OBESITY-RELATED COMORBIDITIES, DISABILITY, PHYSICAL INACTIVITY, AND FOOD INSECURITY IN GEORGIA SENIOR CENTERS

by

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(Under the Direction of Mary Ann Johnson)

ABSTRACT

This dissertation examines the problem of obesity in older adults participating in Georgia's Older Americans Act Nutrition Programs (OAANP) at senior centers. Three studies were conducted that focused on: 1) the influence of obesity on the prevalence of obesity-related comorbidities, 2) the extent to which moderate physical activity attenuated obesity-related comorbidities, and 3) the role of physical limitations as underlying causal factors in the food insecurity-obesity paradox. Obesity markedly increased the prevalence of diabetes, high blood pressure, arthritis, and poor or fair self-reported health by about 20-percentage points. Moderate physical activity did not attenuate the effects of obesity on the comorbidities, but did significantly decrease the risk of poor physical function and poor or fair self-reported health. Obesity and weight-related disability both increased the risk of food insecurity, suggesting that certain physical limitations may contribute to the food insecurity-obesity paradox in older adults. Together these studies demonstrated that obesity markedly increased the risk of several comorbidities and food insecurity, emphasizing the need for health promotion programs at senior centers to promote healthy body weights, nutrition, physical activity, food assistance, and food security.

INDEX WORDS: BMI, waist circumference, obesity, comorbidities, physical activity, food insecurity, aging, Older Americans Act Nutrition Program, congregate meals, senior centers

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CHAPTER 1

INTRODUCTION

In Georgia overweight/obesity is reported in 65% of adults [1] and in 63.5% of adults aged 65 and older [2]. Georgia has the 9th fastest growing 60 years and older population in the United States [3]. Among the Medicare population of Georgia, from 1998 to 2000, over 400 million dollars was spent on medical expenditures attributed to obesity alone [4].

The Older Americans Act Nutrition Program (OAANP) was established by the Administration on Aging (AoA) to support the independence and quality of life of community-dwelling older adults. Under Title III of the OAA, the OAANP is authorized to provide grants to State Agencies on Aging to support nutritionally balanced congregate and home-delivered meals, nutrition and wellness education services, nutrition screening, and reduction of hunger and food insecurity [5].

Increased adiposity is of great concern among the older adult population because it exacerbates comorbidities, accelerates age-related decline in physical function, and is costly [4, 6, 7]. Since the comorbidities that are linked to overweight and/or obesity in older adults are similar to those that occur with increased age, and the association between increased weight status and the prevalence of chronic diseases among older adults is controversial, more information is needed to understand whether the high prevalence of these comorbidities among Georgia's OAA participants is associated with overweight and/or obesity status. Moreover, it is not known if increased BMI and WC would be similar indicators of health risks in this population.

Being physically inactive has been shown to increase the risk of an older adult losing muscle strength and balance, which threatens their independence and physical abilities.

Increasing physical activity is a common recommendation for maintaining or increasing physical function in older people including those with existing health problems [8]. Diminished physical function is a strong predictor of disability, nursing home admission, and death [9]. In Georgia, and nationally, about 7% of the population has disabilities that require the use of special equipment [10]. In comparison to all other states, among older adults, Georgia ranks 6th, 7th, and 10th for mobility, cognitive and mental self-care disabilities, respectively [11].

Physically active older adults have a lower prevalence of morbidity and mortality than their inactive counterparts [12]. Among healthy community-dwelling older adults, physical activity improved the outcome of physical function regardless of body weight, but the impact of physical activity on the relationship of obesity with obesity-related comorbidities has not been studied among this vulnerable group of older adults participating in Georgia's OAANP.

An increased prevalence of obesity has been observed among the food insecure. The causes of this paradox have not been clearly delineated, but food insecure-obese older adults are at high risk of poor nutritional health outcomes and physical limitations [13-15]. There is very little information pertaining to the food insecurity-obesity paradox among older adults, and studies have not been conducted in older adults participating in OAA congregate meal-site program.

Obesity is a known risk factor for the development of arthritis and disability [16] and physical limitations have been associated with food insecurity [13], but it is not known whether obesity and physical limitations including weight-related disability are associated with food insecurity. Although not definitively proven, the physical limitations that occur with increased adiposity could be a contributing factor to the high prevalence of food insecurity among this subpopulation of older Americans.

Chapter 2 is a review of the literature outlining the prevalence of obesity across the lifespan and within specific race/ethnic groups, comorbidities associated with obesity, benefits of physical activity on obesity and obesity-related comorbidites, potential explanations for the food insecurity-obesity paradox and the role of physical limitations in exacerbating food insecurity. Also reviewed are common methods used in community studies to assess obesity, comorbidities, physical activity, physical limitations, and food insecurity. The OAA, OAANP, and senior centers as meal-sites for OAANP are also reviewed, because the research conducted for this dissertation explores the interrelationships of obesity, obesity-related comorbidities, physical activity, physical limitations, and food insecurity in participants of OAA programs at senior centers in Georgia.

Chapter 3 is a longer version of a manuscript accepted to the *Journal of Nutrition, Health, and Aging*. This chapter focuses on the relationship of overweight and obesity with the prevalence and number of selected comorbidities among older Georgians participating in the OAA congregate meal-site programs.

Chapter 4 is a manuscript to be submitted to the *Journal of Nutrition, Health, and Aging* that focuses on whether or not moderate physical activity attenuates the relationship of obesity with obesity-related comorbidities among older Georgians at senior centers.

Chapter 5 is a manuscript to be submitted to the *Journal of Nutrition, Health, and Aging* that investigates the role of physical limitations as explanatory factors involved in the food insecurity-obesity paradox among Georgians participating in the OAA programs at senior centers.

Chapter 6 presents a summary of the major findings and conclusion for each study.

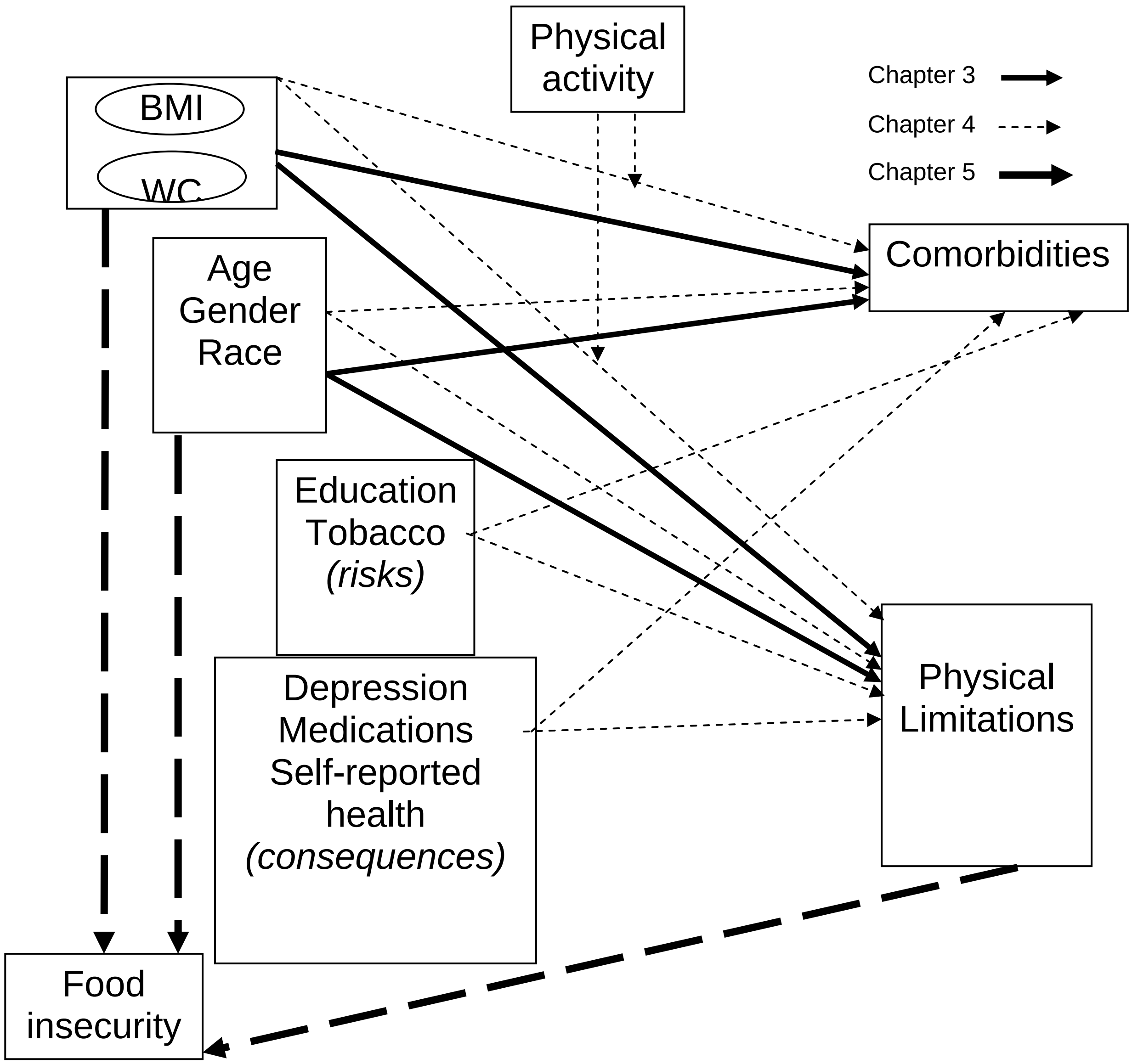

FIGURE 1.1. Conceptual model of the independent and dependent variables included in the analyses. This model conceptualizes the relationships of selected independent variables on the dependent variables examined in a series of analyses. The independent variable of interest for all analyses was obesity as measured by BMI and WC. The dependent variables included comorbidities, physical limitations, and food insecurity.

CHAPTER 2

LITERATURE REVIEW

Introduction

This review summarizes the literature related to the prevalence and measurement of obesity, obesity-related comorbidities, the disablement process, physical activity, and food insecurity in older adults. Topics include the Older Americans Act (OAA) that authorizes community-based provision of nutritious meals and disease prevention services through senior centers and other appropriate sites, the relationship of obesity to comorbidities and disability-related factors, the benefits of physical activity even among those who are overweight or obese, and the food insecurity-obesity paradox. A gap in the literature was identified that involves the lack of information about the impact of obesity on older adults receiving services through OAA programs delivered at senior centers. Such information is needed in order to provide appropriate nutrition and disease prevention services through OAA programs and improve identification and targeting of those most in needed of these services.

The Older Adult Population

Older adults are living longer and as a result the population is growing rapidly. By 2030, the number of older Americans is expected to double from 35 million to 70 million, and 20% of the total population will be aged $\geq$ 65 years. In 2007, 9.9% of Georgia's population was composed of older adults (65+ years), and nationally older adults composed 12.6% of the population [17].

Currently, one third of total US health care costs are allocated to older adults, therefore their decline in health will become an incredible cost burden to the public health system. Lack of physical activity and poor diet predominantly contributes to the obesity epidemic seen in the general US population, as well as in the subpopulation of older people. In 2002, the total cost of overweight and obesity was estimated to be $92.6 billion [18]. It is estimated that 60% of the older adult population, $\geq$ 65, is overweight or obese, and being overweight or obese affects 63.5% of Georgians aged 65 and older [2]. Increased adiposity is of great concern among the older adult population because it exacerbates comorbidities, accelerates age-related decline in physical function, and is costly [6, 7, 18]. Being physically inactive has been shown to increase the risk of an older adult losing muscle strength and balance, which threatens their independence and physical abilities. Furthermore, although not definitively proven, physical limitations such as arthritis, joint pain, poor physical function, and the occurrence of disability, among the overweight and obese, could contribute to food insecurity among this vulnerable population of older Americans. In comparison to national prevalence, Georgia ranks 6th, 7th, and 10th for mobility, cognitive, and mental, self-care disabilities, respectively, among older adults [11].

Currently, body mass index (BMI) and waist circumference (WC) are measurements commonly used in clinical and community-settings to determine weight status to assess health risks among adults, including older people. BMI and WC do not account for body composition and even though an older person may be classified as overweight or obese, this does not necessarily mean that their physical function has declined to a point that their independence is threatened, nor does having a normal BMI or WC guarantee healthy functional independence. It has been estimated that 80% of older adults have at least one chronic disease [19]. Major contributors to the increased prevalence of disease include poor nutritional habits and physical inactivity [20]. The BMI threshold most appropriate for older adults to maintain optimal health with the lowest prevalence of chronic disease is controversial [21].

As physical activity has proved to be beneficial for physical function and disease prevention, it is important for older people to maintain and/or increase their physical activity level, regardless of weight status. Nationally, only 44.5% of men and 36.3% of women, of all ages, met the moderate physical activity guidelines [22]. Physical inactivity accounts for 10% of the direct health care costs in the US with an estimated 77 billion dollars that could be saved annually just through physically inactive adults becoming active [20, 23].

An increased prevalence of obesity has been observed among the food insecure [24]. The causes of this paradox have not been clearly delineated, but the obese food insecure older adults are a vulnerable subpopulation at high risk of poor nutritional health outcomes and physical limitations. Although not definitively proven, the physical limitations that occur with increased adiposity could be a contributing factor to food insecurity among this subpopulation of older Americans.

Older Americans Act and Title III C and D programs for Older Adults

The Administration on Aging (AoA) is within the Department of Health and Human Services (DHHS) [25]. AoA assists in the development of state level service systems that are administered by 56 State and Territorial Units on Aging, 655 Area Agencies on Aging, 226 Native American and Hawaiian organizations, and more than 29,000 local service providers. The Older Americans Act Nutrition Program (OAANP) was established by the AoA in 1972 to support the independence and quality of life of community-dwelling older adults. Under Title III C of the OAA, the OAANP is authorized to provide grants to State Agencies on Aging to support nutritionally balanced congregate (Part C-1) and home-delivered meals (Part C-2), nutrition and wellness education services, nutrition screening, and as stated in Section 330 of the OAA to "reduce hunger and food insecurity" [25]. Meals funded by state and federal sources under the

OAANP must meet the 2005 Dietary Guidelines for Americans [26]. The disease prevention and health promotion services (Title III D) are provided at multipurpose senior centers, congregate meal-sites, home delivered meals program, and at other appropriate sites [25].

Although all older Americans are allowed to participate in the OAANP, it is targeted to those with the greatest social and economic need with particular attention paid to low-income minorities and rural individuals [25]. OAA Title III participants are more likely to have low education, poor self-reported health, low-income, have poor physical function [27], diabetes, cardiovascular diseases, and increased BMI [28] compared to the general population of older adults. Because the older adults attending the senior centers may or may not take advantage of the wellness programs offered at the senior centers we can only speculate that the older adults who do participate in the wellness programs are likely to have greater benefits in health.

The services offered in this program are targeted to help older adults live longer, healthier lives, remain independent in the community, and avoid institutionalization and disability. Other services offered through OAANP include transportation to grocery stores, physical activity programs, socialization, and services to promote the health and well-being of older adults [25]. Evaluations of the OAANP have shown it to be effective in providing services for older adults, and in improving the dietary intake, health outcomes and socialization among participants [29].

Indicators of Obesity-Related Comorbidities and Physical Limitations

This section reviews the indicators used to assess the obesity-related comorbidities and physical limitations used in the research studies described in Chapters 3, 4, and 5 of this dissertation. For the purposes of this dissertation, the term “comorbidity” was used to describe the following chronic diseases or health problems: diabetes, high blood pressure, heart disease, high cholesterol, self-reported health, and "physical limitations" was used to describe arthritis, joint pain, weight-related disability, poor physical function, and low chair-sit-and-reach.

Because of the limitations of the community-setting, such as limited time, staff, and costly and sophisticated equipment, as well as convenience of measure, self-reports were used to assess comorbidities and physical limitations including diabetes, high blood pressure, heart disease, high cholesterol, arthritis, and joint pain. However, as is common practice in the community-setting, assessment questions were derived or adapted from the Behavioral Risk Factor Surveillance System (BRFSS) developed by the Centers for Disease Control and Prevention (CDC) for national surveillance of the US population, including older adults [30]. The BRFSS survey is used to gather information about a wide range of behaviors and health conditions that affect the health of adults 18 years of age and older. The data derived from BRFSS is used by states to identify emerging health problems, establish health objectives and track the states' progress towards meeting the objectives, and to develop and evaluate public health policies and programs to address identified problems [30]. Questions included in the BRFSS go through a rigorous process of question construction and approval that includes determining the usefulness of the data obtained from the question and the reliability of the question [30]. Included questions have either been validated or they have gone through the CDC's recommended protocol for pre-testing questions [30]. Therefore, the questions used by BRFSS have many advantages for assessing the prevalence and predictors of certain health-problems in the community-setting for older adults, such as reliable and valid measures and comparability with state and national-level trends.

Obesity is a risk factor for the development of diabetes. Diabetes is a disease in which the body does not produce or properly use insulin resulting in high blood glucose [31]. Diabetes is commonly diagnosed by a fasting plasma glucose test (FPG) or an oral glucose tolerance test. The American Diabetes Association recommends the FPG test because it is easier, faster, and less expensive to perform. A fasting blood glucose level of > 126 mg/dl, or higher indicates diabetes [31].

In this study, diabetes was assessed using the question "Do you have diabetes?" adapted from the BRFSS [32]. In 2006, 16.8% of older adults aged 75 years and older were diagnosed with diabetes, and the prevalence in Georgia was much higher at 22.8% [33].

Obesity is a risk factor for high blood cholesterol. High cholesterol and obesity are major risk factors for heart disease [34]. The National Heart Lung Blood Institute (NHLBI) recommends that a complete laboratory based lipoprotein profile be used to measure blood cholesterol [34]. In this study, high cholesterol was assessed with the BRFSS question, "Have you ever been told by a doctor, nurse, or other health professional that your blood cholesterol is high?"[35]. Nationally and in Georgia about 37% of adults, of all ages, were told their blood cholesterol was high [36].

Obesity is a risk factor for the development of high blood pressure (hypertension), and high blood pressure is also a risk factor for heart disease and other health problems. Blood pressure can be measured using a stethoscope and sphygmomanometer, or with a digital sphygmomanometer (a blood pressure monitor) [37]. In this dissertation, high blood pressure was assessed with, "Do you have high blood pressure" adapted from the BRFSS [38]. Nationally, 35% of older adults aged ≥ 65+ and 46.8% of those aged ≥ 75+ had hypertension [39]. In the state of Georgia, there is a 63% prevalence of high blood pressure among older adults [40].

Obesity is a risk factor for the development of heart disease, and heart disease is any disorder that affects the heart's ability to function normally. Various forms of heart disease can include, but is not limited to angina, congestive heart failure, heart attack, and coronary artery disease [41]. Several tests can be used to diagnose heart disease and involve both non-invasive and invasive procedures. Initially people are evaluated using simple tests, and then if needed, more complicated tests are used. The specific test used depends on the patient's symptoms and the preference of the physician. The following are examples of tests used to diagnose heart disease: resting electrocardiogram, signal-average electrocardiogram, chest X-ray, echocardiogram, exercise stress test, computed tomography scan, magnetic resonance imaging, magnetic resonance angiography, and several nuclear imaging tests [41]. In this dissertation, the prevalence of heart disease was assessed with the question, "Do you have heart disease such as angina, congestive heart failure, heart attack or other heart problems?" from BRFSS [42]. In Georgia, cardiovascular disease accounted for 32% of deaths in 2006, which is much higher compared to the national rate of 23% [43].

Arthritis is characterized by pain and stiffness in and around one or more joints. Arthritis is used to describe more than 100 rheumatic diseases and conditions that affect the joints [44]. In most cases a physician will diagnose arthritis with a physical examination without laboratory tests, but some forms of arthritis, such as rheumatoid arthritis, do require a blood test. X-rays, and thermal imaging can be used to detect tissue damage surrounding joints [45]. In this dissertation, the prevalence of arthritis was assessed with the question, "Do you have arthritis" adapted from the BRFSS [46]. Nationally, 63% of older adults were diagnosed with arthritis of all types compared to 58% of older Georgians [47]

Joint pain can be caused by injury affecting any of the ligaments, bursae, or tendons surrounding the joint, and also by arthritis. X-rays are used to detect tumors, fractures, arthritis, and degenerative bone conditions associated with joint pain [48]. We assessed joint pain with the question, "During the past 30 days, have you had symptoms of pain, aching, or stiffness in or around a joint?" [49].

Obesity has been associated with increased bone mineral density, which is thought to be protective against the development of osteoporosis [21]. Osteoporosis can be diagnosed by an x-ray of the spine, bone mineral density test such as a dual-energy x-ray absorptiometry (DXA) bone scan [50]. Osteoporosis increases the risk of bone fractures, and is of great concern among older adults. In this dissertation, osteoporosis was assessed with the question, "Have you ever been told by a doctor or other health professional that you have osteoporosis?" [51].

Falls increase the risk of fractures. It is estimated that about one-third of older adults experience at least one fall [52, 53]. Falls are of such concern because they are associated with contusions, lacerations, subsequent fear of falling or depressive symptoms, as well as fractures. Furthermore, the mortality rate is high following a hip fracture, and those that survive a hip fracture experience decreased physical function and reduced quality of life [54]. The results are conflicting concerning body weight and risk of falling. In community-dwelling older adults low body weight [55] or low BMI [56] was found to be associated with increased falls, BMI $\geq$ 30 was associated with increased falls [57], and neither low or high BMI were related to falls [58, 59].

Self-reported health is a single-item global measure of a person's health that is a strong predictor of numerous adverse health outcomes including functional ability and mortality [60-62]. It is a valid measure that is simple to implement and gives a powerful return in that it combines a myriad of factors from various domains of life resulting in a very robust predictor of health outcomes [61]. Self-reported health was assessed by asking "How would you rate your overall health?" with response categories of poor, fair, good, very good, excellent [60]. Several researchers have observed an association between decreased self-reported health and obesity [63, 64].

Overweight and Obesity

Prevalence of Overweight/Obesity Across The Lifespan

Obesity specifically refers to having an abnormally high proportion of body fat to the point that health is impaired [65]. Being overweight refers to an excess of body weight compared to set standards, but the excess weight may come from components of body composition other than fat, such as muscle, bone, and/or body water.

BMI is based on the ratio of weight to height (kg/m^2) and is used by researchers and health care professionals and according to the National Heart Lung Blood Institute (NHLBI) can categorize a person's weight status as underweight (<18.5), normal (18.5 to 24.9), overweight (25.0 to 29.9), or obese (≥ 30.0) [66]. Obesity is further classified into three different categories: class I obese (30.0 to 34.9), class II obese (35.0 to 39.9), and class III extreme obesity (≥ 40.0) [66]. BMI and WC measures are commonly used to assess risk of obesity-related comorbidities. A high WC is associated with an increased risk of type 2 diabetes, dyslipidemia, hypertension, and cardiovascular diseases in people that have a BMI ≥ 25 to < 35 [66].

Obesity-related health risks are similar in all populations, although the specific level of risk, associated with a given level of overweight or obesity may vary with race, ethnicity, age, gender, and socioeconomic status [66]. In 2005 -2006 among men and women aged ≥ 20 years in the United States, about two-thirds were overweight or obese [67]. Figure 1 shows the prevalence of obesity, defined as BMI ≥ 30, among non-Hispanic white, non-Hispanic black, and Mexican American men and women aged ≥ 60 years [67]. Across all age groups it appeared that among women, those who were black or Hispanic had the highest prevalence of obesity.

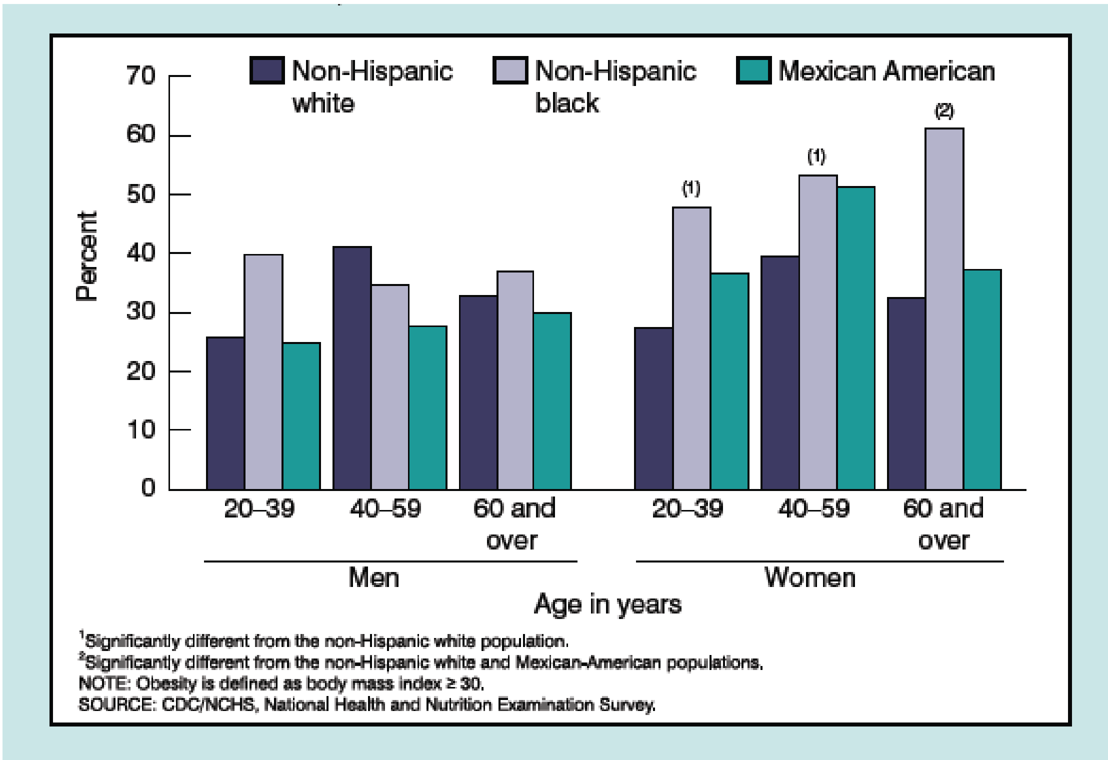

FIGURE 2.1: Prevalence of obesity by age, race/ethnicity, and sex, adults aged 20 years and older. United States, 2005 – 2006 (figure in public domain at: http://www.cdc.gov/nchs/data/databriefs/db01.pdf).

Among adults in the US, the prevalence of overweight and obesity has increased annually at an average rate of approximately 0.3 to 0.8 percentage points across different sociodemographic groups for the past thirty years. By 2015 it is projected that about 75% of the adult population will have a BMI ≥ 25 and about 24% of children and adolescents are expected to fall into this category [68]. As the prevalence of obesity grows it is likely to become the leading preventable cause of disease and death, as it is currently second only to tobacco use [69].

Measuring BMI

As mentioned above, BMI is divided into several categories based on the ratio of weight to height and there are three different classes of obesity. The further subdivision of obesity is necessary because treatment options differ among the different categories of BMI [65] and the morbidity for a number of health conditions increases with increasing BMI [66].

To calculate BMI the measurements of height and weight are needed. BMI is a relatively easy measure to obtain in a clinical-setting. However, assessment of BMI does have its challenges in non-clinical community-settings and telephone and mail surveys, because measures require portable, accurate, and calibrated scales, stadiometers, and tape measures, consideration of clothes and shoes being worn, and potentially having to rely on self-reported measures of height and weight. Although not as ideal as the objective measures of height and weight, gender-specific correction equations can be applied to the self-reported measures [70]. The studies presented in Chapters 3, 4, and 5 of this dissertation used the following equation to calculate BMI: (BMI = (weight (pounds)/height (inches)^2) x 703). Body weight was assessed in several ways: a) weighed with a scale, without shoes and with clothes; b) weighed with a scale with shoes and clothes on; or c) self-reported and we assumed without clothes and shoes. We were unable to find corrections for the weight of shoes and clothes in the literature, therefore the following corrections were applied to measured body weight: -2 pounds for shoes for women, -2 pounds for clothes for women, -4 pounds for shoes for men, and -4 pounds for clothes for men. Linear regression equations derived from Rowland et al. [70] were applied to correct for self-reported body weight:

Males: weight (pounds) = -4.1259 + 1.0185 (self-reported weight in pounds)

Females: weight (pounds) = -3.1974 + 1.0438 (self-reported weight in pounds) – 0.0175 (age in years).

Height was assessed by: a) measurement with a tape measure with shoes on or b) self report. We were unable to find corrections for the height of shoes in the literature therefore a correction of -1 inch from the measured height of both genders was applied. Self-reported height was corrected by applying linear regression equations from Rowland et al. [70]:

Males: height (inches) = + 7.1987 + 0.8865 (self-reported height in inches) + 0.0222 (age in years) – 0.0004 (age^2).

Females: height (inches) = + 7.4583 + 0.8745 (self-reported height in inches) + 0.0424 (age in years) – 0.0007 (age^2).

Limitations that are important to consider when using the BMI to assess weight status in the older adult population is that the BMI does not account for body composition or physical function. As a person ages and their muscle mass decreases and their fat increases, their BMI in any category may underestimate the amount of fat a person may have [6]. Also, the loss in height as a result of vertebral compression and kyphosis could lead to overestimation of BMI [21]. Furthermore, BMI does not indicate the level of physical function nor independence [21].

Measuring Waist Circumference

WC specifically measures central adiposity, whereas BMI assesses general obesity. Although WC and BMI are interrelated, WC provides an independent prediction of risk over and above that of BMI, and is particularly useful for identifying those at increased risk of adverse health outcomes that have a normal or overweight BMI [71] . Central adiposity is an independent risk factor for certain metabolic diseases such as diabetes, dyslipidemia, hypertension, and cardiovascular disease [21, 66, 72]. The studies presented in Chapters 3, 4, and 5 of this dissertation followed the guidelines from the NHLBI to measure WC either over the participants' clothing or underneath their clothing [71]. Corrections for WC when measured over clothes do not appear to be available. Therefore, a correction of -1 inch was applied. Participants' WC was classified as either low risk (men $\leq$ 40 inches and women $\leq$ 35 inches) or high risk (men > 40 inches and women > 35 inches) [66].

WC is a relatively simple measure to obtain in the clinical or community-setting, but it can be challenging to accurately locate the appropriate anatomical positions to obtain a proper measurement. Also, a participant may not want to remove their clothes from their abdomen, particularly in a community-setting, however, participants can be instructed to wear light clothing and correction factors can be applied. Similar to the BMI, WC does not measure body composition and is not a measure of physical function. However, in some studies WC, compared to BMI, was a better predictor of physical function impairment [73].

Overweight, Obesity, and Health

A BMI categorized as overweight and/or obese is associated with increased risk of developing certain comorbidities, such as hypertension, type 2 diabetes, coronary heart disease, stroke, gallbladder disease, osteoarthritis, sleep apnea, respiratory problems, and some types of cancer including breast, endometrial, kidney, esophagus, and colon [66]. There may, however, be benefits to obesity that include increased bone mineral density and decreased osteoporosis and hip fractures in both older men and woman (reviewed by [6]).

In adults, mortality has been shown to modestly increase with a BMI of $\geq$ 25 to < 30, but all cause mortality increases by 50 to 100% once a BMI of 30 and above is reached in relation to persons within the BMI range of 20 to < 25 [66]. Being overweight is an important contributor to morbidity risk in younger people, but the extent of the health hazards and risks for older people is not clear [74]. Comorbidities associated with overweight and/or obesity are similar to those that occur with increased age. These include the physiologic abnormalities related to metabolic syndrome, hypertension, diabetes, cardiovascular disease, and osteoarthritis [6]. Excess abdominal fat has been independently linked with the development of metabolic syndrome in older people aged 70 to 79 years old [72]. Also, arthritis is the leading cause of physical disability in older adults and a high BMI is related to increasing the risk of knee osteoarthritis in older persons [75]. Obesity has also been found to contribute to urinary incontinence in women aged ≥ 65 years [76] and has been associated with specific types of cancer in older adults [77]. Increased prevalence of cataracts has been associated with overweight and/or obesity [78].

Sarcopenic Obesity

As people age it becomes more challenging to maintain muscle mass. This age-related decline in muscle mass is called sarcopenia [79]. Sarcopenia, along with increased joint dysfunction and arthritis, leads to a progressive decrease in physical function, and is exacerbated by obesity. With sarcopenia a person can maintain the same BMI throughout life, but their ratio of muscle mass to fat mass decreases resulting in more fat and deterioration of muscle mass. This shift in body composition has been associated with a decrease in strength [80]. The distribution of fat also changes as there is typically a decrease in fat in the appendages and an increase in visceral fat. A gain in central adiposity is known to be detrimental to health [81] .

Previous research has generally focused separately on the fat and muscle tissues and how each individually contributes to disability. Sarcopenic obesity, however, involves synergistic changes in tissues to cause disability and/or metabolic disorders [82]. One possible mechanism behind the development of sarcopenic obesity, and its associated metabolic disorders, includes the adipokines, tumor necrosis factor-alpha and leptin, and their involvement in insulin resistance, disruption of energy metabolism, and having varying effects on the release of growth hormone. There is no clear definition of sarcopenic obesity, but identifying it does involve quantification of a person's muscle and fat composition. Sarcopenic obesity is known to increase with age, regardless of gender, but it does not account for the muscle quality or the degree of fat infiltration into the muscle. Calculating BMI or measuring fat mass alone cannot be used to identify sarcopenic obesity, rather entire body composition must be assessed.

Currently, the most effective treatment to reverse sarcopenic obesity is resistance training [83]. It is well accepted that overweight and/or obesity impairs physical function, but it is less clear whether it is the increase in fat-load or the age-associated reduction in lean body mass that leads to impairment [84].

Assessment of Body Weight and Weight-management Recommendations for Older Adults

Controversies related to body weight in older adults include appropriateness of recommending weight loss therapy [21], which method is superior – BMI or WC [85], and the recommended healthy BMI range for people aged $\geq$ 65 years [21].

In older adults, results are inconsistent concerning whether BMI or WC is the better predictor of obesity-related health outcomes and comorbidities [85]. Both assess obesity and health-related risks, but the mechanics of the measurements differ. A prospective study by Guallar-Castillon et al. found that WC predicted mobility and agility disability in older adults [86]. Low BMI was found to be a better predictor of mortality than low WC($\leq$ 40 inches) in older men [85]. Janssen et al. found that when BMI and WC were categorized according to NHLBI guidelines, BMI was a better predictor of obesity-related health risks [87], but when WC was stratified into categories relative to the BMI categories, WC was a more reliable indicator of obesity-related diseases in adults aged 20 to 65 years of age [73]. Furthermore, the current NHLBI single WC-threshold was not developed based on the relationship between WC and health risk, but rather they were designed in relation to BMI in order to be used in place of BMI as an alternative way to identify those in need of weight management [73].

Currently, NHLBI recommends that the assessment of body weight should include the evaluation of BMI and WC because WC measurement is particularly useful in identifying health risks for people who are categorized as having a normal or overweight BMI [66]. Data from the Third US National Health and Nutrition Examination Survey (NHANES III) and the Canadian Heart Health Surveys (CHHS) were used to determine the optimal WC thresholds within each BMI category for predicting the risk of future coronary events, and they validated these thresholds in comparison to the NHLBI cut-offs using data from NHANES III and CHHS [73]. They found that the WC-thresholds associated with coronary-event risk increased when moving from normal weight to class II obese and greater BMI categories. The optimal WC-thresholds tended to vary slightly according to age and race/ethnicity, but once stratified by BMI category the differences were attenuated in the class II or higher obesity categories. The threshold cut-offs were then cross-validated in the CHHS data set. The results demonstrated that the cut-offs had a balanced level of sensitivity and specificity across categories, indicating that prediction of health risk improved in comparison to the single measures of WC. They also determined that the thresholds could be used to identify persons at increased risk of coronary events [73].

In comparison to younger or middle-aged adults, the observation of decreased obesity-related comorbidities seen with increasing body mass in older adults, the uncertain effectiveness of obesity treatment, and the potential harmful effects of weight loss on muscle and bone mass makes the clinical decisions of how to treat obesity in older persons controversial [6].

It is well accepted that unintentional weight-loss and having an underweight BMI (<18.5) is associated with increased mortality among older adults [88]. Also, it is well established that weight loss in middle-aged adults improves several adverse metabolic abnormalities that are associated with obesity [6]. Population studies tend to show increased risk of morbidity and mortality in obese older adults, whereas the overweight status is less clearly associated with increased mortality [89-91]. A longitudinal study followed older adults aged $\geq$ 65 years for 9 years and determined that BMI in the overweight range was associated with some modest increase in disease risk, but with a slightly lower overall mortality rate [87]. Several observational epidemiologic studies have observed a contradiction in the "U" or "J" shape curved relationship between BMI and mortality in regards to older people age 75 and greater [66]. After age 75 the association between a BMI $\geq$ 27 and all-cause mortality is weak, but the association is stronger among this population with a BMI $\geq$ 31 (reviewed by [92]). These observations question whether the NHLBI federal guidelines [66] are too restrictive for older persons $\geq$ 75 years as evidence does not support that being mildly to moderately overweight is a risk factor for all-cause and cardiovascular mortality.

Explanations that challenge the idea that in older people relative risk of death decreases in association with a high BMI includes selective survival in which persons most sensitive to the adverse health effects of obesity are more likely to have died before reaching older ages [93], weight history, and the age at which overweight/obesity developed (e.g., later years rather than in their middle ages). People with elevated BMI since middle age have been found to be more likely to have heart disease in later life compared to those who became overweight in old age [74]. Also, the loss in height as a result of vertebral compression and kyphosis could lead to overestimation of BMI [21]. Despite the lack of strong evidence between increased mortality and overweight status in older adults, living with weight-related chronic diseases and having functional impairments can negatively impact quality of life [85].

According to NHLBI, age alone should not rule out treatment for obesity in adult men and women up to 80 years of age [66]. A clinical decision to not address obesity in an older adult should be an informed decision that considers the potential benefits of weight reduction, the impact on daily functioning, the potential of decreasing the risk of future cardiovascular events, and the patient's motivation for losing weight [66].

As mentioned earlier in this chapter, the prevalence of obesity-related comorbidities in Georgia is either higher or similar to national averages. Also, the prevalence of obesity-related comorbidities may be higher still in some subpopulations of older adults, such as those participating in programs at Georgia senior centers that target individuals who are minority and/or in rural settings. For example, in a convenience sample of Georgians participating in the OAA nutrition and wellness program, the prevalence of several obesity-related comorbidities was higher than for the general older adult population: 73% were overweight or obese [94], 28% had poor physical function [95], 41% reported diabetes and 73% reported hypertension [94]. Since the comorbidities that are linked to overweight and/or obesity are similar to those that occur with increased age, and the association between increased weight status and the prevalence of chronic diseases among older adults is controversial, more information is needed to understand the extent to which the high prevalence of these comorbidities among Georgia's OAA participants is associated with overweight and/or obesity status. Furthermore, it is not known if increased BMI and WC would be similar indicators of health risks in this population. Understanding these associations will help better define the nutrition and wellness services that may be needed to help prevent and manage weight-related chronic conditions in OAA programs.

Aging, Physical Limitations, and Independence

A decline in physical capacity is likely to lead to physical impairments, which increases the likeliness of physical function impairments that can progress into disability, morbidity, institutionalization, and then death [9, 96]. Good physical function is critical for prolonging an older adult's independence and ability to live in a community setting [9].

Nationally, 66% of adults with physician-diagnosed arthritis are overweight or obese [97]. Furthermore, arthritis is the number one cause of disability among Americans, and 50% of older adults have physician-diagnosed arthritis [98]. In Georgia, and nationally, about 7% of the population have disabilities that requires the use of special equipment [10]. However, among older adults, in comparison to other states, Georgia ranks 6th, 7th, and 10th for mobility, cognitive, mental and self-care disabilities, respectively [11].

The Disablement Process

Disability is the end result of a pathway of progressive disablement, which ranges from active pathology to disability [99]. "Disablement" refers to the impact that chronic and acute conditions have on the functioning of specific body systems and on a person's ability to act in a necessary, usual, and expected, personally-desirable way in society [99]. "Process" refers to the dynamics of disablement in that it is a continuum over time, and there are factors that affect the direction, pace, and pattern of change of the disablement [99]. The Disablement Process is an extension and elaboration of the Nagi Model [100]. Both models include the stages of active pathology, impairment, functional limitation, and disability [99, 100]. Pathology refers to biochemical and physiological abnormalities that are detected and medically labeled as disease, injury or congenital/developmental condition. The pathology is detected upon evaluation of signs and symptoms that have developed. Impairments are dysfunctions and significant abnormalities in specific body systems, such as musculoskeletal. Functional limitations are restrictions in performing fundamental physical and mental actions used in daily life. Fundamental physical actions include mobility, discrete motions, and strength. Disability is experiencing difficulty doing activities in any domain of life due to health or physical problems. Nagi (1965) defined disability as a pattern of behavior that evolves in situations of long-term or continued impairments that are associated with functional limitations [100]. Functional limitations and disability refer to different behaviors, not to different aspects of measuring the same behavior [99].

Unlike the Nagi Model, the Disablement Process includes social, psychological, and environmental factors that can speed up or slow down progression through the disablement pathway [99]. Pre-disposing risk factors for the stage of impairment include demographics, environment, lifestyle, and other behaviors. At the stage of functional limitation, certain external and internal-individual factors are posited to influence the direction and speed of progression through the pathway. External factors include medical care and rehabilitation, medications, external support (assistive devices, meals-on-wheels, or supervision), and structural modifications at the job or home, access to buildings and public transportation, and laws and regulations. Internal factors include lifestyle and behavioral changes, psychosocial attributes and coping skills, and making activity accommodations.

The study presented in Chapter 5 of this dissertation places the physical limitations of interest into the Disablement Process as follows: pathology (arthritis), impairment (joint pain), functional limitations (poor physical function), and self-reported weight-related disability (disability).

Physical Function and Disability Measurements

Physical function can be assessed by self- and proxy-report, single-measures of muscle strength, single-factor performance, or by a multidimensional physical performance test [101]. An example of a multidimensional physical performance test is the Short Physical Performance Battery (SPPB) Test [9]. Self-reported measures do not distinguish the entire range of function in older adults, but they do focus on inability, need for assistance, and difficulty performing a variety of functions [101]. The multidimensional measure assesses a variety of physical characteristics and provides a summary score across all aspects of function. The single, or multidimensional physical performance tests, can involve the observation of the participant performing an activity accompanied by an observer rating the performance and/or performance measures are assessed with equipment. A limitation to subjective observation is that the reliability decreases compared to the equipment based, while limitations for objective and performance based measures are that the equipment can often be expensive and not easily transportable.

A common single-measure used to assess upper body muscle strength is the hand-grip strength-dynamometer test [102]. This test has been shown to predict mortality, disability, and increased length of hospital stays, and also indicates frailty (reviewed by [103]).

The following tests are composite rating performance tests that are commonly used with older adults: Guarlnik's SPPB Test [9], Berg Balance Scale [104], and Tinetti Balance Assessment [105]. The Berg Balance Scale contains 14 items that simulate tasks common in everyday life. The test evaluates the participant's ability to perform movements of increasing difficulty. Tasks progress from a sitting position, to a bilateral stance, to a tandem stance, and then to a single leg stance. The ability to change positions is also assessed. Each task is graded on a scale of 0 to 4 with the potential of earning a total score of 56.

The Tinetti Gait and Balance Assessment contains items that focus on transitional skills such as sitting to standing, standing to sitting, static balance activities, and balance in response to external perturbations [105]. The assessment also addresses gait initiation, step length and height, symmetry, continuity, and other gait variables. Each of the nine items receives a sore of 0 to 2, and the final balance sore is summed.

Guralnik et al. developed the SPPB (76). It is a short battery of physical performance tests that assesses lower extremity function in community-dwelling older adults, which is a valid predictor of disability, institutionalization, and death [9]. This measure of performance was found to be more highly predictive of death and hospitalization than self-report of disability [9], and it was a better predictor of mortality compared to hand-grip strength [106]. For the studies reported in this dissertation (Chapters 3, 4, and 5), the SPPB test to assess physical function was used. The SPPB assesses balance, gait, and lower extremity strength, and endurance. Each of these categories is scored from 0 to 4 with a maximum summary score of 12. The standing balance test is tested using tandem, semi-tandem, and side-by-side stands. Those able to hold the semi-tandem position for ten seconds progress on to the tandem stand, while those unable to hold the position for ten seconds move to a side-by-side stand. Participants' scores are based on time holding the stand, with timing stopped when participants either move their feet, grasp an object for support, or ten seconds have elapsed. Walking speed is measured using an 8-foot walking course, which can be completed with assistive devices if needed. Participants are timed twice on the amount of time it takes them to complete the walk, with the faster of the two times used for scoring. Strength and endurance are tested using the ability to rise from a chair. Participants' scores are based on the amount of time it takes them to rise from the chair, with their arms across their chest, five times [9]. Performance can be categorized as poor (0 to 4), moderate (5 to 9), or good (10 to 12), and results can be analyzed categorically or as a continuous variable.

A unique attribute of the SPPB test is that physical function performance is measured on a continuum with clear demonstrated gradients of mortality and institutionalization risk across the performance scale. Within the framework of the Disablement Process [99] the SPPB test is considered an objective assessment of the functional limitation stage [9]. Other strengths of the SPPB test are that it can be utilized in a community setting with ease as it is practical, safe, and efficient. Even though the SPPB test measures only lower extremity function, in comparing it to another physical performance test that measured both upper- and lower-body functional performance, the SPPB performed just as well and was shown to be a valid indicator of functional status [107]. Additionally, the SPPB test was found to be a very sensitive indicator of small effective changes in physical function performance [108]. Even though this is a standardized physical performance test, the reliability may potentially decrease when using multiple observers or interviewers to administer the test depending on their training to accurately implement the test.

In this dissertation, flexibility was assessed with an index of hamstring flexibility utilizing the chair-sit-and-reach test, which has been validated and found to be a reliable measure of hamstring flexibility in older adults [109]. Decreased hamstring flexibility has been associated with lower back pain, postural deviations, gait limitation, increased risk of falling, and increased musculoskeletal injuries. Tight hamstrings in older adults can lead to reduced stride length and walking speed, which may be associated with balance problems. The chair-sit-and-reach test is a more user friendly measurement for older adults in comparison to the commonly used sit-and-reach test or the back-saver sit-and-reach test [109]. The chair-sit-and-reach test allows for the older adults to sit in a support-back chair, rather than having them sit on the floor, in which it might be difficult for an older adult to get down and up from the floor [109]. To measure hamstring flexibility, participants sit in a stable chair with knees straight and then they slowly bend forward at the hip joint, while keeping the spine as straight as possible and their head in normal alignment with their spine [109]. Individuals reach forward with their arms to touch their toes, and held this position for 2 seconds while it was measured with a ruler. Reaches short of the toes were recorded as minus scores, and reaches beyond the toes were recorded as plus scores [109].

Measuring disability involves gaining perspective about behaviors that people are unable to perform. Some researchers consider activities of daily living (ADL) and instrumental activities of daily living (IADL) as aspects of disability rather than functional limitations [99]. ADLs include eating, dressing, getting into or out of a bed or chair, taking a bath or shower, and using the toilet. IADLs are the six daily tasks, light housework, preparing meals, taking medications, shopping for groceries or clothes, using the telephone, and managing money, that enable the person to live independently in the community [110]. ADLs and IADLs are activities that a person does as a member of society that depend on functional abilities, such as physical and mental capabilities. The following is an example of the distinction between functional limitation and a disability: “bringing a comb to one’s head,” measures the functional ability to reach, whereas “comb hair” is a measure of the behavior (disability) [99].

Others, however, report ADLs and IADLs as components of the physical function domain. Physical function can be classified into five major domains, which include ADLs, IADLs, leisure and social activities (LSAs), lower extremity mobility (LEM), and general physical activities (GPAs) [111]. Disability is either self-reported by reporting the level of difficulty performing certain tasks, or activities are observed by a test administrator [99].

The Continuous-Scale Physical Functional Performance (CS-PFP) [112] is a complex multidimensional validated instrument that provides an in-depth measure of a combination of tasks that measure physical limitations and disabilities. This test is useful for predicting the success of functioning in the home environment following an inpatient rehabilitation program. The CS-PFP test requires participants to come to the testing site to participate in 15 everyday tasks that assess a wide range of functional levels including upper and lower body strength, upper body flexibility, balance and coordination, and endurance. Examples of tasks used to measure disability included carrying a jug of water and then pouring water into a cup, donning and removing a jacket and seatbelt, and sweeping kitty litter into a dust pan. The total performance score ranged from 0 to 12.

Chapter 5 of this dissertation considers limitations in performing a behavioral task as a disability rather than decreased physical function. Weight-related disability was assessed with the question, "Does your current weight affect your ability to do daily activities such as walk, do housework, shop, etc?" [113]. This measure is a very simple self-reported question that specifically inquires about how body weight impacts the ability to do daily activities. This question does not, however, ask if assistive devices are used while performing these activities.

Physical Limitations and Obesity

Impaired physical function in older people can affect their quality of life and diminish their independence. A loss of independence leads to a number of adverse outcomes including heavy use of health care services, disability, institutionalization, and death [114]. Chronic diseases associated with functional limitation include cardiovascular disease [115, 116, Hubert, 1983 #73]**,** arthritis [117], and diabetes [118].

Obesity exacerbates the age-associated decline in physical function [7]. Apovian et al. [119] found that a 3-unit increase in BMI was associated with a one-point decrease in physical performance among obese older women (scale ranged from 0 to 36). As physical function is the integration of physiological capacity and physical performance, which includes factors such as strength, aerobic capacity, and shorter reaction time [112], obesity may limit physical function by decreasing endurance, altering pulmonary function, and limiting mobility and flexibility. Apovian et al. [120] found that increased BMI may afflict certain aspects of a physical function test more severely than other portions of the test. Among community-dwelling woman (71 $\pm$ 4.9 years) a higher BMI was associated with reduced upper- and lower-body function, but not strength or coordination.

Aging, Overweight/Obesity, and Physical Activity

Physical Activity Recommendations for Older Adults and Benefits of Physical Activity

Physical activity is defined as any bodily movement produced by skeletal muscles that results in increased energy expenditure [121]. Physically active older adults have lower morbidity and mortality rates than their inactive counterparts [12].

Increasing physical activity is a common recommendation for maintaining or increasing physical function in older people despite existing health problems [8]. This is because physical activity is beneficial to an older person's health as it helps manage existing diseases such as diabetes, high blood pressure, and/or high cholesterol [8]. Physical activity can also improve mood and relieve symptoms of depression. All of these benefits combined can increase the time of active independence by improving physical function. The lack of physical activity, on the other hand, is an important contributor to many of the most prevalent diseases afflicting older people, such as heart disease, diabetes, colon cancer, high blood pressure, and obesity [8]. A moderate amount of physical activity is recommended for older people as it is associated with substantial health benefits and because older adults are sensitive to the beneficial effects of exercise [8]. Older adults are recommended to participate in at least 150 minutes of moderate-intensity physical activity each week [122, 123] and muscle-strengthening on two or more days a week that work all major muscle groups (legs, hips, back, abdomen, chest, shoulders, and arms) to obtain health benefits and to help prevent or manage chronic disease [123]. Over five days, the 30 minutes can be broken up into three 10-minute segments throughout the day. Older adults are encouraged to participate in regular physical activity to delay the functional decline associated with aging [123]. Furthermore, older people are recommended to engage in strength training exercises because it has been effective in maintaining and/or improving muscle strength, endurance, and flexibility [8].

In spite of the many great benefits older people receive from increased physical activity, the prevalence of inactivity in this population is high. Nationally, only 44.5% of men and 36.3% of women met the moderate physical activity guidelines [22]. These figures indicate a large portion of the older adult population is at high risk of loss of physical function and for developing chronic diseases, which will lead to a greater dependence on the federal healthcare system.

Overweight/Obesity as a Barrier to Physical Activity

As mentioned above, only a small percentage of older adults achieve the physical activity recommendations. Physical inactivity has been associated with overweight and obesity [124], therefore this subgroup of older overweight and/or obese people is at high risk of developing obesity and physical inactivity-related health outcomes. Obesity has been identified as a barrier to engaging in physical activity [124, 125]. Using data from the Pilot Survey of the Fitness of Australians, Ball et al. reported that 22% of obese respondents said that being "too fat" was a barrier to increased physical activity, compared with 5% of the overweight, and 0.7% of the normal/underweight respondents. Also, there were significant associations of "too fat," for both males and females, with being too shy/embarrassed and too lazy/not motivated [124]. In males there was a significant relationship between being "too fat" and having an injury or disability that prevented them from exercising. In females "too fat" and not being the sporty type were significantly associated as a barrier to exercise. In a separate study data from the Canadian National Population Health Survey found that among older adults a predictor of infrequency of participation in physical activity, that lasted > 15 minutes, included higher BMI [125]. Caperchione et al. also observed that overweight and/or obesity, and the perceived difficulty of engaging in physical activity may impact the decision of study participants to engage in physical activity [126].

Furthermore, Kaplan et al. [125] observed that the presence of chronic conditions were associated with decreased physical activity among older adults. The chronic conditions were grouped together in one variable called "chronic conditions" and included asthma, arthritis, back problems, high blood pressure, chronic bronchitis, diabetes, heart disease, effects of a stroke, bowel disorder, Alzheimer's disease, cataracts, or glaucoma. However, a review by Cyarto et al. showed how the barrier of several chronic disease types were overcome with targeted education programs [127]. Their review demonstrated that despite the presence of multiple morbidities, such as arthritis, diabetes, cardiovascular diseases, and functional limitations, older adults were capable of participating in targeted physical activity interventions that benefited their health.

Additionally, Fitzpatrick et al. described a 16-week community-based physical activity intervention in Georgia senior centers and reported that despite this population having a mean BMI of 30 kg/m^2 and reporting chronic conditions, such as diabetes, heart disease, arthritis, or high blood pressure, there were significant increases in the amount of physical activity and physical function score [95]. Although, the presence of chronic diseases and overweight and/or obesity may initially inhibit the participation of older adults in physical activity these studies demonstrate these barriers can be overcome and positive results achieved using community-based targeted interventions.

Measuring Physical Activity

In Chapter 4 of this dissertation, a question adapted from the BRFSS and Toobert et al. was used to assess whether the older adults were meeting the 150 minutes per day of moderate-intensity physical activity recommendation, "How many days of the last week (seven days) did you participate in at least 30 minutes of moderate physical activity? Examples of moderate physical activities are regular walking, housework, yard work, lawn mowing, painting, repairing, light carpentry, ballroom dancing, light sports, golf, or bicycling on level ground?" [128, 129]. A strength to this question is that it specifies the intensity and time spent doing physical activities as recommended by the guidelines. Additionally, the BRFSS questions on physical activity have been shown to have good sensitivity and predictive value [130]. A limitation with the BRFSS physical activity question and other questionnaires used to assess physical activity in older adults (CHAMPS, RAPA, and PACE) is that activity is not measured in real-time, but rather is self-reported and refers to physical activities that happened in the past.

Overweight/Obesity, Physical Activity, Physical Function, and Health Outcomes

Previous studies have shown that increased adiposity is associated with decreased physical activity, and both increased adiposity and physical inactivity have been shown to be important predictors of decreased physical function in older people [71, 131-133, 134, Koster, 2008 #42, Tager, 2004 #43, Sternfeld, 2002 #41, Haapanen-Niemi, 2000 #44].

Increased physical activity can delay physical function impairments by preventing the chronic conditions that are associated with poor physical function because being physically active is associated with increased strength, balance, and aerobic capacity – all of which are important factors in the preservation of physical function [135]. Moreover, poor physical function itself has been found to predict mortality and nursing home admission in older people [9], which implies that preventing weight gain in later years and promoting physical activity in obese and non-obese people may be important strategies to prolong physical function capacity.

Rather than focusing on BMI, WC, or body composition as an indicator of health risks and functional decline, among the elderly, research is beginning to center on changes in physical function as the outcome. Recently, it has been demonstrated that the risk of developing mobility limitations was greater in less active normal-weight older white and black woman than their highly active overweight counterparts [131]. Bruce et al. [136] found that regardless of BMI status, a population of older adults (62 $\pm$ 5.5 years) who participated in vigorous-intensity physical activity was more likely to delay the development of disability compared to the non-active group.

Community-dwelling active overweight and obese older women were found to have similar physical function scores in comparison to normal-weight active and inactive woman [137]. Furthermore, a study by Lee et al. [138] found that physical fitness more so than BMI was a key indicator in predicting all-cause and cardiovascular disease mortality in middle-aged men (42.0 ± 8.5 years). These studies indicate that maintaining physical function and increasing fitness may be more important to health outcomes than BMI alone.

A study by Koster et al. [131] demonstrated that in a population of healthy 70 year old men and women, physical function was impacted by both the level of physical activity and the degree of adiposity. Medium and high levels of physical activity were associated with a decreased incidence of low physical function in all BMI categories [131]. For example, high physically active obese older people had a decreased incidence of limited physical mobility compared to the low-level physically active normal weight people [131]. Sui et al. [139] found that lower levels of fitness were strongly associated with a higher risk of all-cause mortality in older people, around 60 years of age. They found both fitness and BMI to be strong independent predictors of all-cause mortality. Additionally, they observed that in older fit people mortality risk was not significantly different across the BMI categories, while in unfit individuals the mortality risk was J-shaped, with lower risk associated with a BMI of 25.0 to 34.9 and higher risk with a BMI of 18.0 to 24.9 and ≥ 35.0. Haapanen-Niemi et al. [71] reported that a low level of leisure time physical activity, but not BMI, predicted an increased risk of all cause mortality and cardiovascular mortality among a cohort of obese and non-obese 35 – 63 year old men and women. Schwartz et al. demonstrated that fasting glucose and blood pressure of obese physically active older participants (mean age = 69 ± 8.9 years) were similar to inactive normal-weight participants [140].

Overall, the above studies show that regardless of BMI classification a lifestyle including physical activity can be beneficial to an older person's health and independence because it may improve physical function and decrease the prevalence of obesity-related health outcomes.

Previous data from Georgia senior centers [95] has shown that in the target population of older adults participating in the OAA congregate meals programs, a physical activity intervention significantly improved physical function as assessed by SPPB test scores [9]. However, it is unknown whether or not moderate physical activity attenuates the relationship of obesity with obesity-related comorbidities in older adults. Obtaining those results would help define the nutrition, physical activity, and wellness issues that need to be targeted among this population by using community-based programs to promote healthy behaviors that help prevent and manage excess adiposity and weight-related chronic conditions.

Food Security

Food security is defined as "Access by all people at all times to enough food for an active, healthy life. Food security includes at minimum: (1) the ready availability of nutritionally adequate and safe foods, and (2) an assured ability to acquire acceptable foods in socially acceptable ways (e.g., without resorting to emergency food supplies, scavenging, stealing or other coping strategies)." [141] Conversely, food insecurity is defined as "Limited or uncertain availability of nutritionally adequate and safe foods or limited or uncertain ability to acquire acceptable foods in socially acceptable ways" [141]. The severity of food insecurity is defined as low food security and very low food security. In 2007, 11.1% of US households were considered food insecure, with 7.0% experiencing low food security (LFS), and 4.1% experiencing very low food security (VLFS) [142]. The four categories of food security are defined as follows: Food secure households report no food-access problems or limitations; marginal food secure (MFS) households have experienced anxiety over food sufficiency one or two times over a given period of time, but food intake was not limited; LFS households report reductions in quality, variety, or desirability of diet, but without decreased food intake; VLFS households report disrupted eating patterns and decreased food intake [142].

In 2007, those households experiencing higher rates of FI compared to the national average, 11.1%, included: households living below the poverty line (37.7%), households with children that were headed by a single woman (30.2%), black households (22.0%), Hispanic households (20.1%), households located in principal cities within metropolitan areas (13.5), and households located in the Southern region of the US (11.8%) [142]. Types of households experiencing VLFS higher than the national average, 4.1%, included: those with incomes below the poverty line (14.9%), families with children headed by single women (10.3%), black (7.7%) and Hispanic households (6.6%), and households in principal cities of metropolitan areas (5.0%) [142]. In Georgia, the prevalence of FI is higher than the national average at 13.0% [142]. Concerning households with elderly people, 6.5% were considered FI and 2.4% experienced VLFS in 2007, which increased from 4.1% and 1.8%, respectively, as reported in 2006 [143]. The prevalence of food insecurity among older adults receiving food assistance from local OAA nutrition programs in Georgia and Indiana ranged from18% to 19% [144, 145], suggesting that the amount of food assistance delivered through OAA programs is not sufficient to decrease the prevalence to the levels seen in the older adult population in general, and certainly OAA programs are not eliminating food insecurity.

As discussed above, certain sociodemographic characteristics are associated with food insecurity status such as household composition [146-148], age, gender, race/ethnicity, low-income [146-148], education [13, 15, 142, 147, 148], regional location, employment status, metropolitan residence [147], and participation in food assistance programs [13, 147, 149]. Community-level studies and national studies have identified several characteristics that are associated with the increased prevalence of food insecurity among older adults. These include being a young senior aged 60 to 64 years [15], living at or below the poverty line [13, 15, 146], irregular income [146], low education [13, 15, 144, 146], being black or Hispanic [13, 15, 144, 146], increased BMI [15, 150], being divorced or separated [15], or living with a grandchild [15], living alone [146], experiencing functional impairments [13, 151], social isolation [13, 15], living in the central cities of a metropolitan area [146], living in the Southern region of the US [15, 146], food assistance participation [13, 15, 144, 146], and food access problems [145, 146, 151, 152].

The detrimental health consequences and poor nutritional status related to food insecurity is of great concern across the lifespan as food security is one of several necessary circumstances for a population to be healthy and well-nourished. In general, older adults may experience decreased food intake because of using multiple medications, oral health problems, compromised sense of taste and smell, and factors associated with the aging process [15, 153]. Typically, the diets of older adults have been characterized by having low-intake of calories, fiber, magnesium, and, antioxidants [15]. Food insecurity is associated with poor nutritional status and low-nutrient intake among older adults [15, 154-158]. The diets of food insecure older adults tended to lack in variety and there was a decreased intake of some food groups such as meat [155], fruits [159, 160], vegetables [155, 159, 160], and a tendency to have lower healthy eating index scores [161]

Nutrients that were lacking among food insecure and food insufficient older adults included overall caloric intake [15, 154], protein [13, 155, 158, 162], carbohydrate [154, 155], fiber [159], fat [155], saturated fat [154], thiamin [155, 162], niacin [154, 155, 162], riboflavin [154, 162], vitamin B-12 [154, 155], vitamin B-6 [154, 155, 158, 162], vitamin A [15, 158, 162], vitamin C [15], folate [155], riboflavin [15], and minerals such as calcium [15, 162], magnesium

[15, 154, 158], iron [154, 155], zinc [154, 155, 158], phosphorus [158, 162], and potassium [159].

The health consequences associated with diminished or compromised food intake observed among food insecure older adults include decreased BMI [155], increased BMI [15, 150], increased arm circumference [15], tricep skinfold [15], and subscapular skinfold [15], decreased overall skinfold thickness [154], increased functional impairments [154, 156], restriction in activity [156], less likely to have "excellent" self-reported health [15], more likely to report fair or poor health [154 , 155, 156], increased prevalence of the presence of a chronic disease (these chronic conditions potentially being arthritis, hypertension, health failure, stroke, cataract, cancer, diabetes mellitus and/or emphysema) [154], heart disease [156], high blood pressure [156], diabetes [144, 156], arthritis [144], joint pain [144], depression [156, 158], and burden of disease impacting daily activities [158].

Household Food Security Survey Module to Measure Food Security

The United States Department of Agriculture (USDA) monitors the food security status of the nation using an annual nationally representative survey. The survey is conducted for the USDA by the US Census Bureau as an annual supplement to the Census Bureau's monthly Current Population Survey (CPS) [17]. The purpose of the CPS is to collect information pertaining to monthly unemployment figures and annual poverty rates. Since 1995 the CPS has contained the Food Security Supplement (CPS-FSS), which annually assesses households' food security status with questions that focus on the household's food expenditures, use of federal and community food assistance programs, food security, food sufficiency, and strategies used to cope with food insecurity. The "core module" that identifies the dimension of food insecurity caused by financial limitations is found within the CPS-FSS and is called the US Household Food Security Survey Module (USHFSSM) [141].

The 18-item USHFSSM can stand alone as a validated measure of food security, or it can be included in other surveys to be used to monitor food security at the national, state, and local levels. Furthermore, the core module has been shown to be a stable, robust, and reliable tool for the purpose of assessing the prevalence of household food insecurity [141].

The USHFSSM distinguishes the various levels of severity throughout the full range of food insecurity by identifying changes in household conditions and behaviors. In the first stage, at the level of least-severe food insecurity, questions focus on whether there was worry that food would run out before there was more money to buy more, and whether they were able to afford to eat balanced meals. In the second stage of food insecurity, the questions asked about the adults decreasing food intake because there wasn't enough money for food. In the third stage, severe level of food insecurity, questions centered on whether children skipped meals or if adults did not eat for a whole day because there wasn't enough money for food. Each of the questions determine if the condition or behavior occurred during the previous 12 months and specifies a lack of money or other resources to obtain food as the reason for the condition or behavior. A 30-day reference period can be substituted for the 12 month reference period [163].

To determine a household's score on the food security scale the response to each question is coded as "affirmative" or "negative." The responses of "often true" and "sometimes true" were considered "affirmative" responses. Each question is assigned a 1-point value. The food security scale is on a continuum and captures the full range of food insecurity. The absence of food insecurity is assigned a scale value of 0, whereas the most severe condition is assigned the highest value. Alternatively, the food security scale can be assigned to categories, and a categorical measure can be used to capture the most important thresholds of food insecurity [163]. As mentioned previously these categories include FS, MFS, LFS, and VLFS. For measurement simplicity, these categories can be dichotomized to FS (FS and MFS) and FI (LFS and VLFS) [142].

The USHFSSM can be used in surveys as the 18-item, the 10-item US Adult Food Security Survey Module that is used when children are not present in the household, or the 6-item Short Form of the Food Security Survey Module (Appendix) that is used when survey time or space does not allow for the full models. The advantage of the 18-item is that it is a sensitive measure capable of capturing and distinguishing all the levels of food insecurity caused by financial limitations. It does not however, capture all possible dimensions of food insecurity such as food safety issues, nutritional status, having to obtain food through socially acceptable channels, nor does it measure community-level factors such as available food supply. Using the 12-month reference period may or may not capture a person presently food insecure, and the food security scale is not reliable for assessing status on an individual level, only household populations [141].

Advantages of the 10-item survey is that it is less burdensome to the respondent, it measures the most severe level of adult food insecurity, and avoids asking questions about children's food security, however a limitation is that it does not provide specific information on the food security of children [141].

The 6-item survey is composed of all the adult questions that pertain to the intermediate range of severity in regards to that captured on the full 18-item scale. The advantages of the 6-item is that it is less burdensome to the respondent; it has high specificity, sensitivity, and minimal bias when compared to the 10- or 18-module [163]. This shorter version does not, however, capture the severe range of food insecurity which includes child hunger and the more severe adult hunger. Additionally, it is less precise and somewhat less reliable than the 18-item core module. The raw scores of the 6-item are scored as follows: high FS or MFS (0 to1), LFS (2 to 4), and VLFS (5 to 6) [142].

Regarding comparative research, local surveys that use the core module or the 6-item to assess food security can compare their data to national surveys that used the core module or with research findings published in USDA reports [141].

The Nutrition Screening Initiative and Measurement of Food Security

From the Nutrition Screening Initiative (NSI) the DETERMINE Your Nutritional Health Checklist was developed [164]. It is a checklist used to identify, intervene, and treat nutritional problems before the health and quality of life of older Americans is impaired [164]. The major national organizations involved in its development included The American Academy of Family Physicians, The American Dietetic Association, and The National Council on Aging [164]. The NSI is a checklist of 10 questions that can be self-administered and it has been validated to identify persons at increased risk of poor nutritional status [165]. The NSI describes characteristics associated with poor nutritional status and assigns point values to each question. A score of 0 to 2 is "good", 3 to 5 is "moderate nutritional risk", and $\geq$ 6 is "high nutritional risk". In Georgia, the Area Agencies on Aging and/or service providers are required to assess the nutrition risk level of all applicants for and recipients of Home and Community Based Services (HCBS), by using the NSI DETERMINE Checklist [164]. Within the checklist is a question concerning food insecurity that is worth 4 points, "I don't always have enough money to buy the food I need." Wolfe et al. found this question to have good sensitivity in assessing the prevalence and severity of food insecurity among older adults when compared to the USHFSSM, the Cornell-Radimer, and the Community Childhood Hunger Identification Project [166].

Measuring Food Security in the Older Adult Population

Previous studies have shown that the experience of food insecurity in older adults is somewhat different compared to families with children [13, 14, 145, 151, 152, 157]. The food insecurity of older adults may not necessarily be attributed only to financial restraints, but also because of various factors that make the accessibility and ability to use nutritionally-adequate food difficult [151]. Therefore, the USHFSSM may be underestimating the prevalence of food insecurity among older adults. Using augmented questions, Wolfe et al. identified reasons for food insecurity that would not have been recognized by the USHFSSM and these included transportation limitations, health or mobility limitations, not having the right foods for health/health-related dietary requirements, coping strategies, lack of motivation to cook or eat, and the perception of having adequate food for health [151]. Two community-based studies by Duerr [145, 152] used the augmented items suggested by Wolfe et al. [151] in comparison to the USHFSSM to identify the prevalence of food insecurity among congregate [145] and home-delivered meal recipients [152]. In both studies the augmented items identified a higher prevalence of food insecurity compared to the USHFSSM. The implications of these studies suggest that the addition of the augmented items to the USHFSSM would identify a greater number of older adults as food insecure [145, 152].

Another issue concerning the appropriateness of the USHFSSM to measure older adult food insecurity is that it may not be understood in a similar manner by older adults compared to non-elderly thereby having the potential to affect the accuracy of food insecurity status. A study by Nord [167], however, determined that the USHFSSM was similarly understood and also fairly represented the food security status of older adults, compared with the food security status of nonelderly persons, despite the absence of questions addressing food access problems.

The Food Insecurity-Obesity Paradox

A surprising paradox has been observed among the food insecure that is characterized by obesity and food insecurity co-existing in the same person and within the same household [168]. This counterintuitive relationship has been dubbed the food insecurity-obesity paradox [168]. Currently, the causal relationship between food insecurity and obesity is not known. Lack of physical activity has also been associated with increased food insecurity in women [169, 170]. However, the rooted theme within the reasons to explain the paradox is associated with a disordered pattern of eating caused by the availability of food and/or psychological reasons [24, 149, 171, 172]. Potential reasons include having a limited variety of foods available that result in consumption of high-energy inexpensive foods. For example, Olson et al. [150] found that food insecurity in women was associated with consumption of fewer fruits, vegetables, and nutrients in their diets. Children who grow up in poverty are more likely to become obese adults [173]. Food insecurity itself is considered a stressor and may initiate the consumption of an excessive amount of food to cope with stress [170, 174]. Additionally, the physiological response to stress has been found to promote visceral adiposity [175].

Another proposed mechanism is that food insecurity leads to the development of a pattern of cyclic binging and food-restriction which is dependent upon the availability of food and household supplies [24, 170]. This disordered eating could cause physiological adaptations to take place such as weight-gain in response to re-feeding, a decrease in lean muscle mass, and an increase in body fat because the body is more prone to store energy as body fat [168]. This idea of food insecurity leading to a cyclic disordered pattern of eating has been called "the food stamp cycle" [24, 172, 176, 177]. This conceptual framework entails a 3-week period of overeating when food stamps and money are available, then restrictive eating when money and food is less available, followed by overeating when the monthly food stamp allotment has been restored [24, 172, 176, 177]. The existence of this paradox has been studied among children, adult men and woman, and older adults receiving food assistance in the form of government funded programs [24, 109, 149, 150, 170, 172]. The results from these studies have produced mixed results in trying to determine whether participation in these programs cause obesity [24]. Also, the association of age, gender, and race/ethnicity with this paradox is quite variable [24].

The inconsistent results as to whether food assistance program participation increases obesity are most likely due to the cross-sectional design of the studies [149]. The paradox is very complex with two very different approaches as to the role of food assistance program participation in rectifying the association of obesity with food assistance. One option is to increase food supplementation by the food assistance programs to achieve a more uniform pattern of food consumption to prevent the cyclic disordered eating pattern associated with limited accessibility and anxiety about food. The other option is to decrease spending towards the food assistance program or refuse participation of obese persons in food assistance programs as justified by the logic that if a person is obese they are eating too much [178].

Longitudinal studies have shown that participation in the food stamp program may have offset the weight-loss experienced by people who are food insecure [149, 171], as there was an observed increase in weight associated with food stamp participation [171]. The investigators speculated that the stress associated with being food insecure may have contributed to the weight gain [171]. Data from two different longitudinal data sets were analyzed to determine if food insecurity caused increased weight over time in older adults, and whether the older adults participating in the OAA home-delivered meals program negated the weight-gain effect [149]. Their study showed conflicting results between the two longitudinal data sets concerning the change in prevalence of weight gain, +2.1% and -1.8%. These investigators, however, did not consider whether or not obesity and physical limitations were associated with food insecurity in this population [149]. .

Currently, it is not known whether the food insecurity-obesity paradox exists among older adults participating in the OAA congregate meal-site nutrition program. It is known, however, that functional limitations and disability are risk factors for food insecurity [13], and that obesity is a risk factor for the development of arthritis [98], which can lead to disability [16, 98]. The relationship of food insecurity with obesity and physical limitations is not well studied in the older adult population. These associations are of great concern as there is a high prevalence of obesity along with the increased prevalence of age- and weight-associated physical limitations. These potential associations warrant investigation as the results will provide information important for targeting and policy development concerning the nutrition and wellness services provided to older adults by the OAA programs.

Rationale, Specific Aims, and Hypotheses

This dissertation focuses on the problem of overweight and obesity in older Georgians participating in OAA programs delivered at senior centers. These studies are needed because among this population there was a high prevalence of overweight and obesity (73%) [94], physical inactivity (34%) [95], chronic conditions such as diabetes (41%) [94], poor physical function (28%) [95], and food insecurity (18%) [144]. . However, several gaps in the literature were identified related to OAA programs delivered through senior centers including lack of information regarding the relationship of adiposity with obesity-related comorbidities, the extent to which moderate physical activity can attenuate obesity-related comorbidities, and the existence and potential underlying causes of the food insecurity-obesity paradox among those receiving food assistance. Because it is important to improve the targeting, efficiency, and outcomes of the nutrition, health, disease prevention, and wellness services provided through OAA programs, the purpose of the studies in this dissertation is to characterize selected relationships of adiposity with obesity-related comorbidities, physical function, physical activity, and food insecurity in this vulnerable population.

The first specific aim is to determine the relationship of BMI and WC with the prevalence of selected obesity-related comorbidities including diabetes, high blood pressure, heart disease, high cholesterol, joint pain, flexibility, number of comorbidities, self-reported health, and physical function. The first hypothesis is participants with an increased BMI or WC have lower physical function and a higher prevalence of obesity-related comorbidities in comparison to participants with a normal BMI or WC. Completion of this aim will increase understanding about the magnitude of the relationship of adiposity with obesity-related cormorbidities. The study addressing this aim is found in Chapter 3.

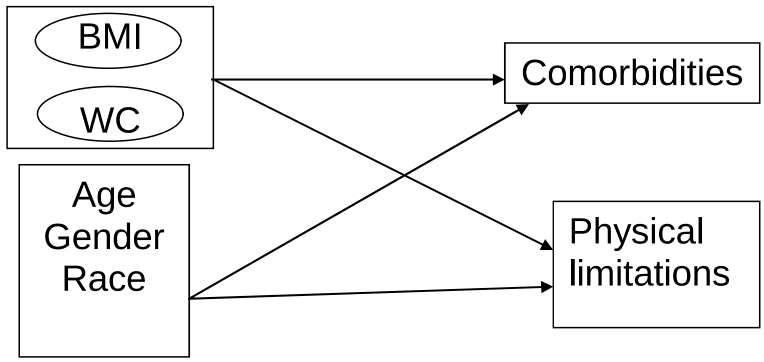

FIGURE 2.2. Conceptual model for Chapter 3 analyses. The analyses in Chapter 3 test the association of increased BMI or WC with the prevalence of comorbidities and physical limitations when controlling for age, gender, and race. The comorbidities include diabetes, high blood pressure, heart disease, high cholesterol, number of comorbidities, and self-reported health. The physical limitations include poor physical function, low flexibility, arthritis, and joint pain.

The second specific aim is to determine whether participation in physical activity attenuates the relationship of obesity with obesity-related comorbidities. The extent to which moderate physical activity attenuates the impact of obesity on obesity-related comorbidities among participants of OAA programs has not been investigated. Thus, the purpose of this study was to determine whether or not moderate-intensity physical activity attenuated the effects of obesity on selected comorbidities in older adults participating in OAA programs at Georgia senior centers. It was hypothesized that meeting the recommendations for moderate physical activity would attenuate the relationship of obesity with these comorbidities. The study addressing this aim is found in Chapter 4.

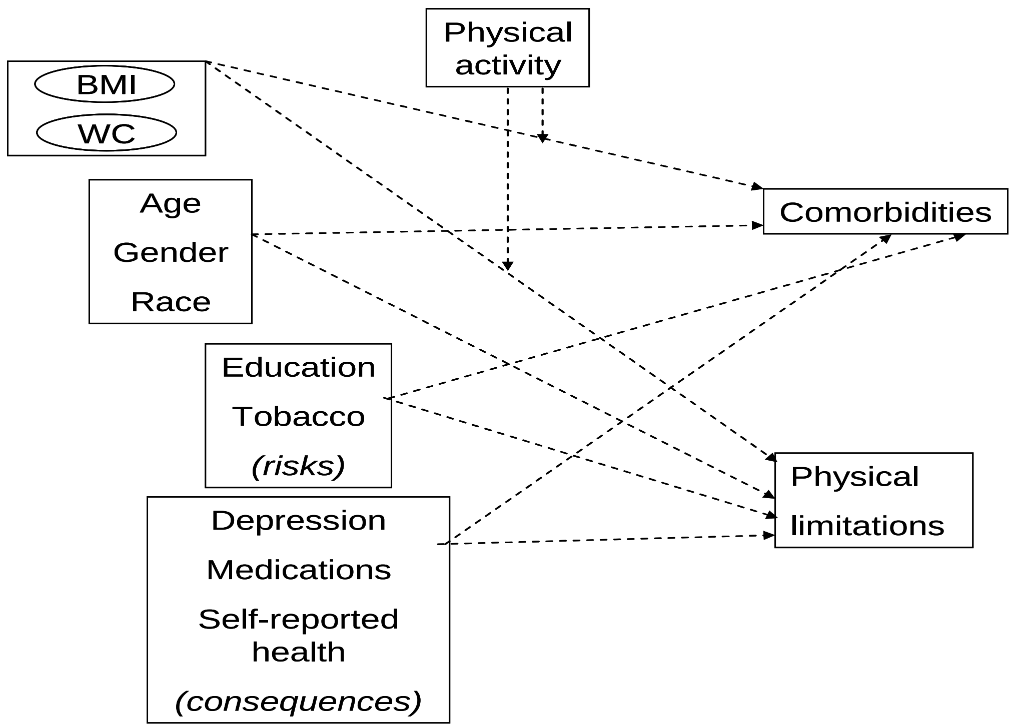

FIGURE 2.3. Conceptual model for Chapter 4 analyses. The analyses in Chapter 4 test whether the relationship of obesity with obesity-related comorbidities and physical limitations is attenuated by physical activity. The dependent variables are the comorbidities diabetes, high blood pressure, and poor or fair self-reported health. The physical limitations are poor physical function, low flexibility, joint pain, and falls. A series of three regression models were examined. The first model included obesity and variables that increases the risk of occurrence of the comorbidities and physical limitations (e.g. age, gender, race, education, and tobacco use). The second model added physical activity, and the third model added variables that may result from the obesity-related comorbidities and physical limitations (e.g. depression, prescription medications, and poor or fair self-reported health).

The purpose of the third study was to determine whether the food insecurity-obesity paradox exists in a sample of older adults known to have a high prevalence of food insecurity, obesity, and physical limitations and who attend senior centers in Georgia with OAA and OAANP services [144, 179]. For the purposes of this study, the term “physical limitations” refers to these measures: arthritis, joint pain, physical function [9] and weight-related disability in daily activities [113].

It is hypothesized that both obesity and physical limitations contribute to food insecurity, but the effects of obesity may in part be moderated by physical limitations. If these hypotheses are correct, then it will be important to determine both obesity and physical limitations in assessing the risk of food insecurity and the need for food assistance in older adults. Results from this study are an important step in understanding the relevance and the potential underlying causes of the food insecurity-obesity paradox in older adults. The study addressing this aim is found in Chapter 5.

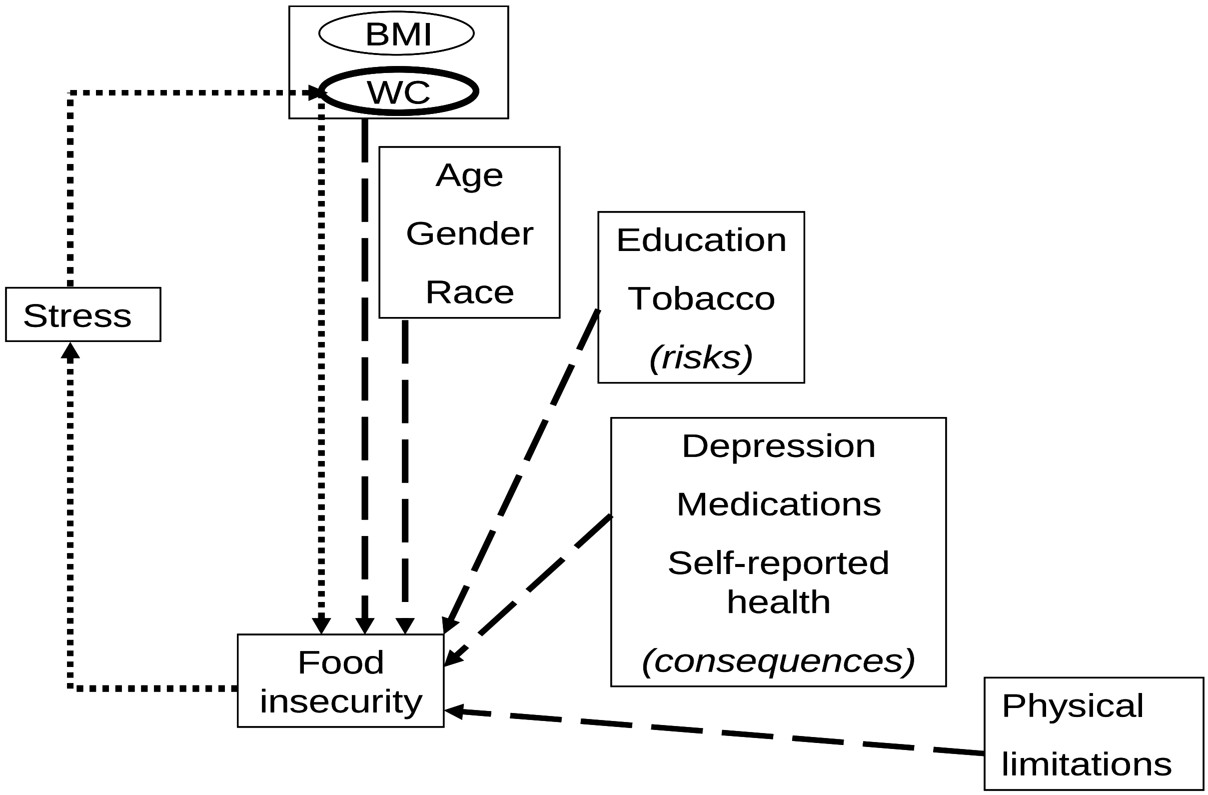

FIGURE 2.4. Conceptual model for Chapter 5 analyses. The analyses in Chapter 5 test whether obesity and physical limitations are associated with food insecurity when controlled for age, gender, race, education, depression, prescription medications, and self-reported health. In addition, this model postulates for the first time that the stronger relationships of food insecurity with WC rather than BMI may involve activation of stress pathways that

CHAPTER 3

INCREASED BMI OR WAIST CIRCUMFERENCE INCREASES THE PREVALENCE OF COMORBIDITIES AND PHYSICAL LIMITATIONS IN OLDER ADULTS IN GEORGIA SENIOR CENTERS

[1]Penn DM, Fischer JG, Lee JS, Hausman DB, Johnson MA. A shorter version of this manuscript has been accepted for publication in the *Journal of Nutrition, Health, and Aging,*

Abstract

Overweight and obesity impair the quality of life in older adults and significantly increase health care costs to local, state, and federal health service programs. Thus, the purpose of this study was to characterize the relationship of increased body mass index (BMI) and high waist circumference (WC) with the prevalence of selected comorbidities and physical limitations in a convenience sample of older adults who receive nutrition and wellness services from Georgia's Older Americans Act programs at senior centers (N = 759, mean age = 75 years, 81% female, 63% white, 36% black, convenience sample). Correction factors were applied to BMI and WC. The prevalence of diabetes, high blood pressure, joint pain, and poor self-reported health showed striking relationships with high WC and increasing BMI. For example, among the corrected BMI categories of < 25, ≥ 30 to < 35, and ≥ 40 kg/m^2, the prevalence of diabetes was about 18%, 35%, and 68%, respectively; of high blood pressure was 60%, 78%, and 93%, respectively; of joint pain was 56%, 74%, and 90%, respectively, and poor self-reported health was 5.6%, 5.1%, and 20.3% (all $p \leq 0.001$). Compared to those with WC in the low risk category, the high risk category scored about 1 point lower on a 12-point physical function scale ($p \leq 0.001$) and had less flexibility in the chair-sit-and-reach test ($p \leq 0.001$). Relationships of BMI and WC categories with comorbidities and physical function were independent of age, gender, and race in regression analyses. These results suggest that there is an urgent need for evidence-based nutrition and therapeutic lifestyle counseling, medical nutrition therapy, and physical activity programs to prevent and manage weight-related health conditions in these older adults.

Introduction

In Georgia overweight/obesity is reported in 65% of adults [1] and in 63.5% of adults aged 65 and older [2]. Georgia has the 9th fastest growing 60 years and older population in the United States [3]. Among the Medicare population of Georgia, from 1998 to 2000, over 400 million dollars was spent on medical expenditures attributed to obesity alone [4]. Chronic age-related conditions, or comorbidities, that are exacerbated by the excess weight include metabolic syndrome, hypertension, diabetes, cardiovascular disease, and osteoarthritis [6], which are prevalent among older Georgians [47], [33]. Obesity also exacerbates the age-associated decline in physical function [7]. An older person's independence diminishes with limited physical function, which is a strong predictor of death, disability, and nursing home admission [9]. In Georgia, 19% of older adults have mobility disabilities [11].

The prevalence of age-related chronic conditions and the impact of overweight and obesity may be particularly problematic in Georgia's Older Americans Act (OAA) programs because the program targets those who have low socioeconomic status, live in rural areas, and belong to a racial/ethnic minority group, all of which are chronic disease risk factors [180]. Compared with national averages, OAA participants are nearly 3 times more likely to meet federal guidelines for poverty [181]. The OAA programs provide supportive home-and community-based services that help older people stay active and healthy by preventing disease and disability through evidence-based programs [66, 86, 181]. The OAA network includes 56 State Units on Aging, 655 Area Agencies on Aging (AAA), 236 tribal and native organizations, and thousands of senior centers, adult day care centers, service providers, caregivers, and volunteers [66, 86, 181].

Among a convenience sample of Georgia's OAA nutrition and wellness program there was a high prevalence of overweight and obesity (73%) [94], poor physical function (28%) [95], and chronic conditions such as diabetes (41%) and hypertension (73%) [94]. Thus, participants in Georgia's OAA nutrition and wellness programs may provide useful information about the impact of overweight and/or obesity on age-related health conditions and physical function. Therefore, the purpose of this study was to determine the extent to which body mass index (BMI) and waist circumference (WC) are associated with the prevalence and number of selected comorbidities and with physical limitations. It was hypothesized that overweight, obesity, and high WC would be associated with an increased prevalence of the comorbidities diabetes, heart disease, high cholesterol, hypertension, and the physical limitations joint pain, arthritis, poor physical function, and low flexibility. The results of this study will help better define the nutrition and wellness services that may be needed to help prevent and manage weight-related chronic conditions in OAA programs. These services might include calorie and portion controlled meals, nutrition counseling, medical nutrition therapy, and physical activity programs.

Methods

Sample

Questionnaires and procedures were approved by the Institutional Review Boards on Human Subjects of the University of Georgia and the Georgia Department of Human Resources. Participants were a convenience sample of people aged 50 and older recruited from 40 senior centers in the fall of 2007, similar to a previous study [182]. Briefly, each of the 12 AAA's in Georgia were asked to recruit about 70 people from senior centers in their area. Senior centers were selected based on the support of the senior center director and interest of the participants. Most participants received congregate meals. Procedures were explained and the consent forms were read to participants, and written informed consent was obtained from participants. People were excluded if they were homebound or when the interviewer determined that the individual may be unable to understand the informed consent and/or answer questions. These recruitment procedures yielded 815 participants of whom 759 were included in this study. Fifty-six participants were excluded due to missing height, weight, and/or WC measurements.

Questionnaires

Participants were interviewed as previously described [182] with trained staff who read the questions to participants and recorded their responses. Demographics and comorbidities were self-reported.

Body weight was either: a) weighed with a scale, without shoes and with clothes (14.7% of participants); b) weighed with a scale with shoes and clothes on (68.2%); or c) self-reported (17.1%) and we assumed without clothes and shoes. We were unable to find corrections for the weight of shoes and clothes in the literature, therefore the following corrections were applied to measured body weight: -2 pounds for shoes for women, -2 pounds for clothes for women, -4 pounds for shoes for men, and -4 pounds for clothes for men. Linear regression equations derived from Rowland et al. [70] were applied to correct for self-reported body weight:

Males: weight (pounds) = -4.1259 + 1.0185 (self-reported weight in pounds)

Females: weight (pounds) = -3.1974 + 1.0438 (self-reported weight in pounds) – 0.0175 (age in years).

Height was assessed by: a) measurement with a tape measure with shoes on (37.8% of participants), or b) self report (62.2%). We were unable to find corrections for the height of shoes in the literature therefore a correction of -1 inch from the measured height of both genders was applied.   Self-reported height was corrected by applying linear regression equations from Rowland et al. [70]:

Males: height (inches) = + 7.1987 + 0.8865 (self-reported height in inches) + 0.0222 (age in years) – 0.0004 (age^2).

Females: height (inches) = + 7.4583 + 0.8745 (self-reported height in inches) + 0.0424 (age in years) – 0.0007 (age^2).

BMI was calculated with the following equation (weight (pounds)/height $(inches)^2$) x 703) and is reported as corrected (using the corrected height and weight values) or as uncorrected. The BMI categories of interest in this study were similar to the clinical guidelines of the National Heart, Lung, and Blood Institute (NHLBI) weight classifications as follows ([66], kg/m^2)): < 25.0 = normal and underweight, $\geq$ 25.0 to < 30.0 = overweight, $\geq$ 30 to < 35 = class I obesity, $\geq$ 35 to < 40 = class II obesity, and $\geq$ 40 = class III obesity.

WC was measured with a tape measure either over the participants' clothing (90.1%) or underneath their clothing (9.9%) by following the guidelines of the NHLBI [66]. We were unable to find corrections for WC when measured over clothes, therefore we applied a correction of -1 inch. Participants' WC was classified as either low risk (men $\leq$ 40 inches and women $\leq$ 35 inches) or high risk (men > 40 inches and women > 35 inches [66]. Both corrected and uncorrected WC was used in our analyses.

The comorbidities that were assessed were self-reported diabetes, high blood pressure, arthritis, heart disease ("Do you have heart disease such as angina, congestive heart failure, heart attack or other heart problems?" [42], joint pain ("During the past 30 days, have you had symptoms of pain, aching, or stiffness in or around a joint?" [49], and high cholesterol ("Have you ever been told by a doctor, nurse, or other health professional that your blood cholesterol is high?" [35]. Response categories were "yes" or "no." Self-reported health was also assessed (poor = 0, fair = 1, good = 2, very good = 3, excellent = 4).

Flexibility was measured using the chair-sit-and-reach method by Jones et al. [109]; participants sat in a stable chair with knees straight, bent over to reach with their arms to touch their toes; the distance, either to the toes or beyond the toes, was measured with a ruler.

Participants' physical function was assessed using the Short Physical Performance Battery (SPPB) [9]. Poor performance on this test predicts future nursing home placement, disability, and death [9]. This test assesses mobility by measuring the three categories of balance, strength, and gait speed as an individual performs a standing balance, chair stands, and an 8-foot walk, respectively, with performance in each category scored from 0 to 4. A summary performance score was calculated by summing each of the three category scores to give a final score ranging from 0 to 12, higher scores indicate higher performance: poor function (0 to 5), moderate function (6 to 9), and good function (10 to 12).

Statistics

Questionnaires and consent forms were sent to the University of Georgia. Data were analyzed with the Statistical Analysis System (SAS) version 9.1 (Cary, NC, [183]). Descriptive statistics, including frequencies, means, and standard deviations were calculated. The differences between uncorrected and corrected BMI and WC were assessed with the Wilcoxon Signed-Rank test for non-normally distributed data, as determined by the Shapiro-Wilk test. The relationships of BMI (uncorrected and corrected) and waist circumference (uncorrected and corrected) with the dichotomous comorbidities and physical limitations were assessed by Chi-square analyses. The relationships of BMI categories with the continuous variables (e.g., WC, number of health conditions, self-reported health, chair-sit-and-reach, and physical function) were assessed with general linear models, while the relationships of the WC categories with the continuous variables were assessed with the Mann-Whitney U test for non-normally distributed data. Differences among the means of the continuous variables within the BMI categories were assessed by Tukey's post hoc test. The Spearman correlation was used to determine the relationship between BMI and WC. Logistic regression and general linear models were used to examine the independent contributions of BMI or WC to the individual comorbidities, self-reported health, chair-sit-and-reach, and physical function when controlled for age (< 80 or ≥ 80), gender, and race (black or white).

Results

Characteristics of the participants with both BMI and WC measures are shown in Table 1. Those who were excluded from the analyses (n = 56) were more likely to be black (50.0% vs. 36.1%, $p \leq 0.05$) have higher corrected BMI (32.6 ± 3.6 vs. 30.0 ± 6.9, $p \leq 0.01$) compared to those included; there were no differences in age, gender, uncorrected BMI, uncorrected or corrected WC, self-reported health, and the prevalence of diabetes, high blood pressure, heart disease, high cholesterol, joint pain, or arthritis. The excluded participants were more likely to have poor physical function (50.0% vs. 23.3%, $p \leq 0.004$), and a lower total physical function score (5.4 vs. 7.4, $p \leq 0.02$) compared to those included, but there was no difference in chair-sit-and-reach.

Compared to the mean uncorrected BMI, corrected BMI was 0.6 ± 0.7 units higher (about 2% higher, $p \leq 0.001$, Table 2). The prevalence of obesity, ≥ 30 kg/m^2, was different between uncorrected and corrected BMI, 38.5% vs. 41.8%, respectively ($p \leq 0.001$, Wilcoxon Signed-Rank test). Compared to the mean uncorrected WC, corrected WC was 0.90 ± 0.3 inches smaller in men and 0.80 ± 0.4 inches smaller in women (about 2% smaller, $p \leq 0.001$), and the prevalence of high risk WC was about 4.5 percentage-points lower ($p \leq 0.001$, Wilcoxon Signed-Rank test).

As BMI or WC increased participants were younger ($p \leq 0.001$) and more likely to be black vs. white ($p \leq 0.01$) (Table 4). In addition, women were more likely than men to be in the high risk WC category ($p \leq 0.01$, Table 4). BMI and WC were highly correlated within men and within women (uncorrected or corrected in men and women: *rho* = 0.71 – 0.79, $p \leq 0.001$).

The prevalence of diabetes, high blood pressure, joint pain, and arthritis, as well as the mean number of self-reported comorbidities were significantly increased with increasing BMI, and in the high risk vs. low risk WC groups (uncorrected and corrected, $p \leq 0.001$, Table 4). Mean self-reported health was significantly lower in the ≥ 40 BMI category compared to the other categories, and in the high risk WC category vs. low risk (uncorrected and corrected, $p \leq 0.001$, Table 4). The BMI categories were inconsistently associated with having high cholesterol, but BMI and WC never were significantly associated with having heart disease.

The mean physical function score of the uncorrected ≥ 25 to < 30 BMI category was significantly higher compared to other categories, except BMI < 25 (Table 5). The higher WC score (uncorrected and corrected) was significantly less than the low risk category (Table 5). Mean chair-sit-and-reach was significantly lower in the ≥ 40 BMI category vs. the other categories and in the high risk vs. low risk WC category (uncorrected and corrected, $p \leq 0.001$, Table 5).

Logistic regression analyses were used to determine the independent contribution of BMI or WC when controlled for age, gender, and race, to the individual comorbidities. General linear models were used to determine the independent contribution of BMI or WC to the number of comorbidities, self-reported health, overall physical function score, and chair-sit-and-reach when controlled for age, gender, and race. In these models both BMI and WC (uncorrected and corrected) were independently associated with the increased prevalence of diabetes, high blood pressure, joint pain ($p \leq 0.05$), and uncorrected BMI was associated with the prevalence of high cholesterol ($p \leq 0.05$). BMI (uncorrected and corrected), and uncorrected WC were independently associated with lower overall health score ($p \leq 0.05$). BMI and WC were independently associated with an increased number of comorbidities (uncorrected and corrected, $p \leq 0.002$), lower physical function score ($p \leq 0.02$), and decreased flexibility as measured by chair-sit-and-reach ($p \leq 0.0002$). However, having heart disease remained unassociated with BMI and WC in these regression analyses.

Discussion

The purpose of this study was to examine the relationship of BMI or WC with selected health-related indices among a vulnerable older adult population participating in nutrition and wellness programs at Georgia senior centers. As BMI or WC increased the prevalence of diabetes, high blood pressure, and joint pain, and the number of comorbidities increased, physical function and flexibility decreased, and these relationships were independent of age, gender, and race.

A strength of this study was assessment of both corrected and uncorrected measurements and finding that the relationships between the selected health-related indices and BMI or WC were nearly always similar when using the corrected or uncorrected values. Although statistically significant, the mean difference between uncorrected and corrected values did not exceed 1 kg/m^2 for BMI or 1 inch for WC. The application of the correction factors did change the number of participants within each BMI or WC category. However, the largest change in the number of participants between the uncorrected and corrected BMI categories was 2.4 percentage-points in the < 25 kg/m^2 group and was 5.6 percentage points in the two WC groups.

At least 80% of participants within the BMI category $\geq$ 35 to < 40, and 90% of participants with BMI $\geq$ 40 had 3 of the 6 comorbidities of interest: high blood pressure, joint pain, or arthritis. Over the range of BMI categories the prevalence of diabetes, high blood pressure, joint pain, and arthritis differed by at least 35% when BMI increased from < 25 to $\geq$ 40, and by 13% in the low risk vs. high risk WC categories. Others have also shown an increase of at least 18% in the prevalence of diabetes, arthritis [87, 184], and high blood pressure [184], and no change in heart disease [87, 184] when BMI increased from the normal to the obese categories in older adults.

The prevalence of obesity and the selected comorbidities, except for high cholesterol, are much higher in our study compared to previous studies of older adults in general [87, 184], perhaps because our participants were a convenience sample and attended senior centers that provide congregate meals and other nutrition and wellness services targeted to older adults with health disparities based on income and social factors. Regardless, the striking relationship between the comorbidities and physical limitations with BMI or WC is of concern. The mean number of health conditions increased from 2 to 4 when BMI increased from the < 25 to the $\geq$ 40 category or WC from the low risk to the high risk category. Schoenberg et al. estimated in 2002 that older adults with 2 comorbidities paid $1,916 more in annual out-of-pocket medical expenses than those with no comorbidities, and those with 4 comorbidities paid $3,475 more [185]. Diabetes was the most costly comorbidity followed by high blood pressure, heart disease, and arthritis, which is of concern because the majority of older adults in our study had multiple comorbidities that increased with weight. Even though these are out-of-pocket expenditures this still creates a financial burden to the taxpayer as these older adults will rely more heavily on government services to compensate for the loss of their disposable income.

An estimated 25,513 adults receive nutrition and wellness services throughout Georgia [3]. Using the prevalence estimates from this study, even being overweight ($\geq$ 25 to < 30) is associated with at least a 10-percentage point increase in the prevalence of diabetes, heart disease, or joint pain. Using diabetes as an example, the prevalence of diabetes was about 18% in the normal weight group and 44% in those with BMI of $\geq$ 25; furthermore about 25% of our study population was normal weight and 75% was overweight or obese. Thus, extrapolating these statistics to these programs statewide, and removing 18% of the overweight/obese participants that might become diabetic regardless of weight, suggests that overweight and obesity may be adding about 6,904 additional cases of diabetes in the senior center nutrition and wellness programs across Georgia. It is estimated that each case of diabetes in adults aged 65 or older costs $9,713 annually [86]. Consequently, for 6,904 excess cases of diabetes, Georgia is spending more than 67 million dollars annually. Moreover, Sullivan et al. estimated that people with diabetes, hypertension, hyperlipidemia, and BMI $\geq$ 25 spend $6,051 more annually on healthcare expenditures compared to those without this disease cluster. About 14% of our study sample had this cluster of diseases. Thus, services are urgently needed to help overweight and obese older people in these OAA programs to decrease their risk of and to mange diabetes and other health conditions. Several studies have shown nutrition counseling to be an effective tool in promoting improved health outcomes for patients as well as cost savings to the primary insurance company [186-188]. Sheils et al. [188] estimated that those receiving Medicare who were diagnosed with cardiovascular disease (n = 10,895) or diabetes (n = 12,308) and received educational programs from dietetians had a projected net savings in 2004 of $470.1 million by decreasing physician visits and hospital services.

Using the Short Physical Performance Battery test [9] to objectively assess participants' physical function was another strength of this study. Poor performance on this test predicts future nursing home placement, disability, and death [9] and poor physical performance has been associated with overweight and/or obesity [120]. The uncorrected BMI category $\geq$ 30 to < 40 had a score of 8.1 and BMI $\geq$ 40 had the lowest score of 6.8. It is not known why the former group had a high score as the general trend showed an inverse relationship between increasing BMI and physical function score. When controlled for demographics; age, gender, and race however, the relationship between decreased physical function and increased BMI, became stronger as demonstrated by corrected BMI reaching significance.

Our results agree with others that obesity, as measured by WC, is associated with poor physical function [7]; in the present study the high risk WC vs. the low risk category differed by at least 1.0 point for both the uncorrected and corrected values. Impaired function can affect quality of life and diminish independence. A loss of independence can lead to a number of adverse outcomes including increased use of health care services, disability, institutionalization, and death [114].

In addition, our results were similar to others that showed a decrease in self-reported health with an increase in adiposity [63, 64]. In the current study as BMI or WC increased self-reported health decreased and was significantly decreased in the morbidly obese (BMI $\geq$ 40) and high risk WC. This relationship remained when controlled for demographic factors. A poor to fair score on this global health assessment has been shown to strongly predict both decreased physical function [62, 189] and increased mortality [62, 189, 190].

Flexibility can be considered as an additional aspect of physical function, but little attention has been given to the relationship of BMI or WC with flexibility in older adults. In the present study, flexibility decreased as BMI or WC increased. This finding may be important for older adults, because a decline in hamstring flexibility has been associated with decreased functional capacity, increased lower back pain, postural deviations, gait limitations, risk of falling, and risk of musculoskeletal injuries [191]. More research may be needed to design and implement programs that are tailored to improving flexibility in obese older adults.

Measuring both BMI and WC was an additional strength of this study. These measurements are frequently used to assess the prevalence of associated diseases such as diabetes, high blood pressure and heart disease [66]. The principles behind the measurements differ and which method is more appropriate for risk assessment is currently a matter of debate [85]. BMI assesses general obesity, whereas WC specifically measures central adiposity, which has been associated with increased risk of metabolic diseases [66, 72] [21]. The purpose of this study was not to compare the superiority of either assessment, but instead to determine whether or not either measurement of increased adiposity was independently associated with increased disease prevalence and physical limitations.

Despite these convincing relationships observed in our population of older Georgians there are some limitations to this study. Objective measures of height, weight, and WC with scales and without clothes and/or shoes would be desirable, but was impractical under our field conditions; however, the strong associations of these measures with the comorbidities and physical limitations show that our methods are practical for use in community-based settings. Another limitation was the lack of knowledge concerning participants' historical weight status, which is important in the development of comorbidities and physical limitations. [74].

Questionnaires were interviewer administered to help overcome possible limitations related to impaired vision and/or hearing in participants.

Overall, the current study observed a high prevalence of obesity in this vulnerable population of older Georgians participating in the OAA programs at senior centers with congregate meal programs. As BMI or WC increased, there were significant increases in several comorbidities and physical limitations, as well as decreases in self-reported health, even after controlling for the demographics age, gender, and race that are known to impact these indices [21]. This study shows an obvious need for targeted education to teach this predisposed population how to make lifestyle changes that promote a healthy diet and high physical function through targeted nutrition counseling, medical nutrition therapy, physical activity, and medication management, as these have been shown to improve health outcomes [68], which have led to fewer medical expenses [186-188].

TABLE 3.1. Characteristics of participants: Georgia senior centers 2007 [1, 2]

	n	Included participants mean (SD) or %	n	Excluded Participants Mean (SD) or %	p-value
Age	759	75.4 (8.1)	56	75.7 (9.6)	0.42
< 69		24.7		28.6	
70-79		44.1		35.7	
≥ 80		31.1		35.7	
Gender	759		56		0.84
Male		19.0		17..9	
Female		81.0		82.1	
Race/ethnicity	759		56		0.05
White		63.0		46.4	
Black		36.1		50.0	
Other		1.0		3.58	
Education (years)	759	12.1 (11.5)	56	10.5 (4.4)	0.21
Body mass index (kg/m^2)	759		56		
Uncorrected		29.5 (6.6)		30.9 (3.6)	0.06
Corrected		30.0 (6.9)		32.6 (4.1)	0.01
Waist circumference (inches)	759				
Uncorrected		38.9 (6.0)		38.0 (4.5)	0.37
Corrected		38.1 (6.0)		37.1 (4.5)	0.37
Self-reported health	759	1.8 (1.0)	56	1.6 (0.94)	0.14
Excellent		6.2		3.6	0.53
Very good		33.2		14.3	
Good		44.7		32.1	
Fair		13.3		42.9	
Poor		3.6		7.1	
Health conditions, self-reported	241-553		54-56		
Diabetes		32.0		41.1	0.16
High blood pressure		73.1		75.0	0.75
Heart disease		30.8		37.0	0.34
High cholesterol		57.8		51.9	0.39
Joint pain		68.9		71.4	0.69
Arthritis		69.5		71.4	0.76
Short physical performance battery (SPPB)[1]					
Total score	686	7.4 (2.8)	56	5.4 (3.7)	0.004
Poor (0-5)		23.3		50.0	0.02
Moderate (6-9)		51.8		36.4	
Good (10-12)		24.9		13.6	
Chair-sit-and-reach (inches)	734	-1.8 (4.5)	56	-1.52 (4.43)	0.49

[1]Participants completed the pre-test.
[2]Self-reported health was rated as 0 = poor, 1= fair, 2 = good, 3 = very good, 4 = excellent.

TABLE 3.2. Body mass index categories before and after corrections for height and weight was applied: Georgia senior centers 2007

BMI (kg/m^2) Category	BMI Uncorrected n (%)	BMI Corrected [1] n(%)	p-value	Participants that had an increase, no change, or decrease in the BMI category after correction applied n (%)
< 25	199 (26.2)	181 (23.8)		Remained in the same category 179 (90.0) Moved up 1 category 20 (10.1)
≥ 25 to < 30	268 (35.3)	261 (34.4)		Moved down 1 category 2 (0.8) Remained in the same category 237 (88.4) Moved up 1 category 29 (10.8)
≥ 30 to < 35	156 (20.6)	161 (21.2)		Moved down 1 category 4 (2.7) Remained in the same category 129 (82.7) Moved up 1 category 23 (14.7)
≥ 35 to < 40	77 (10.1)	86 (11.3)		Moved down 1 category 3 (3.9) Remained in the same category 63 (81.8) Moved up 1 category 11 (14.3)
≥ 40	59 (7.8)	70 (9.2)		Moved down 1 category 0 (0.0) Remained in the same category 59 (100.0)
Mean BMI	**Mean (SD)**	**Mean (SD)**		
	29.4 (6.6)	30.0 (6.9)	0.001	
BMI (kg/m^2) Category				
< 30	61.5	58.2	0.001	
≥ 30	38.5	41.8		

[1]BMI was corrected for shoe weight, clothes weight, and self-report. Height was corrected for shoe height and self-report (see methods).

TABLE 3.3. Waist circumference categories before and after a correction for clothes was applied: Georgia senior centers 2007

	Uncorrected	Corrected [1]	p-value	Participants that remained or decreased in the waist circumference category after correction applied n (%)
Waist circumference (inches)	**n (%)**	**n (%)**		
Low-risk	279 (36.8)	322 (42.2)	0.001	Remained in the same category 279 (100) Moved up 1 category 0 (0)
High-risk	480 (63.2)	437 (57.6)		Remained in the same category 437 (91) Moved down 1 category 43 (9)
Mean waist circumference	**Means (SD)**	**Means (SD)**		
Men	41.3 (5.3)	40.4 (5.3)	0.001	
Women	38.4 (6.0)	37.6 (6.0)	0.001	

[1]Waist circumference was corrected if the measurement was made over a participant's clothing.

TABLE 3.4. Comorbidities, physical limitations, body mass index, and waist circumference: Georgia senior centers 2007 [1, 2, 3]

		BMI (kg/m²)						Waist circumference (inches)		
	Total N	**< 25 mean (SD) or %**	**≥ 25 to <30 mean (SD) or %**	**≥ 30 to <35 mean (SD) or %**	**≥ 35 to <40 mean (SD) or %**	**≥ 40 mean (SD) or %**	**p-value**	**Low-risk mean (SD) or %**	**High-risk mean (SD) or %**	**p-value**
Uncorrected		n = 199	n = 268	n = 156	n = 77	n = 59		n = 279	n = 480	
Age (years)	759	78.4 (7.8)[a]	76.9 (7.8)[a]	73.2 (7.8)[b]	72.1(7.7)[cb]	69.1(5.0)[c]	0.001	77.3 (7.9)	74.4 (8.1)	0.001
Men	144	24.3	38.2	23.6	8.3	5.6	0.53	49.3	50.7	0.01
Women	615	26.7	34.6	19.8	10.6	8.3		33.8	66.2	
White	478	29.3	36.6	20.1	7.7	6.28	0.001	41.2	58.8	0.001
African American	274	19.7	33.6	21.9	14.6	10.2		28.5	71.5	
BMI (kg/m²)	759	22.4 (2.1)[a]	27.4 (1.4)[b]	32.3 (1.5)[c]	37.1 (1.5)[d]	44.7 (4.4)[e]	0.001	24.7 (3.7)	32.2 (6.4)	0.001
Waist circumference (inches)	759									
Men		36.7 (3.6)[e] n = 35	40.0 (3.5)[d] n = 55	43.7 (3.1)[c] n = 34	46.8 (4.8)[bc] n = 12	51.3 (4.9)[ab] n = 8		37.1 (2.6)	45.3 (3.9)	0.001
Women		32.7 (3.4)[e] n = 164	37.4 (3.8)[d] n = 213	40.3 (3.7)[c] n = 122	44.6 (4.5)[b] n = 65	48.3 (4.8)[a] n = 51		32.1 (2.3)	41.6 (4.7)	0.001
Diabetes	755	18.8	27.6	37.4	41.6	69.0	0.001	21.2	38.2	0.001
High blood pressure	757	59.8	73.0	76.9	83.0	95.0	0.001	62.4	79.3	0.001
Heart disease	756	33.3	28.9	30.1	28.5	35.6	0.80	30.1	31.2	0.75
High cholesterol	733	55.0	56.0	57.6	55.6	79.3	0.02	54.5	59.8	0.16
Joint pain	758	55.8	67.0	74.4	80.5	91.6	0.001	60.2	73.9	0.001
Arthritis	757	55.3	69.3	75.0	80.3	89.8	0.001	59.1	75.5	0.001
Mean number of health conditions, self-reported	724	2.2 (1.4)[d]	2.5 (1.2)[dc]	2.8 (1.2)[bc]	2.9 (1.0)[bc]	3.6 (1.0)[a]	0.001	2.3 (1.3)	2.8 (1.2)	0.001
Overall health	759	1.82 (0.88)[a]	1.84 (0.88)[a]	1.72 (0.86)[a]	1.68 (0.94)[a]	1.25 (0.86)[b]	0.002	1.92 (0.91)	1.67 (0.87)	0.001
Excellent		3.0	4.1	3.8	5.2	0.0	0.001	4.3	3.1	0.01
Very Good		16.5	15.7	9.6	9.1	6.8		17.9	10.6	
Good		45.2	44.4	46.2	41.6	32.2		44.8	43.1	

Fair		29.6	32.1	35.3	36.4	40.7		27.6	36.5	
Poor		5.6	3.7	5.1	7.8	20.3		5.4	6.7	
Corrected		n= 181	n= 261	n= 161	n= 86	n= 70		n= 322	n= 437	
Age (years)	759	78.7 (7.8)^{a}	76.5 (7.9)^{b}	73.9 (7.9)^{c}	73.5 (7.8)^{c}	69.2 (5.2)^{d}	0.001	77.3 (7.9)	74.1 (8.0)	0.001
Men	144	23.6	37.5	25.0	8.3	5.6	0.22	54.9	45.1	
Women	615	23.9	33.6	20.3	12.0	10.1		39.5	60.5	0.001
White	478	27.2	36.2	20.3	9.6	6.7	0.002	47.5	52.5	0.002
African American	274	6.1	11.6	8.5	5.32	4.92		33.2	66.8	
BMI (kg/m^2)	759	22.5 (2.1)^{a}	27.6 (1.4)^{b}	32.1 (1.5)^{c}	37.1 (1.5)^{d}	45.0 (4.7)^{e}	0.001	25.5 (3.8)	33.4 (6.7)	0.001
Waist circumference (inches)	759									
Men	144	35.7 (3.7)^{e} n = 34	39.1 (3.3)^{d} n = 54	42.5(3.3)^{c} n = 36	46.3 (4.7)^{b} n = 12	50.4 (4.7)^{ab} n = 8		36.5 (2.7)	45.0 (3.8)	0.001
Women	615	31.8 (3.4)^{e} n = 147	36.1 (3.7)^{d} n = 207	38.9 (3.8)^{c} n = 125	43.1 (4.0)^{b} n = 74	47.0 (5.1)^{a} n = 62		31.8 (2.5)	41.3 (4.5)	0.001
Diabetes	757	17.9	27.6	35.0	39.5	68.1	0.001	21.2	39.9	0.001
High blood pressure	756	59.7	72.4	78.1	77.6	92.9	0.001	64.0	79.8	0.001
Heart disease	733	33.3	27.7	30.0	36.1	31.4	0.58	31.4	30.4	0.78
High cholesterol	758	54.0	56.5	57.9	57.0	73.6	0.09	55.0	60.0	0.18
Joint pain	759	55.8	65.8	74.5	77.9	90.0	0.001	63.7	72.7	0.001
Arthritis	757	56.4	65.5	76.9	77.7	91.4	0.001	61.8	75.2	0.001
Mean number of health conditions, self-reported	724	2.2 (1.4)^{d}	2.5 (1.2)^{dc}	2.7 (1.1)^{bc}	2.9 (1.0)^{c}	3.6 (1.0)^{a}	0.001	2.4 (1.3)	2.9 (1.2)	0.001

Overall health	759	1.80 (0.87)[a]	1.89 (0.88)[a]	1.69 (0.82)[a]	1.73 (0.99)[a]	1.27 (0.85)[b]	0.001	1.84 (0.90)	1.68 (0.88)	0.001
Excellent		2.2	5.0	1.9	8.1	0.0	0.001	3.7	3.4	0.10
Very good		17.1	15.7	11.2	8.1	5.7		17.1	10.5	
Good		44.8	45.2	46.5	38.4	35.7		43.5	43.9	
Fair		29.3	31.0	34.8	39.5	38.5		30.4	35.2	
Poor		6.1	3.1	5.6	5.8	20.0		5.3	6.9	

[1]The mean number of comorbidities does not include arthritis.

[2]Self-reported health was rated as 0 = poor, 1= fair, 2 = good, 3 = very good, 4 = excellent.

[3]Values with different superscripts are significantly different from one another as determined by the Tukey's test, $p \leq 0.05$.

TABLE 3.5. Physical function, body mass index, and waist circumference: Georgia senior centers 2007

		BMI (kg/m^2)						Waist circumference (inches)		
	Total N	**< 25 mean (SD) or %**	**≥ 25 to <30 mean (SD) or %**	**≥ 30 to <35 mean (SD) or %**	**≥ 35 to <40 mean (SD) or %**	**≥ 40 mean (SD) or %**	**p-value**	**Low-risk mean (SD) or %**	**High-risk mean (SD) or %**	**p-value**
Uncorrected										
Short physical performance battery (SPPB)[1]										
Total score	686	7.6 (2.7)[ab]	7.2 (3.0)[a]	8.1 (2.4)[b]	7.0 (2.7)[a]	6.8 (2.9)[a]	0.01	8.0 (2.5)	7.1 (2.8)	0.001
Chair-sit-and-reach (inches)	735	-0.9 (4.0)[b]	-1.7 (4.38)[b]	-2.1(4.81)[b]	-2.5 (3.9)[ab]	-4.1(4.9)[a]	0.0001	-1.2 (4.4)	-2.2 (4.5)	0.0003
Corrected										
Short physical performance battery (SPPB)[1]										
Total score	686	7.6 (2.7)	7.3 (3.0)	7.9 (2.5)	7.2 (2.6)	6.9 (3.0)	0.09	8.0 (2.5)	7.0 (2.9)	0.001
Chair-sit-and-reach (inches)	735	-1.2 (4.22)[b]	-1.44 (4.3)[b]	-1.9 (4.8)[b]	-2.4 (3.7)[ab]	-3.9 (4.9)[a]	0.0001	-1.2 (4.4)	-2.2 (4.5)	0.001

[1] The SPPB total score ranges from 0 to 12 and is calculated from the combined scores of the standing balance (0 to 4), 8 foot walk (0 to 4), and five chair stands (0 to 4) (Guralnik et al., 1994).

CHAPTER 4

PHYSICAL ACTIVITY AND OBESITY-RELATED COMORBIDITIES AND PHYSICAL LIMITATIONS IN OLDER ADULTS AT GEORGIA SENIOR CENTERS

[1]Penn, DM, Lee, JS, Porter, KN, Reddy, S, and Johnson, MA. To be submitted to *Journal of Nutrition, Health, and Aging,*

Abstract

There is a high prevalence of obesity in older adults participating in Georgia's Older Americans Act (OAA) congregate meal-site programs (38% vs. 22.8% nationally among 65+) that is strongly associated with obesity-related comorbidities and physical limitations, such as diabetes, high blood pressure, and joint pain (about 20-percentage points higher in obese vs. normal-weight participants) [179]. Whether physical activity attenuates these relationships of obesity with obesity-related comorbidities and physical limitations in these participants is not known. Therefore, the purpose of this study was to determine whether or not moderate-intensity physical activity attenuated the relationship of obesity with obesity-related comorbidities and physical limitations in older Georgians participating in OAA congregate meal-site programs (N = 683, median age = 75 years, 81% female, and 65% black, convenience sample). Obesity was defined as BMI $\geq$ 30 kg/m^2, waist circumference (WC) class I obesity [73], or traditional WC cut-offs [66]. Physical activity was self-reported as days per week participating in at least 30 minutes of moderate physical activity (< 5 vs. $\geq$ 5 days/week). The comorbidities examined were diabetes, high blood pressure, and poor or fair self-reported health, and the physical limitations examined were poor physical function, poor chair-sit-and-reach (measure of flexibility), joint pain, and falls. A series of logistic regression analyses revealed that when controlled for moderate physical activity and other factors (age, gender, race, education, tobacco, and other health-related factors): a) moderate physical activity was significantly associated with decreased risk of poor physical function and poor or fair self-reported health, b) all three measures of adiposity remained strongly associated with poor chair-sit-and-reach, joint pain, falls, diabetes, and high blood pressure, c) WC-NHLBI remained strongly associated with poor physical function and poor or fair self-reported health, and d) moderate physical activity generally did not

attenuate these associations of obesity with the comorbidities or physical limitations. The possible attenuating effects of physical activity may not have been apparent because of a low sensitivity of the attenuation criteria; the definition and measurement of physical activity and the comorbidities; and/or the cross-sectional nature of this study. In conclusion, this study demonstrated robust adverse associations of obesity with several comorbidities and physical limitations, even when controlled for other factors, emphasizing the need for health promotion programs offered at OAA congregate meal-sites that can help prevent and manage these comorbidities through body weight regulation, nutrition, and physical activity.

Introduction

The purpose of the Older Americans Act (OAA) programs includes promoting independence and preventing disability with community-based services delivered through senior centers, congregate meal programs, and other venues [25]. OAA Title III authorizes grants to states to help provide nutritious meals and disease prevention services to promote health and well-being and delay the onset of adverse health conditions resulting from poor nutritional health or sedentary behavior [25]. OAA programs serve more than 9 million Americans – about 19% of the older adult population [5]. OAA programs target those who belong to minority groups and have low-incomes, which are among the demographic risk factors associated with increased risk for obesity and low physical activity [192]. It is well established in older adults that obesity and/or low physical activity increase the risk for many comorbidities and exacerbate physical decline [4, 6, 7, 193], while participation in physical activity has numerous health benefits [20, 194, 195]. Similar to adults in general, it is recommended that older adults participate in at least 150 minutes of moderate-intensity physical activity per week [122, 123, 196]. Also, guidelines for the prevention and management of obesity in older adults are available [6, 66].

Among older adults, the prevalence of obesity was 22.8% nationally and 25.3% in Georgia [197], while the prevalence of meeting the moderate physical activity guidelines was 44.5% in men and 36.3% in women nationally [22]. In Georgia, many OAA programs at senior centers provide congregate meals and physical activity programs [95]. Thus, more than 50% of older adults participating in these programs reported meeting the guidelines for moderate physical activity in 2005 [95]. However, we found that the prevalence of obesity in older adults at Georgia senior centers was much higher than in the general population of Georgians aged 65+ (38% vs. 25.3%, [179, 197]. Moreover, excess adiposity was strongly associated with several comorbidities and physical limitations [179]. For example, the prevalence of diabetes, high blood pressure, arthritis, and joint pain was at least 20-percentage points higher in obese compared to normal weight participants (BMI ≥ 30 vs. < 25 kg/m^2), while these same conditions were at 13-percentage points higher in those with a high vs. low risk waist circumference (WC) [179].

To our knowledge, the extent to which physical activity attenuates the impact of obesity on obesity-related comorbidities and physical limitations among participants of OAA programs has not been investigated. Thus, the purpose of this study was to determine whether or not moderate-intensity physical activity attenuated the effects of obesity on selected comorbidities and physical limitations in older adults participating in OAA programs at Georgia senior centers. It was hypothesized that meeting the recommendations for moderate physical activity would attenuate the relationship of obesity with these comorbidities and physical limitations. These results are a first step in understanding the relationships among physical activity, obesity, and obesity-related comorbidites and physical limitations in Georgia's senior center participants and will assist in developing evidence-based nutrition, physical activity, and health promotion programs and services that meet the goals of the OAA.

Methods

Sample

Questionnaires and procedures were approved by the Institutional Review Boards on Human Subjects of the University of Georgia and the Georgia Department of Human Resources. Participants were a convenience sample of people aged 50 and older recruited from 40 senior centers in the fall of 2007, similar to a previous study [182]. Briefly, each of the 12 Area Agencies on Aging in Georgia were asked to recruit about 70 people from senior centers in their area. Senior centers were selected based on the support of the senior center director and interest of the participants. Most participants received congregate meals. Procedures were explained and the consent forms were read to participants, and written informed consent was obtained. Potential participants who were homebound or determined by the interviewer to be unable to understand the informed consent and/or answer questions were excluded. These procedures yielded 815 participants of whom 683 were included in the analyses in this study; 132 participants were excluded who had missing data for moderate physical activity, depression, education, tobacco use, prescription drug use, self-reported health, joint pain, height, weight, and/or WC measurements, had a BMI less than 18.5 kg/m^2, or were aged less than 60 years.

Questionnaires

Participants were interviewed as previously described [182] with trained staff who read the questions to participants and recorded their responses. Body weight was: a) weighed with a scale, without shoes and with clothes (14% of participants); b) weighed with a scale with shoes and clothes on (69%); or c) self-reported and we assumed without clothes and shoes (17%).

Height was assessed by: a) measurement with a tape measure with shoes on (38%), or b) self-reported (62%). BMI was calculated as: weight (pounds)/height (inches)^2 x 703 and reported in kg/m^2. Adiposity was defined in three ways (0= low risk or not obese, 1 = high risk or obese): BMI-class I obesity (< 30 vs. $\geq$ 30 kg/m^2, [66]); WC-class I obesity (low risk: men < 43 inches, women < 42 inches; high risk: men $\geq$ 43 inches, women $\geq$ 42 inches, [73]; and traditional WC cut-offs from the National Heart, Lung, and Blood Institute (WC-NHLBI) (low risk: men $\leq$ 40 inches, women $\leq$ 35 inches; high risk: men > 40 inches, women > 35 inches, [66]. According to Arden et al. [73], BMI-class I obesity is more closely aligned with the WC-class I obesity categories than with the WC-NHLBI categories. Previously we applied corrections for gender, clothes and/or shoes for height, weight, and/or WC in this sample and found that the relationships between the selected comorbidities and BMI or WC were nearly always similar when using the corrected or uncorrected values [179]. Therefore, uncorrected values for BMI and WC were used in these analyses.

Moderate physical activity was assessed using the question, "How many days of the last week (seven days) did you participate in at least 30 minutes of moderate physical activity? Examples of moderate physical activities are regular walking, housework, yard work, lawn mowing, painting, repairing, light carpentry, ballroom dancing, light sports, golf, or bicycling on level ground?" that was used in a previous studies [95, 198] and adapted from the BRFSS and Toobert et al [128, 129]. This question specifies the intensity and time spent doing physical activities as recommended by the guidelines. Additionally, the BRFSS questions on physical activity have been shown to have good sensitivity and predictive value [130]. The response categories were "0 to 7" and were dichotomized to "< 5 days/week" (0 = low activity) and "$\geq$ 5 days/week" (1 = moderate activity) to reflect national recommendations for older adults [122, 123].

For the purposes of this study, the term "comorbidities" included diabetes, high blood pressure, and poor or fair self-reported health, and the term "physical limitations" included poor physical function, low chair-sit-and-reach, joint pain, and falls. Participants' physical function was assessed using the Short Physical Performance Battery [9] as described by Fitzpatrick et al. [95]. Poor performance on this test predicts future nursing home placement, disability, and death [9]. This test assesses balance, strength, and gait speed as an individual performs standing balance, chair stands, and an 8-foot walk, respectively. Performance in each category is scored from 0 to 4. A summary score ranging from 0 to 12 was created and categorized as poor (0 to 5), moderate (6 to 9), and good (10 to 12) function. For data analyses, two categories were created: poor and moderate (0 to 9) and good (10 to 12). This was done because the rate of institutionalization was 4.8 to 22.5/100 person years with a physical function score of ≤ 9 vs. 2.7 to 0.7/100 person years with a score ranging from 10 to 12 [9], as well as approximately 75% of the analytic sample had a score of ≤ 9 .

Flexibility was measured using the chair-sit-and-reach method by Jones et al. [109] (0 = ≥ 0 inches, 1 = < 0 inches). Other measures included self-reported (0 = no, 1 = yes): joint pain ("During the past 30 days, have you had symptoms of pain, aching, or stiffness in or around a joint?" [49]), falls ("Have you fallen in the past year?" adapted from [199]), diabetes, and high blood pressure. Self-reported health (0 = good, very good, or excellent, 1 = poor or fair), history of depression (0 = no, 1 = yes, [200]), number of prescription medications (0 = < 5, 1 = ≥ 5), age (0 = < 80, , 1 = ≥ 80 years), gender (0 = male, 1 = female), race (0 = white, 1 = black), education (0 = < 12, 1 = ≥ 12 years), and tobacco use (0 = no, 1 = yes).

Statistics

Completed questionnaires and consent forms were sent to the University of Georgia. Data were analyzed using Statistical Analysis System (version 9.1, Cary, NC, [183]). Descriptive statistics, including frequencies, medians, ranges, and Spearman correlation coefficients were calculated. A series of logistic regression models were used to examine the effects of moderate physical activity on attenuating the relationship of adiposity with the seven comorbidities and physical limitations. For each comorbidity or physical limitation, the series of regression models were: Model 1 included one adiposity variable controlled for factors that might increase the risk of having a comorbidity or physical limitation (age, gender, race, education, and tobacco use); Model 2 added physical activity; and Model 3 added variables that might result from having a comorbidity or physical limitation (medications, depression, and self-reported health, except in the model where self-reported health was the dependent variable). An interaction term between obesity and physical activity was tested in these models, but was not retained because it never reached statistical significance. $P \leq 0.05$ was considered statistically significant.

Results

Characteristics of participants are shown in Table 1. Compared to those who were included in these analyses (n = 683), those who were excluded (n = 132) were significantly more likely to be black, have less than 12 years of education, use tobacco, have BMI < 30, and have lower WC, but there were no differences in the other variables of interest.

There were numerous significant correlations among the independent variables (adiposity and physical activity, age, gender, race, education, tobacco, depression, medications, and self-reported health) and the dependent variables (physical function, chair-sit-and reach, joint pain, falls, diabetes, and hypertension) (Table 2). BMI-class I obesity, WC-class I obesity, and WC-NHLBI, and moderate physical activity were significantly correlated with each other and the dependent variables with the exceptions of BMI and physical function, WC-NHLBI with falls, and moderate physical activity with diabetes and chair-sit-and-reach ($p \leq 0.05$, Table 2).

Logistic regression analyses were used to determine the associations of the dependent variables (comorbidities and physical limitations) with BMI or WC, with and without moderate physical activity (Tables 3 and 4). In Model 1, increased BMI was significantly associated with all of the comorbidities and physical limitations, except for physical function and self-reported health (Table 3); WC-class I obesity was significantly associated with all of the comorbidities and physical limitations; and WC-NHLBI was significantly associated with all of the comorbidities and physical limitations, except for falls (Table 4). In Model 2, the addition of moderate physical activity did not change the relationship of BMI or WC-NHLBI with the comorbidities or physical limitations compared to Model 1 (Tables 3 and 4), but did attenuate the effect of WC-class I obesity on falls (Table 4). In Model 3, the additional adjustments revealed that BMI remained significantly associated with same comorbidities and physical limitations as in the previous models (Table 3), but WC-class I obesity was no longer associated with physical function and poor or fair self-reported health and WC-NHLBI was no longer associated with self-reported health (Table 4). There was very little evidence that physical activity attenuated the effects of adiposity on the selected comorbidities or physical limitations, because the 95% CIs for adiposity generally overlapped across the three models (Tables 3 and 4). In Model 3, moderate physical activity was significantly associated with falls in the BMI model (Table 3) and with physical function and self-reported health in the BMI and WC models (Tables 3 and 4).

Although the primary focus of this study was on class I obesity, analyses using class II obesity were examined. In the final models with all variables of interest, the outcomes for obesity with the dependent variables were as follows: chair-sit-and-reach, joint pain, falls, and high blood pressure were significantly associated with BMI class II obesity; chair-sit-and-reach, joint pain, high blood pressure, and self-reported health was significantly associated with WC class II obesity.

Discussion

The purpose of this study was to determine the extent to which moderate-intensity physical activity, defined as 30 minutes per day on 5 or more days per week, attenuated the effects of obesity on obesity-related comorbidities and physical limitations in older adults participating in OAA programs at Georgia senior centers. Contrary to the hypothesis, physical activity did not attenuate the risk of obesity-related comorbidities or physical limitations in the regression models, except for falls. In fact, the obesity indicators remained associated with at least four out of the seven comorbidities and physical limitations in the final model, Model 3, indicating that obesity is robustly associated with low chair-sit-and-reach, joint pain, diabetes, and high blood pressure. Also, BMI was a better predictor of falls, and WC-NHLBI was a better predictor of poor physical function.

The positive benefits of physical activity on health outcomes are well documented for all age groups [201] including overweight and/or obese older adults [131, 137]. The 2008 physical activity guidelines recommend that older adults engage in at least 150 minutes of moderate-intensity physical activity each week [122]. Physical activity interventions in older adults in Georgia's senior centers [95, 198] and subsidized housing [195] have shown improvements in physical function measurements. In the present study, moderate physical activity remained robustly associated with decreased risk of both poor physical function and poor or fair self-reported health, but physical activity did not appear to attenuate the effects of obesity on the risk of these obesity-related comorbidities and physical limitations. In this study the median physical function score of 7.0 was within the distribution of summary scores reported by Guralnik et al. who validated the physical function test with data from the Established Populations for Epidemiologic Studies of the Elderly (EPESE) that oversampled males, and at least 50% of the population were black older adults [9]. Also, flexibility (chair-sit-and-reach) may not have been significantly associated with physical activity because the abdominal fat tissue may have been a physical barrier to reaching one's toes.

There are several reasons why physical activity may not have attenuated the effects of obesity on obesity-related comorbidities and physical limitations. Perhaps the criteria used for assessing the attenuating effects of physical activity on obesity lacked sensitivity. Essentially, if the association of obesity with a comorbidity or physical limitation remained statistically significant, once physical activity was added in Model 2 or 3 then this was deemed as no attenuation, even if the odds ratio for the obesity variable decreased from Model 1 to Model 2. Perhaps these criteria were not sensitive enough to detect the subtle attenuations that physical activity may have had on the relationship between obesity and the comorbidities or physical limitations.

Other reasons for the lack of an apparent effect of physical activity on attenuating the effects of obesity on the comorbidities or physical limitations were related to the definition and measurement of physical activity, how the comorbidities and physical limitations were defined and measured, and/or the cross-sectional nature of the data. Each of these reasons will be discussed in the following paragraphs.

Although some self-reported measures of physical activity have been shown to be valid and reliable in older adults value [130], a limitation of this study was that the type, amount, and intensity of participants' physical activity was not quantitatively determined, such as would have been done in a physical activity intervention. Perhaps the older adults were not participating in physical activities that would have benefited certain comorbidities or physical limitations, such as specific resistance activities, balance and flexibility exercises, and aerobic exercise. For example, in randomized controlled trials, progressive resistance training improved physical function, glycemic control, and bone mineral density in older adults [127]; balance and flexibility exercises reduced the number of falls [202]; aerobic activities reduced the rates and/or improved control of cardiovascular disease, high blood pressure, and diabetes [201, 203]; and progressive resistance training and aerobic physical activities is recommended for arthritis [203]. Joint pain, falls, diabetes and high blood pressure were measured by asking participants if they had this health condition, or in the case of falling, if they fell in the past year. Detailed quantitative information about these comorbidities and physical limitations were not assessed, such as blood pressure in mm Hg, glucose control via hemoglobin A1c, medication dosages, or the frequency of falls. It is possible that those who were physically active may have had better control of certain comorbidities or physical limitations compared to the less active, which might have been detected if this study had detailed quantitative information about these comorbidities and physical limitations. Others have shown that physical activity improved glucose control and blood pressure to the degree that medication doses were lowered [204]. Types and doses of medications are variables that were not measured that would have been indicative of the positive benefits of physical activity on several of these obesity-related comorbidities and physical limitations.

Obese participants were less likely to meet the physical activity recommendation for older adults compared to the non-obese (e.g., 35% vs. 65%, < 30 vs. ≥ 30 kg/m^2). Due to the cross-sectional nature of this study it is not certain whether the comorbidities or physical limitations prevented individuals from participating in high levels of moderate physical activity, but this is a likely possibility. Kaplan et al. [125] observed that the presence of chronic conditions was associated with decreased physical activity among older adults. However, the barrier of several chronic disease types has been shown to be overcome with targeted education programs as reviewed by Cyarto et al. [127]. Their review demonstrated that despite the presence of multiple comorbidities and physical limitations, such as arthritis, diabetes, cardiovascular diseases, and functional limitations, older adults were capable of participating in targeted physical activity interventions that benefited their health. Among our population, 95% of participants had one or more comorbidities or physical limitation of interest. This high prevalence of chronic disease and physical limitations is alarming and emphasizes the need for continuing interventions that target increasing physical activity among OAA participants, as well as implementing interventions that specifically identify and overcome the comorbidity, or physical limitation, barriers that deter their participation in physical activity.

Moderate physical activity did attenuate the impact of WC-class I obesity on falls in the past year. There are mixed results concerning the impact of adiposity on increased falls. In community-dwelling older adults low body weight [55] or low BMI [56] was found to be associated with increased falls, BMI ≥ 30 was associated with increased falls [57], and neither low or high BMI were related to falls [58, 59]. The reasons for the mixed results are not clear, but could involve limitations in the ways falls were recorded (e.g., self-report) and/or the manner in which adiposity is assessed and defined. For example, in the present study, falls were more strongly associated with BMI than with WC after controlling for potential confounders.

The limitations of this study include use of a convenience sample, multiple interviewers across the state, and not all participants had their height and weight objectively measured [179]. In addition, physical activity relied on a self-reported measure that was adapted from other surveys [128, 129] and addresses meeting the 2008 physical activity recommendations for older adults [122]. The measures of certain comorbidities or physical limitations may not have been sensitive enough to detect the subtle benefits of physical activity on obesity-related comorbidities and physical limitations, while the cross-sectional nature of the study made it difficult to assess how obesity and the comorbidities and physical limitations affected participation in physical activity.

Overall this study demonstrated profound adverse associations of obesity, even when controlled for other factors, on several comorbidities and physical limitations that can be prevented and managed through body weight regulation, nutrition and physical activity. These results demonstrate a need for community-based health promotion interventions targeting Georgians participating in OAA programs that promote physical activity, achievement of a healthy body weight through good nutrition and increased physical activity, and provide referrals for weight management. Programs need to include exercises that address the four core areas of physical activity, endurance, strength, balance, and flexibility, in order to maximize the benefits of physical activity for the different types of comorbidities and physical limitations that are prevalent in these older adults.

TABLE 4.1. Characteristics of participants: Georgia senior centers 2007

	n	Participants included Median (range) or %	N	Participants excluded (missing data) Median (range) or %	p-values
Age	683	75 (60, 97)	132	75 (51, 97)	0.30
<69	159	23.3	28	24.4	0.08
70-79	314	46.0	41	35.7	
≥80	210	30.8	46	40.0	
Gender	683		132		0.62
Male	127	18.6	27	20.5	
Female	556	81.4	105	79.6	
Race/ethnicity	683		123		0.001
White	443	64.9	61	46.2	
Black	240	35.1	62	50.4	
Education (years)	683	11 (0, 20)	117	12 (0, 17)	0.28
< 12	587	86.0	92	78.6	
≥ 12	96	14.0	25	21.4	0.04
Tobacco use	683	7.2	125	15.2	0.003
Depression	683	23.1	128	20.3	0.49
Prescription medications (number)	683		114		0.51
< 5 prescriptions	358	52.4	56	49.1	
≥ 5 prescriptions	325	47.6	58	50.9	
Body mass index (kg/m^2)	683	28.3 (18.9, 64.0)	91	27.9 (14.0, 52.9)	0.10
≥ 18.5 to < 25	170	24.9	18	22.5	0.96
≥ 25 to < 30	245	35.9	30	37.5	
≥ 30 to < 35	143	20.9	18	22.5	
≥ 35 to < 40	71	10.4	9	11.3	
≥ 40	54	7.9	5	6.3	
Class I obesity (kg/m^2)	683		132		0.001
< 30	415	60.8	100	76.8	
≥ 30	268	39.2	32	24.2	
Waist circumference (inches)					
Males	127	41.0 (30.0, 55.0)	18	39.0 (29.0, 57.0)	0.53
Females	556	38.0 (25.0, 57.0)	65	37.0 (26.0, 53.0)	0.24
Waist circumference categories using BMI ranges	683		132		0.0001
Normal	244	35.7	86	65.2	
Overweight	227	33.2	24	18.2	
Class I obese	117	17.1	12	9.1	
Class II & class III obese	95	13.9	10	7.6	
Waist circumference class I obesity	683		132		0.001
Low risk	471	69.0	110	83.3	
High risk	212	31.0	22	16.7	

TABLE 4.1., continued

		Participants included		Participants excluded (missing data)	p-values
Moderate physical activity (days/week)	683	5.0 (0.0, 7.0)	124	4.5 (0.0, 7.0)	0.36
≥ 5	347	50.8	62	50.0	0.87
< 5	336	49.2	62	50.0	
Physical function	617	8 (0, 12)	91	7 (0, 12)	0.06
Poor (0-5)	142	23.0	29	31.9	0.18
Moderate (6-9)	321	52.0	42	46.2	
Good (10-12)	154	25.0	20	22.0	
Physical function (2 categories)					0.54
Poor to Moderate (0 – 9)	463	75.0	71	78.0	
Good (10 – 12)	154	25.0	20	22.0	
Chair-sit-and-reach (inches)	668	0.0 (-26.0, 7.0)	88	-7.0 (-12.0, 7.0)	0.85
≥ 0 inches	366	54.8	54	61.4	0.24
< 0 inches	302	45.2	34	38.6	
Joint Pain	468	68.6	94	71.2	0.56
Falls in the past year	246	36.3	57	48.9	0.10
Diabetes	212	31.2	52	39.7	0.06
High blood pressure	496	72.7	99	75.6	0.50
Self-reported health	683	2.0 (0.0, 4.0)	132	2.0 (0.0, 4.0)	0.85
Excellent (= 4)	40	5.9	11	8.3	0.32
Very good (= 3)	227	33.2	49	37.1	
Good (= 2)	302	44.2	48	36.4	
Fair (=1)	88	12.9	21	15.9	
Poor (=0)	26	3.8	3	2.3	

TABLE 4.2. Spearman correlations between variables of interest: Georgia senior centers 2007

	Age	Gender	Race	Educ	Tobac	SRH	Depr	Meds
Gender	0.01	-						
Race	-0.11**	0.12**	-					
Education	0.07	0.08*	0.02	-				
Tobacco use	-0.10*	-0.06	0.10*	-0.07	-			
Self-reported health	-0.02	-0.03	0.10	0.06	-0.05	-		
Depression	-0.13**	0.07*	-0.08*	0.01	0.04	0.07	-	
Medications	-0.10**	-0.03	0.005	0.11**	-0.07	0.30***	0.18***	-
Poor physical function	0.14***	0.0004	0.17***	0.03	0.10*	0.15**	0.0004	0.11*
Poor chair-sit-and-reach	-0.02	-0.06	0.05	0.04	0.02	0.10**	0.12**	0.11**
Joint pain	-0.05	0.02	0.05	0.01	-0.01	0.23***	0.14**	0.17***
Falls	-0.06	-0.01	-0.08*	0.004	-0.005	0.09*	0.21***	0.17***
Diabetes	-0.23**	-0.04	0.18***	0.02	-0.03	0.21***	0.04	0.33***
High blood pressure	-0.11**	0.03	0.15***	0.07*	-0.02	0.13**	0.07	0.27***
BMI-class I obese	-0.32***	0.01	0.16***	-0.01	-0.003	0.08*	0.08*	0.16***
WC-class I obese	-0.24***	-0.06	0.06	-0.06	0.01	0.13***	0.08*	0.18***
WC- NHBLI	-0.18***	0.13***	0.16***	-0.01	0.03	0.12**	0.003	0.15***
Physical activity	-0.02	-0.01	-0.06	-0.001	0.02	-0.14**	-0.12**	-0.18**

Abbreviations: educ = education, tobac = tobacco, SRH = self-reported health, depr = depression, meds = medications, poor PF = poor physical function, low C-S-R = low chair-sit-and-reach, Jt pain = joint pain, diab = diabetes, HBP = high blood pressure, BMI = body mass index, WCI = waist circumference class I obesity, WC-NHLBI = National Heart Lung Blood Institute waist circumference thresholds.

Variables coded as follows: age (0 = <80, 1 = ≥ 80) gender (0 = male, 1 = female), race (0 = white, 1 = black), education (0 = < 12, 1 = ≥ 12), BMI class I obesity (0 = < 30, 1 = ≥ 30), WC (0 = low risk, 1 = high risk), joint pain, falls, high blood pressure, diabetes, tobacco use, depression (0 = no, 1 = yes), medications (0 = < 5, 1 = ≥ 5), physical function (0 = good ≥ 10, 1 = poor to moderate ≤ 9), self-reported health (0 = good or very good or excellent, 1 = poor or fair), chair-sit-and-reach (0 = ≥ 0, 1 = < 0), and physical activity (0 = < 5 days, 1 = ≥ 5 days).

***p ≤ 0.001, **p ≤ 0.01, *p ≤ 0.05.

TABLE 4.2., continued

	Poor PF	Low C-S-R	Jt pain	Falls	Diab	HBP	BMI	WC I	WC-NHLBI
Gender									
Race									
Education									
Tobacco use									
Self-reported health									
Depression									
Medications									
Poor physical function	-								
Poor chair-sit-and-reach	0.13**	-							
Joint pain	0.11**	0.06	-						
Falls	0.02	0.12**	0.19***	-					
Diabetes	-0.02	0.07	0.10	0.08*	-				
High blood pressure	0.02	0.12**	0.08*	0.04	0.13***	-			
BMI-class I obese	0.03	0.17***	0.16***	0.15***	0.22***	0.17***	-		
WC-class I obese	0.08*	0.18***	0.13***	0.08*	0.22***	0.17***	0.54***	-	
WC- NHBLI	0.12**	0.10*	0.13**	0.05	0.16***	0.20***	0.47***	0.50***	-
Physical activity	-0.11**	-0.05	-0.10**	-0.08*	-0.05	-0.10**	-0.09*	-0.14*	-0.14

Abbreviations: educ = education, tobac = tobacco, SRH = self-reported health, depr = depression, meds = medications, poor PF = poor physical function, low C-S-R = low chair-sit-and-reach, Jt pain = joint pain, diab = diabetes, HBP = high blood pressure, BMI = body mass index, WCI = waist circumference class I obesity, WC-NHLBI = National Heart Lung Blood Institute waist circumference thresholds.

Variables coded as follows: age (0 = <80, 1 = ≥ 80) gender (0 = male, 1 = female), race (0 = white, 1 = black), education (0 = < 12, 1 = ≥ 12), BMI class I obesity (0 = < 30, 1 = ≥ 30), WC (0 = low risk, 1 = high risk), joint pain, falls, high blood pressure, diabetes, tobacco use, depression (0 = no, 1 = yes), medications (0 = < 5, 1 = ≥ 5), physical function (0 = good ≥ 10, 1 = poor to moderate ≤ 9), self-reported health (0 = good or very good or excellent, 1 = poor or fair), chair-sit-and-reach (0 = ≥ 0, 1 = < 0), and physical activity (0 = < 5 days, 1 = ≥ 5 days).
***p ≤ 0.001, **p ≤ 0.01, *p ≤ 0.05.

TABLE 4.3. Logistic regression analyses of the relationships of BMI (class I obesity) and moderate physical activity with selected comorbidities and physical limitations: Georgia senior centers 2007

	Poor physical function	Low chair-sit-and-reach	Joint pain	Falls	Diabetes	High blood pressure	Poor or fair self-reported health
Model 1							
BMI	1.22 (0.821)	2.08*** (1.49, 2.89)	2.05*** (1.42, 2.95)	2.07*** (1.46, 2.90)	2.05*** (1.45, 2.92)	2.03** (1.37, 2.99)	1.30 (0.94, 1.81)
Model 2							
BMI	1.20 (0.80, 1.80)	2.05*** (1.47, 2.87)	1.99** (1.38, 2.86)	2.02*** (1.44, 2.84)	2.03*** (1.43, 2.89)	1.97** (1.33, 2.91)	1.24 (0.89, 1.73)
PA	0.60** (0.41, 0.88)	0.88 (0.64, 1.20)	0.70* (0.50, 0.97)	0.73* (0.53, 1.00)	0.88 (0.63, 1.24)	0.69* (0.49, 0.99)	0.59** (0.43, 0.81)
Model 3							
BMI	1.09 (0.72, 1.65)	1.94*** (1.38, 2.73)	1.83** (1.25, 2.67)	1.84* (1.29, 2.61)	1.78** (1.22, 2.59)	1.70* (1.13, 2.54)	1.05 (0.74, 1.49)
PA	0.65* (0.44, 0.97)	0.98 (0.71, 1.35)	0.84 (0.59, 1.19)	0.84 (0.60, 1.18)	1.04 (0.72, 1.50)	0.79 (0.55, 1.14)	0.65* (0.47, 0.91)

Abbreviations: BMI is body mass index (< 30 vs. ≥ 30) and PA is physical activity.

Model 1 adjusted for BMI class I obesity (0 = < 30, 1 = ≥ 30), age (0 = <80, 1 = ≥ 80) gender (0 = male, 1 = female), race (0 = white, 1 = black), education (0 = < 12, 1 = ≥ 12), and tobacco use (0 = no, 1 = yes).

Model 2 adjusted for all variables in Model 1 plus moderate physical activity (0 = < 5 days, 1 = ≥ 5 days).

Model 3 adjusted for all variables in Model 2 plus prescription medications (< 5 vs. ≥ 5), depression (0 = no, 1 = yes), self-reported health (0 = good or very good or excellent, 1 = poor or fair, except not included as an independent variable in the model with self-reported health as the dependent variable).

***p ≤ 0.001, **p ≤ 0.01, *p ≤ 0.05.

TABLE 4.4. Logistic regression analyses of the relationships of WC-class I obesity and, WC-NHLBI, and moderate physical activity with selected comorbidities and physical limitations: Georgia senior centers 2007

	Poor physical function	Low chair-sit-and-reach	Joint pain	Falls	Diabetes	High blood pressure	Poor or fair self-reported health
WC-class I obesity							
Model 1							
WC-class I obesity	1.79* 1.16, 2.77)	2.24*** (1.59, 3.17)	1.88** (1.28, 2.76)	1.42* (1.01, 2.00)	2.38*** (1.66, 3.40)	2.43*** (1.58, 3.72)	1.73** (1.23, 2.44)
Model 2							
WC-class I obesity	1.69* (1.09, 2.63)	2.21*** (1.56, 3.14)	1.79** (1.21, 2.63)	1.35 (0.95, 1.91)	2.36*** (1.64, 3.38)	2.31** (1.50, 3.56)	1.61** (1.14, 2.28)
PA	0.63* (0.43, 0.93)	0.93 (0.68, 1.27)	0.71* (0.51, 0.99)	0.72* (0.52, 0.99)	0.94 (0.66, 1.32)	0.73 (0.51, 1.04)	0.61** (0.45, 0.85)
Model 3							
WC-class I obesity	1.49 (0.95, 2.34)	2.05*** (1.44, 2.93)	1.52* (1.01, 2.27)	1.17 (0.81, 1.68)	1.94** (1.32, 2.85)	1.94** (1.24, 3.03)	1.36 (0.95, 1.96)
PA	0.67* (0.46, 0.999)	1.02 (0.74, 1.41)	0.84 (0.60, 1.19)	0.83 (0.60, 1.16)	1.07 (0.74, 1.55)	0.83 (0.57, 1.20)	0.67** (0.48, 0.94)
WC-NHLBI							
Model 1							
WC-NHLBI	1.81** (1.22, 2.70)	1.55** (1.11, 2.17)	1.74** (1.24, 2.45)	1.28 (0.91, 1.80)	1.89** (1.29, 2.77)	2.22*** (1.55, 3.18)	1.62** (1.15, 2.28)
Model 2							
WC-NHLBI	1.74** (1.16, 2.60)	1.52* (1.09, 2.13)	1.67** (1.18, 2.36)	1.23 (0.87, 1.73)	1.86** (1.27, 2.74)	2.14*** (1.49, 3.06)	1.53* (1.08, 2.16)
PA	0.63* (0.43, 0.92)	0.87 (0.64, 1.18)	0.70* (0.51, 0.98)	0.71* (0.52, 0.98)	0.89 (0.63, 1.25)	0.72 (0.51, 1.03)	0.61** (0.44, 0.83)
Model 3							
WC-NHLBI	1.58* (1.05, 2.39)	1.47* (1.05, 2.08)	1.53* (1.07, 2.20)	1.15 (0.81, 1.65)	1.53* (1.02, 2.30)	1.90*** (1.30, 2.76)	1.33 (0.93, 1.91)
PA	0.68* (0.46, 1.01)	0.98 (0.71, 1.34)	0.84 (0.60, 1.19)	0.83 (0.60, 1.16)	1.05 (0.73, 1.51)	0.82 (0.57, 1.19)	0.67* (0.48, 0.93)

Abbreviations: WC is waist circumference and PA is physical activity. The waist circumference class I values are specific to BMI class I obesity, low risk (men < 43 inches and women < 42 inches) or high risk (men ≥ 43 inches and women ≥ 42 inches) [73]. NHLBI is National Heart Lung Blood Institute waist circumference thresholds [66], low risk (men ≤ 40 inches, women ≤ 35 inches) high risk (> 40 inches men, > 35 inches women) (low risk = 0, high risk = 1).

Model 1 adjusted for WC (0 = low risk, 1 = high risk), age (0 = <80, 1 = ≥ 80), gender (0 = male, 1 = female), race (0 = white, 1 = black), education (0 = < 12, 1 = ≥ 12), and tobacco use (0 = no, 1 = yes).

Model 2 adjusted for all variables in Model 1 plus moderate physical activity (0 = < 5 days, 1 = ≥ 5 days).

Model 3 adjusted for all variables in Model 2 plus prescription medications (< 5 vs. ≥ 5), depression (0 = no, 1 = yes), self-reported health (0 = good or very good or excellent, 1 = poor or fair, except not included as an independent variable in the model with self-reported health as the dependent variable).

***$p \leq 0.001$, **$p \leq 0.01$, *$p \leq 0.05$.

CHAPTER 5

PHYSICAL LIMITATIONS MAY CONTRIBUTE TO THE FOOD INSECURITY-OBESITY PARADOX IN OLDER ADULTS AT SENIOR CENTERS IN GEORGIA

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Abstract

The role of physical limitations in the food insecurity-obesity paradox has not been extensively examined in older adults. Therefore, the purpose of this study was to explore the relationship of food insecurity with obesity and physical limitations among older Georgians participating in the Older Americans Act (OAA) congregate meal-site program (N = 623, median age = 76 years, 83% female, and 64% white, convenience sample). Food insecurity was assessed with the 6-item US Household Food Security Survey (FI-USDA) or the Nutrition Screening Initiative (FI-NSI); obesity was defined as BMI or waist circumference (WC) class II obesity; and physical limitations were defined as self-reported arthritis, joint pain, physical function, or weight-related disability. About 18% to 18.8% of participants were food insecure, 18.3% had class II obesity, 70.8% had arthritis, 69.7% had joint pain, 75% had poor physical function, and 17.7% had a weight-related disability. In a series of logistic regression models, food insecurity (FI-USDA) was most strongly and consistently associated with a weight-related disability [OR, 95% CI: 1.87 (1.10, 3.18), $p \leq 0.05$] and WC-class II obesity [2.56 (1.47, 4.44), $p \leq 0.001$], but was not associated with BMI-class II obesity, when controlled for age, gender, race, and the other three physical limitations. Also, when measured as FI-NSI, food insecurity was not consistently associated with weight-related disability. In conclusion, among these participants in congregate meal-site programs, weight-related disability emerged as a potential risk factor for food insecurity, but the relationships among food insecurity, obesity, and physical limitations were complex and depended on how these measures were defined. These results suggest that weight-related disability and obesity may be potential risk factors for food insecurity, and that obesity should not be a reason to limit or deny food assistance. Rather, improved targeting is

needed to identify this vulnerable subgroup of obese older adults with disabilities, as they may be in need of food assistance.

Introduction

Food insecurity is defined as "Limited or uncertain availability of nutritionally adequate and safe foods or limited or uncertain ability to acquire acceptable foods in socially acceptable ways" [141]. In older adults, food insecurity has been associated with poor nutritional status, impaired health [15, 154, 157, 205], and risk factors including sociodemographic factors, social isolation, physical limitations, and disability [13, 15].

The paradoxical state of a relatively high prevalence of obesity among some food insecure populations has been termed the "food insecurity-obesity paradox" [168]. This paradox is of concern, because it may lead food assistance programs to question the wisdom of providing food assistance to individuals who are obese [24, 178]. This paradox has been studied in children and adults, but less is known about the food insecurity-obesity paradox in older adults [24, 149, 150, 170-172].

One subpopulation of older adults that may be at particularly high risk for both food insecurity and obesity is recipients of congregate meals and other nutrition-related services from Older Americans Act Nutrition Program (OAANP) that are provided through senior centers. OAA programs served 9 million Americans in 2006, about 19% of older adults, and target minority and low income seniors [5]. The goals of the OAANP include reducing food insecurity by providing nutritious meals and nutrition education [25], thus the OAANP is considered a food assistance program. Studies of congregate meal participants in Indiana [145, 152] and Georgia [144] reported a prevalence of food insecurity of 18% to 20%, which is about three times the national average of 6.5% in households with older adults [142].

OAANP participants may also be at high risk for obesity and several physical limitations that are associated with food insecurity. For example, among older adults attending Georgia senior centers, of whom many receive congregate meals, the prevalence of obesity was 38% (BMI $\geq$ 30 kg/m^2) and some measures of obesity were associated with an increased risk of arthritis and joint pain [179]. Furthermore, arthritis is the leading cause of disability [98] and obesity is a common risk factor for the development of arthritis and disability [16, 97]. Thus, these older adults appear to be at high risk for physical limitations and disability, which are risk factors for food insecurity [13, 156] that may be exacerbated by obesity.

The purpose of this study was to determine whether the food insecurity-obesity paradox exists in a sample of older adults known to have a high prevalence of food insecurity, obesity, and physical limitations, and who attend senior centers in Georgia with OAA and OAANP services [144, 179]. For the purposes of this study, the term "physical limitations" refers to these measures: arthritis, joint pain, physical function [9] and weight-related disability in daily activities [113]. It is hypothesized that both obesity and physical limitations contribute to food insecurity, but the effects of obesity may in part be moderated by physical limitations. If these hypotheses are correct, then it will be important to determine both obesity and physical limitations in assessing the risk of food insecurity and the need for food assistance in older adults. Results from this study are an important step in understanding the relevance and the potential underlying causes of the food insecurity-obesity paradox in older adults.

Methods

Sample

Questionnaires and procedures were approved by the Institutional Review Boards on Human Subjects of the University of Georgia and the Georgia Department of Human Resources.

Participants were a convenience sample of people aged 50 and older recruited from 40 senior centers at the end of 2007, as described previously [179]. Briefly, each of the 12 AAAs in Georgia was asked to recruit about 70 people from senior centers in their area. Senior centers were selected based on the support of the senior center director and interest of the participants. Most participants received congregate meals. Procedures were explained and the consent forms were read to participants, and written informed consent was obtained. Exclusions applied to homebound or when the interviewer determined an individual was unable to understand the informed consent and/or answer questions. Participants were interviewed by trained staff that read the questions to participants and recorded their responses. These procedures yielded 815 participants of whom 623 were included; 192 participants were excluded because of missing data for height, weight, WC, joint pain, arthritis, physical function, disability, food insecurity assessed by the NSI or the augmented US Household Food Security Survey Module 6-item short form (referred to as USDA 6-item short form), race/ethnicity other than black or white, being < 60 years, or having a BMI < 18.5 kg/m^2. Four participants that were missing responses to the USDA 6-item short form had their responses imputed to an "affirmative" answer based on the imputation guidelines [141]**.** We excluded participants with missing information pertaining to the NSI question because we analyzed results using the NSI question (data not shown, see appendix).

Food insecurity was assessed using the augmented USDA 6-item short form that measures food insecurity caused by the household not having enough money for food [141]. The question "You couldn't afford to eat balanced meals" was replaced with "You couldn't choose the right food and meals for your health because you couldn't afford them." Wolfe et al. [151] determined that having the right food and meals for health was important to older adults and provided a more comprehensive assessment of their food insecurity status. One-point is scored for each affirmative response to each question, such that the summary scores range from 0 to 6. In the present study, summary scores of 0 or 1 were designated as "secure" and scores of 2 to 6 were "insecure" (for data analyses 0 = food secure, 1 = food insecure, FI-USDA). A second measure of food insecurity was from the Nutrition Screening Initiative [165], "Do you always have enough money to buy the food you need?" ("no" indicated food insecure; for data analyses 0 = food secure, 1 = food insecure, FI-NSI).

Body weight was estimated as follows: a) with a scale, without shoes and with clothes (14% of participants); b) with a scale, with shoes and clothes on (71%); or c) self-reported and we assumed without clothes and shoes (15%). Height was assessed by: a) measurement with a tape measure with shoes on (43%) or b) self-reported (57%). BMI was calculated as weight (pounds)/height $(\text{inches})^2$ x 703. The BMI categories of interest in this study were similar to the clinical guidelines of NIH weight classifications [66, 73], and focused on class II obesity defined as ≥ 35 kg/m^2.

WC was measured with a tape measure either over the participants' clothing (90% of participants) or underneath their clothing (10%) by following guidelines provided by NIH [66, 73]. The WC threshold values used were validated BMI-specific WC cut-off measurements (established by Arden et al. [73]) and reflected BMI class II obesity, ≥ 35 kg/m^2. Low risk was defined as men < 49 inches and women < 45 inches, or high risk defined as men $\geq$ 49 inches and women $\geq$ 45 inches. Class II obesity was used as the cut-off because preliminary data analysis revealed that food insecurity was more strongly associated with class II rather than class I obesity measures of BMI, however, class I obese WC was strongly associated with food insecurity (see appendix).

We previously reported in this sample that the relationships of the health-related variables with BMI or WC were nearly always similar when using the uncorrected or corrected values for height, weight, and WC, e.g., corrected for gender, clothes and/or shoes being worn [179]. Thus, in the present study, uncorrected values for BMI and WC were used.

The variables associated with physical limitations were self-reported arthritis ("Do you have arthritis?" adapted from BRFFS [46]), joint pain ("During the past 30 days, have you had symptoms of pain, aching, or stiffness in or around a joint?" [49]), and disability ("Does your current weight affect your ability to do daily activities, such as walk, do housework, shop, etc?" [113]). Response categories were "yes" or "no."

Participants' physical function was assessed using the Short Physical Performance Battery [9] as described by Fitzpatrick et al. [95]**.** Poor performance on this test predicts future nursing home placement, disability, and death [9]. This test assesses balance, strength, and gait speed with measures of standing balance, chair stands, and an 8-foot walk, respectively, with performance in each category scored from 0 to 4. A summary performance score ranges from 0 to 12 with higher scores indicating higher performance: poor (0 to 5), moderate function (6 to 9), and good function (10 to 12). For data analyses, two categories were created: poor and moderate (0 to 9) and good (10 to 12). This was done because the rate of institutionalization was 4.8 to 22.5/100 person years with a physical function score of 0 to 9, but was 0.7 to 2.7 /100 person years with a score ranging from 10 to 12 [9], and approximately 75% of the analytic sample had a score of ≤ 9.

Statistics

Completed questionnaires and consent forms were sent to the University of Georgia. Data were analyzed using Statistical Analysis System version 9.1 (Cary, NC [183]). Descriptive statistics, including frequencies, medians, ranges, and Spearman correlation coefficients were calculated. The relationships of the dichotomous food insecurity variable with the continuous variables BMI, WC, and total physical function score were assessed using the Mann-Whitney U test for non-normally distributed data; relationships with the categorical variables were assessed with Chi-square analysis.

Logistic regression analyses were used to examine the independent contributions of BMI or WC (class II obesity, [66, 73]) and the physical limitation variables (arthritis, joint pain, physical function, and disability) to food insecurity status when controlling for age (< 80 or $\geq$ 80), gender, and race (black or white). Eight series of seven logistic regression models were assessed to examine these relationships: 1) FI-USDA with BMI class II obesity and physical limitations (Table 4), 2) FI-USDA with WC class II obesity and physical limitations (Table 5), and the following analyses that can be found in the appendix: 3) FI-NSI with BMI class II obesity and physical limitations, 4) FI-NSI with WC class II obesity and physical limitations, 5) FI-USDA with BMI class I obesity and physical limitations, 6) FI-NSI with BMI class I obesity and physical limitations, 7) FI-USDA with WC class I obesity and physical limitations, and 8) FI-NSI with WC class I obesity and physical limitations. The seven logistic regression models within each series included a demographics only model (age, gender, race), then five regression models with demographics and one other variable (obesity, arthritis, joint pain, physical function, or disability), and then a final 7^{th} model with all variables of interest.

Results

The characteristics of study participants are shown in Table 1. Among the participants included for analyses, 67% were aged 60 to 79 years, and most were female (82%) and white (64%). Significant differences between those included and excluded were that the excluded participants were younger and there was a lower prevalence of WC-class II obesity, but there were no differences in the other variables of interest. The prevalence of food insecurity was 18% to 19%. Since the primary focus of the logistic regression analyses was for FI-USDA, the results for FI-USDA are reported in this chapter and the results for FI-NSI are reported in the appendix.

In Table 2, the bivariate analysis showed that compared to the food secure, the food insecure were younger ($p \leq 0.0001$), more likely to be black than white ($p \leq 0.0001$), had higher BMI ($p \leq 0.0001$) and WC ($p \leq 0.0001$), and were more likely to have arthritis ($p \leq 0.001$), joint pain ($p \leq 0.003$), lower physical function score ($p \leq 0.04$) and poor/moderate physical function ($p \leq 0.05$), and to be have a weight-related disability ($p \leq 0.0001$). Both measures of food insecurity were significantly correlated with all variables of interest except for gender (Table 3). The four physical limitation variables were correlated significantly with one another as well as with both measures of obesity ($p \leq 0.05$).

Logistic regression analyses revealed that race was consistently and significantly associated with food insecurity (FI-USDA, FI-NSI, OR > 3 in all models, Table 4, Table 5, and appendices), but the relationships among food insecurity, obesity, and the four measures of physical limitations were complex (Table 4, Table 5, and appendices). When controlled for demographic factors, food insecurity (FI-USDA) was significantly associated with BMI class II obesity alone or in combination with arthritis only, and joint pain only, but when disability was added to the model the relationship of BMI with FI-USDA was no longer apparent; in the final model disability, but not BMI or any of the other physical limitation variables, was significantly associated with FI-USDA (Table 4, OR 2.18, 95% CI 1.27, 3.73, $p \leq 0.01$). FI-NSI was significantly associated with BMI class II obesity in only one model, as well as with arthritis alone, joint pain alone, and physical function alone, but not with disability; FI-NSI was significantly associated with only race in the final model (appendix A).

FI-USDA was not associated with BMI class I obesity in any model, but was associated with arthritis alone, joint pain alone, and disability alone; in the final model disability emerged as the variable significantly associated with FI-USDA (appendix B). FI-NSI was not associated with BMI class I obesity in any model, but was associated with arthritis alone, joint pain alone, and physical function alone; in the final model race was the only variable significantly associated with FI-USDA (appendix C).

Next the regression models involving WC will be summarized. FI-USDA was significantly associated with WC class II obesity in all models (OR > 2.5) and with arthritis alone, joint pain alone, and disability alone; in the final model both WC (OR 2.56, 95% CI 1.47, 4.44) and disability (OR 1.87, 95% CI 1.10, 3.18) were significantly associated with FI-USDA (Table 5). FI-NSI was significantly associated with WC class II obesity in all of the models (OR > 2) and with arthritis alone, joint pain alone; in the final model both joint pain and WC class II obesity remained significantly associated with FI-NSI (appendix D). FI-USDA was associated with WC class I obesity in all of the models (OR > 1.7) and with arthritis alone, joint pain alone, disability alone; in the final model both disability and WC class I obesity remained significantly associated with FI-USDA (appendix E). FI-NSI was associated with WC class I obesity in only one model, with arthritis alone, joint pain alone; in the final model only race was significantly associated with FI-NSI (appendix F).

Although Catlett [144] found in multivariate regression modeling that education, tobacco use, depression, prescription medications, and self-reported health were not significantly related to FI-USDA, and were inconsistently related to FI-NSI, it was decided to examine the relationship of these variables with FI. When the variables education (0 = < 12, 1 = ≥ 12 years), tobacco (0 = no, 1 = yes), depression (0 = no, 1 = yes), medications (0 = < 5, 1 = ≥ 5), and self-reported health (0 = good or very good or excellent, 1 = poor or fair) were added to these models the results concerning obesity and disability with food insecurity in the final models were similar to analyses that controlled for age, gender and race only. In the final models with the variables of interest the outcomes for FI, obesity, and physical limitations were: FI-USDA that included BMI class II obesity was significantly associated with disability only; FI-NSI that included BMI class II obesity was significantly associated with joint pain only; FI-USDA that included BMI class I obesity was significantly associated with disability only; and FI-NSI that included BMI class I obesity was associated with physical function only.

Concerning WC: FI-USDA that included WC class II obesity was significantly associated with WC only; FI-NSI that included WC class II obesity was significantly associated with WC only; FI-USDA that included WC class I obesity was significantly associated with disability only; and FI-NSI that included WC class I obesity was significantly associated with joint pain only.

There were differences in that disability was no longer associated with FI-USDA in the final model with WC class II obesity ($p < 0.06$), but in the model with disability alone both WC and disability remained significantly associated with FI-USDA. FI-NSI that included BMI class II obesity was significantly associated with only joint pain in the final model with; FI-USDA was no longer associated with WC class I obesity in the final model; and FI-NSI that included either BMI or WC class I obesity was significantly associated with poor physical function only in the final models (data not shown).

Discussion

The major findings of this study were that the bivariate analyses indicated food insecurity was significantly associated with all of the class II obesity- and physical limitation-related measures, but the multivariate analyses demonstrated that FI-USDA food insecurity was consistently and significantly associated in the final regression models (model 7) with being black (vs. white), having a high risk WC, and in models with WC, reporting weight-related disability. Thus, the food insecurity-obesity paradox exists, but it is at least in part accompanied and/or mediated by physical limitations, as hypothesized, and is more apparent when WC rather than BMI is used as the measure of adiposity. To our knowledge, these relationships have not been reported among older adults attending senior centers with OAANP programs. The high prevalence of food insecurity (18% and 19% vs. 6.5% nationally in older adults, [142]), obesity (class I: 40.0% vs. 23% nationally in older adults [67]), and weight-related disability (18%) suggests these relationships are of practical concern in this vulnerable subgroup of older adults.

The discussion will primarily focus on results obtained from the FI-USDA food insecurity with class II obesity measurements, but results derived from the FI-NSI food insecurity with class I and class II obesity measurements and FI-USDA food insecurity with class I obesity measurements, revealed that disability was consistently and significantly associated with FI-USDA, but not with FI-NSI.

Being black may have emerged as a strong indicator of food insecurity, perhaps because the race/ethnicity variable was acting as a proxy for risk factors associated with food insecurity, such as social isolation, lack of transportation, and/or low-income [13, 15], that should be measured in future studies. Others also have reported that physical limitations and/or disability are related to food insecurity in older adults [13, 14, 157, 206]. However, to our knowledge this is the first study to explore the relationships of food insecurity with measures of both obesity and physical limitations that varied in severity. The variables used to assess physical limitations in the present study were selected based on the Disablement Process [99], which is an extension of the Nagi model [100], and fit into the Disablement Process as follows: pathology was defined as arthritis, impairments as joint pain, functional limitations as poor physical function, and disability with the question, "Does your current weight affect your ability to do daily activities, such as walk, do housework, shop, etc?"

Due to the cross-sectional nature of the present study, it is not certain that disability led directly to food insecurity. These variables were significantly correlated (*rho* = 0.18, $p \leq 0.0001$), and a conceptual model developed by Wolf et al. [14] suggests that physical disabilities can lead to restricted mobility that in turn leads to food insecurity. These relationships are of concern because of the detrimental cascade that can be triggered by disability [16]. A new Disablement Process can be initiated from the secondary conditions and dysfunctions created from the original process [99]. For example, obesity-associated arthritis could lead to disability that could lead to food insecurity, which then becomes a risk-factor for establishing a new and more severe outcome of the Disablement Process, such as a debilitating chronic condition that could lead to institutionalization or death [9]. Longitudinal studies are needed to examine the disablement processes, food insecurity, the resulting malnutrition and poor health, and the subsequent risk for institutionalization or death.

The food insecurity-obesity paradox has been studied among children and adults [24, 170, 172]. Concerning older adults, one study examined, in two different longitudinal data sets, whether the prevalence of overweight status changed over time among food insecure older adults who were participating in the food stamp or home-delivered meals programs [149]. They found conflicting results between the two data sets, as there were small changes over time in the prevalence of overweight status of + 2.1% and -1.8%, between the two different data sets [149]. Additionally, these investigators controlled for certain activities of daily living (ADLs) and instrumental ADLs (IADLs), but did not report whether or not the relationships of ADLs and IADLs were significantly associated with food insecurity (12).

The growing obesity epidemic and the association of food assistance with obesity have led to suggestions that funding for food assistance programs should be decreased [178]. Currently, this issue remains unresolved because studies have shown inconsistent results [24, 149, 171, 172], which may be due to the cross-sectional nature of several studies. In the present study, it is not clear why WC, but not BMI, remained associated with food insecurity in the final regression models (model 7). Perhaps the height loss associated with aging complicates measurement and meaning of BMI in older adults. Also, WC may provide a more reliable measure of weight-related physical problems. Although this study did not focus on the relationships of disability with BMI or WC, others have observed that WC was a more sensitive indicator than BMI of some weight-related problems such as disability [86, 134]. A potential reason for this could be that as a person ages the distribution of fat changes, which is characterized by decreased appendage fat, increased visceral fat [81], and decreased strength [80], which in turn may increase the likelihood of disability. Another possibility is that as a psychological stressor, food insecurity could produce a state of chronic stress that is characterized by the release of glucocorticoids that promote the accumulation of visceral fat tissue and a deterioration of muscle tissue [175]. In turn, the accumulated visceral fat secretes pro-inflammatory cytokines that stimulate the stress response resulting in a detrimental cycle of metabolic chaos [175]. Thus, the stress-response to food insecurity may be more related to WC than to BMI due to the accumulation of central adipose tissue, thereby contributing to the stronger relationships of food insecurity to WC than to BMI. Objective assessments of WC, BMI, and behavioral and biochemical indices of stress in future studies would help clarify these aspects of the food insecurity-obesity paradox.

The potential causes behind the food insecurity-obesity paradox are not clearly understood and reasons for this paradox include: food insecurity causing limited access to a variety of foods resulting in consumption of high energy inexpensive foods [150], a pattern of cyclic binging and restrictive eating due to the availability of food, and the physiological adaptations to the disordered pattern of eating that can make the body more prone to store energy as body fat [168]. Additionally, as a psychological stressor, food insecurity may cause excessive consumption of food to cope with the stress [174]. Findings from the present study suggest that physical limitations should be considered and investigated as additional explanatory factors related to the food insecurity-obesity paradox.

As mentioned previously, disability remained as a strong indicator of FI-USDA food insecurity with BMI and WC class I obesity measurements in the models, but was not an indicator of FI-NSI food insecurity. It is not clear why this relationship developed as both measures of food insecurity focus on financial limitations. Possible reasons include that the FI-USDA measure is a valid and better indicator of food insecurity, or simply because more people answered “yes” to the disability question with FI-USDA (34%) compared to FI-NSI (27%).

The limitations of this study include use of a convenience sample, multiple interviewers across the state, and not all participants had their height and weight objectively measured [179]. The number of OAANP congregate meals received each week by participants was not assessed. The disability question did not assess the moderating effects of support (e.g., use of a cane or help from others) and did not determine whether overweight or underweight was the weight-related disability. Underweight participants (< 18.5 kg/m^2) were excluded, so it is likely that being overweight was the weight-related disability. The use of the 6-item US Household Food Security Survey Module is both a strength and a limitation. This survey is a reasonably reliable substitute for the validated 18-item survey and is less burdensome to the respondent. However, the 6-item survey does not measure the most severe levels of food insecurity, does not ask about conditions of children in the household, is less precise and somewhat less reliable than the 18-item measure [141], and has not been validated in older adults [163], but the 6 questions have been shown to have high specificity and sensitivity and minimal bias in comparison to the 18-item measure [163].

In conclusion, this study demonstrated that the food insecurity-obesity paradox exists in older adults attending senior centers that provide OAANP services in Georgia and that obesity (especially high risk WC), weight-related disability, and being black (vs. white) are associated robustly with food insecurity. However, longitudinal studies in representative samples of OAANP participants are needed to disentangle these complex relationships. The high prevalence of food insecurity (18% to 19%), class II obesity (18.3%), and weight-related disability (17.7%) suggest that these relationships are of practical concern and that the OAA programs at senior centers should address these issues in a systematic way, such as by recognizing physical limitations and obesity as potential risk factors for food insecurity, not using obesity as a reason to limit or deny food assistance, developing improved methods of identifying those most in need of food assistance, continued health promotion programs that emphasize and model healthy eating and physical activity, and referral to physicians and dietitians for weight management.

TABLE 5.1. Characteristics of participants: Georgia senior centers 2007

		Participants included (n = 623)		Participants excluded (n = 192)	p-values
		Median (range) or %		Median (range) or %	
	n		n		
Age (years)		76 (60, 97)	192	72 (51, 97)	0.0001
60-69	132	21.1	55	28.7	0.001
70-79	287	46.1	68	35.4	
80-89	178	28.6	44	22.9	
>89	26	4.2	8	4.2	
Gender			192		0.07
Male	109	17.5	45	23.4	
Female	514	82.5	147	76.6	
Race/ethnicity			183		0.26
White	396	63.6	108	59.0	
Black	227	36.4	75	41.0	
Body mass index (kg/m^2)		28.3 (18.9, 64)	192	28.7 (14.0, 53.3)	0.11
≥ 18.5 to < 25	156	25.0	43	28.5	0.78
≥ 25 to < 30	219	35.2	56	37.1	
≥ 30 to < 35	134	21.5	27	17.9	
≥ 35 to < 40	65	10.4	15	9.9	
≥ 40	49	7.9	10	6.6	
Class II obesity (kg/m^2)			192		0.09
< 35	509	81.7	167	87.0	
≥ 35	114	18.3	25	13.0	
Waist circumference (inches)			191		
Men	109	41.0 (29.0, 57.0)	45	39.0 (30.0, 54.0)	0.08
Women	514	38.0 (25.0, 57.0)	147	38.0 (26.0, 57.0)	0.61
Waist circumference categories using BMI ranges (Arden et al.)			191		0.0001
Normal	221	35.5	109	56.8	
Overweight	203	32.6	48	25.0	
Class I obese	111	17.8	18	9.4	
Class II & class III obese	88	14.1	17	8.9	
Waist circumference class II obesity					
Low risk	535	85.9	175	91.2	0.06
High risk	88	14.1	17	8.9	
Arthritis		70.8	190	65.8	0.19
Joint pain		69.7	192	67.2	0.49
Physical function		8 (0, 12)	192	7 (0, 12)	0.15
Poor to moderate (0-9)	467	75.0	67	78.8	0.56
Good (10-12)	156	25.0	18	21.2	
Disability (weight-related)		17.7	180	15.9	0.56
Food insecurity					
FI-NSI		18.0	170	21.4	0.31
FI-USDA		18.8	192	21.9	0.34

N = 623.

TABLE 5.2. Characteristics of food secure and food insecure participants (FI-USDA): Georgia senior centers 2007

	n	Food secure Median (range) Or %	Food insecure Median (range) or %	p-values
Age (years)		77 (60, 97)	72 (60, 89)	0.0001
60-69	132	68.1	31.8	0.0001
70-79	287	82.9	17.1	
80-89	178	85.4	14.6	
>89	26	100.0	0.0	
Gender				0.08
Male	109	87.2	12.8	
Female	514	80.0	20.0	
Race/ethnicity				0.0001
White	396	89.1	11.0	
Black	227	67.4	32.6	
Body mass index (kg/m^2)		28.0 (18.9, 53.5)	30.5 (19.2, 64.0)	0.0001
Normal	156	27.7	13.7	0.0001
Overweight	219	35.8	34.2	
Class I obesity	134	21.5	21.4	
Class II & III obesity	114	15.4	31.6	
Waist circumference (high risk: > 40 inches men, > 35 inches women, NHLBI)	117	61.7	76.9	0.002
Waist circumference categories using BMI ranges [66, 73]	402			0.0001
Normal	221	38.3	23.1	
Overweight	203	33.2	29.9	
Class I obesity	111	18.2	16.2	
Class II & III obesity	88	10.3	30.8	
Arthritis				0.001
Yes	441	68.0	82.9	
No	182	32.0	17.1	
Joint Pain				0.003
Yes	434	67.0	81.2	
No	189	33.0	18.8	
Physical function		8 (0, 12)	7 (0, 12)	0.04
Three categories				
Poor (0-5)	147	22.7	27.4	0.13
Moderate (6-9)	320	50.6	54.7	
Good (10-12)	156	26.7	17.9	
Two categories				
Poor to moderate (0-9)	156	73.3	82.0	0.05
Good (10-12)	467	26.7	18.0	
Disability (weight-related)				0.0001
Yes	110	14.4	31.6	
No	513	85.6	68.4	

N = 623.
Abbreviations: NHLBI = National Heart Lung Blood Institute [66, 73].
P $\leq$ 0.05 is considered statistically significant.

TABLE 5.3. Spearman correlations between variables of interest: Georgia senior centers 2007

	Age	Gender	Race	BMI	WC	Arthritis	Joint pain	Physical function	Disability	FI-USDA
Gender	0.01									
Race	-0.08*	0.08								
BMI	-0.24***	0.03	0.12**							
WC	-0.18***	0.08*	0.09*	0.54***						
Arthritis	0.004	0.02	0.06	0.17***	0.14***					
Joint pain	-0.05	-0.02	0.04	0.16***	0.09*	0.56***				
Physical function	0.14***	0.02	0.16***	0.08*	0.11*	0.13**	0.12**			
Disability	-0.18***	-0.03	0.03	0.37***	0.30***	0.17***	0.16***	0.09*		
FI-USDA	-0.11**	0.07	0.26***	0.16***	0.23***	0.13**	0.12**	0.08*	0.18***	
FI-NSI	-0.10*	0.07	0.24***	0.14***	0.18***	0.11**	0.13**	0.11**	0.11**	0.60***

N = 623.

Variables are coded as follows: gender (0 = male, 1 = female), race (0 = white, 1 = black), BMI (class II obesity: 0 = < 35, 1 = $\geq$ 35 kg/m^2), WC (class II obesity: 0 = high risk, 1 = low risk), arthritis, joint pain, disability (0 = no, 1 = yes), physical function (0 = $\leq$ 9, 1 = $\geq$ 10), FI-USDA and FI-NSI (0 = food secure, 1 = food insecure).

***$p \leq 0.001$, **$p \leq 0.01$, *$p \leq 0.05$

TABLE 5.4. Logistic regression analyses of the relationships of food insecurity (FI-USDA) with BMI (class II obesity) and physical limitations: Georgia senior centers 2007

	Model 1	**Model 2**	**Model 3**	**Model 4**	**Model 5**	**Model 6**	**Model 7**
	Odds Ratios (95% CI)						
Age (0 = < 80, 1 = ≥ 80)	0.57* (0.35, 0.93)	0.66 (0.40, 1.09)	0.63 (0.38, 1.05)	0.66 (0.39, 1.09)	0.63 (0.38, 1.05)	0.70 (0.42, 1.17)	0.65 (0.39, 1.11)
Gender (0 = male, 1 = female)	1.54 (0.82, 2.86)	1.48 (0.79, 2.76)	1.46 (0.77, 2.71)	1.49 (0.80, 2.78)	1.49 (0.80, 2.79)	1.56 (0.83, 2.94)	1.54 (0.82, 2.90)
Race (0 = white, 1 = black)	3.79*** (2.48, 5.78)	3.61*** (2.36, 5.54)	3.59*** (2.34, 5.53)	3.64*** (2.37, 5.59)	3.48*** (2.25, 5.35)	3.80*** (2.46, 5.86)	3.71*** (2.38, 5.77)
BMI-class II obesity (0 = < 35, 1 = ≥ 35)	-	1.85* (1.12, 3.05)	1.65* (0.99, 2.73)	1.67* (1.004, 2.77)	1.81* (1.10, 2.98)	1.37 (0.80, 2.34)	1.23 (0.71, 2.11)
Arthritis (0 = no, 1 = yes)	-	-	2.05** (1.19, 3.51)	-	-	-	1.52 (0.80, 2.90)
Joint pain (0 = no, 1 = yes)	-	-	-	1.94* (1.15, 3.27)	-	-	1.44 (0.77, 2.68)
Physical function (0 = good, 1 = poor/moderate)	-	-	-	-	1.38 (0.80, 2.37)	-	1.20 (0.69, 2.10)
Disability (0 = no, 1 = yes)	-	-	-	-	-	2.42** (1.42, 4.12)	2.18** (1.27, 3.73)

N = 623.

Dash (-) indicates that this relationship was not analyzed in this model.

***p ≤ 0.001, **p ≤ 0.01, *p ≤ 0.05.

Table 5.5. Logistic regression analyses of the relationships of food insecurity (FI-USDA) with WC (class II obesity), and physical limitations: Georgia senior centers 2007

	Model 1	**Model 2**	**Model 3**	**Model 4**	**Model 5**	**Model 6**	**Model 7**
	Odds Ratios (95% CI)						
Age (0 = < 80, 1 = $\geq$ 80)	0.57* (0.38, 0.995)	0.70 (0.42, 1.15)	0.68 (0.41, 1.12)	0.71 (0.43, 1.18)	0.68 (0.41, 1.13)	0.76 (0.46, 1.26)	0.73 (0.44, 1.23)
Gender (0 = male, 1 = female)	1.54 (0.82, 2.86)	1.54 (0.81, 2.92)	1.33 (0.71, 2.49)	1.36 (0.73, 2.56)	1.36 (0.72, 2.54)	1.41 (0.75, 2.66)	1.40 (0.74, 2.64)
Race (0 = white, 1 = black)	3.79*** (2.48, 5.78)	3.72*** (2.41, 5.74)	3.69*** (2.39, 5.71)	3.74*** (2.42, 5.79)	3.61*** (2.33, 5.60)	3.83*** (2.47, 5.93)	3.77*** (2.41, 5.88)
WC-class II obesity (0 = low risk, 1 = high risk)	-	3.33*** (1.97, 5.62)	3.04*** (1.79, 5.15)	3.20*** (1.89, 5.42)	3.23*** (1.90, 5.47)	2.69** (1.56, 4.66)	2.56*** (1.47, 4.44)
Arthritis (0 = no, 1 = yes)	-	-	1.96* (1.14, 3.38)	-	-	-	1.42 (0.74, 2.71)
Joint pain (0 = no, 1 = yes)	-	-	-	1.99** (1.17, 3.37)	-	-	1.53 (0.82, 2.85)
Physical function (0 = good, 1 = poor/moderate)	-	-	-	-	1.26 (0.73, 2.19)	-	1.11 (0.64, 1.97)
Disability (0 = no, 1 = yes)	-	-	-	-	-	2.11** (1.25, 3.56)	1.87* (1.10, 3.18)

N = 623.

Dash (-) indicates that this relationship was not analyzed in this model.

***$p \leq 0.001$, **$p \leq 0.01$, *$p \leq 0.05$.

CHAPTER 6

CONCLUSION

The primary goals of these studies were to characterize, among participants of the OAA congregate meal-site programs, the relationships of adiposity with obesity-related comorbidities, the extent to which moderate physical activity can attenuate obesity-related comorbidities, and the existence of the food insecurity-obesity paradox and how obesity and physical limitations contributes to potential underlying causes.

The purpose of the study presented in Chapter 3 was to determine the extent to which BMI and WC were associated with the prevalence and number of selected comorbidities. This study established the foundation for the remaining chapters as it addressed whether being overweight and/or obese was associated with an increased prevalence of comorbidities. The study included measurements of BMI and WC to determine whether they provided similar associations of comorbidity prevalence. Also, this study compared whether the BMI and WC data were similar between corrected and uncorrected measurements as corrections were applied to height, weight, and waist circumference. For this study, it was hypothesized that overweight, obesity, and high WC would be associated with an increased prevalence of diabetes, heart disease, high cholesterol, hypertension, joint pain, and arthritis, as well as poor physical function, self-reported health, and chair-sit-and-reach. In general, the results demonstrated that the prevalence of select comorbidities is quite high among overweight and obese BMI categories, as well as with high risk WC. In addition, the relationships between the selected health-related indices and BMI or WC were nearly always similar when using the corrected or uncorrected values.

Overall, as BMI and WC increased the prevalence of diabetes, high blood pressure, and joint pain, and the number of comorbidities increased, physical function and flexibility decreased, and these relationships were independent of age, gender, and race. At least 80% of participants within the BMI category ≥ 35 to < 40 and 90% of participants with BMI ≥ 40 had 3 of the 6 comorbidities of interest: high blood pressure, joint pain, or arthritis. Over the range of BMI categories the prevalence of diabetes, high blood pressure, joint pain, and arthritis differed by at least 35-percentage points when BMI increased from < 25 to ≥ 40 and by 13-percentage points in the low risk vs. high risk WC categories.

High risk WC was a stronger indicator of poor physical function compared to BMI. Between the low and high risk WC categories the physical function score was 1-point lower in the high risk WC group, which is a significant decrease and can have serious consequences related to loss of independence that can lead to an increased use of health care services, disability, institutionalization, and death [114]. There was a high prevalence of decreased self-reported health with increasing BMI or WC, which was significantly decreased in the morbidly obese (BMI ≥ 40) and high risk WC. A poor to fair score on this global health assessment has been shown to strongly predict both decreased physical function [62, 189] and increased mortality [62, 189, 190].

This first study demonstrated that the prevalence of obesity-related comorbidities was very high within the obese weight categories among older adults participating in Georgia congregate meal-site programs. Future studies are needed to investigate which measurement of adiposity, BMI or WC, is the most telling as predictors of health risks associated with obesity. In this study the measurements were very similar indicators of most of the comorbidities, except for physical function in which WC was a better indicator. This could be an artifact of the WC cut-off values grouping participants in a certain manner favorable to showing poor physical function or the decrease in muscle mass and increased central adiposity associated with aging leads to poor physical function that would be more likely to appear as a high WC rather than an obese BMI. Community and clinical studies should continue to collect both measurements, if possible, to track which measurement is a more sensitive indicator of poor physical function. Rather than trying to find the most appropriate BMI recommendations for older adults, recommendations for weight management may need to be derived from WC. In addition, there is an obvious need for targeted education to teach this population predisposed to obesity on how to make lifestyle changes that promotes a healthy diet and high physical function with the goal of preventing an increase in weight-category because as this study showed the prevalence of comorbidities increased with increasing weight status.

The purpose of the second study presented in Chapter 4 was to determine whether physical activity attenuated the relationship of obesity with obesity-related comorbidities in older Georgians participating in OAA congregate meal-site programs. It was hypothesized that meeting the recommendations for moderate physical activity would attenuate the relationship of obesity with these comorbidities.

Surprisingly the major finding of this study was that moderate physical activity, 30 minutes per day on 5 or more days per week, did not attenuate the risk of obesity-related comorbidities in the regression models, except for falls. In fact, the adverse associations of obesity, when controlled for demographics, tobacco use, education, and specific health variables (depression, medications, and self-reported health), were robustly associated with several comorbidities.

In this second study, class I obesity and greater, rather than overweight and obesity as in the first study, was assessed because the first study showed the prevalence of diabetes, high blood pressure, arthritis, and joint pain was at least 20-percentage points higher in obese compared to normal weight participants (BMI $\geq$ 30 vs. < 25 kg/m^2), while these same conditions were at 13-percentage points higher in those with a high vs. low risk waist circumference (WC) [179]. The use of WC cut-offs specific to BMI thresholds were introduced in this study because according to Arden et al. [73] these WC categories are more closely in-line with their respective BMI category in regards to predicting health risk. The traditional WC cut-offs used by the NHLBI [66] were not designed based on the relationship between WC and health risk[73], but rather were designed in relation with BMI to be used in place of BMI as an alternative way to identify those in need of weight management intervention.

In this second study, all of the obesity measurements remained associated with at least four out of the seven comorbidities in the final model that controlled for all variables of interest. These comorbidities were low-chair-sit-and-reach, joint pain, diabetes, and high blood pressure. Regarding moderate physical activity, it did remain robustly associated with decreased risk of both poor physical function and poor or fair self-reported health in the final models, but physical activity did not appear to attenuate the effects of obesity on the risk of the selected obesity-related comorbidities.

There are several reasons why physical activity may not have attenuated the effects of obesity on obesity-related comorbidities. The criteria used for assessing the attenuating effects of physical activity on obesity may have lacked sensitivity to detect the subtle attenuations that physical activity may have had on the relationship between obesity and the comorbidities; the definition and measurement of physical activity; how the comorbidities were defined and measured; and/or the cross-sectional nature of the data all may have contributed to the lack of physical activity attenuating the associations of obesity with obesity-related comorbidities.

These results of the second study demonstrate a need for community-based health promotion interventions targeting Georgians participating in OAA programs that promote physical activity, achievement of a healthy body weight through good nutrition and increased physical activity, and provision of referrals for weight management. Future studies are needed to investigate the associations of obesity-related comorbidities and the effect of moderate physical activity among obese older adults. Indicators of improvement should include quantitative measures such as blood pressure in mm Hg, hemoglobin Ac1, and medication doses and types. This would be advantageous as this would be more likely to capture the benefits of physical activity because if a person's blood pressure improved from stage II hypertension to stage I they would still report having high blood pressure, but their measure of blood pressure would be lower thereby demonstrating the positive effects of physical activity. Also a physical activity intervention would provide insight as to whether participation in moderate-intensity physical activity attenuated the relationship of obesity with obesity-related comorbidities. A physical activity intervention could compare exercise programs to identify a program that is most beneficial towards improving obesity-related comorbidities. A study could compare a group that participates in a variety of exercises, appropriate for obese older adults and inexpensive, which focuses on exercises known to improve obesity-related comorbidites, to a group of older adults using "traditional" exercise programs, such as walking, that has shown to have positive health benefits[195]. The outcomes could include improvements in biochemical markers, medication types and doses, strength, flexibility, balance, and gait speed that are specific to each comorbidity.

The purpose of the third study presented in Chapter 5 was to determine whether the food insecurity-obesity paradox existed in a sample of older adults known to have a high prevalence of food insecurity, obesity, and physical limitations who attend senior centers in Georgia with OAA and OAANP services [144, 179]. The physical limitations of interest were arthritis, joint pain, physical function [9] and weight-related disability in daily activities [113]. Food insecurity was assessed using the augmented 6-item short form USHFSSM [141, 151] (FI-USDA) and the NSI question "Do you always have enough money to buy the food you need" [165] (FI-NSI). Class II obesity was used as the cut-off because preliminary data analysis revealed that food insecurity was more strongly associated with class II rather than class I obesity measures of BMI, however, class I obese WC were strongly associated with food insecurity (see appendix). It was hypothesized that both obesity and physical limitations contribute to food insecurity, but the effects of obesity may in part be moderated by physical limitations.

The major findings of this third study were that the multivariate analyses demonstrated that FI-USDA food insecurity was consistently and significantly associated in the final regression models, which included all physical limitations and the obesity measurement of interest, with being black, having a high risk WC, and in models with WC, reporting weight-related disability. Thus, the food insecurity-obesity paradox exists, but it is partly explained by physical limitations, as hypothesized, and is more apparent when WC rather than BMI is used as the measure of adiposity. To our knowledge, these relationships have not been reported among older adults attending senior centers with OAANP programs.

All of the physical limitation variables were analyzed because of their placement in the Disablement Process [99]: pathology was defined as arthritis, impairments as joint pain, functional limitations as poor physical function, and weight-related disability. Understanding the relationship of obesity causing physical limitations and leading to food insecurity is critical because the Disablement Process shows how the end point of one Disablement Process can be initiate a new and more detrimental process [99]. For example, obesity-associated arthritis could lead to disability that could lead to food insecurity, which then becomes a risk-factor for establishing a new condition, such as a debilitating chronic condition that could lead to institutionalization or death [9].

It is not clear why WC, but not BMI, remained associated with food insecurity in the final regression models. Perhaps the height loss associated with aging complicates measurement and meaning of BMI in older adults. As mentioned above, WC may provide a more reliable measure of weight-related physical problems due to changes in muscle and fat re-distribution, which in turn may increase the likelihood of disability.

Another possibility is that as a psychological stressor, food insecurity could produce a state of chronic stress that is characterized by the release of glucocorticoids that promote the accumulation of visceral fat tissue and a deterioration of muscle tissue [175]. In turn, the accumulated visceral fat secretes pro-inflammatory cytokines that stimulate the stress response resulting in a detrimental cycle of metabolic chaos [175]. Thus, the stress-response to food insecurity may be more related to WC than to BMI due to the accumulation of central adipose tissue, thereby contributing to the stronger relationships of food insecurity to WC than to BMI. Objective assessments of WC, BMI, and behavioral and biochemical indices of stress in future studies would help clarify these aspects of the food insecurity-obesity paradox. At this point a cytokine unique to the stress response that is different from the inflammatory response seen with excess-adiposity has not been identified. An interesting study would be to compare the body composition and certain markers of inflammation secreted from adipose tissue, such as interleukin-6 or tumor necrosis factor-alpha, from older adults who are food insecure obese, food secure obese, food insecure normal-weight, and food secure normal-weight to determine how obesity itself, food insecurity itself, and the combination of food insecurity and obesity contribute to the stress response. Among the obese subjects body composition could be used to exam whether the stress response of a food insecure obese person is more pronounced to the degree that these people are at higher risk of developing sarcopenic obesity compared to an obese older adult because a part of the pathology of sarcopenia is the inflammatory response that deteriorates muscle tissue. Therefore, it is possible that the stress associated with food insecurity could increase an older obese adult's risk of sarcopenic obesity, which could lead to disabilities and further health complications. Important factors to consider would be history of excess adiposity and food insecurity, and the level of food insecurity.

Also, studies are needed to further understand the pattern of binge-eating. It would be interesting to compare the metabolism of food insecure obese people with food insecure normal-weight people to determine if the former have lower energy expenditure, decreased fatty acid and glucose oxidation, and increased lipogenesis. Also, it would be interesting to compare the physical activity behaviors and the eating behaviors of both the obese and normal-weight food insecure to determine whether there is a binge-eating pattern in either of the two groups, whether the types of foods that are consumed differ to the degree that weight gain is a result, and if participation in physical activity is a reason why the food insecure normal-weight people are able to maintain a healthy body weight.

The notion that food assistance programs have the potential to make food insecure participants overweight and/or obese is another area that requires further investigation. Longitudinal studies would be needed to study this association and information pertaining to their weight and history of food assistance participation would be critical for studying this relationship.

In conclusion, obesity should not be used as a reason to limit or deny food assistance, instead OAA programs at senior centers should recognize physical limitations and obesity as potential risk factors for food insecurity. As mentioned above, additional studies need to be conducted to characterize the eating patterns, diet composition, and the participation in physical activity to better understand why obesity exists among the food insecure.

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APPENDIX A

SUPPLEMENTAL TABLES FOR CHAPTER 5

Logistic regression analyses of the relationships of food insecurity (FI-NSI) with BMI (class II obesity) and physical limitations: Georgia senior centers 2007

	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6	Model 7
	Odds Ratios (95% CI)						
Age (0 = < 80, 1 = ≥ 80)	0.61* (0.37, 0.995)	0.69 (0.42, 1.15)	0.67 (0.40, 1.11)	0.69 (0.42, 1.15)	0.64 (0.38, 1.07)	0.71 (0.43, 1.19)	0.65 (0.39, 1.10)
Gender (0 = male, 1 = female)	1.60 (0.86, 2.97)	1.55 (0.82, 2.94)	1.53 (0.81, 2.89)	1.56 (0.82, 2.96)	1.57 (0.83, 2.99)	1.59 (0.84, 3.02)	1.58 (0.83, 3.01)
Race (0 = white, 1 = black)	3.42*** (2.23, 5.24)	3.27*** (2.13, 5.04)	3.24*** (2.11, 5.00)	3.29*** (2.13, 5.08)	3.06*** (1.98, 5.73)	3.33*** (2.16, 5.14)	3.16*** (2.04, 4.91)
BMI-class II obesity (0 = < 35, 1 = ≥ 35)	-	1.70* (1.02, 2.83)	1.54 (0.92, 2.58)	1.51 (0.91, 2.53)	1.63 (0.98, 2.72)	1.44 (0.84, 2.47)	1.28 (0.74, 2.22)
Arthritis (0 = no, 1 = yes)	-	-	1.78* (1.04, 3.03)	-	-	-	1.20 (0.64, 2.26)
Joint pain (0 = no, 1 = yes)	-	-	-	2.10** (1.23, 3.59)	-	-	1.80 (0.95, 3.39)
Physical function (0 = good, 1 = poor/moderate)	-	-	-	-	1.80* (1.01, 3.20)	-	1.65 (0.92, 2.97)
Disability (0 = no, 1 = yes)	-	-	-	-	-	2.83 (1.64, 0.95)	1.44 (0.82, 2.50)

N = 623.

Dash (-) indicates that this relationship was not analyzed in this model.

***p ≤ 0.001, **p ≤ 0.01, *p ≤ 0.05.

Logistic regression analyses of the relationships of food insecurity (FI-USDA) with BMI (class I obesity) and physical limitations: Georgia senior centers 2007

	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6	Model 7
	Odds Ratios (95% CI)						
Age (0 = < 80, 1 = ≥ 80)	0.57* (0.35, 0.93)	0.78 (0.45, 1.35)	0.74 (0.43, 1.28)	0.78 (0.45, 1.34)	0.75 (0.43, 1.30)	0.84 (0.48, 1.45)	0.80 (0.45, 1.40)
Gender (0 = male, 1 = female)	1.54 (0.82, 2.86)	0.97 (0.50, 1.89)	0.95 (0.49, 1.85)	0.97 (0.50, 1.88)	0.97 (0.50, 1.89)	1.03 (0.53, 2.03)	1.00 (0.51, 1.98)
Race (0 = white, 1 = black)	3.79*** (2.48, 5.78)	6.03*** (3.58, 10.14)	5.95*** (3.53, 10.04)	6.07*** (3.60, 10.25)	5.71*** (3.36, 9.69)	6.43*** (3.78, 10.94)	6.32*** (3.66, 10.92)
BMI-class I obesity (0 = < 30, 1 = ≥ 30)	-	1.07 (0.61, 1.87)	1.00 (0.57, 1.76)	1.02 (0.58, 1.80)	1.07 (0.61, 1.87)	0.86 (0.48, 1.55)	0.81 (0.44, 1.47)
Arthritis (0 = no, 1 = yes)	-	-	1.79* (0.99, 3.24)	-	-	-	1.29 (0.63, 2.64)
Joint pain (0 = no, 1 = yes)	-	-	-	1.85* (1.03, 3.30)	-	-	1.60 (0.80, 3.22)
Physical function (0 = good, 1 = poor/ moderate)	-	-	-	-	1.39 (0.72, 2.69)	-	1.17 (0.60, 2.31)
Disability (0 = no, 1 = yes)	-	-	-	-	-	3.14** (1.52, 6.46)	2.99** (1.44, 6.22)

N = 623.

Dash (-) indicates that this relationship was not analyzed in this model.

***p ≤ 0.001, **p ≤ 0.01, *p ≤ 0.05.

Logistic regression analyses of the relationships of food insecurity (FI-NSI) with BMI (class I obesity) and physical limitations: Georgia senior centers 2007

	Model 1	**Model 2**	**Model 3**	**Model 4**	**Model 5**	**Model 6**	**Model 7**
	Odds Ratios (95% CI)						
Age (0 = < 80, 1 = ≥ 80)	0.61* (0.38, 1.00)	0.79 (0.46, 1.36)	0.75 (0.43, 1.28)	0.79 (0.46, 1.35)	0.72 (0.42, 1.24)	0.80 (0.47, 1.38)	0.70 (0.40, 1.23)
Gender (0 = male, 1 = female)	1.60 (0.85, 3.02)	1.19 (0.60, 2.37)	1.16 (0.58, 2.32)	1.19 (0.59, 2.37)	1.19 (0.59, 2.38)	1.20 (0.60, 2.40)	1.15 (0.57, 2.31)
Race (0 = white, 1 = black)	3.41*** (2.23, 5.24)	5.01*** (3.00, 8.38)	4.94*** (2.94, 8.29)	5.07*** (3.02, 8.53)	4.49*** (2.67, 7.57)	5.03*** (3.01, 8.42)	4.60*** (2.72, 7.81)
BMI-class I obesity (0 = < 30, 1 = ≥ 30)	-	0.90 (0.51, 1.59)	0.83 (0.46, 1.48)	0.85 (0.47, 1.51)	0.89 (0.50, 1.60)	0.86 (0.48, 1.56)	0.82 (0.45, 1.50)
Arthritis (0 = no, 1 = yes)	-	-	2.09** (1.14, 3.85)	-	-	-	1.43 (0.70, 2.93)
Joint pain (0 = no, 1 = yes)	-	-	-	2.33** (1.27, 4.27)	-	-	1.84 (0.91, 3.73)
Physical function (0 = good, 1 = poor/moderate)	-	-	-	-	2.26* (1.09, 4.66)	-	2.06 (0.98, 4.31)
Disability (0 = no, 1 = yes)	-	-	-	-	-	1.25 (0.56, 2.78)	1.11 (0.49, 2.49)

N = 623.

Dash (-) indicates that this relationship was not analyzed in this model.

***p ≤ 0.001, **p ≤ 0.01, *p ≤ 0.05.

Logistic regression analyses of the relationships of food insecurity (FI-NSI) with WC (class II obesity) and physical limitations: Georgia senior centers 2007

	Model 1	**Model 2**	**Model 3**	**Model 4**	**Model 5**	**Model 6**	**Model 7**
	Odds Ratios (95% CI)						
Age (0 = < 80, 1 = ≥ 80)	0.61* (0.37, 0.995)	0.71 (0.43, 1.18)	0.70 (0.42, 1.16)	0.73 (0.44, 1.21)	0.67 (0.40, 1.11)	0.75 (0.45, 1.24)	0.70 (0.41, 1.17)
Gender (0 = male, 1 = female)	1.60 (0.86, 2.97)	1.45 (0.76, 2.75)	1.43 (0.75, 2.72)	1.47 (0.77, 2.79)	1.47 (0.77, 2.80)	1.48 (0.78, 2.82)	1.48 (0.77, 2.83)
Race (0 = white, 1 = black)	3.42*** (2.23, 5.24)	3.32*** (2.16, 5.12)	3.28*** (2.13, 5.07)	3.33*** (2.15, 5.16)	3.13*** (2.02, 4.85)	3.35*** (2.17, 5.17)	3.20*** (2.06, 4.97)
WC-class II obesity (0 = low-risk, 1 = high-risk)	-	2.54** (1.49, 4.32)	2.35*** (1.38, 4.01)	2.43*** (1.42, 4.15)	2.39*** (1.40, 4.08)	2.26** (1.29, 3.93)	2.12** (1.21, 3.72)
Arthritis (0 = no, 1 = yes)	-	-	1.73* (1.02, 2.95)	-	-	-	1.14 (0.61, 2.15)
Joint pain (0 = no, 1 = yes)	-	-	-	2.15* (1.25, 3.67)	-	-	1.89* (1.00, 3.56)
Physical function (0 = good, 1 = poor/moderate)	-	-	-	-	1.70 (0.95, 3.04)	-	1.57 (0.87, 2.84)
Disability (0 = no, 1 = yes)	-	-	-	-	-	1.50 (0.88, 2.57)	1.29 (0.75, 2.24)

N = 623.

Dash (-) indicates that this relationship was not analyzed in this model.

***p ≤ 0.001, **p ≤ 0.01, *p ≤ 0.05.

Logistic regression analyses of the relationships of food insecurity (FI-USDA) with WC (class I obesity) and physical limitations: Georgia senior centers 2007

	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6	Model 7
	Odds Ratios (95% CI)						
Age (0 = < 80, 1 = ≥ 80)	0.57* (0.35, 0.93)	0.66 (0.40, 1.09)	0.63 (0.38, 1.05)	0.67 (0.40, 1.11)	0.63 (0.38, 1.05)	0.73 (0.44, 1.21)	0.69 (0.41, 1.17)
Gender (0 = male, 1 = female)	1.54 (0.82 2.86)	1.61 (0.86, 3.00)	1.56 (0.83, 2.92)	1.60 (0.86, 3.00)	1.61 (0.86, 3.00)	1.64 (0.87, 3.07)	1.60 (0.85, 3.01)
Race (0 = white, 1 = black)	3.79*** (2.48, 5.78)	3.77*** (2.46, 5.80)	3.73*** (2.42, 5.75)	3.79*** (2.46, 5.84)	3.64*** (2.35, 5.62)	3.89*** (2.52, 6.02)	3.80*** (2.44, 5.93)
WC-class I obesity (0 = low-risk, 1 = high-risk)	-	2.12** (1.37, 3.29)	1.94** (1.24, 3.02)	2.01** (1.29, 3.14)	2.06** (1.33, 3.21)	1.78** (1.13, 2.82)	1.66* (1.04, 2.64)
Arthritis (0 = no, 1 = yes)	-	-	1.98** (1.15, 3.41)	-	-	-	1.44 (0.76, 2.75)
Joint pain (0 = no, 1 = yes)	-	-	-	1.96** (1.16, 3.30)	-	-	1.47 (0.79, 2.75)
Physical function (0 = good, 1 = poor/moderate)	-	-	-	-	1.31 (0.76, 2.26)	-	1.15 (0.66, 2.02)
Disability (0 = no, 1 = yes)	-	-	-	-	-	2.29** (1.37, 3.83)	2.04** (1.21, 3.44)

N = 623.

Dash (-) indicates that this relationship was not analyzed in this model.

***p ≤ 0.001, **p ≤ 0.01, *p ≤ 0.05.

Logistic regression analyses of the relationships of food insecurity (FI-NSI) with WC (class I obesity) and physical limitations: Georgia senior centers 2007

	Model 1	**Model 2**	**Model 3**	**Model 4**	**Model 5**	**Model 6**	**Model 7**
	Odds Ratios (95% CI)						
Age (0 = < 80, 1 = ≥ 80)	0.61* (0.38, 1.00)	0.67 (0.41, 1.10)	0.65 (0.39, 1.07)	0.68 (0.41, 1.12)	0.62 (0.37, 1.02)	0.71 (0.43, 1.75)	0.65 (0.39, 1.09)
Gender (0 = male, 1 = female)	1.60 (0.85, 3.02)	1.64 (0.87, 3.11)	1.60 (0.84, 3.03)	1.64 (0.86, 3.11)	1.65 (0.87, 3.13)	1.70 (0.88, 3.14)	1.62 (0.85, 3.09)
Race (0 = white, 1 = black)	3.41*** (2.23, 5.24)	3.38*** (2.20, 5.20)	3.33*** (2.16, 5.13)	3.38*** (2.19, 5.22)	3.15*** (2.04, 4.87)	3.41*** (2.22, 5.25)	3.22*** (2.08, 5.00)
WC-class I obesity (0 = low-risk, 1 = high-risk)	-	1.58* (1.01, 2.47)	1.46 (0.93, 2.29)	1.49 (0.95, 2.34)	1.51 (0.96, 2.36)	1.42 (0.89, 2.25)	1.30 (0.81, 2.08)
Arthritis (0 = no, 1 = yes)	-	-	1.78* (1.05, 3.03)	-	-	-	1.18 (0.63 2.23)
Joint pain (0 = no, 1 = yes)	-	-	-	2.14** (1.26, 3.66)	-	-	1.83 (0.97, 3.45)
Physical function (0 = good, 1 = poor/moderate)	-	-	-	-	1.76 (0.99, 3.14)	-	1.62 (0.90, 2.91)
Disability (0 = no, 1 = yes)	-	-	-	-	-	1.68 (0.99 2.84)	1.45 (0.85, 2.49)

N = 623.

Dash (-) indicates that this relationship was not analyzed in this model.

***p ≤ 0.001, **p ≤ 0.01, *p ≤ 0.05.

APPENDIX B

LIVE HEALTH GEORGIA CONSENT FORM AND QUESTIONNAIRE

I, ______________________________, agree to participate in the research study titled "Live Healthy Georgia!" conducted by Dr. Mary Ann Johnson in the Department of Foods and Nutrition at the University of Georgia and at my local Senior Center. I understand that participation is voluntary and I do not have to take part if I do not want to. I can refuse to participate and stop taking part anytime without giving any reason and without penalty. I can ask to have all information concerning me removed from the research records, returned to me, or destroyed. My decision to participate will not affect the services that I receive at the Senior Center.

By participating in this study, I may improve my nutrition and physical activity habits and self-management of diabetes and other chronic conditions. This study will also help the investigators learn more about good ways to help older adults improve their nutrition and physical activity habits and self-management of diabetes and other chronic conditions. This study will be conducted at my local Senior Center. If I volunteer to take part in this study, I will be asked to do the following things:

1) Answer questions about my health, nutrition and physical activity.

2) Obtain physician clearance to participate in a physical activity program.

3) Provide information about my health, nutrition, and physical activity and complete a physical measurement of weight and waist circumference in a pre-test and post-test. The pre-test will last up to 60 minutes that may be divided into two sessions. The post-test will last up to 30 minutes that also may be divided into two sessions.

4) Attend up to 12 health, nutrition and physical activity programs that will last about 30 to 60 minutes each over a four-month period. I will learn how to use a step counter and record my daily number of steps and minutes of physical activity.

5) Take part in a physical activity program of chair exercises and walking to improve my strength, balance, endurance, and flexibility.

6) **If I have diabetes**, then I may be asked if I would like to provide blood samples for hemoglobin A1c. A licensed nurse, medical technologist, or phlebotomist will obtain 2-3 drops (about 35 microliters) of whole blood via finger stick and/or up to 3 ml of whole blood via venipuncture on two occasions about four to six months apart. Or, I can provide a hemoglobin A1c value from my physician, health department, clinical laboratory, or hospital. This test will help determine if 12 lessons at my senior center are helping me manage my diabetes. The risks of drawing blood from my finger or arm include the unlikely possibilities of a small bruise or localized infection, bleeding and fainting. These risks will be reduced in the following ways: my blood will be drawn only by a qualified and experienced person who will follow standard sterile techniques, who will observe me after the blood draw, and who

will apply pressure and a Band-Aid to the blood draw site. My blood will not be tested for HIV-AIDS. Any unused portion of my blood sample will be discarded. I understand that these questions and blood tests are not for diagnostic purposes. I should see a physician if I have questions about my test results. In the event that I have any health problems associated with the blood draw or my blood sample, my insurance or I will be responsible for any related medical expenses.

7) Someone from the study may contact me to clarify my information throughout the study.

The instructor may provide food to taste. Mild to no risk is expected by tasting food. However, I will not taste foods that I should not eat because of swallowing difficulties, allergic reactions, dietary restrictions, or other food-related problems.

There is minimal risk to participation in this study. I may experience some discomfort or stress when the researchers ask me questions about my nutrition, health, and physical activity habits. There is a possibility that I could temporarily injure a muscle or be sore from physical exertion. This risk is minimized by ability to rest at any time. The leaders will advise me to stop exercising if I experience any discomfort or chest pains. If additional care is needed, then my insurance company or myself will be responsible for any expense that may be incurred. As a participant, I assume certain risks of physical injury. The researchers will exercise all reasonable care to protect me from harm as a result of my participation. However, I do not give up or waive any of my rights to file a claim with the University of Georgia's insurer (Department of Administrative Services) or pursue legal action by signing this form.

In case of a research-related injury, please contact Dr. Mary Ann Johnson at 706-542-2292.

No information concerning myself or provided by myself during this study will be shared with others without my written permission, unless law requires it. I may choose not to answer any question or questions that may make me uncomfortable. I will be assigned an identifying number and this number will be used on all of the questionnaires I fill out. Data will be stored in locked file cabinets under the supervision of Dr. Mary Ann Johnson at the University of Georgia; only the staff involved in the study will have access to these data and only for the purpose of data analyses and interpretation of results. My identity will not be revealed in any reports or published materials that might result from this study. The data will be destroyed by January 1, 2015.

If I have any further questions about the study, now or during the course of the study I can call Ms. Tiffany Sellers Lommel (706-542-4838) or Dr. Mary Ann Johnson (706-542-2292). I will sign two copies of this form. I understand that I am agreeing by my signature on this form to take part in this study. I will receive a signed copy of this consent form for my records.

Signature of Participant	Participant's Printed Name	Date

Participant Address and Phone

Signature of Investigator	Mary Ann Johnson Printed Name of Investigator	Date

Email: mjohnson@fcs.uga.edu

Signature of Staff who Reads Consent Form to Participant	**Printed Name of Staff**	**Date**

For questions or problems about your rights as a research participant please call or write: The Chairperson, Institutional Review Board, University of Georgia, 612 Boyd Graduate Studies Research Center, Athens, Georgia 30602-7411; Telephone (706) 542-3199; E-Mail Address IRB@uga.edu.

Project # 070702
Consent Form Approval Period
From: 9-11-07 To: 9-1-08
Authorization: mp

University of Georgia
Institutional Review Board
Approved: 9-10-07
Expires 6-4-08

UGA project number: #2006-10842 DHR project number: #070702

LIVE HEALTHY GEORGIA

Name of Interviewer:		Line 1
ID of Participant:		1-4
Phone number to use to clarify information and get step counts:		
1. County/Senior Center		10-12
2. Date (M/D/Y): ___/___/___		13-18
3. Age of Participant: ___ ___ ___		19-21
4. Gender: Male (0) Female (1)		22
5. Ethnicity: White (1) Black (2) Hispanic/Latino (3) Asian (4) Other (5)		23
6. How many years did you complete in school: ____ years		24-25
7. How would you rate your overall health? Circle one: Poor (0) Fair (1) Good (2) Very good (3) Excellent (4)		26
8. Do you use any tobacco products such as cigarettes, cigars, pipe, or chewing tobacco?	No (0) Yes (1)	27
9. Do you have diabetes?	No (0) Yes (1)	28
10. Do you have high blood pressure?	No (0) Yes (1)	29
11. Do you have heart disease such as angina, congestive heart failure, heart attack or other heart problems?	No (0) Yes (1)	30
12. Do you have arthritis?	No (0) Yes (1)	31
13. During the past 30 days, have you had symptoms of pain, aching, or stiffness in or around a joint?	No (0) Yes (1)	32
MEDICATION MANAGEMENT		x
14. How many prescription medications, including insulin, do you take?		34-35
15. How many over the counter medications do you take? *(such as a daily multivitamin, supplements, Aspirin®, etc.)*		36-37
16. Do you go to one pharmacy for **all** of your medications?	No (0) Yes (1)	38
17. Do you have a written list of **all** of your prescription medications, non-prescription medications, and dietary supplements?	No (0) Yes (1)	39
18. Do you carry this written list with you in your purse or wallet?	No (0) Yes (1)	40
19. Have you had a physician, pharmacist, or other health professional look at all of your medications in the past 6 months?	No (0) Yes (1)	41
20. Do you **always** throw out your medications when they are expired (past their "use by" date)?	No (0) Yes (1)	42
21. Do you use a pillbox or other system to help you take your medications?	No (0) Yes (1)	43
22. Do you know the name of **each** of your medications?	No (0) Yes (1)	44
23. Do you know what **each** of your medications is for?	No (0) Yes (1)	45
24. Do you know the possible side effects of **each** of your medications?	No (0) Yes (1)	46

Emotional Support, Life Satisfaction, and Depression		
25. Do you attend a support group for health conditions, such as diabetes, heart disease, cancer, grief, or other conditions?	No (0) Yes (1)	47
26. How often do you get the social and emotional support that you need?	1) Always 4) Rarely 2) Usually 5) Never 3) Sometimes	7 Don't know/ not sure 9 Refused 48
27. Has a doctor or other health care provider EVER told you that you have a depressive disorder?	No (0) Yes (1)	7 Don't know/ not sure 9 Refused 49

Read Questions to Participants and Circle their Answers		
DIET AND PHYSICAL ACTIVITY		Line 1
28. How many fruits and vegetables should older people eat each day? (Circle the participant's response) 0 1 2 3 4 5 6 7 8 9 10 "5 a day" "5 or more a day" "7 to 10 a day" DK Missing		50-52
29. How many servings of fruits and 100% fruit juices do you usually have each day?	0 1 2 3 4 5 6 7	53
30. How many servings of vegetables do you usually eat each day?	0 1 2 3 4 5 6 7	54
31. On how many DAYS of the last WEEK (seven days) did you eat five or more servings of fruits and vegetables?	0 1 2 3 4 5 6 7	55
32. How many DAYS of the last WEEK (seven days) have you followed a healthful eating plan?	0 1 2 3 4 5 6 7	56
33. How many DAYS of the last WEEK (seven days) did you participate in at least **30 minutes** of **moderate** physical activity? Examples of **moderate** activities are regular walking, housework, yard work, lawn mowing, painting, repairing, light carpentry, ballroom dancing, light sports, golf, or bicycling on level ground.	0 1 2 3 4 5 6 7	57
34. How many days of the week do you participate in any physical activity (light or moderate)?	0 1 2 3 4 5 6 7	58
35. About how many minutes of physical activity do you do on the days you are physically active?	____ minutes	59-61
36. How many DAYS of the last WEEK (seven days) did you participate in a specific **exercise session** other than what you do around the house or as a part of your daily activities *(e.g., chair exercises, yoga, aerobics, organized walking programs, using workout machines, etc.)*?	0 1 2 3 4 5 6 7	62

HOME FOOD SAFETY		
37. In the past month, did you **always** wash your hands with **warm water** and **soap** for **20 seconds** before eating food?	No (0) Yes (1)	7 Don't know/ not sure 9 Refused 63
38. In the past month, did you **always** rinse fresh fruits and vegetables with cold running water before eating them??	No (0) Yes (1)	7 Don't know/ not sure 9 Refused 64
39. In the past month, have you checked the temperature of your refrigerator?	No (0) Yes (1)	7 Don't know/ not sure 9 Refused 65
40. Do you cook, reheat or prepare meals in your home?	No (0) Yes (1)	7 Don't know/ not sure 9 Refused 66
41. Do you own a meat thermometer?	No (0) Yes (1)	7 Don't know/ not sure 9 Refused 67

FALLS AND FRACTURES		
42. Have you had a fracture or broken bone after age 50?	No (0) Yes (1)	68
43. Have you fallen in the past year?	No (0) Yes (1)	69
44. Do you feel limited in your daily life by a fear of falling?	No (0) Yes (1)	70
45. Have you ever been told by a doctor or other health professional that you have osteoporosis?	No (0) Yes (1)	71
FOODS AND SUPPLEMENTS		Line 1
46. Do you get a stomachache, gas, or diarrhea after drinking milk?	No (0) Yes (1)	72
47. How many servings of milk products should most older people eat daily?	0 1 2 3 4 DK	73
48. How many whole grain servings should people eat each day?	0 1 2 3 4 DK	74

How often do you eat or drink or take these items? (*includes 3 or more per day)	Line 2
49. Whole wheat or whole grain bread (such as 100% whole wheat bread)? <1/wk 1/wk 2/wk 3/wk 4/wk 5/wk 6/wk 1/day 1-2/day 2/day 2-3/day 3/day* DK	1-2
50. Whole grain cereals (such as oatmeal, Cheerios®, bran flakes or bran cereal)? <1/wk 1/wk 2/wk 3/wk 4/wk 5/wk 6/wk 1/day 1-2/day 2/day 2-3/day 3/day* DK	3-4
51. Milk as a beverage (including soy milk)? <1/wk 1/wk 2/wk 3/wk 4/wk 5/wk 6/wk 1/day 1-2/day 2/day 2-3/day 3/day* DK	5-6
52. Milk on cereal (including soy milk)? <1/wk 1/wk 2/wk 3/wk 4/wk 5/wk 6/wk 1/day 1-2/day 2/day 2-3/day 3/day* DK	7-8
53. Calcium-fortified orange juice? <1/wk 1/wk 2/wk 3/wk 4/wk 5/wk 6/wk 1/day 1-2/day 2/day 2-3/day 3/day* DK	9-10
54. Calcium supplement? <1/wk 1/wk 2/wk 3/wk 4/wk 5/wk 6/wk 1/day 1-2/day 2/day 2-3/day 3/day* DK	11-12
55. Calcium supplement with vitamin D? <1/wk 1/wk 2/wk 3/wk 4/wk 5/wk 6/wk 1/day 1-2/day 2/day 2-3/day 3/day* DK	13-14
56. Multivitamin with vitamin D? <1/wk 1/wk 2/wk 3/wk 4/wk 5/wk 6/wk 1/day 1-2/day 2/day 2-3/day 3/day* DK	15-16
57. Vitamin D-only supplement? <1/wk 1/wk 2/wk 3/wk 4/wk 5/wk 6/wk 1/day 1-2/day 2/day 2-3/day 3/day* DK	17-18

	<1/wk	1/wk	2/wk	3/wk	4/wk	5/wk	6/wk	1/day	1-2/day	2/day	2-3/day	3/day*	DK/Miss	
For the data coder:	00	01	02	03	04	05	06	07	10	14	17	21	99	19-20

FOOD SECURITY		
58. Do you always have enough money to buy the food you need?	No (0) Yes (1)	7 Don't know/ not sure 9 Refused 21
59. In the past month, have you received food from a food pantry or food bank?	No (0) Yes (1)	7 Don't know/ not sure 9 Refused 22
60. Do you currently receive food stamps?	No (0) Yes (1)	7 Don't know/ not sure 9 Refused 23
Think about the past 30 days. I'm going to read you several statements that people have made about their food situation. For these statements, please tell me whether the statement was often true, sometimes true, or never true for you since last (name of current month).		
61. The food that you bought just didn't last, and you didn't have money to buy more.	1) Often 2) Sometimes 3) Never	7 Don't know/ not sure 9 Refused 24
62. You couldn't choose the right food and meals for your health because you couldn't afford them.	1) Often 2) Sometimes 3) Never	7 Don't know/ not sure 9 Refused 25
63. Did you ever cut the size of your meals or skip meals because there wasn't enough money for food?	No (0) Yes (1)	7 Don't know/ not sure 9 Refused 26
63a. If yes, in the last 30 days, how many days did this happen? *(interviewer-please write in participant's response)*	________days	7 Don't know/ not sure 9 Refused 27-28
64. Did you ever eat less than you felt you should because there wasn't enough money to buy food?	No (0) Yes (1)	7 Don't know/ not sure 9 Refused 29
65. Were you ever hungry but didn't eat because you couldn't afford enough food?	No (0) Yes (1)	7 Don't know/ not sure 9 Refused 30

Get Checked Questions

(Adapted from **BRFSS,** http://www.cdc.gov/brfss/questionnaires/pdf-ques/2005brfss.pdf)

Question	Write or Circle Answer	Code
		Line 2
66. About how long has it been since you last had a bone mineral density test?	1) Within the past year 2) Within the past 2 yr 3) Within the past 5 yr 4) 5 or more yrs ago 5) Never	7 Don't know/not sure 9 Refused 31
67. About how long has it been since you last had your blood cholesterol checked?	1) Within the past year 2) Within the past 2 yr 3) Within the past 5 yr 4) 5 or more yrs ago 5) Never	7 Don't know/not sure 9 Refused 32
68. Have you ever been told by a doctor, nurse, or other health professional that your blood cholesterol is high?	1) Yes 2) No	7 Don't know/not sure 9 Refused 33
69. Are you cutting down on saturated fat in your diet (to help manage or lower your risks of developing heart disease)?	1) Yes 2) No	7 Don't know/not sure 8 Refused 34
70. About how long has it been since you last had your blood pressure checked?	1) Within past month 2) Within past year 3) Within past 2 yrs 4) 2 or more years ago 5) Never	7 Don't know/not sure 9 Refused 35
71. Are you cutting down on sodium or salt (to help lower or control your blood pressure)?	1) Yes 2) No 3) Do not use salt	7 Don't know/not sure 9 Refused 36
72. When was the last time you visited ANY eye care professional? (To have your eyes and vision checked?)	1) Within past month 2) Within past year 3) Within past 2 yrs 4) 2 or more years ago 5) Never	7 Don't know/not sure 9 Refused 37
73. When was the last time you visited ANY ear care professional? (To have your hearing or hearing aids checked?)	1) Within past month 2) Within past year 3) Within past 2 yrs 4) 2 or more years ago 5) Never	7 Don't know/not sure 9 Refused 38
74. When was the last time you had your feet checked by a health care professional, such as a doctor or nurse?	1) Within past month 2) Within past year 3) Within past 2 yrs 4) 2 or more years ago 5) Never	7 Don't know/not sure 9 Refused 39
75. If you thought someone was having a heart attack or a stroke, what is the first thing you would do? *Read list to participant and circle their answer.*	1-Take them to the hospital 2-Tell them to call their doctor 3-Call 911 4-Call their spouse or a family member 5-Do something else	7 Don't know/not sure 9 Refused 40

WEIGHT QUESTIONS		
76. Do you consider yourself to be:	1) Underweight? 2) Overweight? 3) About the right weight?	7 Don't know/ not sure 9 Refused 41
77. Would you like to weigh:	1) More 2) Less 3) Stay about the same	7 Don't know/ not sure 9 Refused 42
78. Your primary concern about your current weight is:	1) My health 2) My appearance 3) My weight is about right, no concerns	7 Don't know/ not sure 9 Refused 43
79. Does your current weight affect your ability to do daily activities such as walk, do housework, shop, etc?	No (0) Yes (1)	7 Don't know/ not sure 9 Refused 44
80. In the past year, have you been told by a doctor or health care professional to reduce your weight?	No (0) Yes (1)	7 Don't know/ not sure 9 Refused 45
81. What do you think is the best way to lose weight? *(interviewer-please write in participant's response)*		7 Don't know/ not sure 9 Refused 46
82. In the past year, have you lost weight?	No (0) Yes (1)	7 Don't know/ not sure 9 Refused 47
82a. If you have lost weight in the past year, how much? *(interviewer-please write in participant's response)*		7 Don't know/ not sure 9 Refused 48
82b. Was the weight loss intentional? That is, were you trying to lose weight?	No (0) Yes, trying to change it (1) No loss (2)	7 Don't know/ not sure 9 Refused 49
82c. What method(s) did you use to lose weight? *(interviewer-please write in participant's response)*		50-51
83. In the past year, have you gained weight?	No (0) Yes (1)	7 Don't know/ not sure 9 Refused 52
83a. If you have gained weight in the past year, how much? *(interviewer-please write in participant's response)*		53-54
83b. Was the weight gain intentional? That is, were you trying to gain weight?	No (0) Yes, trying to change it (1) No gain (2)	7 Don't know/ not sure 9 Refused 55
83c. What method(s) did you use to gain weight? *(interviewer-please write in participant's response)*		7 Don't know/ not sure 9 Refused 56-57

7 = Don't know/not sure, 9 = Refused

FOR THOSE WITH DIABETES		Line 2
1. What kind of effect does diabetes have on your daily activities? No effect (1) Little effect (2) Large effect (3)	1 2 3	58
2. Thinking about your diet, on how many DAYS of the last WEEK (seven days) did you space carbohydrates evenly?	0 1 2 3 4 5 6 7	59
3. On how many DAYS of the last WEEK (seven days) did you test your blood sugar?	0 1 2 3 4 5 6 7	60
4. What medications do you take for your diabetes? 0-None 1-pills only 2-insulin only 3-pills and insulin		61
5. On how many DAYS of the last WEEK (seven days), did you take your diabetes medication as prescribed by your doctor?	0 1 2 3 4 5 6 7	62
6. On how many DAYS of the last WEEK (seven days) did you check your feet?	0 1 2 3 4 5 6 7	63
7. On how many DAYS of the last WEEK (seven days) did you inspect the inside of your shoes?	0 1 2 3 4 5 6 7	64
8. What should your hemoglobin A1c level be? ___% *(interviewer-please write in participant's response)*	77 Don't know/ not sure 99 Refused 65-66	
9. What things are the hardest for you to do when managing your diabetes? *(interviewer-please write in participant's response)*	67-68	

WAIST CIRCUMFERENCE:
Instructions for Measuring Waist Circumference

The measurement should be made under the clothes.

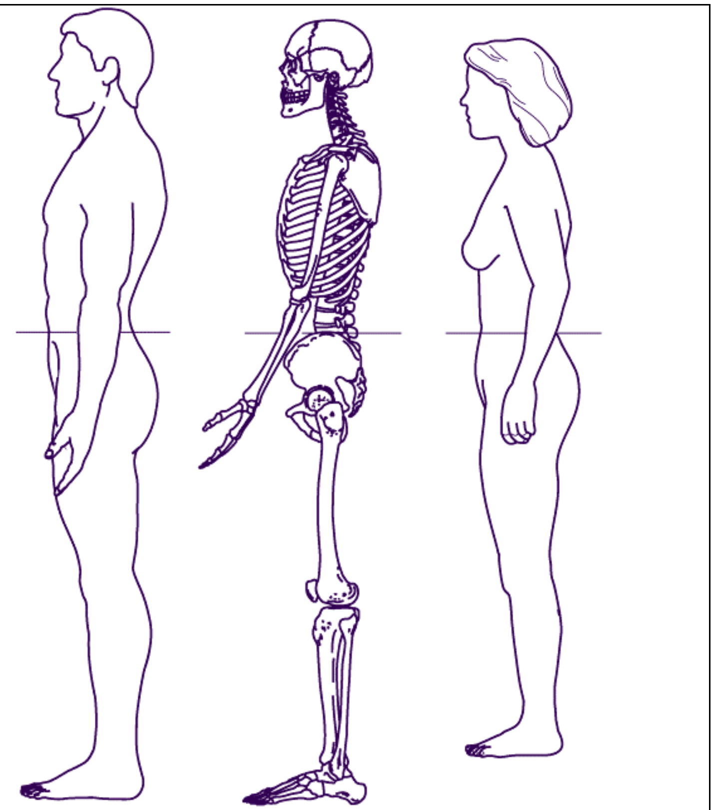
To measure waist circumference, locate the upper hipbone and the top of the right iliac crest. Place a measuring tape in a horizontal plane around the abdomen at the level of the iliac crest. Before reading the tape measure, ensure that the tape is snug, but does not compress the skin, and is parallel to the floor. The measurement is made at the end of a normal expiration.

A high waist circumference is associated with an increased risk for type 2 diabetes, dyslipidemia, hypertension, and CVD in patients with a BMI between 25 and 34.9 kg/m2.

High-Risk Waist Circumference

Men: > 40 in (> 102 cm)
Women: > 35 in (> 88 cm)

http://www.nhlbi.nih.gov/guidelines/obesity/prctgd_c.pdf



84. Waist Circumference = __________ INCHES		Line 3 1-3
85. How was measurement made? (1) Under clothes OR (2) Over clothes	1 2	4
86. What is your current height without shoes? ______ feet and ____ inches		5-7
87. How was the measurement made? (1) With a tape measure OR (2) Self-report	1 2	8
88. What is your current weight without clothes? _______ pounds		9-11
89. How was weight measurement made? PREFERRED: With a scale and without shoes (1) With a scale and with shoes (2) Self-report (3)		12
90. Chair-sit-and-reach: sit in stable chair, knees straight, bend over, reach with arms straight to toes, then measure with a ruler: Number of inches person is short of reaching the toes: ___ ___ . ___ (-) *or* Number of inches person reaches beyond toes: ___ ___ . ___ (+) *Measure to the nearest ½ inch*		13-16 17-20

	Physical Performance Test-Task Descriptions Equipment: <u>Stopwatch</u>, 8-Ft Tape Measure, Ruler, Folding Chair	RECORD TIME IN SECONDS	LINE 4 UGA Staff can score with open coding
ASB	**STANDING BALANCE:** **Time each item until >10.0 sec. OR** **until participant moves feet or reaches for support.** **1a) SEMI-TANDEM** (heel of one foot placed at mid-position of the other) *If can hold for 10 seconds, move to **1b)** *If can NOT hold for 10 seconds, move to **1c)** **1b) TANDEM** (heel to toe, one foot directly in front of the other) **1c) SIDE-BY-SIDE (**toes lined up evenly and feet touching)	**Time to the nearest 10th second:** **a)** ___ ___ . ___ > 10.0 sec. Go to **b)** < 10.0 sec. Go to **c)** **b)** ___ ___ . ___ **c)** ___ ___ . ___	1-4 5-8 9-12
ASB D	**DOMAIN SCORE:** If A= <10 & C= 0-9, score= 0 A= <10 & C= 10, score= 1 A= ≥10 & B= 0-2, score= 2 A= ≥10 & B= 3-9, score= 3 A= ≥10 & B= ≥10, score= 4	**SCORE: _______**	13
AFW	**8 FOOT WALK:** **Participant begins at standing position and will walk a straight distance of 8-feet, measured with tape on the floor.** **Instruct the participant to walk at normal gait using any assistive devices. If possible, have them begin walking a few feet before starting mark, and continue walking a few feet past the 8-foot mark. Tester will start and stop watch at the distance marks.** **Complete the walk twice.**	**Time to the nearest 10th second:** **1)** ___ ___ . ___ **2)** ___ ___ . ___ Use best (lowest) time **Assistive device used?** NO (0) YES (1) Describe ___________	14-17 18
AFW D	**DOMAIN SCORE:** 1= ≥5.7 2= 4.1-5.6 3= 3.2-4.0 4= ≤3.1	**SCORE: _______**	19
ACS	**CHAIR STANDS:** **Participant is asked to stand one time from a seated position in an armless, straight-backed chair (such as a folding metal chair) with their arms folded across their chest.** **If able, participant is asked to stand-up and sit-down 5 times as quickly as possible while being timed.** **If not able to perform, then the test is complete.**	**Time to the nearest 10th second:** **1)** ___ ___ . ___	20-23
ACSD	**DOMAIN SCORE:** 1= ≥16.7 2= 13.7-16.6 3= 11.2-13.6 4= ≤11.1	**SCORE: _______**	24
TDS	**TOTAL SCORE: Add all 3 domain scores (1-12)**	**TOTAL SCORE:__ __**	25-26
Coding: 8 = physically unable, 9=refused, 7=not applicable. Good function (score of 10 to 12); moderate function (score of 6 to 9); poor function (score of 0 to 5).			

ID: __________ DATE (M/D/Year): _______ STAFF NAME: ___________ PHYSICAL PERFORMANCE