# MEASURING PHYSICAL ACTIVITY IN SOUTH AFRICAN PRIMARY SCHOOL CHILDREN: A SELF-REPORT QUESTIONNAIRE VERSUS PEDOMETER TESTING.

By

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**ABSTRACT**

The prevalence of childhood obesity is increasing in South Africa and can be linked to decreased physical activity (PA). It is therefore important to be able to accurately measure children's PA levels. The primary aim of this study was to determine whether children in grades two and three are able to self-report PA by means of a questionnaire. Fifty-eight participants (28 females, 30 males) from a primary school in Gauteng were recruited for the study. The participants had to wear a pedometer (Omron HJ-720) for seven days after which they completed the Physical Activity Questionnaire for older Children (PAQ-C). The average steps per day were 9289, with weekday steps (10 219) being more than weekend steps (6795). The mean (±SD) score for the PAQ-C was 3.14 ± 0.47. There was a significant moderate correlation ($r$ = 0.49; p < 0.01) between the overall PAQ-C score and average steps per day. Therefore the PAQ-C can be an effective way in which to gain insight into PA levels in children but should not replace objective measures of PA. The participants in this study appear to be accumulating insufficient PA over the course of the week.



**KEYWORDS**

Physical activity, physical fitness, pedometer, questionnaire, school children, activity measurement, physical activity questionnaire for older children, PAQ-C, self-report measurement, Omron

**DEDICATION**

IN MEMORY OF JACOBUS PETRUS MALAN.

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## SYNOPSIS

Measuring physical activity in South African primary school children: A self-report questionnaire versus pedometer testing.

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| Degree | MA (HMS) |

The prevalence of childhood obesity is rapidly on the rise in South Africa and can be linked to decreased Physical Activity (PA) levels (Rossouw, Grant and Viljoen 2012). In order to address the problem one must be able to measure it and determine progression, thus there is a need to find a valid and reliable measure to assess PA levels (Biddle, Gorely, Pearson and Bull 2011). Currently there isn't a 'gold standard' with which to measure PA (Kowalski, Crocker and Donen 2004).

A cross-sectional design was selected to compare the PA measured using a pedometer versus a questionnaire of second and third grade students. Participants were recruited from Constantia Park primary school which consisted of a total of 58 participants, 29 from grade two and 29 from grade three (30 males and 28 females). Participants included were those in the specified grades without injury or impediment to PA.

Participants received an Omron HJ-720 pedometer, set up with their average stride length and body mass – which was worn for a week. Upon completion of the week the pedometers were returned for data download and the Physical Activity Questionnaire for Older Children (PAQ-C) was distributed to the participants for completion at home. The questionnaires were collected the following week for analysis and comparison to the pedometer data.

The total steps recorded on average by the participants were 9289 steps / day. This amount falls well short of recommendations of 15 000 steps / day and upwards to promote health. These findings correspond with the other studies conducted on PA levels in children (McVeigh and Norris 2012; Duncan, Al-Nakeeb, Woodfield and Lyons 2007). A pattern that was found is a marked decrease in steps taken over the weekend where the average steps per day was only 6796, compared to weekday steps of 10219. Further trends found in this study were gender differences in activity levels; males not only reported being more active but more steps were detected for male participants in all time segments. Between the grades, grade two was shown to have taken more steps after school compared to grade three. This was the only significant difference between the grades.

The PAQ-C score of the group (3.14 ± 0.47) is similar to that found in two previous studies for similar age groups (age eight to 13 and ages nine to 14) performed by Kowalski, Crocker and Faulkner (1997) (3.23 and 3.35 respectively). When comparing the activity score recorded in the PAQ-C with steps taken for the week, there was a moderately strong correlation ($r = 0.49$; $p < 0.001$) between the two, with a slightly stronger correlation ($r = 0.53$; $p < 0.001$) when only comparing the steps measured during the weekdays with the activity score. Individual items from the questionnaire held some association with steps measured during various intervals but the correlation was never as strong as when using the total aggregate score for the PAQ-C.

The overall PAQ-C score correlated almost perfectly with individual questions from the questionnaire that weren't examining specific time slots (i.e. activity during lunch time) but rather where participants gave themselves an overall description for the entire week (i.e. describe activity level on average for the whole week). This included the first and the ninth question of the questionnaire. The first question was a list of common physical activities and the participants had to select how often they participated in each activity. The ninth question involved participants giving themselves a rating for everyday of the week on general activity levels.

Therefore based on the findings of this study the PAQ-C can be used on a comparable group of South African children to gain insight into overall PA levels. Unfortunately the participants in this study appear to be reaching insufficient levels of PA based on steps measured per day, particularly over weekends. It is possible that this trend extends to the greater South African population (children). This is concerning due to the numerous health implications that insufficient activity levels in children poses. Though there wasn't a direct correlation between PA and body mass, previous research has shown the connection between inactivity and increased body mass as well as resulting increases in health risk factors.

Recommendations for future research include the use of a different pedometer model with a shorter random movement filter – due to the fact that intermittent activity of participants in this age group may lead to underestimating steps taken. It may also be preferable to complete the questionnaire under the supervision of the researcher in order to improve the accuracy with which the questions are answered, if feasible. Lastly, the questions focusing on PA particularly during the weekends could be amended.

An important limitation of this study that must be kept in mind was that two activities that were listed as part of the top five most commonly performed activities were swimming and cycling, which cannot be detected by a pedometer. Therefore this could have contributed to the reduced PA levels measured with the pedometer and influenced the correlation between the two PA measures.

**Key Words: Physical activity, pedometer, PAQ-C, questionnaire, school children, activity measurement**

**SAMEVATTING**

Meeting van fisieke aktiwiteit in Suid-Afrikaanse laerskool kinders: 'n Self-rapporteringsvraelys versus pedometer toetsing.

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Promotor Dr Kim Nolte

Graad MA (MBK)

Die voorkoms van obesiteit in kinders is vinnig aan die styg in Suid Afrika en kan verbind word met die afname van fisieke aktiwiteitsvlakke (Rossouw et al. 2012). Ten einde die probleem aan te spreek moet mens in staat wees om dit te meet en verandering te bepaal, dus is daar 'n behoefte vir 'n geldige en betroubare maatstaf om fisieke aktiwiteitsvlakke te mee te bepaal (Biddle et al. 2011). Huidiglik is daar geen 'goue standaard' waarmee fisiek aktiwiteit gemeet word nie (Kowalski et al. 2004).

'n Deursnitsontwerp is gekies om die fisieke aktiwiteitsmeting van graad twee en graad drie leerders te vergelyk met behulp van 'n pedometer sowel as 'n vraelys. Deelnemers is gewerf van Constantia Park laerskool om 'n total van 58 deelnemers te hê, 29 van graad twee en 29 van graad drie (30 manlik en 28 vroulik). Deelnemers wat in gesluit is, is die van die gespesifiseerde grade wat sonder besering was en sonder enige beperking tot beweging.

Alle deelnemers het 'n Omron HJ-720 pedometer ontvang wat opgestel is met hul gemiddelde treë lengte sowel as liggaamsmassa – wat daarna gedra is vir 'n week.
Na voltooing van die week is die pedometers weer terug gehandig vir die aflaai van die data en die "*Physical Activity Questionnaire for Older Children*" (PAQ-C) vraelys is uitgedeel vir die deelnemers om by die huis te voltooi. Die week daarna is die vraelyste weer ingeneem vir analise en vergelyking met pedometer data.

Die totale treë gemiddeld vir die deelnemers is 9289 treë per dag. Hierdie hoeveelheid is heelwat minder as die aanbeveling van 15 000 treë per dag (en meer) vir die bevordering van gesondheid. Hierdie bevindinge verteenwoordig wel die werk van ander outeurs in verband met die fisieke aktiwiteit van kinders (McVeigh and Norris 2012; Duncan, Nevill, Woodfield and Al-Nakeeb 2010). 'n Patroon wat gevind is, is die duidelike afname van treë wat gegee word oor

naweeksdae, waar die gemiddelde treë per dag slegs 6796 treë was (in vergelyking met 10 219 treë per dag gedurende die weeksdae).

Verdere patrone gevind is die verskil tussen geslag met aktiwiteit; manlike deelnemers het nie net gerapporteer dat hul meer aktief is nie, maar is ook gemeet as die geslag wat die meeste treë gegee het in alle tyd segmente. Tussen die grade, het die graad twee groep meer treë na skool i.v.m. die graad drie groep gegee. Dit was die enigste beduidende verskil tussen die twee grade.

Die PAQ-C telling van die groep (3.14 ± 0.47) is vergelykbaar tot vorige studies se bevindinge vir dieselfde ouderdoms groepe (ouderdomme agt tot 13 en nege tot 14) soos uitgevoer deur Kowalski et al. (1997) (3.23 en 3.35 respektief).

Wanneer die aktiwiteitstelling wat aangeteken is met die PAQ-C vraelys vergelyk word met die treë wat geneem is vir die week, was daar 'n matige sterkte korrelasie ($r$ = 0.49; $p < 0.001$) tussen die twee, met 'n effens sterker korrelasie ($r$ = 0.53; $p < 0.001$) wanneer slegs die treë van die weeksdae vergelyk word met die aktiwiteitstelling.

Individuele items op die vraelys het wel ietwat assosiasie gehou met treë gemeet gedurende verskeie tydsintervalle maar die korrelasie was nooit so sterk soos met die totale telling van die PAQ-C vraelys nie.

Die algehele telling van die vraelys korreleer amper perfek met vrae op die vraelys wat nie slegs een spesifieke tydsperiode ondersoek nie (bv. Aktiwiteit gedurende etenstyd) maar met die waar deelnemers hulself 'n algemene beskrywing moes gee vir die hele week se aktiwiteit (bv. Beskryf aktiwiteitsvlak vir die hele week). Hierdie was waar vir beide die negende sowel as die eerste vrae van die vraelys. Die eerste vraag was 'n lys van algemene aktiwiteite waar die deelnemer moes beskryf hoe gereeld hul deel geneem het aan elke aktiwiteit, vraag nege moes vir elke dag 'n subjektiewe beskrywing gekies word vir algemene fisieke aktiwiteit vlakke.

Gebaseer op die bogenoemde bevindinge, kan die PAQ-C gebruik word op 'n vergelykbare groep Suid Afrikaanse kinders om insig te kry oor oorweegse fisieke aktiwiteit. Huidiglik blyk dit asof die deelnemers nie genoeg fisiek aktiwiteit doen nie, gebaseer op treë gemeet per dag, veral oor die naweeksdae. Dit is moontlik dat hierdie tendens strek tot die groter populasie (kinders) van Suid Afrika. Dit is kommerwekkend a.g.v. die implikasies van 'n tekort aan fisieke aktiwiteit in kinders. Alhoewel daar nie ‘n direkte korrelasie was tussen fisieke aktiwiteit en liggaamsgewig nie, het vorige navorsing wel gewys dat daar ‘n konneksie is tussen onaktiwiteit en verhoogde liggaamsmassa wat dan gesondheids risiko faktore verhoog.

Aanbevelings vir toekomstige toetsing is die gebruik van ‘n ander pedometer model met ‘n korter lukrake bewegingsfilter – die onderbroke aktiwiteit van deelnemers in hierdie ouderdomsgroep mag lei tot die onderskating van treë geneem. Dit mag ook verkiesbaar wees om die invul van die vraelys onder toesig van die navorser te doen om die beste akkuraatheid te verseker, waar moontlik. Laastens, die vrae rondom fisieke aktiwiteit rakend tot die naweek kan aangepas word.

‘n Belangrike beperking van die studie wat ingedagte gehou moet word is dat twee aktiwiteite gekies as deel van die top vyf mees algemene aktiwiteite is swem sowel as fietsry, wat nie gemeet kan word deur die pedometer as fisieke aktiwiteit onderneem nie. Dit kon bygedra het tot die verminderde fisieke aktiwiteitsvlakke gemeet deur die pedometer.Verder kon dit ook die korrelasie geaffekteer het tussen die twee meetings van fisieke aktiwiteit.

**Sleutel woorde: Fisieke aktiwiteit, pedometer, PAQ-C, vraelys, skoolkinders, aktiwiteitsmeting**

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# CHAPTER 1: THE PROBLEM

## 1.1. Research Title

*"Measuring physical activity in South African primary school children: A self-report questionnaire versus pedometer testing*."

## 1.2. Research Question

Can primary school children accurately self-report physical activity (PA)?

## 1.3. Goals and objectives

### 1.3.1. Goal:

To determine whether a self-report PA questionnaire correlated with measured PA (PAQ-C questionnaire compared to pedometer measurement in children of ages seven to nine).

The goal was reached through the objectives which are:

### 1.3.2. Objectives:

1. To determine whether there was a correlation between reported and measured PA in South African primary school children (PAQ-C questionnaire and Omron HJ-720 pedometer measurement).
2. To determine whether children were achieving enough PA levels for health purposes.
3. To determine whether children of higher body mass for age were less active than their counterparts of normal body mass.
4. To examine PA behaviour patterns.
5. To determine applicability and short falls of pedometer use in primary school children doing various forms of PA.

## 1.4. Hypotheses

Considering the review of the literature it is expected that:

- There will be a correlation between PA levels as reported with the PAQ-C and the steps measured via the Omron [HJ-720] pedometer.
- Children who are classified as being overweight for age will report less activity on a PAQ-C and will show to have taken less steps on average.
- There will be differences both between genders as well as between average activity of the week versus weekend.
- There will be activity reported that cannot be measured adequately through pedometers (activities based around swimming, horse riding, cycling, or any other activity not focused on walking or running movements).

## 1.5. Introduction

The inter-related and independent relationship between obesity and many cardiovascular risk factors is well known, including insulin resistance, hypertension, hyperlipidaemia, Type II diabetes mellitus, and atherosclerosis (Hannon, Rao and Arslanian 2005; Steinberger and Daniels 2003). Hannon et al. (2005), in a review of childhood obesity, mentions the Rocchini (2002) statistic that the incidence of children diagnosed as overweight has increased by more than 100% in the last 30 years. In addition the occurrence of diseases related to this epidemic is also on the rise, as is the case with childhood Type II diabetes mellitus (Hannon et al. 2005).

In the "*Health of the nation study*" (Armstrong, Lambert, Sharwood and Lambert 2006) it was found that South African children are showing trends in overweight and obesity that are comparable with those of developed nations ten years ago. Rossouw, Grant and Viljoen (2012) in their research review on overweight and obesity research in the South African context, showed similar statistics, and points to the World Health Organization (WHO) statistics with Africa having the fastest growing rates of overweight and obesity. In South Africa 14.0% of boys have been found overweight and 3.2% obese, for girls the figures rise to 17.9% and 4.9% respectively (Mciza, Goedecke and Lambert 2007; Armstrong et al. 2006). Reasons postulated for the rise in overweight and obesity include increases in diets high in energy dense- foods

(Rossouw et al. 2012; Steinberger and Daniels 2003), decreases in daily PA (McVeigh and Norris 2012; Mciza et al. 2007), as well as differing cultural views on obesity (Armstrong et al. 2006).

There has historically been a viewpoint in sub-Saharan Africa that obesity can be seen as a sign of health, wealth, success and happiness. This linkage could possibly be due to poverty or disease being so commonly linked with thinness (Nelson-Wong, Gregory, Winter and Callaghan 2008; Armstrong et al. 2006). Black girls tend to choose larger size body shapes as ideal when shown a Body Silhouette Chart and show a smaller degree of body dissatisfaction than white school girls, thus illustrating a greater ease with overweight and larger body sizes (Vogt and Banzer 1997). The view of obesity being a positive, clearly still holds some favour. Although this is acknowledged here this study will not attempt to correct for this, but it will be considered with the discussion upon completion.

The World Health Organization as well as the American Heart Association states that the causes for obesity include a consumption of high-energy foods, and the lack of sufficient PA (WHO 2012; Steinberger and Daniels 2003). Sufficient PA levels in South African primary school aged children are only being met by approximately one third of children
(McVeigh and Norris 2012; Duncan et al. 2010) and a direct relationship between low levels of physical fitness and –activity, and obesity, has been shown (Truter, Pienaar and Du Toit 2010).

PA has been proven to be beneficial and able to reverse the consequences of being sedentary (Aguilar, Vizcaino, Lopez, Martinez, Gutierrez, Martinez, Lopez-Garcia and Rodriguez-Artalejo 2010; Oude Luttikhuis, Baur, Jansen, Shrewsbury, O'Malley, Stolk and Summerbell 2009). With the rapid increase in the prevalence of obesity in South African children it is clear that finding ways to increase the PA levels of our children is at least part of the answer.

As we strive to increase PA levels, a need arises to measure current levels of activity according to Biddle, Gorely, Pearson and Bull (2011). This need is partially to know which children perform sufficient amounts of PA, but also to gauge success of programmes of intervention intended to affect PA levels (McVeigh and Norris 2012; Biddle et al. 2011). Measuring PA levels poses unique challenges due to the nature of children's activity behaviour; as well as their level of cognitive development (Welk, Corbin and Dale 2000). An additional difficulty in measuring PA is the absence of a 'gold standard' with which to determine PA (Kowalski et al. 2004). Welk et al.

(2000) described children's activity as tending to have an intermittent pattern, where short bouts of frequent activity occur, having a greater total volume of exercise than adults, but lacking tolerance for high intensity activity and less interest in continuous activity than adults.

Self-report questionnaires, such as the Physical Activity Questionnaire for older Children (PAQ-C), possibly provides a cost effective solution which can be applied on a large scale, having been validated in developed nations. The PAQ-C is a self-report, seven-day recall questionnaire to determine general levels of PA (McVeigh and Norris 2012; Wareham 2001) The PAQ-C was first validated in 1997 on Canadian children of grades four to eight and approximately eight to 14 years of age (Moore, Hanes, Barbeau, Gutin, Trevino and Yin 2007; Kowalski et al. 2004; Kowalski et al. 1997) and have certain strengths to its design including its measure of general PA levels, its use of memory cues, and being cost and time efficient (Kowalski et al. 2004). PA questionnaires (requiring seven-day recall) administered by interviewers have been found to be successful in South African children between the ages of seven to nine years old, (Mciza et al. 2007) but research on self-administration of the same type of questionnaire is lacking. Though there has been validation studies on the use of the PAQ-C, Moore et al. (2007) noted that with the U.S. being a developed nation, the questionnaire could still be better adapted to different ethnic groups. This again affirms the idea that in a different context, such as South Africa, the questionnaire must also be adapted and validated before use.

The PAQ-C is not without its limitations: It measures general PA levels, thus variables such as caloric expenditure, specific frequency, time, and intensities cannot be determined from the answers. The result is thus given as a summary of activity. A further limitation is due to the questions relating around activities found only in the school system, so application cannot occur during holidays (Kowalski et al. 2004). Welk et al. (2000) noted the widespread concerns on the accuracy of using self-report measures with children, whereas Wareham (2001) in his commentary on measuring PA, specifically in Sub-Saharan Africa, was concerned over the appropriateness of such a questionnaire, having been developed for use in developed countries. PA questionnaires tend to have high re-test reliability; the recurring problem is typically that of validity (Wareham 2001). Welk et al. (2000) further mentioned that the PAQ-C, may still be used to separate inactive from active children, even if it can't determine precisely variables such as frequency, intensity and time spent doing the activity (Kowalski et al. 2004). Kowalski et al. (2004) in their PAQ-manual describes that in the literature the PAQ-C aim of use is to classify children into activity levels and to examine the link between PA and health outcomes.

The Wareham (2001) commentary alludes to the fact that objective monitoring (which includes activity monitors) might be the way to standardize these PA measurements internationally, since there will always be inherent drawbacks to using questionnaires to assess PA (Biddle et al. 2011). Mciza et al. (2007) also concluded that in order to understand the value of PA questionnaires they must be compared with objective measures (i.e. pedometers or accelerometers).

With continual reduction in cost and improvement of technological freedom, measuring PA levels may soon enough be measured completely with objective means; but until such time, self-report questionnaires remain the only way to gather data from large sample groups (Biddle et al. 2011). Biddle et al. (2011) noted on the topic of self-report questionnaires that the inaccurate recall that plagues these tools are also a symptom of peoples misperception of their own activity compared to what is actually measured. This fact should be used to guide the structure of educational intervention regarding PA, thus improving awareness of exercise done.

The objective monitoring mentioned above entails determining PA through the use of activity monitors i.e. pedometers and accelerometers (among other devices). Pedometers or 'step-counters', are motion sensors, which when worn, will record the movement that accompanies locomotion (Helal, Chen, Anton and Helal 2008). With walking and running being primary forms of PA, and pedometers being low cost devices that are easy to use (Ryan, Grant, Tigbe and Granat 2006). Measuring PA via pedometry seems a logical step.

These activity monitoring devices come in various forms, and utilize different technologies, with accelerometers being considered more accurate and storing a greater amount and variety of data than spring-levered pedometers that clip onto the waist (Helal et al. 2008). Accelerometer data stored includes 'time stamping' (indicating the time activity that was done), and measures of intensity of movement (Bassett 2012; Holbrook, Barreira and Kang 2008; Ryan et al. 2006).

There have been many studies done on validating the use of pedometers with multiple investigations showing reliability and validity in testing (De Cocker, De Meyer, Bourdeaudhuij and Cardon 2012; Giannakidou, Kambas, Ageloussis, Fatouros, Christoforidis, Venetsanou, Douroudos and Taxildaris 2012; Holbrook et al. 2008). These tests have included both treadmill tests as well as walking at a self-selected pace. From these researchers we can surmise that pedometers provide us with reasonable cost to accuracy ratio for determining PA. Bassett and John (2010) found the waist worn pedometer with dual-axis accelerometer sensors (Omron [HJ-720] used in this study) to be highly accurate in recording steps during continuous bouts. In reviewing studies on the use of pedometers in children, McNamara, Hudson and Taylor (2010) found that pedometers correlated highly with criterion and convergent measures of validity, as well as proving to be a reliable inter- and intra-unit. Furthermore, they concluded that pedometers can effectively be used on children: being easy to use, cost effective, and as a valid and reliable determinant of PA (McNamara et al. 2010). Evaluation of the validity and reliability of locally available pedometers have been investigated before (Cook 2006), and accelerometers have also been used on children in the South African context (McVeigh and Norris 2012). It has been noted that the wearing of pedometers in itself serves as a motivational tool to increase PA (Holbrook et al. 2008; Welk et al. 2000).

Accelerometers also provide estimates for energy expenditure and distance covered, but research has shown that these measurements have questionable accuracy, and will not be included in this study (Bassett 2012; Welk et al. 2000).

A need exists to increase PA and exercise compliance in children, and as a result negate the devastating consequences of inactivity and overweight on their health. As the need exists to increase PA, so too does the need to measure PA effectively. Therefore this study will determine the association between reported PA levels (via questionnaire) and activity levels as measured by pedometers in a group of South African children aged school children. The scientific significance for future studies is the possible improvement in measuring PA levels, helping to measure exercise interventions' efficacy.

## 1.6. Problem setting

Inactivity has a clear link with the current trend of increasing obesity, and likewise obesity can be treated with increases in levels of PA (WHO 2012; Steinberger and Daniels 2003). It is a difficult task to measure the PA of children, especially when a large number of participants are involved; it may require too many testers to measure directly, or funds may limit use of expensive recording equipment. Self-report questionnaires and pedometers, may provide a cost-effective answer.

Self-report questionnaires, such as the PAQ-C, possibly provide a cost effective solution which can be applied on a large scale, having been validated in developed nations. Biddle et al. (2011) reviewing self-report PA instruments in young people short listed the three most suitable questionnaires with the PAQ-C being one of the three. In the same review the PAQ-C was also rated by a panel of experts and backed by statistical data, as having a fair level of reliability and high level of validity. Biddle et al. (2011) stated benefits to this instrument as its easiness to complete, its repeated use in the literature, and due to only having nine items - being time efficient. To this researcher's knowledge, this questionnaire has however not been used in a South African context (McVeigh and Norris 2012) and as Moore et al. (2007) and Wareham's (2001) commentary pointed out, differences of country, culture and ethnicity demands that a questionnaire must be validated in that country before its widespread use. Further, PA questionnaires for children have been used successfully in South Africa when applied by trained interviewers (Mciza et al. 2007), but that limits the potential number of participants.

Self-report questionnaires are affected by problems of recall, and particularly in children where the development of 'abstract thought' is on-going (McVeigh and Norris 2012; Storey and McCargar 2012; Biddle et al. 2011; Welk et al. 2000). A novel way to curb the problem of recall and further enhance questionnaire self-administration is the use of a web-based questionnaire as done by Storey and McCargar (2012). With this approach the investigator has greater control over when data must be completed (such as daily questions to limit problems of memory), the form in which it is received, and the tracking of completed data sets (Storey and McCargar 2012). Sadly, this is not as applicable in developing nations where internet access may be limited, but certainly worth exploring.

There is in general, a lack of locally validated instruments to measure the PA of South African primary school children (Mciza et al. 2007). Even worldwide there exists no clear golden standard for measuring PA in adults or children (Kowalski et al. 2004).

In order for a questionnaire to be valid it must be compared to the most accurate alternative measurement currently available (Wareham 2001), as the questionnaire assesses general PA levels, the comparison will be made with the most accurate measurement practically available for general PA – accelerometry and pedometry. Currently when measuring PA via pedometers, the standard to which other pedometers are measured is to the Yamax Digi-Walker SW-200 (YAM) (spring-suspended pedometer), with this study relying on the Omron [HJ-720IT-E2] (dual-axis acceleration sensor pedometer) which has been shown to have greater accuracy at all walking speeds than the mentioned Digi-Walker (Giannakidou et al. 2012). There have been many studies done on validating the use of pedometers, and the Omron [HJ-720] as is used here has been shown in multiple investigations to be reliable and valid in its testing, even at slower speeds, which are generally the most problematic (De Cocker et al. 2012; Giannakidou et al. 2012; Holbrook et al. 2008). These tests have included both treadmill tests as well as walking under self-selected pace.

The Omron [HJ-720] model also has the benefit of 'time stamping' the data and recording up to 40 days before download onto computer (Giannakidou et al. 2012). A further note should be made that due to the Omron [HJ-720] having dual-axis sensors, it is able to accurately detect movements even if not worn on the body (e.g. on a backpack) or in a non-traditional position (carried in the pocket or worn around the neck) (Holbrook et al. 2008). Traditional spring-suspended pedometers are less accurate partly due to the lack of additional axes of measurement. Most research come from outside our borders, but accelerometers and pedometers have been used on children in the South African context (McVeigh and Norris 2012).

Treating obesity is closely associated with measuring Energy Expenditure (EE). Multi-input devices (including physiological input i.e. heart rate monitoring) such as the SenseWearPro 3 Armband can in such cases create very accurate measures of movement and Energy Expenditure (EE) comparable to the 'gold standard' of the doubly-labelled water technique (DLW) (Bassett 2012). Such devices are however prohibitively expensive. Accelerometers commonly used in assessing PA, such as the ActiGraph devices are single input devices, and like most wearable activity monitors the ActiGraph tends to be less accurate (underestimating) distance covered or energy expended (Bassett 2012). The Omron [HJ-720] pedometer used is very accurate in measuring steps taken, but has the same limitations mentioned for other single input devices (Bassett 2012). For this reason the EE and 'distance walked' readings generated was not used.

The problem can thus be summarized as follows: Obesity and overweight in the youth are on the increase, which can be linked to lack of PA among other factors. Measuring PA has been problematic due to manpower and cost involved in accurately determining PA, thus interventions cannot be assessed for their effectiveness. The PAQ-C questionnaire can potentially be used to quickly, and cost-effectively, assess large numbers of children to determine overall PA levels; the question is if this method is accurate enough when self-administered. The Omron [HJ-720] has repeatedly shown to be a high quality pedometer, delivering reliable and valid results; as such it will be the measurement to which the PAQ-C will be compared. The significance is that accurate measurement could lead to effective interventions.

Due to limitations on single input devices, only the step count will be used and not its estimation on EE.

# CHAPTER 2: LITERATURE REVIEW

## 2.1. Cardiovascular Disease Risk Factors

A risk factor as defined by Plowman and Smith (2013, p. 454) is: *"…an aspect of personal behaviour or lifestyle, an environmental exposure, or an inherited characteristic that has been shown by epidemiological evidence to predispose an individual to the development of a specific disease."*

Cardiovascular disease (CVD) refers to diseases of the heart or blood vessels, and is a major contributor to morbidity and mortality worldwide in all races, genders and age groups (Mudau, Genis, Lochner and Strijdom 2012; Heyward 2006). CVD risk factors are divided between risk factors that are not modifiable (i.e. age, race, gender, genetics), and those that are modifiable, with the modifiable factors to be discussed here (Plowman and Smith 2013). Due to the close relationship between PA, obesity, and these modifiable risk factors, each will be reviewed shortly as to give an overview of the problems that accompany obesity and/or lack of PA. CVD is considered the leading cause of death in all developing nations, apart from the Human Immunodeficiency Virus / Acquired Immunodeficiency Syndrome (HIV/AIDS) pandemic and famines of sub-Saharan Africa (Gersh 2011; Opie and Mayosi 2005). Yuqiu and Wright (2008) attribute 30 % of worldwide deaths to CVD, in comparison with ten per cent from infections.

CVD refers to a range of conditions including: Congestive heart failure, congenital cardiovascular defects, rheumatic heart disease, hypertension, and coronary heart disease (Plowman and Smith 2013). Coronary Heart Disease (CHD) is a major subtype (accounting for more than 50% of all CVD) and is also known as ischemic heart disease or coronary artery disease (Plowman and Smith 2013). It is a condition where the coronary arteries (Figure 1) that supply the myocardium (Figure 2) of the heart are damaged and occluded through a localized accumulation of fibrous tissue and lipids via the process of atherosclerosis (Plowman and Smith 2013). Atherosclerosis as a pathological process will be discussed in the following section.

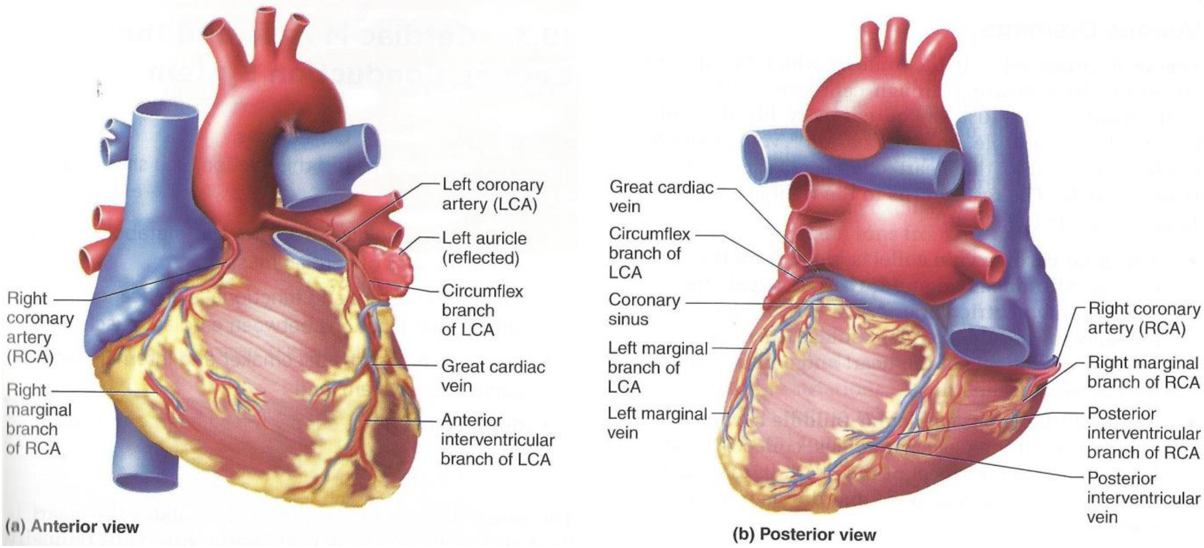



**Figure 1: Anterior and posterior views of coronary arteries supplying the heart (Saladin 2010, p. 729)**

The pattern of mortality in our nation has changed markedly over the past century, where infections such as dysentery and malaria were virtually exclusively the cause of death for adults in 1900, currently non-communicable diseases such as those caused by obesity, hypertension, diabetes, stroke, and certain cancers are much more prevalent and is rising, being second only to HIV/AIDS (roughly 500 000 deaths annually) as the main contributor to overall mortality rate

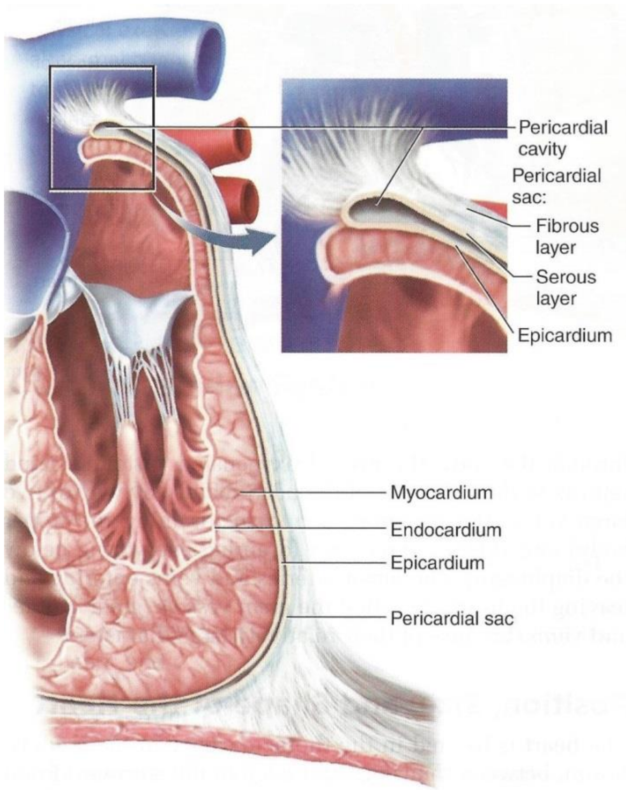



**Figure 2: Heart wall layers with inset of pericardium (Saladin 2010, p. 722)**

in South African (Pretorius, Stewart and Sliwa 2011; Evans, Blitstein, Lynch, De Villiers, Draper, Steyn and Lambert 2009; Raal 2009; Walker 2001). Of all the deaths in South Africa attributed to HIV/AIDS, Maredze, Hofman and Tollman (2011) places CVD contributor to 20 % of the deaths. In 1991 the effects of heart disease and stroke cost the country an estimate of two to three % of Gross Domestic Product (GDP) (possibly over R5 billion), a cost estimated to have doubled by 2010 (Maredze et al. 2011). Kahn, Garenne, Collinson and Tollman (2007) echoed the same message showing increasing trends in mortality rate in South Africa from the mid-90's to date, with the dual threat of rising HIV/AIDS infections and growing prevalence of non-communicable diseases. Schneider, Bradshaw, Steyn, Norman and Laubscher (2009) reviewed the 1998 South African Demographic and Health Survey and found that in the richest districts non-communicable diseases accounted for 39 % of total deaths and 33 % in 'poorest' districts. Schneider et al. (2009) showed further that the risk factors of hypertension and obesity was associated with wealth, whereas the risk factors for the poor were cigarette smoke and alcohol dependence. The 2007 Heart and Stroke foundation of South Africa media document regarding heart disease projects that from the year 2000 to 2030 the number of deaths in individuals of working age will grow by 41% (Steyn 2007).

Despite the contribution of these factors to increases in CVD, Yuqiu and Wright (2008) have shown that when evaluating public knowledge on working age black African individuals of lower socioeconomic class (residents of Ga-Rankuwa) regarding risk factors for CVD, the overall understanding and awareness was low with little or no understanding about the interrelated nature of these risk factors and lifestyle habits. As these cardiovascular risk factors are discussed in the following sections we will see how they are affected by age, such as adult CVD originating in childhood at times.

### 2.1.1. Atherosclerosis

Not to be confused with Arteriosclerosis (the natural thickening, hardening and loss of elasticity of vascular structures that accompanies aging), atherosclerosis is a chronic pathological process by which injury to the endothelium of arteries are met with an inflammatory response leading to a plaque forming against the wall of the blood vessel, which can fissure, rupture or erode leading to thrombosis of the plaque surface, and a progressive narrowing of the lumen of the artery (Plowman and Smith 2013; Mudau et al. 2012; Durstine and Moore 2002; Van der Wal and Becker 1999). Atherosclerosis (Figure 3) can lead to myocardial ischemia and angina pectoris, as well as myocardial infarction (Mudau et al. 2012).

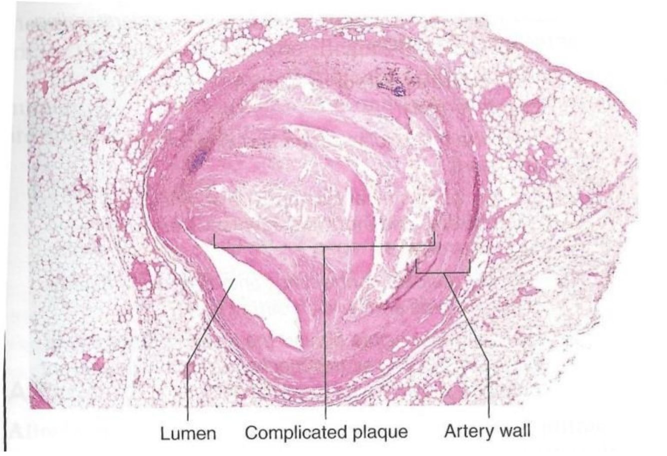



**Figure 3: Cross-sectional view of a coronary artery with advanced atherosclerotic plaque (Van der Wal and Becker 1999, p. 336)**

When high levels of cholesterol are present in the blood, more specifically high levels of low-density lipoprotein cholesterol (LDL-C), an injury to the endothelium leads to LDL-C being oxidized by free radicals upon entering the vessel wall (Plowman and Smith 2013). Endothelial dysfunction is strongly related to the formation of atherosclerosis and considered a link between the CVD risk factors and the formation of atherosclerosis (Mudau et al. 2012). Endothelial dysfunction referring to interference with vasodilatory/vasoconstrictory function, inhibition and stimulation of smooth muscle cell migration and proliferation as well as of thrombogenesis and fibrinolysis; endothelial dysfunction is considered an early marker for atherosclerosis (Davignon and Ganz 2004). LDL-C is oxidized and creates an inflammatory response that draws macrophages into the arterial wall, to phagocytize the LDL-C and in turn this stimulates the smooth muscle of the artery's tunica media to hypertrophy and migrate to the inner layer of the vessel's tunica intima due to the release of chemical signals (Plowman and Smith 2013). The atherosclerotic plaque consists of connective tissue, smooth muscle cells, cellular debris, cholesterol, and possibly calcium in more advanced stages (Plowman and Smith 2013). Atherosclerosis is a complex phenomenon where the interaction between cells of the immune system and those of the vessel walls (smooth muscle cells and endothelial cells) create a plaque with a fibrous cap and a core of lipids and debris termed the 'atheroma' (Van der Wal and Becker 1999). The integrity of the plaque is maintained by the fibrous portion and the thrombotic nature is linked to the softer atheroma (Van der Wal and Becker 1999).

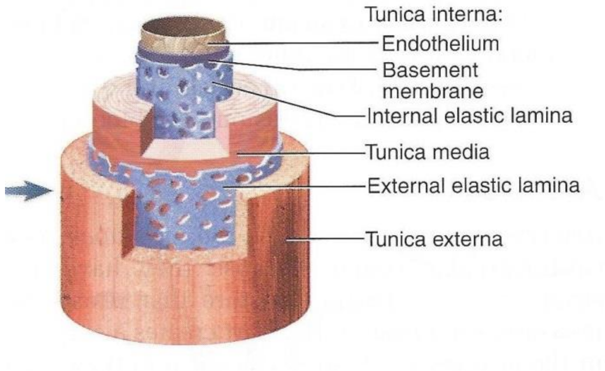



**Figure 4: Anatomy of distributing artery (Saladin 2010, p. 757)**

The initial injury to the endothelium (Figure 4) is typically caused by: tobacco smoke (containing chemical irritants), hypertension (which causes turbulent blood flow), high cholesterol levels, immune complexes, vasoconstrictor substances, high homocysteine levels, viral-, and bacterial infections (Plowman and Smith 2013). Both inflammatory processes and coagulatory abnormalities, as can be caused by smoking, are associated with atherosclerosis (Zatu, Van Rooyen and Schutte 2011).

The immune response to this injury is normal, but the atherosclerotic plaque that results is pathological and is progressive in its decrease of the inner diameter of the blood vessels. (Plowman and Smith 2013). This decrease in diameter, in conjunction with the accumulated plaque, affects the vasodilative ability of the arteries, and as pathology increases it restricts the volume of blood flow through the narrowed artery (Plowman and Smith 2013). Plaque accumulation creates turbulent blood flow, thereby exacerbating the condition; areas where arteries have abrupt curvatures are branches which are also more susceptible to turbulent blood flow and plaque accumulation (Durstine and Moore 2002). Turbulent blood flow is also associated with a greater incidence of aneurism rupture, thus individuals with concurrent anueristic and atherosclerotic vascular disease have a compounded risk of mortality (Plowman and Smith 2013).

Advanced atherosclerotic plaque is highly thrombotic and particularly in unstable plaques can cause blood clots, leading to ischemic death when these clots occlude blood vessels (Plowman and Smith 2013). The plaque consists of layers of different tissue and cell types, and the ratios of the make-up of the plaque can determine how the atherosclerosis manifests itself acutely (Van der Wal and Becker 1999). There can be any ratio of atheroma to fibrous cap, but a large lipid pool (threshold of > 50 % of plaque volume being lipid in nature) with little fibrous tissue tends toward instability and is strongly associated with coronary thrombosis as they are more prone to rupture;,fibrous plaques in contrast are less prone to rupture and considered more stable (Van der Wal and Becker 1999). If this event occurs in the heart it is termed a myocardial infarction or 'heart attack', if it occurs in the brain, a stroke.

The process of atherosclerosis often starts in childhood, and is often without symptoms until it reaches an advanced stage and may present as sudden cardiac death (Plowman and Smith 2013; Rayner 2012; Raal 2009). Children as young as three have shown atherosclerotic lesions, with epidemiological research from South Africa already showing up to 30 % of white children as young as five years old having increased risk for developing atherosclerosis based on blood lipid levels, and 23.9 % of black African children based on blood pressure(Steyn, De Wet, Richter, Cameron, Levitt and Morrel 2000). this early development of atherosclerosis may track into adulthood increasing mortality and morbidity (Plowman and Smith 2013; Raal 2009; Steyn et al. 2000). The starting point for minimizing CVD in adults should thus include a careful examination of how the traditional risk factors for CVD impact children as well.

Though atherosclerosis has a definite genetic component making it partly a non-modifiable risk factor (Galton 1997), the progression of the process is modifiable as we will see, and it will be discussed as such.

### 2.1.2. Major Modifiable Risk Factors

Several factors have been linked with the development and advancement of CHD. These risk factors are behaviours, inherited characteristics, or environmental factors that lead to a predisposition in disease development, some of these factors cannot be changed, others are modifiable (Plowman and Smith 2013). Factors that influence CHD, yet are not modifiable, include age, heredity, race, and gender (Plowman and Smith 2013). Age becomes a risk factor for males past the age of 45 and for females after 55, though children are not exempt from atherosclerosis (Plowman and Smith 2013; Heyward 2006). Heredity is considered a risk factor when a person's sibling or parent has a history of CVD risk factors or medical intervention towards an existing CVD, or developed early CVD (male younger than 55 and female 65) or died as result of CVD causes (Plowman and Smith 2013). The risk factors of hyperlipidaemia, hypertension, cigarette smoking, obesity, and diabetes mellitus are top risk factors for cardiovascular mortality and have been estimated to be responsible for up to 90 % of all CVD worldwide (Mudau et al. 2012; Raal 2009). Mungal-Singh (2012) has shown that the prevalence of all these modifiable risk factors (except for smoking) have been on the increase in prevalence over the last ten years. Though there are non-traditional risk factors (such as c-reactive protein, fibrinogen, fibrinolytic activity and emotional stress) (Plowman and Smith 2013) and alternative measurements done (such as measuring carotid intima-media thickness via ultrasound) (Rheeder, Duim-Beytell, Meijer, Gustavsson, Danler, Ahmed and Van Zyl 2012), the focus in this text will be to give an overview of established knowledge, particularly, where possible, in South African children.

## 2.2. Cholesterol-Lipid Fractions

Lipids are either simple / neutral fats, compound fats or derived fats (Plowman and Smith 2013). The most common simple fat is triglyceride (TG), compound fats are a combination of simple fats and another substance, and derived fats are created from simple and compound fats – cholesterol falls into the latter category (Plowman and Smith 2013).

Lipids are water insoluble and require binding to a carrier substance to allow transportation through our water-based circulatory system (Plowman and Smith 2013). When bound to a protein, the result is termed a lipoprotein, with the protein portion being called an apolipoprotein (Plowman and Smith 2013). The five types of lipoproteins are called very low density lipoproteins (VLDLs), intermediate-density lipoproteins (IDLs), LDLs, high-density lipoproteins (HDLs) and chylomicrons (Plowman and Smith 2013). Of these five types of lipoproteins, chylomicrons (derived from exogenous triglyceride sources) and VLDLs (synthesized in the liver) transport TG and some cholesterol from the small intestine or liver to adipose- or muscle tissue for either storage or to be used as energy substrate (Plowman and Smith 2013; Durstine and Moore 2002). VLDLs from which the liver have removed its TG content is then termed IDLs, which is viewed as a sub-fraction of LDL (Plowman and Smith 2013; Durstine and Moore 2002). LDL transports the majority of cholesterol from the liver to the rest of the body, and consists largely of cholesterol, with lesser portions of TG and protein; it is therefore referred to as LDL-C, with its major apolipoprotein being termed Apo-B (Plowman and Smith 2013). Lastly HDL transports cholesterol (revered to as HDL-C, with its major apolipoprotein being Apo-A1), but in reverse compared to LDL-C, thus from the body to the liver to be removed (Plowman and Smith 2013). Lipids such as TG and cholesterol are transported via several enzymes and their interactions including: lipoprotein lipase, hepatic lipase, lecithin-cholesterol acyltransferase, and cholesterol ester transfer protein (Durstine and Moore 2002).

LDL-C is involved in forming atherosclerotic plaque, and HDL-C is a negative risk factor, thus preventing plaque formation (Plowman and Smith 2013). VLDLs and chylomicrons are not considered atherosclerotic however the TGs they transport are an independent risk factor as well as total cholesterol (TC) levels (Plowman and Smith 2013). 'Hyperlipidaemia' refers to a person having excess lipids in the blood; normal blood lipid levels for adults and children are shown in Table 1 below taken from Plowman and Smith (2013, p. 458):

**Table 1 Classification of TC, LDL-C, HDL-C Blood Levels, and TGs adapted from Plowman and Smith (2013)**

| Lipid and Category | Level for adults ($mg.dL^{-1}$) / [mmol/l] | Level for children ($mg.dL^{-1}$) / [mmol/l] |
|---|---|---|
| **Total Cholesterol** | | |
| Desirable | < 200 [5.17 mmol/l] | < 170 [4.4 mmol/l] |
| Borderline high | 200 – 239 [5.17 – 6.18 mmol/l] | 170 – 199 [4.4 – 5.15 mmol/l] |
| High | ≥ 240 [6.2 mmol/l] | ≥ 200 [5.17 mmol/l] |
| **LDL-cholesterol** | | |
| Optimal | < 100 [2.59 mmol/l] | < 110 [2.84 mmol/l] |
| Near optimal | 100 – 129 [2.59 – 3.34 mmol/l] | |
| Borderline high | 130 – 159 [3.36 – 4.11 mmol/l] | < 110 – 129 [2.84 – 3.34 mmol/l] |
| High | 160 – 189 [4.14 – 4.89 mmol/l] | 130 [3.36 mmol/l] |
| Very high | ≥ 190 [4.91 mmol/l] | |
| **HDL-cholesterol** | | |
| Low | < 40 [1.03 mmol/l] | |
| High | ≥ 60 [1.55 mmol/l] | |
| **Triglycerides** | | |
| Normal | < 150 [1.69 mmol/l] | |
| Borderline high | 150 -199 [1.69 – 2.25 mmol/l] | |
| High | 200 – 499 [2.26 – 5.63 mmol/l] | |

Also important to note is that the amount of TC in the blood is not the only concern, but also the fractions of LDL-C (and Apo-B) and / or HDL-C (and Apo-A1); LDL-C and Apo-B being positively related to CHD and HDL-C and Apo-A1 being inversely related to CHD (Plowman and Smith 2013).

Classification of an individual can be done with the Framingham risk factor scale, updated and adopted by the South African Heart Association (SA Heart) and Lipid and Atherosclerosis Society of South Africa (LASSA) in 2011 (Klug, Raal, Marais, Taskinen, Dalby, Schamroth, Rapeport, Jankelow, Blom, Catsicas and Webb 2012).

The initial intervention towards individuals with hyperlipidaemia involve altering dietary intake in order to decrease consumption of saturated fat and cholesterol (Raal 2009). Drug therapy is initiated when lifestyle interventions fail or when familial risk for hypercholesterolaemia is too great (Raal 2009).

For children the changes in blood lipid levels occur as follows: At birth the levels for TC and HDL are 70 $mg.dL^{-1}$ (1.81 mmol/l) and 35 $mg.dL^{-1}$ (0.91 mmol/l) respectively, in the first few weeks TC changes to 100 $mg.dL^{-1}$ (2.59 mmol/l) then to 150 $mg.dL^{-1}$ (3.88 mmol/l), and from 2 years old until adulthood the value remains relatively constant at 160 $mg.dL^{-1}$ (4.14 mmol/l) for males and 165 $mg.dL^{-1}$ (4.27 mmol/l) for females, whereas HDL-C rises to between 50 $mg.dL^{-1}$ (1.29 mmol/l) and 55 $mg.dL^{-1}$ (1.42 mmol/l) (Plowman and Smith 2013). Differences between gender includes males generally having a reduction in HDL-C and females a reduction in LDL-C, but childhood lipid profiles do not necessarily reflect those they will attain as adults (Plowman and Smith 2013). For comparison with childhood and adult values, see Table 1 above.

Evidence of the effect of apolipoproteins in children may still be lacking but early atherosclerotic lesions have been found in children as young as three, and is seen frequently by the age of ten years (Plowman and Smith 2013; Raal 2009). It has been shown in the highest risk patients, those with a strong familial history of hypercholesterolaemia, that for the ages of 20 – 40 years the risk for a fatal cardiac event is increased 100 fold (Raal 2009). In an epidemiological study of five year old South African children, the highest mean levels of TC and LDL-C were found in white children with 30 % of white and Indian children having a lipid profile that placed them at risk for CVD in later life, and only 13.7 % of black children being at risk (all groups had the same levels of HDL-C but black children had a more favourable ration of % HDL-C/TC) (Steyn et al. 2000). With regards to HIV and children, 50 % of children treated with highly active anti-retroviral therapy tend to have raised cholesterol level and or raised LDL-C levels (Raal 2009), an important note due to the prevalence of HIV in South Africa and the concurrent treatment using anti-retroviral therapy.

## 2.3. Diabetes Mellitus Type II

Diabetes mellitus refers to metabolic diseases where insulin secretion or its action on the body is impaired (Whaley, Brubaker and Otto 2006). There are four types/categories of diseases that fit this description, Type I – and Type II diabetes, gestational, and other specific types (Plowman and Smith 2013; Durstine and Moore 2002). The most prevalent are: Type I- and Type II diabetes mellitus of which up to 90 % - 95 % of individuals with diabetes fall into the Type II category (Plowman and Smith 2013; Whaley et al. 2006; Durstine and Moore 2002).

Type I diabetes mellitus is caused by an autoimmune disease destroying the beta (β) cells of the pancreas; there is no production of insulin (an external source of insulin is required) and as a result ketoacidosis (high concentrations of ketone bodies) and hyperglycaemia (high concentrations of blood glucose) is common with this absolute insulin deficiency (Plowman and Smith 2013; Whaley et al. 2006; Durstine and Moore 2002).

Type II diabetes mellitus is referred to as a relative insulin deficiency, as insulin may be produced in normal, supra-normal, or sub-normal levels but insulin resistance still present with hyperglycaemia (Whaley et al. 2006; Durstine and Moore 2002). In Type II diabetes mellitus, peripheral insulin resistance due to hyperglycaemia and dysfunction in insulin secretion, leads to glucose not being taken up into the target tissues, and further secretion of insulin to occur despite this measure being ineffective (Durstine and Moore 2002). The resistance to insulin is likely related to defect in receptor binding and in the post-receptor events, though the precise mechanism is unclear (Durstine and Moore 2002). Type II diabetes mellitus is termed 'non-insulin dependent diabetes mellitus (NIDDM)', and differences between Type I and II include: the average onset of (40 years) is greater in Type II than with Type I diabetes (which often develop during childhood or adolescence), Type II often involves elevated insulin concentrations (at least initially) whereas in Type I no insulin is produced, and development of

Type II diabetes is closely related to body fat, particularly abdominal adiposity whereas Type I is caused by an autoimmune response that affects only 5% - 10% of individuals who have diabetes (Whaley et al. 2006; Durstine and Moore 2002).

Diabetes mellitus is an important risk factor as more than 50 % of diabetic patients will die as a result of CHD (Okeahialam, Alonge, Puepet, Pam and Balogun 2012; Raal 2009). In the UK 80 % of diabetics will die due to CVD, and in all populations diabetes increases risk for CVD two-fold or more (Okeahialam et al. 2012). A study done on Nigerian diabetics without hypertension showed that when compared to non-diabetic hypertensives the group had worse lipid profiles and was worse off regarding their physical inactivity, cigarette smoking, and excess alcohol use (Okeahialam et al. 2012). Thus whilst not only having a greater risk factor from diabetes mellitus, the risk is compounded with these additional risk factors.

A factor that should also be kept in mind is that due to the high rate of HIV infections in South Africa and the treatment with highly active anti-retroviral medications, is that these medications are associated with diabetes mellitus and impaired glucose tolerance, apart from the known negative effects of some anti-retrovirals on blood-lipid profiles (Govender 2012).

In his review of epidemiological trends of Type II diabetes in South Africa Rheeder (2006) states that the prevalence of diabetes in sub-Saharan Africa is expected to double from the year 2000 to 2030, in the same time the total worldwide figure for diabetes will rise from 171 million to 366 million individuals. Investigating the prevalence of diabetes mellitus in specifically South African Indians showed 15.8 % of the study sample to have diabetes mellitus, with only three per cent of white South Africans having diabetes mellitus (Seedat 2005). Reasons stipulated included intra-abdominal obesity, dietary habits, physical inactivity, as well as insulin resistance leading to hyperinsulinaemia occurring more readily in the Indian population.

Results from the US have shown a dramatic increase in the incidence of children being diagnosed with type II diabetes: where 1-2% of children diagnosed with type II diabetes in 1990, it has risen to 43% of new cases as of 2009 (Marran and Segal 2009). Marran and Segal (2009) also report that in Japan the trend is similar with a reversal of Type I diabetes being more common than Type II previously. Unfortunately currently similar statistics are not available for South Africa.

Children with Type I or Type II diabetes mellitus are at risk of developing atherosclerosis earlier, and as they will remain diabetic into adulthood the already formed lesions of atherosclerosis will progress at a greater pace (Plowman and Smith 2013). As levels of obesity has risen, so too has children developing Type II diabetes mellitus, as it is a disease that is associated with an unhealthy lifestyle, despite it having a strong genetic component to it (Plowman and Smith 2013; Hannon et al. 2005; Durstine and Moore 2002). Although the mechanism of pathology is similar between adults and children, the β cells degrade much faster in children than in adults leading also to increased incidence of cardiovascular disease(Marran and Segal 2009).

## 2.4. Hypertension

Hypertension is a condition where the pressure within the circulatory system, namely the arteries, is elevated, increasing the risk for the individual to develop CVD and accelerate existing atherosclerotic lesions (Plowman and Smith 2013). The greater the level of hypertension the greater risk to the individual, as cardiovascular mortality and morbidity is directly related to level of hypertension (Durstine and Moore 2002). Hypertension is an independent risk factor for CVD (Kang, Guo, Guo, Hu, Wu, Zhou, Zhou, Liu and Chen 2010). Hypertension is a result of the interplay between cardiac output and the total peripheral resistance of the body; an increase in either factor or both will increase blood pressure, with increases in blood pressure also resulting in turbulent flow of blood and injury to the endothelial wall (Plowman and Smith 2013). Atherosclerosis results when high levels of blood lipids are present and injury to the endothelial lining occur; hypertension is a direct cause for endothelial injury (Plowman and Smith 2013).

Hypertension also creates an afterload on the heart which will in time thicken the ventricle wall often in a concentric fashion (though can also lead to an eccentric hypertrophy), it decreases diastolic filling, decreasing the efficacy of the heart, and it also thickens and stiffens small blood vessels though it is also known to effect even the largest blood vessels such as the aorta (Plowman and Smith 2013; Opie 2007). Hypertension is usually associated with hypertrophy of the left ventricle, but it can also create atrial enlargement and is linked to atrial fibrillation, which also leads to vascular disease in the form of emboli, albeit micro-emboli than will in time lead to cognitive decline (Opie 2007). In 90 % to 95 % of hypertensive cases, the cause is unknown, this is termed primary-, idiopathic-, or essential hypertension (Plowman and Smith 2013; Durstine and Moore 2002). There are however many lifestyle behaviours which are related to an increase in blood pressure, among them physical inactivity, unhealthy diet, excessive alcohol consumption, smoking, abnormalities of blood glucose or lipid-fractions, and body composition (Mungal-Singh 2012).. A further factor showing the interrelatedness of CVD risk factors is the effect of obesity on hypertension, causing a 1.7 to 3.4 times greater chance of hypertension with obesity, similarly a reduction in obesity is also linked to a reduction in hypertension (Norton and Woodiwiss 2011).

In children, hypertension can be diagnosed as young as six years old, and is defined as a persistent average systolic blood pressure or diastolic blood pressure equal or greater to the $95^{th}$ percentile based on the child's age, sex, and height (Plowman and Smith 2013; Rayner 2012; Monyeki and Kemper 2008). Ideally, to ensure that no false positives are recorded, frequent measurements should be used and not just a single record, even using a continual 24 hour ambulatory measurement (Rayner 2012). Childhood hypertension tend to track into adulthood, as children with high systolic blood pressure (SBP) have three times the risk to have the same during adulthood and high diastolic blood pressure (DBP) leads to twice the risk of continuing to have high diastolic blood pressure as adults (Plowman and Smith 2013; Rayner 2012; Monyeki and Kemper 2008). Figures from the United States have shown where paediatric hypertension used to be extremely rare in 1977, currently the prevalence has risen to 4.4% and is related to the concurrent increase in obesity (Rayner 2012). Rayner (2012) reviews the evidence linking the obesity epidemic with the increase in paediatric hypertension, showing that when Body Mass Index (BMI) reaches the $85^{th}$ percentile, there is fourfold increase in the incidence of hypertension – this was linked to the hormone Leptin and heart rate increases. Rayner (2012) also mentioned additional factors related to childhood hypertension: family history of hypertension, low birth weight, reduced nephron number, and elevations in uric acid. Steyn et al. (2000) showed that 22.3 % of five year old South African children have significant or severe hypertension, of which the prevalence was greatest in black African children (23.9 %) followed by coloured children (14 %), Indian (10.5 %), and white (4.4 Regardless of the cause, lifestyle intervention is a process that should start from birth all the way through life with knowledge and modifications to lead to reduced risk for CVD (i.e. hypertension) as Monyeki and Kemper (2008) stated. The process must start this early due to familial causes for CVD risk factors and parental behaviours that influence CVD risk such as cigarette smoking, activity-, and dietary habits which are influenced by education and knowledge on the topic (Monyeki and Kemper 2008; Reddy, James, Sewpaul, Koopman, Funani, Sifundi, Josie, Masuka, Kambaran and Omardien 2008).

## 2.5. Cigarette Smoking and Second Hand Smoke

The negative outcomes of smoking on health is well documented with cancer and diseases of the respiratory system being common end results (Plowman and Smith 2013). Smoking is also a major modifiable risk factor for CVD, chemical constituents of cigarette smoke such as nicotine stimulate the sympathetic nervous system, this increases blood pressure and heart rate, in turn increasing the afterload on the heart and further accelerating formation of atherosclerotic plaque due to endothelial injury (Plowman and Smith 2013). Carbon monoxide in cigarette smoke binds irreversibly with haemoglobin rendering it useless, in addition the lipid profile of the blood is negatively altered by smoking: TC, LDL-C, and TG are increased and HDL-C is decreased (Plowman and Smith 2013; Zatu et al. 2011). Furthermore smoking affects blood clotting mechanisms by causing blood platelets to adhere to one another, enhancing the rate of forming clots (partly due to the ischemia leading to red blood cell stimulation), and creating clots which are then tougher to dissolve (Plowman and Smith 2013; Zatu et al. 2011). Smoking decreases prostacyclin which is a vasodilator, this can lead to spasms in small arteries and capillaries thus occluding blood flow; this effect coupled with the increase incidence of blood clots forming, and arteries already narrowed by atherosclerotic plaque increases the probability that a thrombus or embolism may lead to blockage and ischemic death to the tissues being supplied (Plowman and Smith 2013). The nicotine found within cigarettes has a stimulatory effect on heart rate and cardiac output through stimulating beta-adrenergic receptors, the result is increases in blood pressure (Zatu et al. 2011). Smoking's effect on TG levels via nicotine-mediated lipolysis, as well as raised levels of growth hormone and corticosteroids, also lead to insulin resistance (Zatu et al. 2011). From the above, smoking can be seen as both an independent but also as exacerbating factor for CVD (Plowman and Smith 2013). It should be noted that simply reducing the amount of tobacco use does not eliminate the risk for Cardiovascular (CV) disease – there is no acceptable level of smoking above 'none', thus the aim is complete cessation of use (Mungal-Singh 2012).

Over the past decades the South African government have had success in limiting the total number of smokers by 33% from 1993 to 2003 by limiting public use, altering advertisement and warning information, and through taxation (Maredze et al. 2011). As smoking is related to CVD incidence, there has also been a steady decline in smoking related deaths parallel to the smoking decline (Maredze et al. 2011).

The deleterious effect of smoking on health should be traced back to the effects it may cause even prenataly, as mothers who smoke during pregnancy may cause harm to foetus/embryo which will remain post-partum (Viljoen 2005). The blood nicotine concentrations that the foetus is exposed to is relatively higher than that of the smoking mother as it concentrates in placental tissue, amniotic fluid and breast milk (Viljoen 2005). According to Viljoen (2005) effects of nicotine that have been documented relate to: maternal and foetal cardiovascular systems, uterine, umbilical and cerebral blood flow, the development of the cerebral cortex, development of the epithelium of the respiratory system, and lastly on foetal growth. It is thought that nicotine may affect brain development as well as smoking patterns later in life by its interaction with nicotine receptors (Viljoen 2005). The endothelium damage associated with the atherosclerotic process (as mentioned earlier) may be caused even prenataly (Viljoen 2005). Further possible effects of nicotine on the developing foetus include spontaneous abortion, preterm labour as well as a low-birth weight which has been associated with an increased risk of obesity in later life (Viljoen 2005). Low birth weight has also been linked to decreased insulin sensitivity in adult life (Choi, Kim, Lee, Park, Hong, Lee, Park and Lee 2000), as well as linked to greater inflammation and endothelial activation (Balci, Acikel and Akdemir 2010). Some researchers such as Hirschler, Bugna, Roque, Gilligan and Gonzalez (2008) however did not find a connection between low-birth weight and overweight/obesity or the metabolic syndrome in children nine years of age, and others even found increased birth weight being associated with obesity at ages 3-6 years (Zhang, Liu, Tian, Wang, Ye, Liu, Li, Wang, Tyang, Yu and Hu 2009).

Children exposed to second hand smoke increases their CVD risk by at least 25 % (Plowman and Smith 2013). According to the 2008 South African Youth Risk Behaviour Study (YRBS), 6.8 % of all smokers had smoked their first cigarette before the age of ten years old, and 29.5 % of all learners from grade eight to 11 have smoked previously and 21% were current smokers. Reddy et al. (2008) in the YRBS also showed that significantly more current smokers (children) had someone smoke in their presence in the last week and have at least one parent or guardian smoking compared to those children who had never smoked. Steyn et al. (2000) when examining the CVD risk factors for five year old South African children also found that overall 64 % of children were exposed to environmental cigarette smoke, and 6.7 % of children at age five have experimented with cigarette smoking. It was also stated that high levels of environmental exposure to parents smoking leads to greater likelihood of hospitalisation for babies (due to pneumonia and bronchitis), chronic cough and phlegm in children, greater frequency of respiratory diseases in children as well as when they reach adulthood, and finally to increase children's experimentation with cigarette smoking (Steyn et al. 2000). From this we can see that many children who are exposed to an environment where smoking is prevalent will also form the habit of smoking, and those that are exposed to second hand smoke but do not smoke themselves are also at an increased risk for developing CVD.

Exercise does seem to have a protective effect when it comes to smoking, as Charilaou, Karekla, Constantinou and Price (2009) showed with adolescents from Cyprus showing a strong an inverse correlation between level of PA and smoking behaviour. Those who were most physically active had the least chance of smoking heavily, and a greater chance of being a non-smoker; although the study cannot explain the cause of this relationship it does show a trend that may guide anti-smoking programs into including PA as part of an intervention (Charilaou et al. 2009). Kujala, Kaprio and Rose (2007) also showed that Finnish adolescents who were persistently inactive were correlated to adult smoking behaviour even when the smokers who started during adolescence were excluded from the study.

## 2.6. Physical Inactivity

Physical inactivity as a risk factor increases relative risk for CVD to the same extent as cigarette smoking (Plowman and Smith 2013). It has been shown that individuals who spend their day sedentary and sitting for the greatest part of the day has 40 – 63% greater odds of metabolic disease or individual CVD risk factors (Sisson, Camhi, Church, Tudor-Locke, Johnson and Katzmarzyk 2010). Studies from the US have shown that males from 12 to 17 years of age attaining recommended levels of PA is less than 50 % of population, and less than 30 % for females; the recommendation used is 60 minutes per day (min.$d^{-1}$) but more current research suggest increasing the recommended amount to 90 min.d$^{-1}$ accumulated throughout the day (Plowman and Smith 2013; Walter 2011). Measurements of Canadian children's PA via pedometer testing found that 40% of boys and 50 % of girls were not meeting adult levels of 10 000 steps/day, whilst requirements for children as stated by Canada's PA Guide are 16 500 steps/day (Craig, Cameron, Griffiths and Tudor-Locke 2010). In the same study one quarter of boys and a third of girls did not even reach 7000 steps/day (Craig et al. 2010).

It has been shown that there is a linear decrease in risk for CHD / CVD with an increase in PA, particularly in those individuals that are most inactive (Plowman and Smith 2013; Brage, Wedderkopp, Ekelund, Franks, Wareham, Andersen and Froberg 2004). Brage et al. (2004) showed that there is inverse relationship between PA and metabolic risk in Danish children of nine years of age with the greatest benefits to be attained by children who have the lowest levels of cardiovascular fitness (Plowman and Smith 2013). Brage et al. (2004) also shows that PA and Physical Fitness (PF) are two distinct and separate factors that affect risk for CVD, and that being physically fit shows the greatest difference in risk reduction compared to purely PA measurements. This might be due to the difficulty in measuring PA, regardless, PA and fitness must be promoted and ideally both must be measured to more accurately portray relative risk for CVD (Plowman 2005). Inactivity already carries an equal risk for CVD as does hyperlipidaemia, cigarette smoking, and systolic hypertension (Plowman and Smith 2013; Plowman 2005). PA and PF are both important to health and it should be remembered that PA is the process and PF the result, and setting goals based on manipulating the more modifiable variable (PA) could be more effective than modifying PF which can be strongly affected by heredity (Plowman 2005).

With regards to children and PA habits, Plowman and Smith (2013) introduces the concept of "*tracking*", meaning a characteristic that retains its relative rank over a long time span, for example a child who develops a habit of exercising regularly tends to keep this characteristic into adulthood.

Maia, Lefevre, Claessens, Renson, VanReusel and Beunen (2001, p. 765) describes tracking as: *"…the maintenance of a relative position in a group over time."*

Action in childhood may thus prevent or decrease modifiable risk factors in adulthood through the process of tracking. Pate, Baranowski, Dowda and Trost (1996) was able to show that PA as a variable did track during early childhood. Maia et al. (2001) also showed that PF as a whole is rather stable throughout adolescence and can be predicted from early years, even if PF is broken up into its constituent parts. It must be noted that some researchers do not believe the evidence is convincing enough that childhood PA will track into adulthood (Erlandson, Sherar, Mosewich, Kowalski, Bailey and Baxter-Jones 2011; Livingston, Robson, Wallace and McKinley 2003). Tracking or lack thereof does not seem to be strongly related to biological maturity as shown by Erlandson et al. (2011). It has been shown however that physical inactivity tracks more clearly than PA, and it is also true of other CVD risk factors tracking clearly from childhood to adulthood such as hypertension tending to track, overweight and obesity, and smoking tracks from adolescence to adulthood quite clearly (Plowman and Smith 2013). Though there is no conclusive proof that PA will track into adulthood, there is however evidence that suggests that those who do participate in PA as children and adolescents and maintain the habit into adulthood have a much lower risk for cardiovascular disease than those who adopted the habit only in adulthood (Rangul, Bauman, Holmen and Midthjell 2012). For women in particular in a Finnish study, regular high levels of PA was an independent protective factor against abdominal obesity (not so for men after correcting for confounding variables), showing that tracking behaviour in childhood (study used age group of nine to 18 year olds with a 21 year follow-up) can affect adult CVD risk factors (Yang, Telema, Viikari and Raitakari 2006). It is important to remember that although we are hoping to create a habit of regular PA, the idea is not that it will create a lasting protective effect, but that PA must always be part of the present behavioural patterns as it only protects at present. Positive effects will revert when activity ceases as shown by Conroy, Cook, Manson, Buring and Lee (2005) in their 37 169 participant cohort study of US women, aged 18 – 22 and followed over nine years.

In children and adolescents the aim of PA and exercise is not always to alter CVD risk factor variables, for normal variables are unlikely to change (and abnormal values are consistently and positively improved via PA and exercise), but rather to maintain normal values and establish a habit of movement and a healthy lifestyle (Plowman and Smith 2013). Another example of this would be the work of Aarnio, Winter, Kujula and Kaprio (2002) which showed that there are correlations for Finnish adolescents showing that those who were physically inactive had a less healthy lifestyle, fared worse in their educational progression and also rated their health status as being worse.

In their discussion on physical inactivity and obesity Bar-or, Foreyt, Bouchard, Brownell, Dietz, Ravussin, Salbe, Schwenger, Jeor and Torun (1998) states that inactivity as a cause for obesity must not be seen as purely the lack of energy expenditure, but also the association that sedentariness has with other behaviours, such as hours spent watching television is directly related to obesity, as well as smoking, fat-, and alcohol consumption. Given as an example in the above discussion is the fact that in both children and adults' sedentariness and its effects on obesity remains an independent risk factor despite the effects of vigorous PA (Bar-or et al. 1998). Hancox, Milne and Poulton (2004) showed that television viewing time during adolescence and childhood can lead to an increase in adult CVD risk factors; watching more than two hours was associated with an increase in rates of overweight, poor PF, raised cholesterol levels, and incidence of smoking whereas watching less than one hour had the opposite effect.

South African children do show sedentary patterns of behaviour with one in four adolescents watching in excess of three hours of television daily (Reddy, Panday, Swart, Jinabhai, Amosun, James, Monyeki, Stevens, Morejele, Kambaran, Omardien and Van den Borne 2003), with more recent assessment showing the figure closer to one in three (29.3 %) (Reddy et al. 2008).

Physical inactivity and obesity is explained in part by technology that causes sedentariness, so Bassett, Tremblay, Esliger, Copeland, Barnes and Huntington (2007) investigated the PA in Amish children who are not affected by technological change and found they have much higher levels of PA, and that obesity was present in only 1.4% of the population (overweight children totalled 7.2 %) compared to US statistics of 16.5 % being overweight. The higher rates of PA due to physical chores, active play, and walking being the major transportation method (Bassett et al. 2007). Similar patterns were found for Mennonite and Amish children by (Bassett 2008ar).

Sallis, Prochaska and Taylor (2000) showed nine variables that influence children's physical activity behaviour: sex (male), overweight parents, preference for PA, intention to exercise, previous PA, healthy diet, access to programs/facilities offering PA, and time spent outdoors were all positively associated with PA behaviour; whereas barriers to PA (real or perceived) were associated with less PA.

A hurdle that is not always discussed with regards to the physical inactivity of children, or the excessive television watching of children, is the fact that many do not have access to safe areas to play after school, a trend that has been seen in low-income urban areas in the United States

(Evans et al. 2009; Bar-or et al. 1998). Walter (2011) states the scarcity of sports and recreation opportunities, especially in previously disadvantaged areas, is a hurdle to PA outside school. She goes on to mention that where there is a decrease or absence of physical education in school there is a correlated decrease in sports participation (Walter 2011). In her comparison of school children's PA with the 60 $min.d^{-1}$ recommendation, Walter (2011) showed that 58 % (35 min) of the 60 minutes were collected during school hours, although 90 % of grade six learners did not accumulate 30 minutes of activity, as well as 53 % of all girls tested. A list of possible reasons why play and outdoor recreation may be limited is provided by Bar-or et al. (1998) as:

- Lack of safety – including danger from traffic
- Smaller families
- Transport being mostly automated
- Lack of Physical Education in school
- Community funds lacking (No after school programs)
- Limited use of school facilities after hours
- Increased technology use in day to day life – computer games

Reddy et al. (2008) showed that the youth are well aware that exercise has a potential effect on body weight; the most common answer given when students asked how they have attempted to lose weight is 'exercise' (56.5 %), whilst 'eating less food, fewer calories or foods low in fat' only drew 13.8 % of the answers. A distinction must be made here between male and female respondents, as more male learners (64.0%) reported using exercise to control weight than females (49.3%), and more female respondents attempted to lose weight via calorie restriction than males (16.3% vs. 11.3%). Whilst not all obese children show anthropomorphic changes to exercise when using BMI or body mass, body composition however often improves, and children who participate in moderate or vigorous PA have lower body fat percentages than those who do not (Plowman and Smith 2013). Though the use of PA to try and lower the body fat of children and adults is a common goal, there are several adjunct benefits that accompany the changes such as increases in physical fitness, self-esteem, and improvement in blood pressure as well blood lipid profiles (Bar-or et al. 1998). Adults, adolescents, and children alike share the pattern of those with the least amount of PA and lowest levels of fitness who stand to attain the greatest benefits with even mild increases in activity and fitness (Plowman and Smith 2013).

The link between physical inactivity and CVD risk factors has been discussed increased morbidity and mortality; motor developmental effects of physical inactivity must also be taken into consideration. Graf, Koch, Kretschmann-Kandel, Falkowski, Christ, Coburger, Lehmacher, Bjarnason-Wehrens, Platen, Tokarski, Predel and Dordel (2004) showed that overweight and obesity is associated with poor gross motor development and that being more physically active is correlated positively with gross motor development (in children of the first grade). Dokic and Mededovic (2013) showed that overweight and obese children had significant reductions in speed of running, muscle strength of arms, shoulders, trunk, as well as explosive strength of the legs compared to normal weight children (grades three to six). Not all motor abilities appear to be impacted equally, Korsten-Reck, Kaspar, Korsten, Kromeyer-Hauschild, Bos, Berg and Dickhuth (2007) found improved upper body strength when throwing a medicine ball for the obese children in their study (ages eight to 12) though other variables were similarly decreased for weight bearing activities.

Interventions to improve motor abilities of children have been shown to be successful provided enough time is spent regularly with the children on these activities (Savicevic, Suzovic and Dragic 2012). Korsten-Reck et al. (2007) showed that with reduction in obesity there was an increase in aerobic endurance capabilities.

## 2.7. Obesity

Obesity as risk factor for CVD can be assessed through multiple methods, but can be defined as an excess accumulation of body fat, particularly in the abdominal region, and is both an independent risk factor for CVD but is also related to other risk factors (Plowman and Smith 2013; Whaley et al. 2006; Monyeki, Van Lenthe and Steyn 1999). Classification of obesity is a BMI score of ≥30 $kg.m^{-2}$ (18.5 to 24.9 $kg.m^{-2}$ representing normal weight, and 25 to 29.9 $kg.m^{-2}$ representing overweightness), however other measurements used to determine whether a person is at risk for CVD based on level of obesity also include: Body fat percentage, height/weight tables, an estimation of body fat distribution (measurement of waist : hip ratio) and waist circumference alone (Plowman and Smith 2013; Whaley et al. 2006; Durstine and Moore 2002).

Though universal standards for body fat percentages are lacking, Plowman and Smith (2013) states typical normal values used for males between the ages of 20 – 29 years are 12-15% and for females of the same ages 22-25%, with an allowance made of 2% for each decade of age, and obesity classified as the above normal value.

For children the BMI is less reliable and there isn't a linear progression that tracks parallel to chronological age, therefore weight classification is done: normal weight being ≥ 5$^{th}$ percentile and ≤ 85$^{th}$ percentile (Steyn 2005). Children with a weight ≥ 85$^{th}$ percentile and ≤ 95$^{th}$ percentile are at risk for overweight and above is classified as 'overweight' (Steyn 2005; National Center for Health Statistics in collaboration with the National Center for Chronic Disease Prevention and Health Promotion 2000).

Durstine and Moore (2002, p. 149) listed the effects that obesity may have as:

- Increased fasting insulin and insulin response to glucose with a decreased sensitivity of insulin
- Decreases in hormone-sensitive lipase
- Decreases in growth hormone and the response of growth hormone to insulin stimulation
- Increases in adrenocortical hormones
- Increases in cholesterol synthesis and excretion.

The metabolic syndrome (Table 5) refers to a cluster of risk factors for CHD such as dyslipidaemia, insulin resistance, hypertension, impaired fibrinolysis, chronic low-grade inflammation, and visceral abdominal obesity (with last mentioned being the central risk factor) that are interrelated and directly contribute to the development of atherosclerosis as well as diabetes mellitus (Plowman and Smith 2013; Monyeki and Kemper 2008; Whaley et al. 2006; Monyeki et al. 1999). These risk factors are metabolic in nature and work synergistically to increase the risk and prognosis of CVD (Whaley et al. 2006). Kang et al. (2010) found that metabolic syndrome increased CVD risk 2.45 fold compared to those without metabolic syndrome (upon follow-up 5-8 years from initiation). For an individual to be diagnosed with metabolic syndrome, three or more of the following criteria must be met: abdominal obesity, excessive TG levels, low levels of HDL-C, raised blood pressure, or raised fasting glucose (Whaley et al. 2006).

**Table 2 Clinical Identification of the Metabolic Syndrome (Whaley et al. 2006, p220)**

| Risk Factor | Defining Level |
|---|---|
| Abdominal obesity | Waist circumference |
| Men | > 102 cm |
| Women | > 88 cm |
| Triglycerides | ≥ 150 $mg.dL^{-1}$ [≥ 1.69 mmol/l] |
| High-density lipoprotein cholesterol | |
| Men | < 40 $mg.dL^{-1}$ [<1.03 mmol/l] |
| Women | < 50 $mg.dL^{-1}$ [<1.3 mmol/l] |
| Blood Pressure | ≥ 130/≥85 mm Hg |
| Fasting Glucose | < 110 $mg.dL^{-1}$ [<6.10 mmol/l] |

Visceral abdominal adipocytes are stimulated to release free fatty acids (FFA) (via the enzyme lipoprotein lipase) which are taken up by cells (such as muscle cells) to be oxidized and release energy in the form of adenosine triphosphate (ATP) to be used during cellular respiration; alternatively, the FFA may also be converted in the liver to VLDL's, and then in turn to LDL-C (Plowman and Smith 2013). The excess of released FFA creates an enhancement of lipid oxidation, making it a preferred fuel source to the body at the expense of glucose utilization (Plowman and Smith 2013). As a result glucose levels rise in the blood, and high FFA levels (which directly inhibits insulin clearance in the liver) leads to hyperinsulinemia, the combination results in a decrease in insulin sensitivity (Plowman and Smith 2013). For individuals predisposed to developing Type II diabetes mellitus, the continual high levels of insulin and glucose hastens the disease development, and the hyperinsulinemia may also trigger hypertension through sodium retention in sensitive individuals (Plowman and Smith 2013).

The result is a cluster of CVD risk factors that occur together and are interrelated due to having high levels of abdominal visceral obesity: dyslipidaemia due to increased TG and decreased HDL-C, glucose intolerance, insulin resistance (possibly Type II diabetes mellitus with progression), and hypertension (Plowman and Smith 2013). It is debated whether metabolic syndrome comprises a greater risk for CVD than merely the sum of the individual factors; Kang et al. (2010) did not find greater risk when metabolic syndrome is separated into its individual constituents than merely the sum of its parts and Plowman and Smith (2013) suggested the 'metabolic syndrome' diagnosis is perhaps more useful in its role of convincing the patient of the seriousness of the matter and interrelatedness of its sub-factors.

Due to the very high prevalence of HIV infected patients in Southern Africa and the treatment thereof with anti-retroviral medications, it is important to once again note the patients on these medications are at greater risk to develop the metabolic syndrome and thus CVD (Govender 2012).

Apart from the effect that obesity has on the risk for CVD, obesity is also a major risk factor for non-communicable diseases including: musculoskeletal disorders (such as osteoarthritis), and certain cancers (including endometrial, breast, and colon) (WHO 2012). Childhood obesity also increases risk for fractures, breathing difficulties, psychological conditions, and other CVD risk factors previously discussed including hypertension, insulin resistance and the early development of atherosclerosis (WHO 2012). Markers of inflammation and changes in vascular function and structure are already present in obese children, with 60 % of overweight and obese children having an additional major CVD risk factor, as such metabolic syndrome affects children and adolescents before onset of adulthood (Plowman and Smith 2013).

According to the World Health Organization, in 2008 more than 1.4 billion adults were overweight or obese, and of those 500 million were in the obese category; thus one in ten adults of the world population is considered obese (WHO 2012). South Africa is no exception to the rule, the 2002 South African Demographics and Health Survey showed according to Rheeder (2006), 29.2 % of South African men being overweight and obese, and 56.6% of women. Figures from the United States' Surgeon General shows that the number of overweight children have doubled and the number of overweight adolescents have trebled since 1980 (Figure 5) (Rheeder 2006). In the 'Heart of Soweto' study it was shown that up to 70 % of their participants were overweight with 43 % being obese, making it the most prevalent CVD factor in that population (Pretorius et al. 2011). As of 2010, more than 40 million children under the age of five were considered overweight or obese, and 35 million overweight children were living in developing nations, compared to eight million in developed countries
(WHO 2012).

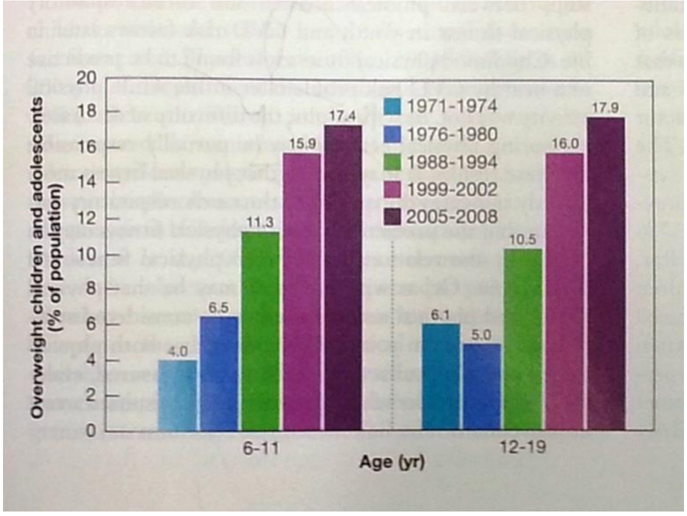



**Figure 5 US trends in obesity prevalence in children and adolescents according to age and year (Plowman and Smith 2013, p. 477)**

The Reddy et al. (2008) reported that 19.7 % of South African children are overweight (27.8 % female and 11.2 % male), with 5.3% being obese (7.2 % female and 3.3 % male). Childhood obesity definitely 'tracks' into adulthood as obese children are more likely to be obese adults, and obesity in childhood is also associated with greater rates of morbidity and mortality in adulthood (WHO 2012; Bar-or et al. 1998). Almost 80 % of obese children will go on to be obese adults (Plowman and Smith 2013). Obese children as young as six years old already carry 50 % risk for adult obesity (Steyn 2005). Childhood obesity can thus be said to 'track' into adulthood (Bar-or et al. 1998).

In the Canadian 'CANPLAY' study where 19 789 children were recruited to have their PA levels monitored, there were clear patterns between parental variables and those of PA of the children; children took a greater number of steps when the parents had a higher level of education (particularly girls), when the parents rated themselves as being more active, or when the parental income is greater the children also took more steps (Craig et al. 2010). Not only is the education level of the parents important in determining PA levels of children but Biddle and Goudas (1996) also showed that encouragement from parents was a predictor of children's PA as measured by self-report measures. The YRBS study performed in 2008 (also previously performed in 2002) sampled more than 10 000 South African learners in grades eight to 11 and provides an overview of the current situation and views held in the South African youth: Despite Reddy et al. (2008) reporting 19.7 % of our nations learners being overweight, only 12.1 % considered themselves to be overweight. Interestingly, though 24.7 % of learners considered themselves to be 'underweight', only 8.4 % and 13.1 % were classified to be underweight by weight-for-age and 'height-for-age' measurements, respectively (Reddy et al. 2008). The trend here seems to be that overweight learners do not recognise the problem and that learners of normal weight tend to view themselves as underweight, both cases shows a tendency towards a heavier norm being considered 'normal'.

Monyeki et al. (1999) found there was a smaller percentage of overweight black African children who have started to attend school compared to infants (based on BMI percentile ratings); as the researchers stated parental supply and control of food is greater during this early period and alludes to parental responsibility towards the obesity problem. South Africa is still in a process of epidemiological transition, meaning there is currently a shift towards westernization and urbanization which brings with it diseases of lifestyle such as obesity and diabetes mellitus Type II (Pretorius et al. 2011; Evans et al. 2009; Raal 2009; Tibazarwaa, Ntyintyanea, Sliwa, Gerntholtzb, Carrington, Wilkinsonc and Stewart 2009). Although these problems have real health consequences, more basic needs often take precedence over PA and nutritional needs (Evans et al. 2009).

In the American College for Sports Medicine (ACSM) roundtable discussion on juvenile obesity (including children and adolescents), Bar-or et al. (1998) mention that dietary data from the United States shows an increase in obesity in spite of a decrease in overall fat consumption.
Though not specifically related to obesity, black African individuals have been shown to be sensitive to salt intake which can cause or exacerbate hypertension, furthering the problem as it relates to obesity (Monyeki and Kemper 2008). Dietary intake is also limited in rural and township communities as affordable healthy food may simply not be available (Evans et al. 2009). Furthermore in South African schools, the low-income schools typically have no feeding scheme for the learners or inadequate schemes, and as Evans et al. (2009) referenced Steyn et al. (2005) in this regard: children who are stunted at an early age (via malnutrition) have a two-fold risk for developing obesity later in life (Steyn, Labadarios, Maunder, Neld and Lombard 2005). On a similar note, diet has been shown to be affected by the environment in the sense that greater access to supermarkets has shown to increase fresh produce consumption, and greater availability of high fat, low nutrient foods at schools leads to greater consumption of these products by learners (Evans et al. 2009).

Lawlor, Smith and Ebrahim (2004), building on the work of others, showed that the link between environment and CVD is not only related to the present environment, but that even adult coronary artery disease (post-menopausal women) can be predicted by poor childhood socioeconomic conditions past, such as the link with poor diet, chronic emotional stress, and associated behaviours of poverty such as smoking and physical inactivity. Salonen, Kajantie, Osmond, Forsen, Yliharsila, Paile-Hynarinen, Barker and Eriksson (2011) showed that factors that can influence childhood growth and even pre-natal factors (such as birth weight and childhood BMI) can be predictive of adult leisure time PA.

The importance of parents' role in fighting childhood obesity cannot be overstated, apart from the obvious control they have over diet and PA patterns, parental obesity is associated with increased failure rate in childhood obesity interventions (Evans et al. 2009). The associations and causes related to the obesity epidemic are vast and varied, a 14 % increase risk for obesity for every additional ten grams of fat per person has been seen in households where parents do not supply nutrient rich foods but energy dense foods (Ransley, Donnelly, Botham, Khara, Greenwood and Cade 2003).

In the review by Bar-or et al. (1998)on PA, genetic factors and nutrition states that up to 25 – 40% of the contribution to obesity can be explained by genetic factors. In the United States, both parents will be obese in 30 % of obese children, but in 25 – 35% of cases the parents will be off normal weight (Bar-or et al. 1998).

In summary of the causative factors mentioned above, the causes for obesity are many and diverse. Some factors are controllable, others are not. Increasing PA is clearly not the only variable that needs to be addressed; however it is a variable that definitely needs to be improved as it has shown that PA and PF does impact obesity and modifiable CVD risk factors.

## 2.8. Conservative Treatment of Cardiovascular Disease Risk Factors

The WHO suggests the limitation of total energy intake from fats, and sugars, whilst increasing consumption of fruits, vegetables, legumes, whole grains, nuts, and increasing PA to achieve healthy weight (WHO 2012). Similar instructions are common such as promoting healthy eating habits, being more physically active, but also creating a supporting family environment and altering behaviour causing overeating (Steyn 2005).

### 2.8.1. Physical activity

Plowman and Smith (2013, p.5, 11) defines exercise as: "*A single acute bout of bodily exertion or muscular activity that requires an expenditure of energy above resting level and that in most, but not all, cases results in voluntary movement.*" And exercise training as: "*Consistent or chronic progression of exercise sessions designed to improve physiological function for better health or performance.*"

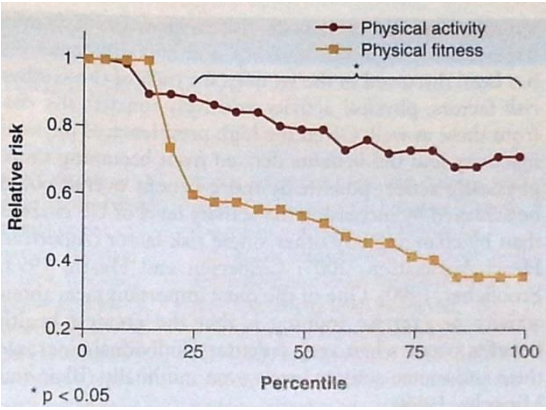



**Figure 6 Comparing the effects of physical fitness versus physical activity on heart disease risk factors (Plowman and Smith 2013, p. 469)**

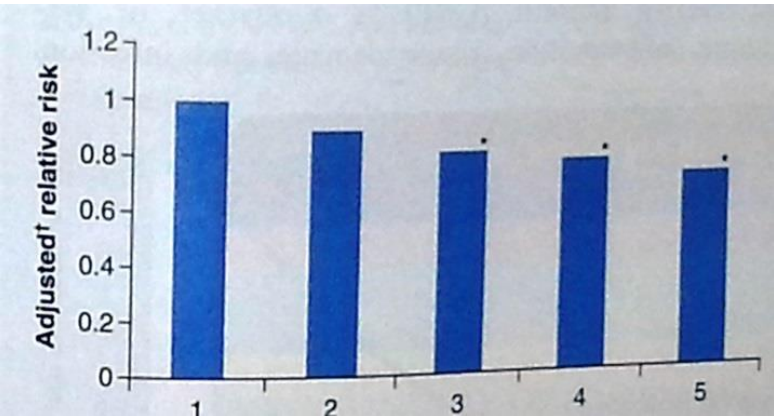



**Figure 7 Quintiles of physical activity by estimated energy expenditure for adult women (Plowman and Smith 2013, p. 469)**

Both PA and its result, PF, have shown evidence of increase in health outcomes (Figures 6 & 7) (Plowman and Smith 2013). For adults, the recommendation from the American College for Sports Medicine for regular PA is 30 minutes of moderate intensity cardiovascular activity on ≥5 days of the week, this is over and above regular low intensity activities of daily living (Garber, Blissmer, Deschenes, Franklin, Lamonte, Lee, Nieman and Swain 2011; Whaley et al. 2006). Mungal-Singh (2012) gives the South African Hypertension Guidelines for 2011 as 30 minutes of activity ranging as at least 40 – 60% of maximum on preferably all days of the week. Other descriptors given by Mungal-Singh (2012) as minimum PA needed also includes:

- 30 minutes day (or 10 minutes x 3) at moderate intensity for five days / week
- 20 minutes of vigorous PA three times / week
- 150 minutes of moderate intensity PA per week or 75 minutes of vigorous aerobic activity
- Children and youth should accumulate at least 60 minutes of PA per day (Garber et al. 2011)

Greater benefits are generally seen with increases in the level of PA past this minimum level, and it is recommended that cardiovascular activities be supplemented by strengthening exercises at least two to three days/week (Plowman and Smith 2013; Mungal-Singh 2012; Garber et al. 2011).

Increases in PA via steps per day have been shown to decrease the risk factors for metabolic syndrome with improvements in body composition and blood lipid profiles, with participants in the highest activity level showing the most improvements (Sisson et al. 2010). For children the goal is rarely weight loss in the same sense as for adults, the goal is to maintain the weight and

with age gradually having a lower percentile weight – thus 'growing into your weight' (Steyn 2005). Only when weight passes the 95th percentile in ≥ seven year olds, or when a child is overweight with co-morbid CVD risk factors such as hypertension, hyperlipidaemia, insulin resistance or orthopaedic concerns, might weight reduction be considered (Steyn 2005).
Sallis et al. (2000) published a review on all the data from 1976 to 1999 regarding the correlations that were found with children's PA, and found that with regards to statistically significant associations a link was found with the sex of the children (males being more active), the weight status of the parents, their PA preferences as well as intention to be active, an inverse correlation with their perceived barriers to PA, previous PA, healthy diet, access to facilities or programs, and lastly with time spent outdoors. There were also associations found for adolescents and PA namely, sex (males being more active), ethnicity (caucasians being more active), an inverse correlation with age and sedentary behaviour after school and on weekends, as well as with depression status, perceived competence, intentions to participate in PA, previous PA participation, community sports, sensation seeking behaviour, support from parents as well as others, sibling PA, opportunities to exercise as well as direct help from parents (Sallis et al. 2000). Some of these traits listed are not modifiable such as age, sex and availability of opportunities, though many are dependent on the family and peer groups, indicating that a lifestyle intervention with a broad focus and multiple goals may be very successful in promoting a positive behavioural change.

PA has effects on several of the CVD risk factors, and also affects the atherosclerotic process itself by delaying the disease as well as limiting the risk of mortality from CVD (Plowman and Smith 2013). This delay and/or improvement in the atherosclerotic individual may be due to chronic exercise and PA showing improvement in endothelial function and myocardial perfusion (in patients who already have established coronary heart disease); partly the effect may be due to the sum of the individual risk factors being attenuated, and partly it may be due to nitric oxide (vasodilator) being more freely available with exercise training (Plowman and Smith 2013).

Although the effects of PA are varied and the benefits numerous such as for example the importance of PA to bone health (especially in the young) and preventing osteoporosis (Bielemann, Martinez and Gigante 2013), due to the brevity of those effects, all will not be discussed in this text and the focus kept on CVD risk factors.

### 2.8.2. Benefits to Childhood Physical Activity and Physical Fitness

Longitudinal observation studies that examined PA and PF (cardiorespiratory fitness) in youth and comparing to CVD risk factors in later life found PF was a predictor of healthier CVD status but PA was not; the researcher mentioned that accurate measurement of PA may be partially an interfering factor to the results, but more likely it is due to PF having a close relation to quality of the cardiorespiratory system, and body fat percentage (Plowman and Smith 2013). As PA and PF appears to have distinct effects and correlations, the researcher also suggested, as have been mentioned elsewhere, that both measures must preferably be measured, evaluated and considered in the process of intervention (Plowman and Smith 2013).

Bassett (2008) showed that when investigating Amish and Mennonite children, they were found to have much higher levels of PA than contemporary children yet did not differ in terms of PF when comparing aerobic endurance between the groups. Interestingly, when contrasting the effects on the opposite side of the spectrum, namely investigating malnourished children and PA and PF the same connections towards health and improved body composition does not exist between body composition and PA, despite PA often having a muscle sparing effect in reduced caloric intake situations (Monyeki, Koppes, Twisk, Monyeki and Kemper 2006). Though the rising rates of obesity and current prevalence as shown by epidemiological evidence is a very real concern in South Africa, it can be easy to forget that malnourishment and obesity exists side-by-side in this country (Madhavan and Townsend 2007). Whilst obesity is more prevalent in urban settings, in rural settings malnourishment may reach as high 53 % for boys and 60 % for girls in certain areas (Madhavan and Townsend 2007).

**Table 3 The effects and benefits of PA on various CVD risk factors for children and adolescents as adapted from Plowman and Smith (2013, p474-479)**

| **CHILDREN** |
|---|
| **Cholesterol-Lipid fractions**<br><br>Active youngsters have more beneficial lipid levels for CV health: (Anderson, Harro, Sardinha, Froberg, Ekelund, Brage and Anderssen 2006)<br>Increased HDL-C levels |

**CHILDREN**

(Anderson et al. 2006)
Decreased TG levels
(Anderson et al. 2006)

PF has stronger relationship with lipid levels than PA (Boreham and Riddoch 2001)
Those with higher PF and/or muscular fitness levels have more favourable lipid-metabolic profiles (Plowman and Smith 2013; Boreham and Riddoch 2001)

Cardiorespiratory fitness in childhood and adulthood can serve as predictor for abnormal blood lipid levels in adulthood (Plowman and Smith 2013)

Minimum amount of activity needed to see beneficial results: 40 minutes of moderate to vigorous aerobic exercise, five days/week for at least four consecutive months (Strong, Malina, Bumke, Daniels, Dishman, Gutin, Hergenroeder, Must, Nixon, Pivarnik, Rowland, Trost and Trudeau 2005)

**Diabetes mellitus**

PF is an independent predictor of insulin sensitivity, but not PA (Henderson, Gray-Donald, Mathieu, Hanley, Rabasa-Lhoret and Lambert 2011)
Early establishment and maintenance of PA does lead to improvements in body fatness and reduced glucose and insulin variability (Moschonis, Mougios, Papandreou, Lionis, Chrousos, Malandraki and Manios 2013; Plowman and Smith 2013)

As with adults adequate amounts of aerobic activity as well as resistance training needs to be done (Moschonis et al. 2013; Plowman and Smith 2013)

**Hypertension**

Strong evidence cardiorespiratory fitness in childhood and adolescence will predict hypertension in adulthood (Kvaavik, Klepp, Tell, Meyer and Batty 2009)
Blood pressure in youth shows a dose-response relationship (Plowman and Smith 2013; Hopkins, Stratton, Tinken, McWhannell, Ridgers, Graves, George, Cable and Green 2009)
Least fit boys and girls have greatest likelihood for hypertension (even stronger relationship when only comparing unfit children (Plowman and Smith 2013; Hopkins et al. 2009)
Inverse relationship between PA and BP (Farpour-Lambert, Aggoun, Marchand, Martin, Herrman and Beghetti 2009)

Exercise improves childhood hypertension but usually does not return BP levels completely to normal (Plowman and Smith 2013; Danforth, Allen, Fitterling, Danforth, Farrar, Brown and Drabman 1990)
Aerobic activity of 30-60 min/day for three days/week intense enough to improve aerobic fitness will improve hypertension levels if exercise training is maintained regularly (Plowman and Smith 2013; Farpour-Lambert et al. 2009)
Dynamic resistance training will not reduce hypertension levels when used alone but will maintain improvements made after a period of aerobic training (Millar and Goodman 2014; Plowman and Smith 2013)

**CHILDREN**

**Obesity**

Strong evidence that body composition in childhood and adolescence will predict adult CVD risk factors (Jekal, Kim, Yun, Kim, Naruse, Park, Lee, Hong and Jeon 2014)

Strong evidence that increased BMI in childhood and adolescence will increase risk of early adult death (Berentzen, Gamborg, Holst, Sorensen and Baker 2014; Franks, Hanson, Knowler, Sievers, Bennett and Looker 2010)

Adolescent fitness predicts adult fatness (Jekal et al. 2014)

Fatness mediator between PA and several other risk factors (Moschonis et al. 2013)

High levels of body fat's deleterious effects can be counter acted by improvements in cardiorespiratory fitness (Brage et al. 2004)

PA appears to have a dose -response relationship with obesity (Plowman and Smith 2013; Sothern 2004)

PA and PF have relationship with metabolic risk factors (Brage et al. 2004)

Stronger relationship with PA in children with low CR fitness, those with lowest level stands to benefit the most (Brage et al. 2004)

Several studies show improvement in specific elements of metabolic syndrome, independent of whether the participants were obese or not (Moschonis et al. 2013)

Prevention of fatness in youth is most dependent on the training variable of 'volume', especially the volume of vigorous intensity activity (Plowman and Smith 2013; Sothern 2004)

Exercise training needed for overweight children and adolescents to show favourable changes in total body fat as well as visceral fat is: 30 - 60 min/day of moderate intensity aerobic activity, 3-7 days/week (Plowman and Smith 2013)

Resistance training also elicits favourable changes in body composition (Strasser, Arvandi and Siebert 2012)

### 2.8.3. Lifestyle intervention

Lifestyle interventions are focused around avoiding risky behaviour or habits such as cigarette smoke and excess alcohol, improving PA levels on a consistent and appropriate basis, and improving dietary patterns to avoid or reduce saturated fats, trans fats, cholesterol, refined carbohydrates, high salt intake, sugary foods, and excess calories, and lastly to achieve desirable body composition (Plowman and Smith 2013; Klug et al. 2012; Heyward 2006).

The initial treatment for all these modifiable CVD risk factors includes a lifestyle modification which is often successful without further treatment, except in more advanced and higher risk cases (Plowman and Smith 2013; Klug et al. 2012). Recommendations by the South African Heart Association (SA Heart) and LASSA (Figure 8) for lifestyle intervention for patients with dyslipidaemia can be of use for all patients at risk for atherosclerotic disease and for treatment of current atherosclerotic or modifiable risk factor (Klug et al. 2012).

A follow-up study on Finnish students have shown that those who remain physically active did smoke less (in addition to having healthier diets, better insulin levels, higher HDL-C, and lower TC levels) than those who did not (Plowman and Smith 2013).

**Appendix 2. South African Heart Association/LASSA guidelines for lifestyle modification for patients with dyslipidaemia**

1. Stop smoking and avoid exposure to environmental tobacco smoke.
2. Increase your physical activity. Try to do exercise of moderate intensity, such as brisk walking, for at least 30 minutes on all or most days of the week.
3. Achieve and maintain ideal body weight.
4. Reduce your intake of saturated fats, trans-fats and cholesterol. Avoid eating fatty meats, processed meats, chicken skin, processed meats, confectionery such as pies, pastries and cookies, fast foods, deep-fried potato chips ('slap chips'), butter, ghee, cream, hard cheeses and salty crackers.
5. Replace saturated fats with unsaturated fats. Avoid the use of hard margarines, butter and ghee for cooking or adding to food. Use unsaturated fats such as canola oil, olive oil and sunflower oil for cooking. Use oils sparingly and avoid all deep-frying of food. Remove all visible fat before cooking. Increase your intake of all types of fish, especially oily fish such as sardines and salmon, to a minimum of twice a week.
6. Increase your intake of fibre, especially soluble fibre. Include foods such as oats, fresh fruit and legumes (dry beans, soya beans, chickpeas, all types of lentils). Include a minimum of five portions of fresh fruit and vegetables in your daily diet.
7. Replace all refined carbohydrate types of foods with foods high in fibre, such as whole grains. Avoid eating products made from white flour, such as white bread and rolls, pizzas, vetkoek, samoosas, pies, prego rolls and bakery items such as cakes and biscuits. Incorporate whole- grain foods such as oats, barley, stampkoring (pearl wheat), crushed wheat, samp and beans, brown rice, brown/wild rice, whole-grain breakfast cereals, health and seed breads.
8. Avoid foods high in free sugars (sucrose, high-fructose corn syrup, fructose) such as sweets, chocolates, all fizzy soft drinks, fruit juices, all flavoured and sweetened waters, low-fat sweetened milky drinks.
9. If you consume alcohol, do so in moderation – no more than 2 drinks for men and 1 drink for women per day.
10. Avoid adding salt to food after cooking. Choose and prepare foods with little or no salt by using more herbs and spices.

**Figure 8: South African Heart Association/LASSA guidelines for lifestyle modification for patients with dyslipidaemia (Klug, et al., 2012, p165)**

According to Bar-or et al. (1998), lifestyle interventions yield greater long term effects than regimented physical exercise programs; limiting sedentary behaviours create more sustainable long term results in children than merely an exercise program. Bar-or et al. (1998) in their ACSM roundtable discussion mention that Epstein, Coleman and Michelle (1996) already showed that a family based behavioural intervention can show benefits up to ten years later. Bar-or et al. (1998) also goes on to describe weight management as a lifelong process that starts with children and circles around the use of healthy choices and habits, small realistic habits, and without compromising nutritional value.

It should be noted that lifestyle interventions can have complex interplay between social factors such as family, school/work, social network or support system, community at large, and the physical and commercial environment itself according to Mungal-Singh (2012). The individual may have the choice to make a lifestyle intervention, yet the willpower and all the control may not be entitled to him – policy makers and health promoters often have a say from a top – down approach (Mungal-Singh 2012).

**2.8.4. Diet**

Mungal-Singh (2012) in his review on lifestyle changes for hypertensives describes the basic intervention as consisting of decreasing caloric content of diet and increasing the energy expenditure through exercise (preferably at least moderate in intensity and a combination of resistance training and cardiovascular activity for 45 – 60 minutes every day). Mungal-Singh (2012) also describes the South African Hypertension Guideline of 2011's stand point on desirable dietary practices as: a diet containing low levels of sodium, sugar, caffeine, and fat (especially saturated- and trans-fats), with fish being preferential to red meat, and high intake of fruits, vegetables, and wholegrain foods to be consumed (five portions per day).

A short review of the types of diets/dietary interventions used in the treatment of childhood obesity can be categorized as Type I: "*Protein sparing modified fast*" (PSMF) which involves a diet low in total calories as well as carbohydrates but high in protein, considered a very low calorie diet; type II: "*Balanced hypo-caloric diet*" (BHD); and Type III: A combination of dietary and PA with a comprehensive lifestyle intervention program with attainable goals for the entire family (Bar-or et al. 1998). PSMF has been suggested to be appropriate for weight loss in children since it preserves fat free mass but does lead to rapid weight loss, and in particular when added to an exercise program since it also has an anabolic effect (Bar-or et al. 1998). Though this approach is only for a short term rapid reduction in weight for the morbidly obese (Bar-or et al. 1998). For children, limiting dietary intake with regards to obesity may be problematic as children require nutrients for their continuing development and to ensure optimal growth, for example below two years of age fat intake may not be limited and up to age five fat intake must be limited only up to 30% of total caloric intake (Bar-or et al. 1998).

A novel tool applied to children to help manage dietary intake include the stoplight diet that places foods into groups that can be eaten readily ('green-light foods'), foods used more sparingly ('yellow-light foods'), and the foods that are restricted ('red-light foods') (Steyn 2005;

Bar-or et al. 1998). The aim with this type of diet is to maximize the nutrient density of food (Bar-or et al. 1998).

Though a comprehensive discussion of dietary intervention is not within the scope of this text, using diet to treat and prevent obesity concerns control over caloric balance, thus the energy intake via food and drink, compared to expenditure through resting metabolic rate, thermic effect of food, and energy expenditure through PA and exercise (Plowman and Smith 2013; Steyn 2005; Milne and Pinkney-Atkinson 2004).

Pharmacological agents that may be used in treating obesity include Orlistat to block absorption of fat through its inhibition on lipase (indicated for use in adolescents), and Sibutramine hydrochloride (only indicated for use in adults) (Steyn 2005).

### 2.8.5. The Five Fitness Components

Exercising in order to be healthy means to avoid or prevent diseases of inactivity as well as to rehabilitate from already existing diseases through being physically active(Plowman and Smith 2013). Furthermore, it is to establish or maintain a high functioning physiological capacity to deal with activities of daily living and not just exercise in order to improve sports performance but those physiological systems that aren't involved in sports performance yet are influenced by our PA (Plowman and Smith 2013).

According to Plowman and Smith (2013) exercise for health-related goals (Figure 9) is centred around the achievement of minimum levels of fitness in the following five components: cardiovascular- respiratory endurance, body composition and muscular fitness (sub-divided into muscular strength, muscular endurance, and muscular flexibility) (Whaley et al. 2006).

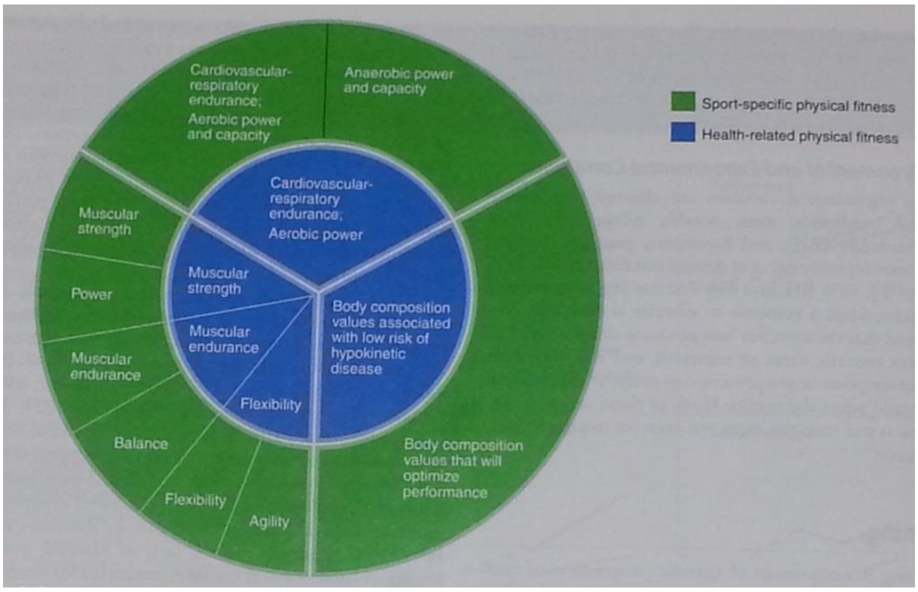



**Figure 9 Health-related physical fitness vs. Sport-specific physical fitness (Plowman and Smith 2013, p.12)**

Lacking in any one of these five components is generally linked to increased risk for one hypokinetic disease or other. Some of these have been mentioned with regards to the connection to CVD risk factors, other such as muscular endurance and muscular flexibility are linked to other hypokinetic conditions such as lower back pain which is not discussed in this text.

**2.8.5.1. Flexibility Training**

"*Flexibility is the range of motion in a joint or series of joints that reflects the ability of the musculotendon structures to elongate within the physical limits of the joint*" (Plowman and Smith 2013, p.603). Flexibility is affected by a range of variables including age, gender, connective tissue structure, PA, previous injuries, muscle bulk, and joint architecture (Plowman and Smith 2013; Baechle and Earle 2008). Flexibility has static and dynamic components with dynamic components being more important to athletic performance as well as joint health (Plowman and Smith 2013; Baechle and Earle 2008).

Two of the most common stretching techniques for improving flexibility is static stretching and proprioceptive neuromuscular facilitation (PNF) (Plowman and Smith 2013; Baechle and Earle 2008). Static stretching involves holding the area to be stretched at or near the maximum to which it can be extended for 10 – 30 seconds (Plowman and Smith 2013; Baechle and Earle 2008). A PNF stretch involves a maximal contraction of the muscle prior to it being stretched (with or without subsequently contracting the antagonist) in an attempt to further relax the target muscle either via contraction of its antagonist (stimulating the neuromuscular spindles and reciprocal inhibition) or via the Golgi tendon organs and the inverse myotatic reflex (autogenic inhibition) (Plowman and Smith 2013; Baechle and Earle 2008).

Other types of stretching include ballistic stretching which involves a rapid movement and is deemed to be more intense and often not recommended for its potential to create injury (Plowman and Smith 2013; Baechle and Earle 2008). There is also dynamic stretching which is a more functional and controlled version of ballistic stretching used to prepare for activity; typically done as part of a comprehensive and sport specific warm-up (Baechle and Earle 2008).

#### 2.8.5.2. Resistance Exercise

*“Resistance training is a systematic program of exercises involving the exertion of force against a load, with the goal of developing strength, endurance, and/or hypertrophy of the muscular system.”* (Plowman and Smith 2013, p. 568). Generally accepted as the minimum recommended amount for health purposes, an individual should try and perform 8-10 resistance exercise doing 8-12 repetitions per exercise for a total of 2-3 days/week (Plowman and Smith 2013; Whaley et al. 2006). Some of the benefits toted with resistance training is not just general improvements in quality of life and health, but also specifically reducing the chance of the individual developing certain diseases such as colon cancer, coronary artery disease, Type II diabetes mellitus, and functionally improving dynamic stability and preserving the individual’s functionality (Plowman and Smith 2013; Whaley et al. 2006). A further benefit is the fact that it can be safely done with prepubescent children (Plowman and Smith 2013).

#### 2.8.5.3. Cardiovascular Exercise

Plowman and Smith (2013, p. 393) defines cardiovascular fitness as: *“The ability to deliver and use oxygen under the demands of intensive, prolonged exercise or work”*, and defines aerobic exercise as *"…activity that involves large muscle groups and is sustained for prolonged periods of time [and] has the potential to increase cardiorespiratory fitness."*

The benefits of cardiovascular exercise are numerous and well documented (Sisson et al. 2010). The Diabetes prevention program have shown that a modifying one's lifestyle, such as the inclusion of regular PA can reduce the risk for developing Type II diabetes mellitus by 58 % (Seedat 2005). For children with autoimmune associated diabetes the decrease in plasma glucose concentrations is at least 25% with exercise with the addition of increases in insulin sensitivity and decrease in inflammatory markers, though other lifestyle interventions may also contribute to these changes (Field 2012). Improved lipid profiles for diabetic children have also been illustrated with cardiovascular exercise (Field 2012).

Fortunately higher HDL-C and lower TG levels are associated with higher PA levels in children, as shown by cross-sectional studies, despite intervention studies showing only weak correlations between PA levels and HDL-C and TG levels (Plowman and Smith 2013). Activity levels that were needed to show beneficial effects in lipid levels were cardiovascular exercise of 40 min/day, five days/week, of moderate to vigorous intensity for more than four months (Plowman and Smith 2013). Despite this high level of activity needed and the seemingly mild effects that it causes, it may instil a diligence of the PA habit that will cause greater effects as an adult (Seedat 2005).

Adults with diabetes mellitus benefit from exercise by increases in sensitivity to insulin as well as taking up of glucose independent of insulin, but with children and adolescents the evidence for this relationship appears to be weak (Plowman and Smith 2013; Whaley et al. 2006; Durstine and Moore 2002). Slinger, Van Breda, Keizer, Rump, Hornstra and Kuipers (2008) did show that in seven to eight year old children, PA showed a greater link than PF towards playing a protective role with regards to preventing the development of insulin resistance. This effect was explained by the role PA has on body composition and as well as Leptin levels; Leptin being a hormone associated with satiety (Slinger et al. 2008). With children this relationship is dependent on adiposity, so establishing PA early will have an effect on body fatness, but maintenance in the long run will likely positively affect glucose and insulin mechanisms independently as well (Plowman and Smith 2013).

Dynamic aerobic endurance training have shown inconsistent reductions in hypertensive children, the reduction is only partial and requires consistency with the exercise routine in order to maintain levels reached (Plowman and Smith 2013). Dynamic resistance training in itself does not decrease hypertension but when used after a period of dynamic endurance training, can help maintain reductions without the dynamic aerobic endurance exercise (Plowman and Smith 2013). The exercise pattern is thus the same for adults as it is for children.

## 2.9. Measuring Physical Activity Levels

Beets, Patton and Edwards (2005) express the difficulty in measuring PA accurately, particularly in children between five and 12 years old. The reasons stated are the same as previous researchers have mentioned: children have sporadic and intermittent unstructured play, and they rarely spend extended time in Moderate to Vigorous Physical Activity (MVPA) or Vigorous Physical Activity (VPA), mostly low-moderate intensity for extended periods (Beets et al. 2005). For this reason a volume measurement is recommended such as step count in a day (Beets et al. 2005). He also goes on to say that self-report measures may be the wrong tools to assess these age groups with as problems with recall, social desirability bias, and inability to properly categories their activities as PA or not (Beets et al. 2005). Self-report however do have the advantages of cost efficiency and ease of administration in bulk.

### 2.9.1 Pedometers and Accelerometers

#### 2.9.1.1. Mechanics of Pedometers and Accelerometers

An accelerometer is a device used to measure the body’s movement and thus make inferences about PA by detecting and recording acceleration, which can translate to exercise intensity and volume (Bassett and Chen 2005). Acceleration is the change in velocity in relation to time with the unit of measure being ‘gravitational acceleration units’ or ‘g’ (1 g = 9.8 $m.s^{-2}$) (Bassett and Chen 2005). Monitors of PA that function via accelerometer sensors, have one to three piezoelectric sensors mounted perpendicularly to one another to create uniaxial, biaxial, or tri-axial sensors; multi-axial sensors detecting acceleration in more directions (Bassett and Chen 2005). Welk (2005 ) showed that monitors with sensors in addition to just the vertical sensor are more accurate in terms of different body positions not affecting the measurement. Piezoelectric acceleration sensors contain a seismic mass as well as a piezoelectric element that is deformed by the seismic mass when the unit is accelerated (Figure 10); the result is a 'variable output measure' as it can provide a voltage signal related to the quality of deformation, thus the rate of acceleration (Bassett and Chen 2005).

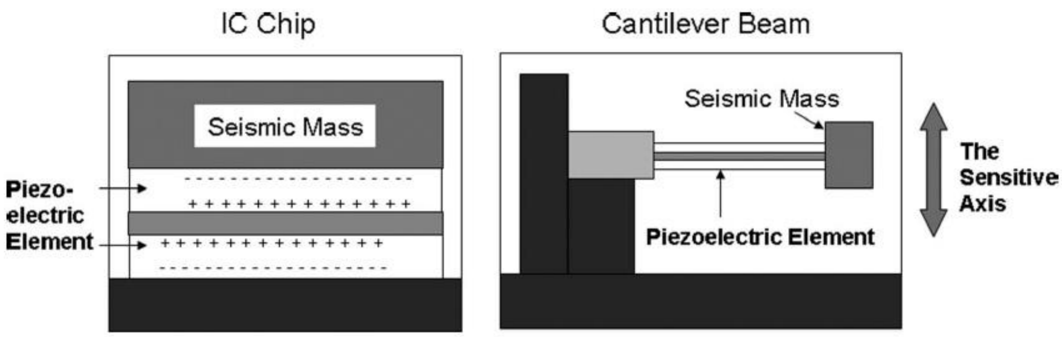



**Figure 10: Schematic of the two common piezoelectric accelerometer configurations (Basset and Chen, 2005, p. S491)**

The piezoelectric sensor can either be a cantilever beam configuration, or the newer 'Integrated Chip' sensors (termed IC sensors) which works by direct compression/tension (Bassett and Chen 2005). The beam type sensor will bend when acceleration is applied, the side towards which it bends is the side the piezoelectric sensor is most sensitive, for that reason it is often called 'uniaxial', but since it could be bent when force from a different direction is applied and also generate acceleration signals – others call it 'omnidirectional' (Bassett and Chen 2005). The sensitivity of forces and bending towards directions other than the standard vertical plane, is dependent on the construction and materials of the unit, but all piezoelectric beam accelerometers are 'omnidirectional' to some degree (Bassett and Chen 2005). The unit will not differentiate between which direction the force came from with a single piezoelectric sensor, to truly measure multidirectional movement, multiple uniaxial sensors are mounted together to form longitudinal, transverse, and anteroposterior axes; in such a configuration IC sensors are used (Bassett and Chen 2005). Accelerometers are dependent on acceleration to record movement and are not capable of recording movement at a constant speed or measuring angles when the body is static; this is a reason why body posture is not detected and certain modes of activity will not be properly recorded by these PA monitors (Bassett and Chen 2005). The voltaic signal that is generated and subsequent recording that is made is filtered to avoid artefacts not related to PA(Bassett and Chen 2005). Very low frequency recordings (which can be affected by temperature and age of the piezoelectric sensors) and very high frequency recordings (affected by electric and electronic noise) are removed to give a truer reflection of PA, though very slow gait patterns are still often difficult to record accurately for PA monitors (Bassett and Chen 2005). Thus from this description we can see that an upper- and lower threshold for the movements are in place to give the most accurate reading – a frequency that is too high is ignored as interference and a frequency too low is ignored as background artefacts. An in depth description of the data sampling and analysis is not within the scope of this paper, as the OMRON HJ-720 is also not a true accelerometer, thus making that information redundant.

Spring levered pedometers are an older and simpler design which relies purely on the vertical accelerative force of the walking gait to move a horizontally positioned spring in order to complete a circuit and trigger the counting mechanism via electrical contact; differences in spring tension however is also a potential source of inaccuracy with this mechanism as are similar problems as mentioned regarding accelerometers such as movement in the wrong plane, interference and undetectable (for the pedometer) movement (Nakae, Oshima and Ishii 2008; Beets et al. 2005). The OMRON pedometer used in the present study is not a spring-levered pedometer but relies on piezoelectric sensors which have in previous research been shown to be more accurate (Nakae et al. 2008). Spring levered pedometers must be mentioned as they have been commonly used in research.

There have been great innovations in the area of PA monitoring: Multi-sensor devices using input from acceleration sensors placed on the limbs (e.g. 'Intelligent Device for Energy Expenditure and Activity' or 'IDEEA'), devices using multiple types of input in addition to acceleration sensors including heart rate monitoring, various types of body thermometers, and galvanic skin sensors (e.g. 'Actiheart monitor' and 'SenseWear Armband') and ankle foot mounted acceleration sensors (e.g. 'Nike Triax' and 'Polar S1 foot pod') (Bassett and Chen 2005). There are disadvantages with next generation sensors, foremost is cost; in addition, some devices have limited substantiation in literature (e.g. 'Nike Triax' and 'IDEEA') (Bassett and Chen 2005). Heart rate monitoring to determine EE seems to be inaccurate at lower intensities and participant interference from caffeine, emotion, environment, hydration, and fatigue. Lastly foot worn accelerometers are less accurate during uphill movement or when transitioning to running (Bassett and Chen 2005). That being said these devices also have many advantages and their widespread use is inevitable.

#### 2.9.1.2. The use of Pedometers and Accelerometers

Measuring PA through pedometers and accelerometers provides an easy to understand variable, 'steps per day', which can be reported and measured, and pedometers have been shown to have a moderate to high correlation with other objective measurements of PA (Nakae et al. 2008). Pedometers provide an effective and simple way to measure PA without intrusiveness and in a scientifically recognized way (Nakae et al. 2008; Le Masurier, Beighle, Corbin, Darst, Morgan, Pangrazi, Wilde and Vincent 2005). Bassett and Chen (2005) concluded that the research that has been done, has used mostly durable, compact, inexpensive, and reliable accelerometers, indicating a recommendation for this method of measuring. As the present study uses a pedometer that depends on accelerometer sensors, accelerometers are included in review. Though pedometers have some inherent limitations, i.e. it cannot give indications of intensity as well as being prone to background movement (vibrations and movement not related to ambulation), it does record ambulatory activity validly and objectively (Schmidt, Cleland, Shaw, Dwyer and Venn 2009). Beets et al. (2005) showed that spring-levered pedometers are less accurate than piezo-electric pedometers, though at a reduced financial cost (Nakae et al. 2008). In comparing these two types of pedometers in children, Nakae et al. (2008) concluded that spring-levered pedometers are not accurate enough to be used in this population. Different types of pedometers have been tested on children, and spring-levered pedometers were found to be inaccurate, underestimating steps taken by as much as 25 %, whilst piezo-electric pedometers were shown to be accurate enough with measurements being within three percent of actual steps taken (Nakae et al. 2008). Reasons postulated included the decreased vertical acceleration of the lumbar spine as well as decreased ground reaction forces leading to underestimation of activity (Nakae et al. 2008). Beets et al. (2005) tested the accuracy of pedometer measurements in children at various walking speeds and found the accuracy was comparable with adult use, and that very slow speeds of walking (≤54 $m.min^{-1}$) was also less accurate, as with adults. Beets et al. (2005) also concluded that placement of the pedometer is not responsible for variations between units of the same type. When measuring pedometer accuracy, a common standard of accuracy is that set by the Japanese Industrial

Standards where error of steps must be within ± three percent (Nakae et al. 2008). The pedometer used in the present study, OMRON HJ-720, is similar series model to that tested on Japanese school children, in that it is also a piezo-electric, dual-axis sensing pedometer using acceleration sensors, and it also has a four-second 'random-movement filter function', meaning movement must continue for more than four seconds, otherwise the steps will not be counted (Nakae et al. 2008).

Accelerometers and pedometers are both devices capable of measuring steps taken though they work through different mechanisms, with accelerometers being more sensitive and so more accurate (Sisson et al. 2010). Meta-analysis of pedometer interventions have shown to decrease BMI and blood pressure, and more steps per day are associated with improvements in insulin resistance and glucose control, changes in body composition, and improvements in blood lipid profiles (Sisson et al. 2010). As pedometer measurements are recorded in steps/day, data should be collected for different populations in order to accurately prescribe sufficient activity per day via steps measured (Sisson et al. 2010). It is especially important to correlate number of steps taken per day with reduction in CVD risk factors (Sisson et al. 2010). Pedometers are intended to record ambulatory activity, walking forwards at moderate speed on a level plane in particular, however pedometers have been shown to be able to accurately record steps even when climbing steps, stepping up and down on a bench, walking slowly or fast – depending on the make of pedometer (Giannakidou et al. 2012; Bassett 2008). Pedometer measurement requires wearing the pedometer consecutively for typically seven days, to evaluate weekday and weekend differences, and often times measuring is repeated at different times during the year, to measure seasonal differences, and when measuring children the participants are often grouped into age-groups, weight/BMI-groups, ethnical/racial groups, or by geographical location (Craig et al. 2010; Tully and Tudor-Locke 2010; Bassett et al. 2007; Trost, Pate, Sallis, Freedson, Taylor, Dowda and Sirard 2002).

In a review on 32 published studies covering 12 different motion sensing devices, De Vries, Van Hirtum, Bakker, Hopman-Rock, Hirasing and Van Mechelen (2009) concluded that motion sensors are in general a valid measure of PA. De Vries et al. (2009) also reiterated that measuring EE via motion sensors is not accurate enough with over- and underestimation being frequent. A hurdle that must be kept in mind is the effect that non-compliance has on the data collected, i.e. forgetting to wear a pedometer or the researcher not receiving the pedometer back after testing concluded. Strategies that have been suggested to improve compliance are reminders via phone calls, text messages, flyers or posters for refrigerators, activity logs and face-to-face interaction (De Vries et al. 2009).

**2.9.1.3. Measuring Physical Activity with Pedometers and Accelerometers**

Measuring PA with pedometers allows for screening, evaluation of programmes or intervention efficacy, whilst participants are in their natural living conditions (De Vries et al. 2009; Nakae et al. 2008). It is believed that measuring PA with objective measures such as pedometers and accelerometers is more accurate and more comparable with other studies of the same nature (Beets, Bornstein, Beighle, Cardinal and Morgan 2010). Pedometers have been validated in children using studies with large numbers of participants such as the CANPLAY study (Craig et al. 2010). PA as measured via step counters is non-specific with only an approximate of intensity being determinable from the measurement and volume (Sisson et al. 2010). Another benefit of measuring PA in this way is the fact that it is not self-reported, objectively monitoring PA removes bias and recall problems and to an extent eliminates participant error in data collection (Sisson et al. 2010). The only major compliance issue is that of wearing the measuring devices.

Sisson et al. (2010) reported that 67% to 70% of total steps recorded were recorded during low intensity activity, and mentions that public health recommendation for PA focuses around the portion of time spent on moderate-to-vigorous activity, yet total activity is also associated with chronic disease risk. Sisson et al. (2010) went on to state that there is a need to determine steps/day and the dose-response relationship to better determine potential benefits. Schmidt et al. (2009) in their review on the relationship between steps/day and cardiometabolic risk for older and younger adults, showed that in all age groups (except young men) there is a marked drop in risk for individuals achieving ≥ 5000 steps/day (for younger men the threshold was ≥10 000 steps/day). Younger women showed a large drop in risk factors by merely achieving the minimum of ≥ 5000 steps/day; a possible reason given was that men may occupationally give more steps, but of insufficient duration and intensity to alter risk factors (Schmidt et al. 2009). Differences in age categories may be explained by a stronger relationship between long-standing habitual activity and improvements in risk factors, that is to say older individuals show greater response to PA since their PA patterns have been established over a longer time period

(Schmidt et al. 2009). They recommended that to improve health benefits, 3000 steps in 30 minutes per day, reconciles their findings with current recommendations of 30 minutes of daily PA for adults (Schmidt et al. 2009). Benefits that have been shown in relation to increasing steps/day, is a decrease in systolic blood pressure and body mass (Sisson et al. 2010).

The recommended amount of steps in children as used in the CANPLAY study as used by Canada's PA Guide was 16 500 steps/day, when using the recommendations of Epstein, Paluch, Kalakanis, Goldfield, Cerny and Roemmich (2001) 15 000 steps/day were recommended (which translates to 150 minutes of activity), and 15 000 steps/day for boys and 12 000 steps/day for girls as per the works of Craig et al. (2010); Tudor-Locke, Hatano, Pangrazi and Kang (2008); Tudor-Locke, Pangrazi, Corbin, Rutherford, Vincent, Raustorp, Tomson and Cuddihy (2004). In similar fashion Beets et al. (2005) describes a novel approach to pedometer/accelerometer use which describes steps taken in shorter time units(not just per day), as this can gauge intensity of exercise and not just volume. In the present study using the Omron [HJ-720] pedometer this is achieved partially over one minute intervals – If the pedometer detects continuous steps of more than 60 steps/minute for more than ten minutes with breaks of less than one minute in between, the steps are counted not just towards total and hourly measurements, but to a category called 'aerobic steps' and these are tallied separately (Giannakidou et al. 2012). Due to the stated intermittent nature of children's PA, the ten minute requirement may underestimate children's higher intensity activity and warrant a recommendation that this epoch be reduced when measuring children, so as to achieve a reasonable indication of what percentage of time is spent at higher intensity (e.g. short sprints during play). Thus: steps taken per 'x' amount of seconds.

The gold standard for pedometers in the literature is the Yamax SW-200 (spring levered) step counter (Yamasa, Japan), which has been used in many studies (Craig et al. 2010; Ayabe, Aoki, Ishii, Takayama and Tanaka 2008; Bassett et al. 2007; Le Masurier and Tudor-Locke 2003), and has been used in a wide age group range, including six to 18 year olds in the study on Amish children by Bassett et al. (2007). The Yamax pedometer's accuracy has been measured at many walking speeds, but also against ascending and descending stair climbing and bench step test and found to be reliable and accurate (Ayabe et al. 2008; Le Masurier and Tudor-Locke 2003). A common problem with all pedometers is the underestimation of steps taken when moving very slowly, or due to the tilt of pedometer by the stomach when worn by obese or pregnant individuals (Giannakidou et al. 2012; Ryan et al. 2006; Le Masurier and Tudor-Locke 2003).

The results of steps taken by Amish children showed that boys in the age range six to eight took an average number of steps of 19 012 ±4250 during four weekdays, 11 428 ±4857 for Friday, Saturday, and Sunday, with 16 845 ±3469 average over a week (Bassett et al. 2007). For Amish girls the number of steps were 16 320 ±2335 for four weekdays, 9709 ±3817 for Friday, Saturday, and Sunday, and 14431 ±2183 total for one week (Bassett et al. 2007). Loucaides, Chedzoy and Bennett (2004) compared rural and urban children from Cyprus and found urban children were more active during the winter (13 583 steps/day vs. 12 436 steps/day), and rural children were more active in summer (16 450 steps/day vs. 14 531 steps/day). Bassett (2008) found Old Order Mennonite children accumulated 15 min/day more vigorous PA, had lower skinfold thickness, and had greater grip strength than Saskatchewan children. These children were more physically active and had more favourable body composition yet did not participate in organise sport, instead activity was lifestyle dependant: walking as transport, physical play, and chores around the home (Bassett 2008; Bassett et al. 2007). Common patterns shown through pedometers measurements are, European and Western Pacific children tend to be more active than children from North America, there is an age related decline in PA, seasonal change affects PA, as well as that girls tend to be less active than boys in volume and intensity (Beets et al. 2010; Craig et al. 2010; Bassett 2008; Bassett et al. 2007; Le Masurier et al. 2005; Loucaides et al. 2004; Vincent, Pangrazi, Raustorp, Tomson and Cuddihy 2003; Trost et al. 2002). Trost et al. (2002) found that there is early on a sharp drop-off in PA levels in children when grades one to three were compared to grades four to six; also noted was the same pattern of boys being more active, but it was not as significant in this case.

Trost et al. (2002) stated that a reason for noticing a sharp drop-off maybe due to lack of previous studies of a large enough cohort, or purely due to limitation in the number of studies on such a young population. Measuring with accelerometers, Trost et al. (2002) was able to determine what time was spent in MVPA and VPA seeing that there was a large difference in VPA (boys achieved 45 % more) and more moderate differences with MVPA (boys achieved 11 %). From this we can see that the major differences occur during higher intensity activities. Le Masurier et al. (2005) reviewed the findings of Trost et al. (2002) and stated that there is usually an even greater difference in PA shown between grades one to three compared to grades four to six but this may be due to differences in how pedometers record data compared to accelerometers, and added that more data are needed on large scale groups measured with pedometers.

Devices which have been used in the South African context include the Actigraph accelerometer (Walter 2011). Children tend to have a very intermittent pattern of PA, with few bouts of continuous activity as Trost et al. (2002) showed when comparing accelerometer readings for 375 children; virtually no bouts of VPA and few bouts of MVPA of 20 minutes or greater were recorded. Trost et al. (2002) did find that 72.9 % of boys and 87 % of girls had three or more bouts of five minutes MVPA. Though the present study does not have the same capability to measure time spent doing activity, Cardon and De Bourdeaudhuij (2004) have compared MVPA steps taken with time spent, to which boys taking 15 340 steps and girls 11 317 steps, and 13 130 when not accounting for gender equalled 60 minutes of activity.

With regards to determining energy expenditure for children from scores achieved with accelerometers, Puyau, Adolph, Vohra, Zakeri and Butte (2004) found that accelerometers were able to give valid measures of EE if the aim is to divide participants into sedentary, light, moderate, and vigorous levels of PA, but more research is needed to accurately predict EE for each individual.

### 2.9.2. Physical Activity Questionnaires

#### 2.9.2.1. Administering Physical Activity Questionnaires

Nakae et al. (2008) have stated that potential problems with self-report questionnaires include limitations to recall, floor effects, social desirability, and children not being able to distinguish between PA and non-PA. Misperception of their PA is a prevailing concern (Biddle et al. 2011). De Vries et al. (2009) added that although they are easily administered and at a low cost; they over-estimate time spent in vigorous activity and underestimate time spent in unstructured low-intensity activity. Questions of applicability or appropriateness of questionnaires developed in first world nations and being used in sub-Saharan Africa have been raised (Wareham 2001). Further concerns as to the usual pattern of questionnaires having a high retest reliability but lower validity of the tests used (Wareham 2001). Cardon and De Bourdeaudhuij (2004) compared multiple objective recording of activity (via continuous heart rate telemetry and accelerometry) with subjective measures in the form of activity diaries and found self-report measures were only reliable relative to the participant but not in absolute terms. Participants overestimated certain values by up to 100% and on average over estimated time spent with activity by 29 minutes and 48 minutes by the two questionnaires used respectively (Physical Activity Checklist Interview and the Self-Administer Physical Activity Checklist) (Cardon and De Bourdeaudhuij 2004). Cardon and De Bourdeaudhuij (2004) did find an interesting pattern, where the correlation for boys using self-report measures were better with heart rate measurements, and for girls, the correlation was better with accelerometry. Though much can be said regarding problems of subjective recording of PA, it must however be taken into account that even costly objective monitoring devices have limitations, such as accelerometers which may not detect certain types of activity at all (Giannakidou et al. 2012; McVeigh and Norris 2012; Sisson et al. 2010; Ryan et al. 2006; Welk et al. 2000) and where a simple questionnaire would be better suited.

#### 2.9.2.2. The Physical Activity Questionnaire for Older Children (PAQ-C)

The PA questionnaire for older children is a seven-day recall measure used to assess children during the school year for children eight to 14 years of age (McVeigh and Norris 2012; Wareham 2001; Crocker, Bailey, Faulkner, Kowalski and McGrath 1997). Some of its design strengths include measuring PA in general, using memory cues, and like most questionnaires being cost effective and time efficient (Kowalski et al. 2004). Further benefits are an ease of completion and repeated use in literature (Biddle et al. 2011). Some of its weaknesses include: the inability to determine caloric expenditure, and specific exercise variables such as frequency, intensity and time, and thus the result is merely a summary of total activity, and also the fact that it must be used during school months and due to question structure does not function during holidays (Kowalski et al. 2004). What can be said for the PAQ-C is that despite the inability to differentiate between precise exercise variables, it is still useful in separating inactive children from their active peers (Welk et al. 2000). One must be cognisant then that the intention for the information gathered from this questionnaire is to identify children whose PA levels are so low as to put them at risk for CVD (Kowalski et al. 2004).

The present questionnaire has been used previously and a panel of experts along with statistical data backs up the use of the present questionnaire as having fair reliability and high level of validity according to Biddle et al. (2011). It has however to this researcher's knowledge not been used in the South African context. Since other researchers have also reported a lack of validated instruments of PA measurement in South Africa (Mciza et al. 2007), using this questionnaire will provide another use in the local context for future researchers to build on.

# CHAPTER 3: METHODOLOGY

The following methods and procedures were used for the study.

## 3.1 Participants

Participants were recruited from Constantia Park Afrikaans primary school by sending out letters to the parents of the 2nd and 3rd grade students. Participation was voluntary and consent as well as assent forms were signed and handed in to allow participation. (Appendix C)

This study formed part of a larger study for which the inclusion age was determined and for which ethical clearance was received. Convenience sampling was used, for this study. (Appendix G)

Inclusion criteria

- Male and female participants
- Students enrolled at Constantia Park primary school
- Grades two or three

Exclusion criteria

- Children who were injured or ill were excluded from study.
- All children who had previously asked not to be involved in the research.

### 3.1.1. Participant distribution

Interaction with the participants as well as preparatory testing was done as a group during the physical education periods of the learners (KDA periods). There were participants from both grade three and grade two classes; the grade three participants were from eight separate grade three classes and the grade two participants from nine separate grade two classes.

Then n = 200 participants listed in Assent form (Appendix C) was eventually not reached as it was the target of the overhead study. Due to drop-outs the total reached n = 58 participants, after dropouts were eliminated.

## 3.2. Equipment and procedures

### 3.2.1 Stride length

Stride length is defined by Beets et al. (2005, p. 514) as: *"…the distance travelled by the same point on the same foot during two successive steps (one right, and one left stride length)…"*
A flexible tape measure was used to measure off one meter intervals on tile floor indoors where the children usually performed their indoor PA classes.

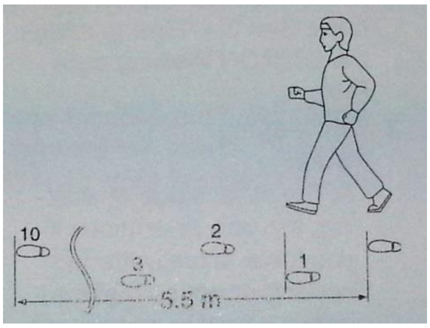



**Figure 11 Measurement of stride length as per OMRON HJ-720 pedometer manual (Omron Healthcare 2007)**

Each participant was given three attempts to walk ten consecutive steps, each attempt was recorded, and in the event of a participant not following one of the instructions, the attempt was not counted and the participant asked to perform another attempt (Figure 11) (Beets et al. 2005). An average stride length was then calculated for the attempt. The average of the three attempts was used to set up that participant's allocated pedometer (Omron HJ-720).

*Instructions given:*

Keep head level, looking neither up nor down.

Walk with a constant and steady rhythm.

Walk at a speed and rhythm you (the participant) would describe as your normal walking rhythm.

Walk with normal heel-toe action (not walking on toes).

Walk barefoot.

Do not stretch out or diminish the last step.

### 3.2.2 Body Mass

To determine body mass the participants where measured with a Tanita scale - model BF-350 (Figure 12). Two measurements were taken and where a difference was found the average was taken and recorded to the nearest 0.1kg. Participants were weighed without footwear and in minimal school wear (jackets and jerseys where removed but no other clothing). This measurement was used to set-up the Omron HJ-720 pedometer used in this study.

**Figure 12 Tanita scale model: BF-350**

### 3.2.3 Omron HJ-720 Pedometer

The calibration for the Omron HJ-720 pedometer (Figure 13) requires entering the body mass and stride length of each child which was measured as described above and entered into the pedometer by the researcher. These settings cannot be changed by the participants after receiving the pedometer, despite the pedometer being unsealed. New batteries were inserted 7 days before testing began, the batteries can keep the pedometers going for several months before needing replacing – thus no replacements were made during the testing or data download time period. After measuring the body mass and stride length of the participants, the researcher explained and demonstrated the placement and function of the pedometers, this was done to a group of two classes' participants per session during the KDA period. The pedometers were then labelled and handed out to every participant the following week after pedometers were entered with participant data. A pedometer logbook was not used as all data is stored on the pedometers for 40 days, and can be downloaded by the researcher personally after the test week.

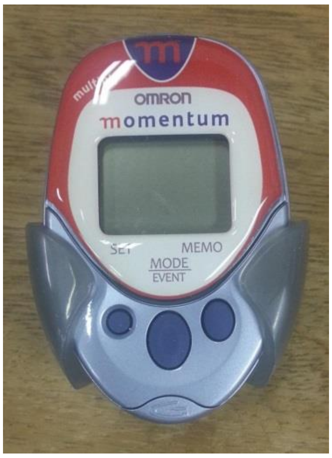



**Figure 13 The Omron HJ-720 pedometer**

The pedometer was to be worn clipped onto the waist band of the boys' clothing at the midline of the thigh (De Cocker et al. 2012; Omron Healthcare 2007), and for the girls they had the option of wearing it in the front shirt pocket or to wear the pedometer around the neck attached to lanyard as described by De Cocker et al. (2012) and as described in the Omron HJ-720 user guide manual (Omron Healthcare 2007), since the uniform did not allow for wearing a pedometer at the waist (it should be noted that the lanyard can affect the accuracy of the readings, but the uniform design left limited options) (De Cocker et al. 2012). The pedometers were not sealed – participants could thus see on the screen how many steps they were taking.

Pedometers were worn for a total of seven days, after which the pedometers were collected at the school during the register period for the Grade two and grade three pupils. Pedometer data were then downloaded by the researcher into spread sheet format.

For every day the pedometer had to be worn, a bundled SMS (short message service) was sent to all participants to remind them to wear the pedometer and thus not have days of missing data. At the end of the trial the SMS system was also used to make sure all pedometers were returned.

### 3.2.4 Physical activity questionnaire for older Children (PAQ-C)

Kowalski et al. (2004, p. 5) describes the PAQ-C as follows*: "The PAQ-C is a self-administered, seven-day recall instrument. It was developed to assess general levels of PA throughout the elementary school year for participants in grades four to eight and approximately eight to 14 years of age. The PAQ-C can be administered in a classroom setting and provides a summary PA score derived from nine items, each scored on a 5-point scale."*

The PAQ-C was handed out the same day as collection of the pedometers took place. Thus the PAQ-C was used to report on the same week that the pedometer had just been worn for. The PAQ-C was sent to the 17 classes where the children were to take the questionnaire home, and could be filled in with aid of their parents. The questionnaire had been used earlier the same year, as such the participants were familiar with the questionnaire.

The original PAQ-C is an English medium questionnaire, however since the home language of most, if not all the participants, was Afrikaans, a translated version of the questionnaire was sent out. SMS bundles were used to ensure compliance and return of questionnaires.

### 3.2.5 Procedure

Stride length and body mass was recorded during KDA periods where after the researcher set up the pedometers for each participant over the course of a week. The following week all pedometers were handed out to be worn by the participants and reminded via SMS at six am every morning to be worn. After seven days of wearing the pedometers, they were collected again and a questionnaire handed out to the participants to subjectively report on the past week. The questionnaires were collected again the following week. The questionnaires were sent out with instructions for the parents to ensure that the children completed and returned the questionnaire, though there was nothing preventing the parents from assisting in the completion of the questionnaire.

The data collection was done in the middle of November 2012 (13th – 19th). November was selected as the month of collection as this was the time when most school sports have ended for the year, but exams and evaluations have not yet started.

### 3.2.6 Data recording

#### *3.2.61 Pedometer data download*

The Omron HJ-720 pedometer allows for downloading of data into excel format with spread sheets for each participant. The participants' data was also time coded for each hour allowing the researcher to only select the data from the same seven day period. Data was downloaded via mini-USB cable using Omron's Health Management Software Version 1.3 (available from: http://www.omron-healthcare.com/eu/en/our-products/activity-monitoring) and aggregated to a single spread sheet document manually (Omron Healthcare 2014).

Due to time coding, the data can be grouped to show steps taken in total and average for the following time periods: Before school (12am – 7am), steps taken during school time (8am – 1pm) and steps taken after school (1pm – 12am), as well as separating weekday and weekend periods. Note that the hour between 7am – 8am could not be allocated to either before or during school as it falls half way into both, it was used however in calculating the totals for the days.

#### *3.2.6.2 Questionnaire (PAQ-C)*

The questionnaire consists of ten-items to be scored with a breakdown given by Kowalski et al. (2004) as follow:

Item one provides a list of activities and is meant to assess spare time activity and is given a scoring rating from one to five for each activity ("*no activity*" = one; "*seven times or more*" = being a five)

Items two to eight refer to physical education classes, recess, lunch time, time right after school, evening, weekends, and general PA rating over the past seven days. They are multiple choice questions with options, "*one*" being the least active, and "*five*" being the most active response.

In Item nine a score is given to each day of the week between one and five (one = inactive; five = highly active) and then averaged to get another mark out of five.

Item ten is only intended to identify children with unusual activity in the previous week and is not used to count towards the final score.

A value of one to five has now been assigned to each of the first nine items, of which a mean is calculated and assigned as an overall score. Thus a final score of one shows low PA and five indicates high PA (Kowalski et al. 2004).

Item number one was altered slightly to reflect sports more common to South Africa: Football, street hockey, ringette and cross-country skiing were removed and rugby, field hockey, netball, tennis, and cricket were added.

### 3.2.7 Ethical considerations

Permission was firstly obtained from the Department of Biokinetics, Sport and Leisure Sciences at the University of Pretoria. Ethical clearance was then obtained from the ethics committee of the Faculty of Humanities at the University of Pretoria prior to the execution of this study. The Gauteng Department of Education was also contacted and permission acquired for research involving school children.

Permission was obtained from the governing board of the school and subsequently informed consent and assent from the parents and the participants themselves before testing started.

The study was to form part of a larger study (Appendix G), and therefore the consent/assent forms requested permission to perform skinfold and fitness testing as well (Appendix C) but was not included in the present study.

### 3.3 Research Design and Statistical analysis

The study was of a cross-sectional (correlational) nature, comparing the results of participants wearing the pedometer with their completion of a PA questionnaire (describing / rating their activity during the period that the pedometer was worn). Thomas and Nelson (2001) describe observational research as a type of descriptive research often using the questionnaire format as a tool. The study was observational in nature with no intervention planned, but it is necessary to note that the introduction of the worn pedometer could lead to a motivational effect on PA.

Statistical analysis was performed by an independent statistician. Descriptive statistics were used to describe the sample (frequencies, means, standard deviations) and the non-parametric procedures of the Mann-Whitney U test as well as Spearman's rho were used to determine the significance of intergroup differences. Parametric statistical tests are based on assumptions of normal distribution, independence of observation and equal variation (Thomas and Nelson 2001) with non-parametric test referring to statistical techniques where data do not meet assumptions required to perform parametric tests (Thomas and Nelson 2001). Thomas and Nelson (2001) states the Mann-Whitney U test is a non-parametric statistical technique, being analogous to the parametric independent t-test, with Spearman's rank difference correlation being analogous to the parametric Pearson *r.* Independent t-tests are used to determine if two sample means differ reliably from each other (Thomas and Nelson 2001). The relatively small sample size of the participant groups was the reason for using non-parametric measurements as normal distribution could not be assumed, and non- parametric measures were found to be common in similar studies. The strength of correlations where described according to the classification of Landis and Koch (1977) as seen in Table 2.

**Table 2 Landis and Koch reliability classification scale**

| Association value | Interpretation |
|---|---|
| 0.00 | Poor |
| 0.01-0.20 | Slight |
| 0.21-0.40 | Fair |
| 0.41-0.60 | Moderate |
| 0.61-0.80 | Substantial |
| 0.81-1.00 | Almost perfect |

Statistical level of reporting was reported for both 90th percentile as well as 95th percentile where appropriate. The statistical level of reporting was indicated in each case.

All data was included in the statistical analysis, apart from pedometer logs that showed no activity being recorded – pedometers malfunctioning due to water damage or participants that forgot to where the pedometers.

### 3.3.1 Variables measured

The following variables were determined from the data collected:

- Reported measures (Subjective):
  - PAQ-C item one: Frequency of participation in selected activities
  - PAQ-C item two: Frequency of vigorous activity during PE classes
  - PAQ-C item three: Frequency of vigorous activity during recess
  - PAQ-C item four: Activity reported during lunch time
  - PAQ-C item five: Frequency of vigorous activity after school
  - PAQ-C item six: Frequency of vigorous activity in the evenings
  - PAQ-C item seven: Frequency of vigorous activity over the weekend
  - PAQ-C item eight: General description of self over past seven days
  - PAQ-C item nine: Frequency of general PA for each day

        - Monday, Tuesday, Wednesday, Thursday, Friday, Saturday, Sunday, as well as average of the days, weekdays versus weekends
    - PAQ-C item ten: Sickness or injury incurred over the past week.
    - PAQ-C questionnaire in total – aggregate score for total PA
- Measured activity (Objective):
    - Steps taken in total for seven days
    - Steps taken on average for past seven days
    - Steps taken in total for weekdays
    - Steps taken on average for weekdays
    - Steps taken in total for weekend days
    - Steps taken on average for weekend days
    - Average steps taken before school on weekday (12 am – 7 am)
    - Average steps taken during school on weekday (8 am – 1 pm)
    - Average steps taken after school on weekday (1 pm – 12 am)
- Gender (male / female)
- Grade (two / three )
- Body mass (kg)

# CHAPTER 4: RESULTS

## 4.1 Descriptive statistics of the sample group

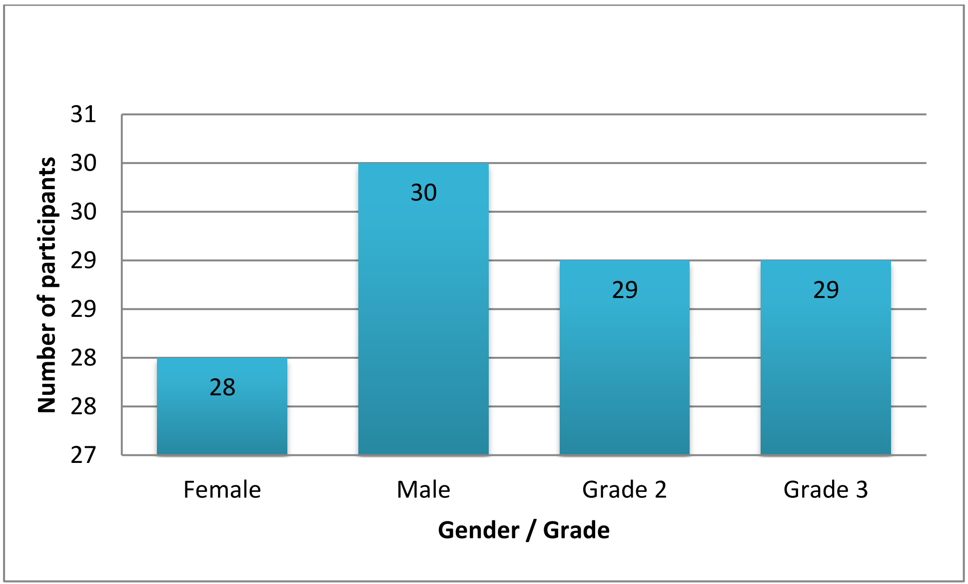



**Figure 14 Sample description**

There were a total of 58 participants with 28 being female and 30 being male. The 58 participants were equally distributed between the second and third grade (Figure 14).

## 4.2 Descriptive statistics of the activity measured with pedometers

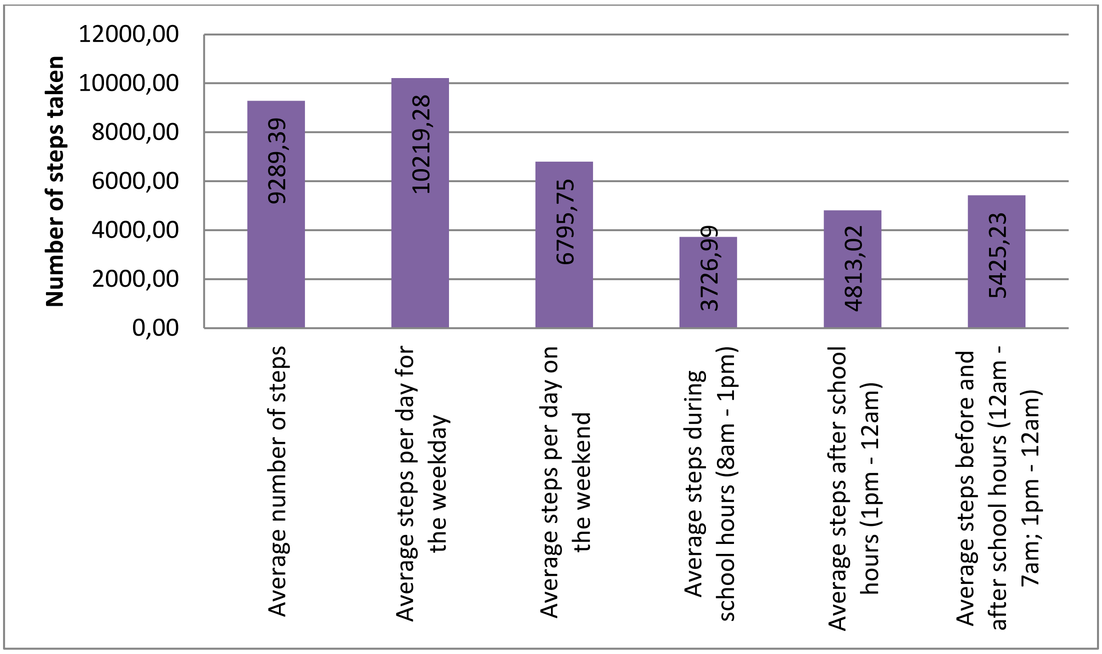



**Figure 15 Descriptive statistics of average number of measured steps during various time slots**

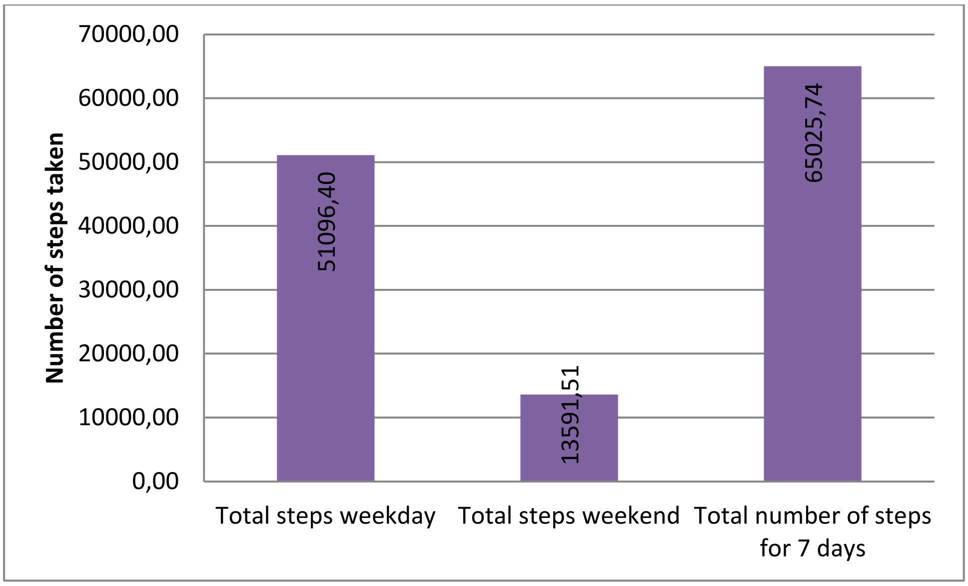



**Figure 16 Descriptive statistics of averages of total number of measured steps for participants**

Figures 15 and 16 shows the number of steps that were recorded for the group of participants.

## 4.3 Descriptive statistics of the activity reported by means of the PAQ-C

### 4.3.1 Description of questions one to nine, and overall score

For question one, the participants were given a list of common physical activities and sports and asked to answer for each activity how often they participated in that activity for the previous week.

An answer of "*zero*" was the first option, "*1 – 2 times*" the second option, "*3 – 4 times*" the third, "*5 – 6 times*" the fourth, and lastly, "*7 or more*" was the fifth option. From these answers the most common physical activities are shown as seen in Figure 17. The answers to this question are also used to determine an overall score and calculate an average frequency of activity for this item. All answers for these items are added together and an average is calculated. Question one doesn't indicate time spent on an activity nor the intensity of activity, and thus only displays the variation of activities for a given participant.

For question two, participants selected how busy they were during physical education classes and those that answered "*often*" or "*always*" were grouped as reporting high levels of PA for that question and were then compared to the participants who selected "*sometime*", "*rarely*", or "*I do not do physical education*" as the group reporting low levels of physical education.
For Question three, the participants were asked what they did most often during their break times. Those who answered "*Sit (talk, read, do schoolwork)"* or *"Stood or walked around"* were grouped into the low activity group for this question. Those who answered "*Ran or played a little*", "*Ran and played for a while*", or "*Ran and played most of the time*" were grouped into the high activity group for this question item.

For Question four, participants were asked what they usually did during lunch break over the past seven days, apart from eating. Those who answered "*Sit (talk, read, do schoolwork)*" or "*Stood or walked around*", "*Ran or played a little*" were grouped into the low activity group for this question. Those who answered "*Ran and played for a while*", or "*Ran and played most of the time*" were grouped into the high activity group for this question item.

For question five, participants were asked how many days they were active directly after school. Those that answered "*none*", "*once last week*", or "*two to three times last week*" were grouped into the low activity group for this question. Those that answered "*four times last week*" or "*five times last week*" were grouped into the high activity group for this question.

For Question six, the participants were asked how many evenings they participated in sport, dance, or played games in which they were very active. Those that answered "*none*", "*once last week*", or "*two to three times last week*" were grouped into the low activity group for this question. Those that answered "*four to five times last week*" or "*six or more times last week*" were grouped into the high activity group for this question.

For Question seven, participants had to answer how often they participated in sport, dance, or played games in which they were very active over the last weekend. Those that answered "*none*", "*once*", or "*two to three times*" were grouped into the low activity group for this question. Those that answered "*four to five times*" or "*six or more times*" were grouped into the high activity group for this question.

For question eight, participants were asked to select the descriptor that described them the best over the past seven days. Those that selected "*All or most of my free time was spent doing things that involve little physical effort*", or "*I sometimes (1 – 2 times last week) did physical things in my free time (e.g. played sports, went running, swimming, bike riding, did aerobics)*" were grouped into the low activity group. Those that answered "*I often (3 - 4 times last week) did physical things in my spare time*", "*I quite often (5 – 6 times last week) did physical things in my free time*", or "*I very often (7 or more times last week) did physical things in my free time*" were grouped into the high activity group.

For question nine, the participants were asked how many times per day were they busy on each day of the previous week and were given descriptors to choose from. The options were: "*None*", "*Very little*", and "*A little bit*", "*Medium*", "*Often*", and "*Very*". The first two options, "*None*" and "*Very little*" were grouped together as the first of five options with each subsequent option being another category. A total score for question nine was tallied and averaged for the score for the week.

The PAQ-C allows for a single score to be calculated for each child, to give an indication of a child's overall PA level. Each question item, from two to eight, has five simple multiple choice options which can be added together and averaged with those of questions one and nine to get an overall score. The scoring for question one and nine are explained above. Thus for the participants this score was calculated and correlated with the measured steps taken.

The options selected for questions one to nine are shown in Table 3 in order to indicate the distribution of reported activities for each question.

| | Question 1 | Question 2 | Question 3 | Question 4 | Question 5 | Question 6 | Question 7 | Question 8 | Question 9 |
|---|---|---|---|---|---|---|---|---|---|
| Category one (Least active) | 56,9 | 0 | 0 | 31 | 17,2 | 19 | 1,7 | 3,4 | 7 |
| Category two (slightly active) | 43,1 | 6,9 | 3,4 | 13,8 | 6,9 | 6,9 | 17,2 | 6,9 | 14 |
| Category three (moderately active) | 0 | 10,3 | 24,1 | 24,1 | 34,5 | 43,1 | 43,1 | 39,7 | 36,8 |
| Category four (moderate to highly active) | 0 | 37,9 | 22,4 | 25,9 | 22,4 | 22,4 | 20,7 | 29,3 | 36,8 |
| Category five (highly active) | 0 | 44,8 | 50 | 5,2 | 19 | 8,6 | 17,2 | 20,7 | 5,3 |

**Table 3 Percentage of answers given to question items one to nine showing from least to most active answers**

### 4.3.2 Question 1

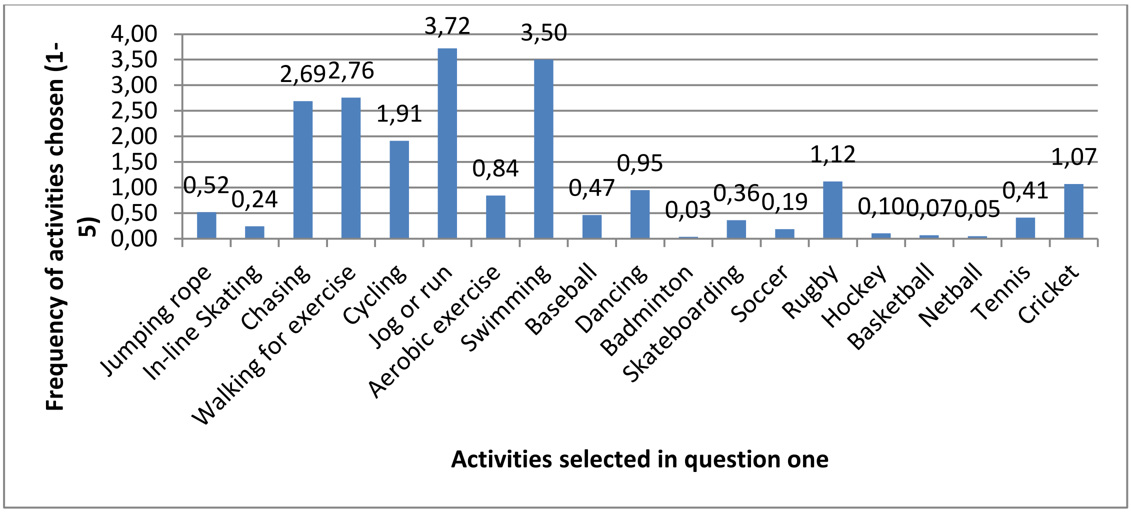



**Figure 17 Descriptive statistics of frequency of various activities over seven days**

Figure 17 illustrates the most common activities selected by the participants with 'chasing', walking for exercise, cycling, jog or run, and swimming being the most common.

### 4.3.3 Question 2

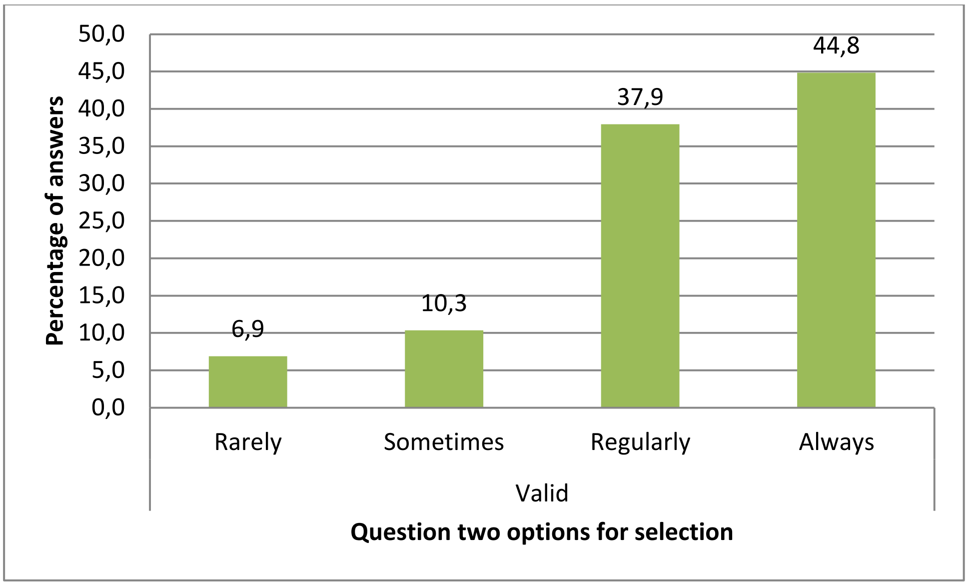



**Figure 18 Question two: Reported frequency of playing vigorously during physical education classes**

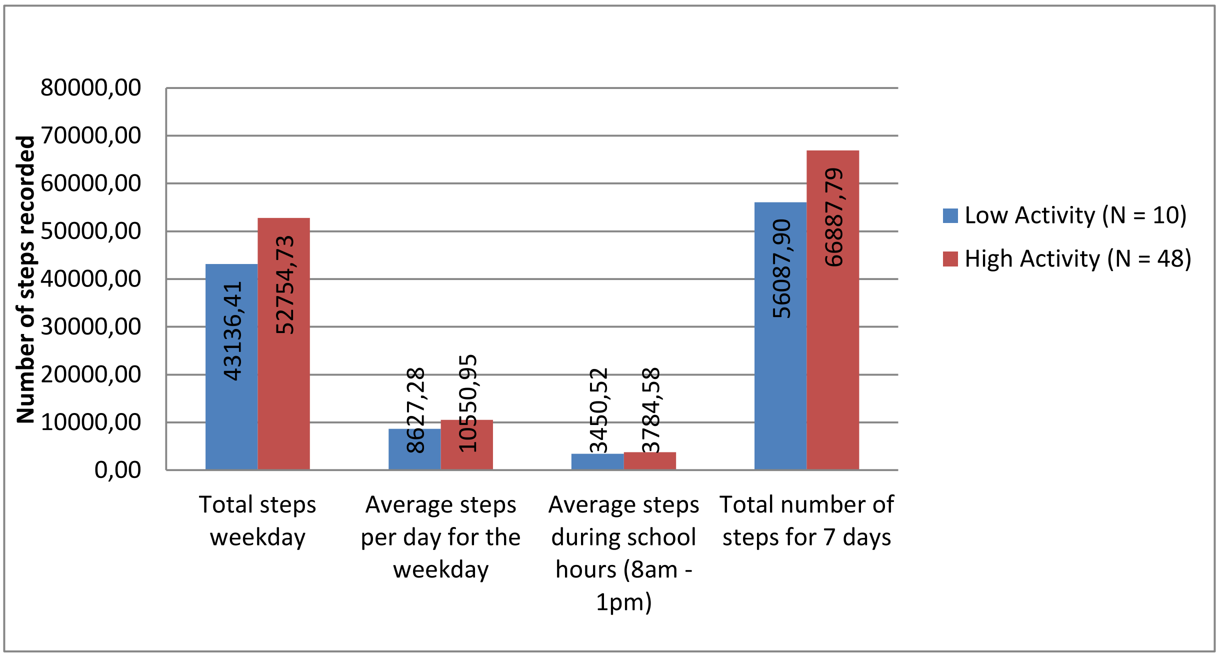



**Figure 19 Question two: comparing the high versus low activity groups during physical education classes**

The participants who reported being more active and were classified as the "*high activity group*" (Figures 18 & 19) during their physical education classes took more steps:

- on average and in total during the weekdays (p = 0.05)
- in total for the entire seven days (p = 0.06)

These differences were significant to the 10 % level of significance (90% confidence level).

#### 4.3.4 Question 3


**Figure 20 Question three: Reported activity during break time**

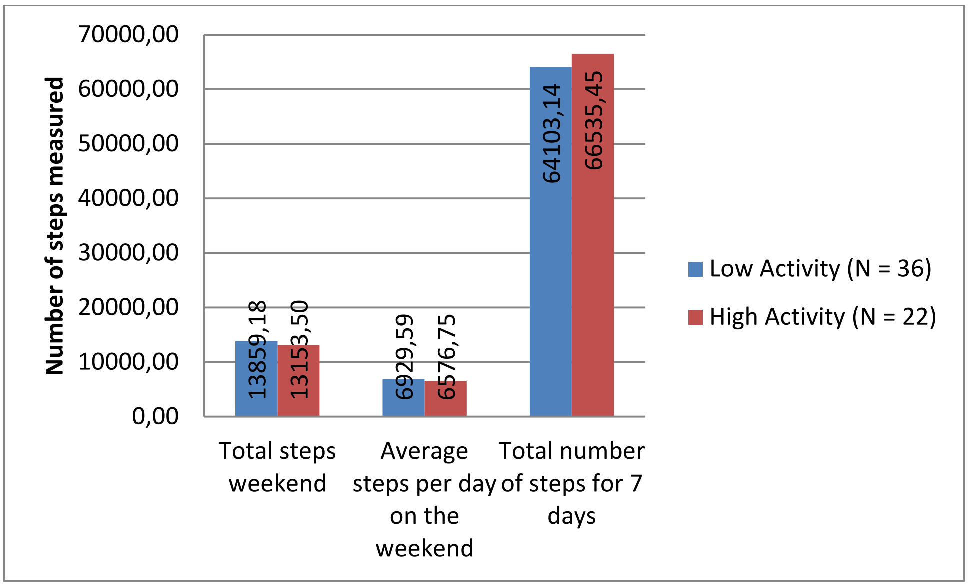



**Figure 21 Question three: comparing high versus low activity groups during break time**

For this question there was no statistically significant correlations between steps measured and reported activity nor was there a statistically significant difference between the low versus high activity groups in terms of steps measured (Figures 20 & 21).

### 4.3.5 Question 4

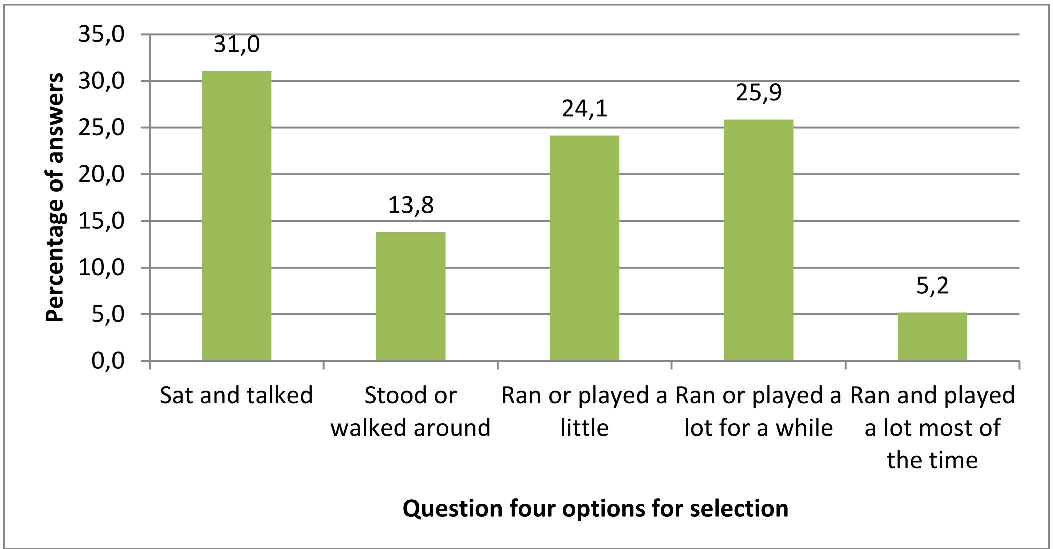



**Figure 22 Question four: Reported activity during lunchtime**

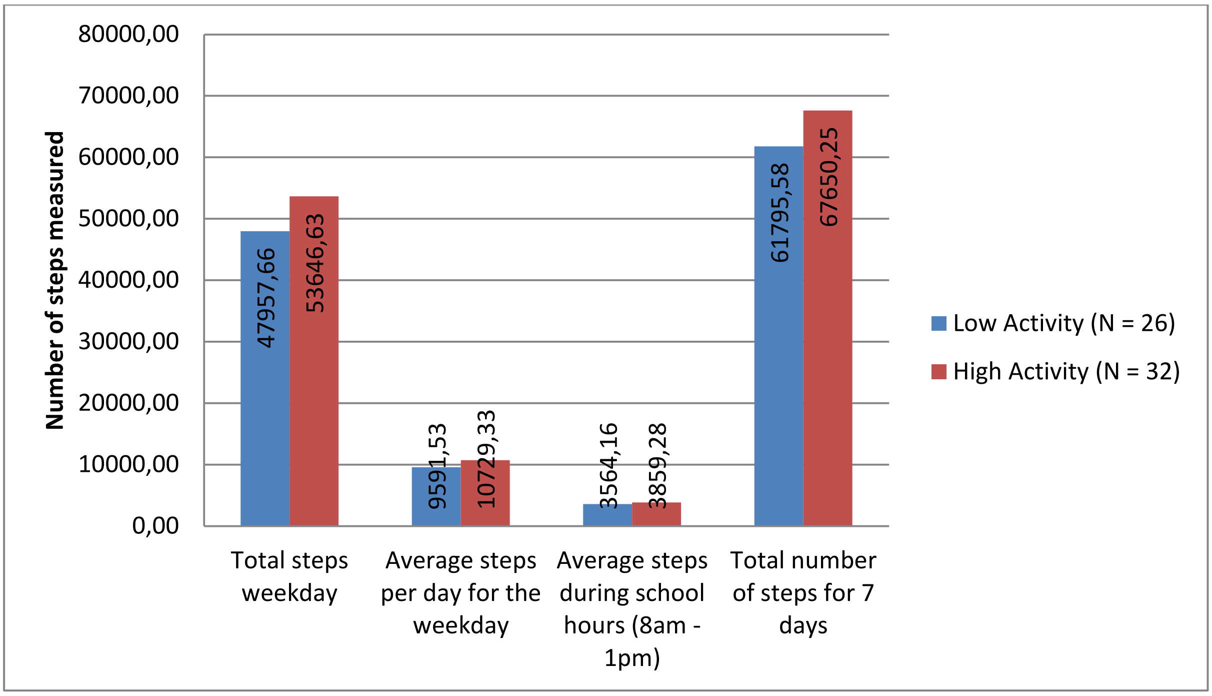



**Figure 23 Question four: comparing high versus low activity groups during lunch time**

The participants who said they were more active during lunch break and were classified as the "*high activity group*" (Figures 22 & 23), gave more steps in total and on average for the weekdays than those who said they were less active during their lunch break (p = 0.09). These differences were significant to the 10 % level of significance (90% confidence level).

### 4.3.6 Question 5

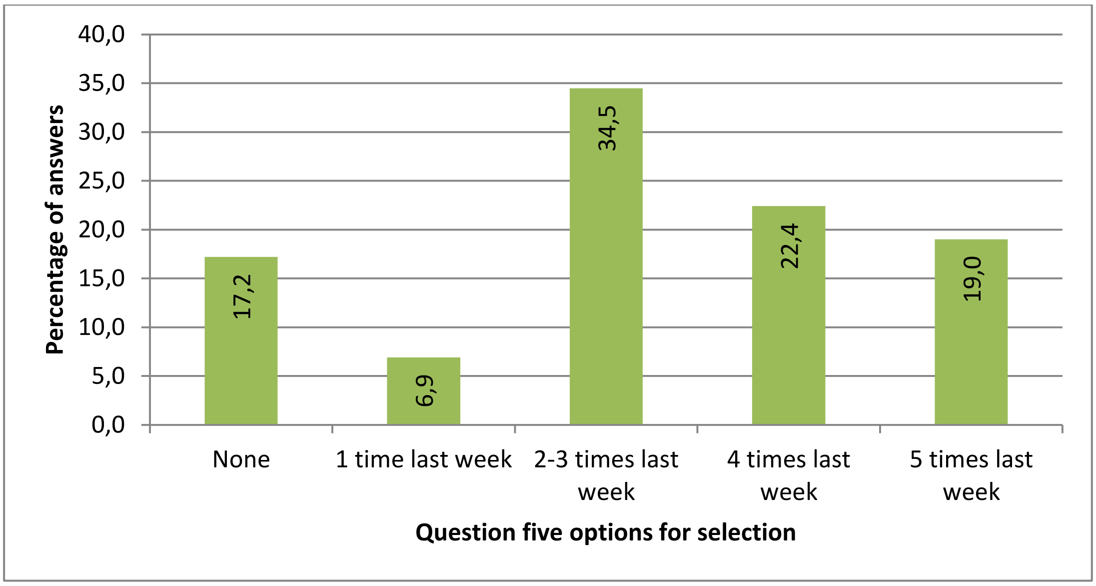



**Figure 24 Question five: Reported number of days participating in activities directly after school**

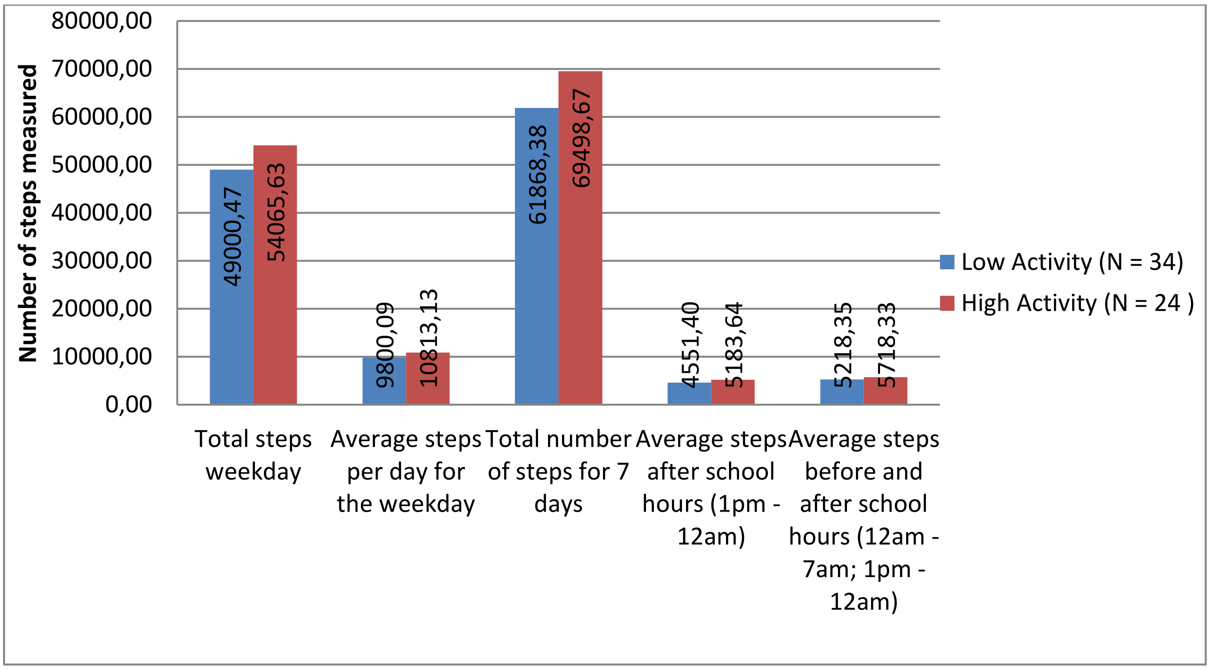



**Figure 25 Question five: comparing measured steps of high versus low activity groups after school**

For this question there was no statistically significant correlations between steps measured and reported activity nor was there a statistically significant difference between the low versus high activity groups in terms of steps measured (Figures 24 & 25).

### 4.3.7 Question 6

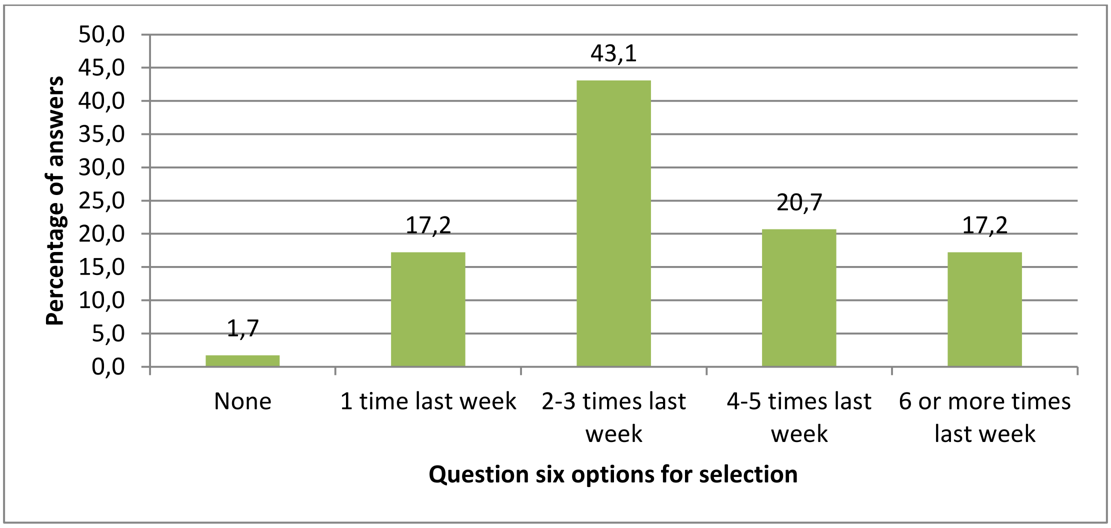



**Figure 26 Question six: Reported number of days participating in sport in evenings**

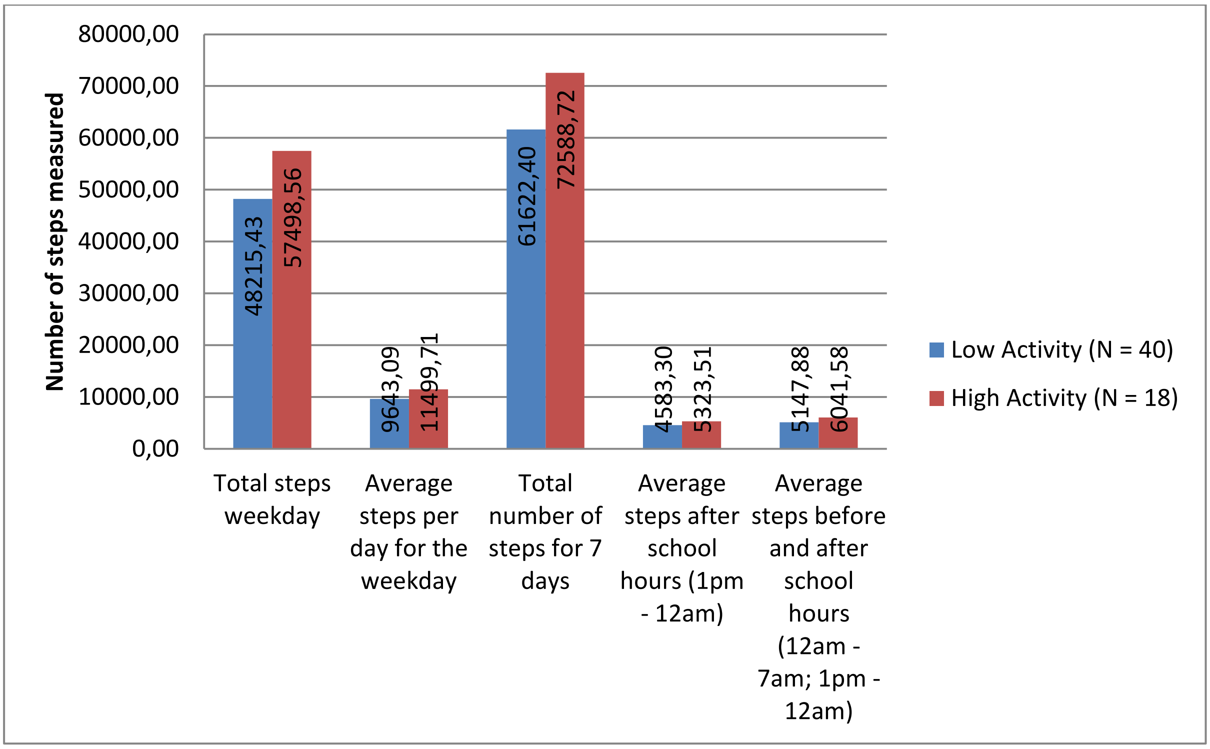



**Figure 27 Question six: comparing high versus low activity groups during the evenings**

Participants who reported greater physical activity during the evenings and were classified as the "*high activity group*" (Figures 26 & 27) took more steps:

- In total and on average for the weekdays (p = 0.02)
- Took more steps in total for the whole seven days (p = 0.03)
- These differences were significant to the 5 % level of significance (95% confidence level).

### 4.3.8 Question 7

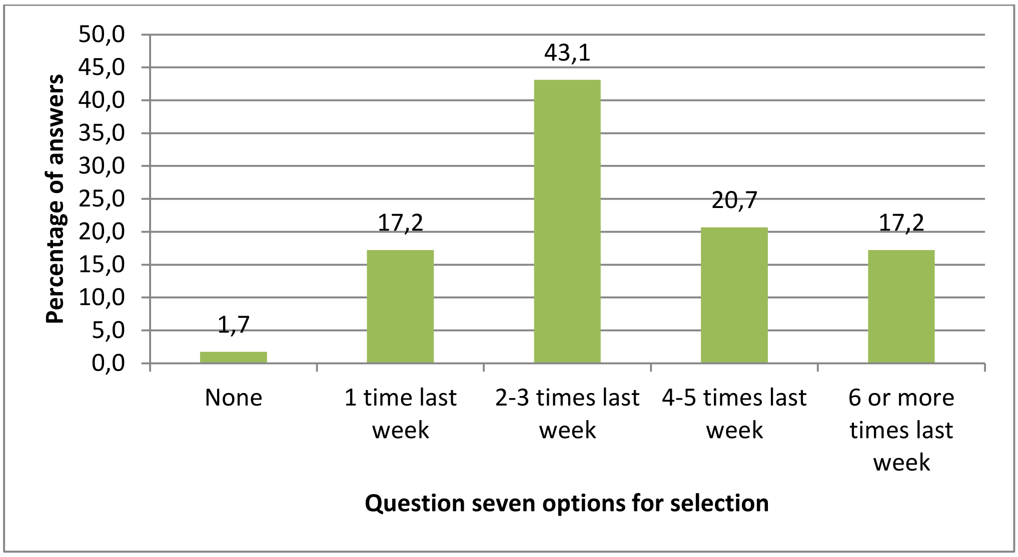



**Figure 28 Question seven: Reported activity over the past weekend**

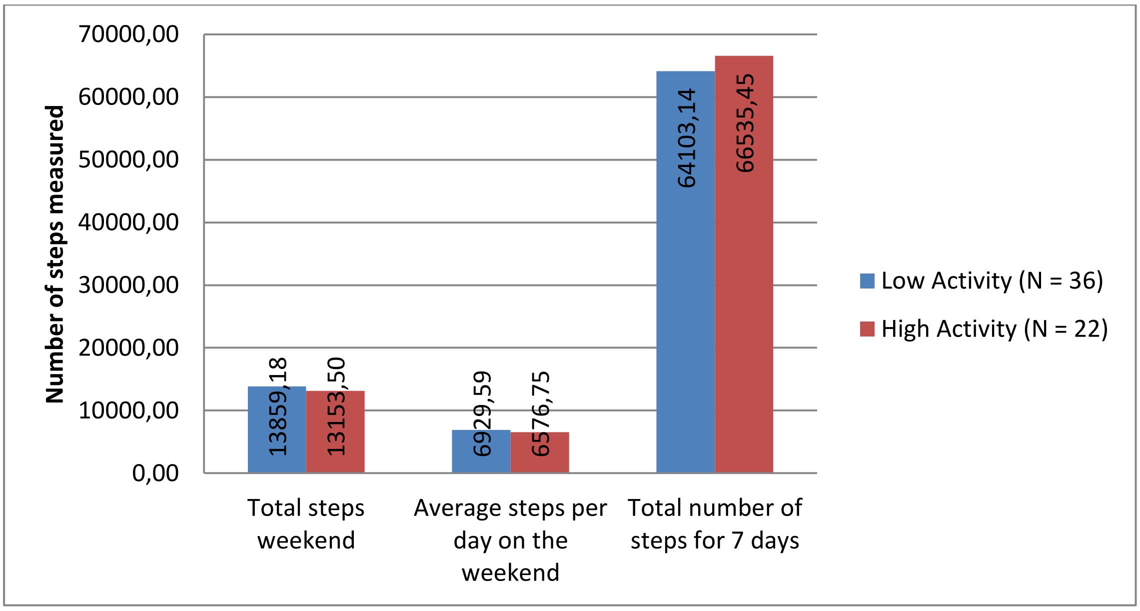



**Figure 29 Question seven: comparing high versus low activity groups over the weekend**

For this question there was no statistically significant correlations between steps measured and reported activity nor was there a statistically significant difference between the low versus high activity groups in terms of steps measured (Figures 28 & 29).

### 4.3.9 Question 8

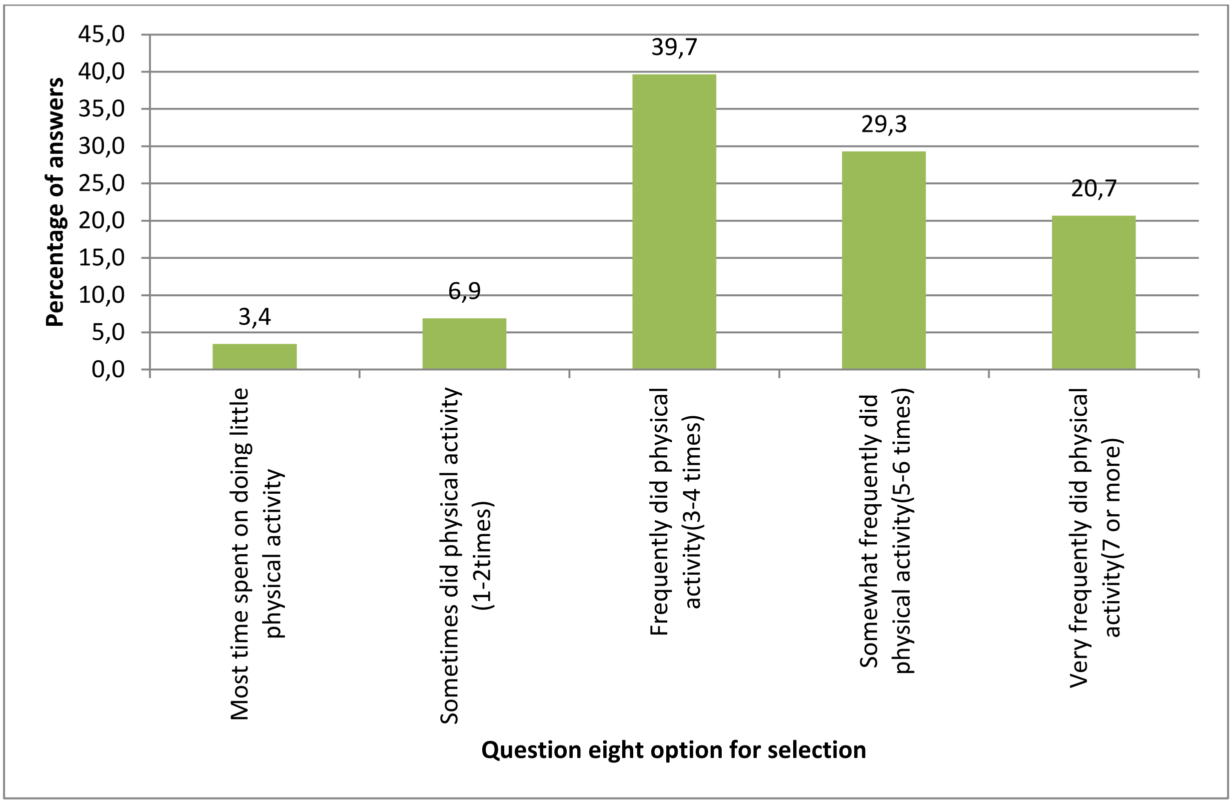



**Figure 30 Question eight - General description of physical activity over past seven days**

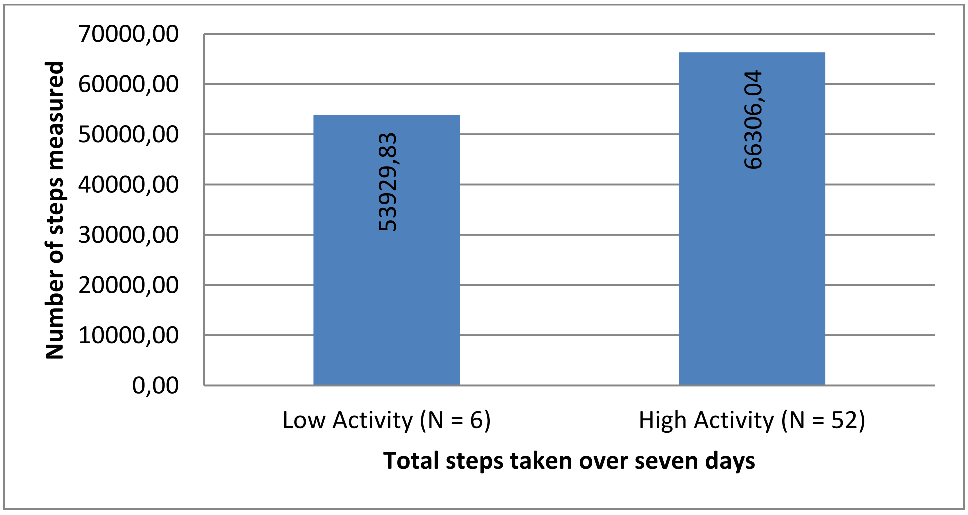



**Figure 31 Question eight: comparing high versus low activity groups in general over the last seven days**

Participants who rated themselves as more active overall for the whole seven days and were classified as the "*high activity group*" (Figures 30 & 31) also took more steps in total for the seven days (p = 0.09). These differences were significant to the 10 % level of significance (90% confidence level).

**4.3.10 Question 9**

Question nine asked participants how regularly they did PA on each day of the previous week (Figure 32). The ratings for the seven weekdays were counted up to give a single mark out of five as for the other questions. The aim of this question is not to differentiate between activity of different days or of activity of weekends versus weekdays, but to have an aggregate for the week. Figure 32 is for illustration purposes of the ratings for the week.

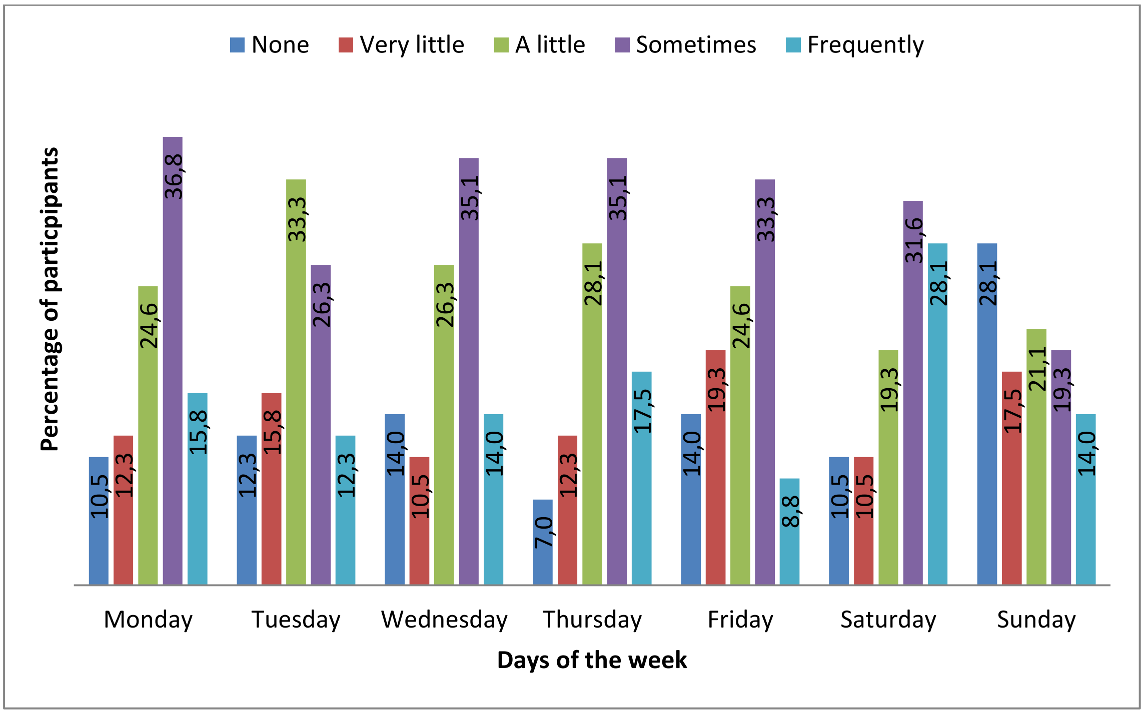



**Figure 32 Question nine: Reported frequency of physical activity (Monday - Sunday)**

**4.3.11 Question 10**

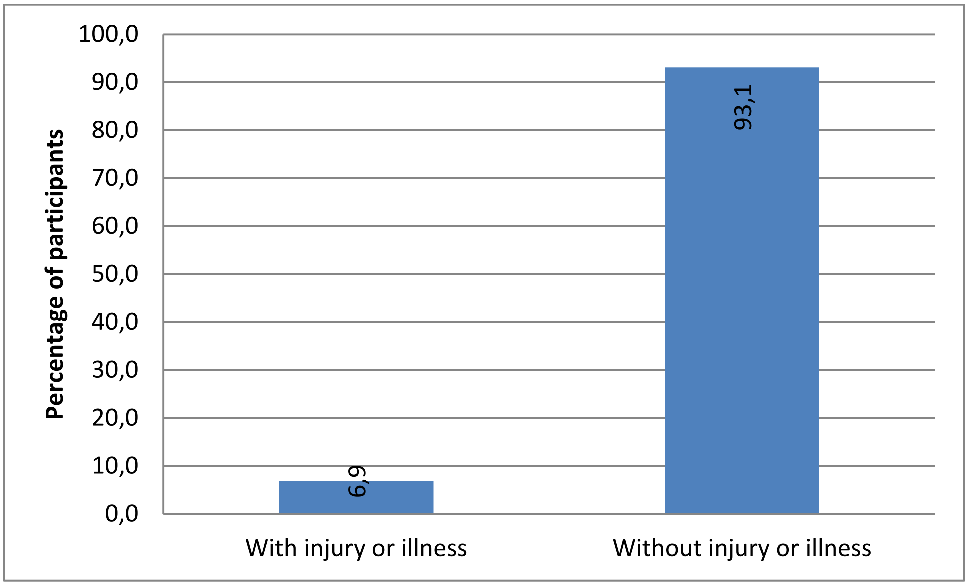



**Figure 33 Question ten: Illness or injury in the previous week**

Question ten (Figure 33) was used to determine whether participants were performing their regular physical activity. Participants were also given an opportunity to explain if they answered 'yes' to this question. Their descriptions did not point to any conditions which would limit their activity.

### 4.3.12 Total score for PAQ-C

The total scores collected for participants are illustrated in Figure 34 and 35 below.

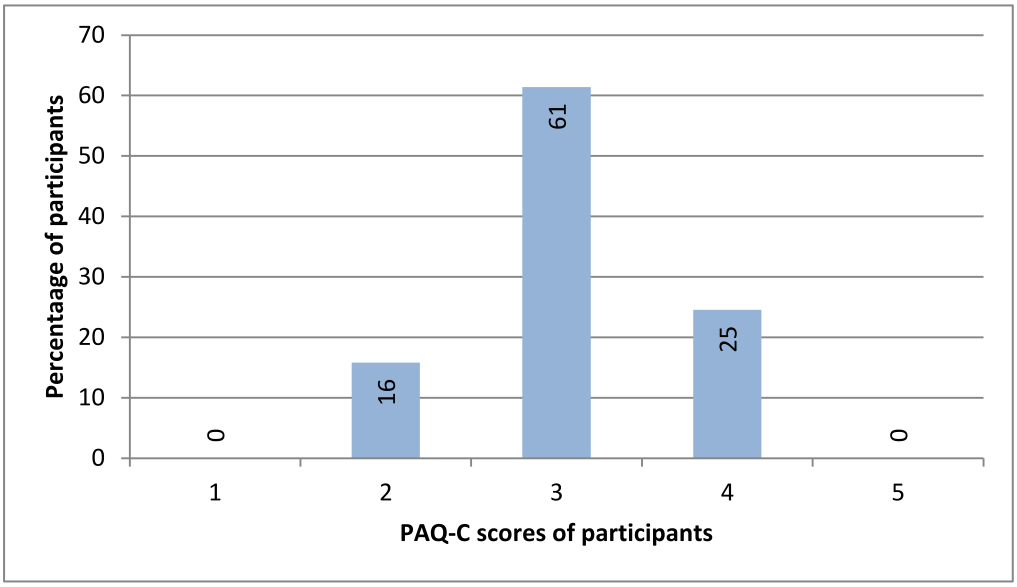



**Figure 34 Overall scores for PAQ-C questionnaire**

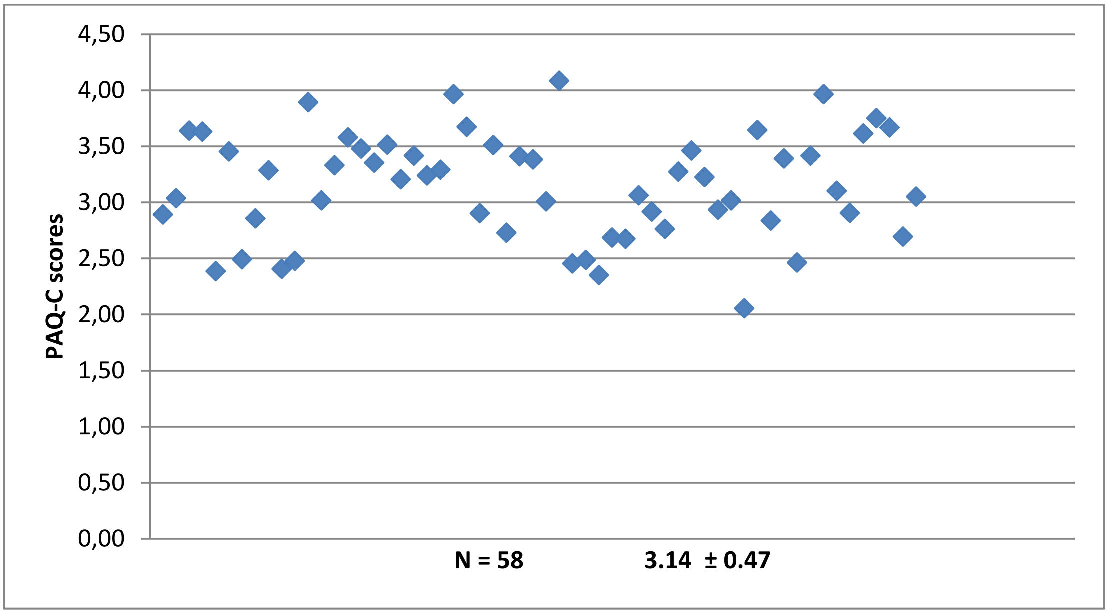



**Figure 35 Distribution of PAQ-C scores**

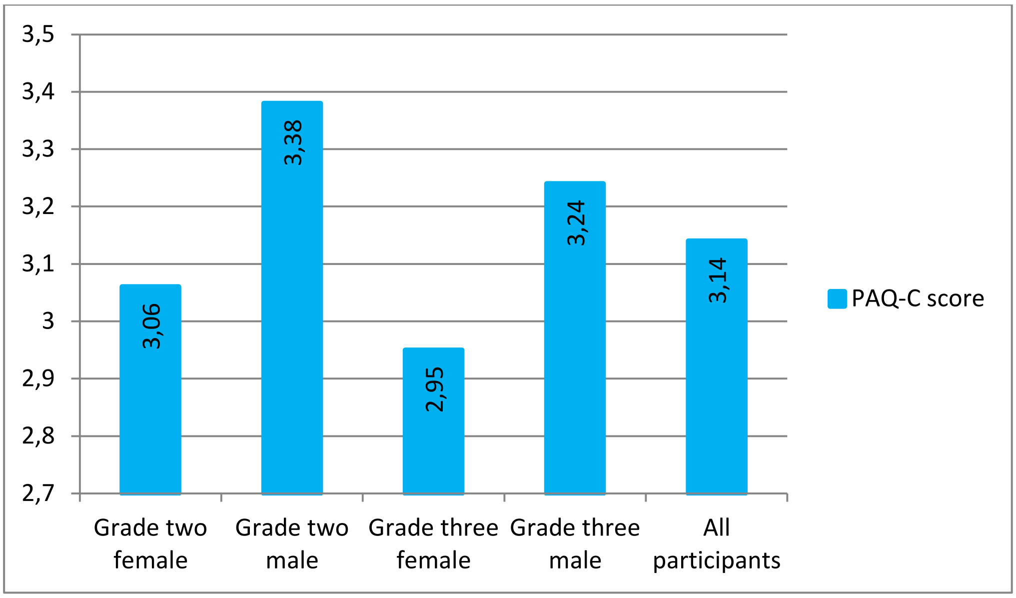



**Figure 36 Break-up of scores for PAQ-C questionnaire**

Most participants selected answers which placed them in the middle of the scale with none ending up in the highest and lowest categories of PA (Figures 34, 35, & 36).

## 4.4 Correlations: Reported activity and measured activity

Table 4 indicates the correlations between measured activity variables (pedometer) and reported activity variables (PAC-Q). Only relationships that indicated significant correlations are included, with the strength of the correlation described.

**Table 4 Correlations between measured activity and reported activity**

| Correlations between measured activity and reported activity | | | | |
|---|---|---|---|---|
| **Reported variable** | **Correlation Strength** | | **Significance level** | **Measured variable** |
| Frequency (total and average) of activity with question one | Fairly | *r* = 0.39 | p = 0.002* | Average steps per day<br>Total number of steps for seven days |
| Average activity reported for the week (seven days) in question nine | Fairly | *r* = 0.28 | p = 0.03** | Average steps per day<br>Total number of steps for seven days |
| Total PAQ-C score (Questions one through to nine) | Moderately | *r* = 0.49 | p < 0.001* | Average steps per day<br>Total number of steps for seven days |

| Correlations between measured activity and reported activity | | | | |
|---|---|---|---|---|
| **Reported variable** | **Correlation Strength** | | **Significance level** | **Measured variable** |
| Total reported activity for weekdays in question nine | Fairly | *r* = 0.31 | p = 0.02** | Total number of steps for weekdays<br>Average steps per day for the weekdays |
| Total reported activity for weekdays in question nine | Fairly | r = 0.28 | p = 0.04** | Total number of steps for seven days |
| Average activity reported for the week (seven days) in question nine | Fairly | *r* = 0.30 | p = 0.02** | Total number of steps for weekdays<br>Average steps per day for the weekdays |
| Total PAQ-C score (Questions one through to nine) | Moderately | *r* = 0.53 | p < 0.001* | Total number of steps for weekdays<br>Average steps per day for the weekdays |

* 0.01 significance level; ** 0.05 significance level

Table 5 indicates the correlations between various measured activities. Only relationships that indicated significant correlations are included, with the strength of the correlation described.

**Table 5 Correlations between various measured activities**

| Correlations between different measured activities | | | | |
|---|---|---|---|---|
| **Measured activity** | **Correlation Strength** | | **Significance level** | **Measured activity** |
| Steps taken over the weekend (both total and average number of steps) | Fairly | *r* = 0.36 | p = 0.005* | Total number of steps for weekdays<br>Average steps per day for the weekdays |
| Total number of steps for seven days | Almost perfectly | *r* = 0.93 | p < 0.001* | Total number of steps for weekdays<br>Average steps per day for the weekdays |
| Total number of steps for seven days | Substantially | *r* = 0.64 | p < 0.001* | Total number of steps for weekend<br>Average steps per day for the weekend |

*0.01 significance level

The following Table 6 shows the relationships between different reported activities. Only relationships that indicated significant correlations are indicated, with the strength of the correlation given and described.

**Table 6 Correlations between various reported activities**

| Correlations between different reported activities | | | | |
|---|---|---|---|---|
| **Reported activity** | **Correlation Strength** | | **Significance level** | **Reported Activity** |
| Average activity reported for the week (seven days) in question nine | Moderately | *r* = 0.44 | p < 0.001* | Frequency (total and average) of activity with question one |
| Total PAQ-C score (Questions one through to nine) | Almost perfectly | *r* = 0.81 | p < 0.001* | Frequency (total and average) of activity with question one |
| Total PAQ-C score (Questions one through to nine) | Almost perfectly | *r* = 0.82 | p < 0.001* | Average activity reported for the week (seven days) in question nine |
| Total reported activity for weekends in question nine | Substantially | *r* = 0.62 | p < 0.001* | Total reported activity for weekdays in question nine |
| Average activity reported for the week (seven days) in question nine | Almost perfectly | *r* = 0.94 | p < 0.001* | Total reported activity for weekdays in question nine |
| Average activity reported for the week (seven days) in question nine | Almost perfectly | *r* = 0.84 | p < 0.001* | Total reported activity for weekend in question nine |
| Total PAQ-C score (Questions one through to nine) | Substantially | *r* = 0.77 | p < 0.001* | Total reported activity for weekdays in question nine |
| Total PAQ-C score (Questions one through to nine) | Substantially | *r* = 0.67 | p < 0.001* | Total reported activity for weekend in question nine |

*0.01 significance level

## 4.5 Differences between genders, grades and body mass categories with regards to reported- and measured activity

### 4.5.1 Gender differences

Regarding differences between genders, the following variables were significant ($p < 0.05$):

- Total frequency of activity reported in question one,
- Average of activity reported in question one,
- Average number of steps over seven days,
- Average and total number of steps during the weekday,
- Total and average number of steps over the weekend,
- Average number of steps during school (8 am – 1pm),
- Average number of steps after school hours (1pm – 12 am),
- Average number of steps before and after school hours (12am – 7am; 1pm – 12am).
- Total number of steps over seven days
- Total reported physical activity during weekdays in question nine
- Total reported physical activity during weekends in question nine
- Total reported average for the week in question nine
- Total activity over questions one through to question nine (PAQ-C aggregate score)

Males were significantly ($p < 0.05$) more active for all variables listed, compared to females

Figures 37 to 39 indicate the differences between genders with regards to their physical activity.

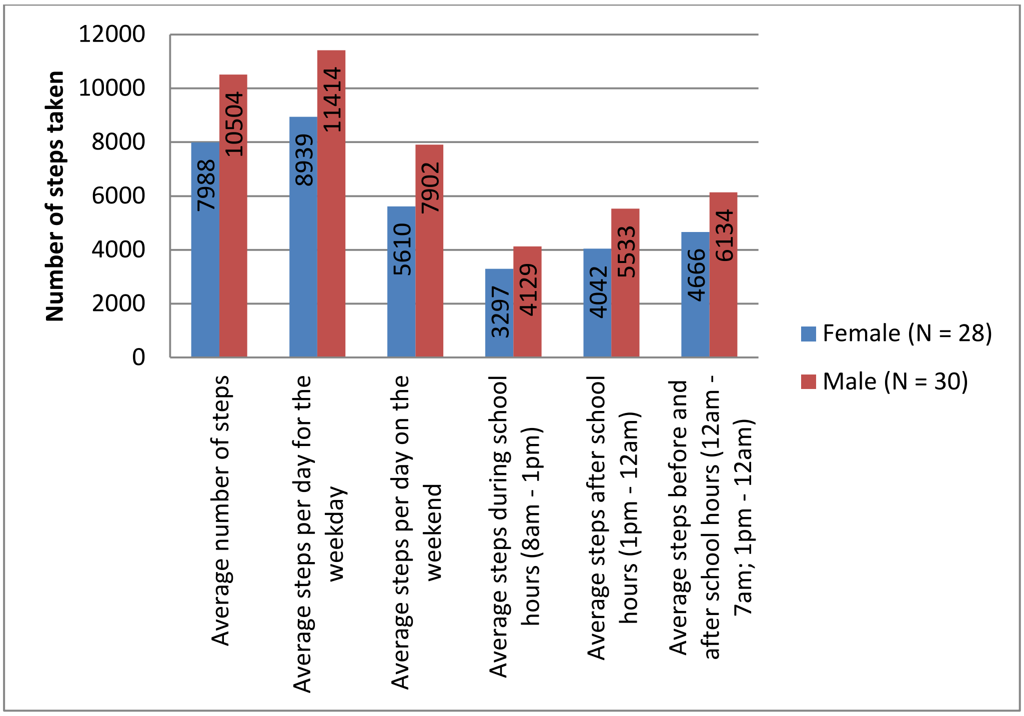



**Figure 37 Gender differences regarding average number of steps taken**

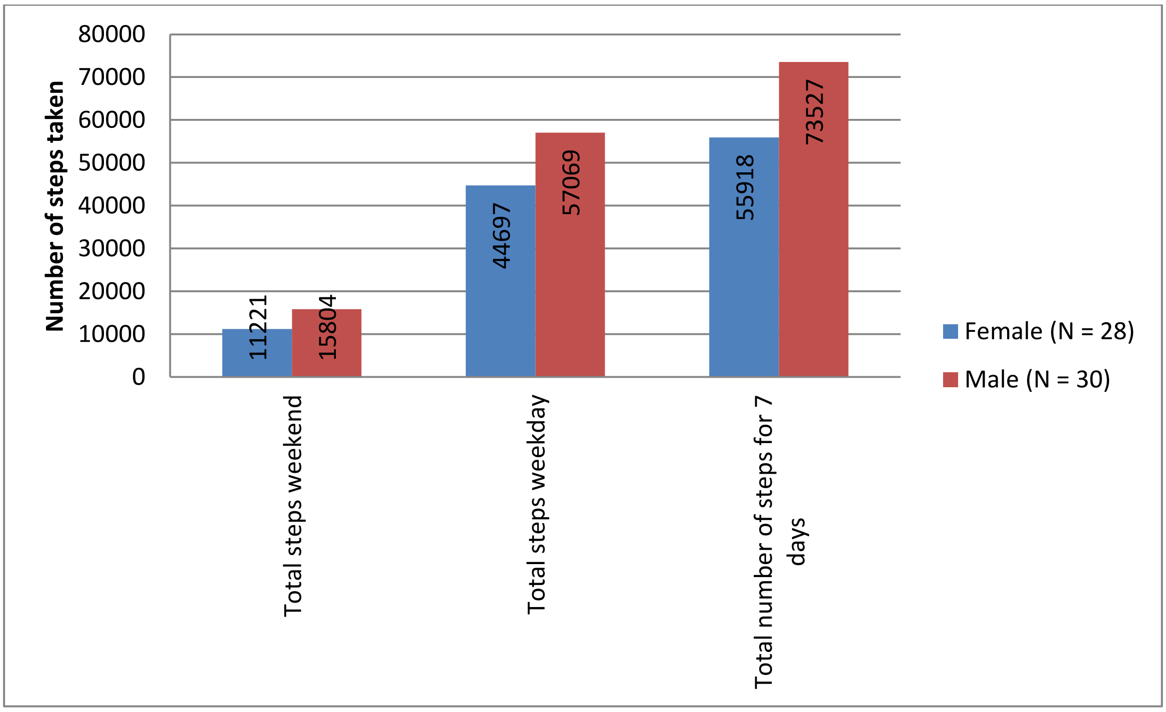



**Figure 38 Gender differences regarding total number of steps taken**

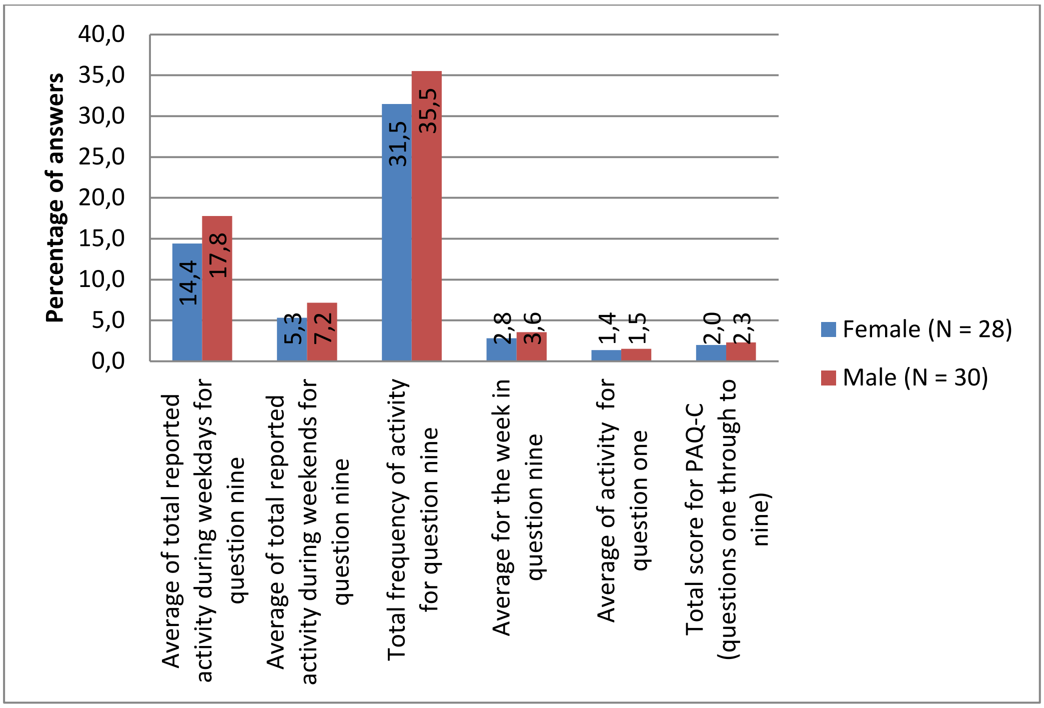



**Figure 39 Gender differences reporting physical activity levels**

### 4.5.2 Differences between grade two and grade three participants

Regarding differences between grades (two and three) the following variable was significant:

- Average number of steps after school hours (1pm – 12 am) ($p < 0.1$) as seen in Figure 40.

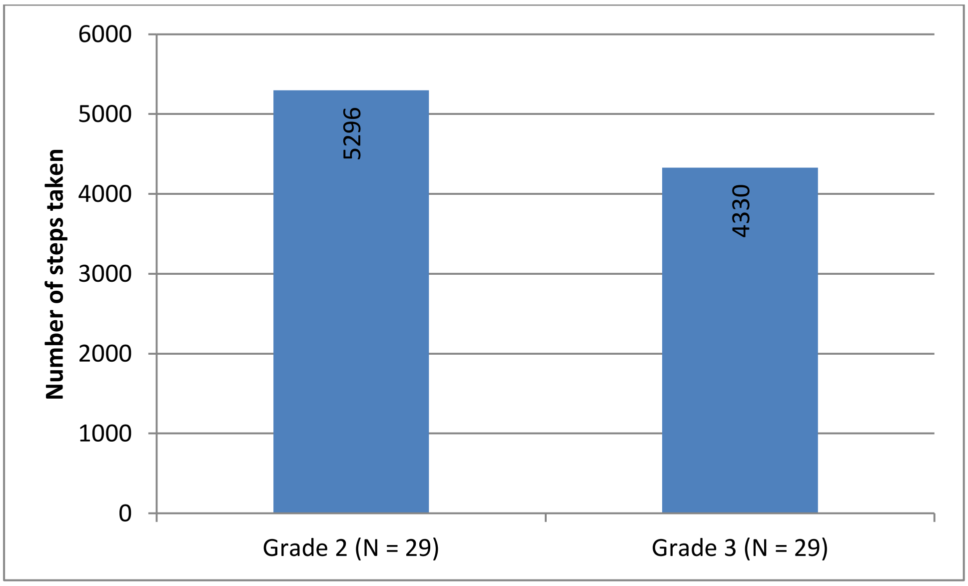



**Figure 40 Difference in average steps after schools for grades two and three**

### 4.5.3 Effect of body mass on the physical activity of the participants

Regarding body mass of the participants (Figure 41, 42,& 43), there was no statistically significant difference between PA recorded or measured in relation to the body mass of the participants. Therefore, the participants who weighed the most did not report being less active, nor were they measured as having taken fewer steps. This was true for both grades.

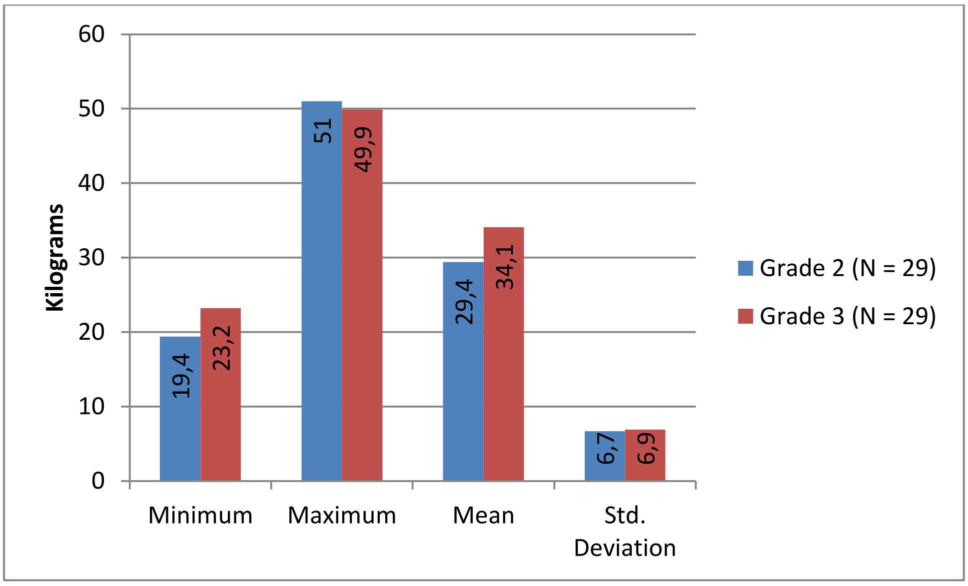



**Figure 41 Body mass distribution data of the participants**

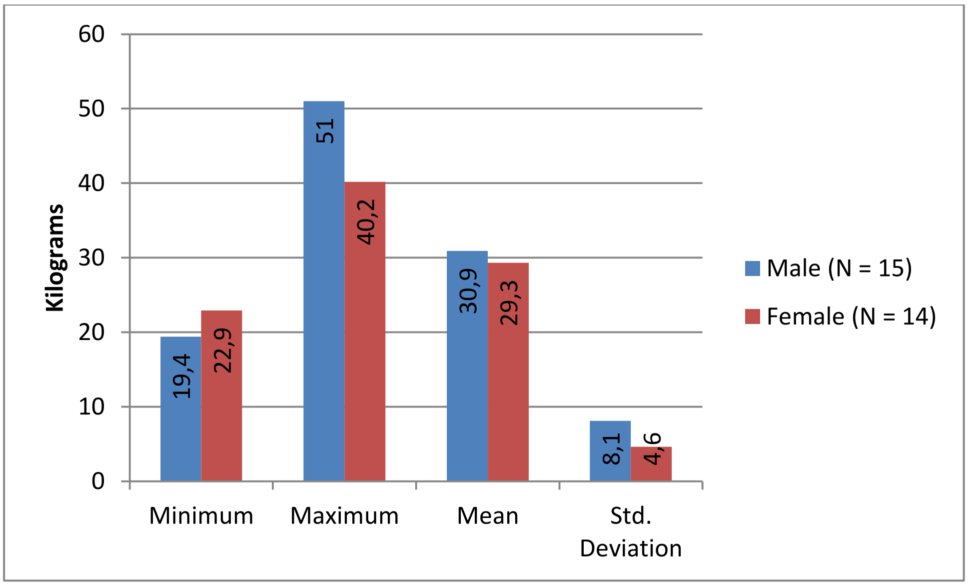



**Figure 42 Body mass distribution data of grade two participants**

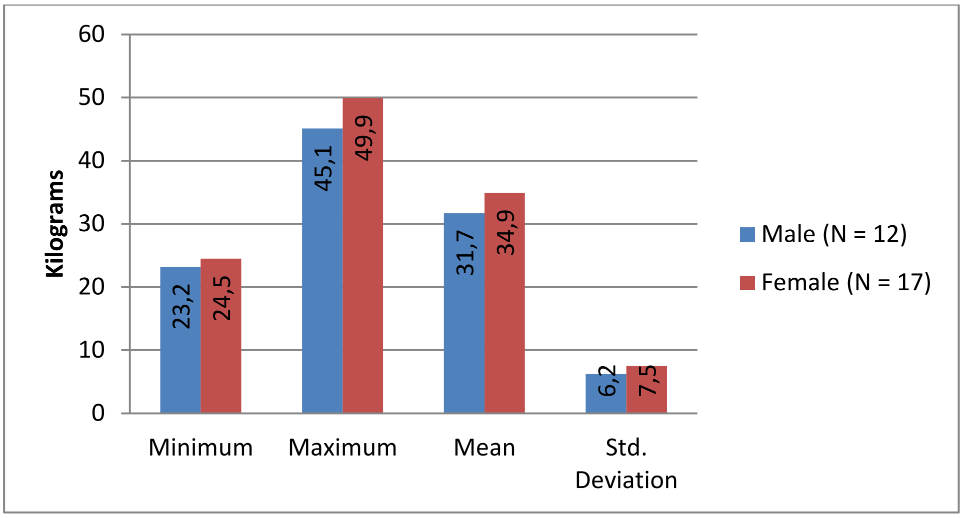



**Figure 43 Body mass distribution data of grade three participants**

The National Center for Health Statistics in collaboration with the National Center for Chronic Disease Prevention and Health Promotion (2000) publishes "*Body weight for age*" charts for boys and girls for ages two to 20 (See Appendix H & Appendix I). According to theses charts the mean body mass for the groups fit into the following percentiles:

**Grade two (values were used for eight-year olds)**

Males: Mean falls on ~80th percentile (range from below 3$^{rd}$ percentile to above 97$^{th}$).

Females: Mean falls on 75$^{th}$ percentile (range from 25$^{th}$ percentile to above 97$^{th}$ percentile).

**Grade three (values were used for nine-year olds)**

Males: Mean falls on ~75$^{th}$ percentile (ranges from ~6th percentile to above 97$^{th}$ percentile).

Females: Mean falls on ~80th percentile (range from 25$^{th}$ percentile to above 97$^{th}$ percentile).

The groups' body mass measurements were all shifted towards being heavier than the average child of that age according to CDC charts.

# CHAPTER 5: DISCUSSION

## 5.1 PA for health in children

One of the objectives of this investigation was to determine whether children are adequately active for the purposes of promoting and preserving health. Based on the recommendations of the CANPLAY study (Craig et al. 2010) of 16500 steps/ day or on the recommendations of Epstein et al. (2001) of 15 000 steps/day, it is clear that this group of participants are not getting adequate PA with an average of 10219 steps/day for the weekday and 6796 steps/day over the weekend (average of 9289 steps/day for the week) as measured using the pedometer. Of all participants only two reached 15 000 steps/day on average. Thus, this group of participants may be at a greater risk in terms of developing diseases of lifestyle (hypokinetic disease) or to predispose themselves to CVD risk factors as adults, particularly for the traits that are shown to track into adulthood atherosclerosis, hypertension, overweight/obesity, and smoking (Plowman and Smith 2013; Rayner 2012; Monyeki and Kemper 2008). Particularly in overweight and obese children, thus a lack of PA appears to be a common problem (Kemp and Pienaar 2011)

Results from the PAQ-C questionnaire showed that the participants were rated in the middle options (two, three, or four out of five) with none scoring the highest or lowest options. This could imply that the children were not active enough, but could also indicate a ‘social desirability bias’ towards answers in the mid-range. The original validation studies on American youth, ages eight – 13, had mean scores of 3.23 and 3.35 respectively compared to the results from this study with a mean score of 3.14 (Kowalski et al. 1997). Thus very similar results were obtained with various factors complicating a direct comparison of this study with the results of the original validation study. Namely, the purpose of the original validation study was different to the present study, a different motion sensor (Caltrac motion sensor) was used to validate the questionnaire, and the present study’s questionnaire was translated into Afrikaans which could have influenced the interpretation of the questions. There was no pilot study done on the Afrikaans translation of the questionnaire. This is a limitation of the study and would have identified problems with wording and clarity that affects validity of the questionnaire.

In the present study the participants were measured objectively as below optimal activity, the subjective questionnaire rating of 'average' or three out of five could then be viewed as too little activity to meet requirements if this test is repeated to check for change. Thus if they were measured as being sub-optimally active with a pedometer, should that measurement be correct, then a score of three on the questionnaire would be considered as insufficient PA being performed by the children.

What has been found in a related study is that rural South African children (ages seven, 11, and 15) tend to have a high volume of activity at a low intensity using accelerometry (Craig, Bland and Reilly 2013); the present study differs regarding the volume of activity that the participants performed and unfortunately the intensity (to determine MVPA and VPA) was not measurable with the Omron HJ-720 pedometer. The present study only uses volume as measure of PA (number of steps taken) as the Omron pedometer cannot adequately quantify acceleration to determine intensity. Based on the number steps taken the participants were shown to take less steps per day than recommendations from other authors such as the CANPLAY study (Craig et al. 2010). Craig et al. (2013) used an accelerometer which can measure intensity of activity and thus time spent doing MVPA and VPA (results showing little time spent doing MVPA and VPA but with great volume of time doing low intensity activity). Though the testing apparatus was different in the present study compared to Craig et al. (2013)(pedometer versus accelerometer) opposing conclusions were reached regarding children's volume of PA.

Loucaides et al. (2004) found that there are differences between rural and urban children (Cyprus) with regards to PA. This might also be true for South African youths as these urban youths had particularly low activity during weekends whereas the Craig et al. (2013) showed higher volume (in rural population) as mentioned above, and differences have been found in the past (Tudor-Locke, Ainsworth and Popkin 2001). Reasons stated by Tudor-Locke et al. (2001) include active commuting to school, and can also include different home life requirements as with Amish youths (Bassett 2008) and leisure time preferences. The Craig et al. (2013) study agreed though that the total PA did not meet set requirements for MVPA, and so according to set standards fell below the minimum PA for children.

It is however important to note that the lack of activity recorded could also be partly due to an intrinsic measurement problem of the device (Omron HJ-720) used to measure activity levels and steps taken. The pedometer has a random movement filter of four seconds, meaning movement must be continuous for four seconds or more before it is recorded; walking for three seconds and then stopping will cause no recording (Nakae et al. 2008). The purpose of this form of recording is to prevent false positives being recorded, but leads to false negatives being recorded (Beets et al. 2005). Beets et al. (2005) showed that a different pedometer, the Sun TrekLINQ, using a five step random movement filter showed a marked decrease in accuracy compared to other pedometers at low speeds and may be problematic due to the intermittent nature of children's PA, particularly when in an uncontrolled environment. Furthermore Trapp, Giles-Corti, Bulsara, Christian, Timperio, McCormack and Villanueva (2013) showed that multiple brands of pedometers tend to undercount the steps taken by children unless the walking speed is fast.

Another important consideration is the time of year that the testing took place in. The testing was performed in the middle of November 2012, which the school calendar showed all sporting activity sponsored by the school had ended and only those participants that are in outside sporting clubs would still have continued training and competing. This questionnaire can only be administered during school terms due to its structure, and most of the school year has schedule sporting activities. Thus if the pedometer testing coincided with training or competition for a particular sporting activity, it will reflect as an exaggeration on PA for those participants e.g. Grade two girls might appear much more active than they would otherwise. The values measured for the participants would therefore be some of the lowest of the school year for the group as a whole, and could rise greatly during other months. This month was chosen for the reason that it shows what the baseline activity of the participants are; as they would need to accumulate the minimum amount throughout the entire year regardless of sporting season.

In this study no link was shown between body mass and PA levels (reported or recorded). The expected result was participants with the least activity would have had the highest body mass. This was found in the works of Kemp and Pienaar (2011) and McVeigh and Meiring (2014) where the decrease in energy expenditure as a result of physical inactivity, caused increases in body fat. Regarding the children's age, their ages were grouped together according to their grade in school (grade two or grade three), and there appeared to be no significant correlation between body mass and activity for the two groups or for the total sample of participants. As the participant's grade was used to group them together, a more accurate description would possibly be to use each participant's date of birth to determine actual chronological age, as birthdays are spread out over the entire calendar – making a grade three born in December closer in age to a grade two participant born in January than some of those in his or her own grade. BMI could be an easy alternative to also categorize the participants' body mass, but since it does not differentiate between lean body mass and body fat – anthropometric measurements (though more time consuming) could perhaps have shown an association between activity and body mass.

Overall the group of participants can be said to be heavier than expected according to 'body-weight-for-age' tables, with the mean of the group being roughly at the 75$^{th}$ percentile for their respective ages and genders. As this study did show that physical inactivity was a common problem, it stands to reason that a PA intervention is applicable even if it didn't correlate with body mass since it has in previous studies been shown to improve body composition (Plowman and Smith 2013; Sothern 2004).

## 5.2 Recorded PA versus reported PA in children

A second objective of this study was to determine whether there is a link between activity recorded and activity reported so as to determine whether the questionnaire is an accurate reflection of actual activity. The overall score for the PAQ-C showed a moderate correlation ($r$ = 0.49; $p < 0.001$) with the average number of steps taken per day as well as for the total activity the pedometer measured over the week, and a slightly stronger correlation ($r$ = 0.53; $p < 0.001$) when only taking weekdays into account and not weekend days This was the strongest correlation between the PAQ-C or sub-items of the questionnaire and any measured pedometer reading. Although these correlations were only of moderate strength, the significance was at the 99% confidence level. The questionnaire can thus be said to moderately correlate with the participants steps as measured by the mentioned Omron HJ-720 pedometer, similar to the findings of Mciza et al. (2007) using the PAQ-C questionnaire. It is possible that parental involvement could have affected the questionnaire answers as parents answering by proxy for children have been shown to be inaccurate at times (Chow and Au 2009). Even adults measured with pedometers and questionnaires show differences in correlations with their activity (Cleland, Schmidt, Salmon, Dwyer and Venn 2011).

Individual question items of the questionnaire also correlated in the fair to moderate range with the steps measured: The frequency of individual activities listed in question one (total and average) correlated moderately ($r$ = 0.39; p =0.002) with average steps per day and total activity for the week, and question nine held a fair correlation with average and total steps for the week. For question nine the children had to rate themselves for overall activity during the week, and if this reported measure is compared to steps taken during that week, then the correlation is weaker ($r$ =0.28; p =0.03) than for the questionnaire as a whole and only a moderate increase ($r$ =0.31; p =0.02) in correlational strength is observed when the same report measure is compared to pedometer measured weekday steps.

This shows that these individual items did reflect the activity that the pedometers recorded, though not to the same degree of accuracy that the questionnaire as a whole had with measured weekday steps. There wasn't a statistically significant relationship between the steps measured over the weekend and the reported activity from the questionnaire when examined in isolation. As the questionnaire is based more around the memory clues of the week, with only one multiple choice question aimed at the weekend, underestimation or overestimation error in reporting becomes exaggerated. It is also possible that due to the fact that the overall activity measured for the weekend was also low, continuous steady state exercise and fast walking speeds could have been decreased – skewing the pedometer measurement for the time period.

The only time period where all participants did similar activity was during their PE classes. As the classes have a curriculum which would be the same for all participants, their answers should all be alike regarding their activity during the class. For question two where participants were asked to rate how often they played vigorously during their PE classes, the majority of participants (82.7%) stated "*Regularly*" or "*Always*". The significance is that the participants appear to rate the same experience very similarly. Those who report being very active and those who report not being very active during PE classes also showed a significant (to the 90% confidence level) difference in their totals steps taken. Therefore the participants' understanding of the questions and answering thereof seems appropriate; this was a concern as the participants were slightly younger than the PAQ-C target group.

For question four regarding lunch time activity, very few (only 5% of participants) selected the highest activity category for this question. There was a significant correlation to the 90% confidence level showing greater reporting of activity during lunch time and greater measured activity overall. Question four is similar to question two due to the fact that it is an activity which should be similar for all participants – eating lunch and thus sitting more.

Question six showed to the 95% confidence level that those who reported participating more in sport in the evenings also took more steps in total as well as for the weekdays alone. A reason might be that those who choose to participate in extra-curricular PA are most likely to do it during this time period – school sport activities for example are almost all scheduled during this period, and those who choose to participate in these activities are also more likely to be more active overall.

For questions three, five, and seven which dealt with activity during break time, directly after school, and sport, dance, or games over the weekend, there were no significant correlations between activity reported and activity measured.

In answer to the question: "*Could these primary school children accurately fill in a self-report questionnaire to determine their PA?*" – Only to a moderate extent. Meaning these results could be used to determine whether an intervention has made a difference to the activity levels of a group of children, or to relatively easily distinguish between children of high and low activity levels. But not to the extent that it could be a replacement for objective measurement in research. This is in agreement with Beets et al. (2005) that objective measurement still remains superior to self-report in age groups from five to 12; this questionnaire, as is, remains more appropriate to just separate the children with the highest activity levels from those with the lowest (Kowalski et al. 2004), despite cost implications.

## 5.3 PA patterns measured (pedometer) in children

When only examining the pedometer data and not that of the report questionnaire data, it is very clear that the participants are most active during weekdays (Monday – Friday) and not over the weekends (Saturday and Sunday). There was a marked decrease in the PA of the children on weekend days compared to weekdays and this is a finding that has been confirmed by other studies (Ramirez-Rico, Hilland, Foweather, Fernandez-Garcia and Fairclough 2014; Comte, Hobin, Majumdar, Plotnikoff, Ball and McGavock 2013). The average number of steps taken on the weekdays was 10219, and over the weekends only 6795, authors who have measured intensity via accelerometry have also found that youths tend to participate in very few MVPA during sedentary time (Ramirez-Rico et al. 2014; Comte et al. 2013). When comparing the variables of "*Steps taken over the weekend*" to "*Steps taken during the weekdays*" the relationship was fair, but "*Total steps taken for seven days*" correlated almost perfectly when compared to the "*Average weekday steps*". This shows a difference in activity on weekends compared to weekdays (with weekends showing more inactivity) but also that weekday steps might be measured more accurately as it correlates more strongly with a child's overall activity – not just because it comprises a greater part of the week but also because it is measured more accurately via the pedometer. Though there should be more free time for play over the weekend and thus more activity recorded – free time appears to be spent more sedentary when the structure of school and after school sports are removed. No inventory was taken on how the weekend was spent in terms of activities; this could be the focus of future research. With little activity reported it can be reasonably assumed the preferred free time activities are largely sedentary such as computer-, handheld-, and console games, or television watching with little in the way of outside play and sports based activities. Muthuri, Wachira, Onywera and Tremblay (2014) showed that when comparing Kenyan children to Canadian children in terms of PA patterns, Kenyan children had greater MVPA over the weekends, though the patterns were very similar. In that study Kenyan children from lower socioeconomic backgrounds had greater MVPA, in contrast with many other higher income countries – therefor engaging in more active play. In the South African context a moderately strong link has also been shown between television viewing time and lack of PA (Lennox, Pienaar and Wilders 2008).

When analysing the breakdown of the weekday steps taken, the largest block was the steps taken after school hours at an average of 4813 steps, compared to during school hours which were an average of 3726 steps (the time since waking until the start of school accounted for 612 steps on average). It should be noted that the time allocated to "*after school*" is longer than that of during school hours and should account for more free time and play, however the figures are quite comparable as this section also includes the hours from bedtime to midnight.

The results are comparable to that of Walter (2011) showing that a large part of daily PA for children occur during school hours (58% in his study). Apart from recess and a PE class twice per week, school hours are spent largely sedentary, yet the afternoons accounted for only 23% more activity than the mornings of school days. As with weekends, free time and play appears not be structured around games and sports which promote PA, but around sedentary entertainment. Daley (2009) showed that 'active' new-generation gaming is still lacking evidence regarding health benefits. As long as modern entertainment is sedentary children will not self-select to do adequate PA, however if schools can to a greater extent draw children in to programs based around PA (with encouragement from parents) this activity deficit can decrease Daley (2009). Parental lifestyle has been shown to affect the PA habits of their children as well (Morgan, Lubans, Callister, Okely, Burrows, Fletcher and Collins 2011), part of the solution is thus parents modelling the behaviour that they wish their children to follow. Additionally parents can help take control of children's sedentary past times by having group play sessions for children, each parent takes turns to supervise the group of children for a Saturday morning with PA (playing games outside, going hiking, ice skating etc.), thus a group of 4 or 5 children can be busy every Saturday with each set of parents helping out on a different weekend. Television time has been shown to be related to risk in CVD (Hancox et al. 2004; Bar-or et al. 1998) and as such should also be limited in order to promote more physically demanding activities.

## 5.4 PA reported (PAQ-C intra-questionnaire) in children

When comparing items in the questionnaire which analyse similar PA patterns to one another, as well as to the overall questionnaire score, we find almost perfect correlations between the overall questionnaire score and how children rated themselves (average and total week activity for each day of the week) for question item nine ($r$ = 0.82; $p < 0.001$). There is an equally strong correlation with question item one where children were given a list of activities and asked to rate themselves on how often they did these activities ($r$ = 0.81; $p < 0.001$). This confirms the questionnaire reliability already established by the creators of the PAQ-C (Kowalski et al. 2004; Kowalski et al. 1997).

Once again the relationship is weaker between weekend activity self-rating for question item nine compared to the overall score for the questionnaire or when compared to self-rating of weekday activity for question item nine. This confirms the drop-off in activity that the pedometer showed for weekday versus weekend steps; the participants thus also rated themselves as having a different (more inactive) lifestyle over weekends compared to the weekdays.

An additional reason for the weaker correlations as well as the more inactive activity profile of the weekend, maybe the structure of the questionnaire itself – the questionnaire is largely structured around school activities as beacons to describe activity (e.g. "*Activity during break time*", "*activity during lunch time*", "*activity during PE classes*", "*activity after school*" etc.). This could lead to difficulty in reporting for the weekends since these cues are absent, hampering accurate recall and making comparisons with weekday activity difficult. There are fewer cues on a weekend that would be the same for all participants as the regimented structure of the school during the week, what remains could still be used to ask detailed questions on activity based around daily tasks i.e. "*Did you play any games that involve fast running early morning on Saturday?*" or "*After Sunday lunch time, what did you do for most of the afternoon?*" (with suitable multiple choice answers available). From previous research collected most families indicated strongly Christian family views and are likely to also attend a church and or catechesis which could be used as another time cue on the weekend.

With the advent of smart phone and tablet technology the solution might be simple; create cues via the devices which should be more comparable than assumptions on weekend activities. A simple alarm that goes off at pre-determined time based on the researchers needs with a pop-up question on activity. As the participants in this study all attend an upper-middle class primary school, it is likely that most, if not all, families have at least one such device. With regards to cost involved this would in fact be cheaper than even paper questionnaire hand outs – no printing, no phone calls or SMS reminders, no unnecessary travel costs to hand out or collect questionnaires.

One of the hypotheses of the study was that there would be common activities listed that cannot be measured by pedometers. Of the activities that were participated in the most (according to average selected frequency), given as a rating out of five, were: Jog/run (3.72), swimming (3.5), walking for exercise (2.76), game of ‘tag’/chasing (2.69), and cycling (1.91). Swimming and cycling, being the second and fifth most commonly selected activities respectively, are examples of activities which cannot be evaluated through the use of a pedometer and confirms that many daily activities will go unmeasured by traditional hip-worn PA monitors.

### 5.5 Gender differences

For almost all variables, in particular total and average steps measured as well as total PA reported for PAQ-C, males were significantly more active than females for both grade two and grade three participants. The differences were significant to the 95% confidence level and were for both reported and measured PA, thus male participants not only rated themselves as being more physically active than female participants but were also measured as taking more steps. The variance between the genders with pedometer steps measured appear to be similar throughout the entire day and not merely during after school period when sports are normally played. The pattern of boys being more physically active than girls has been shown by various other studies (Tudor-Locke et al. 2008; Bassett et al. 2007; Cardon and De Bourdeaudhuij 2004; Trost et al. 2002).

### 5.6 Age differences

When comparing the reported PA as well as measured PA of grade two participants versus grade three participants, there was only one significant difference (to the 90% confidence level) between the two groups - steps measured after school. Participants in grade two had an average of 5296 steps after school and participants from grade three having an average of 4330 steps. Numerous studies have found that there is a definite drop-off in physical activity levels with progressing age (Nader, Bradley, Houts, McRitchie and O'Brien 2008; Trost et al. 2002). The difference in this study cannot be explained purely as a result of age, but a change in after school sport schedules between the two grades could also play a role – though there should have been little school sponsored sporting activities for that time of year. Trost et al. (2002) and Le Masurier et al. (2005) found that there is a sharp drop-off when comparing PA from participants in grades one to three with those in grades four to six, but it does not explain such a drop from one grade to the following. For a confirmation of difference in activity between the two grades the study can be repeated at a different time of year, ideally multiple times in one year. It should be noted that there wasn't an overall difference between the grades and not for any other time segment either.

### 5.7 Strengths, limitations and recommendations for future research

Strengths of the present study include the use of a dual-sensor accelerometer-based pedometer which has been shown to be more accurate when used by children and slower walking speeds than the traditional spring levered pedometers (Nakae et al. 2008). Strengths also include the time of testing during the year – summer month, with no exams, or sporting responsibilities – an ideal time to show the baseline activity that participants will self-select without the limitation of winter weather or tests needing preparation (Craig et al. 2010). The use of a questionnaire that has been validated in literature (though not in South Africa to the researcher's knowledge) can also be said to be a strength – though it must be noted that it was applied to a slightly younger participant group than previous validation studies (Kowalski et al. 2004; Kowalski et al. 1997).

The lack of a random sample of participants (convenience sample) can be said to be a limitation of the study, as well as the fact that the pedometers were unsealed – meaning participants could see the number of steps they were taking, thus possibly motivating them to pay more attention to their PA and be more active than they otherwise would have been.

Another limitation of this study and future research recommendation would be that a pedometer with a shorter movement filter be used and compared to the results from the presently mentioned pedometer to see to what extent the impact is on accuracy, more specifically by how much the Omron HJ-720 underestimates the intermittent activity in children. As the Omron HJ-720 needs four-seconds of continual movement to make recordings, much of the participants' activity may not have been recorded.

An additional problem with most wearable activity monitor devices (specifically referring to pedometers) is their inability to assess all PA. Upper body movement is not detected (Welk et al. 2000), slow walking speeds and obesity often lead to underestimation of activity (Giannakidou et al. 2012; Ryan et al. 2006), water-based activities, as well as activities where the pedometer cannot record activity, for example horizontal movement activities such as cycling (McVeigh and Norris 2012; Duncan et al. 2007). Mitre, Lanningham-Foster, Foster and Levine (2009) found commercially available pedometers suffer the same inaccuracy in obese and overweight children as they do in adults. In the present study there were activities reported for which the pedometer would not be able to detect movement involved in the activity. Horse riding being an activity mentioned by three participants where activity measured may not be reflective of the exertion of wearer of the pedometer, in addition to swimming and cycling. Few participants were involved in horse riding, though swimming and cycling were common. A recommendation would be to combine pedometry with new innovations that can track movements of the arms and legs as separate from the body overall, as well as to waterproof the devices – not only to record water-related activities but also to curb loss of data from damaged pedometers.

Question one lists various activities and sports and asks the participant to select how often they performed each activity. For this particular question the adaptation to the South African context could still be improved – activities that were listed by participants under the option ‘other’ include: table tennis, acrobatics, wrestling, trampoline, karate, golf, gymnastics, horse riding, and roller skating. Some activities that were changed at the onset of this study was the inclusion of rugby, field hockey, netball, tennis, and cricket. Football (grid iron), street hockey, ringette and cross-country skiing were removed. Some of the remaining choices that fetched no answers and can be considered for removal from list include: rowing/canoeing, flight ball, ice skating, and ice hockey.

The circumstance or environment in which the questionnaires were completed could have influenced the results. The participants took the questionnaire home as a circular letter to be completed and returned to the school the following day using the given instructions on the questionnaire. Control over how much parents were involved is thus not controlled for. Ideally each class of participants should fill in the questionnaire under the supervision of the researcher. The participants would then all receive a uniform explanation of the questions and questionnaire and the researcher would also be available to answer questions, as was the case with Platat and Jarrar (2012) who also used participants of the same age groups. Unfortunately, the school timetable and distribution of participants over 17 classes prohibited this manner of data collection in this study. A possible solution to some of these problems as well as to investigate the effect of the time of the year on PA, is to use the pedometers over a greater period of time than seven days and to repeat again in a different season. The pedometers can record up to 40 consecutive days of activity, this will help average out activity during the sporting seasons and will allow researchers time to implement testing one class at a time.

The strategies of Trapp, Giels-Corti, Martin, Timperio and Villanueva (2011) should be considered for similar studies to maximize the chances of success: 1. Building positive relationships with key school personnel, 2. Child-centred approaches to survey development, 3. Comprehensive classroom management techniques to standardize and optimize group sessions, 4. Extensive follow-up procedures for collecting survey items, 5. A specially designed data management/monitoring system. For the present study item two could have possibly received more attention to confirm the participants' understanding of the questions, and item three was not applicable, but items one, four, and five were adhered to closely.

A recommendation can be made for altering the components of the questionnaire dealing with physical activity over the weekend. Whilst the weekday portion is filled with clues surrounding the daily routine which can jog memory and put the amount of activity in perspective, the weekend is less so. Using an online form of completion via the internet or smart device 'app' (software application) or even simply the routine of filling in sections to the questionnaire at specific time intervals over the weekend could shorten the duration between activity and writing down the activity. The current questionnaire's questions format would have to be altered as the questions are not phrased in such a way. A simple method that could enhance accuracy is merely to decrease the recall time from the current seven days.

Participants appear not to self-select being physically active, so to promote PA to further health outcomes, suggestions can be made from the study. Based on patterns observed in the study, focus should be on participation in structured school and after school PA, such as encouraging regular school PE classes. A regular after school programme providing 30 – 60 min of PA as in the case of Lennox and Pienaar (2013) can boost the total PA performed during a week that the average daily requirement is still met over the course of seven days. After school activities can also be structured and controlled more rigidly to ensure that it is not only a perception of adequate PA that is occurring but PA that is intense and great enough in volume to elicit favourably physiological change. Faith, Berman, Heo, Pietrobelli, Gallagher, Epstein, Eiden and Allison (2001) suggested a novel approach of improving PA habits of children by making sedentary activities contingent on PA. In their study obese children had to use an arm cycle for one minute in order to have the television turned on for two minutes (Faith et al. 2001). This markedly reduced time spent watching television but also increased PA compared to the control group. Therefore by adopting more contingencies that enforce PA as prerequisite to sedentary activities could help change sitting time in children.

## 5.8 Summary

The participants in this study appear to be accumulating insufficient PA over the course of the week as per health recommendations, with particularly low levels of activity over the weekend. The PA trend observed in this study confers with other studies on South African children. It is necessary to find ways to increase PA levels in South African children in order to prevent the dire consequences of hypokinetic diseases. School activity appears to promote PA, and further increases in school PA are recommended to meet criteria for improving health. The PAQ-C showed a moderate correlation with the average and total number of steps taken per day as recorded by pedometer, and a slightly stronger correlation when only taking weekdays into account. Thus, the questionnaire could possibly be used to determine PA levels in South African primary school children but the limitations of the tool must be taken into consideration. The body mass of the participants did not appear to be related to PA reported or recorded. Thus, children with higher body mass were not less active than children of a normal or lower body mass. Although the participants' body mass measurements were all shifted towards being heavier than the average child of that age according to CDC charts. For future research it is recommended that a pedometer with shorter movement filter or in conjunction with additional sensors be used. In addition, the structure of the questionnaire could be altered especially in terms of recording weekend activity. To conclude, this study contributes to the limited data on PA of South African primary school children and the use of the PAQ-C and pedometers on this population to record or measure PA.

## 6 ABBREVIATIONS

| | | |
|---|---|---|
| ACSM | - | American College for Sports Medicine |
| APO-A1 | - | Apolipoprotein-A1 |
| APO-B | - | Apolipoprotein-B |
| ATP | - | Adenosine Triphosphate |
| BMI | - | Body Mass Index |
| BP | - | Blood Pressure |
| CHD | - | Coronary Heart Disease |
| CV | - | Cardiovascular |
| CVD | - | Cardiovascular Disease |
| DBP | - | Diastolic Blood Pressure |
| EE | - | Energy Expenditure |
| FFA | - | Free Fatty Acids |
| GDP | - | Gross Domestic Product |
| HDL-C | - | High Density Lipoprotein Cholesterol |
| HIV / AIDS | - | Human Immunodeficiency Virus / Acquired immunodeficiency syndrome |
| IC | - | Integrated Chip (sensor) |
| IDL | - | Intermediate Density Lipoprotein |
| Kcal/week | - | Kilocalories per week |
| KDA | - | Physical Activity Period |
| $Kg.m^{-2}$ | - | Kilogram per meter square (Measurement unit for BMI) |
| LASSA | - | Lipid and Atherosclerotic Society of South Africa |
| LDL-C | - | Low Density Lipoprotein Cholesterol |
| $M.s^{-2}$ | - | Meter per second squared (Measurement of Acceleration) |
| $Mg.dL^{-1}$ | - | Milligram per decilitre (Measurement of Concentration) |
| $Min.d^{-1}$ | - | Minutes per day |
| MmHg | - | Millimetre of Mercury (Measurement of Blood Pressure) |
| Mmol/L | - | Millimole per litre |
| MVPA | - | Moderate to Vigorous Physical Activity |
| NIDDM | - | Non-Insulin Dependent Diabetes Mellitus |

| | | |
|---|---|---|
| PA | - | Physical Activity |
| PAQ-C | - | Physical Activity Questionnaire for older Children |
| PF | - | Physical Fitness |
| PNF | - | Proprioceptive Neuromuscular Facilitation |
| RM | - | Repetition Maximum |
| SBP | - | Systolic Blood Pressure |
| SMS | - | Short Message Service |
| TC | - | Total Cholesterol |
| TG | - | Triglycerides |
| VLDL | - | Very Low Density Lipoprotein |
| VPA | - | Vigorous Physical Activity |
| WHO | - | World Health Organization |
| YRBS | - | Youth Risk Behaviour Study |

# 7 APPENDICES

**Appendix A Physical Activity Questionnaire for Older Children (PAQ-C) [Original]**

Physical Activity Questionnaire

Name: ___________________________

Age: ____________

Sex: M_______ F_______

Grade: ___________

Teacher: _________________________

We are trying to find out about your level of physical activity from the last 7 days (in the last week). This includes sports or dances that make you sweat or make your legs feel tired, or games that make you breathe hard, like tag, skipping, running, climbing, and others.

**Remember:**

1. There are no right and wrong answers — this is not a test.
2. Please answer all the questions as honestly and accurately as you can — this is very important.

Physical activity in your spare time: Have you done any of the following activities in the past 7 days (last week)? If yes, how many times?

(Select only one circle for each activity)

**0** **1-2** **3-4** **5-6** **7 times or more**

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| Skipping............................... | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 or more |
| Rowing/canoeing................. | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 or more |
| In-line skating..................... | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 or more |
| Tag.................................... | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 or more |
| Walking for exercise............ | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 or more |
| Bicycling............................. | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 or more |
| Jogging or running............... | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 or more |
| Aerobics............................. | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 or more |
| Swimming........................... | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 or more |
| Baseball softball.................. | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 or more |
| Dance................................ | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 or more |
| Football.............................. | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 or more |
| Badminton.......................... | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 or more |
| Skateboarding..................... | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 or more |
| Soccer................................ | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 or more |
| Street hockey..................... | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 or more |
| Volleyball........................... | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 or more |
| Floor hockey....................... | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 or more |
| Basketball.......................... | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 or more |
| Ice skating.......................... | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 or more |
| Cross-country skiing............ | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 or more |
| Ice hockey/ringette............. | 0 | 1 | 2 | 3 | 4 | 5 | 6 | 7 or more |

Other:________________________________

2. In the last 7 days, during your physical education (PE) classes, how often were you very active (playing hard, running, jumping, throwing)? ***(Check one only.)***

I don't do PE .........................................................

Hardly ever..........................................................

Sometimes............................................................

Quite often...........................................................

Always.................................................................

3. In the last 7 days, what did you do most of the time at recess? ***(Check one only.)***

Sat down (talking, reading, doing schoolwork)……

Stood around or walked around ..............................

Ran or played a little bit ........................................

Ran around and played quite a bit ..........................

Ran and played hard most of the time ....................

4. In the last 7 days, what did you normally do at lunch (besides eating lunch)? ***(Check one only.)***

Sat down (talking, reading, doing schoolwork).......

Stood around or walked around ..............................

Ran or played a little bit ........................................

Ran around and played quite a bit ..........................

Ran and played hard most of the time ....................

5. In the last 7 days, on how many days right after school, did you do sports, dance, or play games in which you were very active? ***(Check one only.)***

None ……………………………………………………………….

1 time last week .....................................................

2 or 3 times last week .............................................

4 times last week ....................................................

5 times last week ....................................................

6. In the last 7 days, on how many evenings did you do sports, dance, or play games in which you were very active? ***(Check one only.)***

None ........................................................................

1 time last week ......................................................

2 or 3 times last week ............................................

4 or 5 last week ......................................................

6 or 7 times last week ............................................

7. On the last weekend, how many times did you do sports, dance, or play games in which you were very active? ***(Check one only.)***

None ........................................................................

1 time .......................................................................

2 — 3 times ..........................................................

4 — 5 times ..........................................................

6 or more times ......................................................

8. Which one of the following describes you best for the last 7 days? Read all five statements before deciding on the one answer that describes you.

**A.** All or most of my free time was spent doing things that involve little physical effort

**B.** I sometimes (1 — 2 times last week) did physical things in my free time (e.g. played sports, went running, swimming, bike riding, did aerobics)

**C.** I often (3 — 4 times last week) did physical things in my free time

**D.** I quite often (5 — 6 times last week) did physical things in my free time

**E.** I very often (7 or more times last week) did physical things in my free time

9. Mark how often you did physical activity (like playing sports, games, doing dance, or any other physical activity) for each day last week.

None Very Little A Little Bit Medium Often Very Often

Monday .........................

Tuesday ........................

Wednesday ...................

Thursday .......................

Friday ............................

Saturday ........................

Sunday ..........................

10. Were you sick last week, or did anything prevent you from doing your normal physical activities? (Check one.)

Yes .......................................................

No .........................................................

If Yes, what prevented you? ___________________________________

**Appendix B Physical Activity Questionnaire for older Children (PAQ-C) – Translated and adapted**

Naam en Van: ___________________________

Ouderdom: ____________

Geslag: Seun / Dogter

Graad: ________Klas nommer:__________

Onderwyser: _________________________

Ons probeer uitvind wat jou vlak van fisiese aktiwiteit vir die afgelope 7 dae (in die laaste week) was. Dit sluit in sport of dans wat jou laat sweet of jou bene laat moeg voel, of speletjies wat jou laat swaar asem haal, soos "*touchers*", tou te spring, hardloop, klim, en enige iets anders.

**Onthou:**

Daar is geen reg en verkeerde antwoorde - dit is nie 'n toets nie.

Beantwoord asseblief al die vrae so eerlik en akkuraat as wat jy kan - dit is baie belangrik.

**1.** Fisiese aktiwiteit in jou vrye tyd: Het jy enige van die volgende aktiwiteite in die afgelope 7 dae (verlede week) gedoen? Indien ja, hoeveel keer?

**0** **1-2** **3-4** **5-6** **7 of meer**

Tou spring .......................... 0 1 2 3 4 5 6 7 of meer

Roei / kano ..........................0 1 2 3 4 5 6 7 of meer

In lyn skaats ....................... 0 1 2 3 4 5 6 7 of meer

Jagertjie ............................ 0 1 2 3 4 5 6 7 of meer


Stap vir oefening ................ 0 1 2 3 4 5 6 7 of meer

Fietsry ................................ 0 1 2 3 4 5 6 7 of meer

Draf of hardloop ................. 0 1 2 3 4 5 6 7 of meer

Aërobiese oefening ............ 0 1 2 3 4 5 6 7 of meer

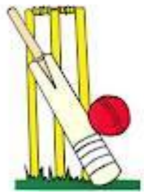

Swem ................................. 0 1 2 3 4 5 6 7 of meer

Bofbal of sagtebal . ............ 0 1 2 3 4 5 6 7 of meer

Dans .................................. 0 1 2 3 4 5 6 7 of meer

Pluimbal .............................. 0 1 2 3 4 5 6 7 of meer

Skaatsplank ....................... 0 1 2 3 4 5 6 7 of meer



Sokker ................................ 0 1 2 3 4 5 6 7 of meer

Rugby ................................. 0 1 2 3 4 5 6 7 of meer

Vlugbal ............................... 0 1 2 3 4 5 6 7 of meer

Hokkie ............................... 0 1 2 3 4 5 6 7 of meer

Basketbal ........................... 0 1 2 3 4 5 6 7 of meer

Ysskaats ............................ 0 1 2 3 4 5 6 7 of meer

Yshokkie ............................ 0 1 2 3 4 5 6 7 of meer

Netbal................................. 0 1 2 3 4 5 6 7 of meer

Tennis................................. 0 1 2 3 4 5 6 7 of meer

Krieket................................ 0 1 2 3 4 5 6 7 of meer

Ander :__________________ 0 1 2 3 4 5 6 7 of meer

**2.** In die afgelope 7 dae, tydens jou liggaamlike opvoeding (LO) klasse, hoe dikwels het jy baie aktief hard gespeel, gehardloop, gespring, of gegooi? (Kies slegs een.)

Ek doen nie LO nie .................................. ......... ... ...

Selde ..........................................................

Soms ..........................................................

Dikwels ..........................................................

Altyd ................................................

**3.** In die afgelope 7 dae, wat het jy die meeste van die tyd gedoen gedurende pouse? (Kies slegs een.)

Gaan sit (praat, lees, skoolwerk doen) ......

Rond te staan of loop ..............................

Gehardloop of 'n bietjie gespeel ........................................

Hardloop en baie gespeel vir 'n rukkie..........................

Baie gehardloop en gespeel vir meeste van die tyd ....................

**4.** In die afgelope 7 dae, wat het jy gewoonlik gedoen (behalwe middagete eet) by die middagete? (Kies slegs een.)

Gaan sit (praat, lees, skoolwerk doen) ... ...

Rond te staan of loop ..............................

Gehardloop of 'n bietjie gespeel ........................................

Hardloop en baie gespeel vir 'n rukkie..........................

Baie gehardloop en gespeel vir meeste van die tyd ....................

**5.** In die afgelope 7 dae, op hoeveel dae direk na skool, het jy sport, dans, of speletjies gespeel waar jy baie aktief was? (Kies slegs een.)

Geen ............................................... ............... ... ...

1 keer verlede week ........................................... .........

2 of 3 keer verlede week ......................................... ..

4 keer verlede week ........................................... .......

5 keer verlede week ........................................... .......

**6.** In die afgelope 7 dae, hoeveel aande het jy sport, dans, of speletjies gespeel waar jy baie aktief was? (Kies slegs een.)

Geen ............................................. ......................

1 keer verlede week .................................... .........

2 of 3 keer verlede week .......................................

4 of 5 verlede week .......................................

6 of 7 keer verlede week ........................................... ..

**7.** Oor die laaste naweek, hoeveel keer het jy sport, dans, of speletjies gespeel waar jy baie aktief was? (Kies slegs een.)

Geen .............................................. ......................

1 keer ............................................. ......................

2 - 3 keer ........................................... ...............

4 - 5 keer ........................................... ...............

6 of meer keer ........................................... ..........

**8.** Watter een van die volgende beskryf jou die beste oor die afgelope 7 dae? Lees al vyf stellings voordat jy besluit op die een antwoord wat jy beskryf.

A. alle of die meeste van my vrye tyd is bestee aan dinge te doen wat min
fisiese inspanning behels

B. ek het soms (1 - 2 keer die afgelope week) fisiese dinge in my vrye tyd gedoen (bv. Sport gespeel, gaan hardloop, swem, fietsry, of aerobics)

C. Ek het dikwels (3 - 4 keer verlede week) fisiese dinge in my vrye tyd gedoen

D. ek het heel dikwels (5 - 6 keer verlede week) fisiese dinge in my vrye tyd gedoen

E. ek het baie dikwels (7 of meer tyd in die vorige week) fisiese dinge in my vrye tyd gedoen

**9.** Merk hoe veel kere per dag het jy fisiese aktiwiteit (soos sport, speletjies, dans, of enige ander fisiese aktiwiteit) verlede week vir elke dag gedoen.

Geen  Baie min  'n Bietjie  Partykeer  Dikwels  Baie dikwels

- Maandag ..........................
- Dinsdag ........................
- Woensdag ...................
- Donderdag .......................
- Vrydag ............................
- Saterdag ........................
- Sondag ..........................

**10.** Was jy siek gewees verlede week, of het iets verhoed dat jy jou normale fisiese aktiwiteite te doen? (Kies een.)

Ja .................................................

Nee ......................................................

- Indien Ja, wat het jou verhoed? ________________________________________

**Appendix C Informed Assent**

**ASSENT FORM FOR 7-18 YEARS FOR RESEARCH**

**MEASURING PHYSICAL ACTIVITY IN SOUTH AFRICAN PRIMARY SCHOOL CHILDREN: A SELF-REPORT QUESTIONNAIRE VERSUS PEDOMETER TESTING.**

We wish to know if you would like to be part of a research study where we will take certain measurements from you. We are asking you, because your weight might be high and may cause you to be unhealthy when you are grown up. It will help us to tell you what you can do to lose weight.

About 200 children are going to take part in this study, and it will last 12 months. During that time we will call you and ask you if you are following our advice and if it is helping you to lose weight.

Today we will do different kinds of tests on you. You can see the photos below this paragraph. We will measure your fitness, your body's fat, and how much you weigh and give you some questions to answer. You will feel no pain.

**If you do not want to take part today or you may decide not to carry on. No-one will force you to carry on. No-one will be cross or upset with you if you don't want to. You don't have to give us your answer now, take your time and read the rest of this form and look**

**at the pictures before you decide.**

If you sign at the bottom it will mean that you have read this paper, and that you would like to be in this study

| | | | |
|---|---|---|---|
| | **Name** | **Signature** | **Date** |
| **<u>Witness:</u>** | | | |
| | **Name** | **Signature** | **Date** |

**Appendix D Research proposal and ethics committee (RESPEthics)**

FACULTY OF HUMANITIES

**UNIVERSITY OF PRETORIA**

DECLARATION OF ETHICAL INTENT

UNIVERSITEIT VAN PRETORIA
UNIVERSITY OF PRETORIA
YUNIBESITHI YA PRETORIA

We declare that we are fully aware of the stance taken by the RESPEthics Committee, Faculty of Humanities, regarding the importance of obtaining informed consent from research participants.

We acknowledge their concerns and reservations regarding the lack of written informed consent documents due to the fact that we deem it impossible to obtain such in the current research project.

We declare that, in the course of the research, we will take due care to protect and safeguard the rights and autonomy of all parties, which includes the participants, the University of Pretoria, RESPEthics, our Department and all outside parties with whom we make contact either physically, verbally or through documents and documentation.

We undertake to be ethical in all our dealings and at all times during the research endeavour.

**STUDENT:** Guillaume Francois Malan___________________________

**SUPERVISOR:** Me K Nolte_______________________________________

**HEAD OF DEPARTMENT:** Prof F Hagemann__________________________

**PROJECT TITLE:** **MEASURING PHYSICAL ACTIVITY IN SOUTH AFRICAN PRIMARY SCHOOL CHILDREN: A SELF-REPORT QUESTIONNAIRE VERSUS PEDOMETER TESTING.**

**Appendix E Declaration of Integrity**

**UNIVERSITY OF PRETORIA**

**FACULTY OF HUMANITIES**

**DEPARTMENT OF BIOKINETICS, SPORT & LEISURE SCIENCES**

The Department of BIOKINETICS, SPORT & LEISURE SCIENCES places great emphasis upon integrity and ethical conduct in the preparation of all written work submitted for academic evaluation.

While academic staff teach you about systems of referring and how to avoid plagiarism, you too have a responsibility in this regard. If you are at any stage uncertain as to what is required, you should speak to your lecturer before any written work is submitted.

You are guilty of plagiarism if you copy something from a book, article or website without acknowledging the source and pass it off as your own. In effect you are stealing something that belongs to someone else. This is not only the case when you copy work word-by-word (verbatim), but also when you submit someone else's work in a slightly altered form (paraphrase) or use a line of argument without acknowledging it. You are not allowed to use another student's past written work. You are also not allowed to let anybody copy your work with the intention of passing it off as his/her work.

Students who commit plagiarism will lose all credits obtained in the plagiarised work. The matter may also be referred to the Disciplinary Committee (Students) for a ruling. Plagiarism is regarded as a serious contravention of the University's rules and can lead to expulsion from the University.

While you are a student in the Department of BIOKINETICS, SPORT & LEISURE SCIENCES, the declaration which follows must be appended to all written work submitted. No written work will be accepted unless the declaration has been completed and attached.

I (full names) ______________________________________________

Student number______________________________________________

Topic of work ______________________________________________

**Declaration**

1. I understand what plagiarism is and am aware of the University's policy in this regard.

2. I declare that this report is my own original work. Where other people's work has been used (from a printed source, internet or any other source), this has been properly acknowledged and referenced in accordance with departmental requirements.

3. I have not used another student's past written work to hand in as my own.

4. I have not allowed, and will not allow, anyone to copy my work with the intention of passing it off as his or her own work.

Signature ___________________________________

**Appendix F Data storage form**

**FACULTY OF HUMANITIES**

**RESEARCH ETHICS COMMITTEE**

## Declaration for the storage of research data and/or documents

I/ We, the principal researcher(s): **Guillaume Malan**

and supervisor(s): **Kim Nolte**

of the following study, titled: **Measuring physical activity in South African primary school children: A self-report questionnaire versus pedometer testing.**

will be storing all the research data and/or documents referring to the above-mentioned study in the following department: **Department of Biokinetics, Sport and Leisure Sciences**

**We understand that the storage of the mentioned data and/or documents must be maintained for a minimum of 15 years from the commencement of this study.**

Start date of study: July 2011 (Subject to ethical clearance)

Anticipated end date of study: January 2015

Year until which data will be stored: 2030

| Name of principal researcher(s) | Signature | Date |
|---|---|---|
| Guillaume Malan | | |

| Name of supervisor | Signature | Date |
|---|---|---|

| | | |
|---|---|---|
| Kim Nolte | | |

| Name of Head of Department | Signature | Date |
|---|---|---|
| Prof Fred Hagemann | | |

**Appendix G Ethical Approval for parent study**

The Research Ethics Committee, Faculty Health Sciences, University of Pretoria complies with ICH-GCP guidelines and has US Federal wide Assurance.

* **FWA** 00002567, Approved dd 22 May 2002 and Expires 13 Jan 2012.

* **IRB** 0000 2235 IORG0001762 Approved dd Jan 2006 and Expires 13 Aug 2011.

UNIVERSITEIT VAN PRETORIA
UNIVERSITY OF PRETORIA
YUNIBESITHI YA PRETORIA

Faculty of Health Sciences Research Ethics Committee

Fakulteit Gesondheidswetenskappe Navorsingsetiekkomitee

**DATE: 25/11/2010**

PROTOCOL NO. **214/2010**

PROTOCOL TITLE Childhood obesity in Gauteng: A comparative pilot study between obese and non-obese children between the ages of 8 and 10 years on a medical aid

| | |
|---|---|
| INVESTIGATOR | **Principal Investigator:** CC Grant |
| SUBINVESTIGATOR | Dr DC Janse van Rensburg |
| SUPERVISOR | None |
| DEPARTMENT | **Dept.:** Section Sports Medicine **Fax:** +27 12 362 3369 |
| **E-Mail:** Rina.Grant@up.ac.za **Cell:** 0832587580 | |
| STUDY DEGREE | MSc Physiology SPONSOR Not Applicable MEETING DATE **24/11/2010** |

The Protocol and Informed Consent Document were approved on 24/11/2010 by a properly

constituted meeting of the Ethics Committee subject to the following conditions:

1. The approval is valid for 2 years period [till the end of December 2012, and
2. The approval is conditional on the receipt of 6 monthly written Progress Reports, and

3. The approval is conditional on the research being conducted as stipulated by the details of

the documents submitted to and approved by the Committee. In the event that a need arises to change who the investigators are, the methods or any other aspect, such changes must be submitted as an Amendment for approval by the Committee.

*Members of the Research Ethics Committee:*

Prof M J Bester (female)BSc (Chemistry and Biochemistry); BSc (Hons)(Biochemistry); MSc(Biochemistry); PhD (Medical Biochemistry)

Prof R Delport (female)BA et Scien, B Curationis (Hons) (Intensive care Nursing), M Sc (Physiology), PhD (Medicine), M Ed Computer
Assisted Education

Prof VOL Karusseit MBChB; MFGP(SA); MMed(Chir); FCS(SA) - Surgeon

Prof JA Ker MBChB; MMed(Int); MD – Vice-Dean (ex officio)

Dr NK Likibi MBBCh – Representing Gauteng Department of Health)

Prof TS Marcus (female) BSc(LSE), PhD (University of Lodz, Poland) – Social scientist

Dr MP Mathebula (female)Deputy CEO: Steve Biko Academic Hospital

Prof A Nienaber (female) BA(Hons)(Wits); LLB; LLM(UP); PhD; Dipl.Datametrics(UNISA) – Legal advisor

Mrs MC Nzeku (female) BSc(NUL); MSc(Biochem)(UCL, UK) – Community representative

Prof L M Ntlhe MBChB(Natal); FCS(SA)

Snr Sr J Phatoli(female) BCur(Eet.A); BTec(Oncology Nursing Science) – Nursing representative

Dr R Reynders MBChB (Prêt), FCPaed (CMSA) MRCPCH (Lon) Cert Med. Onc (CMSA)

Dr T Rossouw (female) M.B,.Ch.B. (cum laude); M.Phil (Applied Ethics) (cum laude), MPH (Biostatistics and Epidemiology (cum laude), D.Phil

Dr L Schoeman (female) B.Pharm, BA(Hons)(Psych), PhD – Chairperson: Subcommittee for students' research

Mr Y Sikweyiya MPH; SARETI Fellowship in Research Ethics; SARETI ERCTP; BSc(Health Promotion) Postgraduate Dip (Health Promotion) – Community representative

Dr R Sommers (female) MBChB; MMed(Int); MPharmMed – **Deputy Chairperson**

Prof TJP Swart BChD, MSc (Odont), MChD (Oral Path), PGCHE – School of Dentistry representative

Prof C W van Staden MBChB; MMed (Psych); MD; FCPsych; FTCL; UPLM - **Chairperson**

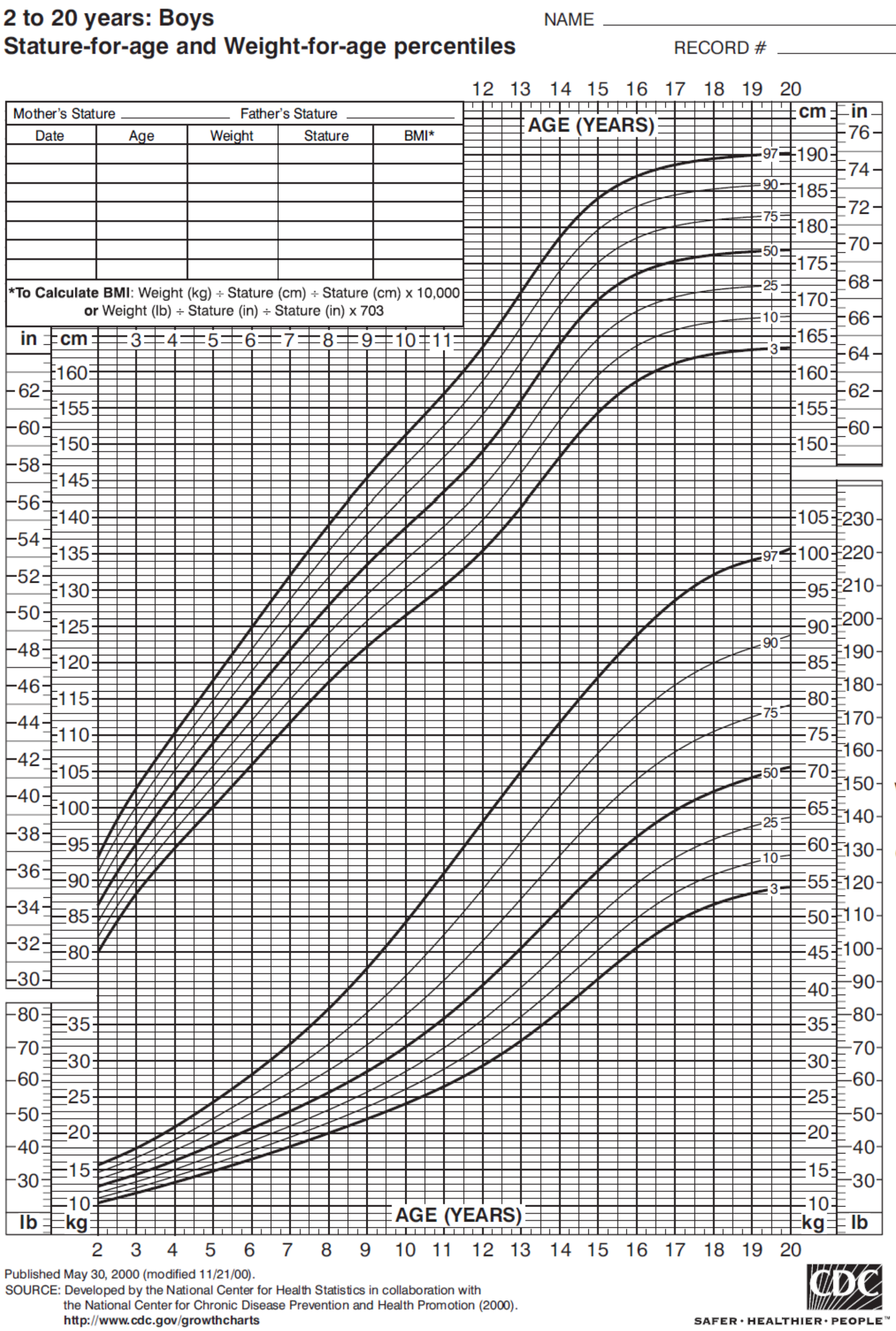
**DR R SOMMERS;** MBChB; MMed(Int); MPharmMed.

Deputy Chairperson of the Faculty of Health Sciences Research Ethics Committee, University of Pretoria

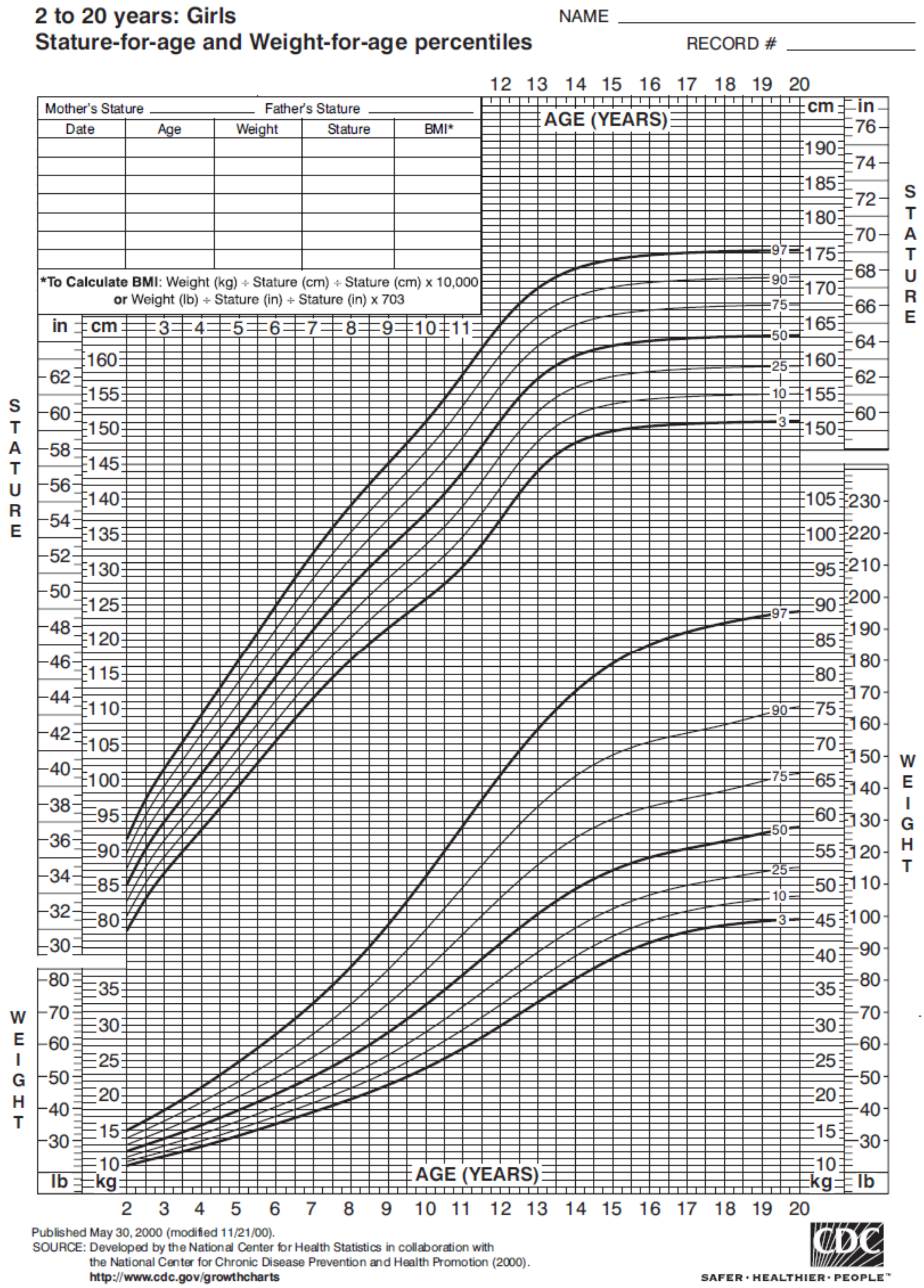
Tel:012-3541330 Fax:012-3541367 / 0866515924 E-Mail: manda@med.up.ac.za

Web: //www.healthethics-up.co.za H W Snyman Bld (South) Level 2-34 P.O.BOX 667, Pretoria, S.A., 0001

**Appendix H Centre for Disease Control charts: Two to 20 years: Boys stature- and weight-for-age**



**Appendix I Centre for Disease Control charts: Two to 20 years: Girls stature- and weight-for-age**



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