

The association between physical activity, functional
fitness and balance in senior citizens

A VOLSCHENK

The association between physical activity, functional fitness and balance in senior citizens

Volschenk, A (B.A. Hons.)

**Dissertation submitted in fulfilment of the requirements for the degree Magister Artium at the
North-West University (Potchefstroom Campus).**



Supervisor: Me E.J. Bruwer

Vice supervisor: Prof S.J. Moss

May 2011

Potchefstroom

Acknowledgements

The successful completion of this study would never have been possible without the contribution, guidance and assistance of various individuals. Hereby I would like to thank the following people:

- 🌸 My **Heavenly Father** who has given me the opportunity, the mental capability, vision and guidance to continue my studies and for protecting me on this path I have undergone.
- 🌸 Me **Erna Bruwer**, my study leader and friend. Thank you for your contribution, advice and support throughout this project.
- 🌸 **Prof. Stydom** and **Prof. Moss**, thank you for the guidance you gave me during the writing of my research articles
- 🌸 Dr **Suria Ellis**, for helping me with all my statistical calculations and all your inputs concerning my data.
- 🌸 **Prof. Lesley Grevenstein** for the language editing.
- 🌸 My **Parents**, Hennie and Marlien for all your love and support throughout the good and the bad times. Thank you for giving me the opportunity to continue my education and for believing in me.
- 🌸 My **Sisters**, Elmaine and Rulien for your motivation and support.
- 🌸 All the **Participants** that were willing to put their bodies on the line for my research. Thank you for your time and good spirit.

The author

Author's contribution

This dissertation is submitted in article format and includes a literature review (Chapter 2) on the association between functional fitness, physical activity and balance in the elderly, as well as two research articles. Research article one (Chapter 3) is entitled “Functional fitness and balance status in a geriatric cohort” and research article two (Chapter 4) is entitled “The role of physical activity on functional fitness and balance in a geriatric cohort”. The co-authors of these articles, Ms. E.J. Bruwer and Prof. S.J. Moss, hereby give permission to the candidate, Ms. A. Volschenk, to include the literature review and two articles as part of a Master's dissertation. The contribution made by the co-author was limited to academic advice and support, thereby enabling the candidate to submit this dissertation for examination purposes. This dissertation, therefore, serves as partial fulfillment of the requirements for the M.A. degree in Human Movement Science within the School for Biokinetics, Recreation and Sport Science in the Faculty of Health Sciences at the North-West University (Potchefstroom Campus)

Me E.J. Bruwer (Supervisor)

Co-author (Chapter 3 & 4)

Prof. S.J. Moss (Co- author)

Summary

During the past decades there has been an increase in longevity. These aging trends have an enormous economic impact and present challenges to policymakers, families, and health care providers to meet the needs of aging individuals. Aging is accompanied with various physiological changes that can limit the elderly's functional status and their independency. Some of the most noticeable changes occur within the musculoskeletal system, however cardiorespiratory changes, as well as changes in the body composition limits the elderly's aerobic capacity and therefore increases the risk for cardiovascular and hypokinetic diseases. Moderate physical activity reduces the risk, or prolong the onset of physiological changes and various diseases. Physical activity can also enhance functional fitness amongst the elderly. Functional fitness is having the physiologic capacity to perform normal everyday activities safely and independently without undue fatigue.

The aim of this study was to determine the functional fitness as well as static balance and dynamic balance status of senior citizens. Secondly, to determine the association between: physical activity, aerobic endurance and functional fitness and status amongst senior citizens. Thirdly, to determine the association between physical activity status, aerobic endurance and static- and dynamic balance amongst elderly. A once off subject availability study was performed, and 58 senior citizens (32 females and 26 males) between the ages of 65 years and 96 years participated. The physical activity index was determined with the Sharkey and Gaskill Physical activity index questionnaire. Functional fitness was measured using the Rikli and Jones Fullerton's functional fitness test protocol. The static balance and dynamic balance was tested with the one leg balance eyes closed and functional reach test respectively. Descriptive statistics were used to describe the status of the participants. Two way summary tables were used to categorize the amount of weak test results. Partial correlations were used to determine the association between physical activity, functional fitness and static and dynamic balance.

The male participants' functional fitness status compared well with USA normal ranges, however the functional fitness test scores of the female participants were even lower than the older age group (75 to 79 years) of the USA normal ranges. The results of the frequency distribution indicated that 80.77% and 68.75% of the male and female participants respectively, tested poorly in more than

four of the functional fitness tests. Neither the male nor the female participants' static balance score were adequate, although it does not indicate a fall risk. Aerobic endurance showed to have medium ($r = 0.3-0.49$) to high ($r \geq 0.5$) partial correlation with all functional fitness tests for the total group, as well as in the female participants. In the male participants aerobic endurance only showed high correlation ($r \geq 0.5$) with lower body strength and dynamic balance and agility. Dynamic balance correlated well ($r \geq 0.5$) with all functional fitness tests as well as aerobic endurance and physical activity index in the female participants, and only showed a medium correlation with agility in the male participants.

This study showed alarming percentages of poor test results for both male and female senior citizens and highlights the need for physical activity interventions in old age homes. The correlations between aerobic endurance, as well as dynamic balance and functional fitness tests indicates that even simple interventions such as walking programs could enhance the functional fitness of senior citizens and thereby increase their independency.

Key words:

Functional fitness, elderly/older adults/geriatrics, balance, physical activity, musculoskeletal changes

Opsomming

Oor die afgelope aantal dekades was daar 'n toename in lewensverwagting as gevolg van beter mediese dienste en minder akute siektes. Hierdie verouderings tendense het 'n groot ekonomiese impak en is 'n uitdaging vir die staat, families, besigheidsektor asook gesondheidsektor om aan die behoeftes van bejaardes te voldoen. Veroudering gaan gepaard met fisiologiese veranderinge wat bejaardes se funksionele kapasiteit, sowel as hul onafhanklikheid bedreig. Die mees opvallende fisiologiese verandering is die van die muskoskeletale stelsel, alhoewel kardio-respiratoriese veranderinge sowel as veranderinge in liggaamsamestelling die bejaarde se aerobiese vermoë beperk, verhoog die verandering ook bejaardes se risiko vir ortopediese beserings, hipokinetiese siektes en kardiovaskulêre siektes. Matige fisieke aktiwiteit verlaag die risiko of vertraag die aanvang van fisiologiese veranderinge sowel as verskeie siektes. Fisieke aktiwiteit verhoog ook funksionele fiksheid by bejaardes. Funksionele fiksheid is die fisiologiese vermoë om daaglikse take veilig, onafhanklik en sonder uitputting uit te voer.

Die doel van die studie was eerstens om die funksionele fiksheid status, statiese- en dinamiese balans status van bejaardes te bepaal. Tweedens, om te bepaal of daar 'n verwantskap is tussen fisieke aktiwiteit, aerobiese fiksheid en funksionele fiksheid status by bejaardes. Derdens, om die verwantskap tussen fisieke aktiwiteit, aerobiese fiksheid en statiese- en dinamiese balans te bepaal. 'n Eenmalige beskikbaarheidsstudie is gebruik. Bejaardes (n=58) tussen die ouderdomme van 65 jaar en 96 jaar het deelgeneem aan die studie. Die fisieke aktiwiteits indeks van Sharkey en Gaskill is gebruik om daaglikse fisieke aktiwiteit te bepaal. Funksionele fiksheid is bepaal deur Rikli en Jones se Fullertons funksionele fiksheid protokol. Statische balans en dinamiese balans is onderskeidelik bepaal deur gebruik te maak van eenbeen balans toets en funksionele reik toets. Beskrywende statistiek is ook gebruik. Twee-rigting tabelle is gebruik om die aantal swak toetse in groepe te verdeel. Partiële korrelasie is gebruik om die assosiasie tussen fisieke aktiwiteit, funksionele fiksheid asook statiese- en dinamiese balans te bepaal.

Manlike proefpersone se funksionele fiksheid status vergelyk goed met die van VSA normale waardes. Die funksionele fiksheids toets resultate van die vroulike proefpersone was laer as die van die ouer bejaarde groep (75 tot 79 jaar) van die VSA normale waardes. Die resultate van die

frekwensie distribusie is 'n indikasie dat 80.77% en 68.75% van die manlike en vroulike proefpersone onderskeidelik swak getoets het in vier of meer funksionele fiksheids toetse. Alhoewel statiese balans nie 'n indikasie is van 'n verhoogde val risiko nie, was nie een van die twee groepe se statiese balans waardes voldoende nie. Aerobiese fiksheid toon 'n medium ($r = 0.3 - 0.49$) tot 'n hoë ($r \geq 0.5$) korrelasie met al die funksionele fiksheids toetse vir die totale groep sowel as by die vroulike proefpersone. Manlike proefpersone se aerobiese fiksheid toon slegs 'n hoë ($r \geq 0.5$) korrelasie met onderlyf krag, dinamiese balans en ratsheid. Dinamiese balans korreleer goed met al die funksionele fiksheid toetse sowel as aerobiese fiksheid en fisieke aktiwiteits indeks by vroulike proefpersone en toon slegs 'n medium korrelasie met ratsheid by manlike proefpersone.

Hierdie studie toon die groot persentasie swak toets resultate vir die bejaardes en beklemtoon die behoefte aan 'n fisieke aktiwiteits intervensie vir bejaardes. Die korrelasie tussen aerobiese fiksheid sowel as dinamiese balans en funksionele fiksheids toetse toon dat eenvoudige intervensies soos 'n stap program, bejaardes se funksionele fiksheid kan verbeter en sodoende hul onafhanklikheid kan verhoog.

Sleutelterme:

Funksionele fiksheid, bejaarde, balans, fisieke aktiwiteit, muskuloskeletale veranderinge

Table of contents

	p.
Acknowledgments	ii
Authors Declaration	iii
Summary	iv
Opsomming	vi
Appendices	xii
List of figures	xiii
List of tables	xiv
List of abbreviations	xvi

Chapter 1

Problem statement and aims

	p.
1.1 Problem statement	1
1.2 Objectives	3
1.3 Hypotheses	4
1.4 Structure of dissertation	4
References	6

Chapter 2

The association between physical activity, functional fitness and balance in senior citizens: Literature review.

	p.
2.1 Introduction	9
2.2 Physiological changes associated with aging	11
2.2.1 Cardiovascular changes with an increase in age	11
2.2.2 Respiratory changes with an increase in age	15
2.2.3 Body composition changes with an increase in age	18
2.2.4 Musculoskeletal changes, balance and falls related to aging	19
2.3 Physical activity and functional fitness amongst elderly	23
2.4 Test battery	25
2.4.1 Lower body strength	26
2.4.2 Upper body strength	26
2.4.3 Aerobic endurance	26
2.4.4 Lower body flexibility	27
2.4.5 Upper body flexibility	27
2.4.6 Dynamic balance and motor ability	27
2.4.7 Static balance testing	27
2.4.8 Dynamic balance testing	27
2.5 Physical activity intervention and functional fitness	28
2.6 Summary	30

References	32
------------------	----

Chapter 3

Functional fitness and balance status in a geriatric cohort.

	p.
3.1 Introduction	45
3.2 Methods and materials	46
3.2.1 Subjects	46
3.2.2 Measuring instruments	47
3.2.2.1 Medical history questionnaire.....	47
3.2.2.2 Resting blood pressure and resting heart rate measurements ...	47
3.2.2.3 Functional fitness tests	47
3.2.2.4 Static balance.....	48
3.2.2.5 Dynamic balance	48
3.2.3 Procedure	48
3.2.4 Statistical analysis	48
3.3 Results	49
3.4 Discussion	51
3.5 Conclusion	53
References	54

Chapter 4

The role of physical activity on functional fitness and balance in a geriatric cohort

	p.
4.1 Introduction	60
4.2 Methods and Materials	61
4.2.1 Subjects	61
4.2.2 Measuring instruments	62
4.2.2.1 Medical screening	62
4.2.2.2 Resting blood pressure and resting heart rate measurements ...	62
4.2.2.3 The physical activity questionnaire.....	62
4.2.2.4 Functional fitness tests	62
4.2.2.5 Static balance	63
4.2.2.6 Dynamic balance	63
4.2.3 Procedure	63
4.2.4 Statistical analysis	64
4.3 Results	64
4.4 Discussion	69
4.5 Conclusion	71
References	72

Chapter 5

Summary, conclusion, limitations and recommendations

	p.
5.1 Summary	75
5.2 Conclusion	77
5.2.1 Hypothesis 1	77
5.2.2 Hypothesis 2	77
5.2.3 Hypothesis 3	78
5.3 Limitations and recommendations	79

Appendices

	p.
Appendix A: Guidelines for authors	80
Appendix B: Informed consent	85
Appendix C: Test proforma	87
Appendix D: Medical history screening questionnaire	88
Appendix E: Sharkey and Gaskill physical activity index	90

List of figures

		p.
Figure 2.1	Percentage persons aged 60 and over by region of the world 2006 and 2030	10
Figure 2.2	Association between diastolic blood pressure and CVD...	12
Figure 2.3	Association between systolic blood pressure and CVD....	12
Figure 2.4	Age as the major risk factor for cardiovascular (CV) disease	17
Figure 2.5	The effect of a physical active lifestyle on aging	17
Figure 2.6	Effects of musculoskeletal changes on the elderly's independence	22
Figure 2.7	Functional fitness continuums	25
Figure 4.1	Association between physical activity levels and functional fitness	67
Figure 4.2	Association between aerobic endurance and functional fitness	67
Figure 4.3	Association between static balance with functional fitness and physical activity.	69
Figure 4.4	Association between dynamic balance with functional fitness and physical activity	69

List of tables

	p.
Table 2.1	
Older Population in the selected age groups for South Africa: 1990, 2006, 2015, and 2030 (In thousands).....	9
Table 2.2	
Classification of blood pressure for adults	12
Table 2.3	
National Cholesterol education programme adult treatment panel III classification	13
Table 2.4	
BFMI and FFMI values for corresponding BMI values in healthy adults	19
Table 2.5	
Functional ability framework	25
Table 2.6	
Normal ranges of functional fitness test scores for men.....	29
Table 2.7	
Normal ranges of functional fitness test scores for women...	30
Table 3.1	
Descriptive statistics for body composition, functional fitness variables and static and dynamic balance	49
Table 3.2	
Inter quartile ranges for functional fitness test scores for male participants versus the USA normal ranges.....	50
Table 3.3	
Inter quartile ranges for functional fitness test scores for female participants versus USA normal ranges.....	50
Table 3.4	
Frequency distribution of test results for males and females.	50

Table 4.1 **Descriptive statistics for body composition, physical activity Index and functional fitness variables** **64**

Table 4.2 **Partial correlations: Association between functional fitness, physical activity and 6 minute walk test** **66**

Table 4.3 **Partial correlations: Association between functional fitness, physical activity and static balance and dynamic balance...** **68**

List of Abbreviations

%BF	Percentage body fat
5 th	fifth
8 th	eighth
ACSM	American college of sport medicine
AIDS	Acquired immunity deficiency syndrome
BFMI	body fat mass index
BMI	body mass index
CHD	coronary heart disease
cm	centimetre
CV	cardiovascular
CVD	cardiovascular disease
DBP	diastolic blood pressure
<i>et al.</i>	<i>Et alibi</i> (and others)
Etc.	et cetera (and so forth)
FFM	fat free mass
FFMI	fat free mass index
HDL	high density lipoprotein
HDL-C	high density lipoprotein cholesterol
HIV	human immunodeficiency virus
kg	kilogram
LDL	low density lipoprotein
LDL-C	low density lipoprotein cholesterol
m	metre
mg/dL	milligram per decilitre
mm Hg	millimetre mercury
R ²	multiple regression
SBP	systolic blood pressure
sec	seconds

TC	total cholesterol
UK	United Kingdom
VO _{2max}	maximum oxygen consumption

Chapter 1

Problem statement and study objectives of this study.

1.1 Problem statement

The past decades have shown an increase in longevity throughout the industrialized world due to better health care systems and fewer acute diseases (Tanaka *et al.*, 2000:162). According to Velkoff and Kowal (2007:11), the number of people older than sixty years in South Africa will be an estimated 4.8 million in the year 2030, increasing the senior citizen population by 36%. In the United States the population segment over 65 years has grown by 84% from 1965 to 1995 and it is predicted that by 2025 this population segment will increase to 20% of the total population (Ehrman *et al.*, 2003:571). Similar statistics in the UK predicted that the number of people over the age of 80 years will increase by 50% from 1995 to 2025 (Department of Health, 2001:1). These aging trends have an enormous impact and present challenges to policymakers, families, businesses, and health care providers to meet the needs of aging individuals (Velkoff & Kowal, 2007:3). The increase in the number of disabilities and disease that accompany advancing in age results in a greater need for health care systems for the elderly (Islam *et al.*, 2004:9).

As people age progressive deterioration in the cardiovascular system results in a reduced cardiac output in both ventricles and a reduction in oxygen transport to tissue of the central and peripheral circulations (Taylor *et al.*, 2004:707). Cardiovascular changes include a decrease in heart rate, stroke volume and elasticity of the blood vessel walls, as well as systolic and diastolic blood pressure (Edward & Lakatta, 2007:302; O'Rourke, 2003:628; Ehrman *et al.*, 2003:575; Nichols *et al.*, 1985:1179). Pulmonary changes include pulmonary artery stiffening, a reduced inspiratory and expiratory capacity and a reduced pulmonary function (Ehrman *et al.*, 2003:575). Respiratory system efficiency in the elderly is influenced by factors such as kyphosis, reduced mobility of the ribs, diminished efficiency of the respiratory muscles, reduced nasopharyngeal function, reduced respiratory rate, a decline in the number of alveolar sacks, as well as a loss of tissue elasticity (Jensen *et al.*, 2009:9-11; Harrod, 2005:79). Physical impairment of aerobic endurance reduces an elderly's ability to perform daily tasks which require walking long distances and climbing stairs (Rikli & Jones, 2002:25).

Musculoskeletal fitness is very important for the elderly to maintain functional independency (Warburton *et al.*, 2006:805). Some of the most notable changes in the elderly involve the musculoskeletal system such as a decrease in lean body mass while interstitial fat content increases (Kell *et al.*, 2001:866-867). Research shows that there is a 10-15% loss of muscle strength per decade during the 5th and 8th decade, especially in the postural muscles (Reeves *et al.*, 2006:192; Melzer *et al.*, 2003:243). Both women and men have a progressive loss of bone mineral density and by the age of 70 years most people have lost 10%-15% of their peak bone density (Brennan, 2002:20). Inadequate muscle strength and muscle flexibility can inhibit functional activities which in return reduce the elderly's ability to take care of themselves (Rikli & Jones, 2002:25).

According to Chu *et al.* (1999:40), muscle weakness especially of the lower limbs is a high predictive indicator for the incidence of falls among the elderly. Reasons for the loss in proper body balance can be attributed to the loss of muscular strength, large body fat mass and muscle atrophy which complicates the correct muscle tone and that disturbs corrective reactions (Melzer *et al.*, 2003:240). Decreases in postural balance are also accompanied by decreases in functional fitness (Islam *et al.*, 2004:10; Rikli & Jones, 2002:25). According to Islam *et al.* (2004:9), falls amongst the elderly lead to multiple hip fractures and people being placed into nursing homes.

All the above evidence indicates that as people advance in age it becomes more difficult to perform many functional activities, such as taking personal care of themselves, getting up from a chair, doing shopping, as well as work in and around the house. Therefore, aging inhibits an independent lifestyle (Jameson, 2007:63, Cavani *et al.*, 2002:444; Tanaka *et al.*, 2000:171). Individuals that are in the same chronological age categories may differ dramatically from each other based on their physiological age and response to daily activity (ACSM, 2006:246). To be able to perform functional movements a person has to rely on sufficient physiological reserves (i.e. flexibility, strength, endurance, balance) (Rikli & Jones, 2002:25). Functional fitness is defined as having the physiological capability to perform normal everyday tasks safely and independently without any undue fatigue (Rikli & Jones, 1999:162). Rikli and Jones (1999:163) developed a functional fitness test that presumes that you require certain functional movements (e.g. climbing stairs, carrying objects, bend forward) to perform your everyday activities. Functional fitness components include upper and lower body strength, upper and lower body flexibility, motor balance and agility and aerobic endurance.

Maintenance of functional capacity is one way to achieve independence and health (Lloyd-Sherlock, 2000:893). In the elderly a physically active lifestyle can achieve relatively high levels of cardiovascular, skeletal and metabolic muscle function (Fletcher *et al.*, 2005:104). Talbot *et al.* (2002:1189) found that leisure time physical activity and aerobic fitness had a protective effect against cardiac events. Older adults that are physically active also have a lower morbidity and mortality rate than older adults that are inactive (Brach *et al.*, 2004:502). According to Cavani *et al.* (2002:448), a moderate intensity exercise programme during a six-week period improved performance in functional fitness. Brach *et al.* (2004:502), however, stated that although the elderly are aware of the benefits of a physical active lifestyle, more than 60% of the elderly do not participate in regular physical activities.

Therefore, the research questions to be answered by this study are:

- 1.1.1 What is the functional fitness, static balance and dynamic balance status of Caucasian senior citizens (65 – 95 years) of a South African community?
- 1.1.2 Does physical activity status and aerobic endurance have an influence on the functional fitness status of Caucasian senior citizens (65 – 95 years) of a South African community?
- 1.1.3 Do physical activity and aerobic endurance influence the static and dynamic balance status of Caucasian senior citizens of a South African community?

The results obtained from this study will expose limitations in the physical status of the Caucasian senior citizens in a South African community for future intervention studies.

1.2 Objectives

The objectives of this study are to determine:

- 1.2.1 The functional fitness, static balance and dynamic balance status of Caucasian senior citizens (65 – 95 years) in a South African community.
- 1.2.2 The association between physical activity status, aerobic endurance and functional fitness status of Caucasian senior citizens (65 – 95 years) in a South African community.
- 1.2.3 The association between physical activity status, aerobic endurance and static and dynamic balance status of Caucasian senior citizens (65 – 95 years) in a South African community.

1.3 Hypotheses

This study is based on the following hypotheses

- 1.3.1 Caucasian senior citizens (65 – 95 years) in a South African community will present with low functional fitness scores as well as poor performances in static balance and dynamic balance test.
- 1.3.2 Caucasian senior citizens (65 – 95 years) in a South African community with a higher physical activity status and aerobic endurance will perform better in the functional fitness test.
- 1.3.3 Caucasian senior citizens (65 – 95 years) in a South African community with higher physical activity status and aerobic endurance will perform better in the static and dynamic balance tests.

1.4 Structure of the dissertation

This dissertation will be presented in an article format. This implies that the results of this study will be presented in two research articles. The research articles will be submitted to the *African Journal of Physical Health Education, Recreation and Dance* for possible publication. Both the referencing and format style of the articles will be in accordance with the specific journal, chapter one and two which is written according to the Harvard style specification of the North-West University. Guidelines for the authors as provided by the journal can be found in the Appendix.

The dissertation will be presented as follows:

- ❖ Chapter 1 - Problem statement and objectives of the study

Title: Problem statement and objectives of the study

This chapter contains the problem statement, research questions, objectives and hypotheses. References will be provided at the end of chapter one in accordance with the North-West University's guidelines.

- ❖ Chapter 2 - Literature review

Title: The association between physical activity, functional fitness and balance in senior citizens.

This chapter serves as the literature review for this study and forms the base of the following research articles. References are provided at the end of the chapter in accordance with the North-west University's guidelines.

Chapter 3 - Research article 1

Title: Functional fitness and balance status in a geriatric cohort.

This chapter will be presented in accordance with the author guidelines of the *African Journal of Physical Health Education, Recreation and Dance*.

Chapter 4 - Research article 2

Title: The association between physical activity, functional fitness and balance in a geriatric cohort

This chapter will be presented in accordance with the author guidelines of the *African Journal of Physical Health Education, Recreation and Dance*.

Chapter 5 - Summary, conclusion, limitations and recommendations

Title: Summary, conclusion, limitations and recommendations

In this chapter a short summary and conclusions about the study will be given as well as recommendations for future research.

References

AMERICAN COLLEGE OF SPORTS MEDICINE. 2006. ACSM's Guidelines for exercise testing and prescription. 7^{de} Ed. Philadelphia: Lippincott, Williams & Wilkins. 366 p.

BRACH, J.S., SIMONSICK, E.M., KRITCHEVSKY, S., YAFFE, K. & NEWMAN, A.B. 2004. The association between physical function and lifestyle activity and exercise in the health, aging and body composition study. *Journal of American Geriatric Society*, 52(4):502-509, April.

BRENNAN, H.F. 2002. Exercise prescription for active seniors: A team approach for maximizing adherence. *Physician and Sports medicine*, 30(2):19-29, Feb.

CAVANI, V., MIER, C.M., MUSTO, A.A. & TUMMERS, N. 2002. Effects of a 6-week resistance-training program on functional fitness of older adults. *Journal of Aging Physical Activity*, 10:443-452.

CHU, L.W., PEI, C.K. & CHIU, A. 1999. Risk factors for falls in hospitalised older medical patients. *Journal of Gerontology, Series A: Biological Sciences and Medical Sciences*, 54:M38-M43.

DEPARTMENT OF HEALTH. 2001. National service framework for older People. London: The stationery Office. [Web:] http://www.dh.gov.uk/prod_consum_dh/groups/dh_digitalassets/@dh/@en/documents/digitalasset/dh_4071283.pdf. [Date of use: 1 May 2008]

EDWARD, G. & LAKATTA, M.D. 2007. Central arterial aging and the epidemic of systolic hypertension and atherosclerosis. *Journal of the American Society of Hypertension*, 1(5):302-340, May.

EHRMAN, J.K., GORDON, P.M., VISICH, P.S. & KETEVIAN, S.J. 2003. Clinical exercise physiology. Champaign, IL, USA. Human Kinetics. 617 p.

FLETCHER, B.J., GULANICK, M. & BRAUN, L.T. 2005. Physical activity and exercise for elders with cardiovascular disease. *Medsurg Nursing*, 14(2):101-110, April.

HARROD, K.H. 2005. Epithelial pathogen interactions in the aged lung. Lovelace Respiratory institute, Albuquerque, NM, USA. 79p.

ISLAM, M.M., TAKESHIMA, N., ROGERS, M.E., KOIZUMI, D. & ROGERS, N.L. 2004. Relationship between balance, functional fitness, and daily physical activity in older adults. *Asian Journal of exercise and Sport Science*, 1(1): 9-18.

JAMESON, J.R. 2007. Healthcare for an aging population. China. Churchill Livingstone Elsevier. 335 p.

JENSEN, D., OFIR, D. & O'DONNELL, D.E. 2009. Effects of pregnancy, obesity and aging on the intensity of perceived breathlessness during exercise in healthy humans. *Respiratory physiology & Neurobiology*, 167:87-100: 1-14, Jan.

KELL, R.T., BELL, G. & QUINNEY, A. 2001. Musculoskeletal fitness, health outcomes and quality of life. *Sports Medicine*, 31(12):863-873.

LLOYD-SHERLOCK, P. 2000. Population ageing in developed and developing regions: implications for health policy. *Social science and medicine*, 51(6):887-895.

MELZER, I., BENJUYA, N. & KAPLANSKI, J. 2003. Effects of regular walking on postural stability in the elderly. *Gerontology*, 24:240-245, September.

NICHOLS, W.W., O'ROURKE, M.E. & AVOLIO, A.P. 1985. Effects of age on ventricular-vascular coupling. *The American Journal of Cardiology*, 55(9):1179-1184.

O'ROURKE, M.F. 2003. Vascular mechanics in the clinic. *Journal of Biomechanics*, 36:623-630, November.

REEVES, N.D., NARICI, M.V. & MAGANARIS, C.N. 2006. Musculoskeletal adaptations to resistance training in old age. *Manual Therapy*, 11(3):192-196, April.

RIKLI, E.R. & JONES, J.C. 1999. Functional fitness normative scores for community-residing older adults, ages 60-94. *Journal of Aging and Physical Activity*, 7(2):162-181.

RIKLI, E.R. & JONES, J.C. 2002. Measuring functional fitness of older adults. *The Journal of active aging*, 1:24-30, March/April.

TALBOT, L.A., MORRELL, C.H., METTER, E.J. & FLEG, J.L. 2002. Comparison of cardiorespiratory fitness versus leisure time physical activity as predictors of coronary events in men aged ≤ 65 years and > 65 years. *The American Journal of Cardiology*, 89(10):1187-1192, May.

TANAKA, K., SHIGEMATSU, R., NAKAGAICHI, M., KIM, H. & TAKESHIMA, N. 2000. The relationship between functional fitness and coronary heart disease risk factors in older Japanese adults. *Journal of Aging and Physical Activity*, 8(2):162-174.

TAYLOR, A.H., CABLE, N.T., FAULKNER, G., HILLSON, M., NARICI, M. & VAN DER BINJ, A.K. 2004. Physical activity and older adults: a review of health benefits and the effectiveness of interventions. *Journal of Sports Sciences*, 22(8):703-725, June.

VELKOFF, V.A. & KOWAL, P.R. 2007. Population aging in Sub-Saharan Africa: Demographic dimensions 2006. [Web:] <http://www.census.gov/prpd/2007pubs/p95-7-1.pdf> [Date of use: 6 Aug. 2009].

WARBURTON, E.R., NICOL, C.W. & BREDIN, S.S.D. 2006. Health benefits of physical activity: The evidence. *Canadian Medical Association Journal*, 174(8):801-809, March.

Chapter 2

The association between physical activity, functional fitness and balance in senior citizens: Literature review.

2.1 Introduction

The past decades have shown an increase in longevity in most countries worldwide due to fewer acute diseases and better health care systems (Tanaka *et al.*, 2000:162; Velkoff & Lawson, 1998:2). According to Velkoff and Kowal (2007:11-12), it is predicted that the number of people above sixty years of age in Sub-Sahara Africa will increase by 36% in 2030 to over 4.8 million. The older population of South Africa will increase from 2006 to 2030, while the total population will decrease (Table 2.1) (Velkoff & Kowal, 2007:28). A possible reason for the South African population tendency is the influence of HIV and AIDS (Velkoff & Kowal, 2007:22; Lloyd-Sherlock, 2000:888). Escalating costs of health care systems propose financial challenges for the elderly and the government, since most elderly cannot afford medical insurance or private medical care (Joubert & Bradshaw, 2009:13). The more a population ages, the more important quality of life becomes (Konno *et al.*, 2004:154).

Table 2.1: Older Population in the selected age groups for South Africa: 1990, 2006, 2015, and 2030 (In thousands). (Velkoff & Kowal, 2007:28)

Year	Total population	Population aged 50 and over		Population aged 60 and over		Population aged 80 and over	
		N	%	N	%	N	%
1990	38,391	4,677	12.2	2,307	6.0	238	0.6
2006	44,188	6,964	15.8	3,512	7.9	366	0.8
2015	42,261	7,594	18.0	4,120	9.7	478	1.1
2030	38,414	7,646	19.9	4,764	12.4	739	1.9

As illustrated in Figure 2.1, more developed countries have a higher percentage of their total population in older age groups. These countries also show the largest senior population growth compared to Eastern and African countries (Velkoff & Kowal, 2007:3). In the United States the population segment over 65 has grown by 84% from 1965 to 1995 and occupies up to 13% of the

total population. It is predicted that by 2025 this population segment will increase to 20% of the total population (Ehrman *et al.*, 2003:571). Similar statistics have been found in the UK, where it is predicted that the number of people over the age of 80 will increase by 50% from 1995 to 2025 (Department of Health, 2001:1).

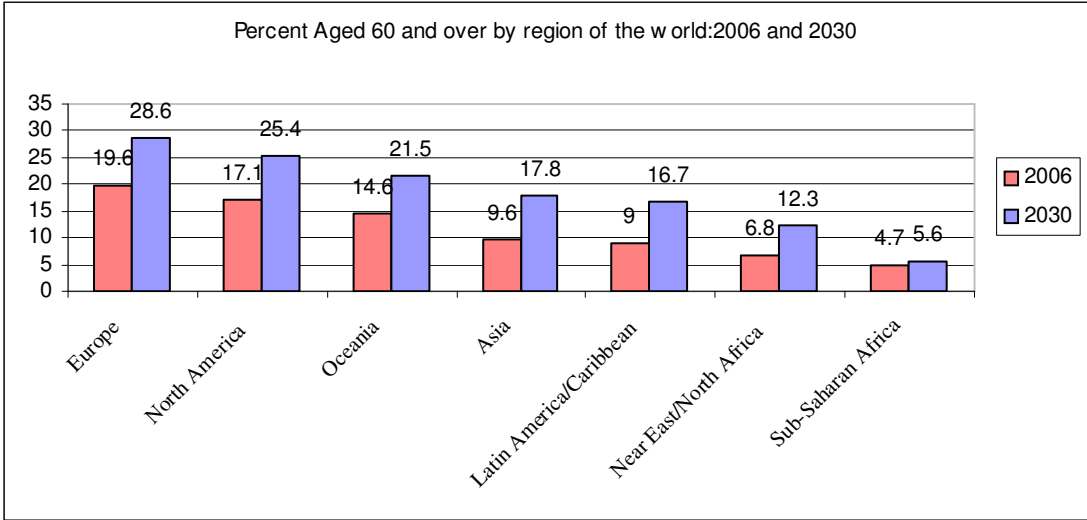


Figure 2.1: Percentage persons aged 60 and over by region of the world 2006 and 2030 (Velkoff & Kowal, 2007:11&12)

These aging trends have an enormous economical impact and present challenges to policymakers, families, businesses, and health care providers to meet the needs of aging individuals (Velkoff & Kowal, 2007:3; Velkoff & Lawson, 1998:2). Caregiving for elders proposes a problem for middle-aged adults who will have the responsibility to look after their elders and in some circumstances may result in reduced working hours and income for the caregivers (Velkoff & Lawson, 1998:2). Many older adults also act as caregivers for others (older adults, spouses, children and grand children) because of various factors, such as death, illness, HIV/AIDS, drug abuse and child abuse (Velkoff & Lawson, 1998:3). In research done by Konno *et al.*, (2004:155), activities of daily living (bathing, dressing, toileting, standing and eating) and instrumental activities of daily living (using the telephone, managing heat for cooking, using public transport, taking medication and handling finances) were measured. The researchers found that aging and difficulty in walking are predictors for losing independence and the prevalence of disability increases with age (≥ 85 years) for both activities of daily living and instrumental activities of daily living (Konno *et al.*, 2004:156-158). When elderly lose the ability to care for themselves, they become dependent on others and institutions. This can have not only an economic impact on them, but also a social, psychological and physical impact. Therefore, it is important for older adults to stay healthy and functionally fit for as long as

possible, to continue having an independent lifestyle and to reduce the economic burden for the involved countries. In order to understand the impact of aging on the body and functionality of the body the physiological changes that accompany aging will be discussed.

2.2 Physiological changes associated with aging

As people age physiological changes take place (Ehrman *et al.*, 2003:571). Some of the changes that occur with aging include: Cardiovascular, Respiratory, Body composition, Musculoskeletal, Balance, Social, Psychological and Economical challenges.

2.2.1 Cardiovascular changes with an increase in age

According to the ACSM (2010:28), the risk factors for cardiovascular diseases are the following: Family history, cigarette smoking, hypertension, dislipidemia, impaired fasting glucose, obesity and physical inactivity. Age is a dominant risk factor for cardiovascular diseases and the presence of any cardiovascular disease accelerates changes within the cardiovascular system. The structure of central arteries is subject to change throughout a persons' lifespan. These changes includes luminal dilation, diffuse intimal and medial thickening, increased stiffness, reduced compliance, endothelial dysfunction as well as a decrease in peak exercise heart rate, ejection fraction, stroke volume and cardiac index and an increase in blood pressure and cardiac dilatation (Edward & Lakatta, 2007:302; Peterson *et al.*, 2003:1108; Stratton *et al.*, 1994:1651). Cardiac output is increased by increasing stroke volume rather than increasing heart rate (Delerme & Ray, 2008:252). Progressive deterioration in the cardiovascular system results in a reduced cardiac output in both ventricles and a reduction in oxygen transport to tissue of the central and peripheral circulations (Taylor *et al.*, 2004:707).

Hypertension is clinically defined as an elevation in arterial blood pressure equal to or exceeding a systolic blood pressure of 140 mmHg and/or a diastolic blood pressure of 90 mmHg (ACSM, 2010:47). According to Messerli *et al.* (2007:591), the chance to develop hypertension in the industrialised countries exceeds 90%. The prevalence of hypertension increases with age and is higher in men than in women (Burt *et al.*, 1995:63). Table 2.2 indicates the different classifications of blood pressure (ACSM, 2010:47). Masley *et al.* (2006:395) found that there is a linear relationship between increasing systolic blood pressure (SBP) and an increasing risk of cardiovascular disease (CVD) in patients between the ages of 64 and 75 (Figure 2.3). Masley *et al.* (2006:395) also found a U-shaped relationship between diastolic blood pressure (DBP) and

cardiovascular disease for patients older than 75 years of age (Figure 2.2). Diastolic blood pressure lower than 70 mmHg and diastolic blood pressure greater than 90 mmHg increase the risk of cardiovascular diseases in this population. A SBP lower than 120 mmHg has a reduced risk of CVD events and a DBP of 80 mmHg to 90 mmHg have the lowest risk for CVD (Masley *et al.*, 2006:396).

Table 2.2: Classification of blood pressure for adults. (ACSM, 2010:47)

BP Classification	SBP (mm Hg)	DPB (mm Hg)	Lifestyle modification
Normal	<120	And <80	Encourage
Pre-hypertension	120-139	Or 80-89	Yes
Stage 1 Hypertension	140-159	Or 90-99	Yes
Stage 2 Hypertension	≥160	Or ≥ 100	Yes

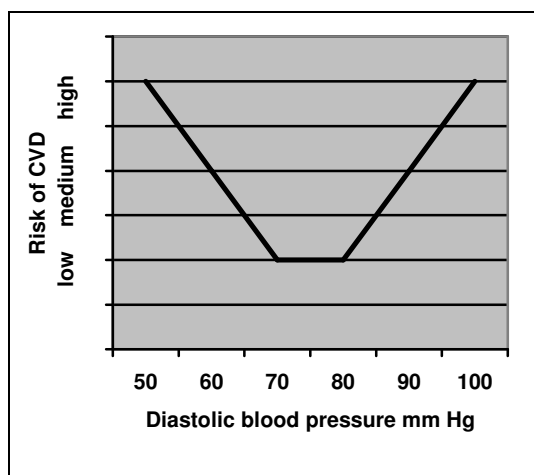


Figure 2.2 Association between diastolic blood pressure and CVD (Masley *et al.*, 2006:395)

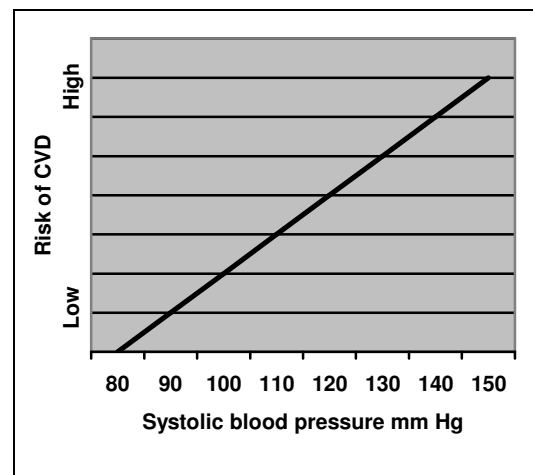


Figure 2.3 Association between systolic blood pressure and CVD (Masley *et al.*, 2006:395)

Moderate physical activity has a positive influence on blood pressure values (Kostic *et al.*, 2007:78). According to Rodriguez *et al.* (2008:173), 60 minutes of moderate intensity (50%-60% of VO_{2max}) walking during a week for 12 weeks produces a significant drop of SBP and DBP in previously sedentary participants (70.72 ± 7.23 years old). Long-term sub-maximal resistance training can improve systolic and diastolic blood pressure as well as blood lipid profiles amongst elderly, and these changes associate with a reduced risk of cardiovascular diseases (Kell *et al.*, 2001:866).

Serum total cholesterol, high-density lipoprotein cholesterol (HDL-C), and the ratio of HDL-C and non-HDL cholesterol are risk factors for myocardial infarction in the elderly (Mazza *et al.*, 2005:609; Houterman *et al.*, 1999:30). Table 2.3 presents the classification of blood cholesterol levels according to the literature (ACSM, 2010:48). According to Wong *et al.* (2010:167), older people that have elevated levels of low density lipoprotein cholesterol (LDL-C) or non-HDL-C have greater risks of developing CVD in people that are normotensive or pre-hypertensive. This risk of developing CVD is elevated in people that are hypertensive, regardless of their LDL-C or non-HDL-C levels. High levels of HDL-C are associated with better survival and longevity amongst very old and frail older adults and low levels of HDL-C is a marker for disability (Landi *et al.*, 2008:77; Zuliani *et al.*, 1999:321). The protective effect of HDL-C can be attributed to its promotion of reverse cholesterol transport, anticoagulant properties, antioxidant activity, and anti-inflammatory actions on endothelial cells (Zuliani *et al.*, 1999:321). Peterson and Ray, (2007:28) found that lowering low density lipoprotein (LDL) to <70 mg/dL can lead to a subsequent reduction of up to 40% in myocardial infarction, unstable angina or death in patients older than 70 years. According to Curb *et al.* (2004:1977), there is a non-linear relationship between total cholesterol (TC) and LDL-C and coronary heart disease (CHD) in elderly men. Men with a high or low level of TC and HDL-C have a high risk to develop CHD. This is likely to be associated with metabolic and physiological changes that occur during aging (Curb *et al.*, 2004:1977). High TC levels are a strong risk factor for CHD in elderly men and low levels of cholesterol can be a predictor of non-cardiovascular and cause mortalities in both genders (Tuikkala *et al.*, 2010:125; Casilgia *et al.*, 2003:360-36)

Table 2.3: National Cholesterol education programme adult treatment panel III classification (ACSM, 2010:48)

LDL cholesterol (mg . dl⁻¹)	Classification
<100	Optimal
100-129	Near optimal
130-159	Borderline high
160-189	High
≥190	Very high
Total cholesterol (mg . dl⁻¹)	Classification
<200	Desirable
200-239	Borderline high
≥240	High
HDL cholesterol (mg . dl⁻¹)	Classification
<40	Low
≥60	High
Triglycerides (mg . dl⁻¹)	Classification
<150	Normal
150-199	Borderline high
200-499	High
≥ 500	Very high
<i>Note: LDL – Low density lipoprotein, HDL – High density lipoprotein</i>	

According to Knight *et al.* (1999:216), high-density lipoprotein cholesterol (HDL-C) is higher in physically active older adults (> 60 years) than in physically inactive older adults (> 60 years). Research done by Marques *et al.* (2009:85) compared the effects of resistance and multi-component exercise programmes on the lipid profiles of older women between the ages of 60 to 79 years. The multi component exercise regimen consisted of slow warm up activities, aerobic exercises (walking, dance, jogging etc.), muscular endurance, balance training and a cool down period (Marques *et al.*, 2009:85). These sessions were performed twice a week for 60 minutes (Marques *et al.*, 2009:85). Marques *et al.* (2009:88) concluded that a multi-component exercises are more effective to improve blood lipid profiles than resistance exercises.

Diabetes Mellitus is a metabolic disorder characterized by raised levels of blood glucose (Jameson, 2007:206; ACSM, 2010:232). Elderly are more glucose intolerant and insulin resistant than younger individuals (Jameson, 2007:206). Symptoms of diabetes mellitus include frequent thirst and urination, weight loss, infections and cuts that heal slowly, blurred vision, fatigue and weakness and irritability, nausea and vomiting (Powers & Howley, 2007:338; Ehrman *et al.*, 2003:135). There are four categories of diabetes mellitus namely, type 1 diabetes mellitus, type 2 diabetes mellitus, other specific types and gestational diabetes. Type 2 diabetes mellitus was formerly named adult-onset or non-insulin-dependant diabetes mellitus (Ehrman *et al.*, 2003:130-131). Race, family history and increasing age are some non-modifiable risk factors for type 2 diabetes mellitus (Jameson, 2007:206). Type 2 diabetes mellitus is associated with excess body fat and the distribution of upper body fat (ACSM, 2006:207). According to Doucet *et al.* (2008:578), 68% of patients diagnosed with diabetes mellitus have one or more cardiovascular diseases while the two main cardiovascular risk factors associated with diabetes mellitus are excess weight and hypertension. Diabetes mellitus can compromise the healing of foot wounds and increase the risk of amputations (Doucet *et al.*, 2008:578).

Treatment for diabetes mellitus includes diet and exercise to achieve weight loss and improve insulin sensitivity (Powers & Howley, 2007:338; Dewan & Wilding, 2003:143). The primary aim for treating diabetes mellitus should be to improve glycaemic control, keep blood pressure <140/80 mmHg and monitor for diabetic complications (Dewan & Wilding, 2003:143). Physical activity plays an important role in prevention and treatment of diabetes mellitus (Häkkinen *et al.*, 2009:803). Hu *et al.* (1999: 1438) concluded that both vigorous activities and moderate activities such as walking can reduce the risk of type 2 diabetes mellitus. Hu *et al.* (1999: 1439) recommended that thirty minutes of moderate intensity exercise should be performed on most days of the week. According to Zhao *et al.* (2011:135), older adults with diabetes mellitus do

not exercise enough to meet physical activity recommendations. Inactive individuals with the risk of type 2 diabetes mellitus had the poorest quality of life and health (Häkkinen *et al.*, 2009:803). These people had some musculoskeletal, cardiovascular or other disease or symptom. The profile of older adults with low adherence to physical activity includes: female gender, older age (≥ 75 years), obesity, black race and ethnicity, people with coronary heart disease and disability (Zhao *et al.*, 2011:135). Physical activity has beneficial effects on all eight dimensions of the participants' health related quality of life. Patient education is also a fundamental part of management for elderly with diabetes mellitus and would eventually reduce costs and medical expenditures (Erwin *et al.*, 2006:82; Dewan & Wilding, 2003:143).

2.2.2 Respiratory changes with an increase in age

Advancing age is associated with a decline in the strength of skeletal muscles as well as respiration muscles (Summerhill & Angov, 2007:315). Respiratory system efficiency in the elderly is influenced by factors such as kyphosis, reduced mobility of the ribs, diminished efficiency of the respiratory muscles, reduced nasopharyngeal function, reduced respiratory rate, a decline in the number of alveolar sacks, as well as a loss of tissue elasticity (Jensen *et al.*, 2009:9,11; Harrod, 2005:79). Pulmonary changes include pulmonary artery stiffening, a reduced inspiratory and expiratory capacity, loss of diaphragmatic mass and strength and a reduced pulmonary function (Delerme & Ray, 2008:252; Ehrman *et al.*, 2003:575). Total lung capacity does not change, but functional residual capacity as well as residual volume increases with age (Delerme & Ray, 2008:251).

Regular exercise is associated with stronger inspiratory and expiratory muscles and a significantly greater diaphragm muscle mass thickness (Summerhill & Angov, 2007:318). According to Summerhill and Angov (2007:318), respiratory muscles can be strengthened by non-respiratory activities such as recruitment of the abdominal muscles that raises intra-abdominal pressure which stimulates strength training of the diaphragm and expiratory muscles (Summerhill & Angov, 2007:315). Research done by Watsford and Murphy (2008:258) on elderly women between the ages of 60 to 69 years, found that eight weeks of respiratory muscle training can improve maximum respiratory pressure by up to 30%. The respiratory muscle training was performed with the Powerlung device and participants completed 12 sessions a week that focused on respiratory muscle strength and endurance (Watsford & Murphy, 2008:250). It was also found that after the respiratory muscle training participants' heart rate during aerobic testing (incremental walking test) was lower (Watsford & Murphy, 2008:257).

These findings was supported by Borel *et al.* (2009:172) who found that exercise tolerance increased significantly after an 8 week home based exercise programme which included moderate cycling and walking for patients with thoracic restrictive disorders. People with thoracic restrictive disorders like severe scoliosis or tuberculosis sequelae, face an increased breathing rate leading to impaired alveolar ventilation and increased perception of dyspnoea. Respiratory muscle training can have great benefits for the improvement of quality of life for the elderly by contributing to greater aerobic endurance and functional fitness (Borel *et al.*, 2009:173; Watsford & Murphy 2008:258).

As previously mentioned aging is accompanied by physiological changes. These physiological changes contribute to an increase in hypokinetic diseases for example hypertension, obesity, high cholesterol as well as an increase in cardiovascular diseases like angina and stroke as seen in Fig 2.4. According to Kell *et al.* (2001:866), improvements in heart rate, stroke volume and cardiac output can decrease myocardial stress at a sub-maximal intensity in the elderly. Moderate physical activity can reduce the risk, or prolong the onset of these physiological changes and various diseases. Talbot *et al.*, (2002:1189) found that leisure time physical activity and aerobic fitness had a protective effect against cardiac events. Huhn *et al.* (2009:512) concluded that the higher the intensity and regularity of the exercises are, the more physiological benefits will be experienced and the lower is the prevalence of metabolic disorders. Leisure time activities are not effective at reducing the prevalence of metabolic disorders (Huhn *et al.*, 2009:512).

Fig 2.4 summarizes the effect of aging on physiological changes which could eventually lead to cardiovascular and hypokinetic diseases, decreased independency and mortality. The effect of physical active lifestyle on aging is portrayed in Fig 2.5. Physical activity amongst the aging individual can reduce the risk for hypokinetic and cardiovascular diseases and increase independency and decrease medical costs.

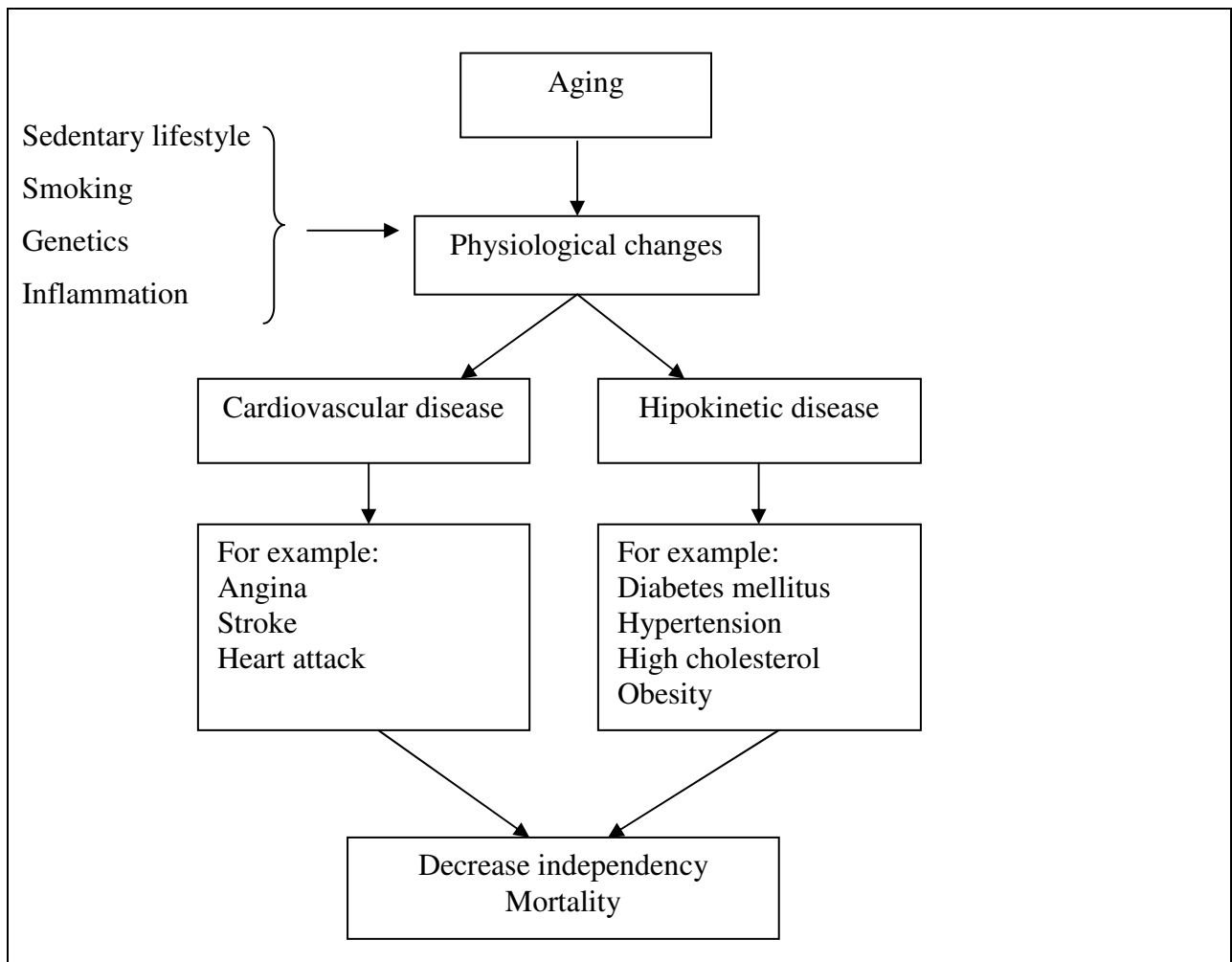


Figure 2.4: Age as the major risk factor for cardiovascular (CV) disease. [As adapted from Edward and Lakatta (2007:302-303)].

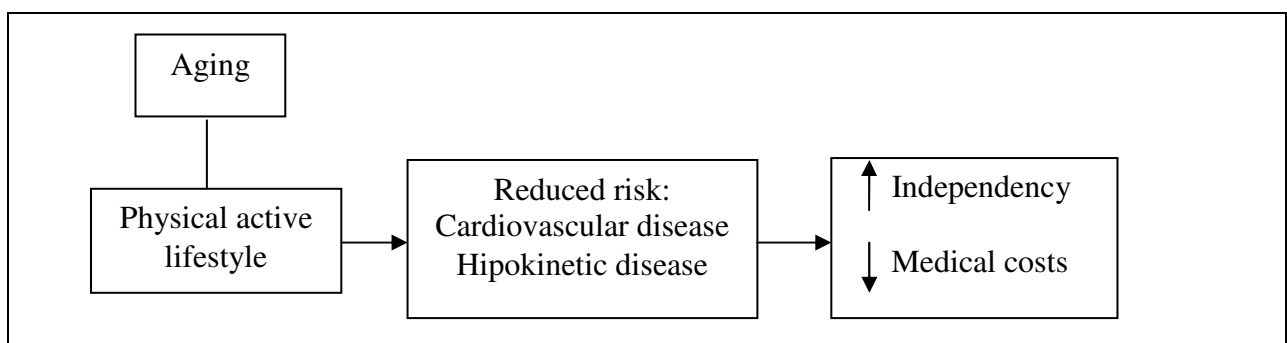


Figure 2.5: The effect of a physical active lifestyle on aging

2.2.3 Body Composition changes with an increase in age

According to Raguso *et al.* (2006:579) healthy elderly people undergo body composition changes over a period of time even though body weight remains stable. As people age they have an increase in their percentage body fat and a decrease in fat free body mass and bone mass (ACSM, 2010:71; Dewan & Wilding, 2003:137). The increase in body weight and BMI increases until the age of 60 years after which body weight and BMI begins to decline (Dewan & Wilding, 2003:137). Coin *et al.* (2008:92) found that body fat and BMI increases until the age of 70 years, after which it declines. According to Sharkey and Gaskill (2007:254), a person loses four percent of his metabolic active cells for every decade after the age of twenty-five. In order to maintain a constant weight a person has to adapt by either increasing energy expenditure and/or decreasing energy intake (Sharkey & Gaskill, 2007:254). Excess body fat is associated with hypertension, type-2 diabetes mellitus, stroke, coronary heart disease, hyperlipidemia, sleep-breathing disorders and increased risk of cancer (ACSM, 2010:62; Dewan & Wilding, 2003:137).

Research done by Kyle *et al.* (2004:256) explored the effects of age and physical activity on body mass index (BMI), fat free mass index (FFMI), body fat mass index (BFMI) and percentage body fat (%BF). According to Kyle *et al.* (2004:257-258), physically active men and women have low and normal BFMI values compared to their sedentary male and female counterparts and physical activity results in the maintenance of FFMI. Physically active men and women were significantly more likely to have low BMI, BFMI and %BF. FFMI is stable until the age of 74 years and declines after the age of >75 years (Kyle *et al.*, 2004:82). Coin *et al.* (2008:92) also found that fat free mass diminishes beyond the age of 70 years and that fat mass remains relatively constant. FFMI can be maintained as long as the FFM weight increases are enough to counteract the decrease of FFMI with age (Kyle *et al.*, 2004:86). According to Kyle *et al.* (2004:86), a 1.4 kg and 0.9 kg weight gain (lean body mass) per decade of age in sedentary and physically active adults respectively would result in maintenance of FFM.

Kyle *et al.* (2004:258) found that people older than 60 years of age have a lower FFMI and high and very high BFMI compare to people younger than 60 years of age. Older people with high body weight and BMI's also have higher FFMI's to support the body weight (Kyle *et al.*, 2004:258). Declines in muscle mass and strength as well as large percentage body fat can inhibit proper balance and increase the risk of falls amongst elderly (Melzer *et al.*, 2003:240). An obese individual needs more muscle force to regain-balance during loss of balance (Hassinen *et al.*,

2005:303). According to Rossi *et al.* (2008:1428) and Wannamethee *et al.* (2005:1001), pulmonary functional decline is associated with a decline in fat free mass and an increase in abdominal fat is the most significant predictor of lung function decline. Abdominal fat deposition may prevent the descent of the diaphragm, while fat deposition in the chest wall may inhibit rib cage movement (Wannamethee *et al.*, 2005:1001). These respiratory impairments can limit an individual's aerobic capacity and, therefore, functional fitness (Wannamethee *et al.*, 2005:1001).

Table 2.4: BFMI and FFMI values for corresponding BMI values in healthy adults (Kyle *et al.*, 2004:87)

	BMI	BFMI or FFMI category	BFMI	FFMI
Men	≥30	Very high	≥8.3	≥21.7
	25-29.9	High	5.2-8.2	19.8-21.6
	18.5-24.9	Normal	1.8-5.1	16.7-19.7
	<18.4	Low	≤1.7	≤16.6
Women	≥30	Very high	≥11.8	≥18.2
	25-29.9	High	8.2-11.7	16.8-18.1
	18.5-24.9	Normal	3.9-8.1	14.6-16.7
	<18.4	Low	≤3.8	≤14.5

There is a positive correlation between the level of physical activity and muscle and body cell mass and a negative correlation between whole-body fat and abdominal fat accumulation (Raguso *et al.*, 2006:577). Leisure time physical activity alone is not sufficient to prevent muscle mass loss and body fat increase in the elderly (Raguso *et al.*, 2006:579). According to Houston *et al.* (2009:1890), older adults should perform moderate-intensity exercises to obtain health benefits. Nevertheless, improved body composition related to physical activity level, could delay the occurrence of impairing sarcopenia and reduce the risk of metabolic syndrome (Raguso *et al.*, 2006:579).

2.2.4 Musculoskeletal changes, balance and falls related to aging

Musculoskeletal fitness includes muscular strength, muscular endurance and flexibility (Kell *et al.*, 2001:871). Enhancing musculoskeletal fitness improves both basic and instrumental activities of daily living, overall health status, reduce the risk of cardiovascular diseases and improves quality of life (Warburton *et al.*, 2001:232; Kell *et al.*, 2001:866 & 871). Falls are the leading cause of injury related deaths amongst people aged sixty-five and older (Stevens, 2005:409). These falls and fall-related injuries place a great burden on the individuals, their society and health care systems (Stevens, 2005:411). There are a variety of factors that

contribute to falls amongst the older population, including: disease and medication, environmental factors, physiological factors and poor postural balance (Keskin *et al.*, 2008:58; Jameson, 2007:64; Islam *et al.*, 2004:9). According to Chu *et al.* (1999:40), muscle weakness especially of the lower limbs is a high predictive indicator for the incidence of falls among the elderly. Atrophy of muscles, neuromuscular changes, biomechanical insufficiencies, pain and soft tissue overloads contribute to postural changes in the elderly (Benedetti *et al.*, 2008:32; Ostrowska *et al.*, 2003:222). According to Ostrowska *et al.* (2003:224), there is a flattening of lumbar lordosis and a deepening of thoracic kyphosis in elderly men between the ages of 61 and 83 years. A flexed posture is associated with back pain, impaired vision because of neck flexion, muscular impairments and motor function limitations (Balzini *et al.*, 2003:1425). Lack of physical fitness can cause significant deterioration of posture stability and balance control (Ostrowska *et al.*, 2003:222). Reasons for the loss in proper body balance can be attributed to the loss of muscular strength, large body and fat mass and muscle atrophy which complicates the correct muscle tone and that disturbs correct reactions (Melzer *et al.*, 2003:240). Decreases in postural balance are also accompanied by decreases in functional fitness (Islam *et al.*, 2004:10; Rikli & Jones, 2002:25). According to Islam *et al.* (2004:9), falls amongst the elderly lead to multiple hip fractures and people being placed into nursing homes.

Aging is characterized by a loss in muscle size and strength and a decline in function, impaired mobility and physical frailty (Reeves *et al.*, 2006:192; Kell *et al.*, 2001:866; Taaffe & Marcus, 2000:245). Research shows that there is a 10-15% loss of muscle strength per decade during the 5th and 8th decade, especially in the postural muscles (Melzer *et al.*, 2003:243). Goodpaster *et al.* (2008:1500) found that physically inactive older adults can lose up to 22% of muscle strength during one year of aging, while physically active older adults only lost 1.5% of their muscle strength. Mendis *et al.* (2009:534) studied the effect of prolonged bed rest (8 weeks) on the anterior hip muscles. After 8 weeks of bed rest there was preferential atrophy of the Sartorius and Iliopsoas muscles at the hip joint. This muscle atrophy has serious complications for joint function, for it can cause muscular imbalances and increase the risk of injury. Furthermore, it influences the kinetic chain of the lower limb and puts strain on the spine (Mendis *et al.*, 2009:536). After 8 weeks of bed rest it is possible to regain complete muscle strength and bone mass loss can be recovered completely in male participants (32 years of age) (Rittweger & Felensberg, 2009:223). Rittweger and Felensberg (2009:222) found that after bed rest the calf muscle recovered fully cross sectionally within 90 days after re-ambulation and showed increases after 180 days of normal every day impact activities and various sporting activities. Rittweger *et al.* (2005:1028) found that moderate exercise (flywheel exercise that consisted of 4

sets of 7 repetitions every third day or calf press 4 sets of 14 reps and supine squat 4 sets of 7 repetitions) have the potential to prevent muscle atrophy.

There are a number of factors that could lead to the progressive loss of flexibility during aging. These factors include disease, deterioration of joint structures, tendon stiffness, immobilisation and inactivity (Kell *et al.*, 2001:870; Karamanidis, *et al.*, 2008:987). It is also confirmed that these age-related deficits are associated with lower body strength and tendon stiffness (Karamanidis *et al.*, 2008:988). A stretching programme developed to improve hip flexor, extensor muscles and ankle plantar flexor muscles flexibility was efficient at increasing hip and ankle range of motion. The increase in range of motion resulted in a faster gait and increased step length (Cristopoliski *et al.*, 2009:617). According to Karamanidis *et al.* (2008:988), the main mechanism humans use to regain balance is to broaden their base of support and older adults have deficits in using these mechanisms to regain dynamic balance.

Balance is linked to motor abilities and affects activities of daily living and quality of life in the elderly. Balance is the ability to maintain the body's position over its base of support (Rogers *et al.*, 2001:292). Dynamic balance is the ability to anticipate any changes in balance and coordinate muscle activity to maintain balance and stability. The maintenance of balance is important to reduce the risk of falling and prevent premature mortality, negative health and socio-economic burdens (Zisi *et al.*, 2006:111). According to Hassinen *et al.* (2005:303), overweight, central obesity and reduced muscular fitness are associated with impaired balance and walking abilities in the elderly. Muscle fatigue of the lower extremities (knee extensors and ankle plantar flexors) result in a decrease in dynamic balance and increased risk of falls and injury amongst elderly (Rad *et al.*, 2010:148). Women have a strong association between reduced muscle strength and impaired balance (Hassinen *et al.*, 2005:303). Postural sway is the corrective body movement resulting from the control of body position (Rogers *et al.*, 2001:292). The centre of gravity continues to vary positions, in the body even in a still upright position (Rogers *et al.*, 2001:292). Age is associated with an increase in postural sway and decline in functional reach (Demura *et al.*, 2008:196; Hageman *et al.*, 1995:964). According to Islam *et al.* (2004:10), there is an association between a decline in postural balance and functional fitness. These declines that accompany age can limit older adults to perform activities of daily living and restrict their independency (Islam *et al.*, 2004:10). Figure 2.6 indicates the effect of physical inactivity on musculoskeletal changes of the elderly.

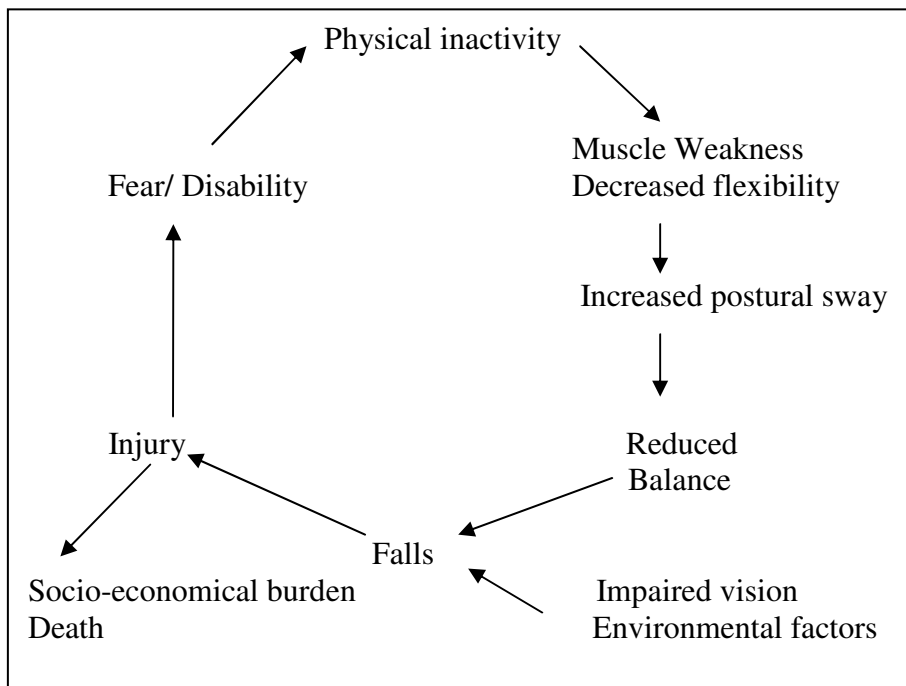


Figure 2.6 Effects of musculoskeletal changes on the elderly's independence

As illustrated in figure 2.6 a physically inactive lifestyle causes a decline in muscle strength and endurance and a decrease in flexibility (Toraman & Ayceman, 2004:567; Kell *et al.*, 2001:866 & 871). These limitations are causes of reduced balance for the elderly (Pijnappels *et al.*, 2008:194). Reduced balance, environmental factors and impaired vision increase the risk of falls among the elderly (Stevens, 2005:37). Falls amongst the elderly contribute to the greatest amount of trauma injuries among elderly. The implication of these injuries can cause a huge socio-economical burden, disability or even death. Injury and falls can also inflict fear amongst elderly which prohibits them from taking part in activities and they maintain a more passive lifestyle as illustrated in figure 2.6 (Keskin *et al.*, 2008:62; Stevens, 2005:36; Stalenhoef *et al.*, 2002:1088).

Above-mentioned musculoskeletal changes and consequences can be altered with regular physical activities. Moderate physical activity can prevent progressive muscle weakness in older adults (Goodpaster *et al.*, 2008:1502). Reeves *et al.* (2006:195) concluded that after a fourteen-week resistance training programme the musculoskeletal system still has the capacity to adapt throughout old age. Older adults participating in resistance training can achieve substantial strength gains as well as enlargement of the gross muscle area (Reeves *et al.*, 2006:195). Developing musculoskeletal fitness via a long-term resistance-training programme can enhance cardiovascular function and musculoskeletal metabolism (Kell *et al.*, 2001:866). Light to moderate intensity resistance training can enhance flexibility in the elderly (Fatouros *et al.*,

2006:641). Flexibility exercises should be done for all the major joints ideally five to seven days a week (ACSM, 2010:250). Decreased flexibility in the major joints is associated with reduced mobility and decreased independency. Increased flexibility is associated with a higher perception of health and a decrease in premature mortality and morbidity rates (Warburton *et al.*, 2001:232). According to Benedetti *et al.* (2008:41) and Balzini *et al.* (2003:1425), a physical exercise programme designed specifically for flexed postures is more effective than non-specific exercise programmes. These programmes should include pectoral, hip flexors and hamstring flexibility and strengthening of the back extensor muscles. Rodgers *et al.* (2001:296) found that postural sway and functional reach can be improved with exercise programmes incorporating stability balls. Islam *et al.* (2004:14) found that physical activity can improve static balance, but did not correlate with dynamic balance. Maejima *et al.* (2009:132) researched the effect of a 31 month exercise programme consisting of walking and comprehensive exercise regimen to improve dynamic balance of senior citizens. Results concluded that dynamic balance improved in the first 7 months and gradually thereafter. De Bruin and Murer (2007:118) observed that a combination of strength and balance exercises improves dynamic postural balance. These improvements may reduce the risk of falling while older adults go about their activities of daily living (Zisi *et al.*, 2006:113; Rodgers *et al.*, 2001:296). Although walking is a practical means for elderly to exercise, it is not effective enough to improve balance and because balance is closely related to falls, it is important to combine walking with balance specific exercises (Yoo *et al.*, 2010:248). Stevens (2005:411) proposes that a multi-component intervention is needed that is specific for needs of the elderly. A multi component exercise routine has many benefits for the elderly including increased flexibility and muscle strength, balance and walking ability (Iwamoto *et al.*, 2009:1239). This intervention should include gait-training, balance training, reducing and/or modifying medication and treating cardiovascular disorders.

2.3 Physical activity and functional fitness amongst elderly

Mazzeo *et al.* (1998:992) categorised the elderly into three groups, based on their chronological age: Old age (65-74 years), very old age (75-84 years) and oldest old age (85 years and older). Chronological aging is not always in conformity with physiological aging. People with the same chronological age may differ extremely in their physiological responses to physical activity and exercise (ACSM, 2010:190). Aging is inevitable, but the rate an individual ages can be modified by lifestyle choices and physiological changes can modify the aging process and increase longevity (Jameson, 2007:4).

Brach *et al.* (2004:502-503) defined physical activity as any bodily movement produced by skeletal muscles that result in an increase in energy expenditure. Physical activity can have great benefits for the older population. Although the elderly population is aware of the benefits physical activity have for them, few of them engage in regular physical activity (Fletcher *et al.*, 2005:101). The elderly are less active because of the presence of disease, fear of injury or previous injuries, social isolation or limited functional capacity (Watanabe *et al.*, 2010:34; Keskin *et al.*, 2008:62; Stevens, 2005:36; Stalenhoef *et al.*, 2002:1088). Elderly with balance impairments have greater and more prolonged sensations of tiredness and similar changes in their gait compared to healthy older adults. This contributes to frailer older people limiting the amount of time spent on physical activities, thereby compromising health and independence. Gait alteration might put them at risk of falling (Egerton *et al.*, 2009:101-102). Elderly engaging in a physically active lifestyle can achieve relatively high levels of cardiovascular, skeletal and metabolic muscle function (Fletcher *et al.*, 2005:104). Declines in physical activity and performances are generally consistent with declines in functional fitness (Rikli & Jones, 1999:163).

As people age physical impairments like muscle weakness and loss of balance could lead to functional limitations. People become unable to perform activities of daily living, like climbing stairs, lifting objects, bending and walking. These disabilities could eventually lead to the elderly losing their independence. This has a social-economic impact on the elderly because they have to spend money on healthcare, medication and even be submitted to institutions. Elderly that were previously independent and part of a social structure have to adapt to new environments and are dependent on others to do their daily tasks. Elderly that participate in physical activities can improve muscle strength, muscle endurance, flexibility and mobility. This could lead to an increase in functions like walking, bending, lifting objects and reaching. Physical activity, therefore, contributes to greater independency and quality of life amongst the elderly (Figure 2.7).

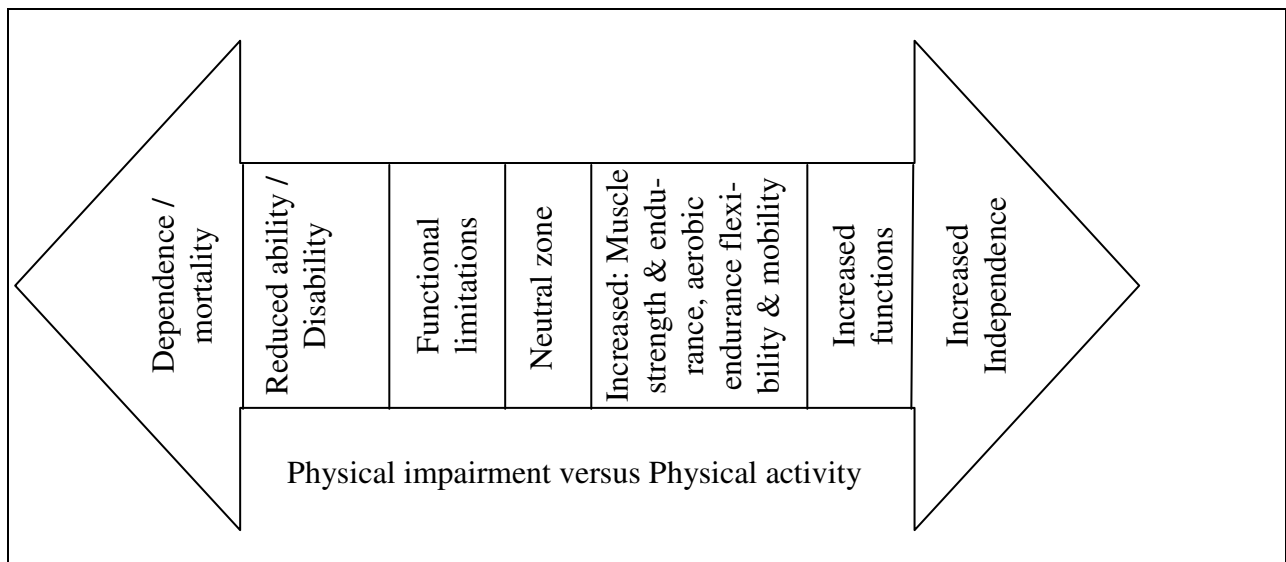


Figure 2.7: Functional fitness continuums (Rikli & Jones, 2002:25)

A test battery, namely the Fullerton’s Functional fitness test was developed to evaluate older adult’s functional fitness (Rikli & Jones, 2002:25). Rikli and Jones (1999:163) defined functional fitness as having the physiologic capacity to perform normal everyday activities safely and independently without undue fatigue. This functional fitness test presumes that you require certain functional movements (for example climbing stairs, carrying objects, bending forward) to perform your everyday activities (for example personal care, shopping, housework) as illustrated in table 2.5. To be able to perform these functional movements a person has to rely on sufficient physiological reserves (i.e. flexibility, strength, endurance, balance) (Rikli & Jones, 2002:25).

Table 2.5: Functional ability framework (Rikli & Jones, 2002:25).

Physical parameters	Functions	Activity goals
<ul style="list-style-type: none"> • Muscle strength/endurance • Aerobic endurance • Flexibility • Motor ability, power, speed/agility, balance • Body composition 	<ul style="list-style-type: none"> • Stair climbing • Standing up from chair • Walking • Jog/run • Lifting/reaching • Bending/kneel 	<ul style="list-style-type: none"> • Personal care • Errands • Housework • Gardening • Sports • Traveling
Physical impairment	Functional limitations	Reduced ability/Disability

2.4 Test Battery

Few fitness instructors conduct physical assessments on the elderly in a community setting. Reasons for this include lack of time, space, budget constraints, lack of requirements by facility management, lack of personnel resources, lack of appropriate assessment tools for the wide

range of functional levels, and lack of training on conducting and interpreting test scores (Jones & Rikli, 2000:195). The assessment of functional fitness can have mutual benefits for the older adult as well as the instructor (Jones & Rikli, 2000:195). Benefits include effective exercise prescriptions, identifying and predicting people at risk for loss of physical independency, set personal goals, provide feedback and it is an effective method to recruit participants (Jones & Rikli, 2000:195).

The aim for developing functional fitness tests for older adults was to assess underlying physical parameters associated with functional mobility (Jones & Rikli, 2000:195). The functional fitness tests and static and dynamic balance tests include:

2.4.1 Lower body strength:

Lower body strength is determined with the thirty-second-chair stand. The total number of times a participant stands up and sits down from a chair in 30 seconds is counted (Rikli & Jones, 2002:29). Lower body strength is necessary for everyday activities like walking, getting up from a chair or climbing stairs.

2.4.2 Upper body strength:

Upper body strength is measured by counting the number of arm curls completed in 30 seconds with a 2.27 kg dumbbell for women and a 3.63 kg dumbbell for men (Rikli & Jones, 2002:29). Upper body strength is important for activities such as picking up and carrying around objects and pushing heavy objects.

2.4.3 Aerobic endurance:

The six-minute walk test is used to assess aerobic endurance, which is important for walking long distances. Walking is important for the elderly for daily activities such as shopping and socializing. The distance (m) an individual can walk in six minutes around a course are measured (Rikli & Jones, 2002:29). If there is insufficient space to perform the six-minute walk test the participants can do a two-minute step test (Rikli & Jones, 2000:196).

The two-minute step test is an alternative aerobic endurance test. The instructor counts the number of steps the participant completes in two minutes. The participant should raise his knee to a mark midway between his patella and iliac crest (Rikli & Jones, 2002:29).

2.4.4 Lower body flexibility:

Lower body flexibility is measured by the chair sit and reach test. The participant stretches forward towards his/her toes while seated (Rikli & Jones, 2002:29). If the participants exceed their toes they will obtain a positive score and if their reach is too short they will have a negative score. Lower body flexibility is not only necessary for the prevention of injuries but also daily activities like tying shoe laces or reaching for the ground to pick up objects.

2.4.5 Upper body flexibility:

Upper body flexibility is measured by using the back scratch test. The participant places his one arm in full abduction and external rotation with palm against the back. With the other arm the participant adducts the arm with medial rotation with the dorsal side of the hand against the back. The participant will attempt to touch the extended middle fingers of both hands and the distance is measured in centimetres (Rikli & Jones, 2002:30). Upper body flexibility is needed to perform daily tasks such as combing hair, or bathing one's self.

2.4.6 Dynamic balance and motor ability:

Motor ability and balance is determined by the "eight foot-up and go" test. Participants get up from a chair and walk as quickly as possible around either side of a cone placed eight feet away from the chair and return to sit on the chair again. The number of seconds needed to complete the test is measured (Rikli & Jones, 2002:30). Dynamic balance and motor ability is necessary to perform daily activities such as getting up from a chair, reaching forward and it reduces the risk of injury by means of tripping and falling over.

2.4.7 Static balance testing:

Static balance is tested doing a one-leg balance with eyes closed. The participants rest their hands on their hips while standing on one leg. When a signal is given the participant will close his or her eyes. The test will be scored based on the number of seconds the individual can keep his/her foot off the ground or before the person loses his/her balance (Islam *et al.*, 2004:10). Static balance enables elderly to stand and work without the fear that they might fall and injure themselves. With good static balance and strength elderly can rely less on canes or other mechanisms for mobility and performing daily activities.

2.4.8 Dynamic Balance testing:

A functional reach test is used to determine the dynamic balance. A functional reach scale will be placed against a wall horizontal to the floor. The functional reach scale should be shoulder

height for the participants. Participants stand next to the wall with their feet together and their arms flexed horizontally in front of them. Their fingertips are at the 0 centimetre level of the scale. The participants reach forward as far as possible with their heels remaining on the ground. The distance in centimetres is measured (Islam *et al.*, 2004:10). Dynamic balance is very important for mobility of the elderly. Dynamic balance influences every task the elderly does in movement. When dynamic balance is inadequate, the elderly will find it harder to perform simple tasks such as reaching forward, walking, climbing stairs or carrying bags, and risk of falling increases.

2.5 Physical activity intervention and functional fitness

Toraman *et al.* (2004:538) conducted research to evaluate the effect of a multi-component training programme on functional fitness in older adults. Forty two older adults between the ages of 60-86 years were divided into a control group (n=21) and an exercise group (n=21). The exercise group and the control group did not differ in their baseline functional fitness measurements except for the six minute walk test (Toraman *et al.*, 2004:544). After the nine week multi-component training programme there was a significant improvement in the exercise group regarding the chair stand, arm curl, six minute walk and 8ft up and go tests (Toraman *et al.*, 2004:547). They concluded that functional fitness can be enhanced by moderate physical training (Toraman *et al.*, 2004:550). Toraman and Ayceman (2005:567) found that after only six weeks of detraining, functional fitness scores were lower than after a nine week multi-component exercise programme. These declines were also age dependant, hence the older participants had a more rapid decline in certain functional fitness components than the younger old participants (Toraman & Ayceman, 2005:257). Cavani *et al.* (2002:443) studied the effects of a six week resistance and flexibility programme on functional fitness. Participants between the ages of 60-79 years were divided into an exercise group (n=22) and a control group (n=15). The exercise group only performed one set of 12-15 repetitions for various muscle groups and 20 minutes of stretching, two to three days a week (Cavani *et al.*, 2002:444). These moderate intensity exercises were sufficient to obtain better functional fitness results within the six weeks of training (Cavani *et al.*, 2002:448). Research done by Nakamura *et al.* (2007:171) concluded that participation in exercise only twice a week is not sufficient to improve functional fitness amongst elderly. The elderly should participate in exercise at least three times a week for functional fitness benefits (Nakamura *et al.*, 2007:171). According to the ACSM, (2010:193), elderly should perform moderate intensity cardiorespiratory exercise most days of the week. Vigorous exercise should be performed two to three days a week (ACSM, 2010:193)

Rikli and Jones (1999:162) conducted a nation wide study to develop normative performance data of functional fitness for older adults. The study sample consisted out of 7183 participants (5048 women and 2135 men) aged between 60 and 94 (Rikli & Jones, 1999:165). Participants completed the functional fitness tests and their BMI were also calculated (Rikli & Jones, 1999:164). The data were divided into five year age groups for men and women separately (Table 6 and Table 7). Rikli and Jones (1999:178) concluded that the data provide information about variations within different age groups. The data can provide a tool for assessment of individuals or groups to determine their functional capacity. The normal ranges of the normative scores are defined as the middle (50%) of the population. Those participants scoring above this range would be considered above average for their age and those scoring below the ranges are considered below average (Rikli & Jones, 1999:164). Normal ranges of functional fitness test scores for men as illustrated in table 2.6 and those applicable to women in table 2.7.

Table 2.6: Normal ranges of functional fitness test scores for men (Rikli & Jones, 1999:164).

Normal range of scores for men							
	60-64	65-69	70-74	75-79	80-84	85-89	90-94
Chair stand (no. of stands)	14-19	12-18	12-17	11-17	10-15	8-14	7-12
Arm curl (no. of reps)	16-22	15-21	14-21	13-19	13-19	11-17	10-11
6 minute walk (no. of yards)	610- 735	560- 700	545- 680	470- 640	445- 605	380- 570	305- 500
2 minute step (no. of steps)	87-115	86-116	80-110	73-109	71-103	59-91	52-86
Chair sit and reach (inches +/-)	-2.5- +4.0	-3.0- +3.0	-3.5- +2.5	-4.0- +2.0	-5.5- +1.5	-5.5- +0.5	-6.5- +0.5
Back scratch (inches +/-)	-6.5- +0.0	-7.5- -1.0	8.0- -10	-9.0- -2.0	-9.5- -2.0	-10- -3.0	-10.5- -4.0
8 foot up and go (seconds)	5.6-3.8	5.7-4.3	6.0-4.2	7.2-4.6	7.6-5.2	8.9-5.3	10.0- 6.2

Table 2.7: Normal ranges of functional fitness test scores for women (Rikli & Jones, 1999:164).

Normal range of scores for women							
	60-64	65-69	70-74	75-79	80-84	85-89	90-94
Chair stand (no. of stands)	12-17	11-16	10-15	10-15	9-14	8-13	4-11
Arm curl (no. of reps)	13-19	12-18	12-17	11-17	10-16	10-15	8-13
6 minute walk (no. of yards)	545-660	500-635	480-615	430-585	385-540	340-510	275-440
2 minute step (no. of steps)	75-107	73-107	68-101	68-100	60-91	55-85	44-72
Chair sit and reach (inches +/-)	-0.5-+5.0	-0.5-+4.5	-1.0-+4.0	-1.5-+3.5	-2.0-+3.0	-2.5-+2.5	-4.5-+1.0
Back scratch (inches +/-)	-3.0-+1.5	-3.5-+1.5	-4.0-+1.0	-5.0-+0.5	-5.5-+0.0	-7.0-+1.0	-8.0-+1.0
8 foot up and go (seconds)	6.4-4.4	6.4-4.8	7.1-4.9	7.4-5.2	8.7-5.7	9.6-6.2	11.5-7.3

2.6 Summary

The literature predicts that the senior population continues to grow worldwide, which will have a huge socio-economical impact on the lives of the elderly, their caretakers as well as countries in the future. In South Africa the number of senior citizens is growing, while the number of working class people is decreasing. With senior citizens getting older they would have to stay financially independent and physically fit for longer in order to provide for themselves and people dependent on them.

The physiological changes accompanied by aging are the biggest hurdle the elderly face. This includes the deterioration of the cardiovascular system, respiratory system, body composition, musculoskeletal system and balance. These changes cause illness and frailty that could eventually result in the elderly losing their functional capacity and independence. Although physiological changes are inevitable these changes could be delayed or even reversed by changing behaviours and making good lifestyle choices.

Physical activities have various benefits for the elderly. As mentioned earlier, moderate exercise can delay or reverse the onset of physiological changes that accompany aging. Physical activity enhances aerobic endurance, muscle strength and muscle endurance, flexibility and balance as well as the health profile. Thus physical activity can enhance independence as well as functional wellbeing. The literature indicates that physical activity is closely related to functional fitness

and functional fitness can be linked to the independence of the elderly. The components (flexibility, muscle strength and endurance, agility and balance and aerobic endurance) of functional fitness that have been identified by Rikli and Jones which are necessary for completing daily activities can easily be modified by moderate intensity exercises. Inevitably the effects of physical activity can reduce medical costs, dependence on caregivers and delay morbidity and mortality.

The South African population is very diverse and different ethnic groups struggle with their own health risks and these problems propose challenges to the communities and government. In certain cultures and communities it becomes the responsibility of children to tend to senior citizens and this can put economical strain on families. Therefore it is important for the elderly to be functionally fit and independent so that family and community members can spend more time generating an income and less time tending to the elderly. It is also important that functional fitness be tested amongst various ethnic groups in South Africa, for normal ranges to be developed and an awareness campaign about physical activity for senior citizens can be launched. This is important for the development of future strategies for the welfare of senior citizens and their communities.

It is of importance for every country to predict the future growth of its elderly population, identify associated risks and present a strategic action plan accordingly. Medical professions play an important role in the wellbeing of the elderly population. This aging trend creates an excellent opportunity for example, for the Biokinetics profession to assess the functional fitness and physical activity levels of the elderly, and implement exercise interventions to lessen dependency of the older population.

References

AMERICAN COLLEGE OF SPORTS MEDICINE. 2010. ACSM's Guidelines for exercise testing and prescription. 8th Ed. Philadelphia: Lippincott, Williams & Wilkins. 366 p.

AMERICAN COLLEGE OF SPORTS MEDICINE. 2006. ACSM's Resource manual for guidelines for exercise testing and prescription. 5th Ed. Philadelphia: Lippincott, Williams & Wilkins. 749 p.

BALZINI, L., VANNUCCHI, L., BENVENUTI, F., BENUCCI, M., MONNI, M., CAPPOZZO, A. & STANHOPE, S.J. 2003. Clinical characteristics of flexed posture in elderly women. *Journal of the American Geriatric Society*, 51(10): 1419-1426.

BENEDETTI, M.G., BERTI, L., PRESTI, C., FRIZZIERO, A. & GIANNINI, S. 2008. Effects of an adapted physical activity program in a group of elderly subjects with flexed posture: clinical and instrumental assessment. *Journal of neuroengineering and rehabilitation*, 25(5):32-42, Nov.

BOREL, J., VERGES, S., PEPIN, J., VIVODTZEV, I., LEVY, P. & WUYAM, B. 2009. Home exercise training with non-invasive ventilation in thoracic restrictive respiratory disorders: A randomized study. *Respiratory physiology and neurobiology*, 167(2):168-173, March

BRACH, J.S., SIMONSICK, E.M., KRITCHEVSKY, S., YAFFE, K. & NEWMAN, A.B. 2004. The association between physical function and lifestyle activity and exercise in the health, aging and body composition study. *Journal of American geriatric society*, 52(4):502-509, April.

BURT, V.L., CUTLER, J.A. & HIGGINS, M. 1995. Trends in the prevalence, awareness, treatment and control of hypertension in the adult US population. Data from the Health examination surveys. 1960 to 1991. *Hypertension*, 26(1):60-69.

CASILGLIA, E., MAZZA, A., TIKHONOFF, V., SCARPA, R., SCHIAVON, L. & PESSINA, A.C. 2003. Total cholesterol and mortality in the elderly. *Journal of Internal Medicine*, 254(4):353-362.

- CAVANI, V., MIER, C.M., MUSTO, A.A. & TUMMERS, N. 2002. Effects of a 6-week resistance-training program on functional fitness of older adults. *Journal of Aging Physical Activity*, 10:443-452.
- CHU, L.W., PEI, C.K. & CHIU, A. 1999. Risk factors for falls in hospitalised older medical patients. *Journal of Gerontology, Series A: Biological Sciences and Medical Sciences*, 54:M38-M43.
- COIN, A., SERGI, G., MINICUCI, N., GIANNINI, S., BARBIERO, E., MANZATO, E., PEDRAZZONI, M., MINISOLA, S., ROSSINI, M., DEL PUENTE, A., ZAMBONI, M., INELMAN, E.M. & GIULIANO, E. 2008. Fat-free mass and fat mass reference values by dual-energy X-ray absorptiometry (DEXA) in a 20 – 80 year-old Italian population. *Clinical Nutrition*, 27(1): 87-94, Oct.
- CRISTOPOLISKI, F., ANGELO BARELA, J. LEITE, N., FOWLER, N.E. & FELIX RODACKI, A.L. 2009. Stretching exercise program improves gait in the elderly. *Gerontology*, 55(6):614–620, August.
- CURB, J.D., ABBOTT, R.D., RODRIQUEZ, B.L., MASAKI, K., POPPER, J., CHEN, R., PETROVITCH, H., BLANCHETTE, P., SCHATZ, I. & YANO, K. 2004. Prospective association between low and high total and low-density lipoprotein cholesterol and coronary heart disease in elderly men. *Journal of the American Geriatric Society*, 52(12):1975-1980.
- DE BRUIN, E.D. & MURER, K. 2007. Effects of additional functional exercises on balance in elderly people. *Clinical Rehabilitation*, 21(2):112-121, July.
- DELERME, S. & RAY, P. 2008. Acute respiratory failure in the elderly: diagnosis and prognosis. *Age and aging*, 37(3):251-257, April.
- DEMURA, S., KITABAYASHI, T. & AOKI, H. 2008. Body-sway characteristics during a static upright posture in the elderly. *Geriatrics and gerontology*, 8(3): 188-197, April.
- DEPARTMENT OF HEALTH. 2001. National service framework for older People. London: The stationery Office. 1 p.

- DEWAN, S. & WILDING, J.P.H. 2003. Obesity and type-2 diabetes in the elderly. *Gerontology*, 49(3):137-145.
- DOUCET, J., DRUESNE, L., CAPET, C., GREBOVAL, E., LANDRIN, I., MOIROT, P. & MICAUD, G. 2008. Risk factors and management of diabetes in elderly French patients. *Diabetes and Metabolism*, 34(6 Pt 1):574-580, Oct.
- EDWARD, G. & LAKATTA, M.D. 2007. Central arterial aging and the epidemic of systolic hypertension and atherosclerosis. *Journal of the American Society of Hypertension*, 1(5):302-340, May.
- EGERTON, T., BRAUER, S.G. & CRESSWELL, A.G. 2009. Fatigue after physical activity in healthy and balance-impaired elderly. *Journal of Aging and Physical Activity*, 17(1):89-105.
- EHRMAN, J.K., GORDON, P.M., VISICH, P.S. & KETEVIAN, S.J. 2003. Clinical exercise physiology. Champaign, IL, USA. Human Kinetics. 617 p.
- ERWIN, G., IYER, S., RAJAGOPALAN, R., ASTUTO, J., WILSON, P., SCHANEMAN, J. & KLEINMAN, N. 2006. Type 2 diabetes mellitus treatment patterns and healthcare cost in the elderly population. *Dis manage health outcomes*, 14(2):76-83.
- FATOUROS, I.G., KAMBRAS, A., KATRABASAS, I., LEONTSINI, D., CHATZINIKOLAOU, A., JAMURTAS, A.Z., DOUROUDOS, I., AGGELOUSIS, N. & TAXILDARIS, K. 2006. Resistance training and detraining effects on flexibility performance in the elderly are intensity-dependent. *Journal of strength and conditioning research*, 20(3): 634-642.
- FLETCHER, B.J., GULANICK, M. & BRAUN, L.T. 2005. Physical activity and exercise for elders with cardiovascular disease. *Medsurg Nursing*, 14(2):101-110, April.
- GOODPASTER, B.H., CHOMENTOWSKI, P., WARD, B.K., ROSSI, A., GLYNN, N.W., DELMONICO, M.J., KRITCHEVSKY, S.B., PAHOR, M. & ANNE B. NEWMAN, A.B. 2008. Effects of physical activity on strength and skeletal muscle fat infiltration in older adults: a randomized controlled trial. *Journal of Applied Physiology*, 105(5):1498-1503, Sept.

HAGEMAN, P.A., LEIBOWITZ, J.M. & BLANKE, D. 1995. Age and gender effects on postural control measures. *Archives of the physical medical rehabilitation*, 76(10): 961-965.

HÄKKINEN, A., KUKKA, A., ONATSUS, T., JÄRVENPÄÄ, S., HEINONEN, A., KYRÖLÄINEN, H., TOMAS-CARUS, P. & KALLINEN, M. 2009. Health-related quality of life and physical activity in persons at high risk for type 2 diabetes. *Disability and Rehabilitation*, 31(10): 799–805, July.

HARROD, K.H. 2005. Epithelial pathogen interactions in the aged lung. Lovelace Respiratory institute, Albuquerque, NM, USA. 79p.

HASSINEN, M., KOMULAINEN, P., LAKKA, T.A., VAISANEN, S.B. & RAURAMAA, R. 2005. Associations of body composition and physical activity with balance and walking ability in the elderly. *Journal of physical activity and health*, 2(3): 298-306.

HOUSTEN, D.K., NICKLAS, B.J. & ZIZZA, C.A. 2009. Weight concerns: the growing prevalence of obesity among older adults. *Journal of American dietetic association*, 109(11): 1886-1895.

HOUTERMAN, S., VERSCHUREN, W.M.M., HOFMAN, A. & WITTEMAN, J.C.M. 1999. Serum cholesterol is a risk factor for myocardial infarction in elderly men and women: the Rotterdam study. *Journal of Internal Medicine*, 246(1):25-33.

HU, F.B., SIGAL, R.J., RICH-EDWARDS, J.W., GOLDITZ, G.A., SOLOMON, C.G., WILLETT, W.C., SPEIZER, F.E. & MANSON, J.E. 1999. Walking compared with vigorous physical activity and risk of type 2 diabetes in women: A prospective study. *Journal of American medical association*, 282(15):1433-1439, Oct.

HUHN, V., HALLE, M., SCHMIDT-TRUCKSASS, A., RATHMANN, W., MEISINGER, C. & MIELCK, A. 2009. Physical activity and the metabolic syndrome in elderly German men and women: Results from the population-based KORA survey. *Diabetes Care*, 32(3):511–513, March.

ISLAM, M.M., TAKESHIMA, N., ROGERS, M.E., KOIZUMI, D. & ROGERS, N.L. 2004. Relationship between balance, functional fitness, and daily physical activity in older adults. *Asian Journal of exercise and Sport Science*, 1(1): 9-18.

IWAMOTO, J., SUZUKI, H., TANAKA, K., KUMAKUBO, T., HIRABAYASHI, H., MIYAZAKI, Y., SATO, Y., TAKEDA, T & MATSUMOTO, H. 2009. Preventative effect of exercise against falls in the elderly: a randomized controlled trial. *Osteoporos International*, 20(7):1233–1240.

JAMESON, J.R. 2007. Healthcare for an aging population. China. Churchill Livingstone Elsevier. 335 p.

JENSEN, D., OFIR, D. & O'DONNELL, D.E. 2009. Effects of pregnancy, obesity and aging on the intensity of perceived breathlessness during exercise in healthy humans. *Respiratory physiology & Neurobiology*, 167(1):87-100: 1-14, Jan.

JONES, C.J. & RIKLI, R.E. 2000. The application of Fullerton's fitness Test for older adults in a group setting. *Science & Sport*, 15:194-197.

JOUBERT, J. & BRADSHAW, D. 2009. Population aging and health challenges in South Africa. [Web:] www.mrc.ac.za/chronic/cdlchapter15.pdf [Date of use: 20 March 2010].

KARAMANIDIS, K., ARAMPATZIS, A. & MADEMLI, L. 2008. Age-related deficit in dynamic stability control after forward falls is affected by muscle strength and tendon stiffness. *Journal of Electromyography and Kinesiology*, 18(6): 980–989.

KELL, R.T., BELL, G. & QUINNEY, A. 2001. Musculoskeletal fitness, health outcomes and quality of life. *Sports Medicine*, 31(12):863-873.

KESKIN, D., BORMAN, P., ERSOZ, M., KURTARAN, A., BODUR, H. & AKYUZ, M. 2008. The risk factors related to falling in elderly females. *Geriatric Nursing*, 29(1):58-63.

KNIGHT, S., BERMINGHAM, M.A. & MAHAJAN, D. 1999. Regular non-vigorous physical activity and cholesterol levels in the elderly. *Gerontology*, 45(4):213-219, Nov.

- KONNO, K., KATSUMATA, Y., ARAI, A. & TAMASHIRO, H. 2004. Functional status and active life expectancy among senior citizens in a small town in Japan. *Archives of gerontology and geriatrics*, 38(2): 153-166, Sept.
- KOSTIC, R., MLADENOVIC, I. & MIKALACKI, M. 2007. The relation between physical/functional fitness and the blood pressure of elderly men and women. *Physical Education and Sport*, 5(1): 75-84, Dec.
- KYLE, U.G., GENTON, L., GREMION, G., SLOSMAN, D.O. & PICHARD, C. 2004. Aging, physical activity and height-normalized body composition parameters. *Clinical Nutrition*, 23(1):79-88, May.
- KYLE, U.G., MORABIA, A., SCHULTZ, Y. & PICHARD, C. 2004. Sedentarism affects body fat mass index and fat-free mass index in adults aged 18 to 98 years. *Nutrition*, 20(3):255-260.
- LANDI, F., RUSSO, A., PAHOR, M. CAPOLUONGO, E. LIPEROTI, R., CESARI, M., BERNABEI, R. & ONDER, G. 2008. Serum high-density lipoprotein cholesterol levels and mortality in frail, community-living elderly. *Gerontology*, 54(2):71-78, Sept.
- LLOYD-SHERLOCK, P. 2000. Population ageing in developed and developing regions: implications for health policy. *Social science and medicine*, 51(6):887-895.
- MAEJIMA, H., SUNAHORI, H., OTANI, T., SAKAMOTO, N., YOSHIMURA, O & TOBIMATSU, Y. 2009. Effect of long-term, community-based daily exercise on the ability to control the dynamic standing balance of Japanese elderly persons in relation to falls. *Nursing and Health Sciences*, 11(2): 128-134.
- MARQUES, E., CARVALHO, J., SOARES, J.M.C., MARQUES, F. & MOTA, J. 2009. Effects of resistance and multi-component exercise on lipid profiles of older women. *Maturitas*, 63(1):84-88, March.
- MASLEY, S.C., PHILLIPS, S.E. & SCHOCKEN, D.D. 2006. Blood pressure as a predictor of cardiovascular events in the elderly: The William Hale research program. *Journal of human Hypertension*, 20(6):392-397, Jan.

- MAZZA, A., TIKHONOFF, V., SCHIAVON, L. & CASIGLIA, E. 2005. Triglycerides + high-density-lipoprotein-cholesterol dyslipidaemia, a coronary risk factor in elderly women: the Cardiovascular Study in the Elderly. *International medicine journal*, 35(10): 604-610. Oct.
- MAZZEO, R.S., CAVANAGH, P., EVANS, W.J., FIATARONE, M., HAGBERG, J., MCAULEY, E. & STARZELL, J. 1998. Exercise and physical activity for older adults. Position stand. *Medicine and science in sports and exercise*, 30(6): 992 – 1008, June.
- MESSERLI, F.H., WILLIAMS, B. & RITZ, E. 2007. Essential hypertension. *Lancet*, 370(9587): 591 – 603, Aug.
- MELZER, I., BENJUYA, N. & KAPLANSKI, J. 2003. Effects of regular walking on postural stability in the elderly. *Gerontology*, 49(4):240-245, Aug.
- MENDIS, M.D., HIDES, J.A., WILSON, S.J., GRIMALDI, A., BELAVY, D.L., STANTON, W., FELSEMBERG, D., RITTWEGER, J. & RICHARDSON, C. 2009. Effect of prolonged bed rest on the anterior hip muscles. *Gait and posture*, 30(4): 533-537, Aug.
- NAKAMURA, Y., TANAKA, K., YABUSHITA, N., SAKAI, T. & SHIGEMATSU, R. 2007. Effects of exercise frequency on functional fitness in older adult women. *Archives of gerontology and geriatrics*, 44(2):163-173, May.
- OSTROWSKA, B., ROZEK-MROZ, K. & GIEMZA, C. 2003. Body posture in elderly, physically active males. *The aging male*, 6(4):222-229.
- PETERSON, L.R., RINDER, M.R., SCHECHTMAN, K.B., SPINA, R.J., GLOVER, K.L., VILLAREAL, D.T. & EHSANI, A.A. 2003. Peak exercise stroke volume: associations with cardiac structure and diastolic function. *Journal of applied physiology*, 94(3): 1108-1114, Nov.
- PETERSON, L.D. & RAY, K.K. 2007. Achieving LDL cholesterol goals in elderly patients with ACS. *Cardiology review*, 24(9):27-30, Sept.
- PIJNAPPELS, M., REEVES, N.D. & VAN DIEËN, J.H. 2008. Tripping without falling; lower limb strength, a limitation for balance recovery and a target for training in the elderly. *Journal of Electromyography and Kinesiology*, 18(2):188-196, Feb.

POWERS, S.K. & HOWLEY, E.T. 2007. Exercise physiology: Theory and application to fitness and performance. 6th ed. Hong Kong. The McGraw-Hill Inc. 540p.

RAD, A.G., ABDOLVAHHABI, Z. & ZADEHI, N.G. 2010. The effects of ankle plantar flexor and knee extensor muscles fatigue on dynamic balance of the female elderly. *Ovidius University Annals, Series Physical Education & Sport/Science, Movement & Health*, 10(2): 143 -148.

RAGUSO, C.A., KYLE, U., KOSSOVSKY, M.P., ROYNETTE, C., PAOLONI-GIACOBINO, A., HANS, D., GENTON, L. & PICHARD, C. 2006. A 3-year longitudinal study on body composition changes in the elderly: Role of physical exercise. *Clinical nutrition*, 25(4): 573-580, Oct.

REEVES, N.D., NARICI, M.V. & MAGANARIS, C.N. 2006. Musculoskeletal adaptations to resistance training in old age. *Manual Therapy*, 11(3):192-196, April.

RIKLI, E.R. & JONES, J.C. 1999. Functional fitness normative scores for community-residing older adults, ages 60-94. *Journal of Aging and Physical Activity*, 7(2):162-181.

RIKLI, E.R. & JONES, J.C. 2002. Measuring functional fitness of older adults. *The Journal of active aging*, 1:24-30, March/April.

RITTWEGER, J. & FELSEMBERG, D. 2009. Recovery of muscle atrophy and bone loss from 90 days bed rest: Results from a one-year follow-up. *Bone*, 44(2):214-224, Oct.

RITTWEGER, J., FROST, H.M., SCHIESSL, H., OHSHIMA, H., ALKNER, B., TESCH, P. & FELSEMBERG, D. 2005. Muscle atrophy and bone loss after 90 days' bed rest and the effects of flywheel resistive exercise and pamidronate: Results from the LTBR study. *Bone*, 36 (6): 1019-1029, April.

RODRIGUEZ, D., FERNANDES DA COSTA, R., VIEIRA, A.S., GIROLAMO, L., RAYMUNDI, L.Y., GUISELILI, M. & PONTES, F.L. 2008. Efficiency of two sessions of jogging per week for the reduction of the blood pressure in previously sedentary elderly hypertensive women. *Fitness performance Journal*, 7(3):169-174, May/June.

- ROGERS, M.E., FERNANDEZ, J.E. & BOHLKEN, R.M. 2001. Training to reduce postural sway and increase functional reach in the elderly. *Journal of Occupational Rehabilitation*, 11(4):291-298.
- ROSSI, A., FANTIN, F., FRANCISCO, V.D., GUARIENTO, S., GIULIANO, K., FONTANA, G., MICCIOLO, R., SOLERTE, S.B., BOSELLO, O. & ZAMBONI, M. 2008. Body composition and pulmonary function in the elderly: a 7-year longitudinal study. *International journal of obesity*, 32(9):1423-1430, June.
- SHARKEY, B.J. & GASKILL, S.E. 2007. Fitness and health. 6th ed. Champaign, IL, USA. Human Kinetics. 428 p.
- STALENHOEF, P.A., DIEDRIKS, J.P.M., KNOTTNERUS, J.A., KESTER, A.D.M. & CREBOLDER, H.F.J.M. 2002. A risk model for the prediction of recurrent falls in community-dwelling elderly: A prospective cohort study. *Journal of Clinical Epidemiology*, 55(11):1088-1094, Aug.
- STEVENS, J.A. 2005. Falls amongst older adults – risk factors and prevention strategies. *Journal of Safety Research*, 36(4):409-411, Oct.
- STRATTON, J.R., LEVY, W.C., CERQUEIRA, M.D., SCHWARTZ, R.S. & ABRASS, I.B. 1994. Cardiovascular responses to exercise. Effects of aging and exercise training in healthy men. *Circulation*, 89(4):1648-1655, Jan.
- SUMMERHILL, E.M. & ANGOV, N. 2007. Respiratory muscle strength in the physically active elderly. *Lung*, 185(6):315-320, Oct.
- TAAFFE, D.R. & MARCUS, R. 2000. Musculoskeletal health and the older adult. *Journal of rehabilitation research and development*, 37(2): 245-254, March/April.
- TALBOT, L.A., MORRELL, C.H., METTER, E.J. & FLEG, J.L. 2002. Comparison of cardio-respiratory fitness versus leisure time physical activity as predictors of coronary events in men aged ≤ 65 years and > 65 years. *The American journal of cardiology*, 89(10):1187-1192, May.

TANAKA, K., SHIGEMATSU, R., NAKAGAICHI, M., KIM, H. & TAKESHIMA, N. 2000. The relationship between functional fitness and coronary heart disease risk factors in older Japanese adults. *Journal of aging and physical activity*, 8(2):162-174.

TAYLOR, A.H., CABLE, N.T., FAULKNER, G., HILLSON, M., NARICI, M. & VAN DER BINJ, A.K. 2004. Physical activity and older adults: a review of health benefits and the effectiveness of interventions. *Journal of sports sciences*, 22(8):703-725, June.

TORAMAN, N.F., ERMAN, A. & AGYAR, E. 2004. Effects of multicomponent training on functional fitness in older adults. *Journal of aging and physical activity*, 12(4):538-553.

TORAMAN, N.F. & AYCEMAN, N. 2005. Effects of six weeks of detraining on retention of functional fitness of old people after nine weeks of multicomponent training. *British Journal of Sports Medicine*, 39(8):565-568, Dec.

TUIKKALA, P., HARTIKAINEN, S., KORHONEN, M.J., LAVIKAINEN, P., KETTUNEN, R., SULKAVA, R. & ENLUND, H. 2010. Serum total cholesterol levels and all-cause mortality in a home-dwelling elderly population: a six-year follow-up. *Scandinavian Journal of Primary Health Care*, 28(2): 121 – 127, April.

VELKOFF, V.A. & KOWAL, P.R. 2007. Population aging in Sub-Saharan Africa: Demographic dimensions 2006. [Web:] <http://www.census.gov/prpd/2007pubs/p95-7-1.pdf> [Date of use: 6 Aug. 2009].

VELKOFF, V.A. & LAWSON, V.A. 1998. Gender and aging: caregiving. [Web:] <http://www.census.gov/ipc/prod/ib-9803.pdf> [Date of use 10 Jan. 2010].

WATANABE, H., URABE, K., TAKAHIRA, N., IKEDA, N., FUJITA, M., OBARA, S., HENDONA, T., AIKAWA, J. & ITOMAN, M. 2010. Quality of life, knee function, and physical activity in Japanese elderly women with early stage knee osteoarthritis. *Journal of orthopaedic surgery*, 18(1):31-34, April.

WANNAMETHEE, A.G., SHAPER, A.G. & WHINCUP, P.H. 2005. Body fat distribution, body composition, and respiratory function, in elderly men. *The American journal of clinical nutrition*, 82(5):996-1003, Oct.

- WARBURTON, D.E.R., GLEDHILL, N. & QUINNEY, A. 2001. Musculoskeletal fitness and health. *Canadian journal of applied physiology*, 26(2):217-237.
- WATSFORD, M. & MURPHY, A. 2008. The effects of respiratory muscle training on exercise in older women. *Journal of aging and physical activity*, 16(3):245-260.
- WONG, N.D., LOPEZ, W.A., ROBERTS, G.S., SOLOMON, H.A., BURKE, G.L., KULLER, L., TRACY, R., YANEZ, D. & PSATY, B.P. 2010. Combined association of lipids and blood pressure in relation to incident cardiovascular disease in the elderly: the cardiovascular health study. *American journal of hypertension*, 23(2): 161-167, Feb.
- YOO, E.J., JUN, T.W. & HAWKINS, S.A. 2010. The effects of a walking exercise program on fall-related fitness, bone metabolism, and fall-related psychological factors in elderly women. *Research in Sports Medicine*, 18(4): 236-250, May.
- ZHAO, G., FORD, E.S., LI, C. & BALLUZ, L.S. 2011. Physical activity in U.S. older adults with diabetes mellitus: prevalence and correlates of meeting physical Activity recommendations. *Journal of the American Geriatric Society*, 59(1): 132 – 137, Jan.
- ZISI, V., THEODORAKIS, Y., SKONDRAS, G. & NATSIS, P. 2006. The relation of balance performance and balance confidence with physical activity in elderly fallers and non-fallers. *Studies in physical culture and tourism*, 13:111-114.
- ZULIANI, G., ROMAGNONI, F., BOLLINI, C., LEOCI, V., SOATTIN, L. & FELLIN, R. 1999. Low levels of high-density lipoprotein cholesterol are a marker of disability in the elderly. *Gerontology*, 45(6):317-322, March.

Chapter 3

Functional fitness and balance status in a geriatric cohort.

Authors: Volschenk, A., Bruwer, E.J. & Moss, S.J.

Physical activity, Sport and Recreation in School for Biokinetics, Recreation and Sport Science,
North-West University (Potchefstroom Campus), Potchefstroom, South Africa,

Author:

A. Volschenk
234 A Joubertstreet
Proteapark
Rustenburg
0299

E-mail: annegret.volschenk2gmail.com

Tel: (+27) 73 153 7667

Corresponding author:

E. J. Bruwer
PO Box
19148
Noordbrug
Potchefstroom
2522

E-mail: Erna.Bruwer@nwu.ac.za

Tel: (+27)82 410 2027

Manuscript prepared for submission to: *African Journal of Physical Health Education, Recreation and Dance.*

Functional fitness and balance amongst elderly

Abstract

The worldwide increases in the elderly segment of the population propose enormous health care and socio-economic challenges. Physical activity can have great benefits for the elderly, increasing their functional capacity to complete the normal activities of daily living and be more independent. The aim of this study was to determine the functional fitness, static and dynamic balance status of Caucasian senior citizens in a South African community. A cohort of 58 senior citizens (32 females and 26 males) were recruited and tested non- recurrently. Participants completed a medical screening questionnaire after which a functional fitness test as well as a static balance and a dynamic balance test were completed to determine the functional fitness and balance status of the participants. Descriptive statistics (means, standard deviation and interquartile ranges) were performed and compared to published normal ranges for functional fitness testing. A frequency distribution was performed to identify the test results that the males and females tested poor. The results indicate that males performed better than females compared to USA normal ranges. Although 80.8% of the males performed poorly in more than four of the six functional fitness tests, 68.8% of females had more than four weak test results. The upper and lower body flexibility tests, showed the weakest results. In conclusion the performances of the senior citizens cohort for the functional fitness and balance tests were very poor and there is a need to establish percentile scales for functional capacity parameters and introduce intervention to improve the functional status of the elderly.

Keywords: Functional fitness, physical activity, balance, aging

3.1 Introduction

The past decades have shown an increase in longevity due to fewer acute diseases, better health care systems and lower fertility rates (Velkoff & Lawson, 1998; Fougere & Merette, 1999; Lloyd-Sherlock, 2000; Tanaka, Shigematsu, Nakagaichi, Kim & Takeshima, 2000; Joubert & Bradshaw, 2009). In the first world countries, it is predicted that the percentage of senior citizens (≥ 60 years) will increase during the next few decades to occupy a greater percentage of the total population (Department of Health, 2001; Velkoff & Kowal, 2007). A prediction in Sub-Saharan Africa shows that the number of people above sixty years of age will increase to 36% by 2030 to over 4.8 million people (Velkoff & Kowal, 2007). Escalating costs of health care systems and lifestyle costs propose financial challenges for the elderly and the government, since most elderly cannot afford a medical aid fund or private medical care or are unable to find employment because of social isolation and lack of necessary skills (Lloyd-Sherlock, 2000; Joubert & Bradshaw, 2009). Aging is inevitable, but the rate an individual age can be modified by lifestyle choices (Jameson, 2007). A relatively high physiology capacity in senior citizens lead to lower their health care costs and a decreased dependence on caregivers (Velkoff & Lawson, 1998). Therefore, the more a population ages, the more important quality of life becomes (Konno, Katsumata, Arai & Tamashiro, 2004).

Aging is accompanied by various physiological changes in the cardiovascular system, respiratory system and musculoskeletal system and these changes make the elderly vulnerable to hypokinetic diseases, cardio-respiratory diseases and musculoskeletal changes that can compromise an individual's capability to function normally (Taaffe & Marcus, 2000; Kell, Bell & Quinney, 2001; Peterson, Rinder, Schechtman, Spina, Glover, Villareal & Ehsani, 2003; Reeves, Narici & Maganaris, 2006; Edward & Lakatta, 2007). Chronological aging is not always in conformity with physiological aging. People with the same chronological age may differ extremely in their physiological responses to physical activity and exercise (ACSM, 2010). Elderly that have a physically active lifestyle can achieve relatively high levels of cardiovascular, skeletal and metabolic muscle function (Fletcher, Gulanick & Braun, 2005). Enhancing musculoskeletal fitness and aerobic endurance improves both basic and instrumental activities of daily living and increases independency amongst the elderly (Kell *et al.*, 2001; Rikli & Jones, 2002). Declines in physical activity and performances are generally consistent with declines in functional fitness and an increase in dependency (Rikli & Jones, 1999).

In South Africa 7.6% (3.8 million) of the population is older than sixty years of age (Statistics South Africa, 2010). According to Joubert & Bradshaw (2009), the dependency ratio of the older age (65+years) will increase and this will put more pressure on the working class to support the elderly. Therefore it is important for the elderly to stay independent to generate more resources so that they can provide for themselves. This includes for example having a job, the physical capability to do household duties, having their own transportation and taking care of other members of society. Maintenance of functional capacity is one way to achieve independence and health in the elderly. Lloyd-Sherlock (2000) proposed the question whether longevity trends mean an extension of healthy active living or is it bluntly an extension of morbidity? To answer this question research worldwide needs to establish the independency of senior citizens. Limited research in the South African population has been conducted in the elderly. The objective of this study was, therefore, to determine the functional fitness and balance status of senior citizens in a Caucasian South African cohort.

3.2 Methods and Materials

3.2.1 Subjects

In this cross sectional research design 58 senior citizens aged between 65 to 96 years (females 72.75 ± 7.15 years and males 74.89 ± 6.31 years) participated after giving informed consent. Participants were excluded from the study when they met any of the following. Exclusion criteria after the medical screening of the participants:

- High-risk category: Participants with two or more signs and symptoms or known cardiovascular, pulmonary or metabolic disease (ACSM, 2010).
- Participants that underwent an orthopaedic operation and are not functionally fit to perform tests.
- Participants walking with canes or who are dependent on wheelchairs for mobility.
- Participants with a resting heart rate of >100 beats per minute.
- Participants with a resting blood pressure response of systolic ≥ 200 mm Hg and/or diastolic ≥ 110 mm Hg.
- Participants must have the mental capacity to communicate accurate information regarding their health, complete questionnaires and perform functional fitness and balance tests.

All senior citizens that cleared medical screening completed informed consent forms prior to functional fitness and balance tests.

3.2.2 Measuring instruments

3.2.2.1 Medical history questionnaire (Heyward, 2006)

The Medical History Questionnaire was used for health screening (Heyward, 2006) to exclude those senior citizens who were not physically and mentally healthy to participate in the study.

3.2.2.2 Resting blood pressure and resting heart rate measurements

A sphygmomanometer and a stethoscope were used to determine the blood pressure (mm Hg). The resting heart rate was determined by counting the number of beats in one minute, using a stethoscope. Procedure as stated by ACSM (2010) was followed.

3.2.2.3 Functional fitness tests (Rikli & Jones, 2002)

These tests were designed to assess physiological capacity of senior citizens that are associated with independence and include the following:

Lower body strength was determined by the thirty second chair stand, recording the total number of times sitting down and rising from a chair. **Upper body strength** was determined by the number of arm curls completed in 30 seconds by the women with a 2.27 kg dumbbell and the men with a 3.63 kg dumbbell. **Aerobic endurance** was measured by the six minute walk test, recording the distance (m) the individual walked around a course in six minutes. **Lower body flexibility** was determined by the chair-sit-and-reach test, where participants stretched forward towards their toes while seated with legs remaining straight. If the participants exceeded their toes they obtained a positive score and if their reach was too short they had a negative score. **Upper body flexibility** was measured by the back scratch test, where the participants placed one arm in full abduction and external rotation with palm against their back. The participant adducted the other arm with medial rotation with the dorsal side of the hand against the back. The participants attempted to touch the extended middle fingers of both hands and the distance between the fingers was measured in centimetres. A positive score is obtained if the participant's finger tips reached across the other hand's finger tips and a negative score is obtained when a participant is unable to reach the other hands fingertips. **Motor ability and balance** were determined by the eight foot-up and go test. Participants got up from a chair and walked as quickly as possible around a cone placed eight feet away from the chair and returned

to sit on the chair again. The number of seconds needed to complete the test was measured with a stopwatch.

3.2.2.4 Static balance (Islam, Takeshima, Rogers, Koizumi & Rogers 2004)

Static balance was determined while standing on one leg with eyes closed and their hands on their hips. When a signal was given the participant closed his/her eyes. The test was scored based on the number of seconds the individual could keep his/her foot off the ground or before the participant lost his/her balance (Islam *et al.*, 2004).

3.2.2.5 Dynamic balance (Islam *et al.*, 2004)

A functional reach scale was placed against a wall horizontal to the floor. The functional reach scale was positioned at shoulder height for each participant. Participants stood sideways against the wall, elbows straight, shoulder flexed at 90° and their fingertips starting at the 0 centimetre level of the scale. The participants reached forward as far as possible with their heels remaining on the ground. The distance the participants could reach was measured in centimetres (Islam *et al.*, 2004).

3.2.3 Procedure

Each participant completed a health screening (Heyward, 2006) after which the resting heart rate and blood pressure were measured. This determined whether the subjects could participate in the study. Various anthropometric parameters were also measured including height (m), mass (kg), waist circumference (cm) and hip circumference (cm). The Rikli and Jones functional fitness tests (Rikli & Jones, 2002) followed as well as the static balance and dynamic balance tests (Islam *et al.*, 2004). Lastly the participants completed the 6 min walk test to determine aerobic endurance.

3.2.4 Statistical analysis

The statistical consultation services of the North-West University analysed the data by means of the STATISTICA, version 9.0 data analysis software. Descriptive statistics, including means and standard deviations of all measured variables were determined. The data was divided into quartile ranges for the males and females. The inter quartile range is classified as average for the participants in this study and any value above the inter quartile is considered good and values below the inter quartile as poor. Distribution of the weak tests for males and females was

determined by two way summary tables. The weak tests were divided into three categories: Participants who did not perform poorly in any of the six functional fitness tests (0 weak tests), participants who performed poorly in one to three of the weak tests (1-3 weak tests) and those who performed poorly in four to six of the tests (4-6 weak tests).

3.3 Results

There was no statistical significant ($p \leq 0.05$) differences between the various old age groups, however, statistical significant difference in gender was observed. Therefore, the results of male and female participants are demonstrated separately. The results obtained (Table 3.1) indicate the average BMI is in the overweight category for both males and females. Both the chair sit and reach test and the back scratch test obtained negative scores. A negative score was obtained when the participant could not reach the desired distance, in other words the participants demonstrated poor flexibility. Note that a lower value (seconds) in the eight foot up and go tests indicates better agility thus, less time was needed to complete the test.

Table 3.1: Descriptive statistics for body composition, functional fitness variables and static and dynamic balance

	Male and Female		Male		Female	
	N	X ± SD	N	X ± SD	N	X ± SD
Age (years)	58	73.71 ± 6.81	26	74.89 ± 6.31	32	72.75 ± 7.15
BMI (kg/m ²)	58	26.97 ± 3.84	26	27.43 ± 3.64	32	26.61 ± 4.02
W/H ratio	56	0.89 ± 3.84	25	0.95 ± 0.08	31	0.83 ± 0.06
30 second chair stand (n)	55	12.56 ± 11.26	25	14.68 ± 5.89 *	30	10.80 ± 3.64 *
Armcurl (n)	56	19.98 ± 5.73	26	23.58 ± 13.1 *	30	16.87 ± 7.05 *
Chair sit and reach (cm)	58	-4.30 ± 10.72	26	-3.47 ± 10.12	32	-4.97 ± 11.54
Back scratch (cm)	58	-12.00 ± 10.86	26	-14.49 ± 21.53	32	-11.21 ± 15.26
Eight foot up and go (sec)	54	7.70 ± 3.43	24	6.44 ± 2.00 *	30	8.72 ± 3.99 *
6 min walk (m)	52	482.13 ± 146.53	21	529.5 ± 101.7 *	31	450.0 ± 164.2 *
Static balance (sec)	52	15.15 ± 25.98	22	15.69 ± 29.66	30	14.76 ± 32.44
Dynamic balance (cm)	55	25.99 ± 9.67	24	28.47 ± 7.36	31	24.06 ± 10.86

* Statistical difference between male and female ($p \leq 0.05$)

Table 3.2 shows the inter quartile ranges for male participants compared to USA normal ranges developed by Rikli and Jones (1999) for the same age groups as the average age of the participants in this study. The arm curls and chair sit and reach of the male participants' for the inter quartile ranges were better than the USA normal ranges. The back scratch test was lower than that of the USA normal ranges. The six minute walk test, eight foot up and go test and 30 second chair stand compared well with the USA normal ranges in the age category 75 -79 years.

Table 3.2: Inter quartile ranges for functional fitness test scores for male participants versus the USA normal ranges

	Inter quartile ranges	USA normal ranges	
	X = 74.89 years	70 – 74 years	75 – 79 years
Lower body strength (30 second chair stand)	12 – 16	12 -17	11 – 17
Upper body strength (Armcurl)	18 – 32	14 – 21	13 – 19
Lower body flexibility (Chair sit and reach (cm))	-4 – 0	-9 - +6	-10 - +5
Upper body flexibility (Back scratch (cm))	-26.5 - -7	-20 - -3	-23 - -5
Dynamic balance and agility (Eight foot up and go (sec))	6.7 - 5	6.0 – 4.2	7.2 – 4.6
Aerobic endurance (6 min walk (m))	450 – 592.5	498 – 622	430 – 585

Developed by Rikli and Jones (1999)

The lowest score in the inter quartile range for the participants in this study was even lower than the scores of the older age group (75-79 years) in the USA ranges for all the tests except the armcurl test. The upper score of the inter quartile range, however, compared well with the 70-74 year USA norms, except for the flexibility test (Table 3.2).

Table 3.3: Inter quartile ranges for functional fitness test scores for female participants versus USA normal ranges

	Inter quartile ranges	USA normal ranges	
	X = 72.75 years	70 – 74 years	75 – 79 years
Lower body strength (30 second chair stand)	8 – 13	10 – 15	10 – 15
Upper body strength (Armcurl)	13 – 21	12 – 17	11 – 17
Lower body flexibility (Chair sit and reach (cm))	-14.5 – 1.5	-3 - +10	-4 - +9
Upper body flexibility (Back scratch (cm))	-20 – 0	-10 - +3	-13 - +1
Dynamic balance and agility (Eight foot up and go (sec))	10.8 - 5.3	7.1 – 4.9	7.5 – 5.2
Aerobic endurance (6 min walk (m))	369 - 585	439 - 562	393 – 535

Developed by Rikli and Jones (1999)

Table 3.4 indicates the frequency distribution of the weak test scores in functional fitness tests for males and females separately. 80.77% of the male participants performed poorly in 4 – 6 of the tests and only one participant had no weak tests. The female participants had 68.75% who scored poorly in 4 to 6 tests and 15.63% who had no weak tests.

Table 3.4: Frequency distribution of test results for males and females

	Total weak tests 0 (n, %)	Total weak tests 1 – 3 (n, %)	Total weak tests 4 – 6 (n, %)
Male participants	1 (3.9%)	4 (15.4%)	21 (80.8%)
Female participants	5 (15.6%)	5 (15.6%)	22 (68.8%)

The functional reach test tested dynamic balance of the participants. Limited functional reach is less than 15.2 – 17.8 cm and adequate functional reach is greater than 25.4 cm. According to the functional reach norms, the average male participants have adequate dynamic balance and the average female participants are below the adequate functional reach norm. The cut point for the static dynamic balance test is less than 10 seconds and a score less than 5 seconds indicates a fall risk. A score of 30 seconds and more shows adequate static balance. Neither male nor female average static balance scores (15.69 and 14.76 seconds respectively) are adequate.

3.4 Discussion

In this study the female participants were more than the male participants. According to Leung, Zhang and Zhang (2004), working males life expectancy was lower than females during the 1940's to 1990's because males invested more time in labour and less time in health. Females on the other hand spent more time looking after their health. This could also explain why the proportion of females in geriatric institutions is currently greater than that of males (Velkoff & Lawson, 1998). The participants in this study were recruited from various institutions and this can also be a possible reason why more females than males were available to be selected. With the progression of gender equality, however, it is predicted that the life expectancy gap between men and women will become smaller (Leung *et al.*, 2004).

Both male and females have an average BMI greater than 25, which categorises them as overweight (ACSM, 2010). According to Raguso, Kyle, Kossovsky, Roynette, Paoloni-Giacobino, Hans, Genton and Pichard (2006), healthy elderly people undergo body composition changes over a period of time even though body weight remains stable. As people age they have an increase in the percentage body fat and a decrease in fat free body mass and bone mass (Dewan & Wilding, 2003; ACSM, 2010). Research shows a 10 – 15 % loss of muscle strength per decade during the 5th and 8th decades (Reeves *et al.*, 2006 & Melzer, Benjuya & Kaplanski, 2003). People can lose up to 10 – 15% of their peak bone density by the age of 70 years (Brennan, 2002). These musculoskeletal changes inhibit proper balance causing impaired mobility and increasing the risk of falls and physical frailty amongst the elderly (Taaffe & Marcus, 2000; Kell *et al.*, 2001; Reeves *et al.*, 2006)

Male participant's average dynamic balance and average static balance were higher than the female participants. Although males are overweight, their lower body strength inter quartile

range compared well with USA normal ranges for males (Rikli & Jones, 2002). Females are also categorized as overweight and their lower body strength inter quartile range is lower than their USA counterparts. According to Hassinen, Komulainen, Lakka, Vaisanen and Rauramaa (2005), women's muscle strength is a stronger determinant of balance than overweight. Thus inadequate muscle strength amongst female participants could be a possible reason for their weaker balance test scores.

Both male and female participants scored poorly in the upper body flexibility test and females also scored poorly in the lower body flexibility test in comparison with the USA normal ranges. There are a number of factors that could lead to the progressive loss of flexibility during aging. These factors include disease, deterioration of joint structures, tendon stiffness, immobilisation and inactivity (Kell *et al.*, 2001; Karamanidis, Arampatzis & Mademli, 2008; ACSM, 2010). According to Karamanidis *et al.* (2008), the main mechanism humans use to regain balance is to broaden their base of support and older adults have deficits in using these mechanisms to regain dynamic balance. It is also confirmed that these age-related deficits are associated with lower body strength and tendon stiffness (Karamanidis *et al.*, 2008). A decrease in tendon stiffness leads to a drop in the rate of force development which can cause age related loss in power generation capabilities during muscle contraction (Kanehisa, Kubo & Fukunaga, 2004). Male dynamic balance is adequate compared to the normative scores and their lower body flexibility compares well with the normal USA ranges. Female participants scored under the normal USA range for lower body flexibility and their dynamic balance is also lower than the adequate functional reach (dynamic balance) norms. Decreased flexibility in the major joints is associated with reduced mobility and decreased independency.

Both male and female participants average six minute walk test score is within the normal USA. Walking reflects well on muscle strength, muscle endurance, balance and coordination and is a very popular activity amongst elderly (Keskin, Borman, Ersoz, Kurtaran, Bodur & Akyuz, 2008). Thus aerobic fitness contributes to better functional fitness and balance. Melzer *et al.* (2003) suggest that regular walking after retirement could improve or maintain muscle strength, bone mass and cardiovascular endurance as well as postural stability and balance control. Improvements in strength, balance and functional performance could also lead to an increase in subjective awareness of postural stability amongst elderly, while they are walking (Hauer, Rost, Rutschle, Opitz, Specht, Bartsch, Oster & Schlierf, 2001).

The participants completed six functional fitness tests which measured all components which is necessary to complete daily activities and be independent. Although, 80.8% of male participants performed poorly in four to six of the functional fitness tests, only one male participant had no weak test. 68.8% of female participants scored poorly in four to six tests and 15.6% had no weak tests. This is an alarming statistic because it indicates that the participants in this study could not master the skills necessary to perform daily activities. This emphasizes the importance of a multi-dimensional approach to functional independency and the need for intervention programme in old age homes.

3.5 Conclusion

Male participant functional fitness status compares well with USA norms except for lower body flexibility. Female participants have a lower functional fitness status compared to USA norms in the older age group (75-79 years) except for upper body strength. Participants especially performed poorly in the flexibility tests. The average male participants have adequate dynamic balance and the average female participants are below the adequate functional reach norm. Neither male nor female average static balance scores are adequate. The frequency distribution of the number of weak test performance showed that 81% and 68% of male and female participants respectively performed poorly in more than four of the functional fitness tests. This emphasizes the need of intervention programme for the elderly in the old age homes that are based on the needs of the South African population. Percentile scales for the different parameters of functional fitness capacity in the elderly need to be established for all ethnic groups in the diverse South African population.

Acknowledgements

The authors acknowledge the participants for their voluntary involvement in this study. Appreciation is extended to the test administrators who helped collect data for this project.

References

- American College of Sports Medicine. (2010). *ACSM's Resource manual for guidelines for exercise testing and prescription* (6th ed.) (pp. 749). Philadelphia, North America: Lippincott, Williams & Wilkins.
- Brennan, H.F. 2002. Exercise prescription for active seniors: A Team approach for maximizing adherence. *Physician & Sports Medicine*, 30(2): 19-29.
- Department of Health. (2001). National service framework for older People. Retrieved May 1, 2008 from the World Wide Web: http://www.dh.gov.uk/prod_consum_dh/groups/dh_digitalassets/@dh/@en/documents/digitalasset/dh_4071283.pdf
- Dewan, S. & Wilding, J.P.H. 2003. Obesity and type-2 diabetes in the elderly. *Gerontology*, 49(3):137-145.
- Edward, G. & Lakatta, M.D. 2007. Central arterial aging and the epidemic of systolic hypertension and arteriosclerosis. *Journal of the American Society of Hypertension*, 1(5):302-340.
- Fletcher, B.J., Gulanick, M. & Braun, L.T. 2005. Physical activity and exercise for elders with cardiovascular disease. *Medsurg Nursing*, 14(2):101-110.
- Fougere, M. & Merette, M. 1999. Population ageing and economic growth in seven OECD countries. *Economic Modelling*, 16(3):411-427.
- Hassinen, M., Komulainen, P., Lakka, T.A., Vaisanen, S.B. & Rauramaa, R. 2005. Associations of body composition and physical activity with balance and walking ability in the elderly. *Journal of Physical Activity and Health*, 2(3): 298-306.
- Hauer, K., Rost, B., Rutschle, K., Opitz, H., Specht, N., Bartsch, P., Oster, P. & Schlierf, G. 2001. Exercise training for rehabilitation and secondary prevention of falls in geriatric patients with a history of injurious falls. *Journal of the American Geriatrics Society*, 49(1): 10-20.

Heyward, V.H. (2006). *Advanced fitness assessment and exercise prescription*. (5th ed.) (pp. 425). US: Burgess Publishing Company.

Islam, M.M., Takeshima, N., Rogers, M.E., Koizumi, D. & Rogers, N.L. 2004. Relationship between balance, functional fitness, and daily physical activity in older adults. *Asian Journal of exercise and Sport Science*, 1(1): 9-18.

Jameson, J.R. (2007). *Healthcare for an aging population*. (pp. 335). China. Churchill Livingstone Elsevier. 335 p.

Joubert, J. & Bradshaw, D. 2009. Population aging and health challenges in South Africa. Retrieved March 20, 2010 from the World Wide Web: www.mrc.ac.za/chronic/cdlchapter15.pdf

Kanehisa, H., Kubo, K. & Fukunaga, T. 2004. The effects of squat training, using body weight, on the stiffness of tendon structures of the vastus lateralis muscle in middle-aged and older women. *International Sports Medicine Journal*, 5(4): 277-297.

Karamanidis, K., Arampatzis, A. & Mademli, L. 2008. Age-related deficit in dynamic stability control after forward falls is affected by muscle strength and tendon stiffness. *Journal of Electromyography and Kinesiology*, 18(6): 980–989.

Kell, R.T., Bell, G. & Quinney, A. 2001. Musculoskeletal fitness, health outcomes and quality of life. *Sports Medicine*, 31(12):863-873.

Keskin, D., Borman, P., Ersoz, M., Kurtaran, A., Bodur, H. & Akyuz, M. 2008. The risk factors related to falling in elderly females. *Geriatric Nursing*, 29(1):58-63.

Konno, K., Katsumata, Y., Arai, A. & Tamashiro, H. 2004. Functional status and active life expectancy among senior citizens in a small town in Japan. *Archives of Gerontology and Geriatrics*, 38(2): 153-166.

Leung, M.C.M., Zhang, J. & Zhang, J. 2004. An economical analysis of life expectancy by gender with application to the united states. *Journal of Health Economics*, 23(4):737-759.

Lloyd-Sherlock, P. 2000. Population ageing in developed and developing regions: implications for health policy. *Social Science and Medicine*, 51(6):887-895.

Melzer, I., Benjuya, N. & Kaplanski, J. 2003. Effects of regular walking on postural stability in the elderly. *Gerontology*, 49(4):240-245.

Peterson, L.R., Rinder, M.R., Schechtman, K.B., Spina, R.J., Glover, K.L., Villareal, D.T. & Ehsani, A.A. 2003. Peak exercise stroke volume: associations with cardiac structure and diastolic function. *Journal of Applied Physiology*, 94(3): 1108-1114.

Raguso, C.A., Kyle, U., Kossovsky, M.P., Roynette, C., Paoloni-Giacobino, A., Hans, D., Genton, L. & Pichard, C. 2006. A 3-year longitudinal study on body composition changes in the elderly: Role of physical exercise. *Clinical Nutrition*, 25(4): 573-580.

Reeves, N.D., Narici, M.V. & Maganaris, C.N. 2006. Musculoskeletal adaptations to resistance training in old age. *Manual Therapy*, 11(3):192-196.

Rikli, E.R. & Jones, J.C. 2002. Measuring functional fitness of older adults. *The Journal of Active Aging*, 1:24-30.

Rikli, E.R. & Jones, J.C. 1999. Functional fitness normative scores for community-residing older adults, ages 60-94. *Journal of Aging and Physical Activity*, 7(2):162-181.

Statistics South Africa. 2010. Mid-year population estimates 2010. Retrieved January 30, 2011 from the World Wide Web: <http://www.statssa.gov.za/PublicationsHTML/P03022010/html/P03022010.html>.

Taaffe, D.R. & Marcus, R. 2000. Musculoskeletal health and the older adult. *Journal of Rehabilitation Research and Development*, 37(2): 245-254.

Tanaka, K., Shigematsu, R., Nakagaichi, M., Kim, H. & Takeshima, N. 2000. The relationship between functional fitness and coronary heart disease risk factors in older Japanese adults. *Journal of Aging and Physical Activity*, 8(2):162-174.

Velkoff, V.A. & Kowal, P.R. 2007. Population aging in Sub-Saharan Africa: Demographic dimensions 2006. Retrieved August 6, 2009 from the World Wide Web: <http://www.census.gov/prpd/2007pubs/p95-7-1.pdf>

Velkoff, V.A. & Lawson, V.A. 1998. Gender and aging: caregiving. Retrieved January 10, 2010 from the World Wide Web: <http://www.census.gov/ipc/prod/ib-9803.pdf>

Chapter 4

The role of physical activity on functional fitness and balance in a geriatric cohort

Authors: Volschenk, A., Bruwer, E.J. & Moss, S.J.

Physical activity, Sport and Recreation in the School for Biokinetics, Recreation and Sport Science, North-West University (Potchefstroom Campus), Potchefstroom, South Africa,

Author:

B. Volschenk
234 A Joubertstreet
Proteapark
Rustenburg
0299

E-mail: annegret.volschenk2gmail.com

Tel: (+27) 73 153 7667

Corresponding author:

E. J. Bruwer
PO Box
19148
Noordbrug
Potchefstroom
2522

E-mail: Erna.Bruwer@nwu.ac.za

Tel: (+27)82 410 2027

Manuscript prepared for submission to: *African Journal of Physical Health Education, Recreation and Dance.*

Physical activity's influence on functional fitness and balance

Abstract

A physically active lifestyle delays the effects of physiological changes that accompany aging, increasing the functional capacity and, therefore, also independence of the elderly. Although the elderly are aware of these benefits, few of them engage in regular physical activity. The purpose of this study was to determine the association between physical activity, aerobic endurance, functional fitness and balance amongst senior citizens in a Caucasian South African cohort. Fifty eight senior citizens (32 females and 26 males) were tested non-recurrently. Participants completed a medical screening and physical activity questionnaire after which the functional fitness test as well as a static balance and a dynamic balance test were completed. Partial correlations were performed to determine associations between the physical activity, aerobic endurance, functional fitness and balance. The results indicated that the female participants perceived physical activity index, aerobic endurance and the dynamic balance test showed medium ($r = 0.3 - 0.49$) to high ($r \geq 0.5$) partial correlations with all functional fitness components. High partial correlations ($r \geq 0.5$) between aerobic endurance with lower body strength and dynamic balance and agility were observed in males. In conclusion this study indicates that higher aerobic endurance is related to improved dynamic balance and contribute to improved functional capacity in the elderly

Keywords: Functional fitness, physical activity, balance, aging

4.1 Introduction

Benefits of a physically active lifestyle amongst the elderly population have been well documented in the literature (Warburton, Nicol & Bredin 2006; ACSM, 2010). These benefits include high levels of cardiovascular, skeletal and metabolic muscle function (Fletcher, Gulanick & Braun, 2005). Although the elderly population is aware of the benefits of physical activity, few of them engage in regular physical activity (Fletcher *et al.*, 2005). Reasons for inactivity include the presence of disease, fear for injury or previous injuries, social isolation or limited functional capacity (Stalenhoef, Diedriks, Knottnerus, Kester & Crebolder, 2002; Stevens, 2005; Keskin, Borman, Ersoz, Kurtaran, Bodur, & Akyuz, 2008). Physically inactive senior citizens have less physiological reserves, therefore, functional fitness is limited and a greater proneness to dependency often occurs (Kell, Bell & Quinney, 2001; Islam, Takeshima, Rogers, Koizumi & Rogers, 2004; Wannamethee, Shaper & Whincup, 2005; Hassinen, Komulainen, Lakka, Vaisanen & Rauramaa, 2005; Zisi, Theodorakis, Skondras & Natsis, 2006). A large number of senior citizens also live in institutions where they are dependent on caretakers, making their activity of daily living less and their participation in physical activity less.

Moderate physical activities reduce the risk, or prolong the onset of physiological changes and various diseases. According to Cavani, Mier, Musto and Tummers (2002) and Toraman, Erman and Agyar (2004), multi component exercise training can enhance functional fitness amongst the elderly. Detraining and physical inactivity can, however, lead to lower levels of functional fitness (Rikli & Jones, 1999; Toraman & Aceman, 2005). These declines are age dependent where the older senior citizens (74-86 years) have a more rapid decline in certain functional fitness components than the younger old senior citizens (60-73 years) (Toraman & Aceman, 2005). Limitations in functional capacity can cause a reduction in balance for the elderly (Pijnappels, Reeves & Van Dieën, 2008). Reduced balance, environmental factors and impaired vision increase the risk of falls among the elderly (Stevens, 2005), which in turn contribute to the greatest amount of trauma injuries amongst the elderly population. The implication of these injuries can cause a huge socio-economic burden, disability or even death. Injury and falls can also inflict fear amongst the elderly which prohibits them from taking part in activities further increasing a more passive lifestyle (Stalenhoef *et al.*, 2002; Stevens, 2005; Keskin *et al.*, 2008).

A functional fitness test was developed and validated at the Ruby Gerontology Centre at California State University, Fullerton. The functional fitness test was developed to determine senior citizens physiological reserves (muscle strength, aerobic endurance, flexibility, balance

and agility) which they need to complete activities of daily living (Rikli & Jones, 1999). There is limited published research available on the South African community regarding functional fitness and physical activity profiles for senior citizens. Before interventions in old aged homes and communities can be implicated, physical limitations and physical activity, functional fitness and balance correlations should be identified. Thus, the purpose of this study was to determine the association between physical activity, aerobic endurance, functional fitness and balance amongst senior citizens in a Caucasian South African community.

4.2 Methods and Materials

4.2.1 Subjects

This was a cross sectional study that implies that the individuals be tested non-recurrently. Participants in this study included 58 senior citizens aged between 65 and 96 years (females' average age 72.75 and males' average age 74.89). The following exclusion criteria were used to select the subjects:

- High-risk category: Participants with two or more signs and symptoms or known cardiovascular, pulmonary or metabolic disease (ACSM, 2010).
- Participants that underwent an orthopaedic operation and are not functionally fit to perform tests.
- Participants walking with canes or who are dependent on wheelchairs for mobility.
- Participants with a resting heart rate of >100 beats per minute.
- Participants with an resting blood pressure response of systolic ≥ 200 mm Hg and/or diastolic ≥ 110 mm Hg.
- Participants must have the mental capacity to perform tests and communicate accurate information regarding their health.

All senior citizens that cleared medical screening completed informed consent forms prior to testing.

4.2.2 Measuring instruments

4.2.2.1 Medical screening (Heyward, 2006)

The Medical History Questionnaire was used for health screening to exclude those senior citizens who were not physically and mentally healthy to participate in this study.

4.2.2.2 Resting blood pressure and resting heart rate measurements

A sphygmomanometer and a stethoscope were used to determine the blood pressure (mm Hg). The resting heart rate was determined by counting the number of beats in one minute, using a stethoscope. Procedure as stated by ACSM (2010) was followed.

4.2.2.3 The physical activity questionnaire (Sharkey & Gaskill, 2007)

Physical activity was measured on the basis of the physical activity index of Sharkey and Gaskill (2007). Although this questionnaire was specifically developed to determine participation in recreational activities, participants in the current study were asked to list all activities of daily living, as well as recreational activities. Therefore, the physical activity index scores obtained were much higher than the original categories developed by Sharkey and Gaskill (2007). The purpose, however, was not to compare these indexes with previous research of participation in recreational activities, but rather to obtain indexes for the senior population which includes all their daily activities. Participants marked the intensity, frequency, and duration of each activity. In order to calculate the physical activity index the frequency, duration and intensity indices of each activity was multiplied and then added together. Participants were assisted by qualified professionals to complete the questionnaire accurately.

4.2.2.4 Functional fitness tests (Rikli & Jones, 2002)

These tests were designed to assess physiological capacity of senior citizens that are associated with independence and include the following:

Lower body strength was determined by the thirty second chair stand, recording the total number of times sitting down and rising from a chair. **Upper body strength** was determined by the number of arm curls completed in 30 seconds by the women with a 2.27 kg dumbbell and the men with a 3.63 kg dumbbell. **Aerobic endurance** was measured by the six minute walk test, recording the distance (m) the individual walked around a course in six minutes. **Lower body flexibility** was determined by the chair-sit-and-reach test, where participants stretched forward towards their toes while seated with legs remaining straight. If the participants exceeded their

toes they obtained a positive score and if their reach was too short they had a negative score. **Upper body flexibility** was measured by the back scratch test, where the participants placed one arm in full abduction and external rotation with palm against their back. The participant adducted the other arm with medial rotation with the dorsal side of the hand against the back. The participants attempted to touch the extended middle fingers of both hands and the distance between the fingers was measured in centimetres. A positive score is obtained if the participant's finger tips reached across the other hand's finger tips and a negative score is obtained when a participant is unable to reach the other hands fingertips. **Motor ability and balance** were determined by the eight foot-up and go test. Participants got up from a chair and walked as quickly as possible around a cone placed eight feet away from the chair and returned to sit on the chair again. The number of seconds needed to complete the test was measured with a stopwatch.

4.2.2.5 Static balance (Islam, Takeshima, Rogers, Koizumi & Rogers 2004)

Static balance was determined while standing on one leg with eyes closed. The participants rested their hands on their hips while standing on one leg. When a signal was given the participant closed their eyes. The test was scored based on the number of seconds the individual could keep their foot off the ground or before the participant lost their balance (Islam *et al.*, 2004).

4.2.2.6 Dynamic balance (Islam *et al.*, 2004)

A functional reach scale was placed against a wall horizontal to the floor. The functional reach scale was positioned at shoulder height for each participant. Participants stood sideways against the wall, elbows straight, shoulder flexed at 90° and their fingertips starting at the 0 centimetre level of the scale. The participants reached forward as far as possible with their heels remaining on the ground. The distance the participants could reach was measured in centimetres (Islam *et al.*, 2004).

4.2.3 Procedure

Firstly each participant completed medical screening (Heyward, 2006) and the resting heart rate and blood pressure were measured to determine whether the subjects were physically and mentally healthy to participate in this study. All chosen participants completed informed consent prior to testing. The physical activity questionnaire (Sharkey & Gaskill, 2007) and the fitness tests were explained verbally and demonstrated to each participant so that they

understood what was expected of them. Various anthropometric parameters were also measured including height (m), mass (kg), waist circumference (cm) and hip circumference (cm). The Rikli and Jones functional fitness tests (Rikli & Jones, 2002) followed as well as the static balance and dynamic balance tests (Islam *et al.*, 2004). Lastly the participants completed the 6 min walk test to determine aerobic endurance.

4.2.4 Statistical analysis

The statistical consultation services of the North-West University, Potchefstroom Campus performed the statistical analysis of the data. The STATISTICA, version 9.0 data analysis software system was used to analyse the data. This was a cross sectional study that implies that the voluntary participants be tested non-recurrently. Partial correlations were drawn to determine associations between physical activity, aerobic endurance, functional fitness and balance. Results from the partial correlation analyses were reported as low ($r = 0.1 - 0.29$), medium ($r = 0.3 - 0.49$) and large ($r = \geq 0.5$).

4.3 Results

The results obtained with this study indicated that the males had significantly higher upper and lower body strength than the women as well as a significantly higher aerobic endurance (Table 4.1). The males also performed significantly better in agility recording a significantly shorter time for completing the eight foot get up and go test.

Table 4.1: Descriptive statistics for body composition, physical activity index and functional fitness variables

Variables	Male and Female		Male		Female	
	N	X ± SD	N	X ± SD	N	X ± SD
Age (years)	58	73.71 ± 6.81	26	74.89 ± 6.31	32	72.75 ± 7.15
BMI (kg/m ²)	58	26.97 ± 3.84	26	27.43 ± 3.64	32	26.61 ± 4.02
W/H ratio	56	0.89 ± 3.84	25	0.95 ± 0.08	31	0.83 ± 0.06
Physical activity index (n)	58	90.83 ± 82.53	26	84.42 ± 60.91	32	96.03 ± 97.32
Lower body strength 30 second chair stand (n)	55	12.56 ± 11.26	25	14.68 ± 5.89 *	30	10.80 ± 3.64 *
Upper body strength Armcurl (n)	56	19.98 ± 5.73	26	23.58 ± 13.1 *	30	16.87 ± 7.05 *
Lower body flexibility Chair sit and reach (cm)	58	-4.30 ± 10.72	26	-3.47 ± 10.12	32	-4.97 ± 11.54
Upper body flexibility Back scratch (cm)	58	-12.00 ± 10.86	26	-14.49 ± 21.53	32	-11.21 ± 15.26
Dynamic balance & agility Eight foot up and go (sec)	54	7.70 ± 3.43	24	6.44 ± 2.00 *	30	8.72 ± 3.99 *
Aerobic endurance 6 min walk (m)	52	482.13 ± 146.53	21	529.5 ± 101.7 *	31	450.0 ± 164.2 *
Static balance (sec)	52	15.15 ± 25.98	22	15.69 ± 29.66	30	14.76 ± 32.44
Dynamic balance (cm)	55	25.99 ± 9.67	24	28.47 ± 7.36	31	24.07 ± 10.86

* Statistical difference between male and female ($p \leq 0.05$)

Mazzeo, Cavanagh, Evans, Fiatarone, Hagberg, Mcauley and Starzell (1998) categorised the elderly into three groups, based on their chronological age: Old age (65-74 years), very old age (75-84 years) and oldest old age (85 years and older). The average ages of the male and female participants in this study are 74.9 years and 72.8 years respectively, which categorises them in the old age group. There were no significant differences between various variables amongst different old age groups, however, there was a statistically significant difference between male and female participants. The results will, therefore, be presented for males and females separately, as well as the group in total. The negative scores for the upper and lower body flexibility indicate that on average, the participants could not reach their toes during the chair sit and reach and their fingers could not touch each other with the back scratch test.

In order to determine the association between functional fitness with physical activity indices and aerobic endurance for the total group, female and male participants respectively, the partial correlations are presented in Table 4.2. In females both the physical activity index and aerobic endurance showed medium to high correlations with all the fitness components. However, the highest correlations ($r \geq 0.5$) were observed with aerobic endurance, especially with lower body strength and dynamic balance and agility. Therefore a higher aerobic endurance was associated with a higher functional fitness test, especially in lower body strength and dynamic balance and agility. The only high partial correlation ($r \geq 0.5$) for men was also between aerobic endurance and lower body strength and dynamic balance and agility. The physical activity index showed no high correlations with any of the fitness tests within the group of men. A negative score was obtained with the balance and agility test because the higher the aerobic endurance was, the shorter amount of time was necessary to complete the test.

Table 4.2: Partial correlations: Association between functional fitness, physical activity and 6 minute walk test.

	Lower body strength 30 second chair stand	Upper body strength Armcurl (reps)	Lower body flexibility Chair sit and reach (cm)	Upper body flexibility Back scratch (cm)	Balance and agility 8 foot up and go (sec)	Aerobic endurance 6 minute walk
Males and Females						
Physical activity index	0.22	0.33	0.41	0.27	-0.42	0.3
Aerobic endurance	0.67	0.44	0.3	0.3	-0.8	1
Females						
Physical activity index	0.42	0.53	0.58	0.35	-0.49	0.35
Aerobic endurance	0.73	0.7	0.37	0.5	-0.79	1
Males						
Physical activity index	0.07	0.3	0.03	0.11	-0.36	0.22
Aerobic endurance	0.59	0.1	0.2	0.33	-0.64	1

	r = 0.1 - 0.29 Low partial correlation
	r = 0.3 – 0.49 Medium partial correlation
	r = 0.5 ≥ High partial correlation

For the convenience of the reader the data in Table 4.2 are also portrayed in Figure 4.1 and Figure 4.2. The graphs show the tendency that, especially for females, the higher aerobic endurance, the better the performances for all the other functional fitness components (however, not always a high correlation).

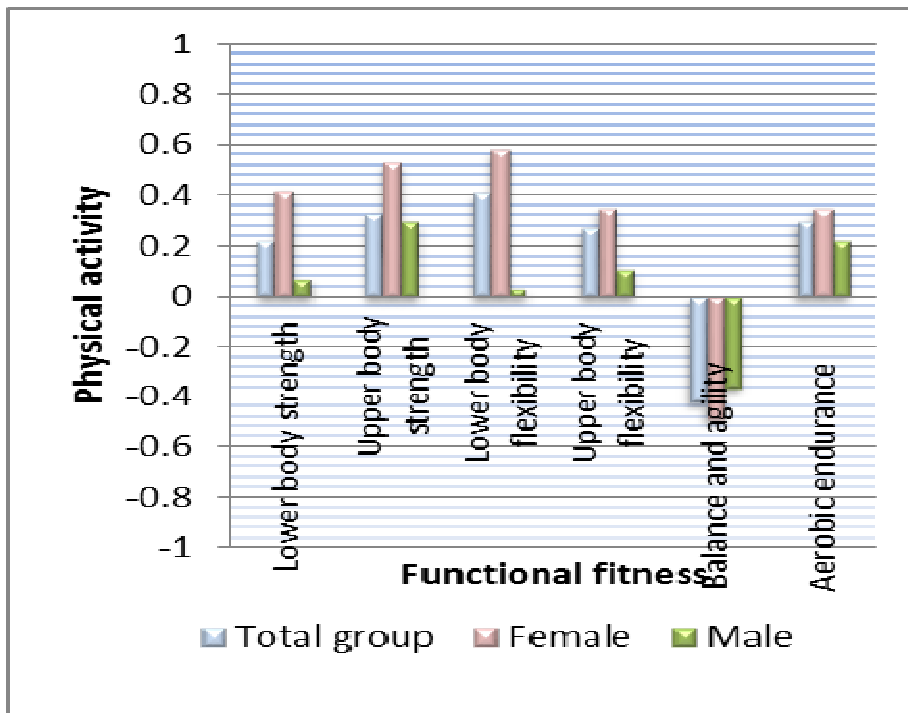


Figure 4.1 Association between physical activity levels and functional fitness

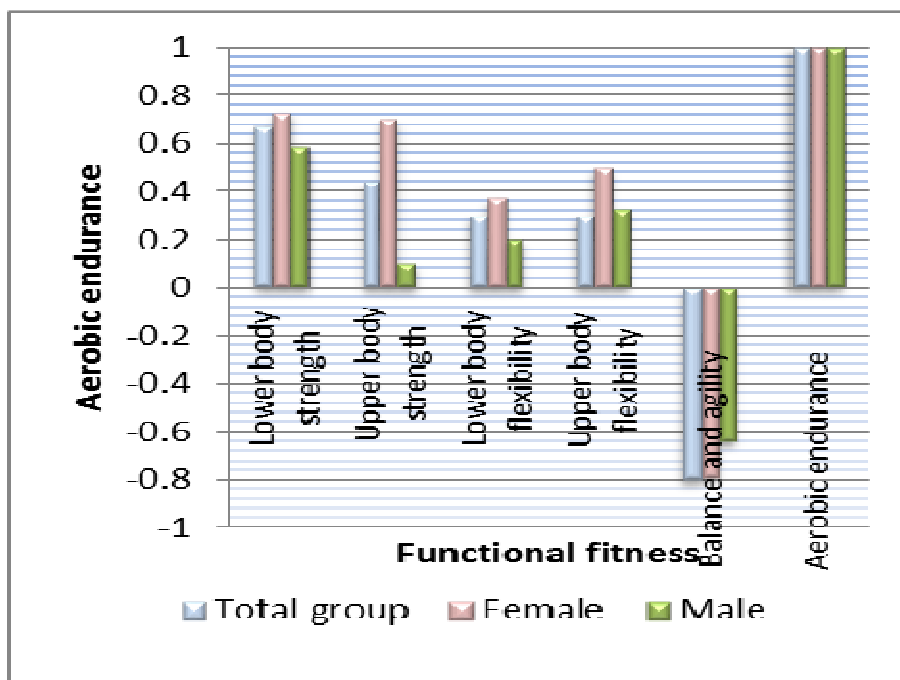


Figure 4.2 Association between aerobic endurance and functional fitness

Table 4.3 indicates partial correlations between dynamic balance and static balance with all functional fitness components, as well as the physical activity index. Note that dynamic balance showed high partial correlations ($r \geq 0.5$) with all components of the functional fitness tests, as well as the physical activity index in females. Females also have a high partial correlation ($r \geq$

0.5) between static balance with lower body strength and aerobic endurance. The only high correlation ($r \geq 0.5$) was between static balance and upper body strength of the men.

Table 4.3: Partial correlations: Association between functional fitness, physical activity and static balance and dynamic balance.

	Physical activity index	Lower body strength 30 second chair stand	Upper body strength Armcurl (reps)	Lower body flexibility Chair sit and reach (cm)	Upper body flexibility Back scratch (cm)	Balance and agility 8 foot up and go (sec)	Aerobic endurance 6 minute walk
Males and Females							
Static balance	0.24	0.24	-0.18	0.19	0.23	-0.35	0.39
Dynamic balance	0.52	0.45	0.51	0.3	0.3	-0.69	0.52
Females							
Static balance	0.35	0.59	0.38	0.25	0.29	-0.44	0.54
Dynamic balance	0.6	0.73	0.79	0.53	0.62	-0.72	0.6
Males							
Static balance	0.09	-0.04	-0.55	0.1	0.24	-0.38	0.32
Dynamic balance	0.4	-0.15	0.21	-0.21	0.01	-0.31	-0.03

	r = 0.1 - 0.29 Low partial correlation
	r = 0.3 – 0.49 Medium partial correlation
	r = 0.5 \geq High partial correlation

For the convenience of the reader the data in Table 4.3 are also portrayed in Figure 4.3 and Figure 4.4. Figure 4.3 gives a clear indication that the better the dynamic balance of the female participants, the better the performances in all functional fitness test components.

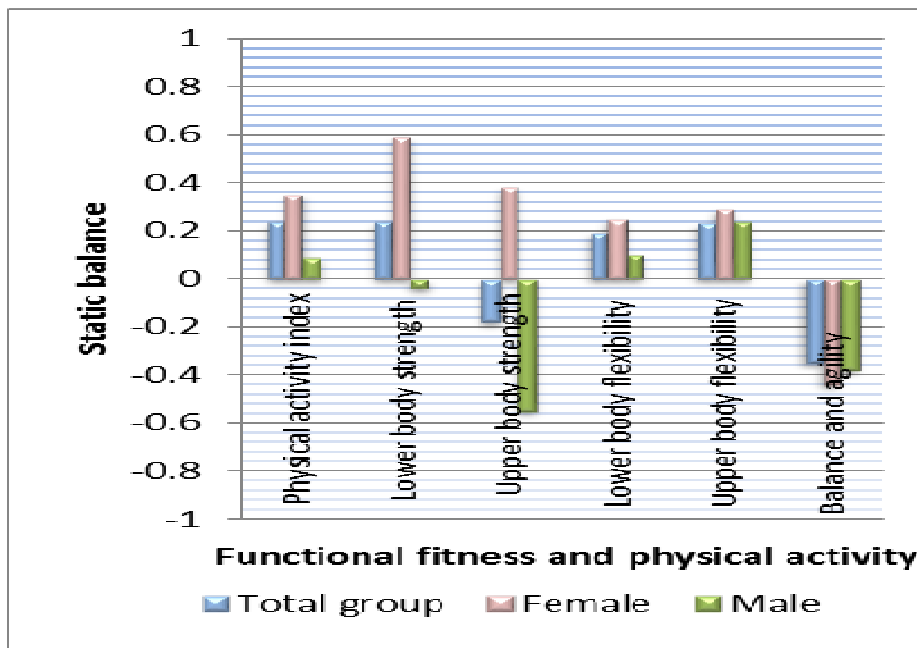


Figure 4.3 Association between static balance with functional fitness and physical activity.

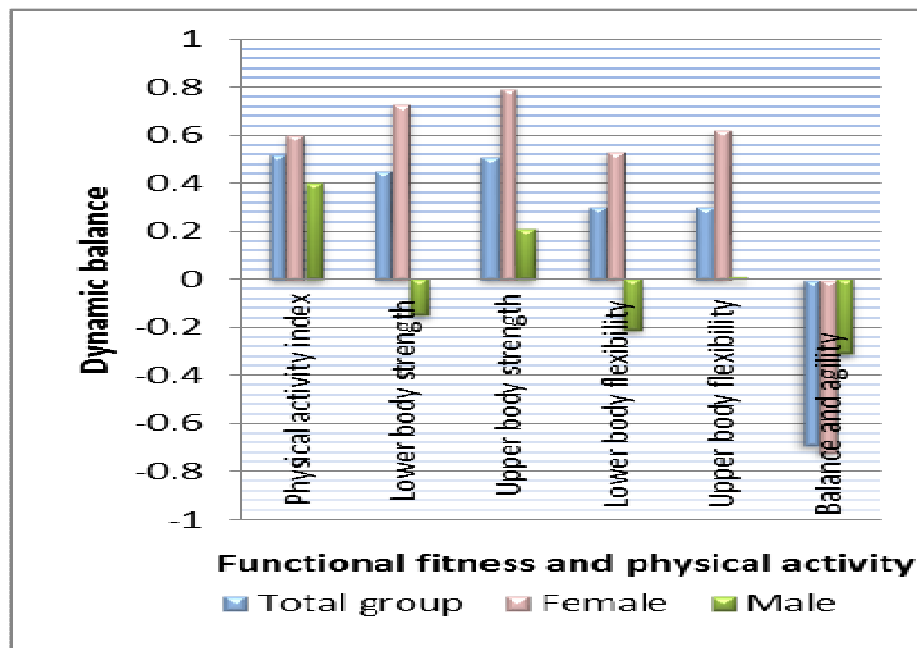


Figure 4.4 Association between dynamic balance with functional fitness and physical activity

4.4 Discussion

Female participants have higher physical activity index scores than males. The physical activity index of the females showed better correlations with the functional fitness components than in male participants. According to Velkoff and Lawson (1998), females tend to take a more caregiving role than males and are more responsible for activities of living like cooking,

shopping, laundry etc. This would give them a higher physical activity index as all activities of daily living, as well as recreational activities were listed for the purpose of this study. This supports the conclusion made by Rikli and Jones (1999) that lower functional fitness levels are associated with lower levels of physical activity, in other words, the lower a senior citizen's functional fitness, the less capable he or she is to participate in any activity and *vice-versa*. Both males and females show better correlation between functional fitness and aerobic endurance than functional fitness and physical activity index. The reason for this could be that the elderly's perceived physical activities are not strenuous enough to enhance functional fitness components. The aerobic endurance were measured objectively with the six minute walk test, eliminating the tendency of over or under reporting of activities as seen in questionnaires by which the physical activity index were calculated.

Aging is characterized by a loss in muscle size and strength, decline in function fitness, impaired mobility and physical frailty which are also enhanced by physical inactivity (Rikli & Jones, 1999; Taaffe & Marcus, 2000; Kell *et al.*, 2001; Reeves, Narici & Maganaris, 2006). Elderly engaging in a physically active lifestyle can achieve relatively high levels of cardiovascular, skeletal and metabolic muscle function (Fletcher *et al.*, 2005:104). Sufficient muscular strength will also allow the elderly to participate in more physical activities which will delay sarcopenia and disuse related illness (Warburton, Gledhill & Quinney, 2001). This may be the reason why female participants have better correlations with physical activity index and functional fitness. Females also have high partial correlation with upper body strength and physical activity index. The reason for this is that there are many activities that need a certain amount of upper body strength to do but do not require aerobic endurance, balance, lower body strength or agility. Therefore people need to participate in a variety of activities to develop all dimensions of functional fitness. Stevens (2005) proposes that a multi-component intervention is needed that is specific to the needs of the elderly. In both males and females there is a large partial correlation between aerobic endurance (walking) with lower body strength and dynamic balance and agility tested by the eight feet up and go. This was confirmed with the other dynamic balance test that showed high correlations with all functional fitness tests. Walking reflects well on muscle strength, muscle endurance, bone mass, balance, coordination and cardiovascular endurance and is a very popular activity amongst elderly (Melzer, Benjuya & Kaplanski, 2003; Keskin *et al.*, 2008). Muscle strength especially of the lower limbs can enhance the elderly's balance and is a predictive for functional performance and can enhance cardiovascular function and musculoskeletal metabolism (Chu, Pei & Chiu, 1999; Kell *et al.*, 2001; Bean, Keily, Herman, Leveille, Mizer, Frontera & Fielding, 2002).

According to Islam *et al.* (2004), there is an association between postural balance and functional fitness. Age is associated with an increase in postural sway and decline in functional reach (Hageman, Leibowitz & Blanke, 1995; Demura, Kitabayashi & Aoki, 2008). This has a big impact on the elderly's ability to perform daily activities and be independent (Islam *et al.*, 2004). Female participants have a high partial correlation between dynamic balance with all functional fitness components and physical activity index. This indicates that high dynamic balance scores have a positive effect on functional capacity. Falls amongst the elderly are a leading cause for hip fractures and people being placed into nursing homes (Islam *et al.*, 2004). The results of the current study confirm the importance of dynamic balance for the elderly to have confidence in performing daily activities. According to Hassinen *et al.* (2005), there is a strong association between reduced muscle strength and impaired balance. According to Melzer *et al.* (2003), regular walking also contributes to the maintenance of postural stability and balance control. The participants in this study have medium to low partial correlations between static balance and physical activity and functional fitness. Thus static balance does not improve functional capacity. This is in contrast with Islam *et al.* (2004), who found that physical activity can improve static balance, but did not correlate with dynamic balance.

4.5 Conclusion

In conclusion this study indicated that aerobic endurance and dynamic balance are associated with functional capacity in the elderly. These results highlight the importance of a physically active lifestyle and even an activity as simple as walking (as tested by the six minute walk test) could contribute to senior citizens being more functionally capable and independent. The worldwide increase in the elderly population is alarming, however, small lifestyle interventions and physical activity interventions in old age homes could make a huge difference.

Acknowledgements

The authors acknowledge the participants for their voluntary involvement in this study. Appreciation is extended to the test administrators who helped collect data for this project.

References

- American College of Sports Medicine. (2010). *ACSM's Resource manual for guidelines for exercise testing and prescription* (6th ed.) (pp. 749). Philadelphia, North America: Lippincott, Williams & Wilkins.
- Bean, J.F., Keily, D.K., Herman, S., Leveille, S.G., Mizer, K., Frontera, K. & Fielding, W.R. 2002. The relationship between leg power and physical performance in mobility-limited older people. *Journal of the American Geriatric Society*, 50(3): 461-467.
- Cavani, V., Mier, C.M., Musto, A.A. & Tummers, N. 2002. Effects of a 6-week resistance-training program on functional fitness of older adults. *Journal of Aging Physical Activity*, 10:443-452.
- Chu, L.W., Pei, C.K. & Chiu, A. 1999. Risk factors for falls in hospitalised older medical patients. *Journal of Gerontology, Series A: Biological Sciences and Medical Sciences*, 54:M38-M43.
- Demura, S., Kitabayashi, T. & Aoki, H. 2008. Body-sway characteristics during a static upright posture in the elderly. *Geriatrics and Gerontology*, 8(3): 188-197.
- Fletcher, B.J., Gulanick, M. & Braun, L.T. 2005. Physical activity and exercise for elders with cardiovascular disease. *Medsurg Nursing*, 14(2):101-110.
- Hageman, P.A., Leibowitz, J.M. & Blanke, D. 1995. Age and gender effects on postural control measures. *Archives of the Physical Medical Rehabilitation*, 76(10): 961-965.
- Hassinen, M., Komulainen, P., Lakka, T.A., Vaisanen, S.B. & Rauramaa, R. 2005. Associations of body composition and physical activity with balance and walking ability in the elderly. *Journal of Physical Activity and Health*, 2(3): 298-306.
- Heyward, V.H. (2006). *Advanced fitness assessment and exercise prescription*. (5th ed.) (pp. 425). US: Burgess Publishing Company.

- Islam, M.M., Takeshima, N., Rogers, M.E., Koizumi, D. & Rogers, N.L. 2004. Relationship between balance, functional fitness, and daily physical activity in older adults. *Asian Journal of exercise and Sport Science*, 1(1): 9-18.
- Kell, R.T., Bell, G. & Quinney, A. 2001. Musculoskeletal fitness, health outcomes and quality of life. *Sports Medicine*, 31(12):863-873.
- Keskin, D., Borman, P., Ersoz, M., Kurtaran, A., Bodur, H. & Akyuz, M. 2008. The risk factors related to falling in elderly females. *Geriatric Nursing*, 29(1):58-63.
- Mazzeo, R.S., Cavanagh, P., Evans, W.J., Fiatarone, M., Hagberg, J., Mcauley, E. & Starzell, J. 1998. Exercise and physical activity for older adults. Position stand. *Medicine and Science In Sports and Exercise*, 30(6): 992 – 1008.
- Melzer, I., Benjuya, N. & Kaplanski, J. 2003. Effects of regular walking on postural stability in the elderly. *Gerontology*, 49(4):240-245.
- Pijnappels, M., Reeves, N.D. & Van Dieën, J.H. 2008. Tripping without falling; lower limb strength, a limitation for balance recovery and a target for training in the elderly. *Journal of Electromyography and Kinesiology*, 18(2):188-196.
- Reeves, N.D., Narici, M.V. & Maganaris, C.N. 2006. Musculoskeletal adaptations to resistance training in old age. *Manual Therapy*, 11(3):192-196.
- Rikli, E.R. & Jones, J.C. 1999. Functional fitness normative scores for community-residing older adults, ages 60-94. *Journal of Aging and Physical Activity*, 7(2):162-181.
- Rikli, E.R. & Jones, J.C. 2002. Measuring functional fitness of older adults. *The Journal of active aging*, 1:24-30.
- Sharkey, B.J. & Gaskill, S.E. (2007). *Fitness and health*. (6th ed) (pp.428). China. Human Kinetics.

- Stalenhoef, P.A., Diedriks, J.P.M., Knottnerus, J.A., Kester, A.D.M. & Crebolder, H.F.J.M. 2002. A risk model for the prediction of recurrent falls in community-dwelling elderly: A prospective cohort study. *Journal of Clinical Epidemiology*, 55(11):1088-1094.
- Stevens, J.A. 2005. Falls amongst older adults – risk factors and prevention strategies. *Journal of Safety Research*, 36(4):409-411.
- Taaffe, D.R. & Marcus, R. 2000. Musculoskeletal health and the older adult. *Journal of Rehabilitation Research and Development*, 37(2): 245-254.
- Toraman, N.F., Erman, A. & Agyar, E. 2004. Effects of multicomponent training on functional fitness in older adults. *Journal of Aging and Physical Activity*, 12(4):538-553.
- Toraman, N.F. & Ayceman, N. 2005. Effects of six weeks of detraining on retention of functional fitness of old people after nine weeks of multicomponent training. *British Journal of Sports Medicine*, 39(8):565-568.
- Velkoff, V.A. & Lawson, V.A. 1998. Gender and aging: caregiving. Retrieved January 10, 2010 from the World Wide Web: <http://www.census.gov/ipc/prod/ib-9803.pdf>
- Wannamethee, A.G., Shaper, A.G. & Whincup, P.H. 2005. Body fat distribution, body composition, and respiratory function, in elderly men. *The American Journal of Clinical Nutrition*, 82(5):996-1003.
- Warburton, D.E.R., Nicol, C.W. & Bredin, S.S.D. 2006. Health benefits of physical activity: The evidence. *Canadian Medical Association Journal*, 174(8):801-809.
- Warburton, D.E.R., Gledhill, N. & Quinney, A. 2001. Musculoskeletal fitness and health. *Canadian Journal of Applied Physiology*, 26(2):217-237.
- Zisi, V., Theodorakis, Y., Skondras, G. & Natsis, P. 2006. The relation of balance performance and balance confidence with physical activity in elderly fallers and non-fallers. *Studies in Physical Culture and Tourism*, 13:111-114.

Chapter 5

Summary, conclusions, limitations and recommendations

5.1 Summary

Physical activity is on the decline throughout the world. This phenomenon is also happening in the ageing population. As people age, physical activity declines. When considering the natural physiological changes that occur with ageing, it is important for the elderly to stay active in order to postpone the deleterious effects of ageing.

In Chapter 1 the problem statement was presented together with the objectives and hypotheses set for this study as an introduction to the dissertation. The problem statement indicated that limited research is available on the functional status of the elderly in South Africa as well as on the association between functional fitness components, balance and physical activity therefore the objectives were firstly to determine the functional fitness status, static and dynamic balance status. Secondly it was to determine the association between physical activity status and aerobic endurance with functional fitness status. Thirdly it was to determine the association between physical activity status and aerobic endurance with static and dynamic balance status.

The literature review (Chapter 2) focused on the expansion of the senior population world-wide and the impact this has on society. It also discusses the impact various physiological changes have on the elderly and how these changes influence the elderly's health and independence. The physiological changes discussed in this chapter include cardiovascular, respiratory, body composition and musculoskeletal changes as well as balance impediments. Cardiovascular changes include hypertension, serum total cholesterol and diabetes mellitus which increase the risk of developing CVD. There is also a decline in respiratory function amongst elderly. As people age there is an increase in their percentage body fat and a decrease in fat free body mass. Musculoskeletal changes also include a loss in muscle size and strength, decreased flexibility and a decrease in balance. These changes can increase the risk of falls and injury amongst elderly. The independence of elderly is closely related to their functional fitness and physical activity participation. Functional fitness is defined as having the physiologic capacity to perform normal everyday activities safely and independently without undue fatigue. Components of functional fitness include: muscle strength, flexibility, aerobic endurance, agility and dynamic balance. Research also confirmed the various benefits moderate physical activity and exercise

have on improving functional fitness amongst the elderly. The chapter concluded that the effects of physical activity can reduce medical costs, dependence on caregivers and delay morbidity and mortality. It highlights the importance of physical activity for senior citizens.

The results of this study, presented in two research articles namely: “Functional fitness and balance status in a geriatric cohort”, presented in Chapter 3 and “The role of physical activity on functional fitness and balance in a geriatric cohort”, presented in Chapter 4. The male participants’ upper body strength and lower body flexibility were better than USA normal ranges while upper body flexibility was lower than the USA normal ranges. Male participants’ aerobic endurance, dynamic balance and agility as well as lower body strength compared well with the USA normal ranges. The female lowest score in the inter quartile range for the participants in this study was even lower than the scores of the older age group (75-79 years) in the USA ranges for all the tests except the upper body strength test. The upper score of the inter quartile range, however, compared well with the 70-74 year USA norms, except for the flexibility tests which compared lower. According to the functional reach norms, the average male participants have adequate dynamic balance and the average female participants are below the adequate functional reach norm. Neither male nor female average static balance scores were adequate. Although male participants compare well to USA normal ranges, 80.77% performed poorly in four to six of the functional fitness tests and only one participant had no weak tests. The female participants had 68.75% who had scored poorly in four to six tests and 15.63% who had no weak tests.

When the association between physical activity, aerobic endurance, functional fitness and balance was analysed by partial correlation females reported a physical activity index and aerobic endurance with a medium to high correlation with all the functional fitness components. However, the highest correlations were observed with aerobic endurance, especially with lower body strength and dynamic balance and agility. The only high partial correlation for men was between aerobic endurance and lower body strength and dynamic balance and agility. The female’s dynamic balance showed high partial correlations with all components of the functional fitness tests, as well as the physical activity index. Females also have a high partial correlation between static balance with lower body strength and aerobic endurance. The only high correlation in male participants was between static balance and upper body strength.

5.2 Conclusion

The conclusions that are drawn from this study are presented in accordance with the hypotheses set in Chapter 1.

5.2.1 Hypothesis 1:

Caucasian senior citizens (65 – 95 years) in a South African community will have mostly low functional fitness scores as well as poor performances in static balance and dynamic balance tests.

Males compared well with USA normal ranges except for lower body flexibility. However, 81% of the male participants tested poorly in more than four of the functional fitness tests. The average dynamic balance of the male participants was adequate and although the static balance scored did not indicate a fall risk, it was not good. Females average functional fitness scores were even lower than the older age group (75 to 79 years) of the USA normal ranges, except for upper body strength. 68% of the females had more than four weak tests and neither static nor dynamic balance average scores were adequate. This emphasizes the need for intervention programmes for the elderly in the old age homes that are based on the needs of the South African population. Percentile scales for the different parameters of functional fitness capacity in the elderly need to be established for all ethnic groups in the diverse South African population. Thus the senior citizens participating in this study have mostly poor functional fitness results as well as low static balance scores. Therefore hypothesis 1 can be accepted.

5.2.2 Hypothesis 2:

Caucasian senior citizens (65 – 95 years) in a South African community with a higher physical activity status and aerobic endurance will perform better in the functional fitness test.

Female participants have higher physical activity index scores than males. Also the physical activity index of the females showed better correlations with the functional fitness components than in male participants. Thus the higher the physical activity status, the higher the senior citizens will score in the functional fitness test. The total group in this study had high or medium correlations with aerobic endurance and functional fitness tests. Thus, the higher aerobic

endurance was the better the performance in the other functional fitness components, especially lower body strength and dynamic balance and agility. Therefore this hypothesis can be accepted.

5.2.3 Hypothesis 3:

Caucasian senior citizens (65 – 95 years) in a South African community with higher physical activity status and aerobic endurance will perform better in the static and dynamic balance tests.

Static balance has low or medium correlations with physical activity and aerobic endurance. Thus higher aerobic endurance and physical activity status does not enhance static balance. However, dynamic balance showed to have medium to high correlations with all function fitness tests, as well as physical activity index for both the total group as well as the female participants. Hypothesis two indicated that the higher the aerobic endurance, the better the lower body strength, dynamic balance and agility will be. This hypothesis indicates the higher the dynamic balance (especially in females), the better all the other functional fitness tests. This indicates that senior citizens with proper balance can participate in physical activities to better their functional fitness. Therefore this hypothesis can only be partially accepted.

The rising number of senior citizens in the population proposes great challenges for the future. Because of the socio-economic environment these senior citizens are under tremendous pressure because of limited resources available to them. This emphasizes the fact that they need to stay independent for as long as they can, to be able to provide for themselves. The results of this study are alarming. When the inter quartile ranges for the participants of this study are compared to USA normal ranges their performance is quite dismal. Also the amount of weak tests is alarming. It also emphasizes the need for the elderly to become more active to maintain their functional capacity. A positive outcome of this study is the high correlations between aerobic endurance and dynamic balance with functional fitness. This provides evidence that senior citizens functional capacity can easily be addressed in old age homes by simple exercise interventions, like walking programmes. Lastly, a nation-wide study is needed to develop percentile scales for the diverse South African community so that the elderly can be evaluated accordingly.

5.3 Limitations and recommendations

The limitations experienced in this study were the following:

- ❖ The small sample size resulted in a loss of statistical power. Furthermore, participants could not be categorized into various age groups because of the small number of participants, and thus it complicates comparisons with USA data.
- ❖ Participants were recruited from selected geriatric institutions. Only volunteers participated in the research. The results therefore, cannot be generalized to all geriatric populations and various culture groups.
- ❖ The health screening questionnaire and the physical activity index was not presented in a way that makes it easy for rural communities to understand and complete the questionnaires and this compromises the accuracy of the information. These participants had to be omitted from the research.

The limited research available on the geriatric population in South Africa emphasises the importance of further research within this population. Future studies should attempt to create and validate a daily physical activity index and health screening questionnaire based on the various culture groups within the South African geriatric population. Furthermore, a risk assessment protocol for potential injuries should be developed, based on activities of daily living. According to that protocol, a functional fitness test protocol should be developed that is based on the needs of the South African geriatric population. In further intervention studies, cost effective strategies should be explored to enhance the functional fitness of geriatric populations in the rural communities as well.

APPENDIX A

GUIDELINES FOR AUTHORS

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

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

GENERAL POLICY

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

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

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

SUBMISSION OF MANUSCRIPT

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

Professor L.O. Amusa

Tel: +27 15 9628076

Centre for Biokinetics, Recreation
and Sport Science, University of Venda for
Science and Technology, P. Bag X5050,
Thohoyandou 0950
Republic of South Africa

Fax: +27 15 9628647/9628035

E-mail: amusalbw@yahoo.com

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

PREPERATION OF MANUSCRIPTS

Manuscripts should be type written in fluent English (using 12-point Times New Roman font and 1½ line-spacing) on one side of white A4-sized paper justified fully with 3cm margin on all sides. In preparing manuscripts, MS-word, Office 98 or Office 2000 for Windows should be used. Length of manuscripts should not normally exceed 12 printed pages (including tables, figures, references, etc.). For articles exceeding 12 typed pages US\$ 10.0 is charged per every extra page. Longer manuscripts may be accepted for publication as supplements or special research reviews. Authors will be requested to pay a publication charge of US\$ 150.0 to defray the very high cost of publication.

Title page:

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

Concise and informative title.

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

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

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

A short running title not longer than 6 words.

Abstract:

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

Text:

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

Introduction

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

Materials and methods

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

Results

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

Discussion

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

References

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

Authors are advised to consider the following examples in referencing:

Examples of citations in body of the text:-

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

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

Multiple references when cited in the body of the text should be listed chronologically in ascending order, i.e. starting with the oldest reference. These should be separated with semi colons. For example, (Tom, 1982; McDaniels & Jooste, 1990; van Heerden, 2001; de Ridder et al., 2003).

Reference list

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

Example of journal references:

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

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

For two authors: Johnson, A.G. & O'Kefee, L.M. (2003). Analysis of performance factors in provincial table tennis players. *Journal of Sport Performance*, 2(3), 12-31.

For Multiple authors: Kemper, G.A., McPherson, A.B., Toledo, I. & Abdullah, I.I. (1996). Kinematic analysis of forehand smash in badminton. *Science of Racket Sport*, 24(2), 99-112.

Example of book references:

Book references should specify the surname and initials of the author(s), year of publication, title, edition, page numbers written in brackets, city where book was published and name of publishers. Chapter

references should include the name(s) of the editor(s) and other specific information provided in the third example below:

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

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

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

Example of electronic references:

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

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

PROOFREADING

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

COPYRIGHT AGREEMENT

The Africa Association for Health, Physical Education, Recreation, Sport and Dance (AFAHPER-SD) holds the copyright for AJIPHERD. In keeping with copyright laws, authors will be required to assign copyright of accepted manuscripts to AFAHPER-SD. This ensures that both the publishers and the authors are protected from misuse of copyright information. Requests for permission to use copyright materials should be addressed to the Editor-in-Chief.

COMPLIMENTARY COPY OF AJIPHERD AND REPRINTS

Principal authors will receive ten (10) complimentary copies of the relevant pages in which their article has been published. In case of two or more joint authors the principal author distributes the copies to the co-authors. Reprints of published papers can be ordered using a reprint order form that will be sent to the corresponding author before publication. Bound copies of the journal may be ordered from: Dynasty Printers, 26 Pretorius Street, Mokopane 0600, South Africa. Tel: +27 15 4914873; Fax: +27 15 4916411; E-mail: Ahmed@dynastyprinters.com; website: www.dynastyprinters.com

APPENDIX B

Informed consent

In order to assess functional fitness, body composition and other physical fitness components the undersigned hereby voluntarily consents to engage in one or more of the following tests:

- Health screening and physical activity questionnaire
- Body composition
- Functional fitness tests
- Balance tests

Explanation of the test

The health screening will be done by completing an questionnaire regarding the participants current health status. It will be used to determine the participant risk category. Blood pressure will also be taken in order to determine possible health risk. Physical activity will also be determined by a questionnaire regarding various activities the participant, participate in. The questionnaire will be personally explained to each participant.

Body composition includes: Height, mass, waist and hip circumferences.

The functional fitness tests include tests that will measure upper body and lower body strength, upper and lower body flexibility, balance and agility and cardiovascular endurance. The balance tests will be used to assess static and dynamic balance.

Risks and discomforts

There is a slight possibility of pulling a muscle or spraining a ligament during the muscle strength and flexibility testing. In addition, you may experience muscle soreness 24 or 48 hours after testing. During the exercise testing certain changes may occur. These changes include abnormal blood pressure, rising heart rate and fatigue.

Expected benefits from testing

These tests will allow us to create a profile of senior citizens functional fitness, balance and physical activity levels. In future the necessary intervention programs will be incorporated for the elderly to improve their quality of life.

Inquiries

Questions about the procedures used in the physical fitness tests are encouraged. If you have any questions or need information, please ask us to explain further.

Freedom of consent

Your permission to perform these physical fitness tests is strictly voluntary. You are free to stop the test at any point, if you so desire.

I have read this form carefully and I fully understand the test procedures that I will perform and the risks and discomforts. Knowing these risks and having had the opportunity to ask questions that have been answered to my satisfaction, I consent to participant in these tests.

Date

Signature of patient

Date

Signature of supervisor

APPENDIX C

Test proforma

Participant number

1. Questionnaire		
2. Blood pressure	Systolic	Diastolic
3. Weight	(kg)	
4. Height	(cm)	
5. BMI		
6. Circumferences	Waist (cm)	Hip (cm)
7. Waist/Hip ratio		
8. 30 sec chair stand		
9. Arm curls		
10. Back scratch	L	R
11. Sit and reach	L	R
12. 8ft up and go	(sec)	
13. 6 min walk	(m)	
14. Static balance	(sec)	
15. Dynamic balance	(sec)	

APPENDIX D

Participant number

NORTHWEST UNIVERSITY, POTCHEFSTROOM CAMPUS.
HUMAN MOVEMENT SCIENCE DEPARTMENT

Please fill in the questionnaire by placing a tick in the relevant answer block or fill the relevant details in.

Surname: _____ Name: _____

Gender:

Age: _____ Date of birth: _____

Phone number: _____

Physician: _____

Date of measurement: _____ Time: _____

Race:

Section A

During the past 12 months Yes No

		Yes	No
1	Have a physician prescribed any medication for you?		
2	Has your weight fluctuated more than a few kilograms?		
3	Did you attempt to bring about weight change through diet or exercise?		
4	Have you experienced any faintness, light-headedness, or blackouts?		
5	Have you occasionally had trouble sleeping?		
6	Have you had any severe headaches?		
7	Have you experienced any temporary change in your speech pattern?		
8	Have you experienced any blurred vision?		
9	Have you felt unusually nervous or anxious for no apparent reason?		
10	Have you experienced unusual heartbeats such as skipped beats or palpitations?		
11	Have you experienced periods in which your heart felt as though it were racing for no apparent reason?		

At present

Yes No

1	Do you experience shortness or loss of breath while walking with others your own age?		
2	Do you experience sudden tingling, numbness, or loss of feeling in your arms, hand, legs, feet, or face?		
3	Have you ever noticed that your hands or feet sometimes feel cooler than the other parts of your body?		
4	Do you experience swelling of your feet and ankles?		
5	Do you get pains or cramps in your legs?		
6	Do you experience any pressure or heaviness in your chest?		
7	Do you experience any pressure or discomfort in your chest?		
8	Have you ever been told that your blood pressure was abnormal?		
9	Have you ever been told that your serum cholesterol or triglyceride level was high?		
10	Do you have diabetes?		

How often would you categorize your stress level as being high?

Occasionally	Frequently	Constantly
--------------	------------	------------

Have you ever been told that you have any of the following illnesses?

Myocardial infarction	Arteriosclerosis	Heart disease	Thyroid disease
Coronary thrombosis	Rheumatic heart	Heart attack	Heart valve disease
Coronary occlusion	Heart failure	Heart murmur	
Heart block	Aneurysm	Angina	

Have you ever had any of the following medical procedures?

Heart surgery	Pacemaker implant
Cardiac catheterization	Defibrillator
Coronary angioplasty	Heart transplantation

Section B

Has any of your immediate family been treated for or suspected to have had any of these conditions? Identify their relationship to you (father, mother, sister, brother)

- A. Diabetes mellitus
- B. Heart disease
- C. Stroke
- D. High blood pressure

APPENDIX E

Participant number

**NORTHWEST UNIVERSITY, POTCHEFSTROOM CAMPUS.
HUMAN MOVEMENT SCIENCE DEPARTMENT**

Please fill in the questionnaire by placing a tick in the relevant answer block or fill the relevant details in.

PHYSICAL ACTIVITY INDEX

List all activities of daily living as well as intensity, duration and frequency of the listed activities.

Activity	Intensity					Durations				Frequency				
	Light	Moderate	Moderately heavy	Intermittent heavy	Heavy, exhausted	Under 10 minutes	10 to 20 minutes	20 to 30 minutes	Over 30 minutes	Once a month	Few times a month	1 to 2 times a week	3 to 5 times a week	Daily or almost daily
	1	2	3	4	5	1	2	3	4	1	2	3	4	5
Walking														
Gardening														
Sport														
Gym														
Shopping														
Cooking														
Resistance training														
Cardio training														
Cleaning														
Laundry														
Care taker														
Other:														