveel aan dat FA 30-45 minute duur, 3-5 maal per week moet plaasvind en van matige-tot hoë-intensiteitaktiwiteit per dag (aërobies, fietstry, draf) moet wees alvorens dit as 'n kondisioneringsprogram kan dien. Verlengde, matige oefening bevoordeel 'n negatiewe energiebalans en gewigsbeheer en staan bekend as metaboliese fiksheid (Verster, 2001:18). Leefstyl-aktiwiteite (byvoorbeeld deur skool toe en

huis toe te loop) het 'n langer gesondheids effek as gedissiplineerde aktiwiteite byvoorbeeld draf (Bar-Or & Baranowski, 1994:348).

2.4.1 Faktore wat FA beïnvloed

Volgens Reynolds *et al.* (1990:541) beïnvloed 'n. aantal faktore deelname aan oefening by kinders en adolessente, naamlik ontwikkelingsfaktore, psigologiese faktore, sosiale en kulturele faktore en fisieke- en omgewingsfaktore. Volgens Bar-Or *et al.* (1998:4) dra verskeie faktore in hul omgewing by tot kinders se lae aktiwiteitsvlak, naamlik:

- Onveiligheid en misdaad.
- Kinders wat skool toe en terug vervoer word.
- Beperkte LO by die skool, wat beperkte FA insluit.
- Beperkte fondse vir skole wat meebring dat FA en sport ingeperk word.
- Beperkte na-uurse toegang tot die skool se fasiliteite.
- Rekenaarspeletjies en TV.

'n Belangrike faktor wat 'n kind se deelname aan FA bepaal, is die genot wat hulle daaruit put (Van Mil *et al.*, 1999:S44). Die invloed van ander aspekte vanuit 'n kind se omgewing moet ook in ag geneem word, soos ryping, duur, frekwensie, intensiteit en tipe oefening; familie, etnisiteit en belangstelling in FA (Van Deventer, 2000:60; Sallis, 1995:126). Woonbuurtveiligheid, geslag en ras speel ook 'n belangrike rol in deelname aan FA (Van Mill *et al.*, 1999:S44). Kinders in 'n veilige woonbuurt is meer aktief as kinders in 'n onveilige woonbuurt (Sallis, 1995:126). 'n Afname in FA kan ook beïnvloed word deur biologiese veranderinge soos ryping (Van Mill *et al.*, 1999:S43).

Verskillende kulture het verskillende behoeftes en verantwoordelikhede en hul blootstelling aan FA verskil ook, wat gevolglik lei tot verskillende opvattings oor liggaamlike opvoeding (LO), sport en rekreasie (Tannehil *et al.*, 1994:406; Tannehil & Zakrajsek, 1993:78). Van Deventer (2000:61) het bevind dat blanke ouers die

meeste belangstelling toon in skoolsport, gevolg deur swart ouers wat weer op hulle beurt meer belangstelling in sport toon as Kleurlingouers.

Sallis (1995:133) het in 'n hul studie gevind dat aktiwiteitsvlakke in die algemeen in die winter laer is en hoër in die somer. Seisoene speel dus ook 'n rol in deelname van FA (Sallis, 1995:133). Seisoensverandering en groeifases beïnvloed die effek van oefening en daarom is 'n kontrole groep baie belangrik om die effek van 'n oefenprogram te kan meet (soos aangehaal deur Monyeki *et al.*, 2005 uit Malina, 1984:60).

Dieetbeperkings en leefstylgewoontes kan biologiese geneigdheid om energiebalans te handhaaf, versteur (Bar-Or *et al.*, 1998:7). Deelname van kinders kan ook deur wanvoeding beïnvloed word (Bar-Or *et al.*, 1998:7). So ook kan sosio-ekonomiese en kulturele vereistes 'n rol speel dat minder energie opgeneem word, wat FA weer laat afneem (Bar-Or *et al.*, 1998:7). Hoër sosio-ekonomiese klasse het beter toegang tot fasiliteite en is ook meer aktief (Van Deventer, 2000:60).

2.4.2 Voordele van fisieke aktiwiteit

Oefening verlaag nie net die risiko vir obesiteit nie, maar hou ook voordele in vir gesondheid (Deheeger *et al.*, 1997:372). Die voordele van FA of fisieke fiksheid begin op relatief lae vlakke, byvoorbeeld om iets te doen is beter as om niks te doen nie, en 'n geringe hoeveelheid fiksheid is beter as 'n uiters lae fiksheidsvlak (Barlow *et al.*, 1990:391). Laer intensiteitsaktiwiteite by 'n obese persoon kan dieselfde, of selfs groter, energieverbruik tot gevolg hê as wat die geval sal wees by hoër intensiteitsaktiwiteite by 'n lenige persoon (Bray, 1990:479). Die hoeveelheid energie wat tydens oefening verbruik word, hang van verskeie faktore af, naamlik intensiteit, duur en die tipe oefening (Bray, 1990:499).

Ten einde langtermynvoordeel uit oefening te trek, moet daar ten minste 3-5 sessies per week geoefen word (Corbin & Pangrazi, 1998:1; Pate *et al.*, 1998:162; Sallis & Patrick, 1994:302; Bray, 1990:506). Goran *et al.* (1997:175) het bevind dat die tyd wat aan FA bestee word, belangriker is as die totale energieverbruik, en dit impliseer dat langdurige lae-intensiteitdeelname aan FA doeltreffer is as korter, hoë-intensiteitaktiwiteite, wanneer gewigsverlies die oogmerk is.

Verbetering van gesondheid vind plaas as gevolg van oefening (Hill *et al.*, 1995:S1062; Tremblay & Alm  ras, 1995:S99). Die gesondheidsverbetering kan 'n verhoogde energiebehoefte tot gevolg h  , wat 'n effek het op voedselinname (Hill *et al.*, 1995:S1062; Tremblay & Alm  ras, 1995:S99). Die effek van oefening op voedselinname hang af van die duur en die intensiteit van die oefening (Bray, 1990:503). Ho  -intensiteit-oefening onderdruk voedselinname en 'n toename in liggaamsmassa (waarskynlik vetvrye massa), terwyl lae-intensiteit-oefening, met dieselfde kalorieverbruik, 'n geringer effek het (Bray, 1990:503).

Matige vlakke van oefening het geen betekenisvolle verandering in kalorie-inname getoon nie (Bray, 1990:504). Oefening en gesonde eetgewoontes is goed vir gewigsbeheer, maar is minder doeltreffend in die korttermyn, daarom moet dit eerder 'n langtermynproses wees (Bray, 1990:504).

Fisiologiese voordele van gereelde oefening sluit onder andere 'n toename in beenminerale, beendigtheid en beenmassa in (Bar-Or & Malina, 1995:98). Die effek van gereelde FA op skeletspiere is afhanklik van die tipe oefenprogram wat gevolg word (Bar-Or & Malina, 1995:98). Gereelde oefening veroorsaak meestal 'n mate van hipertrofie en verhoog kontraktuele prote  ene- en ensiemkonsentrasies (Bar-Or & Malina, 1995:98). Spierhipertrofie word prim  r geassosieer met ho  -weerstand-aktiwiteite en vind nie plaas weens uithouvermo  -oefening nie (Bar-Or & Malina, 1995:98).

Tydens submaksimale oefening vind 'n verhoging in ensieme plaas wat verhoogde

vetoksidasie tot gevolg het (Bray, 1990:499). Op sellulêre vlak word spesifiek die vinnig sametrekkende (rooi) spiervesels betrek en hierdie spiervesels het ook die hoogste kapasiteit vir oksidatiewe metabolisme (Bray, 1990:499). Die metaboliese verandering in die rooi spiervessel is die gevolg van 'n verhoging in die aantal mitochondrieë (Bray, 1990:499).

Oefening lei tot die behoud van bestaande spiermassa, die verhoging van maksimale suurstofopname en 'n toename in krag (Bray, 1990:500). Tydens oefening is daar 'n toename in die maksimale kapasiteit vir suurstofverbruik en die kardiaale omset verhoog, wat gevolglik meer suurstof aan die spiere verskaf (Bray, 1990:500). Suurstofopname in die spiere kan selfs by 'n sedentêre persoon wat vir uithouvermoë-aktiwiteite oefen, verdubbel (Bray, 1990:500). Die kardiovaskulêre sisteem ondergaan ook aanpassings tydens kardiovaskulêre uithouvermoë-oefeninge, terwyl 'n verbetering in glukose-toleransie en 'n afname in insulienkonsentrasies ook plaasvind (Bray, 1990:503).

Ander gesondheidsvoordele ontstaan met gereelde oefening, soos verlaagde bloeddruk, verminderde risiko vir koronêre arteriële siektes, verlaagde risiko vir galblaas siektes en verminderde risiko vir kolonkanker (Schwellnus & Derman, 2003:13). Dit speel ook 'n belangrike rol by die rehabilitasie van lae rugpyn en by osteoporose (Schwellnus & Derman, 2003:13). Oefening word ook met 'n meer voordelige bloedlipied-profiel geassosieer (Pray, 1997:34).

2.4.3 Fisieke aktiwiteitsintervensies

Daar is al relatief baie navorsing gedoen oor dieet- en FA intervensies by adolessente (Marcus *et al.*, 2006). Heelwat FA intervensies is ook al ontwerp met kwantitatiewe riglyne vir 'n effektiewe intervensie (Hillsdon *et al.*, 2005; Dishman & Buckworth, 1996), asook voorstelle vir effektiewe en goedkoop FA bevordering (Kahn *et al.*, 2002). Alhoewel daar baie voorstelle in die literatuur is vir intervensie programme, is daar nie gefokus op spesifieke sub-populasie modaliteite soos ras,

geslag en sosio-ekonomiese groepe nie (Marcus *et al.*, 2006). Min studies het ook fisieke aktiwiteitsvlakke van adolessente oor die langtermyn bestudeer sowel as die effek van fisieke aktiwiteitsintervensies op die langer duur.

2.5 RYPING

Ryping kan bestudeer word deur skelet volwassenheid, voorkoms van sekondêre geslagseienskappe en aanvang van menarg te bestudeer (Dietz, 1994:956). Tydens adolessensie neem lengtegroei met ongeveer 15% van die finale volwasse lengte toe en skeletmassa met ongeveer 45% van maksimale skeletmassa (Spear, 2002:S24).

Tydens die middelkinderjare voel albei geslagte ewe positief oor hul voorkoms, maar fisieke ontwikkeling vind tydens ryping plaas en word meer negatief deur meisies ervaar (Park, 2003:42). Seuns ervaar fisieke verandering meestal positief (Park, 2003:43). Vir meisies bring ryping menstruasie mee en word dit met gewigstoename en moontlike ontevredenheid met hul liggaamsbeeld geassosieer (Sweeting & West, 2003:31). Daar vind egter nie net fisieke verandering plaas nie, maar ook 'n verandering in eetgewoontes en leefstyl wat langtermyn gesondheid kan beïnvloed (Martorell *et al.*, 1994:S45).

2.5.1 Adolessente

In 'n Suid-Afrikaanse studie deur Mantsena *et al.* (2003) is gevind dat adolessente meisies in alle ouderdomme in die Ellisras-omgewing 'n hoër vetpersentasie as seuns gehad het. Velvoudiktes verskil ten opsigte van ras, geslag en ouderdom (Freedman & Perry, 2000:S48), maar daar kom min verskille voor ten opsigte van vetverspeiding by adolessente meisies (Flodmark *et al.*, 1995:941; Beunen *et al.*, 1994:670).

Geslagshormone oefen ook 'n invloed uit op vetverspreiding tydens adolessensie by seuns en meisies (Freedman & Perry, 2000:S48). Swartkinders is meer geneig om 'n sentrale vetpatroon te hê met minder vetdeponering by die ledemate (Malina, 1996:217).

Puberteit vereis energie wat 'n vroeër afname in FA, veral by meisies, kan laat plaasvind (Van Mill *et al.*, 1999:S43). Volgens Van Deventer (2000:60) word adolessente minder aktief met 'n toename in ouderdom tot en met volwassenheid. As oefening 'n effek op ryping het, moet elke aspek van ryping op dieselfde manier beïnvloed word, aangesien dieselfde hormone gedurende adolessensie by liggaamlike-, skeletale- en seksuele ryping betrokke is (Bar-Or & Malina, 1995:99). Gereelde oefening beïnvloed dus nie seksuele ryping nie (Bar-Or & Malina, 1995:100).

Kinders se groei hang onder andere af van genetiese faktore sowel as omgewingsfaktore en nodige nutriënte (Muzzo *et al.*, 2004:867). Adolessensie word beskou as 'n kwesbare voedingstydperk van lewe om verskeie redes (Spear, 2002:S23). Eerstens ontstaan 'n groter behoefte vir nutriënte vir fisieke groei en ontwikkeling, tweedens is daar 'n verandering in leefstyl en eetgewoontes wat hul voedselinname beïnvloed en derdens is daar adolessente met spesiale behoeftes (atlete, chroniese siektes, dieetgebruikers, delm- of alkoholgebruikers) (Spear, 2002:S23). Wat minder duidelik is, is hoe die patroon van adolessente obesiteit verskil in term van ras, geslag en ouderdom (Popkin & Udry, 1998:701).

2.6 SAMEVATTING

Uit die oorsig is dit duidelik dat obesiteit sowel as wanvoeding 'n wêreldwye probleem is. Alhoewel daar meer aandag gegee word aan obesiteit is groeivertraging 'n probleem by adolessente wat groei ondergaan. FA hou verband met obesiteit sowel as groeivertraging. Obesiteit ontstaan as gevolg van

oorvoeding en gebrek aan FA waar groeivertraging die gevolg van wanvoeding is en dit veroorsaak dat daar 'n beperking in FA is by die individue.

Die korrekte antropometriese metodes (LMI, velvou metode, Bod Pod®) moet gebruik word om LS te bepaal sodat obesiteit en groeivertraging korrek geanaliseer kan word. Intra-abdominale vetstoring hou baie negatiewe gesondheidskomplikasies in. Meer gespesialiseerde antropometriese metodes is gevolglik nodig om die hoeveelheid intra-abdominale vet te bepaal. Daar is wel eenvoudige metodes om risiko vir kardiovaskulêre siektes te bepaal, soos byvoorbeeld MHR, LMI en liggaamsvetpersentasie (velvoumetode). Ryping, ras, ouderdom en geslag moet in ag geneem word met hierdie metodes.

Literatuur dui aan dat ryping 'n baie sensitiewe tydperk vir adolessente in terme van hormonale verandering, liggaamlike verandering en emosionele verandering is. Daar bestaan ook baie mites rondom ryping en die groeitydperk. Uit die literatuur is dit duidelik dat FA afneem met 'n toename in ouderdom, wat 'n oorsaak is van obesiteit onder volwassenes.

Daar bestaan verskeie faktore wat wel FA beïnvloed by adolessente soos byvoorbeeld geslag, ras, seisoenale verandering, leefstylgewoontes, veiligheid, kultuur, vervoer, liggaamlike opvoeding by skole, finansies, beperkte fasiliteite, moderne leefstyl, sosio-ekonomiese en huishoudelike omstandighede.

FA blyk belangrik vir die normale ontwikkeling en groei van 'n kind te wees. Dit is ook belangrik vir gesondheid en welstand en die handhawing van 'n gesonde liggaamsmassa vir adolessente en volwassenes. Voordele van FA is fisiologies sowel as psigologies. Om FA in gemeenskappe te bevorder is FA intervensies nodig om kinders sowel as volwassenes in die gemeenskap met die nodige inligting en kennis toe te lig om op die korrekte manier meer aktief te wees.

Opsommend kan die gevolgtrekking uit die literatuur gemaak word dat daar 'n verwantskap tussen LS, FA, en ryping bestaan.

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HOOFSTUK 3

DIE OMVANG EN RESULTATE VAN NAVORSING GEDOEN OOR GROEIVERTRAAGDE EN WANGEVOEDE ADOLESENTE IN AFRIKA EN SUID-AMERIKA: LITERATUUROORSIG

Volgens die voorskrifte van "Human Biology" joernaal

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3.1 ABSTRACT

Children in South Africa are exposed to diseases from which most diseases are because of poor growth and malnutrition. It has also been reported that more children experience stunting during pre-adolescence and stunting/malnutrition is a great concern in developing countries. The aim of this study was to determine what research has been done on stunting in South Africa, Africa and South America. This literature review was done using various internet search engines. Results showed that stunting is common in certain countries such as Africa and South America. Literature showed results of body mass index (BMI), percentage body fat (%BF) and Z-scores (<-2). A South African study (THUSA BANA) found that 23.7% of boys and 26.75% of girls between the ages of 10-15 years were stunted. In conclusion, studies in South Africa showed similar results to those of Africa and South America that stunting is common among children and adolescents. Not much research has been done on stunting in South African among children and adolescents in regards to race, culture and different age groups. It is important to

educate parents and public to make them aware of the dangers and implications of stunting in growing children.

3.2 INLEIDING

Die “World Health Organization (WHO)” het bepaal dat ongeveer 230 miljoen kinders wêreldwyd groeivertraag is (Monyeki *et al.*, 2005). Die term “groeivertraging” (GV) is die deur Waterlow in die sewentigerjare gebruik om die groei-afwyking te beskryf wat voorkom by kinders wat te kort is vir hul ouderdom, as gevolg van wanvoeding, wat ook gepaard gaan met herhaaldelike infeksies (Kikafunda *et al.*, 1998). Volgens Steyn *et al.* (2005) was die voorkoms van GV van 1-9-jarige Suid-Afrikaanse kinders 19.3% in 1999.

Die wêreldwye probleem van GV/wanvoeding kan ook ’n gevolg wees van sosiale, ekonomiese en kulturele probleme, veral in ontwikkelende lande (Mukuddem-Petersen & Kruger, 2004). Die toename in navorsing oor obesiteit kan die beeld skep dat hongersnood iets van die verlede is, maar baie kinders in ontwikkelende lande ly steeds honger (Potera, 2004). GV vind juis plaas as gevolg van ’n tekort aan belangrike nutriënte wat deur wanvoeding veroorsaak word (Post & Victora, 2001). Die gebrek aan voedingstowwe en kalorieë (wanvoeding) kan die effek van infeksies vererger, wat tot die helfte van kindersterftes reg oor die wêreld lei (Potera, 2004).

Kinders in Suid-Afrika word blootgestel aan siektes waarvan die meeste uit swak gesondheid, swak groei en wanvoeding ontwikkel (Mantsena *et al.*, 2003). Daar is ook uit Suid-Afrikaanse studies gerapporteer dat meer kinders progressief GV ondergaan tydens die pre-adolessente jare (Mantsena *et al.*, 2003; Cameron *et al.*, 1994), terwyl daar weer by Ubombo kinders van albei geslagte min of geen voedingsagteruitgang plaasgevind het nie (Mantsena *et al.*, 2003). Voorskoolse kinders, veral in Afrika populasies, word blootgestel aan wanvoeding en dit kan ’n groot impak op groei en ontwikkeling hê (Bènéfice *et al.*, 2001). Volgens Leenstra *et al.* (2005) is ongeveer 35% en 29% van voorskoolse kinders groeivertraag en ondergewig, respektiewelik, suid van die Sahara in Afrika.

GV adolessente lei aan negatiewe aspekte soos 'n lae liggaamsmassa-indeks (LMI) en wanvoeding afwykings en GV het ook 'n negatiewe effek op die ontwikkeling van maksimale skeletale ontwikkeling (Ibrahim *et al.*, 2003). Tydens adolessensie is dit die laaste geleentheid om groei-afwykings te probeer voorkom en herstel en kennis van risikofaktore en risikogroepe is gevolglik belangrik om 'n geskikte intervensie te kan ontwerp (Leenstra *et al.*, 2005). GV kom ook soms by tienermoeders voor wat self nog nie hul volgroeide lengte bereik het nie (Leenstra *et al.*, 2005). Hierdie tieners het 'n hoë risiko om anemies te word en kan ook probleme met die geboorteproses ervaar (Leenstra *et al.*, 2005). Nog moontlike oorsake van GV in Suid-Afrika is werkloosheid en armoede (Erik & Gericke, 2000; Napier & Albertse, 2000).

Verdere ondersoek oor GV by adolessente en kinders word steeds benodig, veral in ontwikkelende lande soos Suid-Afrika. Die doel van hierdie artikel is om bestaande navorsing te kombineer en 'n algemene oorsig te gee om GV beter te verstaan en ook die navorsingsresultate met mekaar te vergelyk.

3.3 ONDERVOEDING EN GROEIVERTRAGING (GV)

In die verlede was daar duidelike verband tussen GV en toegang tot voedsel; hoe meer voedsel beskikbaar was, hoe minder was die voorkoms van ondervoeding (Mukuddem-Petersen & Kruger, 2004). Mukuddem-Petersen en Kruger (2004) stel verder dat bogenoemde verband nie meer so duidelik is nie en daarom meer aandag benodig, veral in Suid-Afrika. Verder het dié navorsers bevind dat daar geen verhouding was tussen GV en oorgewig/obesiteit by kinders tussen die ouderdomme 10 tot 15 jaar in die Noordwes-Provinsie, Suid-Afrika nie.

Verskeie navorsers het bevind dat GV met ouderdom toeneem en ook reeds tydens die voorskoolse jare begin (Cameron *et al.*, 1994; Simondon *et al.*, 1998; Stoltzfus *et al.*, 1997a:1100, b:153 soos aangehaal deur Lwambo *et al.*, 2000). Verder het hulle bevind

dat 'n afname in GV by dogters op die ouderdom van 12 jaar plaasvind, terwyl GV by seuns met 'n toename in ouderdom vererger (Lwambo *et al.*, 2000).

Wanvoeding is 'n chroniese eerder as 'n akute toestand (Napier & Albertse, 2000). Beskikbare data toon aan dat GV 'n baie komplekse en 'n meervoudige-oorsaakverskynsel van wanvoeding is (Kolsteren, 1996). Die begeerte van die Suid-Afrikaanse regering om gesondheid in gemeenskappe te bevorder vereis dat genoegsame basislyndata beskikbaar moet wees vir evaluering van die status van voedings- en gesondheidsorg (Mantsena *et al.*, 2002).

3.3.1 Liggaamsamestelling by GV

Mukudden-Petersen en Kruger (2004) het bevind dat dogters wat GV is meer subkutaneuse vet in die naeltjie-area stoor as dogters wat nie GV is nie. GV adolessente ly ook aan negatiewe faktore soos 'n lae LMI (lae liggaamsmassa maar nie lae vetpersentasie nie) en 'n gebrek aan vitamien en minerale, wat 'n groot uitwerking op die ontwikkeling van maksimale skeletvolwassenheid het (Ibrahim *et al.*, 2003).

3.3.2 Risiko's verbonde aan GV

Die langtermyn effek van wanvoeding wat tot GV lei, wek groot kommer (Bènéfice *et al.*, 2001). Die kleiner liggaamsgrootte van chronies ondervoede kinders beperk hul maksimale aërobiese krag (Bar-Or *et al.*, 1998). Ondervoeding kan ook met 'n kleiner moontlikheid om moeilike fisiese werk te verrig, geassosieer word (Bar-Or *et al.*, 1998). Fisieke fiksheid by kinders word ook deur matige of ernstige ondervoeding geraak (Bar-Or *et al.*, 1998). Kinders wat ondervoed (of GV) is, toon 'n laer maksimale suurstofopname as kinders met 'n beter voedingstatus (Bar-Or *et al.*, 1998). GV het ook 'n negatiewe langtermyn effek op leervermoë, skoolprestasie en produktiwiteit (Partnership for child development, 1999).

In 'n studie deur Ibrahim *et al.* (2003) is gevind dat beenmineraal-digtheid by die GV groep laer was as by die kontrolegroep. Serumvlakke van kalsium en magnesium was ook laer by die GV groep. 'n Beperkte inname van noodsaaklike skeletale beenvormingsvoedingstowwe het 'n groot impak op beenmassa. Osteoporose is 'n siektetoestand as gevolg van 'n afname in die totale beendigtheid wat lei tot beenbroosheid en 'n verhoogde risiko vir frakture (Ibrahim *et al.*, 2003).

GV kom ook soms voor by tienermoeders wat self nog nie vollengte gegroei het nie (Leenstra *et al.*, 2005). Sulke tieners het ook 'n hoë risiko om anemies te wees en kan ook probleme met geboorteskenking ervaar (Leenstra *et al.*, 2005).

3.4 VOORKOMS EN GEVOLGE VAN GV BY KINDERS EN ADOLESSENTE

In die literatuursoektog vir hierdie artikel is van die volgende databasisse gebruik gemaak: RGN Nexus: Lopende en afgehandelde Suid-Afrikaanse navorsing, Repertorium van SA Tydskrifartikels, Sport Discus, Medline, ScienceDirect, World Wide Web - Yahoo-soekenjin, World Wide Web - Google soekenjin.

In die literatuursoektog is spesifiek gesoek na inligting oor die verband tussen liggaamsamestelling, obesiteit, groeivertraging, ryping/puberteit en fisieke aktiwiteit by kinders en adolessente. Tabel 3.1 is 'n opsomming van beskikbare navorsing oor die voorkoms en gevolge van GV by kinders en adolessente.

3.4.1 Verskille in liggaamsamestelling van GV en nie-GV-kindere

Die mees resente navorsing is 'n dwarsdeursnitstudie (op Brasiliaanse kinders) deur Hoffman *et al.* (2006) met die doel om GV kinders en nie-groeivertraagde kinders (7-11 jaar) met mekaar te vergelyk deur gebruik te maak van antropometriese metodes. In die studie is gevind dat GV-kindere ligter en korter was, maar het 'n hoër vetpersentasie getoon soos gemeet met stabiele isotoopmetings as met die velvoue en LMI-metodes. Dit kan heel moontlik toegeskryf word aan intra-abdominale vetstoring.

In Tabel 3.1 kan verder gesien word dat in 'n studie deur Mukuddem-Petersen en Kruger (2004) op Suid-Afrikaanse kinders dat 23.7% dogters en 26.75% seuns uit 'n groep van 1257 adolessente GV was. Die navorsers het geen betekenisvolle assosiasies gevind tussen GV en oorgewig nie, maar het wel gevind dat GV-adolessente groter triseptselvrou en subskapulêre velvou waardes getoon het. GV-dogters toon ook 'n vertraging in ryping en probleme kan voorspel word in terme van oorgewig met toename in ouderdom.

Tabel 3.1 Opsomming van ingesamelde data oor die navorsing van GV by adolessente

Outeur(s)	N	Ouderdom (jaar)	Beskrywing van proefpersone	Studie-ontwerp	Liggaamsame-stellingsmetode	% GV-kindere	Belangrikste resultate
Hoffman <i>et al.</i> , 2006	N = 60	7 – 11 jr. (30 GV) (30 nie GV)	Brasiliaanse kindere	Dwarsdeursnit studie	*Massa-vir-ouderdom *Z-tellings *LMI *% LV met stabiele isotoop-water (H ₂ ¹⁸ O) *Velvoue	50%	GV-kindere was ligter en korter as nie-GV kindere maar LMI het nie verskil nie. Stabiele isotope het hoër vet % waardes getoon as LMI en VV
Leenstra <i>et al.</i> , 2005	N = 928	12 – 18 jr.	Adolessente skooldogters in Wes-Kenia	Dwarsdeursnit (Ewekansige steekproef)	*Ouderdom en menarg *Z-tellings *LMI *Lengte + massa (volgens WGO)	20.1% (12-13 jr) 4.3% (14-18 jr)	GV is algemeen by adolessente dogters in arm dele in westelike Kenia. GV is minder algemeen by ouer adolessente. Dogters wat later begin menstrueer het was meer wangevoed as die wat vroeër begin gemenstrueer het, vir dieselfde ouderdom
Monyeki <i>et al.</i> , 2005	N = 873	8 - 14 jr.	Swart SA-dogters	Gemengde-longitudinale studie	*Z-tellings (<-2) *Velvou vet % *LMI *Bloeddruk *Motoriese vaardigheid	33.45%	GV-adolessente was korter en ligter as normale dogters. Sistoliese bloeddruk was hoër by normale lengte dogters. GV dogters was beter met 1600m hardloop en opsit toetse
Mukuddem-Petersen & Kruger, 2004	N = 1257	10 – 15 jr.	SA-adolessente	THUSA BANA (<i>Enkel dwarsdeursnit</i>) Ewekansige steekproef	*LMI afsnypunte *Velvoue *Middel omtrek *LMI	♀ = 23.7% ♂ = 26.75%	Geen betekenisvolle assosiasie tussen GV en oorgewig. GV-kindere het wel hoër TSVV en SSVV. GV-dogters toon 'n vertraging in menarg en voorspel ook probleme van oorgewig later met ouderdom

Vervolg: Tabel 3.1 Opsomming van ingesamelde data oor die navorsing van GV by adolessente

Outeur(s)	N	Ouderdom (jaar)	Beskrywing van proefpersone	Studie-ontwerp	Liggaamsame-stellingsmetode	% GV kinders	Belangrikste resultate
Ibrahim <i>et al.</i> , 2003	N = 159	13.26±2.00	GV pasiënte van die Nasionale Voedings kliniek in Egipte	Gevalle studie	*Kliniese geskiedenis oor beëindigtheid en minerale.	♀ = 49.06% ♂ = 50.94%	GV-adolescente ly aan negatiewe impakte soos lae LMI en multinutrient afwykings wat 'n effek op maksimale skeletale ontwikkeling het
Mantsena <i>et al.</i> , 2003	N = 2198	3 – 11 jr.	Swart SA kinders Ellisras, Noord Wes-Provinsie	Gemengde-longitudinale studie	•Z-tellings (<-2) •Velvou vet % •LMI	6.01%	GV-kindere was korter as normale kinders. GV kinders het ook 'n hoër vet % en BMI gehad as normale kinders
Bènèfice <i>et al.</i> , 2001	1995: N = 406 1999: N = 191	1995: 11.4±0.5 1999: 15.5±0.5	Senegal dogters	Longitudinale studie	•Z-tellings (<-2) •Velvou vet % •LMI	20%	GV-dogters is geneig om groei in te haal tydens adolessensie. GV-dogters het ook meer subkutaneuse vet getoon in die bolyf
Lwambo <i>et al.</i> , 2000	N = 6801	7 – 18 jr.	Tanzanië kinders en adolessente	Dwars-deursnit Ewekansige steekproef	*Z-tellings (<-2) *Lengte-vir-ouderdom *Massa-vir-ouderdom	52.5% (GV) 43.0% ondergewig	Meer seuns was in hierdie studie GV as dogters. GV verbeter egter met ouderdom. GV en anemie is algemeen onder Afrika skoolkinders

N = steekproef grootte, Oud. (jr) = ouderdom in jare, % GV = Persentasie groeivertraging, GV = groeivertraag, LMI = Liggaamsmassa-ideks (kg/m^2), VV = velvoue, WGO = *Wêreld Gesondheid Organisasie*, SA = Suid-Afrikaanse, TSVV = trisepsvelvou, SSVV = subskapulêrevelvou, ♀ = vroulik, ♂ = manlik, ± = standaard afwyking, Vet % = liggaamsvetpersentasie

3.4.2 Gevolge van unieke liggaamsamestelling van GV-kindere

Uit 'n studie deur Leenstra *et al.* (2005) (Tabel 3.1) is bevind dat GV algemeen in westelike Kenia voorkom. Dié GV dogters wat ondersoek is, het ook later begin menstrueer as nie-GV dogters in dieselfde ouderdom. Uit die totale groep wat ondersoek is ($N = 928$) was 20.1% GV vir die ouderdomme 12 – 13 jaar en 4.3% vir die ouderdomme 14 – 18 jaar onderskeidelik. Hoffman *et al.* (2006), Mantsena *et al.* (2005) en Monyeke *et al.* (2005) het almal bevind dat GV-kindere/adolesente korter in lengte en ligter in massa is as adolesente wat normaal groei, maar dat meeste GV-adolesente 'n hoër velvou-vetpersentasie sowel as 'n hoër LMI getoon het.

Baie faktore beïnvloed intra-abdominale vetneerlegging, naamlik geslagshormone, veroudering, oormaat suikrose-inname, gewigstoename, genetiese samestelling en leefstylgewoontes byvoorbeeld onaktiwiteit, alkoholgebruik en sigaretrook (Lara-Castro *et al.*, 2002). Omdat geslagshormone bekend is vir hul invloed op liggaamsvetverspreiding is dit moontlik dat die hormonale omgewing bydra tot vet-herverspreiding (Freedman & Perry, 2000). Blanke adolesente kindere het meer intra-abdominale vet as swart adolesente (Goran *et al.*, 1997). Verskeie navorsers het intra-abdominale vet direk gemeet, maar die belangrikheid van vetverspreiding tydens kinderjare is steeds onduidelik (Freedman & Perry, 2000).

Daar is verskeie meganismes wat vetverspreiding-metabolisme en kliniese komplikasies kan beïnvloed, maar die aandag het verskuif na intra-abdominale vet as gevolg van die nabyheid aan die lewerpoortaar en die sensitiwiteit tot lipolitiese stimuli (Björntorp, 1990). Intra-abdominale vetstoring speel 'n belangrike rol in die negatiewe effekte van 'n oormaat liggaamsvet soos verhoogde bloeddruk, insulienweerstandigheid en hoë serumcholesterol (Lara-Castro *et al.*, 2002). Ras of etniese verskille in vetverspreiding is al geobserveer (Freedman & Perry, 2000), maar volgens Lara-Castro *et al.* (2002) geld hierdie negatiewe effekte vir beide blankes en swart mense.

3.4.3 Fisiologiese gevare van GV

Ibrahim *et al.* (2003) wat slegs GV-adolessente bestudeer het, het die negatiewe impakte ondersoek soos lae LMI, multinutrient-afwykings en maksimale skeletontwikkeling. Beenmineraal-digtheid by die GV-groep was laer as by die kontrole-groep in hierdie studie. Serumvlakke van kalsium en magnesium was ook laer by die GV-groep (Ibrahim *et al.*, 2003).

Hul het ook bevind dat anemie algemeen by skoolgaande Afrikakinders as gevolg van wanvoeding en nutriënttekorte voorkom. In hierdie studie is uit 'n aantal van 6801 Tanzaniese kinders en adolessente gevind dat 52.5% GV en 43% ondergewig was.

Monyeki *et al.* (2005) het verder bevind dat die sistoliese bloeddruk van nie GV- kinders hoër was as by GV-adolessente. Die NGV-adolessente het ook beter resultate getoon in 'n 1600 meter hardloop toets en ook in 'n opsittoets. Ongeveer 33% uit 'n totaal van 873 kinders was GV.

3.5 SAMEVATTING

Uit die samevatting van data in die literatuur is dit duidelik dat GV algemeen by adolessente en kinders in ontwikkelende lande voorkom. Dit begin alreeds voor skool as gevolg van wanvoeding en tekorte aan belangrike nutriënte wat nodig is vir ontwikkeling en groei. Daar is verskeie antropometriesse afwykings wat met GV voorkom, wat ook fisiologiese risiko's vir die groeiende kind inhou. GV beïnvloed ryping, FA, skeletontwikkeling, abdominale- en subkutaneuse vetstoring en voedingstatus wat siektes kan veroorsaak. Fisiologiese risiko's soos byvoorbeeld hipertensie kan 'n gevolg wees van GV.

Suid-Afrikaanse studies is moeilik vergelykbaar met dié van Afrika en Suid-Amerika omdat steekproefgrootte verskil en ras en kulturele verskille liggaamsamestelling beïnvloed. Tog kan gesê word dat die voorkomssyfer van GV in Suid-Afrika matig

voorkom asook in Afrika en Suid-Amerika. Geen literatuur is in hierdie studie oor navorsing gevind wat aandui hoeveel ouers of selfs lede van die publiek bewus was van statistieke oor GV en die implikasies daarvan nie. Heelwat navorsing word wel gedoen oor GV, maar min intervensies bestaan om GV te voorkom en te behandel, behalwe in voorskoolse kinders (Martorell *et al.*, 1994; Dewey *et al.*, 2008). Met die groeiende probleem van obesiteit in die wêreld het die fokus van navorsing verskuif vanaf ondervoeding en GV en die gewigstoename-epidemie geniet meer aandag. GV moet egter nie verwaarloos word nie, omdat dié toestand ook nagevolge en gevare inhou vir die groeiende kind. Dit wil ook voorkom of Afrikalande en ander ontwikkelende lande, waar voedselnood meer algemeen is, probleme ervaar met GV. Dit is dus belangrik dat elke ouer en selfs kinders bewus moet wees van die komplikasies van GV en wanvoeding.

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HOOFSTUK 4

AFNAME IN LIGGAAMSVET, MAAR NIE IN LIGGAAMSMASSA INDEKS BY SWART SUID AFRIKAANSE ADOLESENTE NA 'n FISIEKE AKTIWITEITSINTERVENSIE: PLAY STUDIE.

*Soos aangebied in die "African Journal for Physical, Health Education, Recreation and
Dance"*

**Decreased body fat, but not body mass index in black South African adolescents after
a physical activity intervention program: PLAY study.**

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Running title: Decreased body fat in South African adolescents after physical
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4.1 ABSTRACT

The aim of this study was to firstly determine the effect of physical activity (PA) intervention on body composition (BC) in black South African adolescents in the North West Province. The second aim was to establish which body composition variables will best describe body composition. A total of 280 black adolescents (113 boys, 167 girls), between ages 13 and 18 years, from two schools were tested. With the intervention group a physical exercise programme was followed for 19 weeks and with the control group, no programme was followed. BC, middle-to-hip ratio (MHR), body mass index (BMI), percentage body fat (%BF) and skin folds were measured for baseline and again at completion of the intervention. Participants of the intervention school were divided into two groups, based on their attendance of the intervention. MHR showed a decrease in both groups with high attendance ($p < 0.05$). With the boys there was a stronger decrease of %BF than with the girls. However, there was no significant decrease regarding the body mass index (BMI). The physical activity (PA) improved the body composition of

the groups with high attendance, especially among the boys. It is recommended that the specific body mass characteristics, i.e. skin folds, %BF, middle circumference and length be used to obtain the results, instead of using the BMI only in adolescents. Growth changes with increasing lean body mass need to be taken into account.

Key words: adolescents, body composition, physical activity, fat percentage, South Africa.

4.2 INLEIDING

Puberteit is vir enige individu 'n dramatiese fase vol verandering (Spear, 2002). Beide geslagte voel ewe goed oor hul voorkoms tydens die voorskoolse jare. Vanweë die fisieke ontwikkeling wat plaasvind tydens puberteit, raak meisies dan meer negatief en skaam oor hulle voorkoms (Park, 2003). Hierteenoor ervaar seuns die fisieke veranderinge gewoonlik as positief (Park, 2003). Wanneer fisieke veranderinge gedurende puberteit gemeet word, is dit belangrik om metodes te gebruik wat akkuraat en toepaslik is ten opsigte van spesifieke bevolkingsgroepe (Houtkooper, Going, Sproul, Blew & Lohman, 2000). Antropometrie is een van die mees basiese metodes om oor- en ondervoeding status te bepaal (Mei, Grummer-Strawn, Pietrobelli, Goulding, Goran & Dietz, 2002). Meer gesofistikeerde liggaamsamestelling (LS) metodes is duurder en dikwels nie beskikbaar in ontwikkelende lande nie (Mei *et al.*, 2002). Inligting ten opsigte van liggaamsamestelling vir spesifieke bevolkingsgroepe kan gebruik word vir vele kliniese- en voedingsverwante studies (Goran, 1998; Mantsena, Monyeki, Brits, Toriola & Kangolle, 2003). Liggaamsamestelling is ook belangrik om oorgewig kinders te identifiseer wat groter risiko's loop ten opsigte van sekere chroniese siektes en mortaliteit later in hul lewens (Nieto, Szklo & Comstock, 1992; Must, Jacques & Dallal, 1992; Power, Lake & Cole 1997). Antropometrie kan addisioneel gebruik word as merker vir metaboliese veranderinge gedurende 'n periode van groei en volgroeiheid, soos byvoorbeeld tydens puberteit (Jürimäe, Leppik & Jürimäe, 2004). Navorsing toon dat ondervoeding een van die oorsake van obesiteit gedurende die pre-adolescente jare en selfs puberteit is. Dit is 'n toenemende kommerwekkende gesondheidsrisiko in industriële- en selfs ontwikkelende lande (Potera, 2004).

In Suid-Afrika is 'n opmerklike gewigstoename onder swart adolessente meisies gedurende die mid-adolessente jare gevind, wat nie noodwendig die geval is by die seuns nie (Kalk, 2001). Dit is belangrik om obesiteit so vroeg as moontlik gedurende die kindertyd te voorkom om publieke gesondheid te verbeter (Bar-Or, Foreyt, Bouchard & Brownell, 1998), omdat gedragspatrone soos byvoorbeeld fisieke onaktiwiteit gedurende die kindertyd en puberteit, heel waarskynlik tot in volwassenheid sal voortduur en baie moeilik is om te verander (Pronk & Boucher, 1999; van der Merwe, 2001; Kalk, 2001). Kindervetsug en 'n gebrek aan FA (fisieke aktiwiteit) is wêreldwyd publieke gesondheidsprobleme en vele kliniese programme word ontwikkel vir die behandeling van obese kinders (Cole, Faith, Pietrobelli & Heo, 2005). In 'n studie deur Owens, *et al.* (1999) op oorgewig kinders, is bevind dat gereelde oefening, sonder dieëntintervensie, verbeterde LS en kardiovaskulêre fiksheid tot gevolg gehad het. Dit bewys gevolglik dat 'n toename in FA, selfs sonder dieët, 'n positiewe effek op kinders se liggaamsamestelling kan uitoefen (Owens *et al.*, 1999). Daar is bevind dat oefening nie slegs vetmassa laat afneem nie, maar ook skraalliggaamsmassa in gesonde adolessente vermeerder (Bar-Or & Baranowski, 1994).

Liggaamsmassa-indeks (LMI) is een van die mees algemene tegnieke wat gebruik word om vetsug onder volwassenes en kinders te identifiseer en word ook gebruik as klassifikasie van oorgewig en obesiteit onder adolessente en kinders (Mei *et al.*, 2002). Dit wil voorkom of LMI sal voortgaan om die gewildste antropometriese metode vir voedingstatus-bepaling te bly omdat dit goedkoop is, maklik is om te gebruik en bestaande data gebruik kan word om vergelykings te tref (Freedman & Perry, 2000). Hoewel LMI 'n gewilde metode is, asook maklik om te gebruik, mag LMI as 'n indikasie vir obesiteit misleidend wees wanneer dit alleen gebruik word (Maddalozzo, Cardinal & Snow, 2002). 'n Atleet met 'n hoë persentasie skraalliggaamsmassa en 'n persentasie liggaamsvet (%LV) van 12 persent kan byvoorbeeld geklassifiseer word as oorgewig in terme van LMI, terwyl 'n volgende persoon klinies oorgewig mag wees en tog oor 'n ideale LMI beskik (Maddalozzo *et al.*, 2002). Hoffman, Sawaya, Martins, McCrory en Roberts (2006) het in hul studie bevind dat, hoewel groeivertraagde kinders korter en ligter as normaal groeiende kinders is, daar geen verskil gevind kon word ten opsigte van die LMI van hierdie twee groepe nie. Hoe dit ook al sy, daar behoort versigtig omgegaan te word met LMI om

persentasie liggaamsvet te voorspel, ongeag dit as metingsmetode vir groeivertraagde of nie-groeivertraagde adolessente gebruik word. Volgens Cameron en Getz (1997), Martorell (2001) en Hoffman *et al.* (2006) is LMI 'n swak metode om te gebruik om liggaamsvet te bepaal, veral in groeivertraagde individue. Deur die jare is verskeie metodes en velvou-vergelykings ontwikkel om persentasie liggaamsvet, vetmassa en skraalliggaamsmassa te bepaal vir kinders, adolessente asook volwassenes (Boye, Dimitriou, Manz, Schoenau, Neu, Widy & Remer, 2002). Dit blyk duidelik uit die literatuur dat akkurate en presiese metodes belangrik is om LS te bepaal om adolessente te identifiseer wat ondergewig, oorgewig en obees is – veral onder adolessente in die groeiversnellingsfase (Freedman & Perry, 2000).

FA kan help om die LS en algehele gesondheid van adolessente te verbeter (Bar-Or *et al.*, 1998). Die belangrikste doelwit van hierdie studie was om die effek van 'n 19 weke lange fisieke aktiwiteitsintervensie-program te bepaal op die LS van swart Suid-Afrikaanse adolessente (13 tot 18 jaar), in 'n dorpsgemeenskap in die Noordwes Provinsie waar groeivertraagtheid 'n bekende publieke gesondheidsprobleem is (Kruger, Margetts & Vorster, 2004). Veranderinge in die LMI is vergelyk met veranderinge in die %LV, gemeet deur lugverplasing *pletismografie*.

4.3 METODES

4.3.1 Proefpersone en liggaamsamestelling

'n Totaal van 279 adolessente (113 seuns, 166 meisies), tussen die ouderdomme van 13 tot 18 jaar is van twee skole in die dorpsgemeenskap gebied van Ikageng, Potchefstroom in die Noordwes Provinsie, Suid-Afrika, gewerf. Die twee skole is op aanbeveling van 'n plaaslike voedingkundige gekies uit vyf skole in die dorpsgemeenskap, omdat daar na verwagting in hierdie twee skole die meeste ondervoede kinders gevind sou word. Alle ouers en kinders het ingeligte toestemming gegee. 'n FA intervensieprogram is vir 19 weke gevolg in die skool met die grootste aantal leerders, en die ander skool is gebruik as die kontrolegroep, sonder enige FA-intervensie. Gewig, lengte, middelomtrek, %LV (Bod Pod) en trisept (TSVV) en subskapulêre (SSVV) velvoue is gemeet vir die basislyn en weer

na afloop van die intervensieprogram om te bepaal of enige veranderinge plaasgevind het. Die kinders se Tanner-fases van ryping is ook vasgestel (Tanner & Whitehouse, 1982).

Groot polemieke bestaan steeds rondom die mees geskikte metode om obesiteit onder adolessente te bepaal. Daarom is verskeie metodes en indekse in hierdie studie gebruik om LS te meet. %LV en skraalliggaamsmassa is gemeet deur lugverplasing *pletismografie* (ADP), ooreenstemmend met die vervaardiger se instruksies (BODPOD Life Measurement Inc). Alle antropometriese metings is gedoen volgens die “*International Society for the Advancement of Kinanthropometry*” (ISAK)- standaard (ISAK, 2001). Die Lohman klassifikasie is gebruik om die kinders te klassifiseer na aanleiding van die som van velvou %LV vir adolessente (Lohman, 1981). Die Cole *et al.*, (2000) afsnypunte is gebruik in die klassifikasie volgens LMI, in besonder vir kinders tussen die ouderdomme van 13 tot 18 jaar.

Apparate wat gebruik is vir die meting van die verskillende antropometriese veranderlikes was: ’n Gekalibreerde elektroniese skaal vir die meting van liggaamsmassa (Precision Health scale, A & D Company, Saitama, Japan), ’n stadiometer om die lengte te meet (IP 1465, Invicta length meter, London, UK) en ’n John Bull (British Indicators, London) velvoutang met ’n konstante drukking van 10 gram per kubieke millimeter (g/mm^2) om die velvoue tot die naaste 0.2 millimeter (mm) te kan meet.

Middelomtrek, wat ook ’n maatstaf vir gewigstatus en voorspeller van kardiovaskulêre siekte-risiko is (Kruger, Margetts & Vorster, 2004), is gemeet met ’n staalmaatband ((Lufkin, Cooper Tools, Apex, NC). Liggaamsdigtheid (%LV en skraalliggaamsmassa) is gemeet in ’n lugverplasing *pletismografie* (ADP) en die BODPOD® skaal (Life Measurements, Inc, Concord, CA) is gebruik. Metings is gedoen volgens die aanwysings en aanbevelings van die vervaardigers: Elke persoon het ’n noupassende swemkostuum en swempet gedra. Na die bepaling van die liggaamsdigtheid is die formule van Siri en Brozek gebruik om %LV te bepaal (Thomas & Nelson, 2001).

4.3.2 Fisieke aktiwiteit intervensie

Gedurende die 19-week intervensie program het een van die twee skole deelgeneem aan die FA program, soos uitgevoer deur nagraadse Biokinetika studente. Die program is twee maal per week in uur-sessies elk uitgevoer. Die program het bestaan uit 20 minute

aërobiese danse (met musiek), 20 minute balverwante vaardigheidspel en speletjies (byvoorbeeld sokker, netbal en basketbal) en 20 minute krag- en soepelheidsoefeninge (byvoorbeeld dra 'n vriend en gebruik 'n vriend om te strek). Die aërobiese afdeling het ingesluit dans, Kataboks en aërobiese oefeninge. Die intensiteit van die aktiwiteitsessie is gestel op 'n harttempo van tussen 115 en 180 slae per minuut (Winnick, 2005). Die intensiteit van die program is deurgaans gemonitor deur middel van die meting van energieverbruik met aktiwiteitsmeters (Actical, Mini Mitter, Bend OR), wat deur sommige van die adolessente in elke sessie gedra is. Groepleiers het ook toesig gehou tydens die intervensieprogram om te verseker dat die oefening teen dieselfde intensiteit geskied. Bywoning is gemonitor deur middel van afmerklyste van proefpersone aanwesig by elke sessie. Die groep adolessente is in drie groepe verdeel, na aanleiding van die frekwensie van bywoning. 0 = Kontroleskool (geen bywoning); 1 = lae bywoningsgroep (0-50% sessies bygewoon); 2 = hoë bywoningsgroep (>50% sessies bygewoon). Daar is bepaal dat tenminste een sessie per week met 'n bywoning van 50% of meer deelname sou voldoende wees om 'n effek te kan hê op liggaamsamestelling oor 'n 19 weke periode. Die proefpersone het vrywillig aan die sessies na skool deelgeneem.

4.3.3 *Statistiese analise*

Statistiek-rekenaarsagteware (Statistica 2007, Stat Soft, Inc. for Windows) van die Universiteit van Noordwes is gebruik om die ingevorderde data te analiseer. Eerstens is beskrywende statistieke gebruik om LS komponente en deelnemers as 'n groep voor te stel. Ko-variëansie analise (ANCOVA) ten opsigte van die verskillende bywoning-getalle is gebruik om die liggaamsamestelling-veranderinge na afloop van die PA intervensie (gekontroleer by basislyn metings, Tanner fase, PA gedurende die week en naweek – PDPAR telling) aan te teken. LMI is voorgestel deur frekwensietabelle te gebruik. Die toepaslikheid is gestel op $p < 0.05$.

4.4 RESULTATE

4.4.1 Antropometriese kenmerke en bywoning van die intervensie

Tabel 1 dui die ouderdomme en liggaamsamestelling van die meisies en seuns respektiewelik tydens basislyn aan. Slegs vyf adolessente van die intervensieskool het geen van die fisieke oefeningssessies bygewoon nie en 41% van die kinders het 50% of meer van die sessies bygewoon. Binne die uur van die oefensessies is gemiddeld 56.5% van die tyd spandeer aan hoë intensiteit aktiwiteite, 24.5% aan matige oefeninge, 17% aan ligte aktiwiteite en 2% aan sittende aktiwiteite volgens die *Actical* maatstawwe (*Actical*, Mini Mitter, Bend OR).

Tabel 1. Ouderdom en liggaamsamestelling metings vir albei geslagte tydens basislynmetings

Geslag	Veranderlike	N	Basislynmetings		
			Gem $\pm$ SA	Minimum	Maksimum
Dogters	Ouderdom (jr)	166	14.31 $\pm$ 1.38	12.00	18.00
	Middelomtrek (cm)	166	63.56 $\pm$ 6.17	48.00	86.00
	Lengte (cm)	166	153.76 $\pm$ 6.50	130.0	172.00
	Massa (kg)	166	46.48 $\pm$ 9.70	22.2	85.8
	LMI (kg/m ²)	166	19.65 $\pm$ 3.68	13.11	38.62
	%LV (%)	125*	28.17 $\pm$ 6.66	14.60	54.90
Seuns	Ouderdom (jr)	113	14.65 $\pm$ 1.26	13.00	18.00
	Middelomtrek (cm)	113	62.95 $\pm$ 4.92	53.00	83.15
	Lengte (cm)	113	156.93 $\pm$ 9.59	135.0	179.00
	Massa (kg)	113	44.21 $\pm$ 9.03	27.6	78.6
	LMI (kg/m ²)	113	17.79 $\pm$ 2.32	13.23	25.64
	%LV (%)	96*	19.17 $\pm$ 5.42	7.20	42.50

N = Aantal proefpersone; jr = jaar; SA = Standaardafwyking; cm = sentimeter; kg = kilogram; LMI = Liggaamsmassa indeks (kg/m²); %LV = Persentasie liggaamsvet. *As gevolg van praktiese redes kon nie al die kinders se %LV gemeet word nie (die BODPOD laboratorium was slegs spesifieke tye beskikbaar en sommige kinders wou nie aan die toets deelneem)

Tabel 2. Aangepaste gemiddeld $\pm$ standaardafwyking van die verskeie bywoningsgroepe na die FA intervensie (Ko-variensie analise is aangepas vir basislyn meetings, Tanner fase en gewoone FA).

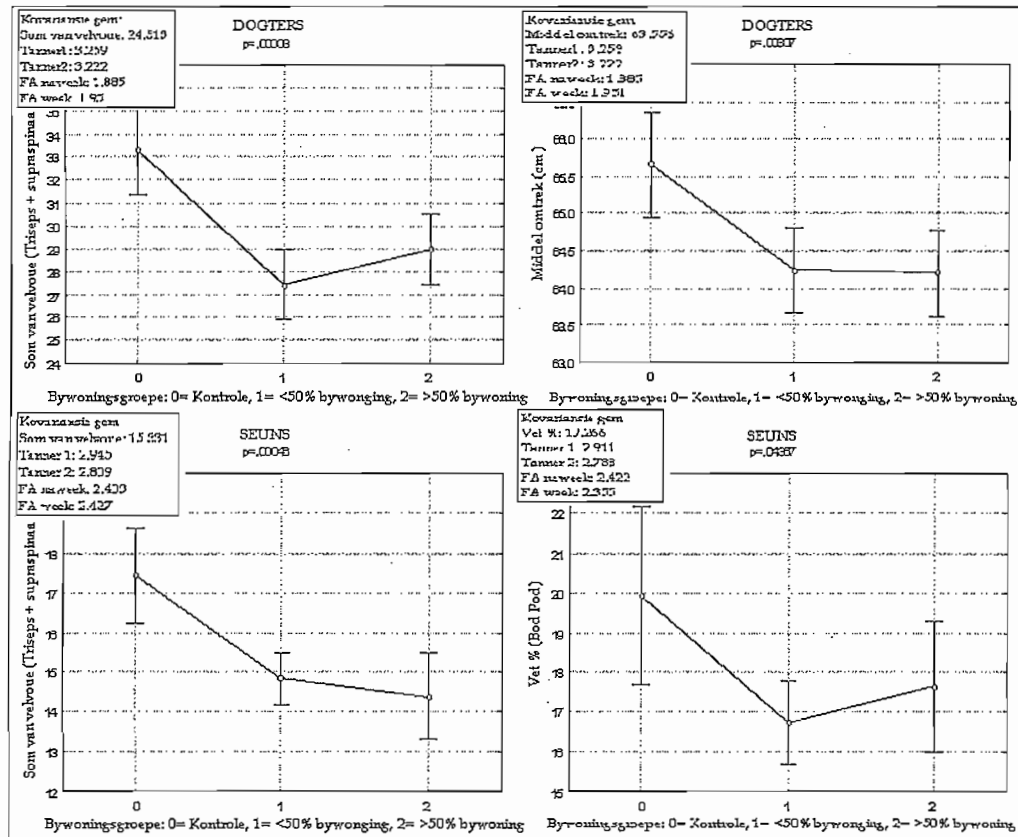
Liggaamsamestelling		DOGTERS			p*
		Kontrole groep	Bywoning 0-50%	Bywoning >50%	
LMI (kg/m ²)	n	41 20.32 $\pm$ 0.14	63 20.34 $\pm$ 0.12	62 20.39 $\pm$ 0.12	0.92
Middelomtrek (cm)	n	41 65.49 $\pm$ 0.38	63 63.96 $\pm$ 0.30	62 63.85 $\pm$ 0.30	<0.001 *
%LV (BODPOD)	n	19 29.35 $\pm$ 0.85	51 28.01 $\pm$ 0.52	55 27.00 $\pm$ 0.50	0.05
TVV+ SSVV (mm)	n	41 33.78 $\pm$ 0.97	63 27.43 $\pm$ 0.77	62 28.97 $\pm$ 0.79	<0.001 *

Liggaamsamestelling		SEUNS			p*
		Kontrole groep	Bywoning 0-50%	Bywoning >50%	
LMI (kg/m ²)	n	21 18.19 $\pm$ 0.13	64 18.23 $\pm$ 0.07	25 18.55 $\pm$ 0.12	0.05
Middelomtrek (cm)	n	21 62.53 $\pm$ 0.44	64 63.12 $\pm$ 0.25	25 62.56 $\pm$ 0.40	0.6
%LV (BODPOD)	n	13 19.94 $\pm$ 1.11	54 16.75 $\pm$ 0.54	23 17.65 $\pm$ 0.83	0.04*
TVV+ SSVV (mm)	n	21 17.44 $\pm$ 0.60	64 14.85 $\pm$ 0.34	25 14.39 $\pm$ 0.54	<0.001 *

n = Aantal proef persone; p = betekenisvollheid (p<0.05); LMI = Liggaamsmassa indeks; %LV = Persentasie liggaamsvet; < = Kleiner as; TVV = tricep velvou; SSVV = supraspinale velvou; FA = FA soos gemeet deur PDPAR(*Previous Day Physical Activity Recall*).

Tabel 2 beskryf die ko-variensie analise vir die verskillende FA intervensie bywoningsgroepe na afloop van die intervensieprogram. Seuns en meisies in die hoë FA bywoningsgroep se %LV was die laagste, met 'n groter afname in %LV by die seuns as by die meisies, hoewel daar nie betekenisvolle verskille waargeneem is in die afname van die LMI nie. Die LMI waardes in al die FA bywoningsgroepe het ooreengestem. Wat die

%LV en die som van velvoue betref, het die lae en hoë bywoningsgroepe laer waardes as die kontrolegroep getoon na afloop van die intervensieprogram.



Figuur 1: Kovariansie analise van die som van 2 velvoue (Trisepe en supraspinaal), middelomtrek (cm) en % LV (Bod Pod) vir verskeie bywoningsgroepe vir seuns en dogters onderskeidelik

Figuur 1 is 'n grafiese illustrasie van die kovariansie analise vir die verskillende liggaamsamestelling-veranderlikes van die verskillende FA bywoningsgroepe na afloop van die FA intervensieprogram. Figuur 1 dui 'n betekenisvolle verskil ($p < 0.001$) tussen die som van twee velvoue (trisepe en supraspinal) vir die verskillende bywoningsgroepe by die dogters aan. Figuur 1 dui vir die middelomtrek die verskillende bywoningsgroepe van meisies betekenisvolle verskille aan ($p = 0.003$). By die seuns (Figuur 1) was daar betekenisvolle verskille in die som van die velvoue ($p = 0.001$) en %LV ($p = 0.04$). Die

%LV vir die dogters en seuns het beide betekenisvolle verskille getoon tussen die drie groepe ($p < 0.05$).

Tabel 3. Lohman (1981) klassifikasie vir die % LV gebaseer op die som van velvoue (trisepe en supraspinaal) vir seuns ($n = 113$) en dogters ($n=166$) van die drie bywoningsgroepe tydens basis metings en na die FA intervensie

Lohman						
%liggaamsvet	Basislyn			Einde		
klassifikasie	Kontrole	< 50%	≥50%	Kontrole	< 50%	≥50%
DOGTERS	groep	(n = 64)	(n = 71)	groep	(n = 60)	(n = 62)
(n = 44)				(n = 34)		
0-15% (laag)	(5) 11.6%	(5) 8.3%	(10) 16.1%	(1) 2.3%	(2) 3.3%	(3) 4.8%
>15-26%	(20) 46.5%	(37) 60.6%	(41) 66.1%	(13) 30.2%	(24) 39.3%	(35) 56.5%
(optimaal)						
>26-30%	(8) 18.6%	(13) 21.3%	(5) 8.1%	(8) 18.6%	(27) 44.3%	(14) 22.6%
(gemiddeld)						
>30-35.5% (hoog)	(6) 13.9%	(4) 6.5%	(5) 8.1%	(11) 25.6%	(5) 8.2%	(7) 11.3%
>35.5%	(5) 11.6%	(5) 8.3%	(10) 16.1%	(1) 2.3%	(2) 3.3%	(3) 4.8%
(baie hoog)						
SEUNS	Kontrole	< 50%	≥50%	Kontrole	< 50%	≥50%
	groep	(n = 64)	(n = 27)	groep	(n = 64)	(n = 26)
(n = 24)				(n = 24)		
0-11% (laag)	(7) 29.2%	(27) 42.2%	(10) 38.5%	(2) 8.3%	(28) 43.7%	(11) 42.5%
>11-20%	(11) 45.8%	(33) 51.6%	(15) 57.8%	(16) 66.7%	(32) 50%	(14) 53.7%
(optimaal)						
>20-25%	(5) 20.8%	(4) 6.2%	(2) 7.7%	(4) 16.7%	(4) 6.3%	(1) 3.8%
(gemiddeld)						
>25-31% (hoog)	(1) 4.2%	-	-	-	-	-
>31% (baie hoog)	-	-	-	(2) 8.3%	-	-

n = Aantal proefpersone, %Liggaamsvet = Persentasie liggaamsvet, <50% = Lae bywoningsgroep – minder as 50% bywoning, ≥50% = Hoë bywoningsgroep – 50% en meer bywoning aan FA intervensie

Tabel 3 dui die %LV klassifikasie aan vir die verskillende bywoningsgroepe van seuns en dogters volgens die Lohman (1981) afsnypunt vir adolessente.

Tydens basislyn en end-metings is die meeste seuns geklassifiseer in die optimale %LV groep. Die hoë bywoningsgroep het 'n afname getoon in %LV, terwyl die lae bywoningsgroep konstant gebly het en die kontrolegroep verhoogde waardes getoon het na afloop van die eindmetings. Die meerderheid kinders in die ander groepe is geklassifiseer as adolessente met 'n optimale %LV. Tydens die end-metings is twee adolessente van die kontrolegroep geklassifiseer met 'n baie hoë %LV. Die hoë bywoningsgroep het die grootste verbetering tydens eindmetings getoon. Die lae bywoningsgroep het min verandering getoon.

Die dogters se resultate betreffende die %LV het opmerklik verskil van die seuns se resultate. Nie enige van die groepe het 'n betekenisvolle verbetering getoon na afloop van die FA intervensie nie, maar die hoë bywoningsgroep het die beste (laagste waardes) klassifikasie gehad in vergelyking met die lae- en geen bywoningsgroepe. Die kontrolegroep en lae bywoningsgroep se resultate was die swakste na afloop van die intervensieprogram en het 'n hoër voorkoms getoon van oorgewig en vetsug onder die adolessente. By die kontrolegroep het die voorkoms van adolessente in die hoë %LV groep verhoog van 13.9% tot 25.6% en van 9.4% tot 23.3% in die baie hoë (>36%) %LV klassifikasie. Hierteenoor is slegs 'n klein persentasie toename waargeneem by die lae- en hoë bywoningsgroepe. Na aanleiding van die LMI maatstawwe (Tabel 4) vir die seuns, het al die kinders in die hoë- en lae bywoningsgroep normale gewigsklassifikasie gehad (100%). Die kontrolegroep het 'n afname getoon in die LMI waardes van 91.2% tot 88.2% in die normale klassifikasie en 'n toename in die oorgewig-groep van 8.8% tot 11.8%. By die hoë bywoningsgroep vir meisies was daar geen vetsugtige adolessente nie en hierdie groep het ook die beste resultate getoon onder die drie bywoningsgroepe. Die kontrolegroep (meisies) het weer hoër LMI waardes getoon en by die lae bywoningsgroep was die verandering gering. Algeheel het die lae bywoningsgroep (<50%) en die hoë bywoningsgroep (>50%) die beste resultate tydens beide basislyn en end-toetsings getoon vir beide geslagte ten opsigte van LMI.

Tabel 4. Liggaamsmassa indeks klassifikasie vir albei geslagte by basislynmetings en aan die einde van die FA intervensie vir die verkillende bywoningsgroepe (Cole *et al.*, 2000)

DOGTERS						
LMI klassifikasie	Kontrole groep (n = 44)	Basis		Kontrole groep (n = 34)	Einde	
		< 50% (n = 64)	≥ 50% (n = 71)		< 50% (n = 60)	≥ 50% (n = 62)
Normaal gewig	(36) 84.5%	(55) 88.6%	(64) 90.6%	(27) 76.8%	(53) 88.4%	(52) 84.4%
Oorgewig	(5) 12.1%	(5) 6.8%	(7) 9.4%	(4) 17.9%	(4) 7.0%	(10) 15.6%
Obees	(3) 3.4%	(4) 4.5%	-	(3) 5.4%	(3) 4.7%	-
SEUNS						
LMI klassifikasie	Kontrole groep (n = 24)	Basis		Kontrole groep (n = 24)	Einde	
		< 50% (n = 64)	≥ 50% (n = 26)		< 50% (n = 64)	≥ 50% (n = 26)
Normaal gewig	(22) 91.2%	(64) 100%	(26) 100%	(21) 88.2%	(64) 100%	(26) 100%
Oorgewig	(2) 8.8%	-	-	(3) 11.8%	-	-
Obees	-	-	-	-	-	-

LMI = Liggaamsmassa indeks (kg/m^2); < 50% = Lae bywoningsgroep; ≥ 50% = Hoë bywoningsgroep; % = Persentasie; n = Aantal proef persone

4.5 BESPREKING

Die resultate toon dat FA voordelig was vir die hoë bywoningsgroepe adolessente, veral vir die seuns. Om liggaamsvetverlies gedurende puberteit te monitor, word die meting van spesifieke antropometrieke kenmerke soos velvoue, %LV (gemeet deur BodPod) en middelomtrek, in plaas van die gebruik van LMI, aanbeveel. Groeiveranderinge en puberteit moet ook in ag geneem word.

Die lae bywoning FA groep en kontrole groep het die minste verandering in velvoue getoon na die 19-week periode, wat 'n aanduiding kan wees dat die deelnemers se lae deelname aan FA nie tot 'n afname in liggaamsvet bygedra het nie. Hoewel daar tekens was van laer %LV in die lae FA bywoningsgroep, het die kontrolegroep geen verandering aangetoon nie. Onaktiwiteit kan beskou word as een van die hooftfaktore wat tot die vetsugprobleem wêreldwyd bydra (Trudeau & Shephard, 2005). 'n Afname in FA kan beïnvloed word deur biologiese veranderinge soos puberteit en hormoonveranderinge (Van Mil, Goris & Westerterp, 1999). Veranderinge in vetweefsel is ook 'n sterk faktor gedurende groei en volgroeiheid, en gereelde oefening kan die patroon en verspreiding daarvan in groeiende kinders beïnvloed (Bar-Or & Malina, 1995). Dit word ook geïllustreer deur die metings in hierdie studie.

Dit is duidelik dat die hoë bywoningsgroep geneig was tot 'n meer optimale liggaamsamestelling (tabel 2) tydens basislynmeting en sommige van die deelnemers het nie veel verbetering getoon ten opsigte van liggaamsamestelling nie, selfs met hoë deelnamevlakke tydens die FA intervensieprogram nie. Hierdie fenomeen staan as die “plafon” effek bekend (Faigenbaum, 1997). Dit mag wees vanweë die feit dat hierdie adolessente hoë vlakke van belangstelling in FA gehad het selfs nog voor die intervensieprogram. Die seuns het deurgaans 'n hoër optimale LS as die meisies getoon. Vir dogters bring puberteit menstruasie en hormoonveranderinge mee, wat geassosieer kan word met toename in liggaamsvet en selfs ontevredenheid met hul liggaamsbeeld (Sweeting & West, 2003). Puberteit het gewoonlik die teenoorgestelde uitwerking op LS en liggaamsbeeld onder seuns (Sweeting & West, 2003).

In Tabel 3 en Tabel 4 kan die verskille in %LV en LMI met mekaar vergelyk word. Die LMI waardes vir oorgewig is heelwat laer as die som van die velvou-metings en selfs %LV gemeet deur middel van APD. Baie min deelnemers in die dogters se groep is as oorgewig of vetsugtig geklassifiseer volgens die LMI klassifikasie (Cole *et al.*, 2000), maar die som van die velvoue en ADP beraminge was meer konsekwent in vergelyking met mekaar. Na afloop van die FA intervensieprogram was daar 'n afname in die som van die velvoue en %LV waardes in die hoë FA bywoningsgroep, maar nie in die LMI nie. Met LMI word die terme “oorgewig” en “vetsugtig” gereeld gebruik om dieselfde toestand te beskryf, maar inderwaarheid beteken oorgewig dat 'n persoon te veel liggaamsgewig vir

sy/haar lengte het, en vetsugtig dat daar 'n surplus liggaamsvet teenwoordig is (Freedman & Perry, 2000).

Een van die probleme ten opsigte van LMI is om onderskeid te tref tussen 'n persoon wat "oor-vet" of "oorgewig" is (Cameron & Getz, 1997). Wanneer LMI gebruik word om gewig-lengte ratio te bepaal, kan die term "oorgewig" gebruik word, maar wanneer subkutaneuse weefsel gemeet word (velvoue) en daar is 'n hoë vetvoorkoms, kan die term "oor-vet" gebruik word om die toestand te beskryf (Cameron & Getz). Eenvoudige metodes soos byvoorbeeld velvoue as maatstaf van oor-vet is nog nie intensief op groot groepe kinders in ontwikkelende lande of groeivertraagde kinders nagevors nie (Hoffman *et al.*, 2006). 'n Studie onder swart Suid-Afrikaanse kinders wys egter dat groeivertraagde meisies meer geneig is om meer subkutaneuse vet en 'n groter middelomtrek te hê as hul nie-groeivertraagde eweknie (Kruger *et al.*, 2004). Verskille in lengte-vir-ouderdom beïnvloed die interpretasie van eenvoudige metodes soos LMI, wat gebruik word om vetsug- en oorgewigkondisies te bepaal (Hoffman *et al.*, 2006). Interpretasie van oorgewig of vetsug behoort gevolglik gedoen te word na aanleiding van liggaamsvetmetings, byvoorbeeld velvoue. In tabel 4 verskil die middelomtrek beduidend tussen die verskillende bywoningsgroepe van die meisies. Volgens Maffei *et al.* (2001), is middelomtrek een van die beste metodes om gewigstatus onder kinders te bepaal. Middelheup-ratio is ook 'n goeie indikator vir kardiovaskulêre siekte risiko en totale liggaamsvet by volwassenes, maar nie noodwendig by kinders nie (Dietz, 1995). Individue by wie vet rondom die naeltjie-area vergader, dra 'n groter risiko vir kardiovaskulêre siektes as individue by wie vet rondom die heup en gluteale area versamel. Tydens die pre-adolessente jare het min kinders 'n sentrale tipe vetverspreiding, maar dit word meer algemeen gedurende puberteit (Goran, 1998). Genetiese faktore speel ook 'n rol (Bar-Or *et al.*, 1998).

'n Beperking van hierdie studie was die klein aantal kinders wat gereeld aan die intervensieprogramsessies deelgeneem het. Talle van die adolessente het gemeld dat hulle huishoudelike take het om te doen en sommige kinders moes selfs werk om hul gesinne te onderhou. Portuurgroepdruk mag ook 'n invloed gehad het op die bywoning. 'n Selfs groter afname in bywoning gedurende die skoolvakansies en eksamentye is waargeneem. Hierdie faktore is vir die kinders moeilik om te oorkom, en dit opsigself is 'n indikator dat

fisieke oefening intervensieprogramme deel van die skoolkurrikulum, in plaas van 'n naskoolaktiwiteit behoort te wees om sodoende die fisieke aktiwiteitsvlakke van 'n dorpsgemeenskap hoërskoolkinders te verhoog.

Die outeurs beveel verdere navorsing aan, met groter groepe en terselfdetyd in verskillende provinsies. Landelike en stedelike verskille in fisieke aktiwiteit en liggaamsamestelling kan ook vergelyk word. Adollesente behoort geleer te word oor korrekte oefeningsmetodes en gesonde eetgewoontes, veral in Suid-Afrika en ander ontwikkelende lande. Ouers en onderwysers behoort betrek te word in die intervensie en implementering van sulke navorsing. Op hierdie manier sal groter groepe geïnteresseer word en dit sal groter beheer oor die intervensie tot gevolg hê. Dit mag moontlik 'n gesonde leefstyl bevorder in hul gemeenskap en in hul eie huishoudings.

4.6 GEVOLGTREKKING

Na aanleiding van hierdie studie kan tot die gevolgtrekking gekom word dat daar 'n algemene verbetering voorgekom het in die LS van adollesente wat aan 50% tot 100% van die 19-weke PA intervensieprogramsessies deelgeneem. Slegs geringe veranderinge is waargeneem by die LMI waardes, wat bewys dat groei en ontwikkeling gedurende die puberteitsjare in ag geneem moet word, veral by seuns. Die afname in %LV en som van die velvoue, met geen verandering in die LMI na afloop van die 19-week intervensieprogram is 'n aanduiding dat, wanneer LS veranderinge in adollesente bestudeer word, % LV of velvoue gebruik moet word vir klassifikasie van vet- en voedingstatus.

4.7 ERKENNING

Hierdie werk is gebaseer op navorsing wat gesteun is deur die Nasionale Navorsingstigting (NNS) van Suid-Afrika. Alle opinies, bevindinge en gevolgtrekkings of aanbevelings wat in hierdie materiaal uitgespreek word, is die outeurs se eie en dus kan die NNS geen aanspreeklikheid aanvaar vir bogenoemde nie. Finansiële ondersteuning is verskaf deur die Noordwes Universiteit, Potchefstroom, Suid-Afrika. Die outeurs bedank die kinders van die twee dorpsgemeenskap skole in Ikageng, Suid-Afrika, wat aan die

studie deelgeneem het. Ook word die bydraes van die PLAY navorsingspan, in besonder dr Cornelia Wessels, erken, vir haar rol in die organisering van die studie, en professor HS Steyn, PH D, Pr Nat Sci vir die statistiese analise.

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HOOFSTUK 5

VERSKILLE IN LIGGAAMSAMESTELLING, LIGGAAMSPROPORSIES EN TYDSBEREKENING VAN PUBERTEIT TUSSEN GROEIVERTRAAGDE- EN NIE- GROEIVERTRAAGDE ADOLESSENTE

*Soos aangebied in die "African Journal for Physical, Health Education,
Recreation and Dance"*

Differences in body composition, body proportions and timing of puberty in stunted and non-stunted adolescents: PLAY study.

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Running title: Body composition, body proportions and timing of puberty of stunted and non-stunted adolescents

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5.1 ABSTRACT

The aim of this study is to determine the differences regarding body composition, proportions and calculation of puberty growth stunting (GS) adolescents as opposed to non-growth stunting (NGS) adolescents in the North West Province, South Africa. A total of 259 black adolescents (118 boys, 141 girls) between ages 13 and 18 years were tested. The following data were collected: length-for-age z-score (HOZ), length, mass, middle circumference (MC), middle-to-length ratio (MLtR), middle-to-hip ratio (MHR), body mass index (BMI), percentage body fat (%BF), Tanner phase, arm span and skin folds. The participants were divided into a GS group and NGS group. There were significant differences between the mass, length, HOZ, arm span, MC, hip circumference and lean body mass of the GS and NGS children. %BF, MHR and physical full-maturity in growth corresponded between the two groups, but the lean body mass was less with the GS groups, which indicates that there is proportionally more fat and less muscle mass present in the GS groups. MLtR of GS adolescents was considerably larger than the MLtR of NGS adolescents, which indicates a more central fat distribution with GS adolescents. Only 3.5% of the subjects had an MLtR >0.5, which indicates abdominal

obesity; but 54% of the subjects had a %BF of above 20% (among the boys) and 25% (among the girls). An MLtR cut-off point of 0.5 might possibly not be appropriate for these adolescents.

Key words: adolescents, body composition, growth retardation, fat percentage, puberty, South Africa.

5.2 INLEIDING

Volgens die Wêreldgesondheidsorganisasie (WGO) is daar ongeveer 230 miljoen kinders wêreldwyd wat groeivertraag is (GV) (Lengte-vir-ouderdom z-waarde (HAZ) < -2). Die wêreldwye probleem van GV of wanvoeding kan toegeskryf word aan sosiale, ekonomiese en kulturele probleme - veral in ontwikkelende lande (Michaelsen, Weaver, Branca & Robertson, 2000). In Suid-Afrika is 19% kinders tussen die ouderdomme van 10 tot 15 jaar GV (Mukuddem-Petersen & Kruger, 2004). Voorskoolse kinders, veral tussen die Afrikaanbevolkingsgroepe, word blootgestel aan wanvoeding en dit het 'n groot invloed op groei en ontwikkeling (Bènéfice, Garnier, Simondon & Malina, 2001). Moontlike oorsake van GV in Suid-Afrika is werkloosheid en armoede (Erik & Gericke, 2000; Napier & Albertse, 2000).

GV in lengte lei tot 'n afname in die finale lengte, of eerder dwergisme (Bènéfice *et al.*, 2001). Die kleiner liggaamsgrootte van chronies-ondervoede kinders beperk hul maksimum aërobiese krag (Bar-Or, Foreyt, Bouchard & Brownell, 1998). Wanvoeding kan ook geassosieer word met 'n kleiner moontlikheid om moeilike fisieke werk te kan verrig (Bar-Or *et al.*, 1998). Verskille in lengte-vir-ouderdom maak dit moeilik om kinders te klassifiseer as oorgewig of vetsugtig na aanleiding van die liggaamsmassa-indeks (Hoffman, Sawaya, Martins, CcCrory & Roberts, 2006).

Geslagshormone het 'n invloed op die verspreiding van vet gedurende adolessensie (Freedman & Perry, 2000). Swart kinders is meer geneig om sentrale vetpatrone te hê met minder vetneerslag op die ledemate (Malina, 1996), en dus speel ras 'n rol in vetverspreiding. Daar is verskeie meganismes hoe vetverspreiding metabolisme

en kliniese komplikasies kan affekteer (Bjorntorp, 1990). Intra-abdominale vet is belangrik vanweë die nabyheid aan die hepatoportale aar en die sensitiwiteit wat hierdie vet teenoor lipolitiese stimulu toon (Bjorntorp, 1990). Intra-abdominale vetstoring speel 'n belangrike rol in die negatiewe effek van oormatige vet, e.g. hipertensie, insulienweerstandigheid en hoë bloedcholesterol (Lara-Castro, Weinsier, Hunter & Desmond, 2002).

Die langtermyn effek van wanvoeding wat tot GV lei, veroorsaak besorgdheid (Bènéfice *et al.*, 2001). In 'n studie deur Ibrahim, Abdel-Maksoud, Samy Matter, Sarhan en Hassan (2003) is gevind dat been-mineraal digtheid in die GV groep laer was as in die kontrolegroep. Kalsium- en magnesiumserum vlakke was ook laer in die GV groep. 'n Beperkte inname van die nodige skeletale beenvormingsvoedingstowwe het 'n groot invloed op die beenmassa. Osteoporose is 'n skeletale toestand wat ontstaan as gevolg van 'n afname in die totale beendigheid, wat op sy beurt lei tot brosheid en 'n verhoogde risiko vir frakture (Ibrahim *et al.*, 2003).

Die doelwit van hierdie studie was om die verskille in liggaamsamestellingskomponente, liggaamsbou en berekening van puberteit tussen nie-groeivertraagde (NGV) en groeivertraagde (GV) adolessente gedurende puberteit te bepaal.

5.3 METODES

5.3.1 Proefpersone en liggaamsamestelling

Die steekproef het bestaan uit beskikbare proefpersone van twee sekondêre swart skole in Ikageng in die Noordwesprovinsie. 'n Totaal van 259 adolessente (118 seuns en 141 meisies) tussen die ouderdomme van 13 tot 18 jaar is ingesluit. Die twee skole is op aanbeveling van 'n plaaslike voedingskundige gekies uit vyf beskikbare skole, vanweë die hoër GV voorkoms in hierdie twee skole. Alle betrokke ouers en kinders het ingeligte toestemming gegee en die studie is goedgekeur deur die etiese Komitee van die NWU. Die volgende veranderlikes is tydens die studie gemeet: Lengte, gewig, middelomtrek, persentasie liggaamsvet (%LV), skraalliggaamsmassa, velvoue (trisept, subskapulere, supraspinal, abdominal, bisept en kuit), Tanner fases van geslagsrypheid (Tanner &

Whitehouse, 1982) en armspan. Liggaamsmassa-indeks (LMI), middel- lengte ratio (MLtR) en middel-heup ratio (MHR) is bereken. HOZ is bereken vir elke adolessent ooreenstemmend met die geslag-spesifieke lengte vir ouderdom persentiel van die Centre for Disease Control (CDC). Deelnemers met 'n HOZ < -2 is geklassifiseer as GV (CDC, 2000).

Fases van ryphheid is deur middel van twee geslagspesifieke vraelyste bepaal. Die “Vroulike selfevaluasie van volwasse kenmerke” vraelys is deur die meisies gebruik deur middel van sketse en vrae gebaseer op die vyf Tanner fases. Die seuns het die “Manlike self-evaluasie van volwasse kenmerke” vraelys voltooi. Tanner klassifikasies is gebruik vir die borsontwikkeling en vroulike pubishaar-ontwikkeling, sowel as die menarg-ouderdom by die meisies. Verandering in stem, hare en reprodktiewe orgaan-ontwikkeling is by die seuns vasgestel. Die meisies en seuns is bygestaan deur volwasse Tswanasprekende vertalers van dieselfde geslag vir die individuele voltooiing van die vraelyste.

%LV en skraalliggaamsmassa is gemeet deur middel van lugverplasing plethysmography (ADP), in ooreenstemming met die vervaardigers se instruksies (BODPOD Life Measurement Inc, Concord, CA, USA). Alle antropometrieë meting is gedoen deur opgeleide nagraadse studente volgens die ISAK standaard (ISAK, 2001). Die volgende apparate is gebruik vir die meting van die verskillende antropometrieë veranderlikes: 'n gekalibreerde elektroniese skaal vir die bepaling van massa (Precision Health Scale, A&D Company, Saitama, Japan), 'n stadiometer vir lengte (IP 1465, Invicta length meter, London, UK), en 'n Harpenden (British Indicators, London, UK) velvoumeetpasser met 'n konstante druk van 10g/mm^2 om velvoudikte tot die naaste 0.2mm te bepaal. Middel-, heup- en ontspane mid-boarm omtrekke is gemeet met 'n staalmaatband (Lufkin, Cooper Tools, Apex, NC).

5.3.2 Statistiese analise

Die Statistica sagtewarepakket vir Windows (Statistica 2009, Stat Soft, Inc. for Windows) is gebruik om die versamelde data te ontleed. Beskrywende statistieke, naamlik rekenkundige en gemiddelde standaardafwyking (SA), is gebruik om die veranderlikes by die GV en NV adolessente te beskryf. Vervolgens is die Mann-Whitney

nie-parametriese U-toets gebruik om die betekenisvolle verskille van sekere veranderlikes tussen die GV en NGV adolessente te bereken. Die Chi-square toets is ook gebruik om die kategoriese veranderlikes, naamlik verskille in die verspreiding binne die vyf Tanner fases, asook die verskille tussen die GV en NGV dogters en seuns afsonderlik, ten opsigte van die verspreiding tussen die groepe met 'n liggaamsvetpersentasie laer of hoër as die mediaan, te bepaal. Die vlak van betekenisvolheid is vasgestel op $p < 0.05$.

5.4 RESULTATE

Tabel 1 en tabel 2 dui die beskrywende statistieke en verskille respektiewelik tussen GV en NGV dogters en seuns aan. Daar was betekenisvolle verskille ($p < 0.05$) in terme van massa, lengte, HOZ, armspan, middelomtrek, arm- en heupomtrek, asook skraalliggaamsmassa tussen die GV en NGV dogters. Die armspan van die GV dogters was opvallend kleiner as die van die NGV dogters, maar die armspan: lengteratio was basies ooreenstemmend in beide groepe, hoewel opmerklik kleiner by die GV dogters. MLtR was opmerklik groter by die GV as by die NGV adolessente ($p = 0.04$ en $p = 0.03$ respektiewelik by die dogters en seuns).

Tabel 2 dui die verskille tussen GV en NV seuns aan met opmerklike verskille ten opsigte van massa, lengte, HOZ, armspan, boarm, middel- en heupomtrek, asook skraalliggaamsmassa. Dit is duidelik dat die velvoue van die GV seuns nie opmerklik kleiner as dié van die NV seuns was nie en die %LV was ooreenstemmend in beide groepe. Die Chi-square toets het betekenisvolle verskille in %LV en skraalliggaamsmassa verspreiding ($p = 0.01$) aangetoon, met meer GV seuns in die groep met die hoër %LV, maar met skraalliggaamsmassa minder as die algehele mediaan van die NGV seuns.

Tabel 1: Verskille in liggaamsamestelling tussen GV en NGV dogters (Mann-Whitney U-toets).

Veranderlikes	NGV		GV		p-waarde
	Gem $\pm$ SA	N	Gem $\pm$ SA	N	
Ouderdom (jaar)	15.4 $\pm$ 1.3	113	15.6 $\pm$ 1.15	28	0.39
Massa (kg)	51.0 $\pm$ 8.57	113	44.1 $\pm$ 7.11	28	<0.0001*
Lengte-vir-ouderdom z-waarde	-0.68 $\pm$ 0.75	113	-2.45 $\pm$ 0.45	28	<0.0001*
Lengte (cm)	157.5 $\pm$ 5.02	113	146.2 $\pm$ 3.37	28	<0.0001*
LMI (kg/m ²)	20.6 $\pm$ 3.30	113	20.6 $\pm$ 3.10	28	0.67
Armspan (cm)	162.7 $\pm$ 7.38	113	149.9 $\pm$ 5.68	28	<0.0001*
Bo-arm-omtrek (cm)	23.7 $\pm$ 2.99	113	23.2 $\pm$ 2.69	28	0.71
Middel-omtrek (cm)	65.0 $\pm$ 6.10	113	62.5 $\pm$ 5.28	28	0.06
Middel:lengte ratio	0.41 $\pm$ 0.04	113	0.43 $\pm$ 0.03	28	0.04*
Heup-omtrek (cm)	86.8 $\pm$ 7.72	113	81.9 $\pm$ 6.39	28	0.005*
Middel:heup ratio	0.75 $\pm$ 0.05	113	0.76 $\pm$ 0.04	28	0.15
Triseps vv (mm)	16.1 $\pm$ 6.56	113	16.0 $\pm$ 4.74	28	0.48
Subskapulêre vv(mm)	12.4 $\pm$ 5.59	113	12.3 $\pm$ 4.45	28	0.69
Supraspinale vv (mm)	10.8 $\pm$ 0.95	113	10.8 $\pm$ 4.87	28	0.82
Abdominale vv (mm)	19.6 $\pm$ 7.71	113	18.6 $\pm$ 7.24	28	0.69
Biseps vv (mm)	9.1 $\pm$ 4.27	113	8.7 $\pm$ 3.01	28	0.86
Kuit vv (mm)	19.2 $\pm$ 6.85	113	18.4 $\pm$ 5.51	28	0.91
%Liggaamsvet (BODPOD)#	29.4 $\pm$ 6.83	104	29.1 $\pm$ 6.53	27	0.72
Skraalliggaamsmassa (kg) #	35.2 $\pm$ 5.33	104	31.0 $\pm$ 3.63	27	<0.0001*
Armspan:lengte ratio	1.03 $\pm$ 0.03	111	1.02 $\pm$ 0.02	28	0.05

GV = Groeivertraag, NGV = Nie-groeivertraag, Gem = Gemiddeld, SA = Standaardafwyking, N = aantal proefpersone, p-waarde = betekenisvolle verskil $p < 0.05$, kg = kilogram, cm = sentimeter, mm = millimeter, LMI = Liggaamsmassa indeks, vv = velvou

Slegs 131 uit 141 dogters is gemeet in die BODPOD as gevolg van tydsbeperking en kinders wat nie gewillig was nie

Die rede vir die kleiner hoeveelheid proefpersone (seuns sowel as meisies) met 'n %LV en skraalliggaamsmassa gemeet deur ADP, was die beperkte tyd vir die toetsing, skaamheid van sommige kinders, asook engtevrees. Vyf dogters uit die totale 142 (3.5%) het 'n MLtR > 0.5 getoon. Geen seun het 'n MLtR groter as 0.5 gehad nie. Meeste van die dogters (78.6%) het 'n %LV van $> 25\%$ getoon. By 28% van die seuns het 'n %LV van $> 20\%$ gehad.

Tabel 2: Verskille in liggaamsamestelling tussen GV en NGV seuns (Mann-Whitney U-toets).

Veranderlikes	NGV		GV		p-waarde
	Gem (SA)	N [§]	Gem (SA)	N	
Ouderdom (jaar)	15.8 ± 1.30	90	15.6 ± 1.39	28	0.59
Massa (kg)	52.2 ± 8.77	90	41.5 ± 2.20	27	<0.0001*
Lengte-vir-ouderdom z-waarde	165.5 ± 6.57	90	152.0 ± 1.12	27	<0.0001*
Lengte (cm)	0.88±0.65	90	2.50±0.41	28	<0.0001*
LMI (kg/m ²)	19.0 ± 2.56	90	17.9 ± 2.10	27	0.04*
Armspan (cm)	171.0 ± 8.41	85	157.8 ± 1.08	26	<0.0001*
Bo-arm-omtrek (cm)	23.2 ± 2.64	88	21.4 ± 1.68	25	0.001*
Middel-omtrek (cm)	66.8 ± 5.16	88	63.0 ± 1.37	25	<0.0001*
Middel:lengte ratio	0.40 ± 0.03	88	0.41 ± 1.53	25	0.03*
Heup-omtrek (cm)	80.5 ± 5.78	87	74.1 ± 1.41	25	<0.0001*
Middel:heup ratio	0.83 ± 0.05	87	0.85 ± 1.00	24	0.09
Trisepts vv (mm)	8.72 ± 4.05	88	8.33 ± 1.13	25	0.52
Subskapulêre vv(mm)	8.10 ± 3.91	88	6.94 ± 4.83	25	0.06
Supraspinale vv (mm)	6.45 ± 4.20	88	6.16 ± 2.53	25	0.86
Abdominale vv (mm)	11.5 ± 7.03	88	10.3 ± 1.45	25	0.21
Biceps vv (mm)	5.20 ± 2.15	88	5.20 ± 1.11	25	0.68
Kuit vv (mm)	11.1 ± 4.33	88	10.2 ± 1.01	25	0.26
%Liggaamsvet (BODPOD)#	17.6 ± 6.35	58	20.2 ± 1.21	22	0.07
Skraalliggaamsmassa (kg) #	42.8 ± 7.49	58	32.5 ± 2.27	22	<0.0001*
Armspan:lengte ratio	1.03 ± 0.02	85	1.03 ± 0.02	27	0.43

GV = Groeivertraag, NGV = Nie-groeivertraag, Gem = Gemiddeld, SA = Standaardafwyking, N = aantal proefpersone, p-waarde = betekenisvolle verskil $p < 0.05$, kg = kilogram, cm = sentimeter, mm = millimeter, LMI = Liggaamsmassa indeks, vv = velvou

Slegs 80 uit 118 seuns was gemeet in die BODPOD a.g.v. tydsbeberking

§ Aantal proefpersone verskil as gevolg van verlore data

Geen betekenisvolle verskille is opgemerk by die verspreiding binne die Tanner fases in beide geslagte in die GV en NGV groepe nie (Tabel 3).

Tabel 3: Vergelyking van Tanner fases tussen GV en NGV adolessente

Geslag	Tanner fase	GV (N=27 [§])	NGV (N=110 [§])
Dogters*	1	1 (3.7%)	0 (0%)
	2	4 (14.8%)	6 (5.5%)
	3	12 (44.4%)	44 (40%)
	4	9 (33.3%)	52 (47.3%)
	5	1 (3.7%)	8 (7.2%)
Seuns#	1	0 (0%)	0 (0%)
	2	1 (3.8%)	9 (10.1%)
	3	10 (38.6%)	15 (16.8%)
	4	14 (53.8%)	53 (59.6%)
	5	1 (3.8%)	12 (13.4%)

GV = Groeivertraag; N = Aantal proefpersone; NGV = Nie-groeivertraag; % = persentasie

*Dogters: *Mediaan* toets, Algemene *Median* = 4.0; Chi-Square = 0.45 df = 1 p = 0.50

#Seuns: *Mediaan* toets, Algemene *Mediaan* = 4.0; Chi-Square = 1.86 (df = 1) p > 0.05

[§] Aantal proefpersone verskil as gevolg van verlore data

5.5 BESPREKING

Die waarneming van skraalliggaamsmassa teenoor die ooreenstemmende % LV in GV kinders is 'n moontlike aanduiding van relatiewe hoër liggaamsvet in verhouding tot skraalliggaamsmassa by hierdie adolessente. In 'n studie deur Mukddem-Petersen en Kruger (2004) is bevind dat GV kinders tussen die ouderdomme van 10 tot 15 jaar in die Noordwesprovinsie, Suid-Afrika meer geneig is om liggaamsvet te stoor as wat hulle 'n toename in skraalliggaamsmassa toon.

Dit is interessant dat die meeste dogters (78.6%) en 'n kwart van die seuns 'n relatiewe hoë vetpersentasie getoon het. In Suid-Afrika is 'n merkbare toename in gewig by swart adolessente dogters gedurende die mid-adolessente periode, en dit is nie noodwendig die geval by die seuns nie (Kalk, 2001). In 'n studie deur Mantsena, Monyeki, Monyeki, Brits, Toriola en Kangolle (2003) in die Ellisras area, Suid-Afrika, is

bevind dat dogters 'n hoër %LV het as seuns van enige ouderdom. Velvoue by kinders verskil met betrekking tot ras, geslag en ouderdom (Freedman & Perry, 2000), hoewel daar kleiner verskille voorkom ten opsigte van vetverspreiding onder adolessente dogters (Flodmark, Sveger & Milsson-Ehle, 1995; Beunen, Malina & Lefevre, 1994). Geslagshormone beïnvloed die veranderinge in vetverspreiding gedurende adolessensie (Freedman & Perry; 2000).

In Tabel 1 kan duidelik gesien word dat velvoue (sukutaneuse vetweefsel) statisties nie noemenswaardig verskil van die velvoue van kinders met 'n normale lengte nie. Indien die velvoue van die twee groepe nie van mekaar verskil nie, maar die GV kinders oor relatief meer liggaamsvet beskik, mag die intra-abdominale vet 'n moontlike rol speel by die verklaring van die kleiner skraalliggaamsmassa, in kontras met die eenderse %LV tussen die twee groepe. Swart kinders neig tot 'n meer sentrale vetverspreiding met minder vetneerslag op die ledemate (Malina, 1996). Daar is verskeie meganismes vir vetverspreiding wat die metabolisme en kliniese komplikasies beïnvloed. Intra-abdominale vet is byvoorbeeld na aan die hepatoportale sirkulasie en is sensitief teenoor die lipolitiese stimuli, wat 'n negatiewe invloed op vetmetabolisme het (Björntorp, 1990). Sentrale vetverspreiding word geassosieer met 'n verhoogde risiko vir kardiovaskulêre siektes en dood, asook die ontwikkeling van tipe 2 diabetes (Rosenbaum, Leibel & Hirsch, 1997; Montague & O'Rahilly, 2000). Verskeie faktore beïnvloed intra-abdominale vet, naamlik geslagshormone, veroudering, toename in gewig, genetiese komposisie en leefstyl (byvoorbeeld onaktiwiteit, gebruik van alkohol en sigarette) (Lara-Castro *et al.*, 2002).

Daar is onlangs gerapporteer dat MLtR 'n beter voorspeller van abdominale vetsugtigheid en kardiovaskulêre risiko's as MHR by kinders is (Nambiar, Truby, Abbott & Davies, 2009; Ashwell & Hsieh, 2005). Die afsnypunt vir 'n hoë MLtR is 0.5 by volwassenes (Ashwell, 2005), met 'n ratio groter as 0.5 geassosieer met 'n groter risiko vir die ontwikkeling van metabooliese sindroom en kardiovaskulêre siekte (Hsieh, Yoshinaga, Muto, Sakurai, & Kosaka, 2000; Hsieh & Yoshinaga, 1995). Ashwell (2005) het ook bevind dat die MLtR afsnypunt toepaslik vir verskeie etniese groepe en kinders. In die huidige studie is bevind dat vyf dogters uit die totale 142 (3.5%) 'n MLtR van >0.5

gehad het, terwyl geen seuns 'n MLtR van >0.5 getoon het nie. Geen literatuur kon gevind word met betrekking tot MLtR van GV adolessente nie.

Vroeëre studies het aangedui dat daar slegs 'n klein verskil tussen lengte en armspan is by kinders van normale lengte (Sinclair, Kitchin & Turner, 1960; Pearson & Lee, 1902). Armspan:lengte ratio was beduidend kleiner by GV dogters as by die NGV groep in die huidige studie, maar daar was geen verskil in die seuns se groepe nie. Die verskil by die dogters was nie prakties beduidend nie, wat 'n indikasie is dat die armspan:lengte proporsioneel dieselfde was vir alle groepe. Oor die algemeen het die dogters 'n groter %LV as die seuns gehad, wat toegeskryf kan word aan hormonale verskille gedurende puberteit (Sweeting & West, 2003). Kindblom, Lorentzon, Norjavaara, Lönn, Brandberg, Angelhed, Hellqvist & Ohlsson (2006) het bevind dat vroeë ontwikkeling van seksuele volgroeiheid die gevolg was van 'n groter sentrale vetverspreiding en MHR. Nie slegs vind fisieke veranderinge tydens puberteit plaas nie, maar ook veranderinge in eetgewoontes en leefstyl, wat die langtermyn-gesondheid van kinders beïnvloed (Mukuddem-Peterson & Kruger, 2004).

Gloabaal word min tyd en aandag aan liggaamlike opvoeding in skole afgestaan, en meer vrye tyd word gewy aan gewilde aktiwiteite soos televisie kyk en rekenaarspeletjies, wat minimum fisiese inspanning verg (Leupker, 1999; Van Mil, Goris & Westerterp, 1999; Bar-Or *et al.*, 1998; Van Deventer, 1998). Wanvoeding veroorsaak GV en kan ook geassosieer word met 'n kleiner vermoë om harde fisieke werk te kan verrig (Bar-Or *et al.*, 1998), wat, soos in hierdie studie bevind is, lei tot verlaagde skraalliggaamsmassa. Uit die resultate van hierdie studie is dit duidelik dat liggaamsbou en liggaamsamestelling tussen GV en NGV dogters en seuns verskil in terme van lengte, gewig, armspan, middelomtrek, heupomtrek en skraalliggaamsmassa. Die armspan, lengte, middel en heupomtrekke van beide geslagte was veel kleiner by die GV groep, wat 'n aanduiding is van die beperkte groei by GV individue.

Beperkinge by hierdie studie was dat sommige adolessente skaam was tydens die meting van die liggaamsamestelling en beantwoording van die seksuele volgroeiheid vrae, in so 'n mate dat hulle nie bereid was om aan die studie deel te neem of toe te laat dat die mates geneem word nie. Die Bod Pod meting is 'n lang proses en die kinders moes stilsit in 'n geslote silinder, wat gelei het tot engtevreë by sommige

kinders. Gevolglik is minder proefpersone met die ADP getoets. Die steekproef wat teen verwagting in kleiner was, het daartoe gelei dat daar slegs 'n klein hoeveelheid GV kinders in hierdie studie was.

5.6 GEVOLGTREKKING

Die laer skraalliggaamsmassa, maar relatiewe hoër %LV, ongeag die selfde velvoudikte in die GV groep, kan moontlik toegeskryf word aan die hoër intra-abdominale vet. Aangesien dit 'n gegewe is dat geslagshormone 'n invloed het op vetverspreiding, is dit moontlik dat die hormonale omgewing bydra tot die vet-herverspreiding (Freedman & Perry, 2000). Verdere navorsing is nodig om vas te stel of die hormonale omgewing in GV adolessente verskil van dié by NGV adolessente. 'n MLtR groter as 0.5 was teenwoordig in slegs 'n klein persentasie dogters, en by geen van die seuns nie, hoewel daar 'n groot persentasie adolessente met relatiewe hoë %LV in die groep was. Dit mag moontlik nodig wees om die MLtR afsnypunt van 0.5 vir die GV adolessente aan te pas. Daarom word aanbeveel dat meer navorsing gedoen behoort te word met betrekking tot optimale MLtR, spesifiek vir GV adolessente. Dit is duidelik dat daar verskille tussen GV en NGV adolessente van beide geslagte in sekere liggaamsamestelling- en liggaamproposie-komponente is, sonder 'n verskil in seksuele ontwikkeling.

5.7 ERKENNINGS

Hierdie studie is gebaseer op navorsing wat ondersteun is deur die Nasionale Navorsingstigting (NNS) van Suid-Afrika. Alle opinies, bevindinge en gevolgtrekkings of aanbevelings wat uitgespreek word in hierdie materiaal, is die outeurs s'n en gevolglik aanvaar die NNS geen aanspreeklikheid met betrekking daarop nie. Finansiële ondersteuning is ook verskaf deur die Noordwes Universiteit, Potchefstroom, Suid-Afrika. Die outeurs wil graag die kinders van die twee skole in Ikageng, Suid-Afrika, bedank wat deelgeneem het aan hierdie studie. Ons wil ook erkenning gee aan die PLAY navorsingspan, in besonder dr RL Mamabolo en dr C Wessels, vir die dataversameling.

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HOOFSTUK 6

VERANDERING IN FISIEKE AKTIWITEITSVLAKKE EN FISIEKE AKTIWITEITSPATRONE BY SWART ADOLESENTE TUSSEN 13 EN 18 JAAR: PLAY STUDIE

Volgens die voorskrifte van Journal of Tropical Pediatrics.

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Lopende titel: Verandering in fisieke aktiwiteitsvlakke en patrone by
adolesente

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6.1 UITTREKSEL

Die doel van hierdie studie was om te bepaal wat die verandering in FA vlakke en patrone by swart adolessente tussen die ouderdomme van 14 en 16 jaar sal wees na deelname aan 'n fisieke aktiwiteitsintervensie. 'n Totaal van 309 swart adolessente in Potchefstroom, Suid-Afrika, (158 seuns, 211 dogters) tussen die ouderdomme van 13-18 jaar het aan die studie deelgeneem. Die groep het bestaan uit 'n eksperimentele groep wat aan 'n FA intervensie deelgeneem het, (N= 282; 130 seuns; 152 dogters) en 'n kontrole groep (N=87; 28 seuns; 59 dogters). Multi-vlak modellering ('n herhaalde metings ko-variansie analise (ANCOVA) (gekorregeer vir bywoningspersentasie, geslag en verskillende groepe, eksperimenteel of kontrole) is gebruik en variansie analise (ANOVA) oor tyd, met 'n Bonferroni post hoc analise om te bepaal hoe die verskeie veranderlikes van mekaar verskil oor die verskeie toetsingsperiodes in maande. FA vlakke en patrone is vir die week en naweek apart ontleed. Die resultate het getoon dat

die twee groepe seuns op ongeveer dieselfde FA vlak begin (0.01 verskil, $p > 0.05$) maar dat die eksperimentele groep op 'n hoër FA vlak as dié van die kontrole groep seuns geïndig het (0.86 verskil, $p < 0.05$). Die dogters het met die basislynmetings statisties betekenisvolle verskille tydens die week sowel as naweek (0.38 verskil, $p = 0.008$ en 0.86 verskil, $p = 0.002$) getoon, waar die eksperimentele groep aanvanklik hoër fisieke vlakke getoon het, alhoewel hierdie verskille nie meer betekenisvol tydens eindmetings was nie. Die groepe seuns en dogters (uitgesluit die eksperimentele groep seuns), het 'n neiging tot afname in FA oor die 30.75-maande tydperk getoon. Die FA intervensie het 'n stabiliserende invloed op die FA vlakke van die seuns wat daaraan deelgeneem het gehad, en veral oor naweke tot hoër FA vlakke bygedra in die groep. Deelname aan soortgelyke FA intervensies word gevolglik vir adolessente seuns aanbeveel, terwyl aanpassings in die inhoudelike van sodanige programme vir dogters aanbeveel word.

Sleutelwoorde: Adolessente, Fisieke Aktiwiteit, FA intervensie, Fisieke aktiwiteitsvlakke, Suid Afrika.

6.2 INLEIDING

Sedentêre gedrag word as een van die hoof oorsake vir sterfte geïdentifiseer (1). Dwarsdeursnit studies toon dat fisieke aktiwiteit (FA) met tot 50% tydens adolessensie afneem (2,3). Sedert die sestigerjare het obesiteit by Amerikaanse dogters (kinders sowel as adolessente) meer as verdubbel met die grootste toename by swart dogters (4). Dit blyk ook dat FA afneem en sedentêre gedrag toeneem gedurende adolessensie (5), veral by dogters (6,7). Treuth et al. (8) het in die verband gevind dat adolessente dogters ook meer aktief tydens weksdae as oor naweke is, alhoewel die meeste van hulle tyd sedentêr spandeer word. 'n Verslag van die Mediese Navorsings Raad (9) toon aan dat daar in Suid Afrika meer seuns (57%) aan matige tot hoë FA as dogters (35%) deelneem en dat deelname aan FA afneem met toename in ouderdom. Meer swart dogters as seuns neem glad nie, of nie volgens die aanbevole FA riglyne, aan FA deel nie volgens die bogenoemde verslag.

Verskeie faktore beïnvloed aktiwiteitspatrone by kinders en adolessente, wat tot afname in FA en toename in obesiteit lei, naamlik ontwikkelingsfaktore, psigologiese faktore, sosiale en kulturele faktore en fisieke- en omgewingsfaktore (10). 'n Afname in FA kan ook beïnvloed word deur biologiese veranderinge soos ryping (11). Die hedendaagse leefstyl lei daartoe dat minder tyd en aandag aan FA en liggaamlike opvoeding in die skool bestee word en meer aan populêre aktiwiteite wat minimale fisieke inspanning verg, soos TV-kyk, rekenaarspeletjies speel (11-14). Vlakke van sedentêre gedrag blyk groter te wees by adolessente met 'n laer sosio-ekonomiese agtergrond en begin al so vroeg as op 11 jarige ouderdom (5), terwyl deelname aan FA by kinders ook deur wanvoeding beïnvloed kan word (13).

Studies toon dat blanke adolessente dogters geneig is om meer fisiek aktief te wees as swart adolessente dogters (2,3,7,15,16,). In 'n studie deur Kimm et al. (7) is gevind dat swangerskap, hoë liggaamsmassa indeks en sigaretrook 'n groot invloed gehad het op FA in hul spesifieke studie op swart adolessente dogters in die VSA. Brodersen et al. (5) het gevind dat seuns gewoonlik meer aktief as dogters is en dat die afname in FA meer was by dogters (46% afname) as by seuns (23%) met toename in ouderdom. Hurter en Pienaar (17) het in die Thusa Bana studie in Suid-Afrika gevind dat 15 jarige seuns meer aktief was gedurende die week teenoor die 13 jariges wat meer aktief tydens die naweek was. Wit en Indiër seuns het die laagste FA vlakke getoon gedurende die week en naweek, terwyl 'n toename in ouderdom nie in hierdie dwarsdeursnitstudie bygedra het tot 'n afname in FA vlakke met weeklikse aktiwiteit maar wel tydens naweek FA vlakke (17).

Dit blyk ook dat verskillende kulture verskillende behoeftes en gevolglik verskillende verantwoordelikhede het en dat hulle blootstelling aan FA ook verskil, wat gevolglik lei tot verskillende opvattinge oor LO, sport en rekreasie (18,19). Vlakke van sedentêre gedrag is groter by adolessente met 'n laer sosio-ekonomiese agtergrond en begin al so vroeg as op 11 jarige ouderdom (5).

Daar is al relatief baie navorsing gedoen oor dieet- en FA intervensies by adolessente

(20). Heelwat FA intervensies is ook al ontwerp met kwantitatiewe riglyne vir 'n effektiewe intervensie (21,22), asook voorstelle vir effektiewe en goedkoop FA bevordering (23). Alhoewel daar baie voorstelle in die literatuur is vir intervensie programme, is daar nie gefokus op spesifieke sub-populasie modaliteite soos ras, geslag en sosio-ekonomiese groepe nie (20). Min studies het ook fisieke aktiwiteitsvlakke van adolessente oor die langermyn bestudeer sowel as die effek van fisieke aktiwiteitsintervensies op die langer duur.

Die eerste doel van hierdie studie was om te bepaal hoe die FA vlakke van swart adolessente uit 'n gedrepeerde omgewing oor die verloop van 'n 3-jaar tydperk sal verander en of 'n FA intervensie 'n invloed daarop sal uitoefen. Tweedens wou bepaal word hoe FA patrone met toename in ouderdom verander en of dit die fisieke aktiwiteitsvlakke van die groep beïnvloed.

6.3 METODE

6.3.1 Navorsingsontwerp

Die studie vorm deel van die PLAY (Physical Activity in Youth) studie wat deur die etiekomitee van die Noordwes-Universiteit (nommer 04MO1) goedgekeur is. Die studie is deur middel van 'n beskikbaarheidssteekproef saamgestel uit twee sekondêre swart skole in Ikageng (Potchefstroom) in die Noordwes Provinsie van Suid Afrika. Die twee spesifieke skole is gekies met behulp van 'n plaaslike voedingsadviseur as gevolg van die hoë voorkoms van groeivertraging by die kinders in hierdie skole. Die studie het 'n longitudinale studie-ontwerp wat vanaf Maart 2004 tot September 2006 gestrek het.

6.3.2 Onderzoekgroep

Adolessente (N=309) in Potchefstroom, Suid-Afrika, (158 seuns, 211 dogters) tussen die ouderdomme 13-18 jaar het aan hierdie studie deelgeneem. Al die leerlinge was in graad 8 in 2004 met die aanvang van die studie en die gemiddelde ouderdom ($\pm$

standaardafwyking) van die seuns was 14.9 ± 1.4 jaar, terwyl die dogters se gemiddelde ouderdom 14.3 ± 1.4 jaar was. Die eksperimentele groep seuns en dogters was 130 en 152 onderskeidelik terwyl die kontrole groep uit 'n totaal van 87 (28 seuns en 59 dogters) bestaan het. Die skole is besoek om die protokol aan die onderwysers, ouers en die kinders te verduidelik en om ingeligte toestemming van die ouers van die kinders te bekom.

6.3.2.1 Ryping: Tanner fases

Fase van ryping is bepaal deur middel van twee geslagspesifieke vraelyste. Vir dogters is die "Vroue self-evaluering van volwassenheid karakteristieke" vraelys ingevul deur gebruik te maak van prentjies en vrae wat op die 5 Tanner fases gebaseer is. By die seuns is gebruik gemaak van die "Manlike self-evaluering van volwassenheid karakteristieke" vraelys. By die dogters is twee Tanner klassifikasies bepaal waar i) borste ontwikkeling meet en ii) vroulike pubiese haarontwikkeling.

Menarg is ook bepaal deur middel van 'n vraelys. By die seuns is stemverandering, haarontwikkeling en geslagsdeelontwikkeling deur middel van vraelys bepaal. Volwasse veldwerkers van dieselfde geslag was verantwoordelik vir die voltooiing van die vraelyste waar die kinders self hulle ryping volgens die figure in die vraelyste moes aantoon.

6.3.2.2 Die Previous Day Physical Activity Recall (PDPAR)

Die Previous Day Physical Activity Recall (PDPAR), wat saamgestel is deur Trost et al. (16), is vir die studie gebruik om die fisieke-aktiwiteitsvlakke te ontleed. Met die PDPAR-vraelys (herroepvraelys oor vier en twintig uur) is inligting ingewin wat verband hou met die kinders se fisieke aktiwiteite van die voorafgaande dag in die week (1 vm tot 11 nm) sowel as een dag in 'n naweek (8 vm tot 11 nm). Die vraelys word ingedeel in intervalle van 30 minute waar die kinders se aktiwiteite deur opgeleide werkers ingevul word vir elke tydperiode. Die proefpersone is gevra om terug te dink aan wat hulle die vorige weekdag of een naweekdag gedoen het.

'n Relatiewe energiewaarde is gebruik om die intensiteit van die aktiwiteite as 'n metaboliese ekwivalent (MET) uit te druk. Die waarde van een MET verteenwoordig die energieverbruik wat met rus geassosieer word en is gelyk aan 1 kkal/kg/uur of 3.5 ml O₂/kg/min. Die PDPAR-meetinstrument is 'n betroubare en geldige meetinstrument (toets-hertoets-betroubaarheidskoëffisiënt = 0.99; $P < 0.01$) en is reeds met welslae deur verskeie navorsers gebruik (24).

Die aktiwiteitsintensiteit van die aktiwiteite wat die kinders vermeld, word dan as hoog (3), matig (2) of laag (1) gekategoriseer. Kinders is soos volg volgens hulle aktiwiteitsvlakke geklassifiseer:

- *Hoog aktief* is die vlak wanneer daar twee of meer periodes van 30 minute elk met MET-waardes van $\geq$ gekodeer is.
- *Matig aktief* is die vlak wanneer daar een of twee periodes van 30 minute elk met MET-waardes tussen 3 en 5.9 gekodeer is.
- *Laag aktief* is die vlak as daar nie aan die hoog of matige aktiwiteitstandaarde voldoen word nie (24).

Sekere byvoegings met betrekking tot die aktiwiteite is gemaak om sodoende by die Suid-Afrikaanse kultuurverskille aan te pas. Enkele tradisionele spele van Tswana-kinders, met die MET-waarde van elke aktiwiteit, is tot die lys van aktiwiteite bygevoeg (17). Die tipe aktiwiteite wat die kinders gerapporteer het is verder in 3 hoofkategorieë verdeel, naamlik Huishoudelike take (bed opmaak, kook, wasgoed was, skottelgoed was), ontspanning (lees, huiswerk, bad, sit, kerk, inkopies, musiek, kuier met vriende, transport, eet, staan, TV kyk) en Oefening (sport beoefen, loop en werk wat inspanning vereis).

6.3.2.3 Intervensieprogram

Die proefpersone (eksperimentele groep) het deelgeneem aan 'n fisieke aktiwiteitsintervensieprogram vir ongeveer een uur, twee dae per week na skool vir drie en twintig weke in 2004 en in 2005 het hulle driemaal per week geoefen vir negentien

weke (Julie skool vakansie uitgesluit). Die fisieke intervensie het bestaan uit twintig minute van aerobiese oefening op die maat van musiek, twintig minute aktiewe spel met sportgerigte balspel en twintig minute versterkings- en soepelheidsoefeninge. Elke kind het eetgoed (pakkie ontbytvlökkies, suiglekkers en vrugte) en koeldrank ontvang na elke sessie voordat hulle huis toe vertrek het. In 2006 het geen intervensie plaasgevind nie maar data insameling het wel tydens twee geleenthede (in die begin en einde van die jaar) plaasgevind. Figuur 1(a) en (b) toon 'n uiteensetting van die metings oor die aantal maande.

Bywoningspersentasie is volgens presensielyste aangeteken en by die eksperimentele groep in drie kategorië opgedeel naamlik laag (0 – 30% bygewoon), matig (30%-60%) en hoog (60% en hoër). In 2004 het 23.3% van die seuns en 45.6% van die dogters meer as 50% van die FA sessies bygewoon. In 2005 het 31.4% van die totale eksperimentele groep 40% en meer sessies bygewoon. Slegs 5 proefpersone het 0% bywoning gehad. Bywoning was laag in die middel van 2005 met die skoolvakansie van vier weke en slegs proefpersone wa naby die skool gewoon het kon die aktiwiteite bywoon. Die belangrikste redes hoekom die proefpersone nie die oefensessies kon bywoon nie was omdat hul huishoudelike verpligtinge gehad het en ver van die skool af gebly het.

6.3.3 Navorsingsprosedures

Die intervensie het by die betrokke skole en by die Noordwes-Universiteit plaasgevind. Die metings en vraelysopnames is by die Noordwes Universiteit gedoen. In 2004 is data insameling aan die begin van die intervensie van twee keer per week, en aan die einde van 2004 gedoen (tydperk van drie en twintig weke). Die intervensie in 2005 is drie maal 'n week gedoen (oor die tydperk van negentien weke) om die effek van 'n hoër frekwensie te toets in vergelyking met die twee dae per week oefenprogram in 2004.

Data insameling (behalwe demografiese data) is drie maal gedoen oor die negentien weke tydperk in 2005. Geen intervensie het in 2006 plaasgevind in 2006 om die invloed van die intervensieprogram op die op die eksperimentele groep te kon analiseer.

Twee geleenthede is gebruik in 2006 vir data insameling met 34 weke rusperiode tussen in. Die kontrolegroep het nie aan al die metings deelgeneem waaraan die eksperimentele groep in die tydperk onderwerp is nie. Daar is nie gemeet in 2005 met die eerste en derde meting as gevolg van aktiwiteite by die spesifieke skool in daardie tydperk. Daar is slegs in 2005 met die tweede geleentheid die kontrole groep gemeet.

6.3.4 Dataverwerking

Die Statistica- (25) en SAS (26) rekenaarverwerkingspakkette is gebruik om die ingesamelde data te verwerk. Vir die ontleding van die verandering in FA data oor tyd is gebruik gemaak van die tegniek van multi-vlak modellering met behulp van gemengde modelle. 'n Herhaalde metings ko-variensie analise (ANCOVA) (gekorregeer vir bywoningspersentasie), oor maande met geslag en groep (eksperimenteel of kontrole) as faktore, is gebruik. en variensie analise (ANOVA) oor tyd, met 'n *Bonferroni post hoc* analise om te bepaal hoe die verskeie veranderlikes van mekaar verskil oor die verskeie toetsingsperiodes in maande. FA vlakke is vir die week en naweek apart ontleed.

6.4 RESULTATE

Die tyd spandeer aan die tipes aktiwiteite wat die eksperimentele en kontrole groepe kinders die meeste gerapporteer het word in Tabel 1 aangedui onder ontspanning, oefening en huishoudelike take. Die grootste verskille tussen die groepe na die 3 jaar intervensie het in die tyd aan oefening spandeer voorgekom, waar die eksperimentele groep se tyd aan hierdie aktiwiteite spandeer en veral oor naweke die meeste was (153.14 min teenoor 52.50 min). Hierteenoor het die kontrole groep tydens die week sowel as die naweek heelwat meer tyd aan ontspanningsaktiwiteite bestee waarvan TV kyk een van die aktiwiteite binne hierdie kategorie was.

Tabel 2 toon die resultate van 'n drie-rigting ANCOVA met maande, groep (eksperimenteel en kontrole) en geslag as faktore en persentasie bywoning in 2004 en 2005 as ko-veranderlikes tydens week sowel as naweek op fisieke aktiwiteit as afhanklike veranderlike.

Tabel 1. Tyd in die groepe spandeer in minute aan gekategoriseerde vrye tyd, huishoudelike take en oefening tydens 6 metingsgeleenthede oor die 30.75 maande tydperk tydens die week en naweek

WEEK							
		Eksperimenteel			Kontrole groep		
		Gem tyd (min)	Std Afw	N	Gem tyd (min)	Std Afw	N
2004	Ontspanning1	627.38	93.96	252	670.45	91.22	66
	Ontspanning 2	595.97	111.20	215	661.45	101.83	62
2005	Onspanning 3	601.76	108.05	204			
	Ontspanning 4	473.85	163.99	78	576.00	118.18	35
2006	Ontspanning5	626.09	100.97	122	640.59	104.93	51
	Ontspanning6	621.98	109.81	86	711.82	105.79	44
2004	Huishoudelik 1	56.07	61.79	252	45.45	50.54	66
	Huishoudelik 2	69.21	79.52	215	54.68	69.25	62
2005	Huishoudelik 3	69.41	72.02	204			
	Huishoudelik 4	129.23	110.81	78	48.86	69.44	35
2006	Huishoudelik 5	53.61	62.58	122	55.29	54.79	51
	Huishoudelik 6	51.28	59.98	86	39.55	54.43	44
2004	Oefening 1	114.76	58.98	252	96.82	50.42	66
	Oefening 2	114.70	63.65	215	102.10	60.11	62
2005	Oefening 3	141.91	66.06	204			
	Oefening 4	141.15	90.98	78	161.14	90.03	35
2006	Oefening 5	140.41	68.48	122	148.24	78.55	51
	Oefening 6	150.70	81.93	86	113.18	66.88	44
NAWEEK							
2004	Ontspanning1	528.41	151.67	252	533.18	167.31	66
	Ontspanning 2	531.81	141.79	215	558.55	158.83	62
2005	Onspanning 3	543.10	142.32	204			
	Ontspanning 4	550.25	153.56	79	574.41	128.16	34

Vervolg tabel 1. Tyd in die groepe spandeer in minute aan gekategoriseerde vrye tyd, huishoudelike take en oefening tydens 6 metingsgeleenthede oor die 30.75 maande tydperk tydens die week en naweek

NAWEEK							
		Eksperimenteel			Kontrole groep		
		Gem tyd (min)	Std Afw	Gem tyd (min)	Std Afw	Gem tyd (min)	Std Afw
2006	Ontspanning5	540.00	150.40	121	623.53	129.01	51
	Ontspanning6	560.93	150.25	86	662.73	136.15	44
2004	Huishoudelik 1	114.17	125.48	252	91.82	111.74	66
	Huishoudelik 2	95.91	95.75	215	71.61	97.38	62
2005	Huishoudelik 3	91.23	99.99	204			
	Huishoudelik 4	72.53	76.50	79	83.82	90.99	34
2006	Huishoudelik 5	98.20	95.25	121	92.94	93.96	51
	Huishoudelik 6	80.93	92.50	86	77.05	94.74	44
2004	Oefening 1	167.74	121.44	252	131.82	130.28	66
	Oefening 2	149.58	137.74	215	166.94	167.66	62
2005	Oefening 3	139.85	141.59	204			
	Oefening 4	130.97	104.53	79	142.94	121.14	34
2006	Oefening 5	173.80	133.26	121	91.76	99.75	51
	Oefening 6	153.14	128.11	86	52.50	59.69	44

Min = minute; Std Afw = Standaard afwyking; N = aantal proefpersone; Gem = gemiddeld; Huishoudelik = Bed opmaak, kook, wasgoed was, skottelgoed was; Ontspanning = lees, huiswerk, bad, sit, kerk, inkopies, musiek, kuier met vriende, transport, eet, staan en TV kyk; Oefening = sport beoefen, loop, werk.

Hieruit (Tabel 2) kan gesien word dat wat die week FA betref, daar 'n betekenisvolle effek gevind is met betrekking tot die maande wat die metings gedoen is ($p < 0.0001$), die groepe ($p = 0.01$) en die geslag ($p < 0.0001$). Die ko-veranderlikes naamlik bywoningspersentasie het geen betekenisvolle invloed getoon nie ($p = 0.65$ en $p = 0.20$ vir 2004 en 2005 respektiewelik). Daar het wel 'n neiging tot betekenisvolheid by die interaksie van groepe, geslag en maandelikse metings ($p = 0.07$) voorgekom.

Tabel 2. Drie-rigting ANCOVA van fisieke aktiwiteit tydens week

Week FA			Naweek FA		
Ko-veranderlikes/ Effekte	Vryheids- grade	P-waarde	Ko-veranderlikes/ Effekte	Vryheids- grade	P-waarde
Bywoning % 2004	1	0.65	Bywoning % 2004	1	0.07
Bywoning % 2005	1	0.20	Bywoning % 2005	1	0.26
Maande	6	<0.0001*	Maande	6	<0.0001*
Groep	1	0.01*	Groep	1	0.08
Groep en Maande interaksie	4	0.60	Groep en Maande	4	0.02*
Geslag	1	<0.0001*	Geslag	1	<0.0001*
Geslag en Maande interaksie	6	0.20	Geslag en Maande	6	0.18
Groep en geslag interaksie	1	0.35	Groep en geslag	1	0.26
Groep, geslag en maande interaksie	4	0.07	Groep, geslag en maande	4	0.01*

FA = Fisieke Aktiwiteit, P-waarde <0.05 is betekenisvol, % = persentasie, * = betekenisvol met $P < 0.05$.

Vir die naweek FA toon bywoning vir 2004 'n neiging tot betekenisvolheid ($p = 0.07$) maar soos in 2005 het bywoning nie 'n groot invloed op die resultate nie. Die maande wat metings gedoen is het 'n betekenisvolle invloed ($p < 0.0001$) getoon vir groepe en maande ($p = 0.02$), geslag ($p < 0.0001$) en die kombinasie van groepe, maande en geslag ($p = 0.01$). Die verskille in FA tussen geslagte en die groepe sal gevolglik verder in die artikel apart ontleed word.

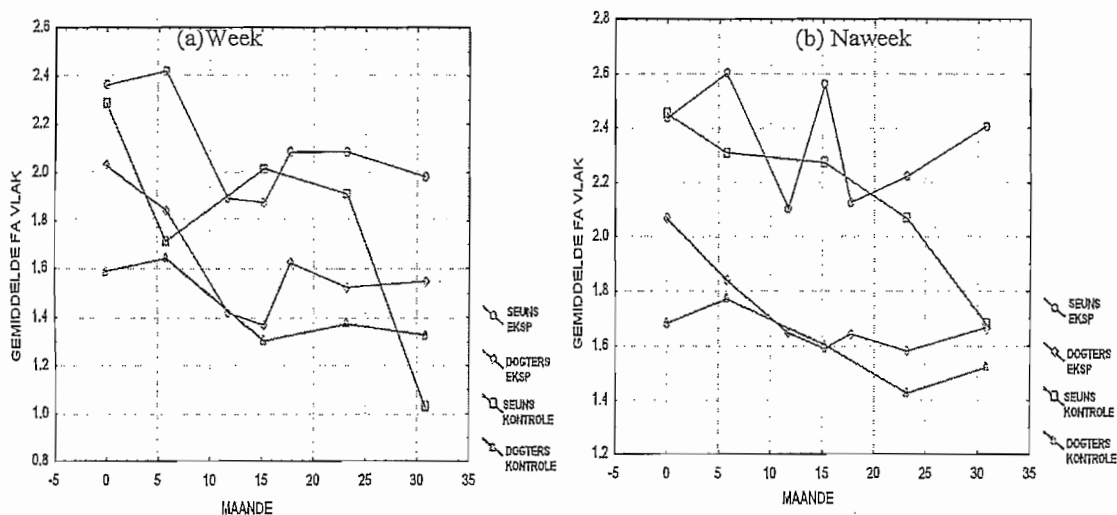
Tabel 3. Tweerigting Variansie analise (ANOVA) vir seuns en dogters afsonderlik met groep en maand as faktore tydens week en naweek vir FA vlakke

SEUNS				DOGTERS		
	Effek	Vg	p-waarde	Effek	Vg	p-waarde
WEEK	Maande	6	< 0.0001*	Maande	6	< 0.001*
	Groepe	1	0.01*	Groepe	1	0.09
	Groep en maand interaksie	4	0.16	Groep en maand interaksie	4	0.38
NAWEEK	Maande	6	< 0.001*	Maande	6	< 0.0001*
	Groepe	1	0.26	Groepe	1	0.27
	Groep en maand interaksie	4	0.004*	Groep en maand interaksie	4	0.42

Vg = vryheidsgrade, betekenisvolheid, * = $p < 0.05$.

Tabel 3 toon 'n betekenisvolle effek by beide geslagte met betrekking tot maande wanneer FA metings gedoen is ($p < 0.001$), met betrekking tot die gemiddelde aktiwiteitsvlakke. By die seuns is die groep (eksperimenteel vs. kontrole) ook betekenisvol met betrekking tot FA vlakke ($p = 0.01$) tydens die week. Vir FA vlakke tydens die naweek is groepe en maandinteraksie hoogs betekenisvol vir die seuns ($p = 0.004$).

Figuur 1 toon die FA patrone van die eksperimentele en kontrole groepe, per geslag grafies aan, soos beraam uit die gemengde modelle, terwyl Tabel 4 die tussengroepverskille soos in die figuur aangedui, verdër met betrekking tot betekenisvolheid van verskille in FA vlakke per maand en week en naweekdag vir seuns en dogters onderskeidelik toelig.



Figuur 1(a en b). Week en naweek FA gemiddelde waardes oor die tydperk van meting by die eksperimentele en kontrole groepe binne elke geslag

Figuur 1(a) wat die weeklikse FA vlakke grafies aandui, toon 'n onreëlmatige patroon in die eksperimentele groep seuns se FA oor die 30.75 maande tydperk. Alhoewel die 2 groepe seuns op min of meer dieselfde FA vlak begin (0.01 verskil, $p > 0.05$, Tabel 4), eindig die eksperimentele groep op 'n hoër FA vlak as dié van die kontrole groep seuns (0.86 verskil, $p < 0.05$, Tabel 4). Hierteenoor toon dogters wel met die basislynmetings statisties betekenisvolle verskille tydens die week sowel as naweek (0.38 verskil, $p = 0.008$ en 0.86 verskil, $p = 0.002$, Tabel 4), waar die eksperimentele groep aanvanklik hoër fisieke vlakke getoon het. Hierdie verskille is egter nie meer betekenisvol tydens eindmetings nie (Tabel 4). Albei groepe dogters toon verder 'n laer kurwe van FA as dié van die seuns (Figure 1a en b). Die eksperimentele groep seuns en dogters, sowel as die kontrole groepe het 'n neiging tot afname in FA oor die 30.75-maande tydperk getoon.

Figuur 1(b) toon die FA vlakke van die groepe en geslagte oor naweke oor die 30.75 maande tydperk. Hier kan gesien word dat die naweekpatrone van die weekpatrone wat in figuur 1(a) geïllustreer is, verskil. By die seuns was daar 'n groter verskil in terme van eindmetings tussen die eksperimentele groep en kontrole groepe ($p < 0.05$, Tabel 4). Die kontrole groep seuns het 'n soortgelyke FA vlak as die eksperimentele groep dogters tydens die eindmetings getoon (Figuur 1(b)).

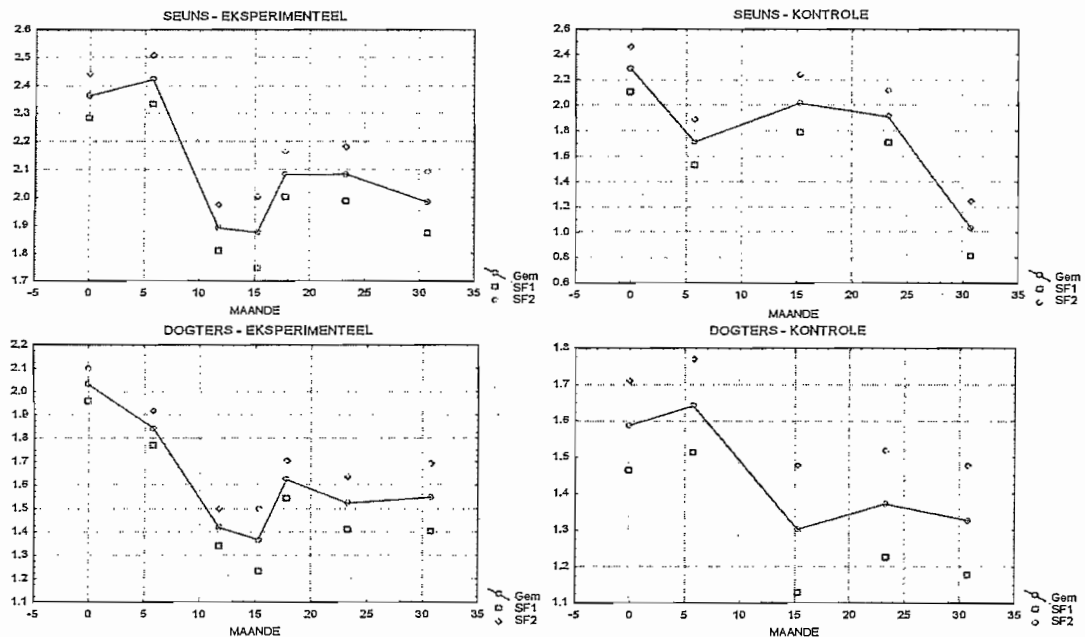
Die figuur toon ook 'n meer reëlmatige patroon van fisieke aktiwiteit in die kontrole en eksperimentele groepe dogters aan. Met toename in ouderdom en oor tyd was daar 'n afname by albei groepe vir albei geslagte, alhoewel die laaste twee metings 'n effense opwaartse kurwe toon, veral by die eksperimentele groep seuns. Figuur 1(a) toon dat die eksperimentele groepe seuns en dogters hoër FA vlakke getoon as die kontrole groepe ongeag die afname oor tyd.

Tabel 4. T-toets vir tussengroepverskille in gemiddeldes tussen die eksperimentele- en kontrole groepe in FA vlakke per maand vir seuns en dogters

SEUNŚ						
Week FA				Naweek FA		
Veranderlike	Gemiddelde verskil in FA	Std fout	p- waarde	Gemiddelde verskil in FA	Std fout	p- waarde
0 maande	0.01	0.19	0.97	0.09	0.20	0.67
5.75 maande	0.32	0.18	0.07	0.74	0.20	<0.001*
11.75 maande	.	.	.	.	.	.
15.25 maande	0.33	0.24	0.17	-0.1	0.30	0.74
17.75 maande	.	.	.	.	.	.
23.25 maande	0.25	0.23	0.27	0.22	0.25	0.37
30.75 maande	0.86	0.24	< 0.001*	1.02	0.25	<0.001*
DOGTERS						
	Week			Naweek		
0 maande	0.38	0.14	0.008*	0.45	0.15	0.002*
5.75 maande	0.07	0.13	0.61	0.21	0.15	0.18
11.75 maande	.	.	.	.	.	.
15.25 maande	-0.04	0.23	0.86	0.09	0.17	0.62
17.75 maande	.	.	.	.	.	.
23.25 maande	0.15	0.13	0.26	0.16	0.15	0.26
30.75 maande	0.08	0.20	0.70	0.22	0.18	0.25

Std fout = standaardfout; * = betekenisvol (p-waarde < 0.05)

Tabelle 5 en 6 dui verskille tussen die groepe se gemiddelde metings tussen die toetsgeleenthede onderling vir die eksperimentele en kontrolegroepe, onderskeidelik, aan vir week FA (geen metings is by die kontrolegroep geneem op 11.75 of 17.75 maande nie). Daar is van Bonferroni aangepaste p-waardes gebruik gemaak om die maande gelyktydig te vergelyk. Tabelle 7 en 8 dui dieselfde verskille tussen metings vir naweek FA aan. Figure 2a-d (week) en 3a-d (naweek) illustreer die verskille binne elke groep grafies soos uit die gemengde modelle beraam en dui ook die standaardfoute tydens elke metingsgeleentheid aan waaruit die variasie in die groep duidelik gesien kan word.



Figuur 2(a-d) Gemiddelde week FA vlakke en standaardfoute (punte onder lyn gee een standaardfout onder die gemiddelde en punte bokant lyn dié bokant gemiddelde) in die eksperimentele en kontrole groepe by seuns en dogters onderskeidelik

Tabel 5. Betekenisvolheid van verskille in aangepaste gemiddelde FA verskil waardes tydens die week FA vlakke vir elke metingsgeleentheid in die eksperimentele groepe seuns en dogters

Eksperimentele groep seuns				Eksperimentele groep dogters		
Effek van maand op maand	Gemiddelde verskil in FA vlak	Std fout	Aangepaste P-waarde (Bonferroni)	Gemiddelde verskil in FA vlak	Std fout	Aangepaste P-waarde (Bonferroni)
0 – 5.75	-0.17	0.11	1.00	0.23	0.09	0.203
0 – 11.75	0.32	0.11	0.05	0.41	0.09	0.0003*
0 – 15.25	-0.15	0.14	1.00	0.46	0.14	0.01*
0 – 17.75	0.30	0.11	0.10	0.42	0.09	0.0002*
0 – 23.25	0.20	0.12	1.00	0.47	0.12	0.001*
0 – 30.75	0.02	0.13	1.00	0.38	0.15	0.20
5.75 – 11.75	0.49	0.11	0.0004*	0.19	0.09	1.00
5.75 – 15.25	0.02	0.15	1.00	0.23	0.14	1.00
5.75 – 17.75	0.47	0.11	0.0009*	0.19	0.09	0.96
5.75 – 23.25	0.37	0.12	0.07	0.25	0.12	0.83
5.75 – 30.75	0.18	0.14	1.00	0.15	0.15	1.00
11.75 – 15.25	-0.47	0.15	0.025*	0.04	0.14	1.00
11.75 – 17.75	-0.02	0.11	1.00	0.00	0.10	1.00
11.75 – 23.25	-0.12	0.12	1.00	0.06	0.12	1.00
11.75 – 30.75	-0.31	0.13	0.41	-0.035	0.15	1.00
15.25 – 17.75	0.45	0.15	0.04*	-0.04	0.14	1.00
15.25 – 23.25	0.35	0.15	0.48	0.02	0.16	1.00
15.25 – 30.75	0.16	0.16	1.00	-0.08	0.18	1.00
17.75 – 23.25	-0.10	0.12	1.00	0.06	0.12	1.00
17.75 – 30.75	-0.29	0.13	0.63	-0.04	0.15	1.00
23.25 – 30.75	-0.19	0.14	1.00	-0.09	0.16	1.00

Gem = Gemiddeld, FA = Fisieke aktiwiteit, Std = Standaard, p-waarde = betekenisvolheid, * = $p < 0.05$ betekenisvol.

Alhoewel afnames in die gemiddelde verskil vanaf begin tot eindmetings (0-30.75) in al die groepe waargeneem word, was geen van die verskille betekenisvol nie. Die

eksperimentele groep seuns het egter feitlik geen verskil getoon vergeleke met die basismetings nie (0.02 verskil teenoor 0.77 verskil in kontrolegroep seuns). Daar was ook betekenisvolle verskille tussen metings in die eksperimentele groep seuns oor die tydperk van die navorsing wat nie by die kontrolegroep seuns voorgekom het nie (Tabel 6), wat dalk op 'n intervensie effek kan dui.

Figure 2(b) en 3(c) dui die standaardfoute by die metings aan. Die eksperimentele groep seuns se FA vlakke het baie gewissel soos in figuur 2(a) gesien kan word, maar die gemiddeld het steeds bo 'n waarde van 2 (wat matige fisieke aktiwiteitsvlakke aandui) gebly.

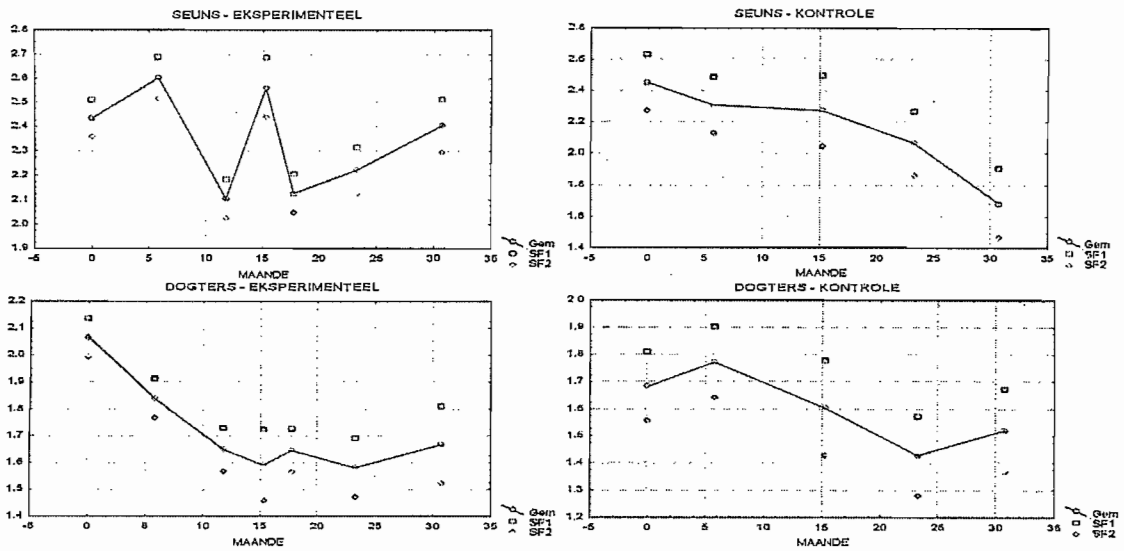
Tabel 6 . Betekenisvolheid van verskille in aangepaste gemiddelde FA verskil waardes tydens die week FA vlakke vir elke metingsgeleentheid in die **kontrole** groepe seuns en dogters.

Kontrole groep seuns				Kontrole groep dogters		
Effek van maand op maand	Gem verskil in FA vlak	Std fout	Aangepaste P-waarde (Bonferroni)	Gem verskil in FA vlak	Std fout	Aangepaste P-waarde (Bonferroni)
0 – 5.75	0.14	0.24	1.00	-0.09	0.17	1.00
0 – 15.25	0.18	0.28	1.00	0.02	0.19	1.00
0 – 23.25	0.38	0.26	1.00	0.26	0.18	1.00
0 – 30.75	0.77	0.27	0.65	0.13	0.18	1.00
5.75 – 15.25	0.04	0.04	1.00	0.11	0.20	1.00
5.75 – 23.25	0.24	0.24	1.00	0.35	0.18	0.55
5.75 – 30.75	0.62	0.62	0.25	0.22	0.19	1.00
15.25 – 23.25	0.20	0.20	1.00	0.25	0.21	1.00
15.25 – 30.75	0.58	0.58	0.56	0.11	0.22	1.00
23.25 – 30.75	0.38	0.38	1.00	-0.14	0.20	1.00

Gem = Gemiddeld, FA = Fisieke aktiwiteit, Std fout = Standaardfout, betekenisvolheid, * = $p < 0.05$

Tydens die naweek het die eksperimentele groep seuns se gemiddelde FA vlak > 1.8 gebly al het dit ook gewissel oor die 30.75 maande (figuur 3(a)). Die kontrole groep seuns het

'n meer geleidelike afname oor tyd getoon oor naweke as tydens die week en hulle FA vlakke het tot ongeveer 1.6 tydens die laaste metingsgeleentheid gedaal alhoewel nie betekenisvol vanaf die eerste metingsgeleentheid nie.



Figuur 3(a-d) Gemiddelde naweek FA vlakke en standaardfoute in die eksperimentele en kontrole groepe by seuns en dogters onderskeidelik

Tabel 7 en 8 dui die betekenisvolheid van verskille in aangepaste gemiddelde FA tydens die naweek FA vlakke vir elke metingsgeleentheid in die eksperimentele en kontrole groepe seuns en dogters. By die eksperimentele dogters was daar heelwat betekenisvolle verskille vanaf maand 0 - 11.75 en maand 5.75 - 15.25 met die weeklikse metings. Die eksperimentele groep seuns het betekenisvolle verskille getoon tussen die metings op 11.75 en 15.25 maand sowel as die metings by die 5.75 maand tot 11.75 maand en ook met die 5.75 en 15.25 maand. In tabel 9 waar die kontrole groep gemeet is is daar geen betekenisvolle verskille by die dogters gevind nie maar wel by die seuns op 30.75 maand.

Tabel 7. Betekenisvolheid van verskille in aangepaste gemiddelde FA verskil waardes tydens die naweek FA vlakke vir elke metingsgeleentheid in die eksperimentele groepe seuns en dogters

Eksperimentele groep seuns				Eksperimentele groep dogters		
Effek van maand op maand	Gem FA vlak	Std fout	Aangepaste P-waarde (Bonferroni)	Gem FA vlak	Std fout	Aangepaste P-waarde (Bonferroni)
0 – 5.75	-0.06	0.12	1.00	0.19	0.09	0.83
0 – 11.75	0.47	0.12	<0.001*	0.61	0.10	<0.001*
0 – 15.25	0.49	0.16	0.04*	0.67	0.14	<0.001*
0 – 17.75	0.28	0.12	0.33	0.41	0.10	<0.001*
0 – 23.25	0.28	0.13	0.61	0.51	0.12	<0.001*
0 – 30.75	0.38	0.14	0.14	0.48	0.15	0.02*
5.75 – 11.75	0.53	0.12	<0.001*	0.43	0.09	<0.001*
5.75 – 15.25	0.55	0.16	0.01*	0.48	0.14	0.01*
5.75 – 17.75	0.34	0.12	0.13	0.22	0.09	0.52
5.75 – 23.25	0.34	0.13	0.26	0.32	0.12	0.18
5.75 – 30.75	0.44	0.15	0.06	0.29	0.15	1.00
11.75 – 15.25	0.02	0.16	1.00	0.06	0.14	1.00
11.75 – 17.75	-0.19	0.12	1.00	-0.20	0.10	0.96
11.75 – 23.25	-0.20	0.13	1.00	-0.10	0.13	1.00
11.75 – 30.75	-0.10	0.14	1.00	-0.13	0.15	1.00
15.25 – 17.75	-0.21	0.16	1.00	-0.26	0.14	1.00
15.25 – 23.25	-0.21	0.17	1.00	-0.16	0.16	1.00
15.25 – 30.75	-0.11	0.18	1.00	-0.19	0.18	1.00
17.75 – 23.25	-0.00	0.13	1.00	0.10	0.13	1.00
17.75 – 30.75	0.10	0.14	1.00	0.07	0.15	1.00
23.25 – 30.75	0.10	0.15	1.00	-0.03	0.17	1.00

Gem = Gemiddeld, FA = Fisieke aktiwiteit, Std fout = Standaardfout, betekenisvolheid, * = $p < 0.05$

Tabel 8. Betekenisvolheid van verskille in aangepaste gemiddelde FA verskil waardes tydens die **naweek** FA vlakke vir elke metingsgeleentheid in die **kontrole** groepe seuns en dogters.

Kontrole groep seuns				Kontrole groep dogters		
Effek van maand op maand	Gem FA vlak	Std fout	Aangepaste P-waarde (Bonferroni)	Gem FA vlak	Std fout	Aangepaste P-waarde (Bonferroni)
0 – 5.75	0.57	0.26	0.33	-0.06	0.15	1.00
0 – 15.25	0.30	0.29	1.00	0.26	0.18	1.00
0 – 23.25	0.44	0.28	1.00	0.20	0.16	1.00
0 – 30.75	1.31	0.29	0.0003*	0.24	0.16	1.00
5.75 – 15.25	-0.27	0.29	1.00	0.31	0.18	0.89
5.75 – 23.25	-0.13	0.28	1.00	0.26	0.16	1.00
5.75 – 30.75	0.74	0.29	0.12	0.29	0.17	0.75
15.25 – 23.25	0.14	0.31	1.00	-0.05	0.19	1.00
15.25 – 30.75	1.01	0.32	0.02*	-0.01	0.19	1.00
23.25 – 30.75	0.87	0.31	0.06	0.04	0.18	1.00

Gem = Gemiddeld, FA = Fisieke aktiwiteit, Std fout = Standaardfout, betekenisvolheid, * = $p < 0.05$

Tabel 9 dui die aangepaste FA waarde verskil en standaardfoute tussen die eksperimentele en kontrole groepe seuns en dogters tydens elke meting aan asook betekenisvolle veranderinge wat oor tyd tussen die groepe plaasgevind het.

Tabel 9 toon betekenisvolle verskille ten opsigte van die verandering van die week se FA vlakke tussen die metings op 5.75 maande en 11.75 sowel as 17.75 maande by die eksperimentele groep seuns tydens die FA intervensie. Verder was daar ook tussen 11.75 en 15.25 maande sowel as tussen 15.25 en 17.75 maande 'n betekenisvolle verskil in FA by dié seuns. Die eksperimentele groep dogters het betekenisvolle verskille in afname van FA vanaf basislynmetings na 11.75, 15.25, 17.75, 23.25 en 30.75 maande getoon, tenspyte daarvan dat daar nie meer 'n FA intervensie gedoen is tussen 23.25 en 30.75 maande nie.

Tabel 9 . Tussengroepverskille in aangepaste fisieke aktiwiteitswaardes oor die tydperk van metings by die onderskeie geslagte en groepe.

Kontrole vs. eksperimentele groepe SEUNS							Kontrole vs. eksperimentele groepe DOGTERS					
Effek van maand op maand	WEEK			NAWEEK			WEEK			NAWEEK		
	Gem FA	Std fout	p- waarde	Gem FA	Std fout	p- waarde	Gem FA	Std fout	p- waarde	Gem FA	Std fout	p- waarde
0 – 5.75	-0.01	0.13	1.00	0.26	0.14	1.00	0.07	0.09	1.00	0.07	0.09	1.00
0 – 11.75										-		
0 – 15.25	0.15	0.16	1.00	0.41	0.17	0.30	0.27	0.12	0.51	0.48	0.12	0.001*
0 – 17.75										-		
0 – 23.25	0.29	0.14	0.83	0.34	0.15	0.55	0.37	0.10	0.009*	0.36	0.11	0.01*
0 – 30.75	0.39	0.15	0.201	0.84	0.16	0.001*	0.11	0.11	0.34	0.38	0.12	0.02*
5.75 – 11.75										-		
5.75 – 15.25	0.03	0.16	1.00	0.15	0.17	1.00	0.12	0.12	1.00	0.41	0.12	0.01*
5.75 – 17.75										-		
5.75 – 23.25	0.31	0.14	0.69	0.08	0.15	1.00	0.11	0.11	0.11	0.29	0.11	0.13
5.75 – 30.75	0.40	0.15	0.17	0.57	0.16	0.01*	0.12	0.12	1.00	0.31	0.12	0.17
11.75 – 15.25										-		
11.75 – 17.75	-0.02	0.11		-0.19	0.12		0.10	0.10		-0.20	0.10	
11.75 – 23.25										-		
11.75 – 30.75										-		
15.25 – 17.75										-		
15.25 – 23.25	0.28	0.16	1.00	-0.07	0.18	1.00	0.13	0.13	1.00	-0.12	0.13	1.00
15.25 – 30.75	0.38	0.17	0.59	0.42	0.18	0.46	0.01	0.14	1.00	-0.10	0.14	1.00
17.75 – 23.25										-		
17.75 – 30.75										-		
23.25 – 30.75	0.10	0.16	1.00	0.50	0.17	0.08	-0.09	0.13	1.00	0.02	0.13	1.00

Gem = Gemiddeld, FA = Fisieke aktiwiteit, Std fout = Standaardfout, betekenisvollheid, * = $p < 0.05$

Wat hier belangrik is is dat die seuns in die eksperimentele groep se FA vlak betekenisvol verhoog het tydens die naweek vanaf die eerste na die laaste meting (0.84, metings 0-30.75), alhoewel dit ook verhoog het tydens die week, maar nie betekenisvol nie (0.39).

6.5 BESPREKING

Uit die resultate wou bepaal word hoe FA vlakke oor 'n tydperk van 3 jaar tussen twee groepe adolessente seuns en dogters, waar die eksperimentele groep 'n FA intervensie ondergaan het teenoor 'n kontrole groep wat geen FA intervensie ondergaan het nie, verander het. In die derde jaar van die studie het geen van die groepe enige intervensie ondergaan nie. Die resultate dui 'n verskil in FA vlakke en patrone by die seuns in die eksperimentele en kontrolegroep aan, wat aan die FA intervensie toegeskryf kan word. Die kontrole groep seuns het 'n voortdurende dalende neiging in FA vlakke tydens die week oor die tydperk van 30.75 maande getoon teenoor die eksperimentele groep wie se FA vlakke dalende en stygende tendense getoon het wat duidelik met die FA intervensie gepaard gegaan het. Die eksperimentele groep se FA vlak was ook feitlik dieselfde tydens die laaste meting na 30.75 maande vergeleke met die eerste basislynmetings en hulle fisieke aktiwiteit was steeds van matige intensiteit. Hierteenoor het die kontrole groepe seuns sowel as dogters (figuur 1(c) en 1(d) vanaf die basislynmetings oor die tydperk van 30.75 maande, 'n afname in fisieke aktiwiteitsvlakke getoon wat in lyn is met navorsing is wat toon dat sedentêre gedrag gedurende adolessensie afneem (5,6). Tabel 1 wat die aktiwiteitspatrone van die kontrole en eksperimentele groepe ontleed het, toon ook dat die kontrole groep se tyd spandeer aan vryetyd, oor die drie jaar van die studie toegeneem het, vergeleke met die eksperimentele groep waar veral tyd spandeer aan oefening oor die tydperk toegeneem het.

Naweek-FA patrone het redelik van dié van week-FA verskil, alhoewel die eksperimentele groep seuns steeds 'n hoër FA vlak as die kontrole groep seuns getoon het en hulle FA vlakke ook betekenisvol toegeneem het oor die tydperk van eerste na die laaste metings (sien Figuur 9). Hierdie toename is in lyn met die toename wat gesien word in die aantal tyd wat hulle aan oefening oor die naweke spandeer (Tabel 1). Die eksperimentele groep seuns het waarskynlik oor naweke die aktiwiteite en spele wat in die intervensie uitgevoer is (soos byvoorbeeld sokker en balspeletjies) herhaal wat die toename in FA oor die naweke kan verklaar. Dit blyk gevolglik of daar dalk 'n oordrageffek van die intervensieprogram by die intervensie groep veral oor naweke met betrekking tot hulle fisieke aktiwiteitsvlakke asook die keuse van aktiwiteite wat tot 'n

hoër fisieke aktiwiteitsvlak bydra, voorgekom het. Die kinders in hierdie studie het egter min geleentheid en toegang tot sportgeriewe in hul omgewing, wat dalk ook kan verduidelik waarom die FA intervensie 'n groot verskil tussen die twee groepe getoon het.

By die dogters was die effek van die FA intervensieprogram anders en dui die resultate daarop dat die intervensie nie 'n noemenswaardige effek op hulle fisieke aktiwiteitsvlakke uitgeoefen het nie. Albei groepe dogters het laer FA vlakke aan die einde van die studie getoon vergeleke met aan die begin van die studie. Die resultaat is lyn met studies soos die van Brodersen *et al.* (5) wat 'n afname in FA van tot 46% by dogters gevind het. Daar behoort gevolglik ander maniere gevind te word om dogters se FA vlakke te verhoog. Navorsing dui aan dat aspekte wat in ag geneem moet word met FA deelname (soos tydens 'n intervensie) is duur, frekwensie, intensiteit en tipe oefening en belangstelling in FA (27,28) en die genot wat uit FA geput word (11). Hierdie aspekte behoort gevolglik meer aandag te kry in die samestelling van FA programme vir dogters. Die aanbod van sodanige programme vir adolessente waar seuns en dogters gesamentlik aan die program deelneem kon dalk ook 'n rol gespeel het in die effek wat verkry is. Dogters se belangstellings asook aktiwiteite wat hulle sou motiveer is waarskynlik op hierdie ouderdom reeds van so 'n aard dat 'n program gerig op hulle eiesoortige behoeftes en belangstellings dalk tot beter resultate aanleiding kon gee het. 'n Ontleding van die aktiwiteitspatrone van verskillende rassegroepe deur Hurter en Pienaar (17), het in die verband verskillende voorkeure uitgewys wat moontlik in die verdere beplanning van intervensieprogramme gebruik kan word.

Omgewingsfaktore soos deelname op skoolvlak aan liggaamlike opvoeding (LO) klasse en aan gemeenskapsrecreasie programme na-uurs speel 'n belangrike rol in FA vlakke van adolessente (29). Hierdie program is na-uurs aangebied en het tot 'n lae bywoningssyfer bygedra waarskynlik omdat baie van hierdie adolessente huishoudelike pligte gehad het om in die middag uit te voer, soos gesien uit Tabel 1. Bar-Or *et al.*, (13) dui in die verband aan dat sosio-ekonomiese en kulturele faktore 'n rol daarin kan speel dat minder energie gespandeer word, wat FA weer laat afneem. Kinders in 'n veilige woonbuurt blyk ook meer aktief te wees as kinders in 'n onveilige woonbuurt (27,28).

Die kinders in hierdie studie moes alleen huis toe stap nadat hulle na skool aan die program deelgeneem het, wat hulle gevoel van veiligheid kon beïnvloed het. Daar wil gevolglik aanbeveel word dat soortgelyke FA intervensieprogramme eerder in skooltyd aangebied word.

Seisoene blyk ook 'n rol in deelname van FA te speel (28). Sallis (28) het bevind dat aktiwiteitsvlakke in die algemeen in die winter laer is en hoër in die somer. Seisoensverandering en groeifases beïnvloed gevolglik die effek van oefening en daarom is 'n kontrole groep belangrik om die effek van 'n oefenprogram te kan meet. In hierdie studie was die dogters van beide die kontrole sowel as eksperimentele groep se week FA vlakke die laagste op 23.25 maane, wat in Februarie 2006 gemeet is en wat een van die warmste maande in Suid Afrika is. Seisoensverandering kan gevolglik moontlike 'n rol gespeel het by die laagtepunte by die dogters op 15.25 maande in figuur 1(b) en 23.25 maande in figuur 1(c). Oor die algemeen het die dogters vir albei groepe egter 'n geleidelike afname in week FA sowel as vir naweke oor die tydperk van die studie getoon, ongeag van die seisoen. Wintersport word wel beoefen by die spesifieke skole, maar slegs 'n klein persentasie van die kinders neem daaraan deel. Sportfasiliteite, veral swembaddens wat redelik gewild is by die kinders, is egter skaars in die gebiede.

Samevattend kan die afleiding gemaak word dat die eksperimentele groepe seuns en dogters hoër FA vlakke getoon het deur die loop van die studie as die van die kontrole groepe en dat die FA intervensie soos aangebied in hierdie studie 'n groter effek op seuns as dogters in die eksperimentele groep se FA uitgeoefen het. Dit kan moontlik toegeskryf word aan die belangstelling van die seuns aangesien baie balgeoriënteerde sportaktiwiteit tydens die intervensie gedoen is, wat die dalk as die dogters geniet het. Die seuns het oor die algemeen ook meer getrou aan die program as die dogters deelgeneem. Die dogters het veral die aerobiese danse op musiek geniet. Toekomstige navorsing kan die intervensie as riglyn gebruik aangesien daar nog nie baie intervensie programme ontwerp is vir dié spesifieke ras asook ouderdomsgroep nie. Uit hierdie studie kan ook gesien word dat die spesifieke intervensie nie noodwendig vir albei geslagte effektief was nie maar dit het wel 'n rol gespeel in die FA tussen 'n eksperimentele groep en kontrole groep van dieselfde geslag. Die navorsing bied ook

meer duidelikheid oor die aktiwiteitsgewoontes, FA vlakke en hindernisse wat swart adolessente in 'n dorpsgemeenskap ervaar om fisiek aktief te wees.

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HOOFSTUK 7

SAMEVATTING, GEVOLGTREKKING EN AANBEVELINGS

INHOUDSOPGAWE

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7.1 SAMEVATTING

Adolesensie is 'n sensitiewe ontwikkelings tydperk tussen die ouderdomme van 13 – 18 jaar. Daar is verskeie aspekte en probleem areas wat met hierdie tydperk van ontwikkeling verband hou. Obesiteit, groeivertraging (veral in onderontwikkelde lande), onaktiwiteit en gesondheidsprobleme blyk om algemeen by hierdie ouderdomsgroep voor te kom. Antropometriese metings kan gebruik word om van hierdie aspekte te ontleed. Verskeie antropometriese metodes word gebruik om liggaamsamestelling (LS) en liggaamsproporsies te bepaal. In hierdie studie is verskeie doelstellings geformuleer om ondersoek in te stel oor groeivertraging en LS en metodes om LS te bepaal by adolessente en die rol van FA intervensies. Die eerste doel was om te bepaal wat die aard van navorsing is wat gedoen is oor LS van groeivertraagde en wangevoede adolessente in Suid-Afrika, Afrika en Suid-Amerika en die omvang van die probleem van GV onder kinders veral in SA. Die tweede doel was om te bepaal watter LS veranderlikes veranderinge in LS by adolessente die beste beskryf na deelname aan 'n FA intervensie. Derdens was die doel om te bepaal watter LS-; -verhoudinge- en rypingsverskille tussen groeivertraagde en nie-groeivertraagde

(NGV) adolessente voorkom. Laastens was die doel om te bepaal of die FA vlakke en FAspatrone van adolessente met toename in ouderdom verander. Die probleem, doel en hipoteses van die studie is in hoofstuk 1 vervat.

Hoofstuk 2 is as 'n literatuuroorsig aangebied. In hierdie hoofstuk is literatuur ondersoek wat die aspekte van adolessente wat met hierdie studie verband hou naamlik groeivertraging, fisieke aktiwiteit (FA), liggaamsamestelling en puberteit by adolessente en verskeie aspekte daarvan beskryf. Met betrekking tot LS is terminologie, wat verband hou daarmee beskryf asook verskille in liggaamsamestelling van verskillende rasse, geslagte, ouderdomsgroepe en populasies. Faktore wat LS beïnvloed, soos FA, ras, geslag, ouderdom, dieet en leefstyl is verder ontleed en vanuit die literatuur bespreek.

Antropometrie vir die bepaling van obesiteit en groeivertraging is beskryf. Obesiteit is ook volledig beskryf tesame met die implikasie en voorkoms daarvan by adolessente. Die literatuurstudie het uitgewys dat daar redelik min literatuur oor groeivertraagde adolessente in Suid Afrika gepubliseer is. Hierdie onderwerp is ook bespreek met betrekking tot oorsake, komplikasies en nadele van groeivertraging en wanvoeding. FA sowel as die voordele en faktore wat FA beïnvloed is volledig beskryf. Daar is veral gefokus op faktore wat 'n invloed op FA het. Ryping is ook bespreek.

Hoofstuk 3 is in artikel formaat aangebied. Die doel van hierdie oorsigartikel was om bestaande navorsing te kombineer om sodoende 'n algemene oorsig te kry om GV beter te verstaan en ook die navorsingsresultate met mekaar te vergelyk. Die meeste literatuur wat in die verband gebruik kon word, is vanaf Noord-Afrika en Suid-Amerika afkomstig. Eerstens is groeivertraging en wanvoeding bestudeer. LS, risiko's van GV, liggaamlike voorkoms en 'n vergelyking van GV kinders met normaal groeiende kinders is bespreek. Die artikel het ook aandag gegee aan die fisiologie van GV en die gevare aan die kondisie verbonde.

Beide hoofstukke 4 en 5 is aangebied in artikel formaat wat in die *"African Journal for Physical, Health Education, Recreation and Dance"* gepubliseer is. Hoofstuk 4 se eerste doelwit was om te bepaal watter invloed 'n FA intervensie op die LS van adolessente gehad het. Tweedens was die doelwit om te bepaal watter LS

veranderlikes, verandering in LS by hierdie adolessente die beste. Die studie is op 280 proefpersone uitgevoer (113 seuns en 167 dogters), met gemiddelde ouderdomme van 14.65 ± 1.26 en 14.31 ± 1.38 jaar respektiewelik. Die steekproef het bestaan uit beskikbare proefpersone van twee sekondêre swart skole in Ikageng in die Noordwesprovinsie. Alle betrokke ouers en kinders het ingeligte toestemming gegee. Daar is gevind dat FA voordelig was vir die adolessente met 'n hoë bywoningsyfer ($>50\%$), veral vir die seuns. Volgens die liggaamsmassa-indeks (LMI) waardes is 'n klein persentasie kinders as oorgewig geklassifiseer, terwyl met metodes soos die som van die velvou berekening van vet persentasie en %LV gemeet deur middel van lugverplasing *pletismografie* (ADP), 'n groter persentasie kinders as "oorvet" geklassifiseer is. Baie min deelnemers in die dogtergroep is as oorgewig of vetsugtig geklassifiseer volgens die LMI klassifikasie, terwyl die som van die velvoue en ADP metings meer konsekwent was in vergelyking met mekaar. Na afloop van die FA intervensieprogram was daar 'n afname in die som van die velvoue en %LV waardes in die hoë FA bywoningsgroep, maar geen afname in die LMI nie. Daar kan gevoglik afgelei word dat groei en ontwikkeling in ag geneem moet word wanneer LS bepaal word by adolessente. Die bepaling van LV% deur middel van velvoue en lugverplasing *pletismografie* (ADP) is 'n meer geldige maatstaf van LS as LMI by hierdie spesifieke groep proefpersone.

Die doel van hoofstuk 5 was om verskille ten opsigte van LS, proporsies oor 'n tydperk van drie jaar van groeivertraagde adolessente teenoor NGV adolessente vas te stel. Daar was beduidende verskille tussen die massa, lengte, LOZ, armspan, MO, heupomtrek en skraalliggaamsmassa van die GV (28 dogters en 28 seuns) en NGV (113 dogters en 90 seuns) groepe. %LV, MHR en fisieke volgroeiheid (Tanner fase) het ooreengestem tussen die twee groepe, maar die skraalliggaamsmassa was minder by die GV groepe, wat aandui dat daar proporsioneel meer vet en minder spiermassa teenwoordig was by die GV groepe. MLtR van GV groep was aansienlik groter as die MLtR van die NGV groep, wat op 'n meer sentrale vetverspreiding by die GV adolessente dui. Slegs 3.5% van die proefpersone het 'n MLtR >0.5 , wat op abdominale vetsugtigheid dui gehad; maar 54% van die proefpersone het oor 'n %LV groter as 20% (onder die seuns) en groter as 25% (onder die dogters) beskik. Uit hierdie studie kan die gevolgtrekking gemaak word dat daar verskille tussen GV en

NGV adolessente van beide geslagte in sekere LS- en liggaamproposie-komponente is, sonder 'n verskil in seksuele ontwikkeling.

Hoofstuk 6 is in artikelformaat en sal aangebied word vir die "*Journal of Tropical Pediatrics*". Die eerste doelwit van hierdie artikel was om te bepaal hoe die FA vlakke van swart adolessente uit 'n gedrepiveerde omgewing oor die verloop van 'n 3-jaar tydperk verander het en of 'n FA intervensie 'n invloed daarop sal uitgeoefen het. Tweedens was die doel om te bepaal hoe FA patrone met toename in ouderdom tydens die week en naweek verander en of dit verband hou met die FA vlakke van die groep. Alhoewel die twee groepe seuns (130 proefpersone in die eksperimentele groep en 28 in die kontrole groep) op min of meer dieselfde FA vlak begin het (0.01 verskil, $p > 0.05$), het die eksperimentele groep op 'n hoër FA vlak as dié van die kontrole groep (0.86 verskil, $p < 0.05$) na die 30.75 maande tydperk geëindig. Hierteenoor het die dogters (152 en 59 proefpersone onderskeidelik) tydens die basislynmetings statisties betekenisvolle verskille tydens die week sowel as naweek (0.38 getoon, $p = 0.008$ en 0.86 verskil, $p = 0.002$) (eksperimentele groep aanvanklik hoër FA vlakke). Hierdie verskille was egter nie meer betekenisvol tydens eindmetings nie. Albei groepe dogters het verder 'n laer kurwe van FA as dié van die seuns getoon. Met toename in ouderdom en oor tyd was daar 'n afname in weeklikse en naweek FA patrone en FA vlakke by albei groepe vir albei geslagte, alhoewel die laaste twee metings 'n effense opwaartse neiging toon, veral by die eksperimentele groep seuns. Die resultate het 'n verskil in FA patrone en vlakke by die seuns in die eksperimentele en kontrolegroep aangetoon, wat aan die FA intervensie toegeskryf kan word.

7.2 GEVOLGTREKKINGS

Die gevolgtrekkings van die studie is op grond van die studie se resultate gevorm.

7.2.1 Gevolgtrekking 1

Hipotese 1 stel dat navorsing oor groeivertraging in Suid-Afrika 'n matige voorkomssyfer by adolessente en kinders toon. Uit die literatuur is gevind dat 'n voorkomssyfer van tussen 6% en 50% voorkom by kinders ondergewig

of groeivertraag in Suid-Afrika, Afrika en Suid-Amerika wat dui dat GV algemeen by adolessente en kinders in ontwikkelende lande voorkom. Die literatuuroorsig het ook aan die lig gebring dat Afrikalande en ander ontwikkelende lande, waar voedselnood meer algemeen is, in 'n groter mate probleme ervaar met GV. Die hipotese word gevolglik aanvaar.

7.2.2 *Gevolgtrekking 2*

Die tweede hipotese stel dat %LV vetpersentasie 'n meer sensitiewe maatstaf van obesiteit as LMI is na deelname aan 'n FAs-intervensieprogram by dorpsgemeenskap-adolessente. Uit die resultate word slegs geringe veranderinge in die LMI waardes waargeneem, terwyl daar betekenisvolle verskille gedokumenteer is vir die som van die velvoue en %LV gemeet met ADP. Daar was 'n afname in %LV en som van die velvoue, maar geen verandering in die LMI na afloop van die 19-week intervensieprogram nie. Die afname in %LV en som van velvoue na die intervensie is 'n aanduiding dat %LV of velvoumetings eerder as LMI as maatstaf van obesiteit gebruik moet word om LS verandering in adolessente aan te toon. Hipotese 2 word gevolglik aanvaar.

7.2.3 *Gevolgtrekking 3*

Die derde hipotese stel dat LS, liggaamsverhoudings en ryping tussen groeivertraagde (GV) en NGV adolessente betekenisvol sal verskil. Die resultate van die studie het getoon dat daar verskille tussen GV en NGV adolessente van beide geslagte in sekere LS- en liggaamproporsie-komponente gevind is, sonder 'n verskil in geslagtelike ryping. Verskille is gevind tussen GV en NGV dogters en seuns in terme van lengte, gewig, armspan, middelomtrek, heupomtrek en skraalliggaamsmassa terwyl LS en liggaamsverhoudings van groeivertraagde en NGV adolessente verder betekenisvolle verskille tussen die groepe uitgewys het. Hipotese 3 word gevolglik aanvaar omdat massa, lengte, middelomtrek, heupomtrek en skraalliggaamsmassa betekenisvol verskil het tussen GV en NGV adolessente in hierdie studie.

7.2.4 *Gevolgtrekking 4*

Die vierde hipotese stel dat deelname aan 'n FA intervensie program sal die FA vlakke en patrone van adolessente seuns en dogters oor 'n tydperk van 3 jaar betekenisvol beïnvloed. Die eksperimentele groep seuns het na 3 jaar (waarvan hulle vir 2 jaar 'n FA intervensie ondergaan het) 'n hoër FA vlak as die kontrole groep seuns getoon, wat nie aan 'n FA intervensie deelgeneem het nie, waaruit afgelei kan word dat dié intervensie wel bygedra het tot verskille in FA tussen die eksperimentele- en kontrole groepe seuns. Die vierde hipotese word gevolglik aanvaar vir seuns. Wat die dogters betref verskil die effek van die seuns wat toon dat die intervensie nie 'n andersoortige effek op FA vlakke van die dogters in die eksperimentele groep uitgeoefen het nie. Die hipotese word gevolglik verwerp vir dogters.

7.3 AANBEVELINGS

Baie min soortgelyke FA intervensies as wat in hierdie studie ondersoek is, is al uitgevoer en gerapporteer. Hierdie studie se intervensie kan gevolglik as riglyn gebruik word vir toekomstige navorsers, aangesien daar nog nie baie intervensieprogramme ontwerp is vir adolessente van dié spesifieke ras en ouderdomsgroep, en wat in gedepriveerde omstandighede grootword nie. Tekortkominge wat uitgewys is in die inhoud van die program moet egter aangespreek word. Dit het uit die studie geblyk dat adolessente woonagtig in gedepriveerde omgewings verskeie hindernisse ervaar om gereeld aan 'n na skoolse FA program deel te neem. Faktore soos dat die adolessente huishoudelike take gehad het en baie van die proefpersone self 'n inkomste moes verdien om hulle families te ondersteun, asook groepsdruk kon invloede uitgeoefen het op deelname aan die FA intervensie. 'n Groot afname in bywoning is ook gedurende die skoolvakansies en eksamentye waargeneem en die veiligheid van die omgewing het 'n verdere bydraende rol tot lae bywoning van die program gespeel. Hierdie faktore is moeilik om te oorkom en daar wil gevolglik aanbeveel word dat 'n FA intervensie eerder deel moet vorm van die skoolprogram eerder as 'n na-uurse program om FA te bevorder by skoolkinders. Die belang van deelname aan sodanige programme soos die fisiologiese voordele wat oefening inhou vir die groeiende kind moet egter ook aan die adolessente gekommunikeer word om 'n groter bewustheid by hulle te skep tot beter FA gewoontes. Ondersteuning van die skole in deprimeerde omgewings en van ouers word aanbeveel om die adolessente aan te moedig

om vol te hou met die FA intervensies. Daar word ook aanbeveel dat 'n FA program en opleiding verskaf moet word aan onderwysers om adolessente ten volle te kan ondersteun om FA intervensieprogramme te wil bywoon.

Die studie se resultate het verder aan die lig gebring dat groot persentasies kinders met GV in Afrika voorkom, en dat die kondisie verband hou met verskeie gesondheidsrisikos, derhalwe wil aanbeveel word dat die probleem meer aandag moet geniet. Dit is ook belangrik dat die bepaling en klassifisering van GV deur kundiges gedoen moet word. Dit is ook belangrik dat medici, ouers en die publiek meer bewus gemaak moet word van die probleem en die probleme wat daaruit voortvloei.

Daar is egter tekortkominge asook ander aanbevelings wat verdere studies van die aard se uitkoms kan verbeter, hoewel gepoog is om beperking tot die minimum te beperk. Die volgende aanbevelings is ter sprake:

- 7.3.1 'n Groter steekproef is nodig vir meer konsekwente en veralgemeenbare resultate op veral gedepriveerde omgewings by groeivertraagde adolessente. Verdere navorsing op groter groepe en in verskillende provinsies moet gevolglik uitgevoer word op dieselfde ouderdom kinders en verskillende rasse om meer inligting oor GV kinders te verskaf.
- 7.3.2 Die verdeling van kinders in 'n GV en NGV groep het in hierdie studie tot klein groepsgroottes aanleiding gegee. Daar wil aanbeveel word dat daar vooraf bepaal word hoe groot die verdeling tussen GV en NGV kinders gaan wees wat tot beter seleksie sal lei. 'n Kombinasie van meer as een skool in 'n provinsie kan groter getalle bied waarop onteldings uitgevoer kan word.
- 7.3.3 Hierdie studie is gebasseer op 'n longitudinale ontwerp. Verskeie faktore het veroorsaak dat daar 'n redelik goot uitvalsyfer van proef persone was en dat die bywoning van program ook laag was, en laer geword het soos wat die program gevorder het en die kinders ouers geword het. Dit het tot klein groepsgroottes aanleiding gegee wat sekere analyses en die veralgemening

daarvan beïnvloed het. Navorsing word aanbeveel om die hindernisse wat kinders in hierdie omgewings ondervind te ondersoek, sodat hulle ook beter ondersteuning in die verband kan kry.

- 7.3.4 Uit die resultate is gevind dat die middel-lengte ratio afsnypunt van 0.5 om abdominale vetsug aan te dui, moontlik aangepas sal moet word spesifiek vir swart GV adolessente. Meer navorsing moet gevolglik gedoen word in terme van adolessente en gepaste middel-lengte verhoudings vir verskeie etniese groepe en geslag.
- 7.3.5 Etniese groepe en geslagte het verskillende belangstellings en behoeftes, gevolglik word verdere navorsing aangemoedig om die gepaste FA intervensie te kan toepas vir spesifieke populasies.
- 7.3.6 Dit het gebeur dat alle metings nie uitgevoer kon word op alle proefpersone nie omdat sommige adolessente skaam was tydens die meting van die LS en beantwoording van die seksuele volgroeiheid vraelyste. Die “BodPod” metings is verder ’n lang proses en die kinders moes stilsit in ’n geslote silinder, wat gelei het tot engtevrees by sommige kinders. Gevolglik is minder proefpersone met die ADP getoets. Daar moet spesifieke toetsdae bespreek word vir die ADP omdat dit redelik tydsaam is wat dit prakties ’n moeilik bestuurbare proses gemaak het. Daarom word aanbeveel dat kinders meer vertrouwd gemaak moet word met die ADP sodat hul kan verstaan hoe die apparaat werk en dat die protokol belangrik is.

BYLAE A-F

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BYLAAG A

Tanner vraelyste vir seuns en dogters

MALE SELF-ASSESSMENT OF MATURITY CHARACTERISTICS

Subject nr:

Name:

Age:

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

No

☐

Unbroken

☐

Signs of breaking

Yes

☐

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 $\checkmark$ in the appropriate box?

EARLIER

☐

LATER

☐

SAME TIME

☐

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 $\checkmark$ in the appropriate box?

EARLIER

☐

LATER

☐

SAME TIME

☐

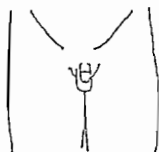
7. The description on this page describes different amounts of male facial hair. Please read each of the descriptions. Then tick $\checkmark$ the appropriate box that describes your stage of facial hair development best.

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 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.

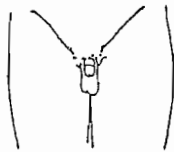
The drawings on this page show different amounts of male pubic hair. Please look at each of the drawings and read the sentences under the drawings. Then tick ✓ the drawing that is closest to your stage of hair development

Picture 1



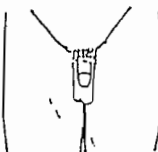
There is no pubic hair at all.

Picture 2



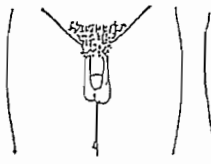
There is small amount of long, lightly coloured hair. This hair may be straight or a little curly.

Picture 3



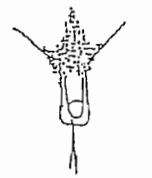
There is darker hair, curlier and thinly spread out to cover a somewhat larger area than in stage 2.

Picture 4



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

Picture 5



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

The testes, scrotum and penis are about the same size and shape as they were when you were a child.

Picture 2

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.

Picture 3

The penis has grown in length. The testes and scrotum have grown and dropped lower than in picture 2.

Picture 4

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.

Picture 5

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!

FEMALE SELF-ASSESSMENT OF MATURITY CHARACTERISTICS

Name: _____	Gender: _____	☐ Male ☐ Female	Age: _____
Subject number: _____			

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



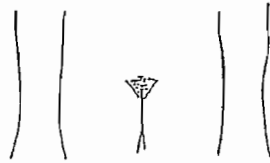
There is no pubic hair at all.

Figure 2



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

Figure 3



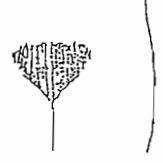
There is darker hair, curlier and thinly spread out to cover a somewhat larger area than in stage 2.

Figure 4



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

Figure 5

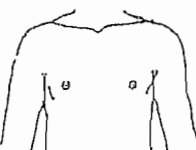
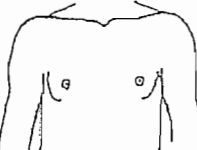
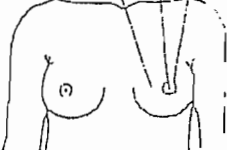


The hair now is widely spread covering a large area, like that of an adult female.

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 flat	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!

BYLAAG B

Demografiese vraelyste

**PLAY STUDY (Demografic)
IDENTIFICATION**

Number of participant:	
Date of interview:	
Household address:	
Total in household	

HEALTH INFORMATION

Has anyone in the household died in the last 12 months	Yes=1	No=2
--	-------	------

If yes, how many people.....

What was the reason for death: 1.....2.....3.....

LIFESTYLE

In the last 12 months did you have sex?	Yes=1	No=2
If yes, do you use a condom	Yes=1	No=2

GENERAL QUESTIONS

Can you communicate your feelings?	Yes	No
Do you find it easy to communicate your feelings?	Yes	No
Do you believe in yourself?	Yes	No
Do you sometimes feel useless?	Yes	No
Do you like yourself?	Yes	No
If your friend has a problem, do you want to help him/her?	Yes	No
If you want to help him/her, do you know how?	Yes	No

Tell me what is your future dreams?

.....

.....

.....

.....

.....

Tell me how do you solve conflict in your life?

.....

.....

.....

.....

In your peer group, will you be able to say no if you don't want to do something?	Yes	No
Are you all participating equally in decisionmaking in your peer group?	Yes	No

Describe your relationship with:

	Good	Average	Bad
A parent			
Friends			
Girlfriend/boyfriend			

Do you believe in a sickness like HIV/AIDS?

Have you ever seen a person died from AIDS?	Yes	No
---	-----	----

If yes, tell me more about the physical symptoms that you saw

.....

.....

Strongly agree Agree Disagree Strongly disagree

On the whole, I am satisfied with myself.	1	2	3	4
Some times I think I am no good at all.	1	2	3	4
I feel that I have a number of good qualities.	1	2	3	4
I am able to do things as well as most other people.	1	2	3	4
I feel I do not have much to be proud of.	1	2	3	4
I certainly feel useless at times.	1	2	3	4
I feel that I'm a person of worth	1	2	3	4
I wish I could have more respect for myself.	1	2	3	4
All in all, I am inclined to think that I am a failure.	1	2	3	4
I take a positive attitude toward myself.	1	2	3	4

Thank you

BYLAAG C

Previous Day Physical Activity Recall (PDPAR)

Physical activity questionnaire of the previous week day

Subject nr

Name:

Race W B C I

Age:

Gender M F

Grade

School:

Teacher

Date:

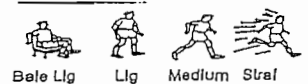
Classification.

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	TYPE	Activity	METS	Classification			
				Very light	Light	Med- lum	Hard
7:00							
7:30							
8:00							
8:30							
9:00							
9:30							
10:00							
10:30							
11:00							
11:30							
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18:30							
19:00							
19:30							
20:00							
20:30							
21:00							
21:30							
22:00							



Physical activity questionnaire of the previous weekend day

Subject
no

Name:

Race: W B C I

Age:

Gender: M V

Grade:

School:

Teacher:

Date:

Classification

Think back about the weekend. 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 weekend that you fill in this form

Time	TYPE	Activity	METS	Saturday		Sunday			
						Very light	Light	Med- um	Hard
7:00									
7:30									
8:00									
8:30									
9:00									
9:30									
10:00									
10:30									
11:00									
11:30									
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19:30									
20:00									
20:30									
21:00									
21:30									
22:00									



BYLAAG D

Antropometrisese datakaart

PLAY-STUDY - DATASHEET

PLAY - DATA sheet		Subject no	
Name:		Gender	M ☐ F ☐
Age:		Grade	
Birth date:		Arm span	
Test date:			
ANTROPOMETRIC MEASUREMENTS			
Stature		Calf sf	
Body mass		Abdominal	
Sub scapular sf		BMI	
Triceps sf		% Bodyfat	
FITNESSGRAM			
Bleep-toets (Levels)		Pacer-toets (Laps)	
Activity monitor			
Curl Up		Trunk lift	
Push Up		Standing long jump	
Sit and reach	R	Step up test	
	L		
Modified sit and reach			
Bent armhang (girls)		Pull-ups (boys)	
		Handgrip strength	

Do you have any medical conditions/illnesses we should be aware of?

BYLAAG E

Riglyne van Outeurs

Human Biology

Guidelines for Contributors

Human Biology publishes scientific articles, brief communications, letters to the editor, and review articles on the general topic of population biology and genetics. Manuscripts should be submitted to

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You should submit an original and three copies of your manuscript. The manuscript should be typed or word-processed and double-spaced throughout, including the author affiliations, the Literature Cited, the figure captions, and the tables. Please use 8.5 x 11 inch (21.5 x 27 cm) paper. The article should follow the style of *Human Biology* and should be written concisely.

Organization. The manuscript should be organized as follows. The first page should be a *title page*, including the title of the paper, authors' names, complete authors' affiliations, and key words. The second page should contain the *abstract* of the paper. The abstract should give a summary of the article and not be merely descriptive of it. For example, state the results and the conclusions; do not use such phrases as "The results are discussed in terms of epidemiology." On the third page of the manuscript you should start the actual text.

The text should contain the following sections: an *introduction* (untitled) outlining the background of your topic and stating your purpose in writing the present article; the *materials and methods* (the study population, statistical methods, measurement methods, etc.); the *results*; and a *discussion*.

After the main text of your article, you should include a complete list of *Literature Cited*. In the text, you should cite the articles by author and date. In the Literature Cited section the articles should be in alphabetical order by author. The reference list should include all articles cited in the text, figure captions, and tables. Please do not pad your list with papers you do not cite. Following the Literature Cited section are the tables and the figure captions.

References. Each reference in the Literature Cited section should be complete. For journal articles this means that you should include all authors' names, date, title of article, journal title (abbreviated according to *Index Medicus*, or spelled out completely if the journal is not listed in the *Index*), volume number, and inclusive page numbers. For chapters in a book you must list all authors' names, date, title of chapter, title of book, editors of book (name them all), publisher and city (and country if outside the United States) where the publisher is located, volume number if necessary, and inclusive page numbers. If you are referencing an entire book, include all the authors' (or editors') names, date, title, and publisher and location. Other types of references (technical reports, dissertations, etc.) should

always include as much information as possible: all authors' names (sometimes the author might be a corporation or an organization), date, title, publishing organization and location, number of report, name of university and location, series designation, etc. Articles appearing in conference proceedings should be treated as chapters in a book; that is, you will list all authors' names, date, title of article, title of conference proceedings book (not the name of the conference, where it was held, and on what date), editors of the proceedings, publisher (probably the organization that sponsored the conference) and location, and volume and page numbers.

Tables. You should place the tables after the Literature Cited section. Each table should be typed on a separate sheet of paper, double-spaced, in *Human Biology* style. Do not use vertical or slant rules. Keep in mind that the table should not contain more columns of data than will fit on a printed page turned sideways. The tables should be numbered sequentially in the order they are to appear. Make sure that each table is cited in the text in sequential order. Each column should have a heading, and all units should be clearly marked (% , cm, etc.).

Figures and Figure Captions. After the tables should be a list of figure captions. Because the figure captions are typeset, they should not be part of the actual illustrations. They should be typed on a separate sheet of paper as you would the text, that is, double-spaced. You do not have to use a separate page for each caption.

All illustrations should be in black and white and numbered sequentially. On the back of each figure, clearly mark the authors' names and figure number. Keys and other internal matter should be lettered on the figure, or if possible, included in the figure caption.

Submit the originals of line drawings or glossy photographs made of them. Photocopies of figures are not acceptable. If you have computer-generated graphics, you should submit good laser printer copies. Photographs should be clear, sharp, and of high contrast. They should be printed on glossy paper. Please keep in mind that your figures will probably be reduced to fit the journal page. Thus make sure that all lettering and symbols will be able to withstand substantial reduction and still be legible.

Style Notes

It is the style of *Human Biology* to use the Human Gene Mapping Workshop nomenclature for genetic systems. This nomenclature system and its terminology are explained by Shows et al. in their article "Guidelines for Human Gene Nomenclature: An International System for Human Gene Nomenclature (ISGN, 1987)" [*Cytogenet. Cell Genet.* 46:11-28 (1987)]. In addition, the abbreviations for specific alleles, enzymes, markers, etc. are given by McAlpine et al. ["Report of the Nomenclature Committee and the 1989 Catalog of Mapped Genes," *Cytogenet. Cell Genet.* 51:13-66 (1989)].

It is also the style of the journal to use metric units. In addition, symbols, diacritical marks, and other unusual characters should be clearly marked on the manuscript. Also be sure to distinguish between the number "1," the letter "l," and the letter "I" if you are using a sans serif typeface.

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BODY FAT, BODY MASS INDEX IN BLACK SOUTH AFRICAN ADOLESCENTS AFTER A PHYSICAL ACTIVITY INTERVENTION PROGRAMME: PLAY STUDY

Dollien Naudé, H. Salome Kruger,
Anita E. Pienaar and R. Lesly Mamabolo

ABSTRACT

The purpose of this study was to firstly determine the effect of a physical activity (PA) intervention on body composition (BC) in black South African adolescents in the North West Province. Secondly, to determine what body composition variables will best describe the body composition changes. A total of 280 black adolescents (113 boys, 167 girls), aged 13-18 years from two schools were tested. A PA intervention programme was followed for 19 weeks in the intervention school, but not in the reference school. BC i.e. waist-to-hip-ratio (WHR), body mass index (BMI), percentage body fat (%BF) and skin folds were measured at baseline and end. Participants of the intervention school were divided into two groups according to their attendance of the intervention. WHR decreased in both genders in the high PA attendance group ($p < 0.05$). Boys showed a higher decrease in %BF than girls, although there were no significant decreases in body mass index (BMI). PA improved the body composition of the high attendance groups, especially for boys. It is recommended that specific body composition characteristics i.e. skin folds, %BF, waist and height rather than BMI alone, should be measured during puberty, keeping growth changes with increasing lean body mass in mind.

Key words: Adolescents, body composition, physical activity, fat percentage, South Africa.

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INTRODUCTION

Puberty is a dramatic time of change in any individual's life (Spear, 2002).

During the pre-school years, both sexes feel equally good about their physical appearance, however, the physical development that takes place during puberty makes girls more negative and shy (Park, 2003). For boys, the physical changes are usually positive (Park, 2003). When physical changes are measured during puberty it is important to use methods that are accurate and appropriate for specific populations (Houtkooper, Going, Sproul, Blew & Lohman, 2000). Anthropometry is one of the most basic methods to determine over- and under-nutritional status (Mei, Grummer-Strawn, Pietrobelli, Goulding, Goran & Dietz, 2002). Other sophisticated body composition (BC) measurement methods are more expensive and often not available in developing countries (Mei *et al.*, 2002). Information regarding BC for specific populations is useful for many clinical and nutrition related studies (Goran, 1998; Mantsena, Monyeki, Brits, Toriola & Kangolle, 2003). BC is also important to identify overweight children that have greater risks for certain chronic diseases of lifestyle and mortality later in life (Nieto, Szklo & Comstock, 1992; Must, Jacques & Dallal, 1992; Power, Lake & Cole, 1997).

Anthropometry can additionally be used as a marker of metabolic change during a period of growth and maturation such as puberty (Jürimäe, Leppik & Jürimäe, 2004). Research has shown that over-nutrition is one of the causes of obesity in the preadolescent years and even during puberty and is becoming a growing health concern in industrial and even developing countries (Potera, 2004).

In South Africa, there has been a remarkable weight increase among black adolescent girls during mid-adolescence, which is not necessarily seen in boys (Kalk, 2001). It is important to prevent obesity as early as in childhood to improve public health (Bar-Or, Foreyt, Bouchard & Brownell, 1998) as behavioural patterns, such as inactivity during childhood and puberty, are most likely to continue in adulthood and are very difficult to change (Pronk & Boucher, 1999; Van der Merwe, 2001; Kalk, 2001). Childhood obesity and lack of physical activity are world wide public health problems and many clinical programmes are developed for treatment of obese children (Cole, Faith, Pietrobelli & Heo, 2005). In a study by Owens *et al.*

(1999) on obese children, it was found that regular exercise, without a diet intervention, improved $\dot{V}O_2$ and cardiovascular fitness. Thus, an increase in physical activity (PA) without a diet has a positive effect on children's $\dot{V}O_2$ and BC (Owens *et al.*, 1999). It is found that exercise does not only have a decreasing effect on fat mass, but increases lean body mass in healthy adolescents (Bar-Or & Baranowski, 1994).

Body-mass-index (BMI) is one of the common techniques used to identify obesity among adults and is also used as a classification for overweight and obesity among adolescents and children (Mei *et al.*, 2002). It seems that BMI will continue to be the most popular anthropometric method to determine nutritional status because it is cheap, easy to use and existing data can be used for comparison (Freedman & Perry, 2000). Although BMI is a popular method for assessment of obesity that is easy to use, it can be misleading when used alone (Maddalozzo, Cardinal & Snow, 2002). For example, an athlete with a high percentage of lean body mass and a percentage body fat (%BF) of 12 percent

All parents and children gave a written informed consent. A physical activity (PA) intervention programme was followed for 19 weeks in the school with the largest number of learners, and the other school was used as a reference school, with no physical activity intervention. Weight, height, waist circumference, %body fat (Bod Pod) and triceps (TSKF) and subscapular (SSKF) skinfolds were measured at baseline and end to determine if changes occurred. The children's Tanner stages were also determined (Tanner & Whitehouse, 1982).

Much controversy still exists regarding the most appropriate method to determine obesity among adolescents. Therefore, various methods and indexes were used in this study to measure body composition. %BF and lean mass was measured with air displacement *Plethysmography* (ADP) according to the instructions of the manufacturer (BODPOD Life measurement, Inc). All anthropometric measurements were done according to the International Society for the Advancement of Kinanthropometry (ISAK)-standard (ISAK, 2001). The

Lohman classification was used to classify the children according to sum of skinfold %BF for adolescents (Lohman, 1981). The Cole *et al.*, (2000) cut-off points were used in the classification of BMI specifically for adolescents aged 15 to 18 years.

Equipment that were used in measuring the different anthropometric variables were a calibrated electronic scale for measuring body mass (Precision Health scale, A&D Company, Saitama, Japan), a stadiometer to measure height (IP 1465, Invicta length meter, London, UK) and a John Bull (British Indicators, London) skinfold calliper with a constant pressure of 10 gram per cubic millimetre (g/mm^3) to measure skinfold thickness to the nearest 0.2 millimetre (mm).

Waist circumference, which is also a measure of weight status and predictor of cardiovascular disease risk (Kruger, Margetts & Vorster, 2004) was measured by using a steel measuring tape (Lufkin, Cooper Tools, Apex, NC). Body density (%BF and lean mass) was measured in an air displacement plethysmography (ADP) and the BODPOD® scale (Life-measure-

-ments, Inc. Concord, CA) was used. Measurements were performed according to the manufacturer's instructions and recommendations, with each subject wearing a tight-fitting swimsuit and swim cap. Once the body density was measured the formula of Siri and Brozek was used to measure body density (Thomas & Nelson, 2001).

Physical activity intervention

During the 19-week intervention, one of the two sampled schools participated in a PA programme supervised by postgraduate Biokinetics students. The programme was performed twice weekly for an hour session per day. The programme consisted of 20 minutes of aerobic dancing (with music), 20 minutes of ball related skills and games (i.e. soccer, netball and basketball) and 20 minutes of strength- and flexibility exercises (i.e. carry a friend and use a friend to stretch). The aerobic training included dancing, Kata boxing, and aerobic exercises and the intensity of the activity session were set at a heart rate level between 115 – 180 beats per minute (Winnick, 2005). The intensity of the programme was monitored through

measuring energy expenditure with accelerometers (Actical, Mini Mitter, Bend OR), worn by some of the adolescents in each session. Group leaders also supervised the intervention to ensure that all children participated at a similar intensity. Attendance was monitored by checking lists of those who were present in each session. The group of adolescents were classified into three groups, according to the frequency of participation: 0 = Reference school (no participation), 1 = low attendance group (0-50% of the sessions attended) and 2 = High attendance group (>50% of the sessions attended). It was decided that at least one session per week or an average of 50% attendance of the intervention programme would be adequate to have an effect on body composition changes over 19 weeks. The children participated voluntarily after school.

Statistical analysis

Statistical computer software (Statistica 2007, Stat Soft, Inc. for Windows) of the North West University was used for the analysis of the collected data.

Firstly, descriptive statistics was used to present BC components and to describe the subjects as a group. Analysis of covariance (ANCOVA) of the different attendance rates was used to determine BC change after a PA intervention (controlled for baseline measurements, Tanner stage, PA during the week and weekend-PDPAR score). BMI is presented using frequency tables. Significance level was set at $p < 0.05$.

RESULTS

Anthropometric characteristics and attendance at the intervention

Table 1 shows the age and body composition of the girls and boys respectively at baseline. Only five children in the intervention school did not attend any of the physical activity intervention sessions and 41% of the children attended 50% or more of the sessions. Within an hour of exercise, on average 56.5% of the time was spent in vigorous activity, 24.5% in moderate activity, 17% in light activity and 2% sedentary according to Actical measurements (Actical, Mini Mitter, Bend OR).

Table 2 describes the analysis of covariance of the different physical activity intervention attendance groups after the PA intervention. Boys and girls in the high PA attendance groups had the lowest %BF, with a greater decrease in %BF in boys than girls, even though there were no significant decreases in BMI. The BMI values were similar in all the different PA attendance groups, whereas for %BF and sum of skinfolds, the low and high attendance groups had lower values than the reference group after the intervention.

Figure 1 is a graphic illustration of the analysis of covariance for different BC variables for the different PA attendance groups after the PA intervention. Figure 1 shows a significant difference ($p < 0.001$) between the sum of two skinfolds (triceps and supraspinal) for the different attendance groups in girls. In Figure 1, the waist circumference for the different attendance groups in girls showed significant differences ($p = 0.003$). For the boys (Figure 1) there was a significant difference in the sum of skinfolds ($p = 0.001$) and %BF ($p = 0.04$).

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Table 1 Age and body composition measurements for both genders at baseline

Gender	Variables	N	Mean±SD	Base line measurements	
				Minimum	Maximum
Girls	Age (y)	166	14.31 ± 1.38	12.00	18.00
	Waist (cm)	166	63.56 ± 6.17	48.00	86.00
	Height (cm)	166	153.76 ± 6.50	130.0	172.00
	Mass (kg)	166	46.48 ± 9.70	22.2	85.8
	BMI (kg/m ²)	166	19.65 ± 3.68	13.11	38.62
	%Body Fat (%)	123*	28.17 ± 6.06	14.60	54.90
Boys	Age (y)	113	14.65 ± 1.26	13.00	18.00
	Waist (cm)	113	62.95 ± 4.42	53.00	81.00
	Height (cm)	113	156.43 ± 9.59	135.0	179.00
	Mass (kg)	113	44.21 ± 9.03	27.6	78.0
	BMI (kg/m ²)	113	17.79 ± 2.32	13.23	25.64
	%Body Fat (%)	96*	19.17 ± 5.42	7.20	42.30

N = Number of subjects, SD = Standard deviation, cm = centimeter, kg = kilogram, BMI = Body mass index (kg/m²), % = percentage. *Due to practical reasons %body fat of all children could not be measured (BODPOD laboratory was only available on specific times).

Table 2: Adjusted means ± standard deviation of the different attendance rate groups after a PA intervention (Analysis of covariance adjusted for baseline measurements, Tanner stage and PA).

Body Composition	Girls			p*
	Reference group	Attendance 0-50%	Attendance >50%	
Body mass index (kg/m ²)	n 41 20.32±0.14	63 20.34±0.12	62 20.39±0.12	0.92
Waist circumference (cm)	n 41 62.49±0.38	63 63.96±0.30	62 63.85±0.30	<0.001*
%Body Fat (BODPOD)	n 19 29.35±0.85	51 28.01±0.52	55 27.00±0.50	0.001*
TSKF+ SSSKF (mm)	n 41 33.78±0.97	63 27.43±0.77	62 28.97±0.79	<0.001*
BOYS				p*
Body mass index (kg/m ²)	Reference group	Attendance 0-50%	Attendance >50%	
	n 21 18.19±0.13	64 18.23±0.07	25 18.55±0.12	0.05
Waist circumference (cm)	n 21 62.53±0.44	64 63.12±0.25	25 62.56±0.40	0.6
%Body Fat (BODPOD)	n 13 19.94±1.11	54 16.75±0.54	23 17.65±0.83	0.04*
TSKF+ SSSKF (mm)	n 21 17.44±0.60	64 14.85±0.34	25 14.39±0.54	<0.001*

N = Number of subjects, p = level of significance (p<0.05), SD = standard deviation, %Body Fat = percentage body fat, < = smaller than. TSKF = triceps skinfold, SSSKF = supraspinal skinfold, PA = physical activity measured by previous day physical activity recall.

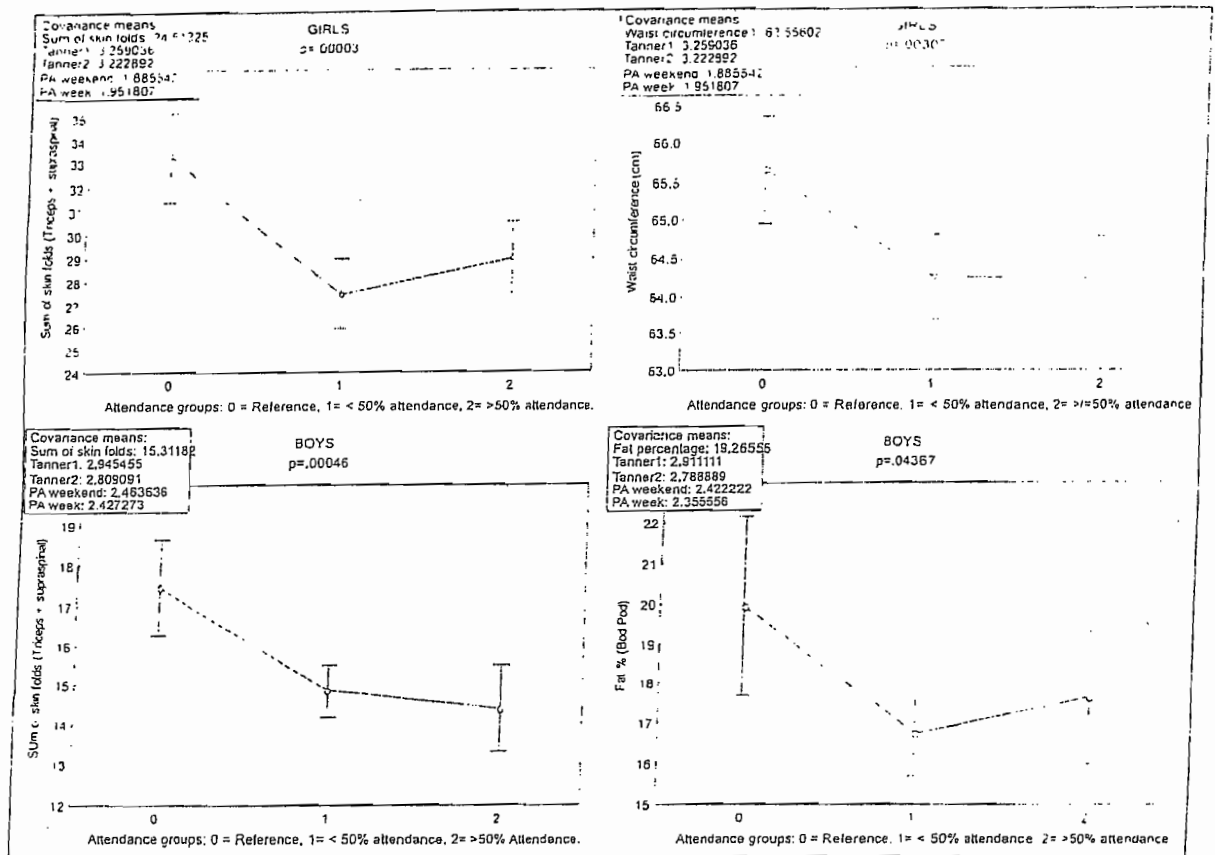


Figure 1: Analyses of covariance for the sum of 2 skin folds (triceps and supraspinal), waist circumference (cm) and % BF (Bod Pod) for different attendance groups in girls and boys, respectively.

The %BF for the girls and the boys both differed significantly between the three groups ($p < 0.05$).

Table 3 shows the %BF classification for the different attendance groups of boys and girls according to the Lohman (1981) standard for adolescents. For the boys (at baseline and end measurements) most of the boys were classified as having an optimal %BF. The high attendance group showed a decrease whereas the low

attendance stayed the same and the reference group had increased values at end measurements (two subjects classified as obese/very high %BF). Most children in all the groups were classified as having an optimal %BF. At end measurements, the reference group had two subjects in the very high %BF range. The high attendance group showed the best improvement at end measurements and the low attendance group showed little change.

Table 3 Lohman (1981) classification for the %BF based on sum of skinfolds (triceps and supraspinal) for boys ($n = 115$) and girls ($n = 166$) of the three attendance groups at baseline and after the PA intervention

Lohman %Body Fat classification	Baseline			End		
	Reference group ($n = 24$)	< 50% ($n = 64$)	?50% ($n = 26$)	Reference group ($n = 24$)	< 50% ($n = 64$)	?50% ($n = 26$)
BOYS						
0-14% (low)	(5) 29.2%	(27) 42.2%	(10) 38.5%	(2) 8.3%	(28) 43.8%	(7) 26.9%
>11-20% (optimal)	(11) 45.8%	(33) 51.6%	(12) 57.7%	(10) 41.7%	(21) 32.8%	(11) 42.3%
>20-25% (average)	(5) 20.8%	(4) 6.2%	(2) 7.7%	(4) 16.7%	(1) 1.6%	(1) 3.8%
>25-31% (high)	(1) 4.2%					
>31% (very high)				(2) 8.3%		
	Reference group ($n = 43$)	< 50% ($n = 61$)	?50% ($n = 62$)	Reference group ($n = 43$)	< 50% ($n = 61$)	?50% ($n = 62$)
GIRLS						
0-15% (low)	(5) 11.6%	(5) 8.3%	(10) 16.1%	(1) 2.3%	(2) 3.3%	(5) 4.8%
>15-26% (optimal)	(20) 46.5%	(37) 60.6%	(41) 66.1%	(13) 30.2%	(24) 39.3%	(35) 56.5%
>26-30% (average)	(8) 18.6%	(13) 21.3%	(5) 8.1%	(8) 18.6%	(27) 44.3%	(14) 22.6%
>30-35.5% (high)	(6) 13.9%	(4) 6.5%	(5) 8.1%	(11) 25.6%	(5) 8.2%	(7) 11.3%
0-15% (low)	(5) 11.6%	(5) 8.3%	(10) 16.1%	(1) 2.3%	(2) 3.3%	(3) 4.8%

N = Number of subjects, %Body Fat = percentage body fat, <50% = low attendance group – less than 50% participation, ?50% = high attendance group – attended 50% and more of the PA intervention

The girls showed a much different picture regarding their %BF compared to the boys. None of the groups showed a significant improvement after the PA intervention, but the high attendance group had the best (lowest values) classification compared with the low attendance and reference groups. The reference group and low attendance group had worst results after the intervention and had a higher prevalence of over-fat and obese children among these adolescents. The reference group increased from 13.9% to 25.6% in the high %BF range, and from 9.4% to 23.3% in the very high (>36%) % BF

classification. Only a small percentage decrease was seen in both the low attendance and high attendance groups. According to the BMI measurements (Table 4) for the boys, all the children in the high attendance group and low attendance group had normal weight classifications (100%). The reference group had a decrease in normal BMI values from 91.2% to 88.2% in the normal classification and an increase in overweight from 8.8% to 11.8%. For the high attendance group in the girls, no obese subjects were reported and they showed the best results between the three attendance groups.

Table 4. Body mass index classification for both genders at baseline and at the end of PA intervention for the three groups (Cole *et al.* 2000)

BMI class	GIRLS					
	Baseline			End		
	Reference group (n = 43)	< 50% (n = 61)	> 50% (n = 62)	Reference group (n = 43)	< 50% (n = 61)	> 50% (n = 62)
Normal weight	(36) 84.5%	(54) 88.6%	(56) 90.6%	(33) 76.8%	(54) 88.4%	(52) 84.4%
Overweight	(5) 12.1%	(4) 6.8%	(6) 9.4%	(8) 17.9%	(4) 7.0%	(5) 12.6%
Obese	(3) 3.4%	(3) 4.5%	-	(2) 5.4%	(3) 4.7%	-

BMI class	BOYS					
	Baseline			End		
	Reference group (n = 24)	< 50% (n = 64)	> 50% (n = 26)	Reference group (n = 24)	< 50% (n = 64)	> 50% (n = 26)
Normal weight	(22) 91.2%	(64) 100%	(26) 100%	(21) 88.2%	(64) 100%	(26) 100%
Overweight	(2) 8.8%	-	-	(3) 11.8%	-	-
Obese	-	-	-	-	-	-

BMI = Body mass index (kg/m^2), < 50% = Low attendance group, > 50% = High attendance group, % = percentage

The reference group (girls) again showed higher BMI values and the low attendance group showed little change. Overall, the low attendance (<50%) and high attendance groups (>50%) showed the best results at baseline and end measurements in both sexes for BMI.

DISCUSSION

The results show that PA was beneficial in the high attendance groups of adolescents, especially for boys. To monitor loss of body fat during puberty, it is better to measure specific anthropometric characteristics i.e. skinfolds, %BF (measured by Bod Pod), waist

circumference, rather than BMI, keeping growth changes and puberty in mind. The low attendance PA group and reference group showed the least changes in skinfold thickness over the 19-week period, which can be an indication that these participants had low PA interests. Although there were signs of lower %BF in the low PA group, the reference group showed no change. Inactivity can be seen as one of the major factors that contribute to the obesity problem in the world (Trudeau & Shephard, 2005). A decrease in PA can be influenced by biological changes such as puberty and hormonal

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changes (Van Mil, Goris & Westerterp, 1999). Changes in adipose tissue are also prevalent during maturity and growth, and regular exercise can influence the patterning and distribution in growing children (Bar-Or & Malina, 1995). This can also be seen in the measurements in this study.

It is clear that the high attendance groups tended to have a more optimal BC (Table 2) at baseline and some of the participants did not show much improvement in terms of BC differences, even though they had high participation levels during the PA intervention. This phenomenon is known as 'the "ceiling" effect' (Faigenbaum, 1997). This may be due to the fact that these adolescents had high interest levels in PA even before the intervention. Boys showed more optimal BC than the girls throughout the study. For girls, puberty brings menstruation and hormonal changes, which can be associated with body fat gain and even possible body image dissatisfaction (Sweeting & West, 2003). Puberty usually has the opposite effect on BC and body image in boys (Sweeting & West, 2003).

In Tables 3 and 4, the differences in %BF and BMI can be compared. The BMI estimates of overweight are much lower than the sum of skinfolds estimates and even %BF measured by ADP. Very few participants were classified as overweight or obese in the girl's groups according to the BMI classification (Cole *et al.*, 2000), but the sum of skinfolds and ADP estimates were more consistent in comparison with each other. After the PA intervention there was a decrease in sum of skinfolds and %BF values in the high PA attendance group, but not in BMI. With BMI, the terms "overweight" and "obesity" are often used to describe the same condition, but to be overweight means that a person has too much body weight for his/her length whereas obesity is a surplus of body fat (Freedman & Perry, 2000). One of the problems with BMI is to distinguish between a person being "over-fat" or being "overweight" (Cameron & Getz, 1997). When BMI is used to determine the height-weight ratio, the term "overweight" can be used, but when subcutaneous tissue is measured (skinfolds) and there is a high amount of fat, the term "over-fat" can be used to

describe the condition (Cameron & Getz, 1997). Simple methods for example skinfolds as a measure of being over-fat have not yet been studied extensively on large groups of children in developing countries and also on stunted children (Hoffman *et al.*, 2006). A study done in Black South African children showed, however, that stunted girls tended to have relatively more subcutaneous fat and greater waist circumference than their non-stunted counterparts (Kruger *et al.*, 2004). Differences in height-for-age do influence the interpretation of simple methods such as BMI, which are used to determine obesity and overweight condition (Hoffman *et al.*, 2006). Thus, the interpretation of overweight or obesity should rather be done according to the measurement of body fat, for example skinfolds. In Table 4, waist circumference (WC) differences were significantly different among the different attendance groups of girls. According to Maffeis *et al.* (2001), the WC is one of the best methods to determine weight status among children. Waist-hip-ratio is also a good indicator of risk for cardiovascular disease and total body fat in adults, but not necessarily for children

(Dietz, 1995). Individuals who accumulate fat around the umbilical area have a greater health risk than the individuals who accumulate fat around the hip and gluteus area. During the pre-adolescent years few children have a central type of fat distribution, but it becomes more prevalent during puberty (Goran, 1998). Genetic factors also play a role (Bar-Or *et al.*, 1998).

A limitation of this study was the small sample size of children who participated regularly in the intervention. Many of the adolescents reported that they had household chores and some of the children even had to work to support their families. Peer pressure may also have had an influence on participation. Even less children participated during the school holidays and during examination times. These factors are difficult to overcome by the children themselves and indicate that physical activity as part of the school curriculum, rather than after-school physical activity interventions should be implemented to increase the physical activity of township high school children.

The authors recommend further research with larger groups and in different provinces at the same time. Rural and urban differences in physical activity and body composition could also be compared. Adolescents need to be educated about correct exercise modes and healthy eating habits, especially in South Africa and other developing countries. Parents and teachers should also get involved in the intervention and implementation of such research. This way, larger groups will be interested and there will be more control over the intervention. This can possibly promote healthy living in the community and in their own households.

CONCLUSION

In conclusion, the results of this study indicate that there was a general improvement in BC among the adolescents who participated in 50%-100% of the 19-week PA intervention programme sessions. Little change was seen in the BMI values, showing that growth and development during puberty should be taken into consideration, especially in boys. The decrease in %BF and sum of skinfolds and no change in

BMI after a 19-week PA intervention could be used to conclude that when studying BC changes in adolescents, %BF or skinfold thickness rather than BMI should form the basis for classifying fatness and nutritional status.

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Differences in body composition, body proportions and timing of puberty between stunted and non-stunted adolescents

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Abstract

The purpose of this study was to assess differences in body composition, body proportions and timing of puberty between stunted and non-stunted South African adolescents in the North West Province, South Africa. A total of 259 black adolescents (118 boys, 141 girls), aged 13-18 years were measured. The following data were collected: height-for-age z-scores (HAZ), height, mass, waist circumference (WC), waist-to-height ratio (WHtR), waist-to-hip-ratio (WHR), body mass index (BMI), percentage body fat (%BF), Tanner stage, armspan and skinfolds. Data of growth stunted (GS) and non-stunted (NS) groups were compared using the Mann-Whitney U-test. There were significant differences between mass, height, HAZ, armspan, WC, hip circumference and lean mass of GS and NS children. %BF, WHR and physical maturation were similar in the two groups, but lean mass was smaller in the GS groups indicating proportionally more fat and less lean mass in the GS groups. WHtR of GS children was significantly greater than WHtR of NS children, indicating a more central fat distribution in GS children. Only 3.5% of children had a WHtR >0.5, indicating abdominal obesity, but 54% of children had a %BF above 20% in boys and 25% in girls. A WHtR cut-off of 0.5 may not be appropriate for these African children.

Key words: *Adolescents, body composition, stunting, fat percentage, puberty, South Africa.*

Introduction

The World Health Organization (WHO) has determined that there is approximately 230 million children worldwide that are growth stunted (GS) (Height-for-age z-value (HAZ) < -2). The worldwide problem of GS or malnutrition can be ascribed to social, economic and cultural problems, especially in developing countries (Michaelsen, Weaver, Branca & Robertson, 2000). In the North West Province of South Africa 19% of children between the ages of 10-15 years are GS (Mukuddem-Petersen & Kruger, 2004). Pre-school children, especially in the African populations, are exposed to malnutrition and this has a huge impact on growth and development (Bénéfice, Garnier, Simondon & Malina, 2001). Possible causes of GS in South Africa are unemployment and poverty (Erik & Gericke, 2000; Napier & Albertse, 2000).

GS in length leads to a decrease in final length, or rather dwarfism (Bénéfice *et al.*, 2001). The smaller body size of chronically undernourished children limits their maximum aerobic strength (Bar-Or, Foreyt, Bouchard & Brownell, 1998). Malnutrition can also be associated with a smaller possibility to perform difficult physical work (Bar-Or *et al.*, 1998). Differences in height-for-age make it difficult to classify children as overweight or obese according to body mass index (Hoffman, Sawaya, Martins, CcCrory & Roberts, 2006).

Sex hormones have an influence on the distribution of fat during adolescence (Freedman & Perry, 2000). Black children are more inclined to have a central fat pattern with less fatty deposits on the limbs (Malina, 1996). Therefore race also plays a role in fat distribution. A South African study indicated that stunted girls had relatively more subcutaneous fat than non-stunted girls and that they had a more central fat distribution (Mukuddem-Petersen & Kruger, 2004). There are various mechanisms concerning how fat distribution can affect metabolism and clinical complications. Intra-abdominal fat is important due to the proximity to the hepatoportal vein and the sensitivity this fat has to lipolytic stimuli (Björntorp, 1990). Intra-abdominal fat storage plays an important role in the negative effect of excessive body fat, e.g. hypertension, insulin resistance and high blood cholesterol (Lara-Castro, Weinsier, Hunter & Desmond, 2002).

The long term effects of malnutrition that leads to GS create concern (Bénéfice *et al.*, 2001). In a study by Ibrahim, Abdel-Maksoud, Samy, Mattar, Sarhan and Hassan (2003) it was found that bone mineral density in the GS group was lower than in the control group. Calcium and magnesium serum levels were also lower in the GS group. A limited intake of the necessary skeletal bone forming nutrients has a large impact on bone mass. Osteoporosis is a skeletal condition that results from a decrease in the total bone density which in turn leads to brittleness and an increased risk of fractures (Ibrahim *et al.*, 2003).

The long term effects of malnutrition that leads to GS create concern, both by limiting ability to perform difficult physical work (Bar-Or *et al.*, 1998) and by being associated with a central fat distribution (Mukuddem-Petersen & Kruger, 2004), which could increase their risk for non-communicable diseases (Lara-Castro *et al.*, 2002). Differences in height-for-age also make it difficult to classify GS children as overweight according to body mass index (Hoffman *et al.*, 2006). Thus, the aim of this study was to determine the differences in body composition components, physique and timing of puberty between non-stunted (NS) and stunted (GS) adolescents.

Methods

Participants

The study comprised an availability sample from two secondary black schools in Ikageng in the North West province. A total of 259 adolescents (118 boys and 141 girls) between the ages of 13 – 18 years were included. The two schools were selected from five available schools with the aid of a local nutritional advisor, as the GS children were more prevalent in these schools. All the parents and children gave informed consent and the study was approved by the Ethics committee of the North-West University (NWU).

The following variables were measured: height, weight, waist circumference (WC), percentage body fat (%BF), lean body mass, skinfolds (tricep, subscapular, supraspinal, abdominal, bicep and calf), Tanner's phases of maturation (Tanner & Whitehouse, 1982) and armspan. Body mass index (BMI), waist:height-ratio (WHtR) and waist:hip-ratio (WHR) were calculated. HAZ was calculated for each adolescent according to the gender specific height-for-age percentile of the Centre for Disease Control (CDC). Participants with a HAZ < -2 were classified as GS (CDC, 2000).

Participants' phases of maturation were determined by means of two gender specific questionnaires. The "Female self-evaluation of adult characteristics" questionnaire was used by the girls using pictures and questions based on the five Tanner stages. The boys used the "Male self evaluation of adult characteristics" questionnaire. Tanner classifications were used to measure breast development and female pubic hair development, as well as age of menarche in girls. Changes in voice, hair and reproductive organ development in boys were determined. The girls and boys were assisted by adult Tswana speaking translators of the same gender as themselves to complete the questionnaire individually and confidentially. There were, however, four girls and three boys who did not give consent to these measurements.

%BF and lean body mass were measured by means of air displacement plethysmography (ADP) according to the instructions of the manufacturers (BODPOD Life Measurement Inc, Concord, CA, USA) (BODPOD - Customer training, 2003). All anthropometric measurements were taken by trained post graduate students according to the ISAK standard (ISAK, 2001). The following apparatus was used to measure the various anthropometric variables: a calibrated

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electronic scale for the measurement of mass (Precision Health scale, A & D Company, Saitama, Japan), a stadiometer for length (IP 1465, Invicta length meter, London, UK), a Harpenden (British Indicators, London, UK) skinfold caliper with a constant jaw pressure of 10 g/mm² to determine the skinfold thickness to the nearest 0.2 mm. Waist, hip and relaxed mid-upperarm circumferences were measured using a steel measuring tape (Lufkin, Cooper Tools, Apex, NC).

Statistical analysis

The Statistica-software package for Windows (StatSoft, 2009) was used to process the collected data. Descriptive statistics, namely mean and standard deviation (SD) was used to describe the variables of the GS and NS adolescents. Furthermore, the Mann-Whitney U-test was used to calculate the significant differences of certain variables between GS and NS adolescents. The Mann-Whitney U-test was selected due to the relatively small number of GS children in the present study and the fact that the distribution of some variables deviated from the normal distribution. The Chi-square test was also used to compare the categorical variables between the two groups, namely differences in the distribution within the five Tanner stages, as well as the differences between GS and NS girls and boys separately in the distribution between the groups with a body fat % lower or higher than the median. Significance level was set at $p < 0.05$.

Results

Tables 1 and 2 show the descriptive statistics and differences between GS and NS for girls and boys, respectively. There were significant differences ($p < 0.05$) in terms of mass, height, HAZ, armspan, waist, arm and hip circumferences, as well as lean body mass between the GS and NS girls. The armspan of the GS girls was significantly smaller than that of the NS girls, but the armspan-height ratio was practically similar in both groups, although significantly smaller in the GS girls. WHtR was significantly larger in the GS than in the NS children ($p = 0.04$ and $p = 0.03$, respectively in girls and boys).

Table 1: Differences in body composition between NS and GS girls (Mann-Whitney U-test)

Variables	NS		GS		p-value
	Mean $\pm$ SD	N	Mean $\pm$ SD	N	
Age (year)	15.4 $\pm$ 1.3	113	15.6 $\pm$ 1.1	28	0.001*
Mass (kg)	51.0 $\pm$ 8.57	113	44.1 $\pm$ 7.11	28	0.001*
Height-for-age z-score	-0.68 $\pm$ 0.75	113	-2.45 $\pm$ 0.45	28	0.001*
Height (cm)	157.5 $\pm$ 5.02	113	146.2 $\pm$ 5.17	28	0.001*
BMI (kg/m ²)	20.6 $\pm$ 3.30	113	20.6 $\pm$ 3.30	28	0.001*
Armspan (cm)	162.7 $\pm$ 7.38	113	149.9 $\pm$ 5.68	28	0.001*
Upper-arm circumference (cm)	23.7 $\pm$ 2.99	113	23.2 $\pm$ 2.64	28	0.001*
Waist circumference (cm)	65.0 $\pm$ 6.10	113	62.5 $\pm$ 5.28	28	0.001*
Waist:height ratio	0.41 $\pm$ 0.04	113	0.43 $\pm$ 0.03	28	0.001*
Hip circumference (cm)	86.8 $\pm$ 7.72	113	81.9 $\pm$ 6.39	28	0.001*
Waist:hip ratio	0.75 $\pm$ 0.05	113	0.76 $\pm$ 0.04	28	0.15
Triceps sf (mm)	16.1 $\pm$ 6.56	113	16.0 $\pm$ 4.74	28	0.48
Subscapular sf (mm)	12.4 $\pm$ 5.59	113	12.3 $\pm$ 4.45	28	0.69
Supraspinal sf (mm)	10.8 $\pm$ 0.95	113	10.8 $\pm$ 4.87	28	0.82
Abdominal sf (mm)	19.6 $\pm$ 7.71	113	18.6 $\pm$ 7.24	28	0.69
Biceps sf (mm)	9.1 $\pm$ 4.27	113	8.7 $\pm$ 3.01	28	0.86
Calf sf (mm)	19.2 $\pm$ 6.85	113	18.4 $\pm$ 5.51	28	0.91
%Body fat (BODPOD)#	29.4 $\pm$ 6.83	104	29.1 $\pm$ 6.53	27	0.72
Lean body mass (kg) #	35.2 $\pm$ 5.33	104	31.0 $\pm$ 3.63	27	<0.0001*
Armspan:height ratio	1.03 $\pm$ 0.03	111	1.02 $\pm$ 0.02	28	0.05

GS = growth stunted, NS = non-stunted, SD = standard deviation, N = number of subjects, p-value = significant difference at $p < 0.05$, kg = kilogram, cm = centimetre, mm = millimetre, WHR = waist-hip-ratio, BMI = Body mass index, sf = skinfold # Only 131 out of 141 girls were measured in the BODPOD due to time limitations

Table 2 shows the differences between GS and NS boys with significant differences in mass, height, HAZ, armspan, upper-arm, waist and hip circumferences, as well as lean body mass. The skinfolds of the GS boys were not significantly smaller than those of the NS boys, and %BF was similar in both groups. The Chi-Square test showed significant differences in %BF and lean body mass distribution ($p=0.01$), with more GS boys in the group with a higher %BF but lean body mass smaller than the overall median than NS boys. The reasons for the smaller number of subjects (boys as well as girls) with %BF and lean body mass measured by ADP are the limited time for measurements, shyness of some of the children and claustrophobia.

Table 2 Differences in body composition between NS and GS boys (Mann-Whitney U-test)

Variable	NS		GS		p-value
	Mean (SD)	N*	Mean (SD)	N	
Age (year)	15.8 ± 1.30	90	15.6 ± 1.25	28	0.84
Mass (kg)	52.2 ± 8.77	90	43.3 ± 2.20	27	0.0001*
Height (cm)	165.5 ± 6.57	90	152.0 ± 1.12	27	<0.0001*
Height-for-age z-score	-0.88 ± 0.65	90	-2.50 ± 0.41	28	<0.0001*
BMI (kg/m ²)	19.0 ± 2.56	90	17.9 ± 2.10	27	0.04*
Armspan (cm)	171.0 ± 8.41	85	157.8 ± 1.08	26	<0.0001*
Upper-arm circumference (cm)	23.2 ± 2.64	88	21.4 ± 1.68	25	0.001*
Waist circumference (cm)	66.8 ± 5.16	88	63.0 ± 1.37	25	<0.0001*
Waist:height ratio	0.40 ± 0.03	88	0.41 ± 1.53	25	0.03*
Hip circumference (cm)	80.5 ± 5.78	87	74.1 ± 1.41	25	<0.0001*
Waist:hip ratio	0.83 ± 0.05	87	0.85 ± 1.00	24	0.09
Triceps sf (mm)	8.72 ± 4.05	88	8.33 ± 1.13	25	0.52
Subscapular sf (mm)	8.10 ± 3.91	88	6.94 ± 4.83	25	0.06
Supraspinal sf (mm)	6.45 ± 4.20	88	6.16 ± 2.53	25	0.86
Abdominal sf (mm)	11.5 ± 7.03	88	10.3 ± 1.45	25	0.21
Biceps sf (mm)	5.20 ± 2.15	88	5.20 ± 1.11	25	0.68
Calf sf (mm)	11.1 ± 4.33	88	10.2 ± 1.01	25	0.26
%Body fat (BODPOD)#	17.6 ± 6.35	58	20.2 ± 1.21	22	0.07
Lean body mass (kg) #	42.8 ± 7.49	58	32.5 ± 2.27	22	<0.0001*
Armspan:height ratio	1.03 ± 0.02	85	1.03 ± 0.02	27	0.43

GS = growth stunted, NS = non-stunted, SD = standard deviation, N = number of subjects, p-value = significant difference at $p < 0.05$, kg = kilogram, cm = centimetre, mm = millimetre, WHR = waist-hip-ratio, BMI = Body mass index, sf = skinfold # Only 80 out of 118 boys were measured in the BODPOD due to time limitations, § Subject number differ due to missing data.

Five girls from a total of 142 (3.5%) had a WHtR > 0.5 , whereas none of the boys had a WHtR greater than 0.5. Most of the girls (78.6%) had a %BF of $> 25\%$ and 28% of the boys had a %BF of $> 20\%$. There were no significant differences in the distribution within the Tanner stages in both sexes between the GS and NS groups (Table 3).

Discussion

The observation of lower lean body mass, but similar %BF in GS children is a possible indication of relatively greater body fat in relation to lean body mass in these children. In a study by Mukddem-Petersen and Kruger (2004) it was found that GS children, aged 10-15 years in the North West province of South Africa were more inclined to store body fat than to exhibit an increase in lean body mass.

Table 3. Comparison of Tanner stage between GS and NS children

Gender	Tanner stage	GS (N=27 [§])	NS (N=110 [§])
Girls*	1	1 (3.7%)	0 (0%)
	2	4 (14.8%)	6 (5.5%)
	3	12 (44.4%)	14 (12.7%)
	4	9 (33.3%)	52 (47.3%)
	5	1 (3.7%)	8 (7.2%)
Boys#	1	0 (0%)	0 (0%)
	2	1 (3.8%)	1 (0.9%)
	3	10 (38.6%)	17 (15.5%)
	4	14 (53.8%)	53 (54.0%)
	5	1 (3.8%)	12 (13.4%)

GS = growth stunted, N = number of subjects, NS = non-stunted, % = percentage *Girls: Median Test, Overall Median = 4.0; Chi-Square = 0.45 df = 1 p = 0.50; #Boys: Median Test, Overall Median = 4.0, Chi-Square = 1.86 (df = 1) p > 0.05

[§] Subject number differ due to missing data.

It is interesting to note that most of the girls (78.6%) and a quarter of the boys possessed a relatively high %BF. In South Africa there is a noticeable increase in weight in black adolescent girls during mid-adolescence, which is not necessarily the case with boys (Kalk, 2001). In a study by Mantsena, Monyeki, Monyeki, Brits, Toriola and Kangolle (2003) in the Ellisras area of South Africa, it was found that adolescent girls possessed a higher %BF than boys of all ages. Skinfold thicknesses in children differ with regard to race, gender and age (Freedman & Perry, 2000), although there are less differences concerning fat distribution among adolescent girls (Flodmark, Sveger & Milsson-Ehle, 1995; Beunen, Malina & Lefevre, 1994). Sex hormones influence the changes in fat distribution during adolescence (Freedman & Perry, 2000).

From Table 1 it is clear that skinfolds (subcutaneous adipose tissue) of GS children did not differ significantly from the skinfolds of children with normal height. If the skinfolds of the two groups did not differ, but the GS children had relatively more body fat, the intra-abdominal fat may play a possible role in explaining the smaller lean body mass in contrast to the similar %BF between the two groups. Black children tend to have a central fat distribution with less fat deposits on the limbs (Malina, 1996). There are various mechanisms for fat distribution to influence metabolism and associated clinical complications. For example, intra-abdominal fat is close to the hepatoportal circulation and is sensitive to lipolytic stimuli which has a negative influence on fat metabolism (Björntorp, 1990). Central fat distribution is associated with an increased risk for cardiovascular diseases and deaths, as well as the development of Type 2

diabetes (Rosenbaum, Leibel & Hirsch, 1997; Montague & O'Rahilly, 2000). Many factors influence intra-abdominal fat, namely sex hormones, aging, increase in weight, genetic composition and lifestyle (e.g. inactivity, use of alcohol and cigarettes) (Lara-Castro *et al.*, 2002).

It was recently suggested that WHtR is a better predictor of abdominal obesity and cardiovascular risk than WHR in children (Nambiar, Truby, Abbott & Davies, 2009; Ashwell & Hsieh, 2005). The cut-off point for a high WHtR is 0.5 in adults (Ashwell, 2005), with a ratio larger than 0.5 associated with a greater risk of developing metabolic syndrome and cardiovascular disease (Hsieh, Yoshinaga, Muto, Sakurai & Kosaka, 2000; Hsieh & Yoshinaga, 1995). Ashwell (2005) also found that the WHtR cut-off point is applicable for various ethnic groups and children. In the current study it was found that five girls out of a total of 142 (3.5%) had a WHtR of >0.5, whereas none of the boys exhibited a WHtR >0.5. In a study by Nambiar *et al.* (2009) the WHtR cut-off point was valid for grade 10 girls but not for the boys. No research literature could be found with regard to WHtR of growth stunted adolescents.

Earlier studies indicate that there was only a small difference between height and armspan in children of normal height (Sinclair, Kithchin & Turner, 1960; Pearson & Lee, 1902). Armspan-height ratio was significantly smaller in the GS girls than in the NS group in the present study, but that there was no difference in the groups of boys. It is clear that the difference in the groups of girls was not practically significant which indicates that the armspan-height ratio was in the same proportion for all groups and the statistically significant difference found in this regard may be just an artefact. In general, the girls possessed a greater %BF than the boys, which can be ascribed to hormonal differences during puberty (Sweeting & West, 2003). Kindblom *et al.* (2006) found that early development of sexual maturation resulted in a larger central fat distribution and WHR. Not only do physical changes occur during puberty, but there are also changes in eating habits and lifestyle which influence the long-term health of children (Mukuddem-Peterson & Kruger, 2004).

Globally little time and attention are devoted to physical education classes in schools and more leisure time is spent on popular activities such as watching TV and computer games, which require minimal physical effort (Leupker, 1999; Van Mil, Goris & Westerterp, 1999; Bar-Or *et al.*, 1998; Van Deventer, 1998). Malnutrition causes GS and can also be associated with a limited ability to perform difficult physical work (Bar-Or *et al.*, 1998) which results in a lowered

lean body mass, as was found in this study. From the results of this study it is clear that physique and body composition differs between GS and NS girls and boys in terms of height, weight, armspan, waist circumference, hip circumference and lean body mass. The armspan, height, waist and hip circumferences of both genders were much smaller in the GS group, which is an indication of deprived growth in GS individuals.

Limitations of this study were that some of the children were shy during the measurement of body composition and answering the sexual maturation questionnaires and therefore were not prepared to take part in the study, or would not allow all the measurements to be taken. The BODPOD measurements require a long process and the children had to sit still in a closed cylinder, which resulted in claustrophobia in some children, and these reduced the number of children measured with ADP considerably. The smaller than expected sample size resulted in a small number of GS children in this study.

Conclusion

The lower lean body mass, but relatively higher %BF, regardless of the same skinfold thicknesses in the GS group can possibly be ascribed to higher intra-abdominal fat. As sex hormones are known for their influence on fat distribution, it is possible that the hormonal environment contributed to the fat redistribution (Freedman & Perry, 2000). Further research is necessary to determine if the hormonal environment in GS adolescents is different from that in NS adolescents.

A WHtR larger than 0.5 was present in only a small percentage of girls and none of the boys, although there was a large percentage of adolescents with relatively high %BF in the group. It could be necessary to adjust the WHtR cut-off point of 0.5 for GS adolescents. It is therefore recommended that more research should be done with regard to optimal WHtR specifically for GS adolescents. It is clear that there are differences between GS and NS adolescents of both genders in certain body composition and body proportion components, but no differences in sexual development.

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