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PHYSICAL ACTIVITY, DAILY STEP COUNTS AND FUNCTIONAL ABILITY IN OLDER ADULTS: USING NHANES DATABASE

A Dissertation Presented

by

CHUNFANG(MAGGIE) CHEN

Submitted to the Graduate School of the
University of Massachusetts Amherst in partial fulfillment
of the requirements for the degree of

DOCTOR OF PHILOSOPHY

September 2022

Elaine Marieb College of Nursing

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PHYSICAL ACTIVITY, DAILY STEP COUNTS AND FUNCTIONAL ABILITY IN OLDER ADULTS: USING NHANES DATABASE

A Dissertation Presented

By

Chunfang(Maggie) Chen

Approved as to style and content by:

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DEDICATION

I want to dedicate this dissertation project to my families, especially grandma who had passed away during my Ph.D. journey abroad and far away from home, as well as to my affiliated families in my hometown, including my parents, grandparents, uncles, aunts, cousins, nephews, nieces. To the family where I came from! To every family member who cared for me and I cared for! As the first generation/person of college education and doctorate degree in my original families, I am proud for being one of you!

Besides to my families, I also want to especially dedicate this dissertation project to myself! Thank myself for being strong and undefeated, for being insisted on during the global pandemic time, for being resilient and courageous when facing difficult times… For all I have done and all the courage I have embraced! Thanks to myself!

ACKNOWLEDGMENTS

I want to acknowledge all the people who have ever helped me, supported me, been nice to me during my Ph.D. journey and all my previous lives till this point! Especially thanks to my parents who have given me a life and body, my kids who are willing to come and choose me as mom, and being with me, also to my husband who have been stayed with me during most of these times. I can’t do this without any of these.

I also want to thank all those people who have made me today as a doctor! My teachers in undergraduate study, my college classmates, roommates, my mentors when working in the hospital, my colleagues, friends, my Ph.D. advisor and committees, and all the other people who have ever influenced me, interacted with me, or had ever affected me in pursuing this doctorate degree, or provided me with any type of information and resource on this. I can’t be the person today without any of these! I learned from every one of these people along the way through here. Thank you!

ABSTRACT

PHYSICAL ACTIVITY, DAILY STEP COUNTS AND FUNCTIONAL ABILITY IN OLDER ADULTS: USING NHANES DATABASE

SEPTEMBER 1ST, 2022

CHUNFANG(MAGGIE) CHEN, B.A., ZHEJIANG UNIVERSITY

Ph.D., UNIVERSITY OF MASSACHUSETTS AMHERST

Directed by: Professor Cynthia Jacelon

Maintaining functional ability and independence are essential in the healthcare of older adults. Physical activity(PA) has been acknowledged as effective and economical health promotion strategies in older population. However, the amount of PA needed to maintain functional ability in older adults remains unclear. This investigation used PRISM Dose-response Curves Stimulation Variable slope model to explore the relationships between the amount of PA and functional ability in community-dwelling young-old, middle-old and old-old age group adults. ANOVA analysis was used to examine the relationship between functional ability and self-perceived active level changes compared to 10 years ago. NHANES 2005-2006 older participants datasets were used. The study found positive dose-response curve relationship in middle-old female adults. Older women aged 75-84 years benefit from every minute spent on PA, an amount of 150 minutes per week is necessary to obtain the most functional benefits. Older adults who are 65 years old and above need to walk 5,400 -6,500 steps per day or spend 1,500-4,500kcal energy, or 150-450 minutes per week on PA to maintain their functional abilities in later ages. Older adults who perceive themselves less active compared to 10 years ago have more difficulties in doing daily activities than those who considered themselves the same active levels.

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CHAPTER 1

INTRODUCTION

1.1 Background

The number of the older population continues to grow unprecedently. The aging world report released by the National Institution of Health (NIH) stated that older people aged 65 and over represent 8.5 percent or 617 million worldwide (He, Goodkind, & Kowal, 2016). This number of older people is projected to increase more than 60 percent in 15 years. In 2030, there will be about 1 billion older people globally, equivalent to 12.0 percent of the total population. By 2050, this percentage is projected to jump to nearly 17 percent of the world's total population (He, Goodkind, & Kowal, 2016). Older adults aged 65 years and over are going to be the most rapidly growing proportion in contrast to the younger population. In 2020, people aged 65 and over outnumbered children under age 5 for the first time in human history. The number of older people in the United States is increasing at an ever-faster speed. America's 65-and-over population is projected to nearly double over the next three decades, from 48 million to 88 million by 2050.

The older population itself is growing older. Older adults are generally defined as aged 65 years and older. The total older population can be distinguished into three sub-groups: the young-old (aged 65–74), the middle-old (ages 75–84), and the old-old (over age 85) (Zizza, Ellison, & Wernette, 2009; Little & McGivern, n.d.). Among the three sub-groups, the number of middle-old and old-old adults are increasing much faster than the young-old. The old-old is the fastest-growing segment among the three older adult age groups. The number of young-old Americans (aged 65-74 group) (31.5 million) in

2019 was more than 14 times larger than in 1900; the 75-84 group (16 million) was more than 20 times larger, and the 85+ group (6.6 million) was 53 times larger since 1900 (U.S. Department of Health and Human Services, 2018). More than 55% of America's 65-and-over population is 75 years and above. The percentage of older people aged 85 years and above is projected to increase more than double from 1.9% in 2012 to 4.5% in 2050. Individuals aged 85 years and older are predicted to start growing faster than the working-age population by 2050 (Administration on Aging (AoA), 2018). Scientists have recognized that describing sub-groups in the 65+ population enables a more accurate portrayal of life activities and significant changes regarding the very different conditions that older adults experience as they grow older (Cicirelli, 2002).

The demographic change presents challenges to the healthcare industry in the older population. Aging comes with the deterioration of physical capacity and gradual loss of functional abilities, including the essential activities for daily living (ADLs) (Chodzko-Zajko et al., 2009). Only 45% of noninstitutionalized people aged 65 and above assessed their health as excellent or very good (AoA, 2018). Most older people have at least one chronic condition, and many have multiple health conditions. Older people are also considered the most vulnerable population groups in many aspects of society, especially the middle-old and old-old adults. Many of them are experiencing complex health problems, such as multiple chronic conditions, retirement transition, loss of loved ones, disability, and loss of physical self-control, etc. The need for caregiving increases as people age. Older American Profiles (2018) stated that more than 20% of older adults age 85 and over need help with personal care. The 2010 Medicare and Medicaid Services reported older citizens made up 13% of the U.S. population but accounted for 34% of healthcare-related expenditure. Healthcare spending per person for people aged 65 and older was about five times as much as per-person spending on children and triple what had been spent on working-age individuals (De Nardi et al., 2015). Overall, maintaining older adults' independence and decreasing the healthcare burden is essential in aging healthcare.

Functional ability in older adults is the essential capacity in performing daily living tasks. It generally determines how much formal and informal healthcare /assistance older adults need and whether they can live independently (Defining Health and Functional Ability, n.d.). Improving and maintaining functional ability is an important task when caring for the older population (WHO, 2015). How to slow down the progression of chronic conditions, prevent disability, and keep older individuals' physical functioning and independence as long as possible is the key to aging healthcare. Although a decline in physical function is inevitable in older adults, studies found that individuals who begin a regular PA program early in life and maintain a physically active lifestyle over the years will likely have high physical performance throughout their lifespan (Chodzko-Zajko et al., 2009; Hillsdon et al., 2005). Regular physical activity can favorably influence a broad range of physiological systems, mitigate age-related biological changes, reduce the risks of developing many chronic diseases, and benefit the preservation of functional capacity (Manini & Pahor, 2009; Chodzko-Zajko et al., 2009). Being physically active and engaging in regular physical activity may be a lifestyle factor that determines successful aging (Miller et al., 2000; Santos et al., 2012). Overall, regular physical activity can decrease the disability progression in activities of daily living

(ADL), instrumental activities of daily living (IADL), and is a good approach for maintaining and improving functional ability in older adults.

Habitual physical activity (PA) benefits occur throughout life. Older adults who are more physically active tend to be more independent in performing ADLs, less likely to experience falls, have a lower risk of age-related loss of function, and exhibit higher levels of cognitive function (Eriksen et al., 2016; Paterson et al., 2010; Nelson et al., 2007; Taylor et al., 2004). Decreased PA in older individuals is a risk factor for many chronic diseases, such as hypertension, arthritis, cardiovascular diseases, cancers, diabetes, etc. (Lee et al., 2012; Marques, Peralta, Martins, Gouveia, & Valeiro, 2018). It also contributes to negative parts of aging, such as fatigue, decreased function, and premature death (Booth, Gordon, Carlson, & Hamilton, 2000; Booth, Roberts, & Laye, 2012). Keeping physically active is essential for older individuals to maintain functional ability and live longer (Keysor, 2003). The amount of physical activity that people engage in generally decreases as their age increases, especially in the 75 years and older population. Older adults are the least physically active age group, and most of them spend a significant proportion of the day being sedentary. Engaging and promoting daily physical activity is important and accessible for general community-dwelling older adults. Above all, habitual PA is a feasible and economical way to improve functional ability and reduce healthcare costs in the older population.

The Physical Activity Guidelines for Americans (2018) recommended that all adults should aim to do at least 150 to 300 minutes of moderate-intensity PA a week, or an amount of 75 to 150 minutes of vigorous-intensity activity, or an equivalent combination of both moderate and vigorous activities. For older adults aged 65 years and above, the guidelines emphasized that multicomponent PA be included, such as walking, hiking, balancing, and muscle-strengthening activities (U.S. Department of Health and Human Services, 2018). The amount of physical activity recommended for older adults was the same as for general adults. World Health Organization (WHO) physical activity guidelines (2020) stated that for adults aged 65 years and older, physical activity includes leisure-time physical activity, transportation (e.g., walking or cycling), occupation (if the individual is still engaged in work), household chores, play, games, sports or planned exercise, in the context of daily, family, and community activities. The amount of physical activity suggested is approximately 30 minutes per day and at least five days a week (WHO, 2020). Overall, current guidelines do not include the amount of physical activity recommended specifically for older adults or any older age group. Physical activity recommendations suggest the same amount for older adults as for general adults, which do not consider older adults' advancing age, structural and functional decline, chronic disease/disability, etc. How much physical activity is enough for older adults is unknown. Researchers identified positive associations between physical activity and functional ability in older adults. It appeared moderate to higher levels of physical activity are effective, and there may be a threshold of at least moderate activity for significantly maintaining functional independence (Paterson & Warburton, 2010). However, it is not clear enough currently on the relationships between functional ability and the amount of physical activity in older adults. Whether a threshold or cutting value of physical activity amount exists remains questionable.

In summary, regular physical activity is essential in maintaining functional ability and independence in older adults, and can be a feasible and economical approach to aging healthcare. However, currently, there is no particular recommendation on the amount of physical activity for the older population group. How much PA is needed for general community-dwelling older adults to maintain functional ability or factors impacting the relationships between the amount of PA and functional ability in older adults are not well studied. There is also a lack of normative data on the amount of physical activity in the older adult population, especially in the middle and old-old groups.

1.2 Purpose

The purpose of this investigation is to understand the relationships between physical activity and functional ability/independent living in the young-old, middle-old, and old-old community-dwelling adults. Furthermore, the effects of physical activity on functional ability, and how much physical activity is needed/enough to maintain functional ability in 65 years and older community-dwelling older adults is unknown. A large national dataset was used to examine the possible dose-response relationships between the amount of physical activity and functional ability, as well as whether any threshold or cutting/ceiling dosage of physical activity exists for each group of older adults. This investigation further helped in understanding physical activity engagement in 65-year and older community-dwelling older adults, and in providing guidance for physical activity prescriptions and public policy in the older populations. The goals are to promote habitual physical activity, enhance independent living, and improve healthy aging in the young-old, middle-old, and old-old community-dwelling adults.

1.3 Significance

The proposed investigation is significant because it focused explicitly on the three sub-age groups of older adults: the young-old, the middle-old, and the old-old adults. There were few studies on the relationships between physical activity and functional ability, especially in 75 years and older. The investigation examined the amount of habitual physical activity both subjectively and objectively (steps per day) in all ages of community-dwelling older adults, which can add to the normative physical activity data for the older population. The study focused on the functional ability of community-dwelling older adults, which is the most essential and fundamental living assessment in the older population. Functional ability is a determinant factor of independent living and the key to successful aging. The proposed investigation is significant because it further explored the specific relationships between habitual physical activity amount/dosage and functional ability in each group of the community-dwelling young-old, middle-old, and old-old adults.

1.4 Aims and Hypotheses

This study aimed to explore the relationships between functional ability and the amount of physical activity, which was assessed both subjectively and objectively, in community-dwelling young-old, middle-old, and old-old adults. We hypothesized that there were dose-response relationships between the amount of physical activity and functional ability in the 65-year and older community-dwelling adult population. The investigation further aimed to explore the shape of dose-response relationships, and whether threshold or cutting/ceiling values of physical activity existed in the dose-response curves. We hypothesized that older adults maintain or gain a higher level of functional ability when engaged in a greater amount of daily physical activity. We also hypothesized that ceiling benefit in functional ability existed when the dose of physical activity reached a certain amount.

The investigation aimed to examine the relationships between functional ability and self-perceived active level changes compared to 10 years ago in community dwelling young-old, middle-old, and old-old adults. We hypothesized that older adults have a higher level of functional ability if they considered themselves as more or about the same active level compared to 10 years ago than those who regarded themselves as less active.

1.5 Primary Research Questions

The primary research questions were:

- What are the relationships between the amount of physical activity (represented both subjectively and objectively) and functional ability in community-dwelling old age groups of young-old (aged 65-74), middle-old (aged 75-84), and old-old (aged 85 and above) adults?
- How much physical activity is enough/needed to maintain/benefit functional ability in community-dwelling young-old, middle-old, and old-old adults?
- What are the relationships between functional ability and self-perceived changes in active level compared to 10 years ago in three old age groups (young-old, middle-old, and old-old) of community-dwelling older adults?

1.6 Theoretical Frameworks

The activity theory and continuity theory provide fundamental guidance on the importance of physical activity and the existence of activity continuity in the aging population. Exploring the balance study adds to the theoretical framework on the relationships between physical activity and healthy aging in the daily lives of community-dwelling older individuals. The dose-response curves between physical activity level and health outcomes serve as an operational framework for this project.

1.6.1 Activity Theory and Continuity Theory

The activity and continuity theories serve as the theoretical foundation for this investigation. These two theories are the major psychosocial theories that describe how people develop in old age. The activity theory(of aging), also known as the implicit theory of aging, normal theory of aging, and lay theory of aging, proposes that successful aging occurs when older adults stay active and maintain social interactions (Havighurst, 1961). The theory takes the view that the aging process is delayed, and the quality of life is enhanced when older people remain active. It assumes a positive relationship between activity and well-being in aging (Schulz, 2006). The activity theory pointed to the importance of engaging in physical activity in aging, which provides a fundamental basis for this project: promoting physical activity and staying active to improve functioning and independence in all groups of older adults. The continuity theory modifies and elaborates upon the activity theory. The continuity theory of normal aging states that older adults will usually maintain the same activities, behaviors, and relationships as they did in their earlier years of life (Atchley, 1989). According to this theory, older adults try to maintain this continuity of lifestyle by adapting strategies connected to their past experiences. The continuity theory guided the examination of long-term physical activity change and the impact of active level change on functioning in the older population. According to continuity theory, older adults will try to maintain their active level by adapting strategies.

1.6.2 EXPLORING THE BALANCE Path-Analysis Study

Maintaining the Balance Model (Jacelon, 2010) and Exploring the Balance project (Pennell, 2017) together provided a further direction on the " Activity" investigation of this study. Physical activity, which included themes of performing ADLs, managing IADLs, and fostering mobility, was the most important theme in the daily lives of community-dwelling older adults, including 75 years and above older individuals. The EXPLORING THE BALANCE study further identified that Activity has direct and second-largest effects on health outcomes in older adults. Meanwhile, "Activity" interacts with all the other factors, including Attitude, Relationships, Number of chronic health problems in the daily life of the community-dwelling older individuals (Pennell, 2017). This investigation explored relationships between daily physical activity and health outcomes in older adults based on previous work. The purpose is to further understand the complicated and advanced relationships between the amount of physical activity and health benefits in different older age group adults.

1.6.3 The Relationships Between Physical Activity and Health Outcomes

The relationship between physical activity and health outcomes has been defined by expertized researchers in the field (Figure 1.1) (Bouchard, 2001). Two paths link physical activity to health outcomes. The first is a direct path in which variation in physical activity level is thought to have an impact on health. The second path is one in which variation in physical activity level translates into changes in health-related fitness, which in turn influences health outcomes. Regular physical activity has positive effects on health outcomes. Physical Activity Guidelines Advisory Committee Scientific Report (2018) reported that physical activity improves physical function for older adults. However, the relationship between the level/amount of physical activity and health outcomes are not that clear, especially the shape of the dose-response curves.

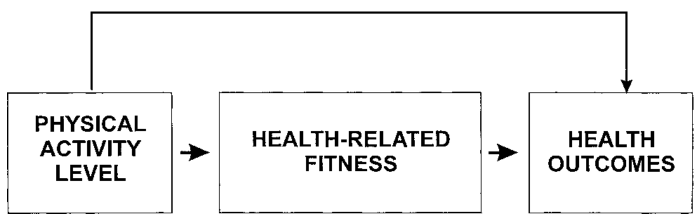


Figure 1.1 The basic paradigm defining the paths from physical activity levels to health outcomes

The dose-response curve describing relationships between regular physical activity levels and health outcomes is shown below (Figure 1.6.3.2) (Haskell, 1994; Bouchard, 2001). The curve B pattern is a linear relationship. This curve, for example, is the most appropriate for the relationship between physical activity level and mortality rates as the mortality rates decrease linearly with the increase in physical activity level(Bouchard, 2001). The other two curves (A and C) provide good fits with other specific health outcomes. Curve A specifies that the health benefits are attained at low to moderate levels of physical activity, and there seems to have a ceiling physical activity value by where health benefits reach their highest limits. The current physical activity recommendations are based upon the curve A pattern. In contrast, curve C specifies that the greatest benefits are obtained only when the level of physical activity is rather high. This dose-response model will be used as an operational foundation for the current investigation to examine the relationships between the amount of physical activity and functional ability as health benefits in community-dwelling young old, middle old, and old older adults.

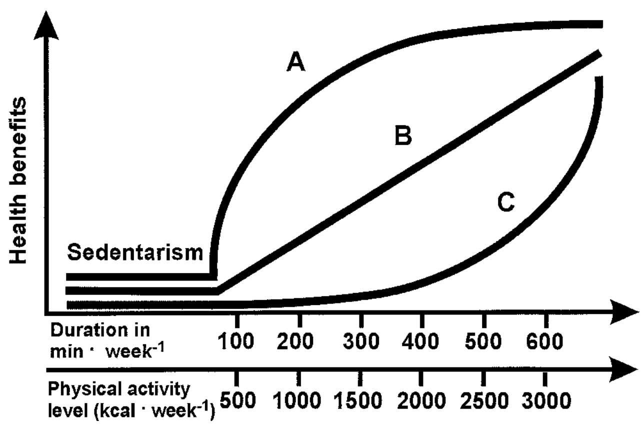


Figure 1.2 Schematic illustration depicting the relationships between physical activity level defined in minutes of participation per week or energy expended

1.7 National Health and Nutrition Examination Survey (NHANES) 2005-2006 Datasets

National Health and Nutrition Examination Survey (NHANES) of 2005-2006 datasets will be used in this investigation to analyze the proposed research questions. NHANES is a part of the Centers for Disease Control and Prevention (CDC) and is a program of studies designed to assess the health and nutritional status of adults and children in the United States (https://www.cdc.gov/nchs/nhanes/about_nhanes.htm). NHANES is a major program of the National Center for Health Statistics (NCHS). NCHS is part of the Centers for Disease Control and Prevention (CDC) and has the responsibility of producing vital and health statistics for the Nation. The NHANES program began in the early 1960s and has been conducted as a series of surveys focusing on different population groups or health topics. In 1999, the survey became a continuous program that has a changing focus on a variety of health and nutrition measurements to meet emerging needs. The survey examines a nationally representative sample of about 5,000 persons each year. These persons are located in counties across the country, 15 of which are visited each year. The sample of NHANES is selected to represent the U.S. population of all ages. To produce reliable statistics, NHANES over-samples persons 60 and older, African Americans, and Hispanics since the United States have experienced dramatic growth in the number of older people during this century. The aging population has major implications for health care needs, public policy, and research priorities. NCHS is working with public health agencies to increase the knowledge of the health status of older Americans. NHANES has a primary role in this endeavor. NHANES findings will be used to determine the prevalence of major diseases and risk factors for diseases. Information will be used to assess nutritional status and its association with health promotion and disease prevention. NHANES Information is made available through an extensive series of publications and articles in scientific and technical journals. NHANES findings are also the basis for national standards for such measurements as height, weight, and blood pressure. Data from this survey will be used in epidemiological studies and health sciences research, which helps develop sound public health policy, direct and design health programs and services, and expand the health knowledge of the Nation.

NHANES 2005-2006 data contains overall 10,348 samples, and individuals aged 60 and over were oversampled in the datasets. NHANES 2005-2006 is also the last dataset containing objective physical activity, monitored by Physical Activity Monitors(PAM). NHANES is the most appropriate dataset for answering the research questions of this investigation. It contains subjective physical activity from self-reported questionnaires and objective physical activity assessments. It also has a large enough nationally representative sample size of the United States.

1.8 Definitions of Terms

1.8.1 The Definition of Physical Activity

Physical activity is defined as any bodily movement produced by skeletal muscles that require energy expenditure, including exercise and incidental activity integrated into daily activity (WHO, 2020). This WHO definition defines physical activity for this study from a kinematic perspective. The meanings of physical activity, specifically in community-dwelling older adults, were adopted from the original Jacelon's Maintaining The Balance model. The meanings of physical activity include performing ADLs, IADLs, fostering mobility/exercises, and maintaining activities using assistive technology (Jacelon, 2010). These codes were derived from the daily lives of community dwelling older adults who are independent and successful in managing daily lives with chronic health problems. Practically, daily living related activities are a major proportion of physical activities for community-dwelling older adults, especially with middle old and old older adults.

Operationally, physical activity will be assessed both subjectively and objectively in this investigation (Table 1.1). Walking step counts measured by physical activity monitors will be used to represent the objective amount of daily physical activity in 65 years and above community-dwelling older adults. Self-reported questions on vigorous and moderate activities will be used as subjective measures of physical activity. The amount of subjective physical activity will be calculated into weekly energy expenditure and weekly physical activity duration (minutes) from each reported activity type, frequency, and duration.

1.8.2 The Definition of Functional Ability

The outcome variable in this investigation is functional ability which represents the independent living ability of community-dwelling older adults. The definition of functional ability is a person's ability to perform daily tasks that are required for living (Elsawy & Higgins, 2011). Older adults' functional ability generally determines what they can do and how healthy they are. Functional ability indicates how much formal and informal assistance they need and has implications for where they can live (Defining Health and Functional Ability, n.d.). Older individuals' functional ability level directly revealed the person's ability/capacity for independent living and healthy aging (WHO, 2015).

The operational definition of functional ability in this investigation was defined by difficulty levels in doing twenty-one types of daily activities, which include managing money difficulty, walking for a quarter mile difficulty, walking up ten steps difficulty, stooping, crouching, kneeling difficulty, lifting or carrying difficulty, house chore difficulty, preparing meals difficulty, walking between rooms on same floor difficulty, standing up from armless chair difficulty, getting in and out of bed difficulty, using forks, knife drinking from cup difficulty, dressing yourself difficulty, standing for long periods difficulty, sitting for long periods difficulty, reaching up the overhead difficulty, grasp/holding small objects difficulty, going out to movies, events difficulty, attending social event difficulty, leisure activity at home difficulty, push or pull large objects difficulty. The total difficulty scores in performing these activities described older individuals' functional ability in independent living (Table 1.1) .

Table 1.1 Operational definitions of variables

Independent variables	**Descriptions**	**Operational definitions**
Physical activity	Weekly energy expenditure(kcal/week) & Weekly physical activity duration -*subjective value*	Calculate from Self-reported vigorous and moderate physical activity types, frequency, and duration;
	Steps per day -*objective value*	Recorded by physical activity monitors;
	Change of active level compared to 10 years ago	Self-perception as more, less, or about the same physically active level as 10 years ago
Dependent variables		

Functional ability	Difficulty levels of performing certain daily activities	Total scores of difficulty levels in performing 21 types of daily activities;
Demographic variables		
Age		Subject's age
Gender/sex		Subject's gender
Race/Ethnicity		Subject's race/ethnicity
Education levels		Subject's education levels
Marital status		Subject's marital status
Co-variables		
Body Mass Index (BMI)		Subject's BMI
Comorbidities	Self-reported medical conditions ever had	Total numbers of medical conditions ever had from 11 types of health problems;

CHAPTER 2

REVIEW OF LITERATURE

2.1 Introduction

This chapter addressed existing evidence of the relationship between physical activity and functional ability in 65 years and older adult population. The review synthesized the current evidence on physical activity and its quantification as well as the development of walking step counts as a universal method expressing daily free-living physical activity. Functional ability in the older adult population and its measurement were analyzed in the existing literature. Physical activity and the amount of physical activity as independent variables, functional ability as health outcomes, and the relationship between these two were analyzed and discussed through the whole literature review process.

2.2 Search Strategies

Web of Science, CINAHL, PubMed, and PsychINFO databases were searched. Key search terms included "physical activity", "activit* of daily living" combined with "functional ability" and terms for the older population as "older" OR "elder*" OR "geriatric" OR "aging" OR "senior". In PubMed, MeSH Terms "physical activity" and MeSH Major Topic "functional ability" were applied as searching strategies (Table 2.1). Snowball sampling was utilized to identify eligible articles. The inclusion criteria were articles focused on the relationship between physical activity and functional ability, targeted on community-dwelling 65 year and older adults, publication time from 2000 through 2019, and written in English. Exclusion criteria included non-human subjects; non-free-living physical activity; physical activity that only involves parts of the body, such as stair climbing activity, up-limb activity, etc.; physical activity under certain situations like after an earthquake, transaction to retirement, etc.; specifically designed PA intervention/training program; disease-management/health promotion related PA. Functional ability only included body parts functioning or non-physical function were all excluded as well as certain groups of older people, such as older veterans, older caregivers, rehabilitation elders, etc. The searching strategies aim to capture free-living daily habitual PA which represents general 65 years and above community-dwelling older adults. The search originally received an overall result of 2403 articles after removing duplicates. 257 records remained after the first screening based on the inclusion and exclusion criteria. Notes were taken during reading on the features and measurements of physical activity and functional ability in the young-old, middle-old, and old-old adults throughout the screening process. The analysis based on PA and functional ability each and their measurements in the literature were described in the following sections.

A second screening reading and analysis was conducted among the remaining 257 articles. Further exclusion criteria included studies that didn’t mention PA amount or quantifying PA, PA wasn’t included as independent variables or health outcomes not related to functional ability. The search eventually finalized 32 articles (see appendix A). The analysis of physical activity dosage/amount and relationships with functional ability in the older adult population is provided in the following section.

Table 2.1 Search strategies

Physical activity OR activit* of daily living	AND
Functional ability	AND
Older OR elder* OR geriatric OR aging OR senior	
"physical activity" (MeSH Terms) AND "functional ability" (MeSH Major Topic)	

2.3 Physical Activity and Measurement in Older Adults

People become less physically active as they age. About 25.4% of adults aged 50–64 years were physically inactive, this number was 26.9% among adults aged 65–74 years, and increases to 35.3% among adults aged ≥75 years (Watson, 2016). Many older adults didn't meet the guidelines-recommended activity level. The percentage of older people who do not meet the physical activity recommendations ranged from 17% to 97.6% (Sun et al., 2013). Physical activity measurement dimensions such as type, intensity, etc. in older adults are also different from younger adults. Older adults do more walking, housework, and gardening activities, while young adults perform more sports (Krems et al., 2004). Older people tend to engage more in light-moderate intensity physical activity and less frequency compared to their younger counterparts. With 75 years and above adults, many rarely engaged in moderate to vigorous PA.

Frequency, intensity, duration (time), and type are four main dimensions measuring physical activity. Intensity measurement is the center for quantifying PA. Metabolic equivalent of task, or MET, is a unit useful for describing the energy expenditure of a specific activity. One MET is considered to represent resting energy expenditure, or approximately 3.5 ml/kg/min in terms of oxygen consumption, activities can be quantified in terms of multiples of this resting oxygen consumption. Public health guidelines had used PA duration and intensity describing the PA amount been recommended. Physical activity intensity in older adults was categorized as sedentary time (ST) (≤1.50 MET), light PA (LPA)(1.51–2.99 MET), moderate PA (MPA) (3.00-5. 99 MET), and vigorous PA (VPA) (more than 6.00 MET) (U.S. Department of Health and Human Services, 2018). METs are used to describe PA intensity for different types of activities. It allows all activities to be compared on a standard scale (Welk, 2002). Energy expenditure and METs are widely used for calculating PA amount.

Subjective (or indirect) and objective (or direct) assessment are two main measures of physical activity. Subjective measures rely on self-report which include questionnaires, diary, log, writing notes, etc. (Kowalski et al., 2012). Objective measures were designed to monitor and record the biomechanical or physiological consequences of performing PA, often in real-time (Trost & Neil, 2014). Various types of self-report questionnaires were developed and modified to measure PA for the older adult population since research in this field started. Subjective PA measures are advantaged in being able to recall back PA retrospectively as well as obtaining all dimensions of PA type, frequency, duration, and intensity meanwhile (Brach et al., 2008). Objectively monitored PA is considered more reliable and accurate in eliminating reporting bias and recall problems compared to self-reported measures (Wilcox & Ainsworth, 2009). More and more objective measures were adopted to monitor PA in the older population in recent decades due to the fast-emergence of new technology and applications with wearable activity monitors, such as pedometers, accelerometers, heart rate monitors, etc. Among those objective metrics used to describe PA, step counts is the simplest and most popular output from most objective monitors. Step is a basic unit of locomotion and provides an easy-to-understand metric of physical activity (Kraus et al., 2019). It is feasible, has a relatively low risk of injury, and can be done year-round in many settings for most 65 years and older adults (U.S. Department of Health and Human Services, 2018). Daily step count is a readily accessible means by which to monitor and set physical activity goals. Daily step counts were used independently or combined to describe PA amount in older adults (Aoyagi et al., 2009; de Melo et al., 2014; Ewald et al., 2014). Overall, both subjective and objective measures of PA are used and mostly combined to report PA amounts for the older population.

Overall, there is not enough research on PA within the group of 75 year and older adults. Normative data on the amount of PA that older adults engaged in daily are lacking. It is not clear about the daily PA engagement conditions and the amount of PA needed to maintain health benefits for older citizens in the U.S. There is a need for more specific and approachable physical activity recommendations in general community-dwelling older adults, especially for middle-old and old-old adults. Physical activity in the older population especially the middle-old and old-old are not well studied.

2.4 Functional Ability and Measurement in Older Adults

Aging comes along with gradual declines in functional status. Maintaining functional ability is the key to keep older adults' independence as long as possible. One of the best ways to evaluate the health status of older adults is through functional ability assessment which provides data that may indicate a future decline in health status, allowing health-care providers to intervene appropriately (The Hartford Institute for Geriatric Nursing, n.d.). Functional ability is the ability to perform basic daily living activities. Katz's ADLs was considered as a standard functional measurement of the client's ability to perform activities of daily living independently, such as toileting, bathing, dressing, feeding, transferring, and continence (Katz, 1983). IADLs refers to a higher level of functioning, usually used to determine an individual's ability to care for him- or herself, such as the ability to use the telephone, food preparation, housekeeping, laundry, shopping, mode of transportation, responsibility for own medications, and ability to handle finances (Lawton & Brody, 1969). Activities of daily living were used for functional ability evaluation in community-dwelling older adults in many studies (Etman et al., 2016; Ewald et al., 2014; Ku et al., 2016; Pereira et al., 2016; Tomita et al., 2018). Laboratory -setting conducted functioning tests and functional fitness tests were used to assess functional ability of older population (Ewald et al., 2014; Tomita et al., 2018), such as walking ability/speed, timed up and go test, upper and lower body strength and balance, etc. (Aoyagi et al., 2009; de Melo et al., 2014; Fielding et al., 2017). ADLs and IADLs included the basic activities that older adults perform every day. Older individuals have to have a certain level of functional ability to maintain independent living.

2.5 The Relationships Between Physical Activity Level and Health Outcomes

A large proportion of current research on the relationship between physical activity level and health benefits/outcomes was focused on the effects (benefits or risks), factors, and mediators between physical activity and health-related outcomes rather than on the PA level /dosage/amount and health benefits in the older adult population. The evolution of the concept of "dose-response" between physical activity and health outcomes emerged in the 1960s, the minimal amount of regular exercise needed to generate significant health benefits was first investigated by Scandinavian and Germany physiologists and physicians (Bouchard, Hollmann, Venrath, Herkenrath, & Schlussel, 1966). Health outcomes/benefits have been studied regarding the dose-response relationship with physical activity included all-cause mortality, cardiovascular disease, blood pressure and hypertension, blood lipids and lipoproteins, coagulation and hemostatic factors, overweight, obesity, and fat distribution, type 2 diabetes mellitus, cancer, quality of life and independent living in the elderly, etc. Dose-response relationships have been identified between physical activity and all-cause mortality, cardiovascular disease, hypertension, type 2 diabetes, cancer, and independent living in the elderly. There was an inverse linear dose-response relationship between physical activity and mortality, as well as cardiovascular disease (Antero Kesaniemi et al., 2001). With independent living in the elderly, scientists found a positive dose-response relationship between physical activity and an improvement in activity of daily living (Antero Kesaniemi et al., 2001). However, most of these findings were from outcomes of uncontrolled or nonrandomized trials or from observation studies. It is not clear enough about the shape of dose-response curve, or whether a minimum dose or cutting value for the amount of physical activity exists. There are also greater risks of injury and physical harm with increasing volumes of activities, especially in the older population, considering many of them have underlying health issues or chronic conditions. Thus, It is important to further understand the dose-response relationships between the amount of physical activity and functional ability in older adults and to identify the possible threshold and/or ceiling dosage of physical activity to achieve the most beneficial health outcomes.

Physical Activity Advisory Committee (2018) stated that there is not enough evidence for a recommended amount of physical activity in older population groups. Large samples of normative data on physical activity are lacking in the 65 years and older population, especially with 75 year and above adults. There is generally a positive relationship between physical activity level and functional ability in the older adult population. However, this relationship is not studied in different older age group. How much physical activity is enough/needed, or whether there is a least amount of physical activity to maintain functional ability and obtain health benefits in the older adult population remains unknown. There is a lack of specific recommendations on PA amount for different age groups of older adults.

2.6 How Much PA is Needed in Older Adults

Physical activity time/duration and steps per day were two major indicators used in reviewed studies to report the needed amount of PA in the older adult population. Public health guidelines recommended that all adults (including older adults) should aim to do at least 150 to 300 minutes of moderate-intensity PA a week, or an amount of 75 to 150 minutes of vigorous-intensity activity, or an equivalent combination of both moderate and vigorous activities (U.S. Department of Health and Human Services, 2018). However, light intensity PA is the major PA in community-dwelling older adults especially the middle-old and old-old age groups (Loprinzi et al., 2015). Many older adults are limited in performing high-intensity PA due to chronic conditions, such as arthritis, cardiac tolerance, etc. The guidelines-recommended level of PA as moderate or vigorous was not direct enough to apply to daily lives of older adults. Researchers reported that guidelines proposed physical activity dosage were based upon the dose-response curve A pattern (Bouchard, 2000), however, they were only for the general adult population. Evidence also showed that being more stable/having less change, or small increases in PA time and energy expenditure was beneficial in maintaining the functional ability for community-dwelling older adults (Etman et al., 2016; Fielding et al., 2017; Pereira et al., 2016). A higher level of PA energy expenditure (>4000 kcal/week) was considered related to functional ability improvement (Tomita et al., 2018). However, these reviewed studies were based on mostly small sample size researches. There was also a discrepancy in older age group categorization among reviewed study samples.

The daily walking step was the most used measure to describe the needed amount of PA for older adults. The Physical Activity Guidelines Advisory Committee (PAGAC) (2018) stated that it is important to better understand how the measurement of steps per day might fit into the assessment of daily or weekly physical activity exposures and their relationship to important health. Step counts incorporate both light and moderate to vigorous physical activity and counting steps has become a common method of assessing daily physical activity for older individuals (PAGAC, 2018). Older adults approximately engaged one-third of their daily time in physical activity (PA). Walking is the major contributor to moderate-to-vigorous physical activity, as well as light PA in functioning community-dwelling 65+ older adults (Cabanas-Sánchez et al., 2019). The measurement of walking steps can be accomplished through objective, readily obtainable technology with physical activity trackers, such as those worn on the ankle, wrist, or finger.

The traditional 10,000 steps/day for healthy adults as the goal for PA was well-recognized earlier from the 1960s (Hatano, 1993). Studies had indicated health benefits and a fair degree of similarity between the 10,000 steps/day recommendation and current public health guidelines for adults (Kang et al., 2009; Tudor-Locke & Bassett, 2004). However, healthy older adults (aged 59-80 years) achieved 6000 steps/day for non-exercise weekday and less than half attained 10,000 steps/day despite attending a structured exercise class (Tudor-Locke C, Jones GR, Myers AM, et al., 2002). Some scientists also suggested a possible progression of osteoarthritis at step count per day greater than 10,000 (Kraus, Sprow, & Powell, et al., 2019). Preliminary evidence suggests that a goal of 10,000 steps/day may not be sustainable for older adults and those living with chronic diseases. Current evidence indicated a linear inverse dose-response relationship of daily steps with important health outcomes included all-cause mortality, cardiovascular events, and type 2 diabetes (Kraus et al., 2019). There is not enough evidence or consensus concluding the relationships between daily step counts and independent living/functional ability in older adults. To maintain functional independence, the reviewed studies resulted that the number of daily steps needed was between 6500 and 8000 or more for community-dwelling 65 and older adults(Ewald et al., 2014) (de Melo et al., 2014) (Aoyagi et al., 2009). A number of 5000 steps per day for those 75- to 79-year-old for achieving most of the benefit from PA (Ewald et al., 2014). However, the reviewed results were based on a small number of studies. There is no recommended suggestion on the number of daily steps on the old-old age group adults. Approximately 7,000-10,000 steps/day for 65+ healthy older adults were suggested based on public health guidelines recommendations (Tudor-Locke et al., 2008; Tudor-Locke Catrine et al., 2011). Above all, there is no consensus on the number of steps needed to maintain functional ability in community-dwelling young-old, middle-old, and old-older adults. The dose-response relationship between step counts and the optimal health benefits for keeping functional ability and independent living in 65 years and above community-dwelling older population is not well studied. There is limited evidence on the middle-old and old-old adult age groups.

2.7 Summary

Attempting to establish an optimal dose of physical activity for maintaining functioning in community-dwelling older adults is essential and necessary. Both subjective and objective measures were used widely to report PA amounts in the older adult population. Step count is one of the best ways to calculate/measure the amount of daily PA in ambulatory community-dwelling 65+ older adults. Walking Step is a readily accessible means by which to monitor and set physical activity goals. Daily step counts were used to express PA dose in most objective measures in studies. Approximately, the number of 6,500 to 8,000 steps and more was associated with improvement in functional ability and independence in community-dwelling older adults. Energy expenditure is also used to calculate PA level/dosage in many subjective measures. However, those reviewed studies didn’t have large enough sample size. There were also geographic and age grouping differences among study samples. Overall, there is no consensus on step number or energy expenditure as to how much is enough/needed for maintaining independent functional ability in 65 years and older community-dwelling adults. There is very limited data on the amount of physical activity in older adults aged 75 years and up, either with 85 years and older people.

CHAPTER 3

METHODOLOGY

3.1 Introduction to Methodology

This investigation utilized a secondary analysis of the existing nationally representative dataset National Health and Nutrition Examination Survey (NHANES) to examine the relationship between functional ability and the amount of physical activity which represented by both self-reported weekly energy expenditure and objective daily step counts in the community-dwelling young-old, middle-old and old-old adult population. NHANES 2005-2006 datasets were used for data analysis. Dose-response relationships between subjective and objective physical activity amount and functional ability levels were examined in three old age groups separately as well as the impact of co-variances on the relationships.

3.2 Secondary Analysis

Secondary analysis is a research method that involves analyzing data collected by someone else. Sources of secondary data include censuses, information collected by government departments, organizational records, research data that was collected by someone else for another primary purpose, etc. Basically, primary data that was agreed by the data owner can be used for another person or entity. Secondary data analysis is becoming prevalent and practical since vast amounts of data that has been collected, compiled, and archived is now easily accessible for research due to technological advances (Johnston, 2014). Secondary analysis is an important resource Especially within population-based health care research (Hoffmann et al., 2008; Wagh, n.d.).

3.2.1 Benefits and Limitations

The advantages of using secondary data analysis include economical, time-saving, high quality data, no need for the ethics committee process, etc. The already existed datasets could save researchers large amounts of time and financial expenses in conducting research and collecting data. It also benefits those researchers or teams that are interested in large sample size national, organizational, or departmental data since it is challenging for individual researchers to conduct these types of projects. Another benefit of secondary analysis is that the whole process will not need to deal with direct human subjects and is no harm to human subjects.

The limitations of secondary analysis are also obvious. The process of research operation and data collection could be not so satisfying as the researcher wanted since it is not originally designed for the current study. Researchers also need to spend time getting familiar with and understanding the datasets based on the primary design. Some secondary data were old and out of date.

3.3 NHANES Datasets Evaluation

3.3.1 NHANES 2005-2006 Plan and Operations

NHANES combines interviews and physical examinations. Health interviews were conducted in respondents' homes. Health measurements were performed in specially designed and equipped mobile examination centers (MEC), which travel to locations throughout the country. In each location, local health and government officials were notified of the upcoming survey. Households in the study area receive a letter from the NCHS Director to introduce the survey. Local media may feature stories about the survey. NHANES was designed to facilitate and encourage participation. Transportation was provided to and from the mobile center if necessary. Participants received compensation and a report of medical findings were given to each participant. All information collected in the survey was kept strictly confidential. Privacy was protected by public laws. The study team consists of a physician, medical and health technicians, as well as dietary and health interviewers. Many of the study staff were bilingual (English/Spanish).

The NHANES interview included demographic, socioeconomic, dietary, and health-related questions. The examination component consists of medical, dental, and physiological measurements, as well as laboratory tests administered by highly trained medical personnel. NHANES questionnaires as Physical activity and physical fitness questionnaires, physical functioning questionnaires, sample participant's demographics, and medical conditions were interviewed in participants' home. Each participant (aged 18 and over) was asked to sign a home interview consent form, agreeing to participate in the household interview portion of the survey. The physical activity monitor(PAM) component was conducted at the conclusion of participants' MEC appointment. Eligible sample participants were recruited to participate in the collection of activities.

All NHANES survey protocols were reviewed and approved by the National Center for Health Statistics (NCHS) Research Ethics Review Board (ERB) before implementation. NHANES data collection instruments that integrated biomedical equipment, questionnaire items, and other data collection and administrative systems were tested for accuracy, calibration, and adherence to protocols. Data from these automated systems underwent stringent review to confirm the accuracy of the data and the data collection software, as well as compliance with data confidentiality requirements.

3.3.2 NHANES 2005-2006 Sample design

NHANES used a complex, multistage probability sampling design to select a sample representative of the civilian noninstitutionalized household population of the United States. About 30 selected counties were visited during a 2-year survey cycle out of approximately 3,000 counties in the country. Each of the four regions of the United States and metropolitan and nonmetropolitan areas is represented each year. The NHANES 2005-2006 sample represents the total noninstitutionalized civilian population residing in the 50 states and District of Columbia. A four-stage sample design was used in NHANES 2005–2006(National Center for Health Statistics (U.S.), 2012). The stages of sample selection are 1) selection of Primary Sampling Units (PSUs), which are counties or small groups of contiguous counties; 2) segments within PSUs (a block or group of blocks containing a cluster of households); 3) households within segments; and 4) one or more participants within households. A total of 15 PSUs are visited during a 12-month time period. An overall 10,348 individual data was collected in NHANES 2005-2006 cycle. Persons 60+ years of age were oversampled in NHANES 2005-2006 due to the dramatic growth in the number of older people in the United States. NHANES excludes all persons in supervised care or custody in institutional settings, all active-duty military personnel, active-duty family members living overseas, and any other U.S. citizens residing outside the 50 states and the District of Columbia. Informed consent was obtained from every participant of NHANES.

3.3.3 NHANES 2005-2006 Variable Measures

3.3.3.1 Functional Ability

Functional ability was assessed in NHANES Physical Functioning Questionnaire(PFQ). The question of PFQ.061 was used in this investigation to describe functional ability in NHANES older participants. Difficulty levels in doing twenty-one types of daily activities were assessed which included managing money difficulty, walking for a quarter mile difficulty, walking up ten steps difficulty, stooping, crouching, kneeling difficulty, lifting or carrying difficulty, house chore difficulty, preparing meals difficulty, walking between rooms on same floor difficulty, standing up from armless chair difficulty, getting in and out of bed difficulty, using a fork, knife drinking from cup difficulty, dressing yourself difficulty, standing for long periods difficulty, sitting for long periods difficulty, reaching up over head difficulty, grasp/holding small objects difficulty, going out to movies, events difficulty, attending social event difficulty, leisure activity at home difficulty and push or pull large objects difficulty. Participants were asked about difficulty levels in doing all these activities, with selective answers of “no difficulty, some difficulty, much difficulty and unable to do”. Answers were coded as 1 for no difficulty, 2 for some difficulty, 3 for much difficulty, and 4 for unable to do. The total score of difficulty levels in doing daily activities ranged from 21 to 84 points. Older adults’ functional ability was represented by how difficulty they perform these daily activities. The functional ability scores were achieved by subtracting total difficulty scores from 0, so that bigger scores represent lower difficulty levels and better functional abilities. The final scores of functional ability ranged from -84 to -21 points.

3.3.3.2 Steps Per Day

Daily step counts were recorded by physical activity monitors (PAM) (ActiGraph AM-7164 (formerly the CSA/MTI AM-7164), manufactured by ActiGraph of Ft. Walton Beach, FL.). The PAM was placed on an elasticized fabric belt, custom-fitted for each participant, and worn on the right hip. Participants were asked to wear the monitor for consecutive 7 days and remove it before water-related activities such as swimming or bathing, and to remove the device at bedtime. The activity monitors were returned by mail in postage-paid padded envelopes that were provided. Subjects received $40 remuneration after their monitors were returned. Participants who used wheelchairs and or had other impairments that prevented them from walking or wearing the PAM device were excluded.

3.3.3.3 Weekly Energy Expenditure and Physical Activity Duration

Subjective physical activity was assessed using NHANES physical activity questionnaires(PAQ). The total amount of physical activity per person was measured combining transportation-related activity, daily activities and leisure time activities. Transportation-related activity was measured by PAQ.020, PAQ.050, PAQ.080. Daily activity in or around home or yard that required moderate or greater physical effort was assessed using PAQ.100, PAQ.120, PAQ.160. Leisure time vigorous physical activity types, frequency, and duration were measured by PAQ.206, PAQ.221, PAQ.281, PAQ.300. PAQ. Leisure time moderate physical activity types, frequency, and duration were measured by 326, PAQ.341, PAQ.401, PAQ.420. Average weekly energy expenditure and weekly physical activity duration were calculated for each participant based on physical activity types, frequencies, and durations.

3.3.3.4 Change of Active Level Compared To 10 Years Ago

Older participants' self-perception of changes in active level compared to themselves 10 years ago was included to evaluate the longitudinal effect of habitual physical activity on functional status. PAQ.540 asked sample participants whether they considered themselves more active now, or less active now, or about the same compared with 10 years ago. The hypothesis here is that older adults have a higher level of functional ability if they are more active or keep the same active level compared to themselves 10 years ago.

3.3.3.5 Demographics

Demographic information was assessed during screener modules and Demographic Questionnaires (DMQ) in NHANES datasets. The demographics included in this investigation include age, gender, race/ethnicity, education levels, and marital status, all of which were adopted from the demographics data file of NHANES 2005-2006.

3.3.3.6 Co-Variances

Body mass index(BMI) and comorbidities (i.e., arthritis, myocardial infarction, stroke, depression, and diabetes) were included as co-variances in this investigation. BMI is a measure of body fat based on weight and height which defines overweight and obesity in adult men and women. Studies indicated that BMI was associated with functional ability in older adults (Sulander, et al., 2005; Gretebeck, et al., 2017). Moreover, a high BMI was related to an increased risk of subsequent functional disability over 4 and 8 years in 65 years and older adults (Tsai & Chang, 2017). Our study included BMI as covariable since it related to both physical activity and functional ability in older adults. Chronic medical conditions were very common among older adults. Many of them live with multiple chronic conditions. Studies demonstrated a consistent association between multimorbidity and functional decline that multimorbidity predicts future functional decline, with greater decline in in older adults with higher numbers of conditions (Ryan, et al., 2015). Comorbidities were one of those important factors in functional ability assessment among older adults.

BMI data was directly adopted from NHANES 2005-2006 body measures examination data files. Comorbidities were adopted from NHANES Medical conditions questionnaires (MCQ). MCQ.010, MCQ.053, MCQ.160a, MCQ.160b, MCQ.160c, MCQ.160d, MCQ.160e, MCQ.160f, MCQ.160g, MCQ.160m, MCQ.160k, MCQ.160l and MCQ. 220 were used to assess participants' medical conditions. Each participant was asked "Has a doctor or other health professional ever told {you/SP} that {you/s/he} had …?" An overall 13 types of medical conditions were asked which including asthma, anemia, arthritis, congestive heart failure, coronary heart disease, angina/angina pectoris, a heart attack, a stroke, emphysema, a thyroid problem, chronic bronchitis, any kind of liver condition and cancer/a malignancy of any kind. The number of medical conditions ever had of each older participant was used to represent their comorbidities status.

Table 3.1 Variable measures in NHANES 2005-2006 dataset

Independent Variables	**Descriptions**	**Operational Definitions**	**NHANES 2005-2006 Measures**
Physical activity	Weekly energy expenditure(kcal/week) & Weekly physical activity duration (mins/week) -*subjective value*	Calculate from self-reported transportation-related activity, daily activity (frequency & duration) and leisure time physical activity (vigorous and moderate physical activity types, frequency, and duration);	PAQ.020, PAQ.050, PAQ.080, PAQ.100, PAQ.120, PAQ.160 PAQ.206, PAQ.221, PAQ.281, PAQ.300 &PAQ.326, PAQ.341, PAQ.401, PAQ.420
	Steps per day -*objective value*	Recorded by physical activity monitors;	PAXSTEP - Device Step Count

	Change of active level compared to 10 years ago	Self-perception as more, less, or about the same active level as 10 years ago	PAQ.540
Dependent variables			
Functional ability	Difficulty levels of performing certain daily activities	Total scores of difficulty levels in performing 20 types of daily activities;	PFQ.061
Demographic/co-variables			
Age		Subject's age	RIDAGEYR - Age at Screening Adjudicated
Gender/sex		Subject's gender	RIAGENDR - Gender
Race/Ethnicity		Subject's race/ethnicity	RIDRETH1 - Race/Ethnicity

Education levels		Subject’s education levels	DMDEDUC2 - Education Level - Adults 20+
Marital status		Subject’s marital status	DMDMARTL - Marital Status
Body Mass Index (BMI)		Subject’s BMI	BMXBMI - Body Mass Index (kg/m**2)
Comorbidities	Self-reported medical conditions ever had	Total numbers of medical conditions ever had from 13 types of health problems;	MCQ.010, MCQ.053, MCQ.160a, MCQ.160b, MCQ.160c, MCQ.160d, MCQ.160e, MCQ.160f, MCQ.160g, MCQ.160m, MCQ.160k, MCQ.160l and MCQ. 220

3.3.4 NHANES 2005-2006 Data Protection Plan

NHANES developed a comprehensive architecture as the Integrated Survey Information System (ISIS) for data collection. ISIS included a private wide area network, or WAN, and a client-server environment with data replication, providing a built-in disaster recovery system. The infrastructure supported changes in survey requirements as needed and was upgraded when necessary.

ISIS used different computing platforms at different points in the data collection process. Tablet personal computers were used by interviewers to collect household interview data, and data was encrypted during all transmissions between the servers in the MEC trailers, the field office, contractor offices, and NHANES' home office. Workstations and database servers were used for database access, data manipulation, review, and numerous other processes. Hardware and software were upgraded and replaced as requirements changed and IT capabilities advanced. All collected data was stored in an analytic database, and the data from all components weas linked internally by a common identifier. All NHANES data was protected with a high level of security, including encryption of the data. NHANES data was protected from loss through a system of regular automated backups and secure off-site storage, and NHANES maintained formal processes for disaster recovery and business continuity in compliance with federal regulations.

NHANES data was released to the public by every two-year groupings (cycles). Data were edited to provide consistency and accuracy and to preserve confidentiality. All direct personal identifiers, as well as any characteristics that could lead to identification, were omitted from the data sets. Data was reviewed by the NCHS Disclosure Review Board (DRB) and edited based on any recommendations from DRB. All data was released in a SAS-readable and -transportable format. Documentation describing edits to the data, and a codebook of data items, were provided for each component. All released data was available on the NHANES website for data users and researchers throughout the world.

3.4 Data Analysis Plan

SPSS multivariable regression was used to determine the impact of covariables on functional ability in the sample. PRISM dose-response curve fitting analysis was used to explore the dose-response relationships between functional ability and amount of physical activity in different age groups of community-dwelling older adults.

Physical activity and functional ability data files were linked by using the common survey participant identification number. Sequence number (SEQN) is a unique ID number assigned to each sample person and is required to match the information on multiple files in the NHANES 2005-2006 data. Merging information from multiple NHANES 2005-2006 data files using SEQN ensures that the appropriate information for each survey participant was linked correctly.

3.4.1 Power

A pre-exploration of NHANES 2005-2006 datasets found older adults aged 65 years and above occupied approximately 10% of the total sample size (N=10,348). The old-old adults sample has the smallest group size (n=170) within three groups of older participants. Using an estimated moderate to large difference value of 0.5 as effect size (Polit, 2009, p241), the G-power analysis found sample size large enough to achieve a power of 0.8 (β=.8) with a significance criterion of .05 (α=.05) for this proposed investigation.

3.4.2 Primary Research Questions

- What are the relationships between physical activity amount (subjective & objective) and functional ability in community-dwelling age groups of young-old (aged 65-74), middle-old (aged 75-84), and older-old (aged 85 and above) adults?

This question was answered using PRISM dose-response curve fitting analysis between functional ability level and physical activity amount in three different older adult age groups. Dose-response relationships were examined as well as the shapes of curves (Statistical Analysis Model 1). The dose-response relationships were compared among three older age groups as well as with the whole group of older adults. Comparisons between the subjective and objective amount of physical activity were analyzed on dosage and patterns of curves within each age group.

- How much physical activity is enough/needed to maintain/benefit functional ability in community-dwelling young-old, middle-old, and older-old adults separately?

This research question was answered based on the proposed dose-response relationship curves of each older adult age group. The possible existence of the minimum or maximum amount (threshold/cutting values) of physical activity were examined based on the shape of dose-response curves. The threshold and/or ceiling values were able to locate on the dose-response curves if existent.

- What is the relationship between functional ability and self-perceived changes of active level compared 10 years ago in three old age groups (young-old, middle-old, and older-old) of community-dwelling older adults?

The research question was answered using ANOVA analysis to examine the impact of active level changes on functional ability in each older age group as well as the whole older adult group (Statistical Analysis Model 2). Self- perceived active level changes compared to ten years ago were also compared among different age groups to explore the maintenance status of habitual physical activity in different older adults age groups.

3.4.3 Statistical Analysis Model 1

PRISM dose-response curve fitting analysis was conducted to explore the relationships between the amount of physical activity (self-reported weekly energy expenditure, weekly physical activity duration, and daily step counts) and functional level in all four groups of older adults as the young-old, middle-old, old-old, and the whole group. The existence of threshold or ceiling values on the dose-response curves were examined as well. Differences in the amount between subjective and objective physical activity were compared. SPSS multivariable regression were used to analyze the impact of demographics and co-variances on functional ability in the older adult population as well.

3.4.4 Statistical Analysis Model 2

ANOVA analysis was applied to examine the functional ability differences by self-perceived active level changes 10 years ago within each older age group as well as between group differences.

3.5 Summary

A secondary analysis method was used to answer the primary research questions by utilizing NHANES 2005-2006 dataset. SPSS and PRISM dose-response curve fitting analysis were applied to explore the relationships between both subjective and objective physical activity dosage and functional ability in young older, middle older, old older and the whole age group. The possible existence of threshold or ceiling values of physical activity dosage were examined as well as the shape of dose-response curves. The amount of subjective and objective physical activity were reported and compared both within and between different age groups. ANOVA analysis was applied to examine the relationships between functional ability differences and self-perceived active level changes compared to 10 years ago. Older adults' self-perceived active level changes were analyzed between different age groups to examine possible trends in habitual physical activity maintenances.

Table 3.2 Statistical analysis models

Statistical Analysis Models	**IV**	**DV**	**Population samples**
Model 1:	Subjective physical activity amount -	Functional ability level	Young -older (65-74 years old)

PRISM dose-response curve fitting analysis; SPSS multivariable regression;	weekly energy expenditure & weekly physical activity duration		Middle -older (75-84 years old)
			Old -older (85 years and above)
			The whole group of older adults (65 years and above)
Model 1: PRISM dose-response curve fitting analysis; SPSS multivariable regression;	Objective physical activity – steps per day	Functional ability level	Young -older (65-74 years old)
			Middle -older (75-84 years old)
			Old -older (85 years and above)
			The whole group of older adults (65 years and above)
Model 2: ANOVA Analysis	Self- perception of active level change compared to 10 years ago	Functional ability	Young -older (65-74 year old)
			Middle -older (75-84 year old)
			Old -older (85 years and above)

CHAPTER 4

RESULTS

4.1 Acquisition of NHANES Datasets

According to the Code of Federal Regulation Basic HHS (U.S. Department of Health & Human Services) Policy for Protection of Human Research Subjects §46.104 Exempt research no.4 regulation, a further IRB review for this secondary research was exempted (Exemptions (2018 Requirements), 2021). All needed datasets and variables were publicly available and were directly downloaded from NHANES website. No limited access data was used in this analysis.

4.2 Datasets Preparation

Sample participants' demographic variables and sample weights were downloaded from NHANES 2005-2006 demographics data file. Physical activity monitor (PAM) data file and body measures file were downloaded from examination data. Current health status, medical conditions, physical activity, physical activity-individual activities, and physical functioning data files were downloaded from NHANES 2005-2006 questionnaire data. All the data files were combined into one dataset based on the respondent sequence number (SEQN). Physical activity monitor data and physical activity-individual activities files both were pre-treated before they can be combined with other data files.

4.2.1 Physical Activity Monitor Data Preparation

The physical activity monitor raw data was a very large data file (> 2 GB) and contains multiple records per subject. The device intensity value and step count records consist of sequential minute by minute records of activity intensity beginning from the time the device was initialized. Each subject had up to 10,080 intensity count records. The treatment of this huge raw data file included several steps. First, questionable PAM data was excluded using the Data Reliability Status Flag. Step records >200 steps per minute were excluded as beyond the device maximum value possible (Tudor-Locke, Johnson, & Katzmarzky, 2009). The remaining data was deemed reliable. Daily step counts were calculated averaged from total monitored steps per subject. A total of zero step count records were excluded for this investigation.

4.2.2 Physical Activity-Individual Activities Data Preparation

Physical activity- individual activities data file was the second of two files on physical activities and includes detailed information about specific leisure time activities only. For each reported leisure time activity, one record was created in the individual activities file. There was a total of more than 47 types of reported leisure activities. Each subject's total leisure activity time was calculated based on their reported frequency and duration. Metabolic equivalent task (MET) minutes scores were calculated for each type of leisure activity and for each participant (Ainsworth, Haskell, Whitt & et al., 2000) (see Appendix B for physical activity codes and Appendix C for suggested MET scores).

Physical activity total MET minutes and duration were summed from daily activity, transportation activity and leisure time activities from both two physical activity data files. Energy expenditure (kcal) was calculated from MET minutes using the standard resting metabolic rate (RMR) of 3.5 (Hall et al., 2014). Weekly energy expenditure and weekly physical activity duration were finally averaged from one month as approximately considered four weeks.

4.3 Descriptive Analysis

4.3.1 Sample Characteristics/ Demographics

A total of 1189 older participants were included in the NHANES 2005-2006 datasets. The young-old (aged 65-74) occupied almost half of the population. The number of the middle-old (aged 75-84) was 36%. The old-old adults was 14.3% of the total sample. All adults who were 85 years and older were coded '85' as age since the reporting of age in single years for adults 85 years and older was determined to be a disclosure risk (https://wwwn.cdc.gov/Nchs/Nhanes/2005-2006/DEMO_D.htm#RIDAGEYR). Either male or female gender was collected in NHANES datasets. Male older adults were a little outnumbered than females both in the young-old and middle-old groups. However, female elders took up to 62% in the old-old age group. More than half of both young-old and middle-old adults in the sample were married. In the old-old group, almost 70% adults were widowed. The majority of this sample were non-Hispanic white. Older adults tended to have more numbers of medical conditions as their age increased. The majority (around 70%) of the older participants had zero or 1-2 medical conditions. More people had 3+ medical conditions in the middle-old and old-old groups than in the young-old group. (Table 4.1).

Table 4.1 Demographics

	Percent/Mean ± SD	Percent/Mean ± SD (Young old)	Percent/Mean ± SD (Middle-old)	Percent/Mean ± SD (Old-old)
Sample Size	N=1189	N=591(49.7%)	N=428(36%)	N=170(14.3%)
Age	65-85	69.3±2.89	79.5±2.80	85
Gender				
Male	612(51.5%)	311(52.6%)	236(55.1%)	65(38.2%)
Female	577(48.5%)	280(47.4%)	192(44.9%)	105(61.8%)
Marital Status				
Married	616(51.8%)	343(58%)	230(53.7%)	43(25%)
Widowed	381(32%)	120(20.3%)	144(33.6%)	117(68.8%)
Divorced	105(8.8%)	67(11.3%)	37(8.6%)	1(0.6%)
Separated	32(2.7%)	23(3.9%)	7(1.6%)	2(1.2%)
Never married	36(3%)	26(4.4%)	7(1.6%)	3(1.8%)
Race/Ethnicity				
Non-Hispanic White	790(66.4%)	329(55.7%)	324(75.7%)	137(80.6%)
Non-Hispanic Black	219(18.4%)	142(24%)	60(14%)	17(10%)
Mexican American	136(11.4%)	94(15.9%)	31(7.2%)	11(6.5%)
Other Race -including multi-racial	26(2.2%)	13(2.2%)	8(1.9%)	5(2.9%)
Other Hispanic	18(1.5%)	13(2.2%)	5(1.2%)	0(0%)
Education Level				
Less Than 9th Grade	244(20.5%)	105(17.8%)	94(22%)	45(26.5%)
9-11th Grade(Includes 12th grade with no diploma)	198(16.7%)	102(17.3%)	70(16.4%)	26(15.3%)
High School Grad/GED or Equivalent	324(27.2%)	165(27.9%)	118(27.6%)	41(24.1%)
Some College or AA degree	237(19.9%)	106(17.9%)	92(21.5%)	39(22.9%)
College Graduate or above	179(15.1%)	111(18.8%)	52(12.1%)	16(9.4%)
Total Numbers of Medical Conditions				
Zero medical condition	267(22.5%)	155(26.2%)	91(21.3%)	21(12.4%)
1-2 medical conditions	615(51.8%)	308(52.1%)	206(48.1%)	101(59.4%)
3-5 medical conditions	268(22.6%)	114(19.3%)	111(26%)	43(25.2%)
>5 medical conditions	38(3.2%)	14(2.4%)	19(4.4%)	5(3%)
Body Mass Index (BMI)	28.1± 5.74	29.2±6.1	27.3±5.17	25.6±4.47
Compare Activity With 10 Years Ago				
More active now	82(6.9%)	56(9.5%)	21(4.9%)	5(3%)
Less active now	800(67.4%)	374(63.3%)	295(68.9%)	131(78%)
About the same	305(25.7%)	161(27.2%)	112(26.2%)	32(19%)

4.3.2 Functional Ability in Older Adults

Older adults' functional ability was measured by total difficulty levels in doing 20 types of daily activities. The final functional scores ranged from 20 to 63 points. Points - 20 meant no difficulty in doing either type of daily activity. The higher the score, the more difficulties in doing activities, and the lower functional ability of the older adults. Among all valid samples (N=732), about 43% (n=318) older participants didn't have any difficulty in doing either type of daily activity. Comparing three old age groups, the old-old has significantly higher level of difficulties (N=55, M±SD=26.5±8.28) in doing daily activities than both the young-old (N=429, M±SD= 22.5±4.13) and the middle-old (N=248, M±SD=23.3±5.29) ($F(2)=16.269$, $p<.001$). There was no difference between the young-old and middle-old groups of difficulties in doing daily activities. Female elders have a significantly higher level of difficulty in doing daily activities than males in young-old and middle-old adults ($t\ (730) = -3.747$, $p<.001$), however, this difference didn't exist in the old-old age group (Table 4.2).

4.3.3 Physical Activity in Older Adults

4.3.3.1 Daily Step Counts

Ambulatory community-dwelling 65 year and above U.S. older adults averagely walk 5700 steps per day (N=991, M±SD =5759± 3570). Older adults' daily walking steps decrease as their age increases. The young-old approximately walks 6700 steps per day, the middle-old adults take around 5100 daily steps and the old-old about 3300 steps per day. There are significant differences in the number of daily steps between either two older adult age groups ($F(2)=56.003$, $p<.001$). Within the young-old and the old-old age groups, male older adults have significantly higher step counts per day than females ($t(515)= 2.109$, $p=.035$) ($t(113)= 2.455$, $p=.016$). However, there is no difference in step counts between males and females in the middle-old age group (Table 4.2).

4.3.3.2 Weekly Energy Expenditure

Older adults' average weekly energy expenditure (kcal) (N=785, M±SD =2911± 4210) varies between individuals (Table 4.2). Energy expenditure is significantly higher in young-old adults than the middle-old and the old-old adults ($F(2)=9.890$, $p<.001$). However, there is no significant difference in energy expenditure between the middle-old and the old-old groups. Male older adults spent significantly more energy in physical activity than females in all older age groups ($F(783)=5.089$, $p<.001$).

4.3.3.3 Weekly Physical Activity Duration

U.S. community dwelling older adults spend different length of time in physical activity weekly (minute) (N=830, M±SD=470± 604). The young-old adults spent significantly more time in physical activity compared to the old-old adults ($F(2)=6.855$, $p=.001$). However, there is no significant difference in activity duration between middle-old adults with either the other two groups. Male older adults spent significantly more time in physical activity than females in the young-old ($t(453)=2.619$, $p=.009$) and middle-old age groups ($t(287)=2.215$, $p=.028$). However, there is no difference in physical activity duration between male and female in the old-old group (Table 4.2).

Comparing the three physical activity measurements, mild correlation was found between objectively measured step counts and self-reported physical activity duration (*Pearson' r*(724) = .228, $p < .001$). Energy expenditure and physical activity duration were highly correlated (*Pearson' r*(785) = .948, $p < .001$). Energy expenditure was calculated based on different physical activity types, intensity METs and durations.

Table 4.2 Functional ability and physical activity in older adults (N=1189)

(∗ P<0.05, α=.05)

	N	Difficulty level in doing 20 types of daily activities (Mean ±SD)	N	Steps per day (Mean ±SD)	N	Weekly energy expenditure (kcal) (Mean ±SD)	N	Weekly physical activity duration(min) (Mean ±SD)
All ≥65								
Male	400	22.5± 4.25	513	6146±3696*	440	3577±4877*	466	532±666*
Female	332	23.8± 5.08*	478	5343±3384	345	2060±2959	364	390±504
Total	732	23.1 ±5.06	991	5759±3570	785	2911± 4210	830	470±604
Missing	457(38.4%		198(16.7%		404(34%)		359(30.2%)	
Young-old								
Male	228	22.0± 3.73	265	7066±3906*	237	4290±5707*	248	601±726*
Female	201	23.1± 4.47*	252	6371±3571	204	2440±3305	212	445±556
Total	429	22.5± 4.13	517	6727±3759*	441	3434±4833*	460	529±657*
Middle-old								
Male	142	22.6±4.12	202	5382±3009	169	2929±3705*	178	479±616*
Female	106	24.3±6.44*	157	4810±2691	104	1707±2519	115	342±445
Total	248	23.3± 5.29	359	5132±2884*	273	2464±3352	293	425±558
Old-old								
Male	30	25.5±6.73	46	4203±3750*	34	1829±2158*	40	332±381
Female	25	27.8±9.82	69	2806±2354	37	957±1205	37	227±275
Total	55	26.5± 8.28*	115	3365±3054	71	1375±1771	77	282±336

4.4 Relationships Between Functional Ability and Physical Activity Amount

The PRISM Dose-response Curves Stimulation Variable slope model was used to explore the relationships between the amount of physical activity and functional ability in each older age group of young-old, middle-old, old-old and the whole older adults group. Gender differences were examined in each age group as well. Since gender difference in physical activity in aging had been recognized earlier (Shephard, 2002, p. 111), it is necessary to include different gender groups when exploring the needed amount of physical activity in older adults.

4.4.1 Functional Ability and Daily Step Counts

There was no dose-response relationship identified between step counts and functional ability in older adults. However, top and bottom values (ranges) were identified with 95% confidence interval in the middle-old and the whole groups (Table 4.3) (all the other group values were unstable and not included in the table). These may can be interpreted as threshold values of daily steps by which older adults' functional ability reached significant higher levels. Generally in the whole group of older adults (≥65 year), a minimum number of 5400 walking steps per day was expected to benefit functional ability (Figure 4.1). Male 65+ older adults have to have more than 6500 steps daily in order to have higher functioning in performing daily activities (Figure 4.2). Middle-old (aged 75-84) adults have to have at least 5800 daily steps in order to maintain functioning (Figure 4.1). However, the R squared of these values were very small and careful considerations should be paid when drawing conclusions. There is no threshold value identified in all the other groups.

Table 4.3 Relationships between functional ability and steps per day (unstable groups not included)

	Middle-old	All older adults	All male older adults
Best-fit values			
Bottom	-22.79	-24.41	-21.81
Top	-23.84	-22.09	-22.92
Span	-1.044	2.320	-1.108
95% CI (profile likelihood)			
Bottom	-23.68 to -21.90	-25.01 to -23.85	?
Top	-24.76 to -22.92	-22.56 to -21.62	?
Goodness of Fit			
Degrees of Freedom	211	640	346
R squared	0.01206	0.05582	0.01867
Sum of Squares	4792	14262	5640
Sy.x	4.766	4.721	4.038
Number of points			
# of X values	876	990	512
# Y values analyzed	215	644	350

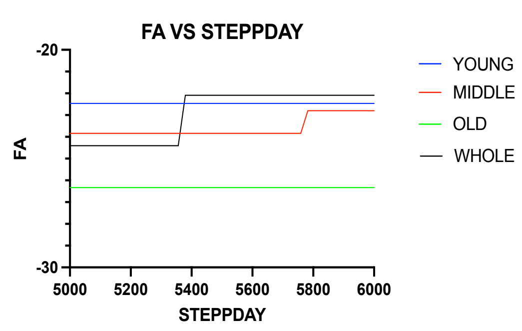


Figure 4.1 Functional ability(FA) and steps per day(STEPPDAY) in all groups

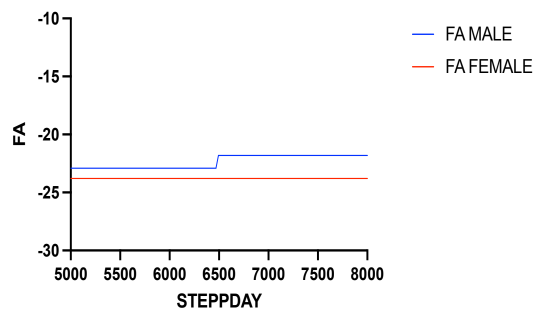


Figure 4.2 Functional ability(FA) and steps per day(STEPPDAY) in gender groups

4.4.2 Functional Ability and Weekly Energy Expenditure

The hypothesized dose-response relationship between functional ability and weekly energy expenditure in older adults is undefined using PRISM curve-fitting analysis. However, similar thresholds of energy expenditure were identified by which functional ability reached higher levels in young-old, middle-old, and the whole group (Table 4.4). Older adults (≥65 year) have to spend at least 1500 kcal energy per week in physical acitvity to benefit their functional ability. Specifically, the young-old have to spend more than 2000 kcal weekly to obtain functional benefit, and the middle-old have to spend more than 4500 kcal per week (Figure 4.3). Regarding the gender differences, a weekly energy of 800 kcal is identified in female middle-old as threshold value to obtain higher functioning in doing daily activities (Figure 4.4). However, these values should be carefully concluded since very small variances were explained (small R squared values).

Table 4.4 Relationships between functional ability and weekly energy expenditure (unstable groups not included)

	Young-old	Middle-old	All older adults	Female middle-old
Best-fit values				
Bottom	-22.92	-22.75	-21.86	-22
Top	-21.67	-21.50	-23.22	-24.16
Span	1.247	1.255	-1.361	-2.161
95% CI (profile likelihood)				
Bottom	-23.46 to -22.37	-23.39 to -22.12	-22.27 to -21.44	-23.39 to -20.61
Top	-22.18 to -21.15	-22.88 to -20.12	-23.68 to -22.75	-25.64 to -22.69
Goodness of Fit				
Degrees of Freedom	348	179	563	62
R squared	0.02956	0.01456	0.03137	0.06838
Sum of Squares	4472	2814	8010	1046
Sy.x	3.585	3.965	3.772	4.108
Number of points				
# of X values	441	714	785	273
# Y values analyzed	352	183	567	66

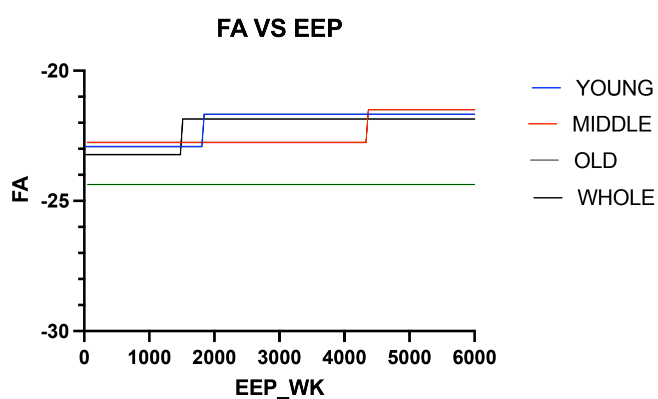


Figure 4.3 Functional ability(FA) and weekly energy expenditure(EEP_WK) in all groups

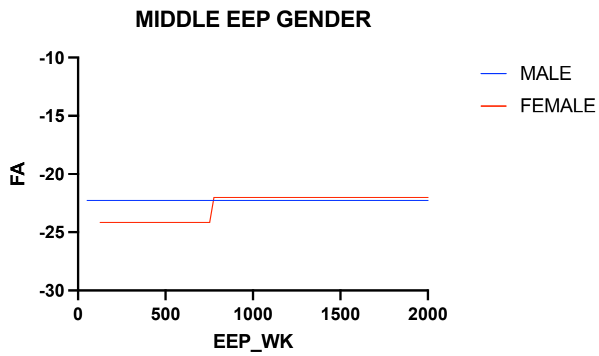


Figure 4.4 Functional ability(FA) and weekly energy expenditure(EEP_WK) in middle-old adults

4.4.3 Functional Ability and Weekly Physical Activity Duration

A dose-response relationship between functional ability and weekly physical activity duration(PAD) was found in the middle-old female group. The dose-response curve has a slope within activity duration of about 150 mins per week, and starts at the point of physical activity duration around 20 minutes (Figure 4.5 & Table 4.5). There is a plateau limit value of functional ability. Middle-old females benefit from every minute spent on physical activity. Their functional benefits increase as physical activity duration increases. Middle-old females have to spend at least 150 mins per week on physical activity in order to achieve the most functional benefits.

Possible threshold of physical activity duration may exist in the young-old, middle-old, old-old and the whole group as well as different gender groups (Table 4.6). Older adults (≥65 year) generally have to spend at least 300 mins per week on physical activity to gain functional benefits (Figure 4.6). Females elders (≥65 year) have to spend at least 250 mins per week to gain higher functional ability (Figure 4.7). With each sub age group, the young-old have to engage in more than 250 mins per week physical activity, among which males and females have to spend respectively at least 450 mins and 250 mins per week to achieve benefits (Figure 4.8). The middle-old have to have at least 300 mins weekly physical activity duration to trigger benefits. The old-old adults, both males and females have to spend at least 240 mins in order to gain higher levels of functional ability (Figure 4.9). However, these threshold/cutting value conclusions should be carefully made due to small variances explained (small R squared values).

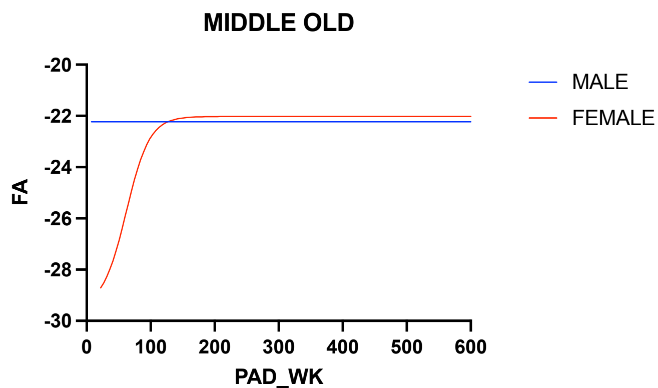


Figure 4.5 Functional ability(FA) and weekly PA duration(PAD_WK) in middle-old adults

Table 4.5 Functional ability and weekly physical activity duration in middle-old females

	Female middle-old
Best-fit values	
Bottom	-22.02
Top	-29.46
LogEC50	61.91
HillSlope	-0.02378
EC50	8.190e+061
Span	-7.434
95% CI (profile likelihood)	
Bottom	-23.59 to -20.29
Goodness of Fit	
Degrees of Freedom	69
R squared	0.2211
Sum of Squares	1022
Sy.x	3.848
Number of points	
# of X values	293
# Y values analyzed	73

Table 4.6 Relationships between functional ability and weekly physical activity duration(unstable groups not included)

	Young-old	**Middle-old**	**Old-old**	**All older adults**	**All female older adults**	**Male young-old**	**Female young-old**	**Male old-old**	**Female old-old**
Best-fit values									
Bottom	-23.28	-22.97	-24.15	-21.85	-22.08	-21.40	-22.03	-24.64	-24.15
Top	-21.55	-22.01	-23.25	-23.07	-23.87	-21.96	-23.67	-22.60	-23.25
Span	1.730	0.9614	0.8998	-1.221	-1.780	-0.5621	-1.634	2.041	0.8998
95% CI (profile likelihood)									
Bottom	-23.86 to -22.71	-23.71 to -22.23	-27.45 to -22.55	-22.28 to –21.42	-22.75 to -21.42	-22.06 to -20.65	-22.82 to -21.25	-29.58 to -21.82	-27.45 to-22.55
Top	-22.02 to -21.09	-22.86 to -21.16	-25.84 to -20.66	-23.50 to -22.64	-24.54 to -23.19	-22.82 to -21.47	-24.51 to -22.82	-26.48 to -18.72	-25.84 to-20.66
Goodness of Fit									
Degrees of Freedom	360	193	30	591	252	191	165	16	30
R squared	0.05554	0.01443	0.01852	0.02577	0.05105	0.01255	0.04534	0.06906	0.01852
Sum of Squares	4442	3052	680.1	8390	3771	2110	2360	495.8	680.1
Sy.x	3.512	3.977	4.761	3.768	3.868	3.324	3.782	5.566	4.761
Number of points									
# of X values	460	753	830	830	830	248	460	40	77
# Y values analyzed	364	197	34	595	256	195	169	20	34

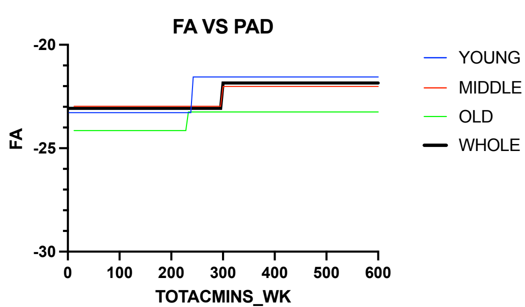


Figure 4.6 Functional ability(FA) and weekly PA duration(TOTACMINS_WK) in all groups

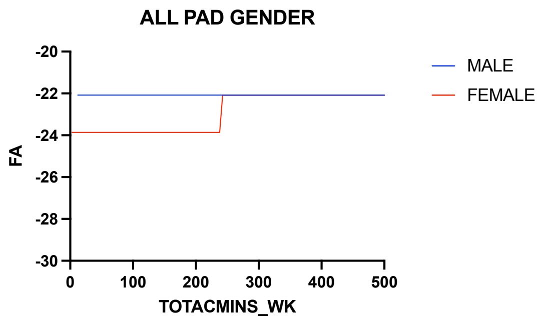


Figure 4.7 Functional ability(FA) and weekly PA duration(TOTACMINS_WK) in all gender groups

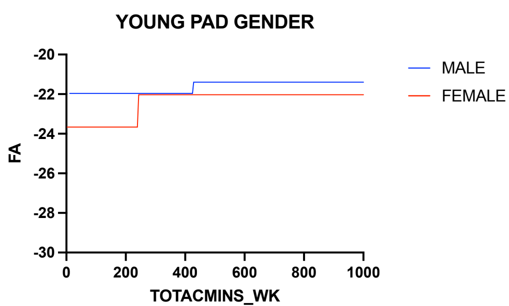


Figure 4.8 Functional ability(FA) and weekly PA duration(TOTACMINS_WK) in young-old gender groups

Figure 4.9 Functional ability(FA) and PA duration(PAD_WK) in old-old gender groups

4.5 Effects of Covariables

A hierarchical multivariate regression model was used to analyze the correlations between other variables and functional ability in this older adult sample (Table 4.7).

Steps Per Day, Total numbers of medical conditions, Body Mass Index, Educational Level, and Gender were identified as significant variables related to young older adults' functional ability (F(8,320) =10.763, p <.01), although the total variances explained was low (R Square =.211). Total number of medical conditions was the only measure that explains the variance in functional ability in middle-old (F8,161) =5.177, p <.01) and old-old adults (F(8,20) =3.1475, p <.05). The number of medical conditions explained a moderated variance of functional ability in 85 years and older adults (R Square= .557).

Table 4.7 The effects of covariables on functional ability in different age groups

	Unstandardized B	**Coefficients Std. Error**	**Standardized Coefficients**	**t**	**P**	**95% Confidence Interval for B**	
			Beta			**Lower Bound**	**Upper Bound**
Young-old							
Steps Per Day	.000	.000	-.160	-3.019	.003*	.000	.000
Energy expenditure per week(kcal)	-5.082E-5	.000	-.068	-,370	.712	.000	.000
Activity minutes Per week	.000	.001	.021	.115	.909	-.002	.002
Total numbers of medical conditions	-.750	.145	-.266	-5.185	.000*	-1.035	-.465
Body Mass Index (kg/m**2)	.128	.039	.193	3.304	.001*	.052	.204
Education Level	-.388	.139	-.142	-2.788	.006*	-.662	-.114
Gender	.852	.380	.117	2.243	.026*	.105	1.600
Middle-old							
Steps Per Day	1.759E-5	.000	.011	.150	.881	.000	.000
Energy expenditure per week (kcal)	.000	.000	.193	.560	.576	-.001	.001
Activity minutes per week	-.002	.002	-.251	-.735	.463	-.006	.003

Body Mass Index (kg/m**2)	-.003	.083	-.003	-.035	.972	-.167	.161
Total numbers of medical conditions	-1.099	.186	-.422	-5.923	.000*	-1.466	-7.33
Education Level	-.221	.230	-.072	-.959	.339	-.676	.234
Gender	1.100	.660	.132	1.668	.097	-.203	2.402
Old-old							
Steps Per Day	.000	.000	-.077	-.493	.637	-.018	.028
Energy expenditure per week(kcal)	-.001	.002	-.358	-.403	.691	-.005	.004
Activity minutes Per week	.005	.011	.433	.479	.637	-.018	.028
Total numbers of medical conditions	-1.749	.434	-.662	-4.035	.001*	-2.654	-.845
Body Mass Index (kg/m**2)	.566	.275	.415	2.058	.053	-.008	1.139
Education Level	.303	.618	.088	.491	.629	-.986	1.1592
Gender	.805	1.549	.093	.520	.609	-2.426	4.037

4.6 Relationships Between Functional Ability and Self-Perceived Active Level Change Compared To 10 Years Ago

Overall, the majority (67.4%) of older adults +65 year old considered themselves less active compared to 10 years ago, and around a quarter (25.7%) self-perceived as "about the same" active level. As age increases, more older adults regarded themselves less active compared to 10 years ago. Comparing with the young-old and old-old groups, most (63.3%) young-old adults considered themselves less active compared to themselves 10 years ago, 27.2% of young-old considered themselves about the same active level, only a few (9.5%) considered themselves more active now. In the old-old group, 78% considered themselves less active than 10 years ago, 19% believed themselves at about the same active level and only 3% considered more active now. As older adults age, a larger percentage of them perceived themselves as less active, and fewer and fewer people considered themselves about the same active level or being more active compared to themselves 10 years ago.

Significant differences in functional ability were found between self-perceived less active group and about the same active group in all three older age groups, as for young-old ($F(2,426) = 5.802$, $p < .01$), middle-old groups ($F(2,245) = 8.795$, $p < .01$), and old-old adults ($F(2,52) = 4.637$, $p < .05$). Older adults who considered themselves less active compared to 10 years ago have more difficulties in performing daily activity than those who regarded themselves at about the same active level as 10 years ago (Table 4.8).

Table 4.8 Functional ability and self-perceived active level change compared to 10 years ago

Age groups	**Self-perceived active level change compared to 10 years ago**			**F**	**P**
	More active Mean(SD)	**Less active Mean(SD)**	**About the same Mean(SD)**		
Young-old	22.18(3.59) (n=44)	23.09(4.52) (n=247)	21.64(3.34) (n=138)	5.80	.003*
Middle-old	23.36(4.67) (n=14)	24.42(6.12) (n=148)	21.50(2.80) (n=86)	8.80	.000*
Old-old	39.50(27.58) (n=2)	27.00(7.21) (n=43)	21.90(4.65) (n=10)	4.64	.014*

* $P<0.05$, $\alpha=.05$

4.7 Summary

The proposed dose-response relationships between functional ability and physical activity duration was identified in the middle-old female adults. Older females' (aged 75-84 years) functional ability increases as time spent in physical activity increases. Every minute counts for functional benefits. Middle-old females have to spend at least 150 mins per week on physical activity in order to achieve the most functional benefits. Dose-response relationship was not found in any other group.

The relationships between functional ability and steps per day, or weekly energy expenditure were undefined by PRISM curve-fitting analysis. However, several possible threshold values were detected on the dose-response lines. Individuals 65 years old and older have to walk at least 5,400 steps per day, or spend 1,500 kcal physical activity energy expenditure per week, or 300 minutes in physical activity per week to obtain functional benefits. Males have to walk 6,500 steps daily to obtain benefits. Females older adults (≥65 year) have to spend at least 250 mins per week to gain higher functional ability. Specifically in sub-age groups, young-old adults have to spend more than 2000 kcal weekly or 250 mins per week to obtain functional benefit. Male and female young-old have to spend respectively 450 mins and 250 mins per week to achieve benefits. Middle-old adults have to have at least 5800 steps or 4500 kcal per week or 300 mins weekly to obtain higher level of functional ability. Female elders (aged 75-84) have to spend 800 kcal or 200 minutes per week in physical activity in order to benefit for functional ability. The oldest old adults, including both males and females have to spend at least 240 mins in order to gain higher levels of functional ability.

Total numbers of medical conditions, Steps Per Day, Body Mass Index, Educational Level, and Gender were the five co-variables significantly related to functional ability in young-old adults. However, number of medical conditions was the only variable that impacted functional ability in both middle and old older groups. Older adults who considered themselves less active compared to 10 years ago have more difficulties in performing daily activity than those who considered themselves about the same active level as 10 years ago.

CHAPTER 5

DISCUSSIONS

5.1 Introduction

This chapter discussed the representativeness of our older adults sample compared to contemporary census older population data. Study sample representativeness needs to be aware of when disseminating and applying study results to larger populations. This chapter then discussed the study results comparing with current literature or most recent scientific evidence. Study limitations, implications for nursing practice and health policy, study conclusions, and suggestions for future research were also included.

5.2 NHANES 2005-2006 Older Participants Sample Representativeness

NHANES 2005-2006 older participant sample characteristics will be compared with 2005 census data on older U.S. adults to examine the representativeness of our older adult sample in this session.

5.2.1 Age and Gender

NHANES 2005-2006 sampled participants were weighted based on population estimates that incorporate the year 2000 Census Bureau counts and after (Curtin, et al., 2012). The goal was to produce data representative of the civilian non-institutionalized U.S. population. According to 2005 census data on 65+ U.S civilians, the number of young-old, middle-old, and old-old adults was 18.3 million, 12.9 million, and 4.7 million (Wan, et al., 2005). The proportion of the young-old in our sample (49.7%) was a little less than nationally (51.0%). The middle-old occupied 36% of the sample, which was close to the national proportion (35.9%). The old-old of this sample (14.3%) was a little overrepresented compared to the national data (13.1%). That's to say, this older adult sample was older than national older population. Overall, NHANES 2005-2006 older adult sample has relatively more proportions of old-old adults and fewer young-old adults than the national older adults population.

Male older adults outnumbered (51.5%) females in this sample compared to the national ratio (male as 41.2%). Males occupied about 55.1% of the middle-old group (Wan, et al., 2005). Overall, Male older adults, especially middle-old males, were over-represented in the sample compared to the percentage of older men in the national older population.

These differences in age groups and gender proportions could result from different sampling methods between NHANES and Census Bureau. Another reason may because that older males, especially middle-old males, are relatively active and much more willing/likely to participate in research studies than their female counterparts.

5.2.2 Marital Status

Older men were more likely than older women to be married. In our sample, about 68.8% of men compared to 46.1% of women aged 65-74 were married. The proportion married was lower at older ages: 35.9% of women aged 75-84 and 9.5% of women 85 and older were married. Among their male counterparts, the proportions were much higher: 68.2% of men aged 75-84 were married, and even among men aged 85 and older, more than half of them (50.2%) were married. 2005 U.S. Census Bureau reported that 74% men and 54% women aged 65-74 were married, the percentages were 70% of men and 34% of women at aged 75-84, 56% among men and 13% of women in the 85 years and older (Wan, et al., 2005).

Widowhood was more common among older women than older men, especially in old-old adults. About 84.8% of women aged 85 years and older were widowed compared with 43.1% of men in this sample. Nationally, 78% of old-old women and 35% of men were widowed (Wan, et al., 2005). Women aged 65 and older (47.8%) were more than twice as likely as men of the same age (17.2%) to be widowed.

Overall, compared with national data, the married percentages of both gender groups in our sample were a little lower, and the percentage of widowhood was slightly higher. This could be due to different categorizations in marital status and life expectancy variances between male and female older adults.

5.2.3 Education Levels

The Census Bureau reported that 72% older population were high school graduates and 17% had at least a bachelor's degree (Wan, et al., 2005). About 62.8% of older participants in our sample had an education level of above high school graduates or equivalent. About 15.1% were college graduates or above. Older adults with lower than a high school education level were overrepresented in this sample compared to the national older population. Overall, our older participants sample had a lower education level than the national older population.

5.2.4 Chronic Medical Conditions

Census data from 2005 reported that about 80% of older adults have at least one chronic health condition and 50% have at least two (Wan, et al., 2005). In our sample, almost 78% of older participants have at least one medical condition and around 36% have at least three medical conditions. Overall, the condition of chronic medical problems in this older participant sample was similar to the national older population.

5.2.5 Summary

This 65+ non-institutionalized U.S. older citizen sample overall was a little older in average age than the whole national older population. The old-old (aged 85 and above) group was overrepresented, and the young-old (aged 65-74) group was underrepresented. Our sample included more male older adults than females, especially aged 75-84, which had a much more significant proportion than the national older men percentage. The average education level of this older participants sample was relatively lower than the national older population level. These sample characteristics should be kept in mind when interpreting the statistical results of this study.

5.3 Statistical Findings

The PRISM Dose-response Curves Stimulation Variable slope model used in this study did not identify the dose-response relationships between the amount of physical activity and functional ability in all age group community-dwelling older adults. A dose-response relationship is one in which increasing levels of exposure are associated with either an increasing or a decreasing risk of the outcome (Pettygrove, 2016). It is a unidirectional relationship. The amount of physical activity represents levels of exposure and functional ability represents the outcome in this dose-response relationship. Possible thresholds/cutting values of physical activity amount were detected on the dose-response broken lines, however, these values should be interpreted with caution since very small variance was explained (small R Squared values).

5.3.1 Relationships Between Physical Activity Duration and Functional Ability

Our study found a dose-response relationship between the amount of time spent on physical activity and functional ability in middle-old females. Females aged 75-84 gain higher levels of functional ability when spending more time on physical activity. The functional benefits gain was the fastest when they spent every one more minute on physical activity up until about 150 minutes in a week (Figure 4.3.3.1). The highest benefit is achieved when spending at least 150 minutes per week on physical activity. Researchers observed dose-response relationships between physical activity and improvement in activity of daily living, quality of life, and independent living in the older adults (Spirduso & Cronin, 2001; Rankinen et al., 2002). Other researchers also concluded that a lower limit in the dose-response relationship between physical activity level and health gains seem to not exist, and any activity can be said better than none (Anderssen & Strømme, 2001). These findings were accordant to our results. The 150 mins/week threshold value is consistent with the guidelines recommended amount (150-300 min) for 65+ older adults (Sparling et al., 2015; U.S. Department of Health and Human Services, 2018).

We didn't find a dose-response relationship in all the other age or gender groups. However, the possible cutting values for age groups ranged from 240-450 minutes

(Figure 4.3.3.2), close to the recommended amount from the guidelines. The activity duration needed for male young-old was more (450min) than female young-old (250min). However, gender has much less impact as older adults age. There is no difference in required activity duration between males and females in the old-old group. This finding was similar to the systematic report of physical activity prevalence across gender and age groups (Sun et al., 2013). However, these possible cutting values should be carefully interpreted since they were not based on the dose-response relationship. There is a lack of existing evidence on physical activity duration threshold or cutting value in either older age or gender group.

5.3.2 Relationships Between Energy Expenditure and Functional Ability

Researchers reported positive correlations between energy expenditure and health benefits, including functional status, mortality, etc., in older people. (Anderssen & Strømme, 2001; Manini et al., 2006; Lopes de Pontes et al., 2021). The proposed dose-response relationship between energy expenditure and functional ability in older adults was undefined in this study. This could be due to our study limitations, or there is a need for more research on this topic (Hall et al., 2014).

The 1500 kcal energy expenditure per week was identified as a possible cutting value. General 65+ older adults have to spend at least 1500kcal energy expenditure on physical activity to obtain a higher level of functional ability. This cutting value is close to Anderssen & Strømme’s (2001) study results. They stated that a minimum "target dose" that will yield substantial health gains for older adults corresponds to an energy expenditure of approximately 150 kcal (630 kJ) per day or slightly more than 1,000 kcal

(4.2 MJ) per week. They also pointed out that health gain seems primarily dependent on the total energy expenditure and less on the intensity (Anderssen & Strømme, 2001).

Other possible threshold values found in our study were 2000kcal for young-old, 4500kcal for middle-old, and 800kcal for middle-old females. Since energy expenditure declines as people age (Starling, 2001), young-old were required to achieve more amount of physical activity energy expenditure (2000kcal) than the average level for older adults (1500kcal). Middle-old females (800kcal) required less energy expenditure than the average amount (1500kcal). The amount of physical activity energy expenditure for middle-old adults (4500kcal) is higher than all the others. This might be due to the over sampling of middle-old males, as discussed previously.

5.3.3 Relationships Between Daily Step Counts and Functional Ability

Our study identified a possible threshold value of 5,400 steps/day for general 65+ older adults. Older adults have to walk 5,400 steps at least to achieve higher functioning. The number of 5000 daily steps was considered a daily background for older adults. Many studies used this number to differentiate low and medium doses of step counts, although it could also be too high for some elders and/or people living with chronic conditions or disabilities (Tudor-Locke Catrine et al., 2011). Other studies had found that lower doses of steps (< 5000 daily) were related to poor functionality in older adults compared to the medium and high dose of daily steps (Dondzila et al., 2015; Duncan et al., 2016). This 5400 daily steps cutting value found in our study is consistent with other study results.

Our findings also indicated threshold values of 6500 steps/day for 65+ older males and 5800 steps/day for aged 75-84 adults. Ewald's (2014) study reported daily step threshold values of 6500 for age 65–70, 5900 for age 70–75, and 5150 for age 75 and over. Both studies revealed fewer daily steps were needed as older adults' age increases. The two studies identified similar daily steps (5800vs5900) for 70+ older adults and 6500 steps for 65+ (male) adults. Ewald's study (2014) found a positive linear dose-response relationship between daily steps and physical function. However, gender differences were not discussed in their results. There were also differences in age grouping methods between the two studies (Ewald et al., 2014).

Overall, our findings resulted that the number of daily steps needed for 65+ older adults was between 5,400-6,500 steps per day to maintain functional ability. Studies considered 7,100-8,000 daily steps as equal to the public health guidelines recommended physical activity amount (Tudor-Locke Catrine et al., 2011). Our identified step value was fewer than public recommendations, which indicated relatively less physical activity needed for older adults than the general adult population. However, step data treatment differences between the two studies should be kept in mind when interpreting these results.

5.3.4 Relationships Between Functional Ability and Self-Perceived Active Level Change Compared To 10 Years Ago

We found older adults (aged 65 and above) had a significantly higher functional ability if they perceived themselves at about the same active level compared to 10 years ago than those who considered themselves as less active compared to 10 years ago. Our findings indicated older adults who maintained their physically active level for long-term periods gained higher functional ability in later ages. Researchers also reported that participation in regular long-term physical activity contributes to a healthier, more independent lifestyle, dramatically improves the functional capacity and quality of life in the older population, and is an effective intervention/modality to reduce/prevent a number of functional declines associated with aging (Mazzeo et al., 1998; Hillsdon et al., 2005; Chodzko-Zajko et al., 2009). Overall, older adults who begin a regular physical activity program early in life and maintain a physically active lifestyle over the years will likely have high physical performance throughout their lifespan.

5.3.5 Summary

Our study found the dose-response relationship between time spent on physical activity and functional ability in 75-84 years old females. Possible threshold/cutting values regarding the needed amount of physical activity in age and gender groups included: 450 mins or 2000kcal energy expenditure per week for 65-74 years old males; 250 mins or 2000kcal energy expenditure per week for 65-74 years old females; 5800 daily steps or 300mins per week needed for 75-84 years old male, 5800 daily steps or 150 mins or 800kcal energy expenditure per week for 75-84 females; 240 mins for 85 years above male and female adults. Compared to public guidelines, our study found a similar amount of physical activity duration and fewer daily step counts needed for older adults to maintain a higher level of functional ability.

5.4 Study Strengths and Limitations

This study has strengths in a few places, including a large sample size, based on an existing dose-response model for health benefits and physical activity amount, and study design involving exploration in each older age and gender group. Limitations included the cross-sectional study design, a large number of missing values, and the primary dependent variable's lack of sensitivity.

NHANES was one of the major national datasets as part of the CDC. 2005-2006 datasets included a nationally representative sample of more than 10,000 persons total and 1,189 older adults. The dose-response model was reported from the physical activity and health symposium which was held by expert scientists in the field (Bouchard, 2000). It provided a strong theoretical and operational foundation for our study. Another strength was that our study differentiated males and females older adults, as well as young-old, middle-old, and old-old in exploring the relationships about physical activity.

One of the study limitations was the cross-sectional design. This study aims to explore the relationships between the amount of physical activity and functional ability in older adults, and to examine the possible physical activity threshold/cutting values for different age and gender adults. However, physical activity has to be performed habitually and in a relatively long-term period to gain benefit. Thus, the ideal method would be longitudinal or retrospective to see functional effects from habitual physical activity.

Missing data was also a limitation using NHANES physical activity dataset. Self-reported questionnaires were used to measure weekly physical activity duration, energy expenditure, and functional ability. Transportation-related activity, daily activity in or around home or yard, and leisure-time moderate/vigorous physical activities summed the total amount of physical activity. More than 40 types of leisure-time physical activity, including duration and frequency, were recorded. Functional ability was scored collectively from 21 short-answer questions. The complex data processing resulted in lots of missing data in these variables.

The other limitation is the sensitivity of the functional ability variable. Total difficulty levels measured functional ability in older adults in doing 20 types of daily activities, which was summed from a four-level Likert scale. The difficulty level in doing each activity was categorized into no difficulty, some difficulty, much difficulty, and unable to do. This response classification was not accurate enough. The differences between levels were individually dependent and lacked measurable criteria. Overall, the description and differentiation between difficulty levels were not sensitive enough. It would be better to measure functional ability more accurately and reflect more variance among participants.

5.5 Implications for Nursing Practice and Health Policy

This study is one of the few studies that explored the dose-response effects of physical activity across age and gender groups in older individuals. The study examined the number of daily steps, weekly physical activity duration, energy expenditure needed, and the importance of maintaining long-term habitual physical activity in relation to functional ability. It adds to the current knowledge about physical activity as health promotion strategies in older populations. The study also contributed as references to physical activity dosage prescription and public health policy in older adults. The study results can be directly applied in nursing practices, such as health education on the importance of long-term habitual physical activity engagement, ensuring high enough amounts of daily physical activity, and awareness of variances in different age and gender groups. The study also provided another perspective on how to maintain functional ability and independence in the older adult populations, especially for those most vulnerable and aged elders, where very little research or data was reported.

5.6 Suggestions for Future Research

Future research would better be designed longitudinally, including stable engagement of habitual physical activity, a relatively long-term intervening period, and sensitive enough functional ability indicators. The validity and sensitivity of different physical activity dimensions should put more focus on the dose-response relationships, such as whether step counts and physical activity duration have the same impact on male and female elders, or on different older age groups.

Many studies and reports stated that most of the older adult population doesn't meet the recommended amount of physical activity in public guidelines. Many older people are sedentary and unable to reach the recommended amount due to chronic health conditions or disabilities. Instead of requiring a certain amount of habitual physical activity in guidelines, future research should emphasize light-intensity physical activity and prevent sedentary behavior. Any movement or activity is better than none. Light intensity physical activity has received increasing attention in recent years. Evidence supports including the amount of light-intensity physical activity in public health guidelines for older adults (Loprinzi et al., 2015). Future research can explore light-intensity physical activity and sedentary behavior and the relationships between health benefits in older adults groups.

5.7 Study Conclusions

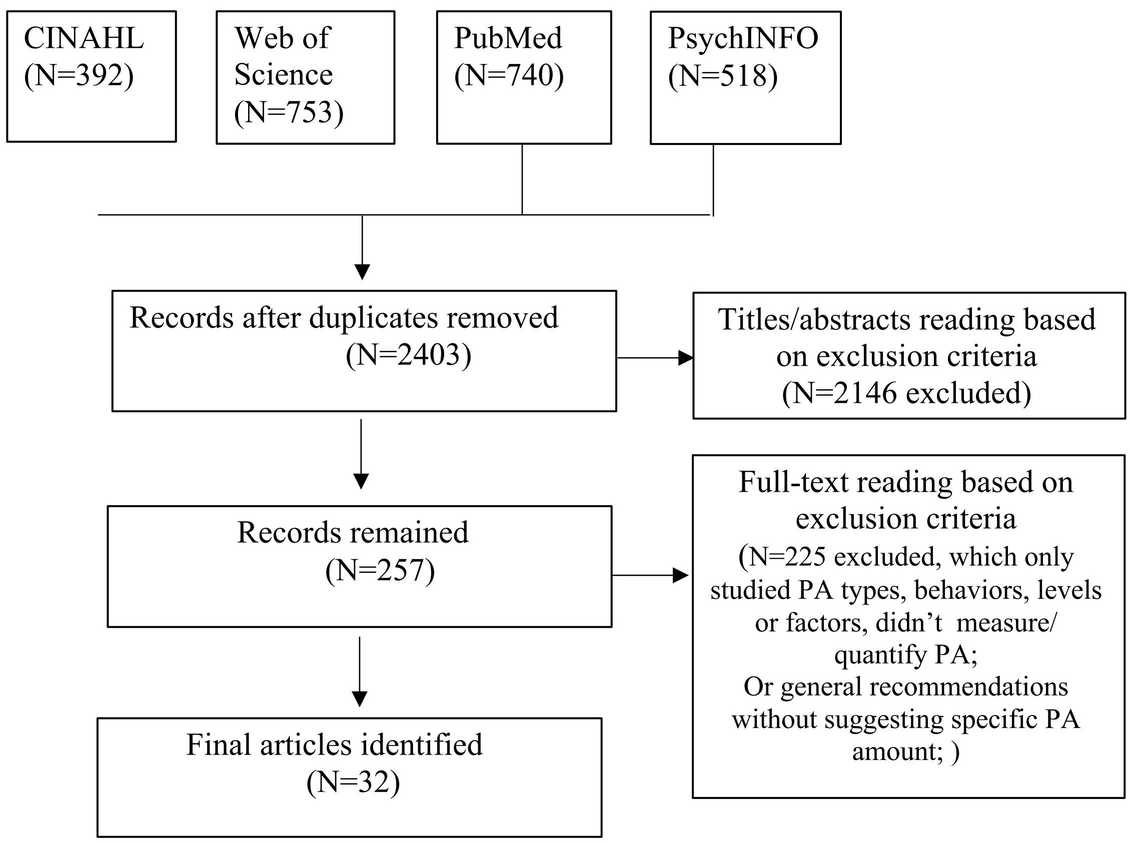
Generally, community-dwelling older adults who are 65 years old and above need to walk 5,400 -6,500 steps per day or spend 1,500- 4,500kcal energy, or 150-450 minutes per week on physical activity to maintain their functional abilities. Engaging in at least this amount of physical activity, plus keeping active level in a long-term period, can improve older adults' functional ability at later ages. We found a direct relationship between functional ability of older women (aged 75- 84 years) and minutes of physical activity engaged in a week. The more time spent on physical activity, the higher the functional ability. One hundred fifty minutes of physical activity per week is the threshold for obtaining the most benefits.

Older males aged 65-74 years are recommended to spend 450 mins or 2000kcal energy expenditure per week on physical activity; females aged 65-74 years need to spend at least 250 mins or 2000kcal energy expenditure on physical activity in a week. Older men aged 75-84 years need walk 5800 daily steps or 300mins per week to maintain functional ability; 75-84 years old females need to walk 5800 daily steps or 150 mins or 800kcal energy expenditure per week. Both male and female old-old adults (85 years above) are recommended to spend at least 240 mins per week on physical activity to maintain higher levels of functional ability. However, these threshold/cutting values should be interpreted with caution and no definite conclusions should be drawn as discussed above.

As older adults get older, fewer daily steps, less time, and less energy expenditure need to be spent on physical activity to maintain function. Male older adults generally require larger amounts of physical activity compared to females; however, the gender differences decrease as age increases. It seems that different dimensions of physical activity have different sensitivities between male and female older adults, such as physical activity intensity (daily step counts) is more sensitive and meaningful to male older adults while physical activity duration is more meaningful to female older adults.

APPENDIX A

FLOW CHART OF SEARCH STRATEGIES



APPENDIX B

PHYSICAL ACTIVITY CODES

Code	Activity	Moderate MET Code	Vigorous MET code
10	Aerobics	5.0	7.0
11	Baseball	5.0	6.0
12	Basketball	6.0	8.0
13	Bicycling	4.0	8.0
14	Bowling	3.0	3.0
15	Dance	4.5	6.0
16	Fishing	3.5	6.0
17	Football	5.0	8.0
18	Gardening	4.0	5.0
19	Golf	3.5	4.5
20	Hiking	6.0	7.0
21	Hockey	6.0	8.0
22	Hunting	5.0	6.0
23	Jogging	6.0	7.0
24	Kayaking	3.5	7.0
25	Push-ups	3.5	8.0
26	Racquetball	7.0	10.0
27	Rollerblading	6.0	7.0
28	Rowing	3.5	7.0
29	Running	7.0	10.0
30	Sit-ups	3.5	8.0
31	Skating	5.0	7.0
32	Skiing – cross country	7.0	9.0
33	Skiing – downhill	6.0	8.0
34	Soccer	6.0	10.0

Code	Activity	Moderate MET Code	Vigorous MET code
35	Softball	5.0	6.0
36	Stair Climbing	6.0	8.0
37	Stretching	2.5	2.5
38	Swimming	6.0	8.0
39	Tennis	5.0	7.0
40	Treadmill	4.5	7.0
41	Volleyball	4.0	8.0
42	Walking	3.5	5.0
43	Weight Lifting	3.0	6.0
44	Yard Work	4.0	6.0
50	Boxing	6.0	9.0
51	Frisbee	3.0	8.0
52	Horseback Riding	4.0	6.5
53	Martial Arts	4.0	10.0
54	Wrestling	6.0	8.0
55	Yoga	2.5	4.0
56	Cheerleading and Gymnastics	4.0	6.0
57	Children's Games - Dodgeball, Kickball, etc.	5.0	6.0
58	Rope Jumping	8.0	10.0
59	Skateboarding	5.0	6.0
60	Surfing	3.0	5.0
61	Trampoline Jumping	3.5	4.5
71	Other	4.5	7.0

(https://wwwn.cdc.gov/Nchs/Nhanes/2005-2006/PAQIAF_D.htm#Appendix_1_Physical_Activity_Codes)

APPENDIX C

SUGGESTED MET SCORES

Variable	Label	Score
PAD020	Walked or bicycled over past 30 days to get to/from work, etc.	4.0
PAQ100	Tasks in or around home or yard past 30 days.	4.5
PAQ180	Average level of physical activity each day (1 - Mainly sit)	1.4
PAQ180	Average level of physical activity each day (2 - Walk a lot)	1.5
PAQ180	Average level of physical activity each day (3 - Carry light loads)	1.6
PAQ180	Average level of physical activity each day (4 - Carry heavy loads)	1.8
PAD440	Muscle strengthening activities	4.0
PAQ560	Number of times per week play or exercise hard	7.0
PAD590	Average number of hours watch TV or videos over past 30 days	1.0
PAD600	Average number of hours used computer over past 30 days	1.5

https://wwwn.cdc.gov/Nchs/Nhanes/2005-2006/PAQ_D.htm#Appendix_1._Suggested_MET_Scores

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