# PhYsical activity in the North-West PROVINCE AS DETERMINED BY QUESTIONNAIRE AND MOTION SENSORS 

M.P. TLhongolo

Honns. B.Sc.
(12940151)


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SUPERVISOR: DR S.J. MOSS
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# "THE GREATEST SOURCE OF MOTIVATION COMES FROM YOUR DEEPEST VALUES" -ANON- 

THIS DISSERTATION IS A DEDICATION TO MY BELOVED SISTER PAULINE LORATO HLONGOLO (1975-2004).

YOU WERE AND FOREVER WILL BE THE DRIVING FORCE BEHIND ALL MY ACHIEVEMENTS AND SUCCESSES; FROM YOU I SOURCED THE DEEP MOTIVATION AND COURAGE TO COMPLETE THIS STUDY SUCCESSFULLY!!!!!!!

## DECLARATION

The co-authors of the articles which form part of this dissertation, Dr Hanlie Moss (Supervisor) and Prof Salome Kruger (co-author) hereby give permission to the candidate Mr. Modiri Peter Tlhongolo to include the two articles as part of the Masters dissertation. The contribution (advisory and supportive) of these co-authors was kept within reasonable limits, thereby enabling the candidate to submit this dissertation for examination purposes. This dissertation therefore serves as partial fulfillment of the requirements for the Msc degree within the School of Biokinetics, Recreation and Sports Science in the Faculty of Health Sciences at the North West University, Potchefstroom campus.

Dr Hanlie Moss
Supervisor and co-author

Prof Salome Kruger
Co-author

## SUMMARY

## Background

Physical inactivity is a modifiable risk factor for cardiovascular diseases and other chronic diseases of life. In countries undergoing economic transition from underdeveloped to being developed, there is an increasing rate of physical inactivity. Accurate assessment of physical activity behaviours is important for determining the presence of physical inactivity, for setting goals for physical therapy interventions to increase physical activity and to utilize physical activity as an outcome measure for physical therapy interventions. There are different techniques used to measure physical activity, namely questionnaires, motion sensors (pedometers and accelerometers) and doubly labelled water. The most used method in large epidemiological research is questionnaires because of their affordability and feasibility. Limitations of physical activity questionnaires include the exclusion of house-hold activities, intensity of work done, bicycling, duration and frequency of leisure time activities. Motion sensors have been mostly used in developed and westernized countries. In the North West Province (NWP) of South Africa the only method that has been used to determine physical activity among the Tswana speaking people was the Transition of Health during urbanization physical activity questionnaire (THUSA-PAQ). The application of other methods such as the motion sensors has never been done.

## Objectives

The study comprised two major objectives: The first objective was to determine the physical activity levels of the rural and urban Tswana speaking people of the NWP using the THUSA questionnaire and pedometers. The second objective was to determine whether there is a relationship in physical activity determined by the THUSA-PAQ, promotional pedometer and an accelerometer determined activity.

## Methods

The participants recruited for this study form part of the larger prospective urban and rural epidemiology (PURE) longitudinal study running over 12 years which started in 2005. A subsample of 200 was randomly selected of which hundred and eighty signed the informed consent ( 90 urban and 90 rural) to participate in the study.

The participants completed the THUSA-PAQ with the assistance help of the fieldworkers in their native language and wore pedometers for seven consecutive days. The number of steps taken per day distance travelled and energy expenditure were recorded in a logbook. Another thirty eight participants from a co-hort in the same geographical area were issued with accelerometers to wear simultaneously with pedometers for a period of twenty four hours and also completed the THUSA-PAQ.

## Results

The rural male and female participants reported higher average physical activity index (PAD) with the THUSA questionnaire $(9.49 \pm 3.67$ and $8.10 \pm 1.26)$ than urban male and female participants $(8.13 \pm 2.47$ and $7.51 \pm 1.65)$ respectively. The same trend was observed with the objectively determined physical activity with the pedometers. A partial correlation adjusted for age and gender showed no statistical significance between the subjectively determined physical activity index (PAI) and the objectively determined activity (average steps per day). Results from the co-hort participants indicated that both male and female participants spent a larger percentage of their time on sedentary activities ( $66.45 \pm 15.84 \%$ and $70.13 \pm 8.39 \%$ ) respectively. Most of the participants, $64.7 \%$ females and $52.1 \%$ males, recorded fewer than 5000 steps per day with a pedometer and reported high PAI ( $9.61 \pm 1.83$ males and $7.79 \pm 1.26$ females) with the THUSA-PAQ. On this population partial correlation analyses that was adjusted for age and body mass index (BMI) showed a statistical significant relationship between ( $p<0.05$ ) time spent on vigorous activities and commute index between male and female participants. There was no statistical significant relationship between the PAI (THUSA-PAQ), activity energy expenditure (AEE) determined with an accelerometer and the number of steps per day determined with a pedometer.

## Conclusion

The major conclusion that can be drawn from this study is that the participants did not meet the recommended physical activity levels ( 30 min moderate physical activity or 10 000 pedometer determined steps per day). The participants reported high subjective physical activity index (PAI) with the THUSA-PAQ which did not correlate with the low objectively determined number of steps per day using the pedometer and AEE. Possible reasons for this include the influence of perception toward physical activity, social desirability, seasonal changes, reactivity and time of the year. Motion sensors gave a better indication of habitual physical activity among the Tswana speaking people of the NWP and should be considered for further research.

## Key Words

Physical activity, physical activity questionnaire, pedometers, accelerometers, North West Province, urban and rural.

## OPSOMMING

## Agtergrond

Fisieke onaktiwiteit is ' $n$ veranderbare risikofaktor vir kardiovaskulêre en ander kroniese leefstyl siektes. In ander lande waar daar oorgang plaasvind tussen 'n onontwikkelde na 'ontwikkelde ekonomie is daar ' $n$ verhoogde voorkoms van fisieke onaktiwiteit. Akkurate bepaling van aktiwiteitsgedrag is noodsaklik vir die bepaling van die teenwoordigheid van fisieke onaktiwiteit, vir die doelstelling van fisieke terapie intervansie en die gebruik van fisieke aktiwiteit vir fisieke aktiwiteit intervensie. Fisieke aktiwiteit kan met verskeie metodes bepaal word. Metodes sluit in vraelyste, doubly isotoop gemete en apparaat wat beweeging waarneem (vernellingsmeters en pedometers). Die metode wat die meeste gebruik word met epidemiologiese navorsing is vraelyste omdat dit die mees bekostigbare metode is. Beperkings van die vraelyste is die uitsluiting van sekere huishoudelike aktiwiteite uitgelaat word en dat die duur en frekwensie van vryetyd aktiwiteite nie korrek weergee word nie. In Westerse en ontwikkelende lande word die apparaat wat beweging waarneem meestal gebruik. Die enigste vraelys wat In Suid-Afrika se Noord Wes Provinsie (NWP) gebruik is om fisieke aktiwiteit by Tswana sprekende mense te bepaal, is die "Transition of Health During Urbanisation in South Africa (THUSA) vraelys. Die gebruik van pedometers en versnellingmeters is nog nie tevore gedoen nie.

## Doelstellings

Die studie bevat twee hoof doelstellings: die eerste doelstelling is om die fisieke aktiwiteit-vlakke van plattelandse en stedelike Tswana sprekende mense in die NWP te bepaal deur gebruik te maak van die THUSA-vraelys en die promosie pedometer. Die tweede doelwit is om die verhouding van fisieke aktiwiteit te bepaal met die THUSAvraelys, promosie pedometer en die fisieke aktiwiteit soos met versnellingmeter bepaal.

## Metodes

Die deelnemers die aan die studie vorm deel van ' $n$ groter plattelandse en stedelike epidemilogiese studie (PURE). Die studies wat oor 12 jaar strek en het in 2005 aanvang geneem het. Van hierdie groep is ' n subpopulasie van 200 geweref waarvan 180 (90 uit die platteland en 90 uit die stedelike gebied) die ingeligte toestemmingvorm geteken het om aan die studie deel te neem. Deelnemers het die THUSA-vraelys in hulle eie taal met behulp van veldwerkers ingevul. Hierna het hulle vir sewe agtereenvolgende dae 'n pedometer gedra. Die aantal tree per dag, energie gebriuk en afstande afgelê is in $n^{\prime}$ joernaal aangteken. Deelnemers uit dieselfde gebied $(n=38)$ het die vraelysTHUSA-PAQ voltooi en is voorsien van ' $n$ versnellingmeter wat gelyktydig met die pedometer vir ' $n$ periode van 24 uur gedra is.

## Resultate

Die plattelandse mans en vrouens het ' $n$ hoër gemiddelde fisieke aktiwiteit-indeks (PAI) aangeteken met die THUSA-vraelys $(9.49 \pm 3.67$ en $8.10 \pm 1.26)$ terwyl die manlike en vroulike stedelinge onderskeidlik ' $n$ indeks van $8.13 \pm 2.47$ en $7.51 \pm 1.65$ aangeteken het. Die selfde tendens is waargeneem by die objektief bepaalde fisieke aktiwiteit soos gemeet deur pedometers. Parsiële korrelasie wat vir die ouderdom en geslag aangepas is het geen statistiese beduidende verwantskap getoon tussen die subjektief-bepaalde fisieke aktiwiteit-indeks (PAD) en die objektief-bepaalde aktiwiteit (aantal tree/dag) nie. Die resultate van die 38 deelnemers uit die selfde gebied toon duidelik dat die manlike en vroulike deelnemers ' $n$ groot presentasie van elke dag onaktief deurbring ( $66.45 \pm 15.84 \%$ en $70.13 \pm 8.39 \%$ ) onderskeidelik. Meeste van die deelnemers, $64.7 \%$ vroue en $52.1 \%$ van mans, het minder as 5000 treë per dag met die pedometer geregistreer maar het ' $n$ hoë PAI met die THUSA-vraelys aangeteken ( $9.61 \pm 1.83$ mans en $7.79 \pm 1.26$ vroue). In hierdie populasie het die parsiële korrelasie wat vir die ouderdom en liggamsmassa indeks (LMD) gekorrigeer het, ' $n$ statisties beduidende verwantskap aangetoon ( $p<0.05$ ) in die tyd bestee aan aktiwiteits energieke spandering en pendelaar indeks tussen manlike en vroulike deelnemers. Daar was geen statisties beduidende verwantskap tussen die PAI (THUSA), aktiwiteit energie-spandering soos met versnellingmeter en aantal treë per dag (pedometer).

## Gevoltrekking

Die gevolgtrekking wat gemaak kan word, is dat die deelnemers nie die aanbevole fisieke aktiwiteit bereik nie ( 30 minute matige fisieke aktiwiteit of 10000 pedometer bepaalde tree per dag). Die deelnemers het hoë subjektiewe fisieke aktiwiteits indeks (PAI) met die THUSA-vraelys gerappoteer wat nie gestrook het met die laê obektief-bepaalde aantal trë̈/dag soos bepaal deur die pedometer en aktiwiteit energie verbruik nie. 'n Moontlike rede hiervoor kan gesoek word by die persepsie omtrent fisieke aktiwiteit, sosiale wenslikheid, seisoenveranderinge, terugwerking en tyd van die jaar. Die apparaat wat beweging waarneem gee ' $n$ beter indikasie van gewoonte fisieke aktiewiteit van die Tswana sprekende mense in die NWP en behoort oorweeg word vir verdere ondersoek.

## Sleutelwoorde

Fisieke aktiwiteit, fisieke aktiwiteit-vraelys, pedometers, versnellingmeters, Noord-Wes Provinsie, plattelands en stedelik.

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## LIST OF ABBREVIATIONS

| A | ACSM | American College of Sports Medicine |
| :---: | :---: | :---: |
|  | AEE | Activity Energy Expenditure |
|  | ANCOVA | Analysis of covariance |
| B | BMI | Body Mass Index |
| C | cal/day $\mathrm{cal} / \mathrm{wk}$ | calories per day calories per week |
|  | CDC <br> cm | Centre for Disease and Control centimeter |
|  |  |  |
| E | e.g. <br> et al | exempli gratia (for example) et alii (and others) |
| D | DBP <br> dis/day <br> dis/wk | diastolic blood pressure distance per day distance per week |
| G | g | gram |
|  | GPAQ | Global physical activity questionnaire |
| H | h | hour |
|  | HEPA | Health enhancing physical activity |
|  | HR | Heart rate |
|  | HS | High school |
| I | i.e. <br> Inc. | id est (that is) incorporation |


| IPAQ | International Physical Activity |
| :--- | :--- |
|  | Questionnaire |
| ISAK | International Society for the |
|  | Advancement of Kinantropomentry |


| K | kcal | kilocalorie |
| :---: | :---: | :---: |
|  | kg | kilogram |
|  | $\mathrm{kg} / \mathrm{m}^{2}$ | kilogram per meter squared |
|  | km | kilometer |
|  | $\mathrm{km} / \mathrm{hr}$ | kilometers per hour |
| L | LASA | Longitudinal aging study Amsterdam |
| M | MET | Metabolic Equivalent |
|  | METPA | Metabolic physical activity |
|  | min/wk | minutes per week |
|  | mm | millimeter |
|  | mod | moderate |
| N | n | number of participants |
|  | N | Number of population |
|  | NWP | North West Province |
|  | NYRBS | National Youth Risk Behavior Survey |
| P | p | probability |
|  | PA | Physical activity |
|  | PAI | Physical activity index |
|  | PE | Physical education |
|  | PURE | Prospective Urban to Rural epidemiology |
| Q | Q | quartile |
| R | r | correlation |
|  | RSA | Republic of South Africa |


| S | S.A. | South Africa |
| :---: | :---: | :---: |
|  | Sed | Sedentary |
|  | SES | Socioeconomic status |
|  | SG | Surgeon General |
|  | SPSS | Statistical Practice for Social Sciences |
| T | T | Time |
|  | THUSA | Transition and health during urbanization in South Africa |
|  | THUSA-PAQ | Transition of health during urbanization in South Africa physical activity questionnaire |
|  | ToTEE | Total energy expenditure |
|  | ToTAC | Total activity |
|  | TTF | Total tissue fat |
|  | TTL | Total tissue lean |
|  | TV | Television |
| U | U.K. | United Kingdom |
|  | U.S. | United States |
|  | USA | United States of America |
| V | vig | vigorous |
|  | VO2 ${ }_{\text {max }}$ | Maximal oxygen uptake |
| W | WHO | World health organization |
|  | WHS | World health survey |
|  | wk | week |
|  | W PAI | Weighted Physical Activity index |
| Y | YPAS | Yale Physical Activity Survey |
|  | yr | year |
|  | YRBS | Youth Risk Behavior Survey |

## LIST OF SYMBOLS

| $\%$ | percentage |
| :--- | :--- |
| 2 | squared |
| $*$ | significance |
| $<$ | smaller than |
| $>$ | greater than |
| $\leq$ | smaller or equal to |
| $\geq$ | greater than or equal to |
| - | minus |
| + | plus |
| $=$ | equals to |
| $\pm$ | plus, minus |

## CONFERENCE PRESENTATIONS

Tlhongolo, M.P.. Moss, S.J. \& Kruger, H.S. The Relationship Between Physical Activity Levels in Rural to Urban Transition. Oral presentation at the $4^{\text {th }}$ International Council for Health Physical Education, Recreation, Sports and Dance (ICHPER.SD) Africa regional congress in Gaborone, Botswana, 14-17 October 2008.

## CHAPTER 1: INTRODUCTION

### 1.1 INTRODUCTION

### 1.2 PROBLEM STATEMENT

### 1.3 OBJECTIVES

### 1.4 HYPOTHESES

### 1.5 STRUCTURE OF THE DISSERTATION REFERENCES

### 1.1 INTRODUCTION

Participation in physical activity has been associated with a low risk for coronary heart disease, type 2 diabetes mellitus, obesity, hypertension, osteoporosis, depression and anxiety (Martinez-Gonzalez et al., 2005:920). In addition regular participation is also associated with health and fitness benefits such as muscular strength, cardio-respiratory and muscular endurance, flexibility as well as reduced body fat and these factors contribute to improved general wellbeing and quality of life (Donnelly et al., 2002:10091011; Tudor-Locke et al., 2002:796-804; Tudor-Locke et al., 2004:159-160; MartinezGonzalez et al., 2005: 922; Booth et al., 2006:263-265 \& Warns, 2006:78S-82S). Physical activity can be assessed with different methods, namely, doubly labelled water, motion sensors and physical activity questionnaires (Hoos et al., 2004:1425-1427).

Doubly labelled water is regarded as the golden standard for validation of other instruments measuring physical activity. This method involves the administration of isotopes of water per kilogram body mass. The amount of isotopes measured in excreted urine after a certain period is equivalent to the amount of metabolic carbon dioxide removed by the body. Metabolic carbon dioxide is equivalent to the total energy expenditure (Bonnefoy et al., 2001:21; Arvidsson et al., 2005:377-378 \& Koebnick et al., 2005:302-303).

This method is expensive, has limited applicability, does not provide information about the pattern or duration of physical activity carried out during the day and is not feasible for large populations (Bonnefoy et al., 2001: 22; Arvidsson et al., 2005:377-378 \& Koebnick et al., 2005:302-303).

Motion sensors that include pedometers and accelerometers (Westerterp, 1999:45-47; Tudor-Locke \& Myers, 2001:93-97; Tudor-Locke et al., 2002:796; Hoos et al., 2004:1425; Tudor-Locke et al., 2004:158-159 \& Warns, 2006:78S-82S) are also used to determine physical activity levels. Pedometers are inexpensive, waist mounted electronic devices that measure cumulative step counts. These devices are designed to detect vertical acceleration and are sensitive to ambulatory movement (Tudor-Locke \& Myers, 2001:19397; Tudor-Locke et al., 2002:796-804; Tudor-Locke et al., 2004:158-159; \& Warns, 2006:78S-82S). Although they are easy to use, they are limited by the inability to quantify frequency and intensity of activity, have poor reproducibility and reliability for subjects with a body mass index (BMC) over $30 \mathrm{~kg} / \mathrm{m}^{2}$ and some are unable to measure energy expenditure during stationary activity. The wearer is required to periodically record the step count which can be time consuming. These devices can be inaccurate in measuring steps at slow speeds as well as for individuals with abnormal gait patterns (Tudor-Locke \& Myers, 2001:93-97; Tudor-Locke et al., 2002:796-804, \& Warns, 2006:78S-82S). The advantages of pedometers are their accuracy as compared to self-report questionnaires, easy management of obtained data, their reliability for determining physical activity in typically sedentary populations and in describing the total daily activities in free living populations (Tudor-Locke \& Myers, 2001: 94 \& Tudor-Locke et al., 2002:796-798).

Accelerometers measure dynamic activities of the body (Westerterp, 1999:S46). They are able to measure physical activity intensity and pattern i.e. the time spent on activities of low (sitting), moderate (walking) and high intensity (running) activities (Hoos et al., 2004:1426). Total energy expenditure can be estimated based on individual characteristics such as age, gender, height and body size (Tudor-Locke \& Myers, 2001: 93-97). Accelerometers quantify body movements through the use of piezoelectric sensors that generate charges when the device changes direction or during acceleration. Accelerometers measure movements in uni-axial vertical planes only or tri-axial omnidirectional planes (Westerterp, 1999:S46; Tudor-Locke \& Myers, 2001:93-97 \& Warns, 2006:78S-82S).

Accelerometers can be placed on the hip, waist, wrist and lower back (Westerterp, 1999:S47; Tudor-Locke \& Myers, 2001:93-97 \& Warns, 2006:78S-82S). Limitations of accelerometers are their high cost, prohibition to large scale applications, technical expertise requirement, additional hardware and software for calibration, input and installation as well as data analyses. The place of attachment also affects the measurement and can result in the discomfort of the participant (Westerterp, 1999: S46; Tudor-Locke \& Myers, 2001: 94; Hoos et al., 2004:1425-1428 \& Warns, 2006:78S-82S).

Physical activity questionnaires are the most frequently used method to estimate physical activity and are reliable during large epidemiological studies (Ainsworth et al., 1999:376377; Mota et al., 2002:269; Koebnick et al., 2005:302-303 \& Martinez-Gonzalez et al., 2005:922). There is a variety of physical activity questionnaires in use world wide, including simplified physical activity record, Longitudinal Ageing Study Amsterdam (LASA), physical activity questionnaire (Koebnick et al., 2005:302), self report activity log books (Mota et al., 2002:270), Stanford 7-day recall (Martinez-Gonzalez et al., 2005: 920-923), and the Transition and Health During Urbanization in South Africa Physical Activity Questionnaire (THUSA-PAQ) (Kruger et al., 2000:54-64) to name the most familiar questionnaires. According to Martinez-Gonzalez et al. (2005:921), physical activity questionnaires are inexpensive, simple and brief. However, these questionnaires have several limitations which include the exclusion of household activities, intensity of work done, bicycling, duration and frequency of leisure activities, failure to capture the lower end of the physical activity characteristics of sedentary populations and the tendency of over reporting time and intensity of the activity (Tudor-Locke \& Myers, 2001:91; Rzewnicki et al., 2003:299; Stel et al., 2004:252; Arvidsson et al., 2005:377; Koebnick et al., 2005:302-304 \& Booth, et al., 2006:263).

### 1.2 PROBLEM STATEMENT

Considering the limitations of the physical activity questionnaires, the THUSA-PAQ, an English questionnaire that has specifically been developed for urban and rural Tswana speaking black South Africans of the North West Province (NWP), has never been related and compared to other instruments that measure physical activity.

With language often a barrier in both rural and urban population, it is necessary to relate and compare the THUSA-PAQ data to other instruments to determine its reliability. The comparison emerges as a result of a variety of instruments used and due their questionable accuracy in determining activity levels in free living populations (Westerterp, 1999:47; Tudor-Locke \& Myers, 2001:91; Donnelly et al., 2002:1010; Tudor-Locke et al., 2002:796-804; Hoos et al., 2004:1426; \& Warns, 2006:78S-82S). This statement is supported by the findings of Rzewnicki et al. (2003:303-304), which indicate that some participants tend to report inaccurate activity levels using physical activity questionnaires, especially the time and intensity of the activity.

Research on determining physical activity using pedometers, accelerometers, and physical activity questionnaire simultaneously, has been done on Caucasian and African American populations, mostly in western and developed countries (Tudor-Locke et al., 2004:159; Berlin et al., 2006:1137 \& Bopp et al., 2006:340). The only method used so far in Tswana speaking South Africans of the NWP is the subjective (self report) THUSA-PAQ (Kruger et al., 2000:54-64). That questionnaire was developed from the Baecke physical activity questionnaire (Baecke et al., 1982:936-942) to determine physical activity among the Tswana speaking population in the NWP. There is, however, lack of evidence on other objective methods such as motion sensors (accelerometers and pedometers) and doubly labelled water among this population. The purpose of this study is thus to determine the physical activity levels using pedometers and the THUSA-PAQ and to determine whether a relationship is present between physical activity measured with a pedometer, an accelerometer and the THUSA-PAQ in free living rural and urban Tswana speaking South Africans in the NWP.

A valid and reliable assessment of physical activity in free living subjects remains a challenge for practitioners in developing countries such as South Africa, because of the different etbnic groups and diverse cultures.

The scientific questions to be answered in this study are: "What are the activity levels of the Tswana speaking people of the NWP?" and "What is the relationship between physical activity determined by pedometer, accelerometer and a questionnaire in free living Tswana speaking population in the NWP?"

The results of this study will provide insight on the physical activity patterns of the rural and urban Tswana speaking people in the NWP and which of the three methods used to determine physical activity among this population is more reliable and suitable. The results will also inform these people of their physical activity levels, and whether those levels are sufficient enough to achieve health benefits. This study may also lead to further research based on physical activity among other black South African ethnic groups.

### 1.3 OBJECTIVES

The objectives of this study are to:

1. Determine physical activity levels of Tswana speaking people of the North West Province by using the THUSA-PAQ, pedometer and an accelerometer
2. Determine the relationship between physical activity measured by means of the THUSA-PAQ, pedometers and accelerometers among the Tswana speaking people in the NWP.

### 1.4 HYPOTHESES

The following hypotheses are set for the study:

1. Tswana speaking people of the North West Province will report higher levels of physical activity with the THUSA-PAQ and lower levels with the pedometer and accelerometer
2. There will be a weak correlation in physical activity measured by the THUSAPAQ, pedometer and accelerometer in Tswana speaking people in the NWP.

### 1.5 STRUCTURE OF THE DISSERTATION

This dissertation will be in the form of an article format with two scientific articles. The introductory chapter (Chapter 1), introduces the reader to the purpose of the study, outline the problem statement of the study and present the objectives as well as the hypotheses of the study. It will be followed by the literature review article (Chapter 2) which is entitled "Factors influencing physical activity measurements and patterns in South Africa: A Review" which will be about the present research on the different methods used to determine physical activity, physical activity levels of South Africans as well as the major factors (barriers) that play a role in physical activity patterns and participation among South Africans. The first research article (Chapter 3) which will be entitled "Higher Physical Activity in Rural participants in a Country in Transition" will outline the methods, results and discussion on physical activity levels determined by pedometers and THUSA-PAQ among the rural and urban Tswana speaking people in the NWP.

The second research article (Chapter 4) entitled "The relationship between a physical activity questionnaire, pedometer and accelerometer in determining physical activity" will be outlining the methods, results and discussions on the relationship (correlation) between physical activity determined by pedometers, accelerometers and the THUSA-PAQ as well the identification of different physical activity patterns of the participants which will be recorded by an accelerometer. Chapter 5 will be summarising the work, drawing the necessary conclusions, outlining the limitations of the study and making relevant recommendations for future research.


Figure 1: Flow diagram of the structure of the dissertation.

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## CHAPTER 2

## FACTORS INFLUENCING PHYSICAL ACTIVITY MEASUREMENT AND PATTERNS IN SOUTH AFRICA: A REVIEW

1. INTRODUCTION
2. ASSESSMENT OF HABITUAL PHYSICAL ACTIVITY
2.1 Doubly labelled water
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## I. INTRODUCTION

Physical activity (PA) is a broad term used to define any bodily movement produced by skeletal muscles that results in energy expenditure (Westerterp, 1999:45; Armstrong \& Welsman, 2006:1067; Berlin et al., 2006:1137 \& Warms, 2006:78S-79S). Physical fitness refers to the physiologic state of being well that allows one to meet the demands of daily living or that provides the basis of sport performance or both. Both low physical fitness and low physical activity are strong predictors of death (Warburton et al., 2006:801).

Four commonly recognised and interrelated domains of physical activity are household, transportation, occupational and lifestyle (Kruger et al., 2006:1143). There is compelling evidence that an active lifestyle maintains health and prolongs life; however, the association is considered to be casual and shows a dose response relationship with the intensity, duration and frequency of physical activity determining the level and nature of health benefits (Chinn et al., 2006:310). PA is also a modifiable risk factor for cardiovascular disease and is associated with a lower risk of other chronic diseases such as Type 2 diabetes mellitus, cerebrovascular diseases, obesity, hypertension, bone and joint diseases (osteoarthritis and osteoporosis), certain cancers (colon and breast), depression, anxiety and functional independence of older adults (Heil et al., 2003:2; Walker et al., 2003:169; Martinez-Gonzalez et al., 2005:920; Berlin et al., 2006:1137-1138; Bopp et al., 2006:341 \& Warburton et al., 2006:801).

Health and fitness benefits such as muscular strength, cardio-respiratory and muscular endurance, flexibility as well as reduced body fat, which contribute positively to general wellbeing and quality of life are obtained with regular participation in PA (Tudor-Locke et al., 2004b:281; Martinez-Gonzalez et al., 2005:921; Warms, 2006:78). To achieve these health benefits, the United States (U.S.) Surgeon General recommends 30 minutes of moderate-intensity activity on most if not all the days of the week, this is equal to 150 kcal of energy per day (Berlin et al., 2006:1137). With these compelling benefits, 20-30\% of South Africans in the Western Cape (Kruger et al., 2005:492) and $25 \%$ of the U.S. (Walker et al., 2003:169; Berlin et al., 2006:1137) population do not engage in regular physical activity.

Sociocultural factors such as ethnic or racial practices and socioeconomic standings are thought to influence participation in regular physical activity (Garcia, 2006:21S).

Therefore, the aim of this review is firstly to give an overview of the different instruments used to determine physical activity patterns and secondly, to review the physical activity levels of South Africans from the published literature.

## 2. ASSESSMENT OF HABITUAL PHYSICAL ACTIVITY

Already there are large numbers of techniques for the assessment of habitual PA. These techniques can be grouped into five categories namely behavioural observations, questionnaires (including diaries, recall questionnaires and interviews), physiological markers (heart rate), calorimetry and motion sensors (Westerterp, 1999:45-46). The techniques can be applied directly or indirectly. Direct techniques include calorimetry, doubly labelled water, motion sensors and observations, whereas indirect methods include fitness measures, heart rate telemetry, self report questionnaires and surveys (Tudor-Locke \& Myers, 2001:92 \& Armstrong \& Welsman, 2006:1068). The assessment technique applied must be socially acceptable, should not be a burden to the participant and should influence the individual's physical activity pattern minimally (Amstrong \& Welsman, 2006:1067-1068).

Frequency, intensity, duration and the mode of activity should be monitored to be able to quantify the habitual PA as accurately as possible (Amstrong \& Welsman, 2006:10671068). According to Kruger et al. (2006:1143), physical activity is assessed from the tasks performed during identifiable segments of daily life or measurement of the occurrence of the activity during nonworking hours. Accurate assessment of physical activity behaviours is important for monitoring the status of important health related behaviour, to determine trends and appropriately allocates resources and to evaluate programme/policy effectiveness (Tudor-Locke et al., 2003:194). Berlin et al. (2006:1137) state that the necessity of physical activity assessment is to identify the presence of physical inactivity, set goals for physical therapy interventions to increase physical activity, to provide incentives to track adherence to recommendations made for increasing physical activity and to utilize physical activity as an outcome measure for physical therapy interventions. Additionally, valid assessment of PA is necessary to understand its health related
behaviour fully for research, surveillance, intervention and program evaluation purposes (Tudor-Locke et al., 2004a:858).

With the different viewpoints and opinions from different authors and researchers on the importance of physical activity assessment, it remains a challenge, however, for this valid assessment as a result of different assessment methods available. The most common methods for research purposes are doubly labelled water, motion sensors (accelerometers and pedometers) and physical activity questionnaires (Hoos et al., 2004:1426). Each of the methods mentioned has been widely used in the literature. Each method has advantages, limitations and applicability in a scientific setting as will be discussed in the following section.

### 2.1 Doubly Labelled Water

This is the most precise and objective method to measure energy expenditure and is regarded as the golden standard for the validation of other instruments measuring physical activity (Bonnefoy et al., 2001:28; Koebnick et al., 2005:303 \& Warms, 2006:79). Doubly labelled water involves the administration of an oral dose of water containing specific isotopes of hydrogen and oxygen per kilogram body mass. The amount of isotopes measured in excreted urine after a twenty four hour period is equivalent to the amount of metabolic carbon dioxide removed by the body. The metabolic carbon dioxide is then used to estimate the energy expenditure (Bonnefoy et al., 2001:28-29; Arvidsson et al., 2005:377; Koebnick et al., 2005:303 \& Warms, 2006:80).

This method is expensive, has limited applicability, does not provide information about the type, pattern, frequency, intensity and duration of physical activity carried out during the day and is not feasible for large populations due to financial cost. In addition, doubly labelled water is scarce, special equipment is needed, highly trained personnel are required for carrying out the test as well as the necessity for collection of complete urine samples which limits its usefulness for people with disabilities who may have incontinence or use urinary collection equipment (Bonnefoy et al., 2001:29; Advirsson et al., 2005:377; Koebnick et al., 2005:303 \& Warms, 2006:80).

### 2.2 Physical Activity Questionnaires

Physical activity questionnaires are the most frequently used method to estimate physical activity and is reliable during large epidemiological studies (Mota et al., 2002:111; Koebnick et al., 2005:304; Martinez-Gonzalez et al., 2005:921 \& Warms, 2006:80). There is a variety of physical activity questionnaires in use world wide, including the simplified physical activity record, world health organization (WHO) questionnaire, Longitudinal Aging Study Amsterdam (LASA) (Stel et al., 2004:252) physical activity questionnaire, self report activity log books, Stanford 7-day recall (Richardson et al., 2001:145), the Transition of Health During Urbanisation physical activity questionnaire (THUSA-PAQ) (Kruger et al., 2000:54-64) and many lesser known questionnaires (Mota et al., 2002:111121; Koebnick et al., 2005:302-309 \& Martinez-Gonzalez et al., 2005:920-927).

The questionnaire method is best for determining activities that are easily recalled such as programmed exercise, recreation or sport activities (Warms, 2006:80). Physical activity questionnaires are inexpensive, simple and brief (Martinez-Gonzalez et al., 2005:921). These questionnaires, however, have several limitations which include exclusion of household activities, intensity of work done, bicycling, duration and frequency of leisure activities, failure to capture the lower end of the physical activity characteristics of sedentary populations and the tendency of over reporting time and intensity of the activity (Richardson et al., 2001:145-146 Tudor-Locke \& Myers, 2001:91; Stel et al., 2004:252; Warms, 2006:81).

Most existing self report methods are subject to inaccuracy and social acceptance, most often demonstration of floor effects in which the lowest score is too high for inactive respondents and their inability to differentiate small but important differences in the level of activity (Warms, 2006:81). Tudor-Locke and Myers (2001:91-92) identify a problem with the existing self report methods with regard to the target population that was questioned at that time, for example the inability to capture the lower end of the continuum of physical activity and the characteristics of a sedentary population. Culture, language and gender are other factors that affect the outcome of the questionnaire results.

Tudor-Locke et al. (2003:194) support the statement by stating that cultural dimensions of physical activity definitions, perceptions and measurements should be considered when the issue of translation and other differential interpretations are taken into consideration. Questionnaires should be as short as possible while capturing important physical activity constructs since the participants do not take time to read many words (Tudor-Locke et al., 2003:194).

### 2.3 Motion Sensors

Motion sensors include pedometers and accelerometers (Westerterp, 1999:45; TudorLocke \& Myers, 2001:91; Tudor-Locke et al., 2002:795 \& Hoos et al., 2004:1425; TudorLocke et al., 2004a:857 \& Warms, 2006:80). They are developed in response to the lack of reliability of self report measures, intrusiveness of direct observation and the complexity of heart rate monitoring (Puyau et al., 2002:152). These devices are, however, more appropriate for physical activity quantification in typically sedentary populations (Tudor-Locke \& Myers, 2001:91-92).

Accelerometers and pedometers are affordable and good enough to measure physical activity, specifically ambulatory habitual physical activity (Tudor-Locke \& Myers, 2001:92). They are usually worn on the waist where vertical motion occurs (Coleman et al., 1999:9 \& Tudor-Locke \& Myers, 2001:92). The frequently reported general problems with these instruments are that the responses are affected by factors such as movement style, walking speed, mode and location of attachment and the amount of soft tissue at the attachment site (Coleman et al., 1999:9).

### 2.3.1 Pedometers

Pedometers are a means of measuring ubiquitous, ambulatory activities objectively as well as other structured physical activities (Schneider et al., 2003:1780). Three main areas where pedometers differ are cost, mechanism and sensitivity (Schneider et al., 2003:1780 \& Cook, 2006:68). They are inexpensive, ranging between $\$ 10$ (R72) and $\$ 200$ (R1440) (Tudor-Locke et al., 2002:796; Schneider et al., 2003:1780; Foster et al., 2005:778; Matevey et al., 2006:2). According to Schneider et al. (2003:1780), there are three primary mechanisms that pedometers operate.

The first type uses a spring suspended horizontal lever arm that moves up and down in response to the hips' vertical accelerations. This movement opens and closes an electrical circuit, while the lever arm makes electrical contact and registers a step. The second type uses a magnetic reed proximity switch and the third type uses an acceleromer type mechanism consisting of a horizontal beam and a piezoelectrical crystal.

They are waist mounted electronic devices that measure cumulative step counts (TudorLocke \& Myers, 2001:91; Tudor-Locke et al., 2002:796; Tudor-Locke et al., 2004a:858; Warms, 2006:80). Although they are easy to use, they are limited by the inability to quantify frequency and intensity of activity, poor reproducibility and reliability for subjects with a body mass index (BMI) of over $30 \mathrm{~kg} / \mathrm{m}^{2}$ and some are unable to measure energy expenditure during stationary activity. The wearer is required to periodically record the step counts which can be time consuming. These devices can also be inaccurate in measuring steps at slow speeds as well as for individuals with abnormal gait patterns (Tudor-Locke \& Myers, 2001:92; Tudor-Locke et al., 2002:796-797; Tudor-Locke et al., 2004:858a \& Warms, 2006:79).

The advantages of pedometers are their accuracy compared to self-reported questionnaires, easy management of obtained data, reliability for determining physical activity in typically sedentary populations and describing the total daily activities in free living populations (Tudor-Locke \& Myers, 2001:92; Tudor-Locke et al., 2002:796-797). Tudor-Locke et al. (2004c:281-291) conducted a systematic review of 25 articles published since 1980, summarizing the evidence of convergent validity for the use of pedometers in research and practice. The review indicated that pedometers correlate strongly with different accelerometers (median $r=0.86$ ), strongly with time in observed activity (median $r=$ 0.82 ), moderately with different measures of energy expenditure (median $\mathrm{r}=0.68$ ) and weakly with self reported physical activity and time spent sitting (median $r=0.33$ and median $\mathrm{r}=0.38$ ) respectively. In the follow up article Tudor-Locke et al. (2004c:282) reviewed the construct validity of pedometers and reported an inverse weak relation between physical activity and age (median $r=-0.21$ ), body mass index (mean $\Gamma=-0.27$ ) and overweight (median $r=-0.22$ ). They further reported positive relations with fitness indicators such as treadmill test and $\mathrm{VO}_{2 \max }$ (median $\mathrm{r}=0.41$ and $\mathrm{r}=0.22$ ) respectively. Matevey et al. (2006:1) define reactivity as a change in behaviour of participants when they are monitored.

They conducted a study with pedometers to determine whether there was a significant reactivity between sealed and unsealed pedometers and found no significance. The significant findings in the literature regarding the assessment of physical activity using pedometers make them reliable for activity monitoring in free living conditions.

### 2.3.2 Accelerometers

Accelerometers determine dynamic activities of the body (Westerterp, 1999:45). They are able to determine physical activity intensity and pattern, i.e. the time spent on activities of low (sitting), moderate (walking) and high intensity (running) activities (Hoos et al., 2004:1425). Total energy expenditure can be estimated based on individual characteristics such as age, gender, height and body size (Tudor-Locke \& Myers, 2001:92). Accelerometers quantify body movements through the use of piezoelectric sensors that generate charges when the device changes direction or acceleration. They determine movements in uniaxial vertical planes only or triaxial omni-directional planes (Westerterp, 1999:45-46; Tudor-Locke \& Myers, 2001:92 \& Warms, 2006:80). They can be placed on the hip, waist, wrist and lower back (Westerterp, 1999:45; Tudor-Locke \& Myers, 2001:91 \& Warms, 2006:80). Limitations of accelerometers are their high cost, prohibition to large scale applications, technical expertise requirement, additional hardware and software for calibration, input and installation as well as data analyses. They are also affected by place of attachment on the body and discomfort to the participant (Westerterp, 1999:46; TudorLocke \& Myers, 2001:92-93; Hoos et al., 2004:1426 \& Warms, 2006:81).

## 3. PHYSICAL ACTIVITY LEVELS OF SOUTH AFRICANS

The South African population is about 44 million. It comprises $79.0 \%$ blacks, $9.6 \%$ Caucasian, $8.9 \%$ people of mixed ancestry, and 2.5\% Indian/Asian (Statistic South Africa, 2003). South Africa (S.A.) is regarded as one of the developing countries in the world because of its rapid urbanisation and adoption of Western lifestyle, especially among Africans who migrate from rural to urban areas seeking employment for better life (Levitt et al., 1999:947; Vorster et al., 2000:505; Walker et al., 2001:368; Kruger et al., 2005:491 \& Kruger et al., 2006:351).

Urbanization is associated with epidemiological transition such as decreased physical activity, infant mortality, fertility, infectious diseases, increase in life expectancy and chronic diseases of life (Vorster et al., 2000:505). The most prominent chronic diseases of life in S.A. are cardiovascular diseases, cancer, chronic obstructive pulmonary diseases, hypertension, stroke and diabetes (Reddy, 2005:175; Rayner \& Becker, 2006:245). In addition to other chronic diseases of life, there is an increasing prevalence of peripheral artery disease among African people (Paul et al., 2007:285). In the year 2000 chronic diseases accounted for $37 \%$ of deaths with premature mortality, and cardiovascular diseases accounting for $17 \%$ (Reddy, 2005:175; Rayner \& Becker, 2006:245). Obesity is strongly associated with some of the chronic diseases of life, namely cardiovascular diseases, hypertension, multiple sclerosis and diabetes mellitus; it has doubled in the past decade in the developed countries. (Kruger et al., 2005:492; McKune, 2006:12; Rayner \& Becker, 2006:246).

In the United States (U. S.) the prevalence of obesity in white men and women is $20 \%$ and $22.4 \%$ respectively, and in France it is $6.5 \%$ and $7.0 \%$ respectively (Berlin et al., 2006:1138). The prevalence of obesity is also high in the Middle East and Jordan among men and women ( $32.7 \%$ and $59.8 \%$ ), low in Southern Iran ( $2.5 \%$ and $8.0 \%$ ) and in Japan $1.8 \%$ and $2.9 \%$ respectively (Walker et al., 2001:368). According to Womack et al. (2007:998), $65 \%$ of the U.S. adults are overweight, $30 \%$ obese and $5 \%$ extremely obese. In S.A. according to the World Health Organisation (WHO) standards, $29 \%$ of men and $56 \%$ of women are overweight (Reddy, 2005:175; Goedcke \& Jennings, 2006:546). Obesity in S.A. is more prevalent in urban than rural people and is highest in the Western Cape, Kwa-Zulu Natal and Gauteng provinces. Similar results were observed in the THUSA (Transition and Health during Urbanisation in South Africa) study carried out in the North West Province (NWP) where rural women had a lower BMI than urban women (Kruger et al., 2005:492).

Among economically active South African adults, $56.4 \%$ of Caucasian men studied were overweight or obese, $49.3 \%$ and $74.6 \%$ of African men and women were overweight or obese and obesity was lower in men (47.5\%) and women (66\%) of mixed ancestry and Asian men (35.5\%) and women (37\%), as well as in Caucasian women (42.2\%) respectively. Additionally, $17.1 \%$ of children aged 1-9 living in urban areas were overweight (Goedcke \& Jennings, 2006:546-547).

## CHAPTER 2

In the NWP, among 10-15 year old children, the distribution of overweight and obesity was similar in all groups, being the smallest in the 11 year old group ( $6.7 \%$ ) and the largest in the 10 and 15 year groups ( $9.1 \%$ ) respectively (Kruger et al., 2006:356). In the same study the prevalence of obesity was high in Caucasian children compared to other races more in females than in males, more apparent in urban areas. Obesity is strongly associated with an increase in physical inactivity (Vorster et al., 2000:506; Walker et al., 2001:368; Sobngwi et al., 2002:1009; Kruger et al., 2005:492; Cook, 2006:67 \& Harrison et al., 2006:206).

As pointed out by McKune (2006:13), physical activity is a modifiable risk factor for obesity and other chronic diseases, therefore, with the increasing prevalence of obesity and other chronic diseases in South Africa, it is expected that South Africans are not physically active enough to meet the minimum requirements to achieve health benefits. At least $60 \%$ of the global population fails to achieve the minimum recommendation of 30 min of moderate intensity physical activity daily (Reddy, 2005:176). According to Bopp et al. (2006:340), $38.9 \%$ of African Americans in the U.S. do not meet the Centre for Disease and Control (CDC) and the American College of Sport Medicine (ACSM) recommendations for physical activity; $24.8 \%$ are completely sedentary.

Additionally, $25 \%$ of the U.S. general population do not engage in regular physical activity, $60 \%$ do not meet the Surgeon General's (SG) PA recommendations and only $15 \%$ engage in 30 min of moderate physical activity for 5 or more days per week (Berlin et al., 2006:1137 \& Lochbaum et al., 2006:58). Only 21-22\% of American youth participate in physical education classes (McKune, 2006:13). In the United Kingdom (U.K.) over three quarters of adults fail to meet the physical activity recommendations and $38 \%$ are completely sedentary (Harrison et al., 2006:207). The youth risk behaviour survey (YRBS) (2002) reported that $37.5 \%$ of the youth aged between 13 and 19 in South Africa do not engage in sufficient physical activity. Furthermore, $25 \%$ of the youth reported watching 3 hours of television per day. Indian male children are the most inactive ( $40.8 \%$ ), followed by those of mixed ancestry ( $36.4 \%$ ), Africans (34.4\%) and the least inactive were the Caucasians ( $28.2 \%$ ). Mixed ancestry females were the most inactive (56.8\%), Africans (42.4\%), Caucasians (37\%) and lastly Indians (36\%) (Table 1).

Table 1: Percentage of 13-19 year olds who participated in insufficient or no PA. (NYRBS, 2002). Adapted from Lambert and Koble-Alexander, (2006:25).


In the study carried out by Engelbrecht et al. (2004) in the NWP, Indian girls (94.1\%) were the most inactive group followed by those from mixed ancestry ( $87.5 \%$ ), then Africans (73.0\%) and Caucasians (61.0\%). African girls were involved in moderate physical activity ( $23.2 \%$ ) and Caucasian girls in high physical activity (16.6\%). Caucasian girls participated mostly in organized school sport (athletics), while traditional games and house chores were the main source of activity among Africans. Walking slowly was the activity enjoyed by all racial groups (Engelbrecht et al., 2004:42) (Table 2).

Table 2: Physical activity levels of each racial group and percentage of the girls from the different racial groups classified in each PA level (Engelbrecht et al., 2004:45).

| Race <br> Groups | $\mathbf{N}$ | $\mathbf{M}$ | $\mathbf{S D}$ | PA-Low <br> $\mathbf{\%}$ | PA-Moderate <br> $\mathbf{\%}$ | PA-High <br> $\%$ |
| :--- | :--- | :--- | :---: | :--- | :---: | :---: |
| White | 42 | 1.50 | 0.77 | 61.0 | 21.4 | 16.6 |
| Black | 215 | 1.30 | 0.53 | 73.0 | 23.2 | 3.7 |
| Coloured | 16 | 1.18 | 0.54 | 87.5 | 6.2 | 6.2 |
| Indian | 17 | 1.06 | 0.24 | 94.1 | 5.8 | 0.0 |

$N=$ Number of participants, $M=$ Classification of activity i.e. ( $M<3$ ) passive and ( $M>3$ ) active

On rural farms in the NWP, physical activity was high among 9-16 year old children. The patterns were accounted for by walking, daily chores, tasks to be carried out on the farm, games played and few hours of watching television (TV) (Prinsloo \& Pienaar, 2005:112113). Furthermore, in the NWP children's physical activity was higher on weekends than on weekdays, with boys being more active than girls. Both genders were least active on weekdays due to low involvement in school activities and sport and increased hours of watching TV (Kruger et al., 2006:356). Another study on 951 high school learners in public schools showed that $32 \%$ of the participants did not meet the requirements of participating in physical activity for three and a half hours per week in order to be classified as active. The mean time of participants who participated in moderate and vigorous physical activity was $2.8 \mathrm{~h} / \mathrm{wk}$ and $4.16 \mathrm{~h} / \mathrm{wk}$ respectively (Franz, 2006:77).

The international physical activity questionnaire (IPAQ) was administered to a representative sample of urban and rural South African adults ( $\mathrm{n}=2014$ ) between December 2002 and May 2003 as part of the world health survey (WHS). In that survey it was found that one third of the population do not meet the CDC/ACSM recommendation for enhancing physical activity ( 30 min of moderate intensity on most but preferably all days of the week) and nearly half were inactive (Lambert \& Kolbe-Alexander, 2006:24) (Table 3).

Table 3: Prevalence ( $95 \%$ CD) of physical inactivity in a representative sample of adult South Africans (World Health Survey, 2003; World Health Organisation). (Adapted from Lambert \& Kolbe-Alexander, 2006:25)

| Activity level |  |  |  |
| :---: | :---: | :---: | :---: |
| Inactive <br> (<600 MET min/wk) | $43(38 ; 49)$ | $49(43 ; 54)$ | $46(42 ; 51)$ |
| Minimally active ( $2600 \mathrm{MET} \mathrm{mi/wk}$ ) | $120$ | Remememe |  |
| Sufficiently active (HEPA) | $37(32 ; 42)$ | $25(20 ; 29)$ | $30(26 ; 34)$ |
| HEPA (health enhancing physical activity; $\geq 7$ days of any combination of moderate and vigorous activity, $\geq 3000$ MET min/wk) |  |  |  |

A study carried out on urban and rural African communities of the NWP ( $n=946$ ) using a THUSA-PAQ validated for the population, demonstrated that $29.1 \%$ of the population could be classified as inactive, $27.9 \%$ as moderately active and $43.0 \%$ as highly active.

Men were more active than women and people living in rural areas were the most inactive. People living on farms were more active with $64.3 \%$ of men and $70.3 \%$ showing the highest physical activity index (PAI) (Kruger et al., 2003:18). Levitt et al. (1999:946-950) found similar results in a community of mixed ancestry using the Stanford 7 day recall on a population aged 15 years and older. In that study half the population did not meet the recommendations required for achieving health benefits and the prevalence of inactivity increased with increasing age. The Yale physical activity survey (YPAS) was used to describe the physical activity patterns of older populations showed that older South Africans spent an average of $2583 \mathrm{kcal} / \mathrm{wk}$ on physical activity, $65 \%$ less than that of North Americans of the same age (Charlton et al., 1997:11.25).

When classifying children racially, Caucasian children in South Africa were involved mostly in organized school sport such as athletics, rugby and netball. Traditional games and house chores occurred more among African girls. Children from mixed ancestry were mostly involved in house chores, family gatherings, religious and family meetings. There was poor information regarding Indian children. The common activity among all the racial groups was walking (Van Deventer, 1999:90 \& Engelbrecht et al., 2004:45). The physical activity pattern analysis of African farm workers' children in the NWP was mostly walking, daily chores, tasks performed on the farms (carrying water and wood as well as looking after the animals), games and TV watching (Prinsloo \& Pienaar, 2005:110).

In the Cape Peninsula most of the employees were employed in occupations requiring minimal PA (57\%) and one quarter requiring moderate amounts of PA ( $25 \%$ ). More than half participated in PA outside working hours (58.5\%) (Sparling et al., 1994:899). In the NWP occupational activity, especially standing was very high in both genders ( $83.4 \%$ men and $90.8 \%$ women) (Table 4). Older adults spent most of their time doing housework, gardening, yard work, care giving, exercise and recreation (Charlton et al., 1997:1128).

## 4. FACTORS AFFECTING PARTICIPATION IN PHYSICAL ACTIVITY

### 4.1 Psychosocial factors

Consistent demographic, psychological, behavioural, social and environmental correlates of physical activity have been identified for the general population (Bopp et al.,

2006:342). Among demographic variables, physical activity is associated with being male, younger, not smoking, learner, more educated, Caucasian and being healthier. Psychological and behavioural variables include higher self efficacy, greater perceived benefits, enjoyment, lower levels of depression, higher incidence of self regulating behaviours, more positive health and fitness and fewer perceived behaviours of physical activity. Social and environmental influences include increased social support from family, friends and health care providers, perceived and actual access to recreational facilities (Bopp et al., 2006:342).

Table 4: Distribution of the subjects of the NWP ( $n=946$ ) in categories of physical activity. (Kruger et al., 2003:19)

| Physical activity <br> category | Level of activity | Men (n=416) | Women (n=530) |
| :--- | :--- | :--- | :--- |
| Occupational activity | Mostly sedentary | $69(16.6 \%)$ | $49(9.2 \%)$ |
|  | Standing activities often | $347(83.4 \%)$ | $481(90.8 \%)$ |
| Commuting activity | No commuting or by car | $295(70.9 \%)$ | $385(72.6 \%)$ |
|  | Walking a short distance |  |  |
|  | Walking/cycling daily | $121(29.1 \%)$ | $145(27.4 \%)$ |
| Stair climbing | No stair climbing/seldom | $375(90.1 \%)$ | $490(92.4 \%)$ |
|  | Regular stair climbing | $41(9.9 \%)$ | $40(7.6 \%)$ |
|  |  |  |  |
| Sport activity | No sport activity | $261(62.7 \%)$ | $472(89.2 \%)$ |
|  | Sport activity $\leq 6$ months/yr | $145(34.9 \%)$ | $54(10.0 \%)$ |
|  | Sport activity $\geq 6$ months/yr | $10(2.4 \%)$ | $4(0.8 \%)$ |
| Leisure time activity | Mostly sedentary |  |  |
|  | Mostly standing activities | $201(48.3 \%)$ | $316(59.6 \%)$ |
| Composite PAI score | Inactive (PAI 1-3.33) | $21.7 \%)$ | $214(40.4 \%)$ |
|  | Moderately active (PAI 3.34-6.67) | $105(25.2 \%)$ | $168(31.7 \%)$ |
|  | Most active group (PAI >6.67) | $211(50.7 \%)$ | $174(32.8 \%)$ |

$P A I=$ Physical activity index

According to Harrison et al. (2006:207), there are individual factors/barriers associated with sedentary behaviour or non participation in physical activity. Those barriers may be described as internal or external.

Internal barriers include psychological (personal) factors such as lack of motivation, time, fatigue cultural perceptions, body size and self perception of needs. External barriers include social factors (structural) such as lack of transport, safety, lack of equipment, cost and care giving duties (Johnson \& Nies, 2005:40 \& Chinn et al., 2006:310).

A study carried out in the U.K. to determine the barriers associated with non participation in physical activity on 351 volunteers showed that individual principal barriers to exercise included both internal and external factors such as poor motivation, lack of time and negative self image (Chinn et al., 2006:315) (Table 5).

In the U.S. study among African Americans, the prominent barrier associated with non participation in physical activity was cost; however, it was identified as a barrier to other participants and an influencing factor to some. The participants with lower income levels reported cost as a barrier and those with a higher income described it as a contributing factor (Johnson \& Nies, 2005:40). Other factors were lack of motivation and not having enough time to exercise. These were classified as personal or internal barriers. Other barriers associated with a lack of physical activity were smoking, diet (not eating the recommended amount of fruit and vegetables) and the relationship with individual health (Harrison et al., 2006:315). There has been a lack of research in South Africa regarding physical activity and psychosocial factors, which is an area of research that needs to be attended to.

### 4.2 Socioeconomic Status (SES)

Health disparities are often associated with socioeconomic status (SES). There are rapid gains for those with high SES and worsening conditions for those with low SES. People from high SES are first to hear about the developments in the health care system and have the necessary resources to put this information to work (Garcia, 2006:23S). SES describe the conditions in which an individual lived or assets he possessed including type of house, electricity, indoor flusbing toilet, indoor running water, television, motor vehicle, refrigerator, microwave, washing machine and telephone (McVeigh et al., 2004:983). Children from low SES backgrounds who did not have the same luxury items found in the houses of those from the high SES backgrounds had the lowest weight, BMI, fat tissue and watched more TV (McVeigh et al., 2004:984).

Additionally more than $90 \%$ of white males and females participated in physical education classes at school compared to $30 \%$ of their black peers. White children spent a greater time sleeping and playing sport while black peers commuted to and from school and watched TV (McVeigh et al., 2004:986) (Table 6). Dreyer et al. (2001:35-49) carried out a study on Caucasian men in Potchefstroom $(\mathrm{n}=525)$ to investigate the relationship between two socioeconomic factors (income and educational attainment) lifestyle, physical activity and health. In that study respondents who had higher education (diplomas and university degrees) had better lifestyle profiles, better health and increased participation in physical activity compared those who had high school education and/or less.

Table 5: Individual barriers to PA cited by the participants and non participants in the UK (Chinn et al., 2006:316).

| Barriers | Participants <br> $\mathbf{( \mathbf { n } = \mathbf { 3 5 1 } ) \%}$ | Non-Participants <br> $\mathbf{( n = 1 0 1 )}$ | Difference <br> $\mathbf{\%}(\mathbf{9 5 \%} \mathbf{C D})^{\mathbf{a}}$ |
| :--- | :---: | :---: | :---: |
| Internal barriers | 16 |  |  |
| Do not enjoy exercise | 15 | 30 | 14 |
| Poor health | 21 | 29 | 14 |
| Too fat | 5 | 14 | -7 |
| Too old | 47 | 10 | 5 |
| Not the sporty type | 29 | 50 | 2 |
| Lack of time | 28 | 32 | 2 |
| Lack of energy |  | 27 | -1 |
| External Barriers | 31 | 18 |  |
| No one to exercise with | 13 | 19 | -13 |
| Adult career | 15 | 20 | 6 |
| Lack of clothes/equipment | 19 | 21 | 5 |
| Lack of transport | 12 | 10 | 2 |
| Lack of facilities-residence | 3 | 4 | -2 |
| Lack of child care-facilities | 23 | 23 | 1 |
| Lack of facilities-work | 22 | 22 | 0 |
| Lack of money | 5 | 16 | 0 |
| Fear of leaving home |  |  | 11 |
| unattended |  |  |  |

Income was positively associated with participation in physical activity but not with health status and lifestyle. Erasmus et al. (2005:25-49) reported contradictory results in the majority of women in Potchefstroom ( $n=440$ ) aged between 30 and 65 (no racial specifications in the study).

He states that they are physically inactive and this can be attributed to educational qualification, income and other constraints such as the feeling of guilt or lack of time. It is clear that those individuals from high SES backgrounds are highly involved in physical activity and vice versa (Dreyer et al., 2001:35-49 \& McVeigh et al., 2004:982-988).

The most influential factors are race, income, availability of recreational facilities, school sport, parental support (children) and level of education (McVeigh et al., 2004:986 \& Garcia, 2006:24S). The above mentioned does not apply to both genders, as females who come from high SES backgrounds tend to be more physically inactive than males (Erasmus et al., 2005:29-45). Reasons reported to be causing the inactivity are time constraints, feelings of guilt, multiple roles, income and job status. Further research in South Africa should be conducted in this area especially among women and children, with race taken into consideration. Cultural difference and perspectives with regard to physical activity may also play a role in the habitual physical activity of individuals (Erasmus et al., 2005:29-45).

Table 6: Socioeconomic, physical activity and anthropometric variables of 9 year old children in SA across SES quartiles. Adapted from McVeigh et al. (2004:985)

|  | $\mathbf{Q 1}(\mathbf{n}=\mathbf{1 1 5})$ | $\mathbf{Q 2 ( n = 7 8})^{\text {n }}$ | $\mathbf{Q 3 ( n = 7 1 )}$ | $\mathbf{Q 4 ( \mathbf { n } = \mathbf { 1 1 5 } )}$ |
| :--- | :---: | :---: | :---: | :---: |
| Asset indicator score (Mean $\pm$ SE) | $4.1 \pm 0.1$ | $6.4 \pm 0.1$ | $8.5 \pm 0.1$ | $10.7 \pm 0.1$ |
| Gender (\% male) | 53.9 | 52.6 | 49.3 | 52.2 |
| Race (\% white) | 0 | 0 | 0 | 68.7 |
| Maternal edu (\% completed HS) | 16.5 | 32.1 | 43.7 | 81.7 |
| Support (\%mothers married or | 40 | 41 | 52.1 | 70.4 |
| living with partner) |  |  |  |  |
| Income (\%with on cash income) | 60 | 43.6 | 35.2 | 27.8 |
| Health of a child (\% good) | 86.1 | 94.6 | 94.4 | 92.2 |
| METPA score (mean $\pm$ SE) | $10.5 \pm 1.0$ | $8.6 \pm 1.3$ | $8.5 \pm 1.3$ | $16.1 \pm 1.0$ |
| PE (\% yes) | 26.1 | 25.6 | 32.4 | 79.1 |
| TV (h) (mean $\pm$ SE) | $21.99 \pm 1.15$ | $26.91 \pm 1.40$ | $26.53 \pm 1.46$ | $20.02 \pm 1.15$ |
| Weight (kg) (mean) | $28.7 \pm 0.6$ | $28.7 \pm 0.7$ | $31.1 \pm 0.7$ | $31.1 \pm 0.6$ |
| Height (mm) (mean) | $1326 \pm 5.6$ | $1322 \pm 6.8$ | $1333 \pm 7.2$ | $1360 \pm 5.8$ |
| BMI (kg/m2) (mean) | $16.3 \pm 0.3$ | $16.4 \pm 0.4$ | $17.5 \pm 0.4$ | $16.7 \pm 0.3$ |
| TTF (g) (mean) | $7255 \pm 406$ | $7575 \pm 483$ | $9000 \pm 518$ | $8824 \pm 408$ |
| TTL (g) (mean) | $2012.3 \pm 260$ | $19839 \pm 344$ | $20874 \pm 367$ | $21085 \pm 391$ |

METPA: Metabolic physical activity score calculated from school sport and commuting to and from school; PE: physical education; TV: television; BMI: Body mass index; TTF: tissue total fat; TTL: tissue total lean

### 4.3 Cultural influences

Garcia (2006:20S-21S) defines culture as the inherited set of implicit and explicit rules guiding how a group's members view, feel about and interact with the world. Additionally, cultural expressions and to a lesser extent values change over time and are influenced by others. The implementation of health promotion interventions across cultures and ethnic groups have resulted in mixed degrees of success as a result of the unequal distribution of diseases and disabilities (Garcia, 2006:22S).

A study by Yackoob (1996:349-357) shows differentiated prevalence of chronic diseases among different races and cultures among South Africans. Caucasian people are more prone to coronary heart disease and Africans to hypertension. Physical activity is one of the major components recognised by health care professionals when working out health promotion programme because of its vast health benefits. Therefore, understanding the needs of different cultures regarding factors associated with participation in physical activity is important for the outcome of those health promotion interventions (Haber, 2005:684; Johnson \& Nies, 2005:40; Garcia, 2006:23S \& Harrison et al., 2006:208). Pender's health promotion model has been used to explain the health promoting behaviours of various ethnic-racial groups (Johnson \& Nies, 2005:39-41).

This model has three classification factors namely, the cognitive-perceptual factors, modifying factors and the likelihood of implementing health promotion behaviours. The cognitive perceptual factors have direct effects on the likelihood of implementing health promoting behaviours and the modifying factors have indirect effects. Therefore, the barriers to health are the cognitive perceptual-factors (Johnson \& Nies, 2005:40). In a regional study carried out in S.A. 30-40\% of young African women in the Western Cape reported low levels of physical activity during leisure time. Physical inactivity affects women more than men and more women of colour than Caucasian women (Garcia, 2006:22S). Mota and Esculcas (2002:111-121) shows similar findings in adolescent boys and girls. In addition to socioeconomic status and other mentioned factors, culture is also a barrier to participation in physical activity (Walker et al., 2001:369 \& Kruger et al., 2005:498).

Obese African Sub-Saharan African women perceive themselves as overweight and moderately overweight women are perceived by the community as attractive, thus associating thinness with illness (Kruger et al., 2005:492). These findings indicate that African black women are physically inactive and, therefore, predisposed to higher prevalence of obesity. The current Western population has a decreased activity as compared to their ancestors. The same trend is prevalent in urban and rural African men and women but urban Africans are more active than Caucasians (Walker et al. 2001:369).

Sobgnwi et al. (2002:1010) and Kruger et al. (2005:493) report higher levels of physical activity among rural farm workers than urban workers among African people in South Africa and Africans in general, while McVeigh et al. (2004:982-988) and Garcia (2006:20S-27S) argue that Caucasian people are more physically active than Africans because of high socioeconomic status. The findings in the literature about physical activity and culture remain controversial with some researchers stating that Caucasian people are more active than Africans (McVeigh et al., 2004:982-988; Kruger et al., 2005:491-500 \& Garcia, 2006:20S-27S) and others stating the opposite (Walker et al., 2001:368-372 \& Sobgnwi et al., 2002:1009-1016). There have been certain barriers such as socioeconomic status, level of education, safety, availability of equipment and income, among others, identified in the literature which have a direct effect on physical activity participation, especially among African-Americans, native Africans and all the other people of colour (McVeigh et al., 2004:986; Johnson \& Nies, 2005:40; Bopp et al., 2006:341 \& Garcia, 2006:22S).

According to Garcia (2006:22S), individual and group beliefs about personal control individualism, collectictivism, spirituality, familial roles and communication patterns contribute to cultural expression. The most important word in the above mentioned statement for this review is communication patterns because of the misunderstandings and inconsistencies that are compounded when culture and language translations are taken into consideration when determining physical activity (Tudor-Locke et al., 2003:196). People from different cultures have their own way of understanding and interpreting certain concepts. The language issue and all the other factors that contribute to physical activity behaviour among people of different cultures should be controlled in order to obtain valid results, although this is virtually impossible. Further research should be conducted on physical activity and culture, using participants of the same status among diverse cultures.

## 5. SUMMARY

Physical activity is associated with many health and psychological benefits (Warburton et al., 2006:801). According to Berlin et al. (2006:1137), 30 minutes of moderate intensity in most if not all the days of the week is necessary to achieve health benefits. Participation among people from developed, developing and under developed countries remains lower than the minimum requirements (Walker et al., 2001:368-372; Harrison et al., 2006:207 \& Chinn et al., 2006:310). This in turn increases the risk of obesity and other related chronic diseases (Vorster et al., 2000:506; Walker et al., 2001:368-369; Sobgnwi et al., 2002:1009-1010; Kruger et al., 2005:491-192; Cook, 2006:67 \& Harrison et al., 2006:207).

There are different ways to determine habitual physical activity in research to assess whether people reach the minimum physical activity required, namely motion sensors, physical activity questionnaires, doubly labelled water, diaries and logs, direct and indirect calorimetry and many others (Tudor-Locke \& Myers, 2001:91; Armstrong \& Welshman, 2006:1067-1068). The only questionnaire that has been validated to determine physical activity among Tswana speaking South Africans in the NWP is the THUSA-PAQ which was developed from the Baecke questionnaire (Baecke et al., 1982:936-942). This questionnaire shows valuable results and is useful during research (Kruger et al., 2000:5464).

There is a lack of research regarding the use of objective methods such as motion sensors to measure physical activity in South Africa as a whole. The most active group of people in South Africa are Africans living on farms, Caucasian children as well as those from high socioeconomic status, while African females, people from mixed ancestry and Indian people are the most inactive (Dreyer et al., 2001:35-49; Kruger et al., 2003:16-23 \& McVeigh et al., 2004:982-988). Physical activity participation is hampered by internal (e.g. lack of motivation) and external (e.g. lack of facilities) barriers (Chinn et al., 2006:309-315). Socioeconomic status and culture are also strongly associated with participation in physical activity (Garcia, 2006:20S-22S).

Caucasian people and people who come from high socioeconomic status tend to be more active than people of colour and those who come from low socioeconomic status (McVeigh et al, 2004:985-986 \& Garcia, 2006:22S). There is, however, still controversy in the literature regarding physical activity and culture where some researchers report high levels of physical activity among Africans (Walker et al., 2001:370) while others report high levels among Caucasian people (McVeigh et al., 2004:985; Kruger et al., 2005:492 \& Garcia, 2006:22S-23S). Further research should be conducted to address this controversy. Furthermore, in South Africa further research should be carried out in determining habitual physical activity using other instruments such as motion sensors and doubly labelled water.

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## CHAPTER 3

## HIGHER PHYSICAL ACTIVITY IN RURAL PARTICIPANS IN A COUNTRY IN TRANSITION

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## HIGHER PHYSICAL ACTIVITY IN RURAL PARTICIPANS IN A COUNTRY IN TRANSITION

## Authors

M.P. Tlhongolo (B.Sc. Hons), S.J. Moss (Ph. D) \& H.S. Kruger (Ph.D)

## M.P. Tlhongolo (B.Sc. Hons) (Specialization: Biokinetics)

School of Biokinetics, Recreation and Sports Science
North West University (Potchefstroom Campus)
Potchefstroom
South Africa
Tel no: +27 182991824
S.J. Moss (Ph. D)
(Specialization: Biokinetics)
School of Biokinetics, Recreation and Sports Science
North West University (Potchefstroom Campus)
Potchefstroom
South Africa
Tel no: +27 182991821

## H. S. Kruger (Ph.D)

(Specialization: Nutrition)
School of Physiology, Nutrition \& Consumer Science
North West University (Potchefstroom Campus)
Potchefstroom
South Africa
Tel no: +27 182992482

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#### Abstract

Purpose: To determine physical activity in urban and rural Tswana speaking people in the North West Province (NWP) with pedometers and a Transition and Health During Urbanisation physical activity questionnaire (THUSA-PAQ). Materials and Methods: Male and female participants $(\mathbb{N}=175)$ living in an urban and a rural area in the NWP completed a THUSA-PAQ, reporting on work, commuting, stair climbing, leisure time and sport activities. The same participants also wore a sealed pedometer for a period of seven consecutive days recording the number of steps taken daily.

Results: The results indicate that rural male and female participants reported a higher self reported physical activity index $(9.49 \pm 3.67$ and $8.10 \pm 1.26)$ compared to urban male and female participants ( $8.13 \pm 2.47$ and $7.51 \pm 1.65$ ). Urban male participants provided an average of $2967 \pm 2880$ steps/day and females $3034 \pm 2112$ steps/day which was less than the rural male and female participants who provided an average of $5415 \pm 2979$ steps and $4624 \pm 2961$ steps per day respectively as determined with the pedometer. There was no correlation between the physical activity determined by means of the PAQ and the pedometer. Conclusion: Participants in the rural area of the NWP reported higher levels of physical activity than participants from the urban area. The fact that the pedometers and THUSAPAQ data did not verify each other indicates that further research is needed on the methodology used to determine physical activity levels in persons living in remote areas.


Key words: Physical activity, physical activity questionaaire, pedometer, rural area and urban area

## Introduction

In the past generation or two, many changes have occurred in everyday living, including dietary changes and a decrease in daily physical activity (PA) to almost uniform sedentarism (Walker et al., 2003). The decrease in PA is associated with obesity and other chronic diseases of life in developed and developing countries (Monteiro et al., 2004; Lambert \& Kolbe-Alexander, 2006; Cook, 2006; Warburton et al., 2006). The United States (U.S.) Surgeon General (SG) recommends 30-60 minutes of moderate PA on most if not all days of the week (Berlin et al., 2006). In the U.S. $25 \%$ of adults do not engage in regular PA and $60 \%$ do not meet the SG 's recommendation (Berlin et al., 2006). In South Africa (S.A.) $37 \%$ of the youth does not participate in sufficient PA, $46 \%$ of adults are inactive and older adults spend only $2583 \mathrm{kcal} / \mathrm{wk}$ on PA (Lambert \& Kolbe-Alexander, 2006). Participation in PA is influenced by barriers such as socioeconomic status (SES), lack of time, lack of facilities, safety concerns, cultural perception of body size, family responsibilities and racial backgrounds (Dreyer et al., 2001; Engelbrecht et al., 2004; McVeigh et al., 2004; Erasmus et al., 2005; Johnson \& Nies, 2005; Bopp et al., 2006; Chinn et al., 2006; Garcia, 2006).

Valid assessment of PA is necessary to understand the importance of this health related behaviour for research, surveillance, intervention and evaluation purposes. There is no accepted gold standard for PA measurement (Tudor-Locke et al., 2004). The most common used methods to determine PA are motion sensors (pedometers and accelerometers), doubly labelled water and self report methods (questionnaires, recalls and logs) (Coleman et al., 1999; Tudor-Locke et al., 2004). There is an increasing interest of objective monitoring of habitual PA using electronic motion sensors including pedometers and accelerometers (Tudor-Locke \& Myers, 2001).

Pedometers are designed to measure the number of steps a person takes during ambulatory activities such as walking and running and offer the best solution for low cost objective monitoring of PA in terms of affordability and practicality (Tudor-Locke and Myers 2001; Berlin et al., 2006). Physical activity questionnaires are the most frequently used method to estimate PA and are reliable during large epidemiological studies.

They are best for determining activities that are easily recalled such as programmed exercise, recreation or sport activities (Mota et al., 2002; Koebnick et al., 2005; MartinezGonzalez et al., 2005; Warms, 2006). In the North-West Province (NWP) of South Africa a Transition and Health During Urbanisation physical activity questionnaire (THUSAPAQ), which was created by the modification of the Baecke questionnaire (Baecke et al., 1982) was found to be reliable and significant in determining PA among the Tswana speaking people of the NWP (Kruger et al., 2000). This questionnaire however, has never been compared to other methods used to determine physical activity. Therefore the main purpose of this study was to correlate the physical activity index (self report) in urban and rural Tswana speaking males and females of the NWP using the THUSA-PAQ with objectively determined physical activity using pedometers.

## Method

## Participants

The subjects recruited for this study form part of larger Prospective Urban and Rural Epidemiology (PURE) longitudinal study over 12 years, which started in 2005. The general aim of the PURE study is to examine the influence of urbanisation on health in the NWP of South Africa. A sample of 200 participants was selected of which 180 signed an informed consent form for participation in the study. Ninety participants were from a rural area and 90 were from an urban area. The participants were between the ages of 20 and 70 years. Ethical approval (ethical number 04M10) was obtained from the ethical committee of the North-West University.

## Measurements of body mass and BMI

Body mass ( kg ) and height ( m ) were directly measured without shoes using an electronic scale (Microlife) and a stadiometer. Body mass index (BMI) was calculated as $\mathrm{kg} / \mathrm{m}^{2}$ according to the guidelines provided by the International Society for the Advancement of Kinantropometry (ISAK).

## Stride length

The stride length of the participants was measured with a measuring tape to the nearest 0.5 cm . The stride length was measured from the front of the toe of the back foot to the front of the toe of the front foot. The average of three strides was used to calculate the average stride length for pedometer calibration.

## Physical activity questionnaire

The THUSA-PAQ compiled by Kruger et al. (2000), derived from the Baecke PA questionnaire (Baecke et al., 1982) which was used to determine physical activity levels of the Tswana speaking people of the NWP. The questionnaire reported physical activity in the form of commuting, stair climbing, sport participation, occupational activity and leisure time activity and the total physical activity index (PAI) was calculated by combining the above mentioned indices. PAI score of 1-3.33 was classified as low, 3.34-667 as moderate and $>6.67$ as high (Kruger et al., 2003). Duration, frequency and intensity of these activities were also reported in the questionnaire.

## Step counts by pedometer

Each participant was issued with a low cost promotional step counter. The body mass (kg), age (yr) and the average of three stride lengths (cm) of each participant was entered in the pedometer for calibration. The study co-ordinator and the field worker visited the participants on daily a basis for seven consecutive days to record the results on a daily step log sheet. Participants were encouraged to wear the pedometers throughout their daily activities and only remove them when bathing. The appropriate location for wearing the pedometer with a waistband was in the hip on the superior aspect of the iliac crest. The pedometer recorded the number of steps, energy expenditure (calories) and the distance travelled (km).

## Statistical Analyses

The SPSS ver. 15.0 (SPSS Inc., Chicago, I11., 2008) statistical programme was used for the data analysis. Descriptive statistics were used to determine the characteristics and the physical activity profiles of the participants. The partial correlation analysis was used to determine the relationship between PAI determined by means of the THUSA-PA questionnaire and the average steps per day, distance per day and calories per day determined by the pedometer. The statistical significant differences of PAI and step
counts, distance and calories per day were determined by ANCOVA with adjustment made for age and gender. The statistical significance was set at $\mathrm{p}<0.05$ for all analyses.

## Results

## Participants

Of the 180 participants that started the study, one male from the urban population and three females and one male from the rural population withdrew from the study during the follow up due to work constraints and loss of interest. Participants ( $\mathrm{N}=175$ ) completed the study filled the physical activity questionnaire and wore pedometers. The demographic characteristics of the urban and rural participants are indicated in Table 1. The average age of rural and urban male and female participants was $49.26 \pm 13.0$ and $45.65 \pm 16.26$ years respectively. Male participants had a higher average age than the female participants in both areas. The urban and rural female participants had a higher BMI ( $26.59 \pm 8.00$ and $26.37 \pm 7.35$ ) than male participants.

## Self reported activity (questionnaire)

Rural male and female participants reported a higher PAI (9.49 $\pm 3.67$ and $8.10 \pm 1.26$ ) compared to urban male and female participants $(8.13 \pm 2.47$ and $7.51 \pm 1.65)$. A summary of PAI components (Figure 1) indicates that the urban and rural participants reported a higher leisure index with males more active during leisure time than females and rural males reporting higher leisure time activity than urban male participants. The rural participants reported a higher work index compared to the urban participants (both genders). The commute index of the urban male and female participants was equal but lower than the rural male and female participants. Urban and rural male participants reported participation in sport than female participants. Stair climbing was reported by the urban participants and males more than females. The male participants of urban and rural area reported more leisure time activities than female participants.

Table 1: Demographic characteristics of the urban and rural participants (mean $\pm$ SD, $\mathrm{N}=175$ )

| Variable | Urban (Potchefstroom) |  | Rural (Ganyesa) |  |
| :---: | :---: | :---: | :---: | :---: |
|  | Males ( $\mathrm{n}=34$ ) | Females ( $\mathrm{n}=55$ ) | Males ( $\mathrm{n}=19$ ) | Females ( $\mathrm{n}=67$ ) |
| Age (yrs) | $45.65 \pm 16.28$ | $40.80 \pm 14.80$ | $49.26 \pm 13$ | $42.52 \pm 13.1$ |
| BMI (kg/m ${ }^{2}$ ) | $22.03 \pm 4.63$ | $26.59 \pm 8.0$ | $20.38 \pm 2.14$ | $26.37 \pm 7.35$ |
| PAI (score) | $8.13 \pm 2.47$ | $7.51 \pm 1.65$ | $9.49 \pm 3.67$ | $8.10 \pm 1.26$ |
| Average steps/day <br> (n) | $2967 \pm 2880$ | $3034 \pm 2112$ | $5415 \pm 2979$ | $4624 \pm 2961$ |
| Total steps/wk (n) | $16495 \pm 17110$ | $17082 \pm 12832$ | $28859 \pm 15402$ | $26070 \pm 18546$ |
| Average dist/day (km) | $1.24 \pm 1.37$ | $1.19 \pm 0.88$ | $2.55 \pm 1.38$ | $2.14 \pm 1.96$ |
| Total dist/wk (km) | $6.99 \pm 8.51$ | $6.73 \pm 5.40$ | $12.99 \pm 5.83$ | $11.47 \pm 9.69$ |
| Average kcal/day (kcal) | $867.24 \pm 978.29$ | $1046.44 \pm 745.16$ | $1707.38 \pm 899.60$ | $1473.95 \pm 911.25$ |
| Total kcal/wk (kcal) | $4717.56 \pm 5336.70$ | $5939.62 \pm 4559.96$ | $9165.39 \pm 4795.55$ | $8390.08 \pm 5990.11$ |

$B M I=$ Body mass index; PAI $=$ Physical activity index; dist $=$ distance; kcal $=$ kilocalories; $w k=$ week


Figure 1: Average indices of the various components determined with the THUSA-PAQ.

## Pedometer determined activity

Urban male participants recorded an average of $2967 \pm 2880$ steps per day and females 3 $034 \pm 2112$ steps per day fewer than the rural male and female participants who provided an average of $5415 \pm 2979$ per day and $4624 \pm 2961$ steps per day respectively. Rural male participants recorded more steps than all the other groups during the course of the week except on weekends (Figure 2). In all groups activity was the highest on Wednesday and lowest on Sundays. As with steps the rural participants reported higher average distances than their urban counter parts (Table 1).


Figure 2: Average steps taken on the different days of the week as determined with a pedometer.

The results of the correlations between the PAI and selected pedometer variables (Table 2) indicate that there was no statistical significant relationship between the PAI and average steps $/$ day $(r=0.538 ; p=0.169)$ among the total urban and rural populations combined.

Table 2: Partial correlations analyses between the PAI and selected pedometer variables adjusted for age and gender among the urban and rural participants.

|  | Steps/day | Distance/day | Calories/day |
| :--- | :--- | :---: | :---: |
| PAI | $\mathrm{r}=0.538$ | $\mathrm{r}=0.576$ | $\mathrm{r}=0.219$ |
|  | $\mathrm{p}=0.169$ | $\mathrm{p}=0.135$ | $\mathrm{p}=0.603$ |

## Discussion

Kruger et al. (2003) classified the PAI into three categories i.e. inactive (1-3.33), moderately inactive (3.34-6.67) and highly active ( $>6.67$ ). The average PAI for the urban population was lower than that of the rural population ( $7.72 \pm 2.01$ to $8.28 \pm 2.30$ ). In a study conducted by Kruger et al. (2003), the male participants of the same age as the participants in this study were categorised as moderately active with the PAI of 3.34-6.67. The female participants were inactive with the PAI of 1-3.33. In this study the urban and rural male and female participants can be categorized as highly active with the PAI of 7.72 $\pm 2.01$ and $8.28 \pm 2.30$ respectively. The rural male and female participants reported higher PAI indices compared to urban participants. This finding is contrary to that of Kruger et al. (2003) who reported low activity levels among the rural populations. The findings in this study can be as a result of high reported activity in working, leisure and commuting activities by the participants. The nearest business area to the rural area is about 70 km whereas the urban area is about 7 km from the nearest business area. Participants from the rural area have one shopping complex where everyone commutes to and fro on foot to shop. People in the urban area have access to public transport to go to the business area for shopping.

This would be costly for the rural participants and can be the explanation of the high commute index reported by the rural population. Poor sport participation in the urban and
rural areas was attributed to lack of sporting facilities, safety concerns, limited knowledge of the importance of being active and cultural perceptions (Johnson \& Nies, 2005; Garcia, 2006). Little and no stair climbing in urban and rural areas reported was as a result of the settlement and housing structures. Increased level of leisure reported by both urban and rural populations is associated with the high levels of unemployment.

Tudor-Locke and Basset (2004) propose the following indices for classification of pedometer determined physical activity in adults free of disabilities or chronic diseases: <5 000 steps per day for a sedentary lifestyle, 5000 to 7499 steps for low activity, 7500 to 9 999 steps for somewhat active, 10000 to 12499 steps a day for active and $\geq 12500$ steps a day for highly active. In this study the urban males recorded an average of $2967 \pm 2880$, females $3034 \pm 2112$ and rural females $4624 \pm 2961$ steps a day respectively. The rural females and the urban participants in the study can be classified as sedentary and the rural males can be classified as low active with an average of $5415 \pm 2979$ steps per day. The most active day of the week for the participants was Wednesday and they least active on weekends, particularly on Sundays. These findings concur with those of Tudor-Locke et al. (2004) who did a one year study of pedometer self-monitoring on twenty three participants at two U.S. universities. For achieving the required 30 minutes of moderate intensity physical activity, the 10000 steps a day is often cited as acceptable (TudorLocke \& Basset, 2004; Berlin et al., 2006). It is clear that the participants in this study did not accumulate the necessary steps to achieve the health benefits of physical activity and thus were prone to chronic diseases associated with inactivity.

There was no statistical significant difference between objectively determined PA and self report. Tudor-Locke et al. (2003) report differences in languages as one of the factors that affect the interpretation of the questions asked. In a study conducted by Tudor-Locke et al. (2003), physical activity meant stretching in another language. In this study language can be one of the factors that contributed to high PAI reported especially when it comes to interpretation of the question asked. People interpret things in different ways and this concept could have occurred during interpretation of the questions asked during the study. Perception towards physical activity can also be a contributing factor.

The explanation for this is that some people believe in performing physical activity for fruitful reasons i.e. performing a task in order to gain something substantial like money or food. Another factor that appears for the high PAI is the structure of the questionnaire. Most of the participants were unemployed and the questionnaire does not caters for the unemployed, only in the category of housework and no other categories such as commuting which also plays a major role in habitual physical activity. A trend of overeporting as was indicated by objective measurement (pedometers). Kruger et al. (2003) observed fewer sporting and recreational facilities in the rural areas while Johnson and Nies (2005) report safety concerns and cost as the major barriers for physical activity. In this study the low objectively determined activity can be associated with unemployment, lack of sporting and recreational facilities in the rural areas and safety in the urban areas. All the factors mentioned could have let to the weak statistical insignificance between the PAI and steps observed in this study.

Cook (2006) conducted a laboratory study on the promotional pedometers (vitality and Qstep) and three research based pedometers (Digiwalker \& Yamax) and concluded that the data from the promotional pedometers should be treated with caution citing order of preference, inclusion of more than one recommendation as a verification procedure for companies initiating those promotional programmes as possible reasons. In this study the promotional pedometer was used because of the large pool of study participants and financial affordability and the data were accepted as valid.

In conclusion it is clear that the participants tend to over report their activity subjectively by questionnaires which do not correlate with the objectively determined activity. Factors such as language and the format of the questionnaire could have led to the high self report activity. By using the proposed pedometer determined activity indices of Tudor-Locke and Basset (2004), the participants in this study can be classified as inactive to low active. This finding can be attributed to high level of unemployment, low SES, low level of education, culture and safety. Pedometers gave a better indication of the activity level of the participants and have to be considered as the method to be used in future studies. Further studies should be conducted comparing the questionnaire with research based pedometers controlling for the influencing factors mentioned above.

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## CHAPTER 4

# THE RELATIONSHIP BETWEEN A PHYSICAL ACTIVITY <br> QUESTIONNAIRE, PEDOMETER AND ACCELEROMETER DETERMINED PHYSICAL ACTIVITY 

Abstract
Introduction
Materials and Methods
Participants
THUSA-PAQ
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Discussion

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# THE RELATIONSHIP BETWEEN A PHYSICAL ACTIVITY QUESTIONNAIRE, PEDOMETER AND ACCELEROMETER DETERMINED PHYSICAL ACTIVITY 

Authors<br>M.P. Tlhongolo (B.Sc. Hons), S.J. Moss (Ph. D) \& H.S. Kruger (Ph.D)<br>M.P. Tlhongolo (B.Sc. Hons) (Specialization: Biokinetics)<br>School of Biokinetics, Recreation and Sports Science<br>North West University (Potchefstroom Campus)<br>Potchefstroom<br>South Africa<br>Tel no: +27 182991824.<br>\section*{S.J. Moss (Ph.D)}<br>(Specialization: Biokinetics)<br>School of Biokinetics, Recreation and Sports Science<br>North West University (Potchefstroom Campus)<br>Potchefstroom<br>South Africa<br>Tel no: +27182991821.<br>H. S. Kruger (Ph.D)<br>(Specialization: Nutrition)<br>School of Physiology, Nutrition \& Consumer Science<br>North West University (Potchefstroom Campus)<br>Potchefstroom<br>South Africa<br>Tel no: +27 182992482.

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#### Abstract

Background: The subjective self reporting of physical activity using the Transition and Health from Urban to Rural Physical Activity Questionnaire (THUSA-PAQ) has been the only method used to measure physical activity in the North-West Province (NWP) of Republic of South Africa (RSA). There is limited data using objective methods such as motion sensors. The questionnaire data has never been compared with other objective methods (pedometers and accelerometers). Methods: 38 Tswana speaking people of a rural village in the NWP were recruited. Participants completed the THUSA-PAQ for reporting subjective daily physical activity and objective physical activity was measured by pedometer and an accelerometer. They wore the motion sensors for 24 hours. Results: There was a weak correlation ( $r=0.180$ ) between objectively measured and subjectively reported physical activity. Accelerometers showed that the participants spent a lot of time doing sedentary activities ( $66.45 \%$ for males and $70.13 \%$ for females). More than half the female participants ( $64.7 \%$ ) and males ( $52.3 \%$ ) recorded less than 5000 steps/day. The participants reported higher physical activity index (PAI) using the THUSA-PAQ. Conclusions: There were weak correlations between the objective and subjective measurement of physical activity among the Tswana speaking people of the NWP. High percentages of sedentary activities recorded by accelerometers and low ambulatory activities could have resulted from time of the season at which the study was done and reactivity. The high subjective self report physical activity could have resulted from social desirability regarding physical activity i.e. participants reporting high levels of physical activity to feel good about themselves.


Key Words: Physical activity, pedometers, accelerometers, rural area.

## Introduction

In the year 2000, 3.3 \% of deaths in South Africa were associated with physical inactivity. ${ }^{1}$ Physical inactivity is also associated with at least a 1.5-2.0 fold risk of most chronic diseases of lifestyle such as ischemic heart disease, Type 2 diabetes mellitus and hypertension. ${ }^{2}$ Physical activity is recommend for the prevention and management of the chronic diseases of life. ${ }^{3}$ According to the World Health Organisation (WHO), $46.6 \%$ of males and $47.5 \%$ of females aged 40-49 in South Africa are inactive. ${ }^{4}$ Accurate measurement of physical activity is a fundamental factor in understanding the relationships between physical activity, obesity and health. ${ }^{5}$ Motion sensors meet the criteria of being objective and are suitable to measure physical activity in large populations over a long period of time to be representative of normal daily life with minimal discomfort to participants. ${ }^{6}$ On the other hand, questionnaires are the most widely used method to obtain information on physical activity due to low cost, simplicity and briefness. ${ }^{7}$

In South Africa physical activity has been measured by self report without the benefits of locally validated instruments and with a variety of questionnaires not standardized across surveys. ${ }^{2}$ The international physical activity questionnaire (IPAQ) was administered to a representative sample of urban and rural South African adults between December 2002 and May 2003 as part of the world health survey (WHS). ${ }^{8}$ In the North-West Province (NWP) the Transition and Health during Urbanisation in South Africa physical activity questionnaire (THUSA-PAQ) based on the Baecke questionnaire ${ }^{9}$ has been the only method used to measure habitual physical activity among free living African adults. This questionnaire is designed to measure habitual physical activity in the form of occupational, commuting, stair climbing, sport and leisure activities. ${ }^{10}$ The disadvantage of this questionnaire is that the habitual physical activity patterns are categorised on subjective self report; duration and energy spent on different activities is not objectively reported. Accelerometers can be used to objectively measure physical activity intensity and patterns. The activities are classified as light, moderate or vigorous, together with the percentage of time spent on each intensity.

Pedometers provide accurate and reliable objective measure of ambulatory activity by counting the number of steps taken per day. ${ }^{11}$ Little research has been done on habitual physical activity patterns, intensity and duration using motion sensors in the NWP.

The purpose of this study is to firstly determine the objectively determined physical activity patterns, intensity and duration using accelerometers, secondly to determine the ambulatory activity using the pedometers and lastly to compare the selected objectively determined habitual physical activity variables (activity energy expenditure and average steps/day) with the self report activity (PAD) by means of a questionnaire.

## Materials and Methods

## Participants

The data were gathered among Tswana speaking African residents of a rural co-hort in the NWP. The participants were recruited from a section of the village by verbal information about the study. Thirty eight participants aged 20-70 years signed the informed consent to participate in the study. The participants had no physical activity restrictions of any kind. Ethical approval for the procedure of the study was granted by the Ethics Committee of the North West University.

## THUSA-PAQ

The THUSA-PAQ, compiled by Kruger et al. (2000) derived from the Baecke PA questionnaire (Baecke et al., 1982) which was used to determine physical activity levels of the Tswana speaking people of the NWP was used. ${ }^{9,10}$ The questionnaire measured physical activity in the categories of commuting, stair climbing, sport participation, occupational and leisure time activity. Duration, frequency and intensity were also reported in the questionnaire for each category. A physical activity index was calculated for each subject from the results obtained using the questionnaire by adding the index of each category.

## Accelerometer

All participants were issued with the Actical accelerometers (Mini Mitter Co., Bend, Oregon, USA). The participants wore the accelerometers on the hip as indicated by the manufacturer for a period of twenty four hours and returned them to the study coordinator for data capturing. The mass $(\mathrm{kg})$ and height $(\mathrm{cm})$ of each subject were entered in the Actical computer programme for calibration.

The Actical had two energy units available namely, the metabolic equivalents (MET's) and activity energy expenditure (AEE). In this study the activity energy expenditure (AEE) was used. Activity energy expenditure was expressed in kilocalories. The Actical software was installed on a computer and data were downloaded into the computer by means of an Actireader.

## Pedometer

Each participant was issued with a low cost promotional step counter to measure physical activity. The body mass (kg), age (yr) and the average of three stride lengths (cm) of each participant were entered in the pedometer for calibration. The pedometers were worn for twenty four hours. Participants were encouraged to wear the pedometers throughout their daily activities and to only remove them when bathing. The appropriate location for wearing the pedometer with a waistband was on the hip on the superior aspect of the iliac crest. The pedometer recorded the number of steps, energy expenditure (calories) and the distance travelled (km). The pedometer was worn simultaneously with the accelerometer.

## Statistical Analysis

The SPSS ver. 15.0 (SPSS Inc., Chicago, Ill., 2008) programme was used for the data analysis. Descriptive statistics were used to determine the characteristics and the physical activity profiles of the participants. Partial correlation analyses that adjusted for body mass index (BMI) and age was used to determine the relationship between self reported physical activity index (PAI) determined by means of the THUSA-PAQ, the activity energy expenditure (AEE) determined by accelerometers in kilocalories and the number of steps per day. The statistical significance was set at $p<0.05$ for all analyses.

## Results

Table 1 presents the characteristics of the study population. Of the 38 participants of the subpopulation, the average age for males $(\mathrm{n}=21)$ was $38.6 \pm 12.4$ years and that for females ( $n=17$ ) was $46.7 \pm 14.1$ years respectively. Female participants showed significant higher average BMI ( $p<0.001$ ) than male participants ( $26.03 \pm 2.99$ and $19.6 \pm$ $2.41 \mathrm{~kg} / \mathrm{m}^{2}$ ) respectively. The male participants reported more steps per day than the female participants.

Table 1: Characteristics of Male and Female participants (mean $\pm$ SD)

| Variable | Males ( $\mathrm{n}=21$ ) |  | Females ( $\mathrm{n}=17$ ) |  |
| :---: | :---: | :---: | :---: | :---: |
|  | Mean | $S D$ | Mean | $S D$ |
| Age (yrs) | 38.57 | 12.39 | 46.71 | 14.09 |
| BMI ( $\mathrm{kg} / \mathrm{m}^{2}$ ) | 19.59** | 2.41 | 26.03** | 2.99 |
| AEE (kcal/day) | 994.99 | 492.07 | 785.65 | 254.75 |
| PAI (score) | 9.61** | 1.83 | 7.79** | 1.26 |
| Steps/day (n) | 6431 | 3886 | 4423 | 2884 |

$\overline{B M I}=$ Body mass index; $A E E=$ Activity energy expenditure; $P A I=P h y s i c a l$ activity index ${ }^{* *}$ significant at $p<0.001$.

## Accelerometer determined activity

The male participants recorded a higher average total activity energy expenditure (AEE) $(994.99 \pm 492.07 \mathrm{kcal})$ compared to female participants ( $785.65 \pm 254.74 \mathrm{kcal}$ ). This finding concurs with the average total time spent on activities. Both males and females spent most of their time doing sedentary activities ( $66.45 \%$ for males and $70.13 \%$ for females). Male participants participated in more vigorous activities than female participants (Table 2). Significant less time was spent on light and moderate activities with male participants spending more time on these activities than female participants.

Table 2: Percentages time spent on different activities.

| Variable | Males $(\mathbf{n}=\mathbf{2 1 )}$ |  | Females (n=17) |  |
| :--- | :---: | :---: | :---: | :---: |
|  | Mean | SD | Mean | SD |
| Total time (min) | 2015.52 | 1061.26 | 1564.41 | 236.75 |
| \% T Sedentary | 66.45 | 15.84 | 70.13 | 8.39 |
| \% T Light active | 15.07 | 7.42 | 15.72 | 4.44 |
| \% T Moderate active | 17.7 | 9.18 | 14.14 | 5.94 |
| \% T Vigorous active | $0.76^{*}$ | 1.67 | $0^{*}$ | 0 |
| H |  |  |  |  |

$T=$ Time $*$ Significant at $p<0.05$

## Self reported activity

On the THUSA-PAQ, male participants reported a higher total PAI than female participants $(9.61 \pm 1.83$ and $7.79 \pm 1.26)$. Figure 1 presents the different indices which made up the total PAI. There was a statistical significant difference between males and female participants on commuting ( $\mathrm{p}=0.02 ; \mathrm{F}=10.6$ ). No stair index was reported by any participants and male participants reported participating in sport regularly than females. Leisure index was the highest of all indices for both male and female participants.

*significant at $p<0.05$

Figure 1: Average indices of different components o the PAI determined with the THUSA-PAQ

## Pedometer determined activity (Steps per day)

Male participants recorded an average of $6431 \pm 3886$ steps per day and female participants recorded $4423 \pm 2884$ steps per day. This finding applies to other pedometer variables including the average distance per day and the average energy expenditure. There was no statistical significant difference between male's and female's steps per day. Figure 2 presents the step counts by sex with $64.7 \%$ of female participants and $52.3 \%$ of male participants recording fewer than 5000 steps per day.

Only one male participant and one female participant recorded more than 12500 steps per day. Table 3 presents the correlations between PAI, AEE and steps/day for the total group; males and females adjusted for BMI and age. There were weak correlations between PAI and AEE ( $r=0.180 ; p=0.296$ ), PAI and steps/day ( $r=0.296 ; p=0.079$ ) for the total group. The correlation between the PAI and steps per day indicate a trend of positive association. The same trends existed for male and female participants.

Table 3: Partial correlation analyses between PAI, AEE and steps/day for the total population ( $n=38$ ), adjusted for age and BMI.

|  | PAI |  |  |  |  |  |
| :---: | :---: | :---: | :---: | :---: | :---: | :---: |
|  | Total ( $n=38$ ) |  | Males ( $n=21$ ) |  | Females ( $n=17$ ) |  |
|  | $r$ | $p$ | $r$ | $p$ | $r$ | $p$ |
| AEE | 0.180 | 0.294 | -0.193 | 0.429 | 0.455 | 0.089 |
| Steps/day | 0.296 | 0.079 | 0.156 | 0.523 | 0.292 | 0.291 |

## Discussion

Objective physical activity measurement in the NWP of the RSA has not been well studied. However, the subjective method used (mainly self report) has indicated that the African people in the NWP are inactive as a result of rapid urbanisation and the adoption of Western lifestyle. ${ }^{12-14}$

The main finding in this study is that the participants spent a large amount of time on sedentary activities ( $66.45 \%$ females and $70.13 \%$ males) or being physically inactive. This is also supported by the leisure activities reported using the questionnaire. Individuals in racial/ethnic minority populations and lower socioeconomic groups generally report low levels of leisure time physical activity but might achieve higher levels of occupational activity. ${ }^{15,16}$ This is contrary to the findings in this study where the participants reported high levels of leisure time physical activity and low levels of occupational activity.


Figure 2: Categories of activity as classified by the number of steps per day for the Male and Female participants

This can be explained by high levels of unemployment observed in the participants. Both male and female participants can be classified as highly inactive with the PAI they reported. ${ }^{13}$ Male participants are classified low active ( 6431 steps/day) and female participants inactive ( 4423 steps/day) using ambulatory activity according to the proposed pedometer norms of Tudor-Locke and Basset, (2004). ${ }^{17}$

The 10000 steps/day guideline is accepted estimate of 30 min of moderate intensity activity per day as recommended by the United States (U.S.) Surgeon General. ${ }^{18-21}$ In this study only $5.8 \%$ and $4.7 \%$ (Figure 2) of male and female participants met that recommendation.

There was a weak correlation ( $\mathrm{r}=0.180$ ) but not statistical significant ( $\mathrm{p}=0.296$ ) difference between AEE, PAI and steps/day but a trend of a positive association between the PAI and the step count in the total group and a trend of a positive association between the PAI and AEE in the female group. The AEE was characterized by a high percentage of sedentary activities and low percentages of vigorous activities especially among the male participants. This study was carried out during the Christmas vacation and this may explain the high levels of sedentarism observed. The percentages of vigorous activity observed in males can be as a result of sport such as soccer because at this time of the year there is a culture of getting involved in local festive soccer tournaments. Light and moderate activities can be associated with commuting to different places as well as to housework and gardening.

High reported PAI was made up of mainly leisure time and work index. Social desirability describes the tendency of respondents to distort self report in a favourable direction and is one of the strongest predictors of self report physical activity in racially diverse adults in the United States. ${ }^{22}$ The participants of this study come from one ethnic and racial group; however social desirability can still be accepted as a predictor of high self report. The participants, just as likely as participants in the U.S. to give feedback which will make them feel good about themselves when completing the questionaaire.

Of all types of physical activity, walking was consistently reported as the preferred leisure time activity and is a fundamental activity of daily living. ${ }^{22}$ Looking at the ambulatory (walking) activity (steps/day) in this study, it is obvious that the participants were inactive to low active. Tudor-Locke et al. (2004) reported a variation of approximately 200 ambulatory steps per day during spring to summer season and 900 steps per day during summer to winter season respectively. ${ }^{23}$ The study was carried out in summer with very high temperatures and this could have affected the ambulatory activity levels of the participants as they could have rested during the bottest time of the day and became busy
during the morning and afternoon hours when the temperature decreased. Reactivity can also be one factor that contributed to low pedometer determined activity among the participants. It is defined as the change in participant behaviour due to monitoring and this limits the pedometers' usefulness and objective measurement of physical activity. ${ }^{24}$ We cannot rule out the possibility of reactivity adjustment due to monitoring among the participants of our study as well.

## Conclusion

In conclusion, accelerometers gave a better objective indication of the patterns and duration of the activities carried out by the participants. Low ambulatory and high self report activities were reported by pedometers and THUSA-PAQ. There was a weak correlation between AEE, PAI and steps per day. Possible reasons include time of the year, seasonal changes and perceptions towards physical activity. The limitations of the study are the small sample size the weather and age distribution. Further studies must be conducted in other Provinces and on other ethnic groups in order to compare the results with the results of this study. More reliable accelerometers should be used, as well as the internationally accepted global physical activity questionnaire (GPAQ) or the international physical activity questionnaire (IPAQ) to determine the best objective measure instruments.

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## CHAPTER 5

## SUMMARY, CONCLUSION, LIMITATIONS AND RECOMMENDATIONS

## 1. SUMMARY

## 2. CONCLUSIONS

## 3. LIMITATIONS AND RECOMMENDATIONS

## REFERENCES

## 1. SUMMARY

According to Warburton et al. (2006:801), physical inactivity is a modifiable risk factor for cardiovascular diseases and other chronic diseases including diabetes mellitus, cancer, obesity, hypertension, bone and joint diseases as well as depression. The United States (U.S.) Surgeon General recommends 30 minutes for adults and 60 minutes ( 10000 pedometer based steps/day or $150 \mathrm{kcal} /$ day) for children of physical activity to achieve the health benefits (Berlin et al., 2006:1137). In the U.S. 38.9\% of African American adults do not meet the Centers for Disease Control and Prevention (CDC) recommendation for physical activity and $24.8 \%$ are completely sedentary (Bopp et al., 2006:340).

In the United Kingdom (U.K.), over three quarters of the adult population fail to meet the physical activity recommendations and $38 \%$ are living sedentary lifestyles (Harrison et al., 2006:801). In 2003 the World Health Organization (WHO) reported that 41.8-50.6\% of South Africans aged 18-69 years do not meet the physical activity recommendations (WHO, 2005:5-6).

There are individual factors/barriers associated with sedentary behaviour or non participation in physical activity (Harrison et al. 2006:206). According to Chinn et al. (2006:311), those barriers may be described as internal or external. Internal barriers include psychological (personal) factors such as lack of motivation, time, fatigue, cultural perceptions, body size and self perception of needs. External barriers include social factors (structural) such as lack of transport, safety, lack of equipment, cost, care giving duties and socioeconomic status in general (Johnson \& Nies, 2005:40).

Accurate assessment of physical activity behaviours is important for monitoring the status of important health related behaviour, determining trends, appropriately allocating resources and evaluating programme/policy effectiveness (Tudor-Locke et al., 2003:194195). Additionally, the necessity of physical activity assessment is to identify the presence of physical inactivity, to set goals for physical therapy interventions to increase physical activity, to provide incentives to track adherence to recommendations made for increasing physical activity and to utilize physical activity as an outcome measure for physical therapy interventions (Berlin et al., 2006:1137).

The techniques used to assess physical activity can be grouped into five categories: behavioural observations, questionnaires (including diaries, recall questionnaires and interviews), physiological markers (heart rate), calorimetry and motion sensors (Westerterp, 1999:45). The most practicable PA measures are subjective self report such as questionnaires, and surveys and objective motion sensors, mostly pedometers and accelerometers (Tudor-Locke \& Myers, 2001:91-92). In most cases questionnaires and surveys are used by researchers because of their low cost and easy administration (Mestek et al., 2008:39).

This phenomenon is observed in the North West Province (NWP) of South Africa (S.A.) where the subjective Transition and Health during Urbanization questionnaire (THUSAPAQ) has been the only method used to assess habitual physical activity in Tswana speaking Africans.

This resulted in the following important research questions to be answered:

1. What are the activity levels of the urban and rural Tswana speaking people of the NWP?
2. What is the relationship between physical activity determined by pedometer, accelerometer and a questionnaire in a free living Tswana speaking population in the NWP?

The results of this study will provide insight into the physical activity patterns of the rural and urban Tswana speaking people in the NWP as well as to indicate which of the three methods used to determine physical activity among this population is more reliable and applicable. The results obtained will also inform the subjects of their physical activity levels, and whether those levels are sufficient enough to achieve health benefits. Results of this study may allude to additional research needed on physical activity among other black South African ethnic groups.

The objectives of this study were to:

1. Determine physical activity levels and differences between physical activity levels of urban and rural Tswana speaking people with the THUSA-PAQ, pedometer and an accelerometer in the NWP;
2. Determine the relationship between physical activity measured by means of the THUSA-PAQ questionnaire, pedometers and accelerometers among the Tswana speaking people in the NWP.

The literature overview in Chapter 2 entitled Factors influencing physical activity measurements and patterns in South Africa: A Review" analyse the present research on the different methods used to determine physical activity, physical activity levels of South Africans as well as the major factors (barriers) that play a role in physical activity participation among South Africans. The different ways which were identified to determine habitual physical activity in research to assess whether people reach the minimum physical activity required for health benefits are motion sensors (accelerometers and pedometers), physical activity questionnaires, doubly labelled water, diaries and logs, calorimetry and many others (Tudor-Locke \& Myers, 2001:91; Armstrong \& Welshman, 2006:1067-1068).

The most active group of people in South Africa are African people living on farms, Caucasian children as well as those from high socioeconomic status, while African females, people from mixed ancestry and Indian people are the most inactive (Dreyer et al, 2001:35-49; Kruger et al., 2003:16-23 \& McVeigh et al., 2004:982-988). Physical activity participation is hampered by internal (e.g. lack of motivation) and external (e.g. lack of facilities) barriers (Chinn et al., 2006:309-315). Socioeconomic status and culture are also strongly associated with participation in physical activity (Garcia, 2006:20S-22S). Caucasian people and people who come from high socioeconomic status tend to be more active than other people of colour and those who come from low socioeconomic status (McVeigh et al, 2004:985-986; Garcia, 2006:22S).

In chapter 3, the correlation of the physical activity index (self report) in urban and rural Tswana speaking males and females of the NWP using the THUSA-PAQ with objectively determined physical activity using pedometers (average steps/day) was determined. There was no correlation between the subjectively determined physical activity index (PAD) and objectively determined steps/day. The participants had a tendency of over reporting their activity subjectively by questionnaires. Factors such as language and the format of the questionnaire could have led to the high self report activity.

The low objectively determined activity can be associated with unemployment, lack of sporting and recreational facilities in the rural areas and safety in the urban areas.

In chapter 4, the comparison of the objectively determined physical activity patterns, intensity, duration and ambulatory activities using the motion sensors (accelerometers and pedometers) variables (activity energy expenditure an steps per day) with the self report activity using the THUSA-PAQ is outlined. The participants spent most of their time on sedentary activities ( $66.45 \%$ for males and $70.13 \%$ for females) and less time on vigorous and moderate activities. More than half of the participants recorded less than 5000 steps per day with the pedometer and reported high physical activity index with the THUSAPAQ. Accelerometers in general gave a better objective indication of the patterns and duration of the activities done by the participants. There was a weak correlation ( $\mathrm{r}=0.180$ ) but not statistical significant difference ( $p=0.296$ ) between AEE, PAI and steps per day but there was a trend in female participants. Possible reasons for the findings included time of the year, seasonal changes, reactivity and perceptions towards physical activity.

## 2. CONCLUSIONS

The conclusions of this study will be presented in line with the hypotheses that have been set for this study:

## Hypothesis 1

Tswana speaking people of the North West Province will report higher levels of physical activity with the THUSA-PA questionnaire and lower levels with the pedometer and accelerometer.

Kruger et al. (2003) classified the PAI measured by the THUSA-PA questionnaire into three categories i.e. inactive (1-3.33), moderately inactive (3.34-6.67) and highly active ( $>6.67$ ). In this study the average PAI for the urban population was 7.72 and that of the rural population was to 8.28 , which are classified as highly active. For achieving 30
minutes of moderate activity the 10000 steps per day is often acceptable. The participants in the study recorded less than 10000 per day using pedometers and are classified as low active. With the accelerometers the participants showed that they spend most of their time on sedentary activities ( $66.45 \%$ males and $70.13 \%$ females). Hypothesis 1 is therefore accepted.

## Hypothesis 2

There will be a weak correlation in physical activity measured by the THUSA-PA questionnaire, pedometer and accelerometer in Tswana speaking people in the North West Province.

There were weak correlations for the total population between PAI and steps/day ( $\mathrm{r}=$ 0.296; $\mathrm{p}=0.079$ ), PAI and activity energy expenditure (AEE) ( $\mathrm{r}=0.180 ; \mathrm{p}=0.294$ ). Hypothesis 2 is accepted.

## 3. LIMUTATIONS AND RECOMMENDATIONS

The limitations of this study were research mortality which included total and partial dropout of participants during follow-up. Some of the participants were unable to complete the study because they had to move away to a different place and some just lost interest and quitted during follow up. Weather was one of the factors beyond our control during the study and was also a major limitation.

When it was rained it became almost impossible to go out to collect data that day. Culture and lifestyle also limited the study, for instance during weekends there were funerals and weddings so it made it difficult to trace some of the participants as they had to travel to other villages and neighboring towns to attend the funerals and weddings of family members and friends. In that instance we were able to see the participant after two or three days and there was uncertainty about the data such people presented. Further research must be done using the subjective international standardized questionnaires such as the global physical activity questionnaire (GPAQ) or the international physical activity questionnaire (IPAQ) and the objective research based pedometers such as the Yamax and/or Digiwalker and accelerometer.

Further research on participants from the same socioeconomic background with the same level of education and knowledge on the importance of physical activity must be considered for the future, taking into consideration the age distribution and same physical activity level.

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## APPENDIX A

## Guide for Authors: Journal of preventive medicine

1. Appropriate cover letter (with CONSORT checklist if appropriate)
2. Conflict of Interest statement

## 3. Reviewer suggestions

4. Correct format (word counts, 1.5 -spaced throughout but table single-spaced, references checked)
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## APPENDIX B

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## APPENDIX C

## Informed consent form

## PART 1

1. School/Institute:
2. Title of project/trial: $\qquad$
$\qquad$
3. Full names, surname and qualifications of project leader:
$\qquad$
4. Rank/position of project leader:
(Professor, Lecturer, research scientist etc.)
$\qquad$
5. Full names, sumame and qualifications of supervisor of the project:
(Complete only if not the same person named in 4.)
$\qquad$
$\qquad$
6. Name and address of supervising medical officer (if applicable):
$\qquad$
7. Aim of this project
8. Explanation of the nature of all procedures, including identification of new procedures:
9. Description of the nature of discomfort or hazards of probable permanent consequences for the subjects which may be associated with the project:
(Including possible side-effects of and interactions between drugs or radio-active isotopes which may be used.)
10. Precautions taken to protect the subjects:
11. Description of the benefits which may be expected from this project:
12. Alternative procedures which may be beneficial to the subjects:
(Complete only if applicable.)
$\qquad$
$\qquad$
$\qquad$

Signature:
Date:
Project leader

## PART 2

You are invited to participate in a research project as described in paragraph 2 of Part 1 of this document. It is important that you read/listen to and understand the following general principles, which apply to all participants in our research project:

1. Participation in this project is voluntary.
2. It is possible that you personally will not derive any benefit from participation in this project, although the knowledge obtained from the results may be beneficial to other people.
3. You will be free to withdraw from the project at any stage without having to explain the reasons for your withdrawal. However, we would like to request that you would rather not withdraw without a thorough consideration of your decision, since it may have an effect on the statistical reliability of the results of the project.
4. The nature of the project, possible risk factors, factors which may cause discomfort, the expected benefits to the subjects and the known and the most probable permanent
consequences which may follow from your participation in this project, are discussed in Part 1 of this document.
5. We encourage you to ask questions at any stage about the project and procedures to the project leader or the personnel, who will readily give more information. They will discuss all procedures with you.
6. If you are a minor, we need the written approval of your parent or guardian before you may participate.
7. We require that you indemnify the University from any liability due to detrimental effects of treatment by University staff or students or other subjects to yourself or anybody else. We also require indemnity from liability of the University regarding any treatment to yourself or another person due to participation in this project, as explained in Part 1. Lastly it is required to abandon any claim against the University regarding treatment of yourself or another person due to participation in this project as described in Part 1.
8. If you are married, it is required that your spouse abandon any claims that he/she could have against the University regarding treatment or death of yourself due to the project explained in Part 1.

## PART 3

Consent

Title of the project:
$\qquad$
$\qquad$

I, the undersigned (full names) read/listened to the information on the project in PART 1 and PART 2 of this document and I declare that I understand the information. I had the opportunity to discuss aspects of the project with the project leader and I declare that I participate in the project as a volunteer. I hereby give my consent to be a subject in this project

I indemnify the University, also any employee or student of the University, of any liability against myself, which may arise during the course of the project.

I will not submit any claims against the University regarding personal detrimental effects due to the project, due to negligence by the University, its employees or students, or any other subjects.

Signed at on $\qquad$

## Witnesses

1. $\qquad$
2. $\qquad$

Signed at
on $\qquad$

For non-therapeutic experimenting with subjects under the age of 21 years the written approval of a parent or guardian is required.

I, $\qquad$
parent or guardian of the subject named above, hereby give my permission that he/she may participate in this project and I also indemnify the University and any employee or student of the University, against any liability which may arise during the course of the project.

Signature: $\qquad$ Date: $\qquad$

Relationship: $\qquad$

For experimenting with married persons the following indemnity from the spouse is required.

I,
, $\qquad$ (full names), the spouse of the subject in this application, hereby undertake not to submit any claims against the University regarding treatment in case of death or injuries of this person due to the project as described in this application, due to negligence of the University, its students or another subject, or in any other way.

Signature: $\qquad$ Date: $\qquad$

Relationship: $\qquad$

## APPENDIX D

## Steps Log sheet

$\qquad$ Subject No. $\qquad$
$\qquad$ Age $\qquad$ DOB $\qquad$

Body Mass $\qquad$ Stature $\qquad$ BMI $\qquad$

Stride Length (1) $\qquad$ (2) $\qquad$ (3) $\qquad$ (Average) $\qquad$

Level of Education (1) $\qquad$ (2) $\qquad$ (3) $\qquad$ (4) $\qquad$ (5) $\qquad$

Resting BP (1) $\qquad$ (2) $\qquad$ Other Risk factors: Diabetes $\qquad$
Smoking $\qquad$
Cholesterol
Family History $\qquad$

| Day | Steps | Calorie | Distance | Comments |
| :--- | :--- | :--- | :--- | :--- |
| Monday |  |  |  |  |
| Tuesday |  |  |  |  |
| Wednesday |  |  |  |  |


| Thursday |  |  |  |  |
| :--- | :--- | :--- | :--- | :--- |
| Friday |  |  |  |  |
| Saturday |  |  |  |  |
| Sunday |  |  |  |  |
| Total <br> Weekly |  |  |  |  |

*Level of education (1) primary; (2) secondary; (3) high school; (4) tertiary (5) other

## APPENDIX E

## THUSA-PAQ

YUNIBESITI YA BOKONE-BOPHIRIMA NORTH WEST UNIVERSITY NORTH WEST UNIVERSITY


Date:
Place:
Interviewer:
The information on this questionnaire is confidential

1. Subject number

## Gender


$(1-4)$
3. What is your main occupation?

| Low level: office work, housework, scholar | 1 |
| :--- | :--- |
| Middle level: factory work, carpentry, farming hospital nurse, plumber | 2 |

High level ("sweat work") : construction work, digging, manual labou

| 1. never | 2. seldom | 3.s |
| :--- | :--- | :--- |
| 1. never | 2. seldom | 3.s |
| 1. never | 2. seldom | 3.s |
| 1. never | 2. seldom | 3.5 |
|  |  |  |
| 1.never | 2.seldom | 3.s |
| 1.never | 2.seldom | 3.s |


| memetimes | 4.often | 5.always |
| :--- | :--- | :--- |
| sometimes | 4.often | 5.apways |
| 4.ofton | S.aways |  |
| sometimes | 4.often | 5.always |

4. At work I sit
5. At work I stand
6. At work I walk

At work I lift heavy loads
B. At work I am tired
9. At work I sweat
10. If you work away from home, how do you get to work/school?
11. How long does it take you to walk/cycle to work/school? (or to the taxi rank/bus stop/train station)
12. If you walk or cycle to work'school, what is your usual pace? (or to taxi rank/bus stop/ train station)
13. Do you climb stairs often?
14. If yes, how many flights of stairs do you climb cach day? ( 1 flight $=10$ steps)
${ }^{1}$ 5. How many days per week do you climb steps?
-3. Do you play sport?
17. Which sport do you play most frequently?
18.

How many hours per week do you practice? $<1 / 1-2 / 2-3 / 3-4 />4$
(Write appropriate code-in space)
$0.5,1.5,2.5,3.5,4.5^{* 2}$
19. How many months per year?
(Write appropriate code in space)
<l/ 1-3/ 4-6/ 7-9/ >9
$0.04,0.17,0.42,0.67,0.92^{* 3}$
${ }^{4}$ intensity code of sport, *2 time code for sport, ${ }^{* 3}$ proportion of year

## YUNIBESITI YA BOKONE-BOPHIRIMA NOOROWES UNIVERSITEIT

20. If you play a second sport, which is it?

| low level: bowling, golf, billiards | I |
| :--- | :--- |
| middle level: tennis, athletics, cycling | 2 |
| high level: soccer, rugby, netball, boxing | 3 |

high level: soccer, rugby, netball, boxing 3
21. How many hours per week do you practice? <1/1-2/2-3/3-4/>4
$1.76(27)$ (28-30)
22. How many months per year?
$0.5,1.5,2.5,3.5,4.5^{* 2}$
<1/ $1-3$ | $4-61 \quad 7-9 />9$
$0.04,0.17,0.42,0.67,0.97^{* 3}$
23. During leisure time I watch TV/ do sitting activities (read, needle-work, play cards)
24. During leisure time I walk/do standing activities (gardening, housework)
25. Other leisure-time activities:.

| 1.never | $\begin{aligned} & \text { 2.sel- } \\ & \text { dom } \end{aligned}$ | 3 some -times | 4.0ften | 5.a1ways |
| :---: | :---: | :---: | :---: | :---: |
| 1.never | $\begin{aligned} & \hline 2 . \mathrm{sel}- \\ & \text { dom } \end{aligned}$ | 3.some -times | 4.0ften | 5.always |
|  | $\begin{aligned} & \text { 2.sel- } \\ & \text { dom } \end{aligned}$ | 3 some -times | 4.often | 5.at- <br> ways |

Other leisure-time activities:............
(leisure-time $=$ time off from work/. school)

