

Research Article

Prevalence of Sarcopenia and Sarcopenic Obesity Vary with Race/Ethnicity and Advancing Age

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What is Known About the Topic

- Individuals are living longer than ever before and in the United States the older adult population is becoming more ethnically and racially diverse.
- There can be genetic variability in body mass index and body composition.
- Sarcopenia and obesity contribute to poor health outcomes and when occurring together as sarcopenic obesity, can cause even further health complications that limit the human condition and functionality.
- Few studies have specifically considered these conditions across different racial/ethnic populations and with advancing age.

What this Paper Adds About the Topic

- This study documented that the prevalence of sarcopenia and sarcopenic obesity increased with age and differed by sex and racial/ethnic group.
- The study further demonstrated a close association of sarcopenia and obesity, particularly for older adults.
- Hispanics were found to have the highest prevalence of sarcopenia and sarcopenic obesity and Non-Hispanic Blacks had the lowest. Within Non-Hispanic Blacks, there was a greater discrepancy between sex, with males having a higher prevalence of sarcopenia and sarcopenic obesity compared to females.
- With the new recognition of sarcopenia as a Centers for Disease Control and Prevention reportable condition and assignment of an ICD-10 CM code for the sarcopenia, this research underscores the importance of identifying and intervening for sarcopenia and sarcopenic obesity, especially among racial/ethnic groups who may be at higher risk.

ABSTRACT

Sarcopenia is the natural age-associated loss of muscle mass/function, often occurring simultaneously with obesity, especially in older adults. Sarcopenia and obesity contribute to poor health outcomes and when occurring together as sarcopenic obesity (SO) can cause further health complications. Few studies have specifically considered these conditions across different racial/ethnic populations. This study examined the prevalence of sarcopenia and SO among U.S. adults by different age, sex, and racial/ethnic groups, using 1999-2004 data from the National Health and Nutrition Examination Survey (NHANES) and its racial/ethnic subpopulation groupings. Sarcopenia was defined as low appendicular lean mass (adjusted for Body Mass Index (BMI) of <0.789 kg/m^2 for males, <0.512 kg/m^2 for females) and self-reported functional limitation. Obesity was defined as BMI ≥30 kg/m^2 with SO defined as those meeting criteria for both sarcopenia and obesity. The analysis included 4367 adult subjects; for each race/ethnic subpopulation, sarcopenia prevalence increased with age. Sarcopenia prevalence varied by sex and race/ethnic subpopulation: Hispanic (26.8% male, 27.2% female); Non-Hispanic (NH) White (15.5% male, 15.1% female); NH Black (8.6% male, 1.6% female); and Other (16.5% male, 23.2% female). Sarcopenic obesity also increased with age and varied by sex and race/ethnic subpopulation: Hispanic (8.57% male, 8.87% female); NH White (6.48% male, 8.06% female); NH Black (3.95% male, 1.12% female); and Other (4.46% male, 0.0% female). Increased awareness of variability in sarcopenia/SO may help develop effective screenings/care management and interventions/public health policies to maintain functionality and reduce health disparities among an increasingly diverse U.S. older adult population.

Keywords: Sarcopenia; Obesity; Ethnic groups; Nutrition surveys; NHANES; Prevalence; Health policy

Introduction

Individuals are living longer than ever before, with older adults making up a larger proportion of the United States (U.S.) population and its older adult population becoming more ethnically diverse. The U.S. Census Bureau has projected that the U.S. population aged 65 years and older is expected to double by 2050 [1]. This is a critical time to focus efforts on understanding factors that may contribute to health disparities, supporting healthy aging, reducing mobility-disability and dependency, as well as helping older adults maintain independence, functionality, and quality of life (QoL). Public health systems,

families, and society can benefit from implementing strategies to help keep older adults living independently for as long as possible.

Aging is associated with changes in body composition, and there is some evidence that these changes in body composition vary by ethnic groups [2-4]. Body composition changes can contribute to the decline in health and physical function. Sarcopenia is one such change and is defined by the loss of lean mass with associated loss of strength and/or physical function [5,6]. Sarcopenia develops naturally as a result of aging, decreased physical activity, or extended immobilization (i.e. hospitalization). Acute and chronic disease can also lead to muscle loss and sarcopenia [7,8]. Sarcopenia is associated with an increased risk for falls and mobility-disability, as well as various deleterious health outcomes including poor balance, reduced activities of daily living (ADLs), and dependency leading to nursing home placement [9,10]. These conditions can perpetuate the cycle of inactivity and muscle loss, eventually leading to frailty and even mortality [11-14]. While the prevalence of sarcopenia varies depending on how it is defined and the specific techniques used to measure muscle mass, it is estimated to occur in 25-45% of older adults in the U.S. and in a substantial proportion of older adults across the world even among healthy populations [7, 15-18].

Obesity is another important health risk that can lead to decreased functionality and carries its own set of metabolic dysfunctions such as insulin resistance, glucose dysregulation, hypertension leading to cardiovascular disease, and metabolic syndrome. The prevalence of obesity continues to increase in the U.S. older adult population with 35% of individuals 65 years and older considered obese in 2010. It is estimated that the prevalence is expected to increase to 50% by 2030 [19,20]. Furthermore, Black and Hispanic populations have a much higher prevalence of obesity than White populations [21].

Recently, healthcare providers have coined the term sarcopenic obesity (SO) to describe an overlap of sarcopenia and obesity. Sarcopenic obesity is a major health concern because of its relationship to decreased ADLs and limitations in physical functions. Several studies have reported rates of impaired ADLs and limitations in physical function that are 2-3 times higher in those with SO compared to non-obese sarcopenic individuals or individuals with normal body composition [10,22]. In addition, some authors have reported that SO individuals are at an estimated 23% increased risk of cardiovascular diseases, as well as poorer quality of life, longer hospitalization, and greater rates of mortality compared to individuals with healthy body composition [23-25]. These issues are likely related to the worsened muscle quality in SO individuals due to inter- and intramuscular fat infiltration and could also be related to cellular changes such as apoptosis and mitochondrial decline [26-29].

The impact of SO on healthy aging extends into addressing racial diversity, health disparities, and the impact of genetic variations on phenotype (body composition, body mass index or BMI) in older adults [1,30-32]. Yet, very few studies have examined the prevalence of sarcopenia and SO across different sex, racial, and ethnic populations and differences with advancing age.

Currently, sarcopenia and SO are not routinely screened for in clinical practice and, therefore, are often unidentified and untreated. The largest problems may be a lack of clinically viable tools to easily measure body composition and an understanding of how to use them. However, the new recognition of sarcopenia as a reportable condition by the Centers for Disease Control and Prevention (CDC) and the assignment of an International Classification of Disease (ICD)-10-CM code for sarcopenia are important milestones, making this an imperative time for researchers, healthcare practitioners, and policy makers to work together in developing guidelines and public health policies for preventing, identifying, and treating sarcopenia, particularly for underserved and diverse populations. Fundamental to establishing such guidelines and policies is a better understanding of the prevalence of sarcopenia and SO, particularly among the U.S. older adult population and racial and ethnic subpopulations.

The objective of this study was to examine the prevalence of sarcopenia and SO among adults in the U.S. by different sex, racial, and ethnic groups and to consider how this prevalence may change with advancing age. We hypothesized that the prevalence of sarcopenia and sarcopenic obesity varies with both race/ethnicity and advancing age.

Methods

For this research analysis, prevalence estimates of sarcopenia and SO in adults (aged 18 years and older) were calculated using data from the National Health and Nutrition Examination Surveys (NHANES) from 1999-2004. The NHANES survey is a series of epidemiological cross-sectional surveys of a nationally representative sample of noninstitutionalized Americans, which oversampled minorities and older adults. The NHANES survey was conducted by the CDC through the National Center for Health Statistics. All NHANES data sets and detailed information about the NHANES study design, participant selection criteria, procedures (including questionnaires),and examination and laboratory components are publicly available online at http://www.cdc.gov/nchs/nhanes.htm. NHANES data sets for the present research analysis were limited to the years 1999-2004, to allow for identification of sarcopenia using available appendicular lean mass measurements obtained by dual-energy X-ray absorptiometry (DEXA). DEXA data in NHANES were not available from more recent time periods, which precluded the use of the more recent NHANES data for this analysis.

For the present study, only those adult subjects (age ≥18 years) who had NHANES body composition data were selected to be included in the analysis. Pregnant females and subjects who were ≥ 192.5 centimeters (cm) (≥6 feet 5 inches) or weighed ≥136.4 kilograms (kg) (≥300 pounds) did not receive the DEXA examination and thus were not included in the current study. There were 4367 adult subjects who met these criteria, including 2458 subjects aged 65 years or older. Demographic characteristics, including age, sex, and race/ethnicity, were obtained using the self-report questionnaire from NHANES. For the current study, racial/ethnic subpopulations were grouped as

non-Hispanic White (NH Whites), non-Hispanic Black (NH Blacks), Hispanics, and Others (races/ethic groups other than White, Black, or Hispanic; included Asian, Native American, and multiracial) based on survey response. The current study also classified age into three groups: 18-39, 40-64, and ≥65 years.

Body composition and health status measurements

As described in NHANES protocols, height was measured using a stadiometer and weight was measured using an electronic digital scale. For the current study, BMI was calculated as weight (in kilograms) divided by height (in meters (m)) squared. DEXA body composition data were obtained from NHANES using a Hologic QDR-4500A fan-beam densitometer (Hologic, Bedford, MA, USA) by trained technicians following manufacturer's protocol. Metal objects, except false dentition and hearing aids, were removed.

Based on the NHANES data, we assessed total fat mass, total lean mass, bone measurements, and appendicular lean mass (ALM) of all limbs. Total body fat percent was subsequently calculated in the present study from these measurements. ALM was calculated as the sum of the muscle mass of the right and left arms and legs. Sarcopenia in our analysis was defined by subjects meeting two criteria: 1) the Foundation for the National Institute of Health (FNIH) sex-specific cut points for low appendicular lean mass index (ALMI), < 0.789 kg/m^2 for males and < 0.512 kg/m^2 for females, with ALMI calculated as ALM divided by BMI; and 2) having self-reported functional limitation. Functional limitation data were collected in NHANES through a self-reported physical functioning questionnaire, available publicly online at: https://www.cdc.gov/nchs/nhanes/nhanes_questionnaires.htm. For this analysis subjects were classified as having self-reported functional limitations if they reported any difficulty with walking ¼ mile; walking up 10 stairs without resting; stooping/crouching/kneeling; lifting or carrying 10 pounds; walking between rooms on the same floor; standing up from a chair; or getting in and out of bed. In this analysis, subjects were classified as obese based on standards used by the CDC (obesity defined as BMI ≥ 30kg/m^2). Subjects in the present study fulfilling the criteria for both sarcopenia and obesity using the above definitions were categorized as having SO.

Statistical analysis

For our analysis, three, 2-year cycles of the NHANES 1999-2000, 2001-2002, and 2003-2004 data were merged into a single data set and analyzed according to the policy and procedure recommendations from NHANES using survey procedures with SAS version 9.4 (SAS Institute, Cary, North Carolina), which account for the sampling design of NHANES and appropriately weight study subjects in statistical models. Subjects were assigned binary outcomes (yes or no) for obese, low ALMI, functional limitations, and sarcopenia based on the above-mentioned definitions. The weighted estimates of prevalence rates of sarcopenia and SO subjects in each age (18-39, 40-64, and ≥65 years) and sex category were calculated.

Results

A total of 4367 subjects were included in the prevalence analysis, of which 2203 were female and 2164 were male. Sample sizes within each age and race/ethnic group are listed (Table 1).

Analysis shows SO is very closely associated with sarcopenia, having similar prevalence regardless of age group, sex, or race/ethnic group (Table 2). The prevalence of sarcopenia and SO increased with age and differed by sex and race/ethnic group. Collapsed across sex and race/ethnic group, the prevalence of sarcopenia was found to be 4.25% in the 18 to 39 age group, 8.85% in the 40 to 64 age group, and 15.51% in the 65 and older age group. For the same groups, SO was found to be 3.28%, 5.48%, and 6.98%, respectively. Among sex and age groups, Hispanics had the highest prevalence of sarcopenia and SO, whereas NH Blacks had the lowest. Older adult NH Whites and Hispanics had similar prevalence of sarcopenia and SO between males and females. Within NH Blacks, there was greater discrepancy between sex, with males having a higher prevalence of sarcopenia and SO compared to females ($P<0.05$). The reverse trend occurred in individuals who fell into the 'Other' racial/ethnic group, with females having a higher prevalence of sarcopenia than males ($P<0.05$).

Table 3 shows the prevalence of individual functional limitation in older adults as associated with normal and low ALMI in persons with normal body composition and obesity. Obese individuals with normal appendicular lean mass had less likelihood of functional limitations at 50.6%, but still had a greater likelihood compared to older adults with normal body composition.

Discussion

In the current study, the prevalence of sarcopenia and SO were found to increase with age and differ by sex and racial/ethnic groups. Our results demonstrate a close association of sarcopenia with obesity, particularly for older adults, with many individuals fulfilling the definition for sarcopenia also having high BMI. In our study, Hispanics had the highest prevalence of sarcopenia and SO, whereas NH Blacks had the lowest. Within NH Blacks, there was a greater discrepancy between sex, with males having a higher prevalence of sarcopenia and SO compared to females.

Although the data on sarcopenia and SO prevalence among racial/ethnic groups is limited, our results are similar to those from other investigations that have also used the NHANES dataset to evaluate sarcopenia and SO prevalence and body composition across various U.S. adult sub-populations. Batsis et al, who investigated rates of sarcopenia and SO and functionality in older adults, found prevalence rates varied by age and ethnicity but did not include adults younger than age 60 years old in their study [33]. Our study included all adults aged 18 years and older, to consider how the prevalence of sarcopenia and SO may change with age. Heymsfield et al., also using NHANES data, (1999-2006) conducted a quantitative critical review on why there are race and ethnic differences in adult body mass index-adiposity relationships and reported NH Blacks had the lowest

Table 1: Body composition characteristics of NHANES (1999-2004) study subjects by race/ethnicity, sex, and age.

	Non-Hispanic (NH) White		NH Black		Hispanic		Other	
	Male	**Female**	**Male**	**Female**	**Male**	**Female**	**Male**	**Female**
Age 18-39 yrs	n = 81	n = 106	n = 43	n = 42	n = 48	n = 36	n = 8	n = 5
Body Mass Index (BMI) (kg/m^2)	26.28 [0.14]	25.87 [0.25]	25.97 [0.23]	28.68 [0.29]	26.52 [0.21]	27.04 [0.33]	25.46 [0.50]	23.96 [0.67]
Weight (kg)	83.06 [0.47]	69.83 [0.71]	81.46 [0.70]	76.87 [0.79]	77.61 [0.65]	68.38 [0.77]	76.44 [2.04]	61.67 [2.16]
Appendicular Lean Mass (ALM) (kg)	26.871 [0.134]	17.677 [0.120]	29.016 [0.269]	20.764 [0.200]	24.775 [0.158]	16.820 [0.166]	24.437 [0.572]	15.888 [0.441]
Appendicular lean mass index (ALMI)	1033.02 [4.17]	697.54 [4.10]	1128.12 [6.88]	734.87 [6.19]	942.79 [5.59]	632.77 [6.04]	967.92 [11.88]	670.85 [8.68]
Total Fat Mass (kg)	22.012 [0.259]	26.838 [0.499]	19.284 [0.325]	30.311 [0.529]	20.973 [0.395]	27.308 [0.503]	20.694 [0.919]	22.716 [1.276]
Total Lean Mass (kg)	59.117 [0.262]	41.435 [0.244]	60.199 [0.457]	45.009 [0.357]	54.928 [0.315]	39.616 [0.344]	53.772 [1.193]	37.509 [0.933]
Age 40-64 yrs	n = 366	n = 370	n = 154	n = 163	n = 199	n = 238	n = 24	n = 26
BMI (kg/m^2)	27.83 [0.13]	27.32 [0.22]	27.19 [0.24]	29.78 [0.33]	27.79 [0.20]	29.36 [0.36]	25.86 [0.60]	25.31 [0.41]
Weight (kg)	87.69 [0.42]	73.10 [0.58]	85.27 [0.87]	79.61 [0.90]	80.26 [0.58]	72.77 [0.84]	73.78 [2.05]	62.31 [1.09]
ALM (kg)	26.638 [0.126]	17.363 [0.107]	28.422 [0.262]	20.051 [0.178]	24.375 [0.131]	16.740 [0.183]	22.422 [0.588]	15.100 [0.247]
ALMI	964.16 [4.24]	645.74 [3.87]	1052.31 [5.39]	680.35 [4.42]	883.62 [5.56]	573.72 [4.11]	868.73 [9.33]	598.43 [8.97]
Total Fat Mass (kg)	25.694 [0.244]	30.019 [0.402]	22.595 [0.427]	33.166 [0.626]	23.250 [0.377]	30.987 [0.507]	21.369 [1.039]	24.754 [0.666]
Total Lean Mass (kg)	60.040 [0.238]	41.611 [0.216]	60.711 [0.491]	44.873 [0.336]	55.260 [0.303]	40.434 [0.359]	50.664 [1.137]	36.308 [0.550]
Age 65+ yrs	n = 758	n = 734	n = 172	n = 169	n = 286	n = 291	n = 25	n = 23
BMI (kg/m^2)	27.25 [0.10]	27.06 [0.21]	26.82 [0.36]	28.96 [0.38]	27.06 [0.41]	27.31 [0.55]	23.83 [0.69]	26.47 [1.17]
Weight (kg)	82.41 [0.33]	68.78 [0.53]	80.11 [1.32]	74.00 [1.03]	75.91 [1.15]	64.60 [1.43]	66.54 [2.67]	62.04 [3.64]
ALM (kg)	23.232 [0.113]	15.495 [0.103]	24.669 [0.357]	17.958 [0.249]	21.587 [0.314]	14.517 [0.383]	19.338 [0.678]	14.589 [0.596]
ALMI	860.42 [5.00]	580.05 [3.55]	927.10 [9.22]	627.56 [5.70]	805.49 [11.86]	537.03 [6.66]	813.80 [24.84]	553.16 [10.15]
Total Fat Mass (kg)	25.878 [0.192]	29.325 [0.348]	23.616 [0.671]	30.885 [0.629]	23.069 [0.729]	27.661 [0.901]	19.917 [1.440]	25.009 [2.280]
Total Lean Mass (kg)	54.440 [0.201]	38.132 [0.217]	54.617 [0.745]	41.320 [0.515]	50.834 [0.471]	35.852 [0.551]	45.135 [1.402]	35.884 [1.450]

Values are mean (Standard Error of the Mean or SEM) for variables within each race/ethnic, sex, and age group

percent fat, followed by NH Whites, while Mexican Americans had the greatest percent fat. They described their findings to be consistent with previous studies documenting young adults with the same BMI but differing race/ethnic group had significantly different levels of adiposity [34-36].

Differences have been documented in the lean body mass composition of various ethnic and racial groups. Silva et al., using a convenience sample of adults aged 18 to 80 years old, evaluated ethnicity-related skeletal muscle differences across the lifespan and found that African American males and females tended to have higher values of skeletal muscle mass across the lifespan, while Asian females and Hispanic males had smaller absolute skeletal muscle mass compared to other groups [2]. A decade earlier Wagner and Heyward (2000) documented biological differences in the body composition of Blacks and Whites, finding Blacks had a greater bone mineral density and body protein content than Whites, resulting in a greater fat-free body density [3]. This finding may help explain the higher BMIs that have been documented in NH Blacks compared to NH Whites, although in our study NH Blacks did not necessarily have higher BMIs.

While there is a general understanding that body composition and BMI vary by ethnic groups, it is uncertain how these variations may apply to the development of sarcopenia and SO. For example, do the potentially higher amounts of lean body mass among NH Blacks compared to other groups help

Table 2: Prevalence (%) of sarcopenia and sarcopenic obesity in NHANES (1999-2004) study subjects by race/ethnicity, sex, and age.

	Non-Hispanic (NH) White		NH Black		Hispanic		Other	
	Male	Female	Male	Female	Male	Female	Male	Female
Age 18-39 yrs								
Sarcopenia	2.45 (1.85)	3.87 (2.00)	0.00 (0.00)	0.00 (0.00)	7.23 (3.08)	18.86 (9.20)	10.59 (10.21)	0.00 (0.00)
Obese	19.68 (1.35)	21.78 (1.56)	19.83 (1.89)	41.95 (2.58)	19.38 (1.81)	27.94 (2.28)	16.09 (4.04)	10.65 (4.21)
Sarcopenic Obesity	0.69 (0.71)	3.87 (2.00)	0.00 (0.00)	0.00 (0.00)	4.17 (2.51)	15.84 (8.96)	10.59 (10.21)	0.00 (0.00)
Age 40-64 yrs								
Sarcopenia	10.06 (1.98)	8.78 (1.62)	0.22 (0.22)	0.40 (0.40)	11.40 (2.96)	16.78 (3.27)	12.06 (8.24)	6.16 (4.58)
Obese	27.52 (1.55)	30.54 (1.97)	26.07 (2.08)	44.38 (3.02)	24.16 (1.77)	39.68 (3.61)	15.68 (5.48)	6.94 (2.96)
Sarcopenic Obesity	6.83 (1.73)	5.75 (1.11)	0.22 (0.22)	0.00 (0.00)	3.79 (1.55)	7.81 (1.65)	0.00 (0.00)	6.16 (4.58)
Age >65 yrs								
Sarcopenia	15.48 (1.51)	15.12 (1.45)	8.58 (1.90)	1.57 (0.93)	26.79 (5.83)	27.18 (4.30)	16.48 (8.54)	23.19 (8.25)
Obese	21.65 (1.56)	25.79 (1.89)	23.87 (3.71)	39.19 (3.60)	20.58 (4.60)	27.66 (5.12)	6.35 (4.70)	14.68 (8.84)
Sarcopenic Obesity	6.48 (0.99)	8.06 (1.11)	3.95 (1.62)	1.12 (0.81)	8.57 (4.47)	8.87 (2.43)	4.46 (4.35)	0.00 (0.00)

Values are mean (Standard Error of the Mean or SEM) for variables within each race/ethnic, sex, and age group.

Table 3: Prevalence (%) of individual functional limitations in NHANES (1999-2004) study subjects who were older adults (aged 65 years and older) associated with low adjusted appendicular lean mass index and obesity.

	Body composition status*			
Functional limitations:	**Normal BMI and normal ALMI****	**Obese and normal ALMI****	**Normal BMI and low ALMI****	**Obese and low ALMI****
Walking ¼ mile	19.03 (1.22)	27.61 (3.49)	33.90 (2.90)	41.09 (4.33)
Walking up 10 steps	15.03 (1.19)	20.67 (2.91)	24.30 (2.56)	41.03 (3.48)
Stooping, crouching, kneeling	37.81 (1.79)	52.65 (3.27)	48.35 (2.90)	64.34 (3.70)
Lifting or carrying 10 lbs	20.66 (0.94)	16.68 (2.35)	28.09 (3.18)	29.61 (4.32)
Walking between rooms on the same floor	3.50 (0.56)	5.51 (1.90)	7.24 (1.68)	9.28 (2.52)
Standing up from armless chair	15.08 (1.11)	22.43 (2.44)	24.78 (2.52)	34.06 (3.83)
Getting in and out of bed	8.58 (0.67)	10.29 (2.10)	15.51 (2.74)	20.27 (3.47)
Any functional limitations	44.72 (3.76)	50.62 (1.93)	61.61 (18.81)	65.74 (2.26)

*Values are weighted prevalence in percentile (SEM).
**ALMI calculated as ALM/BMI.

explain why NH Blacks may have lower rates of sarcopenia? Furthermore, it may be that the same mechanisms of social inequality (i.e. socio-economic status and access to healthcare) that contribute to poor health among minority adults may also lead to decreased physical function with age [4,37]. Data from the Boston Area Community Health/Bone Survey, revealed that racial differences in lean mass did not translate into parallel differences in physical function. In general, White men had lower levels of lean body mass but higher levels of physical function [4]. Similarly, data from the Chicago Health and Aging Project indicated that Black men and women have lower physical function compared with White men and women [38]. Finally, a recent systematic literature review on the epidemiology of sarcopenia concluded Non-White populations experience a more rapid decline in muscle strength and function compared to White populations [39]. Such differences were not reflected in the current study, where NH Black men and women were found to have lower rates of sarcopenia and SO compared to NH Whites. It is not clear if the difference in sample size is driving this difference since there was a much smaller number of NH Black individuals than NH White individuals in the current dataset, especially in the >65 years category.

One possibility to explain the higher rates of sarcopenia and SO in the Hispanic population could be the higher prevalence of poorly controlled chronic disease, particularly diabetes, and other health conditions [40]. Individuals with chronic disease are known to have poorer health outcomes leading to hospitalization, thereby putting these individuals at greater risk for losing muscle mass and strength. Al Snih et al. documented that among older Mexican Americans, diabetes is independently associated with increased risk of developing new limitations in mobility tasks and lower body disability over a 7-year follow-up period [41].

We were surprised to find that Hispanic adults had higher rates of sarcopenia and SO. One possible explanation could be the disparity in mortality rates among ethnic populations. Populations that have greater survival rates may live longer even with poorer health and thus have greater chance of developing sarcopenia. Alternatively, populations which have lower survival rates may not live long enough to develop sarcopenia and thus may identify with lower prevalence of sarcopenia. This explanation appears to be supported by the results of our study and current mortality statistics; NH Blacks have the highest mortality rate, followed by NH Whites, and lastly Hispanics [42]. The lower mortality rates of the Hispanic population have been referred to as the Hispanic or Latino health paradox, where

NH Blacks and Hispanics may experience similar psychosocial and physical health challenges, including high rates of poverty, poor healthcare access, and high rates of obesity, diabetes, and undiagnosed/late-stage diagnosed diseases, yet Hispanics generally experience lower mortality rates than NH Blacks and NH Whites [43].

Potential differences in physical activity levels could also explain the higher rates of sarcopenia and SO in the Hispanic population. Crespo et al. documented that Mexican-American men and women may have lower rates of leisure-time physical activity compared to other populations [44]. More recently, the CDC reported that Hispanics are the group with the lowest percentage of adults meeting the 2008 Physical Activity Guidelines for aerobic and muscle-strengthening activity [45]. Certainly, further investigation is needed to understand the potential of chronic disease, mortality, physical inactivity, body composition and other characteristics to influence differences in the development of sarcopenia and SO.

Excess body fat can mask decreasing skeletal muscle mass making SO easy to overlook. Body weight and BMI measurements do not provide indications about changes in body composition, making SO even more challenging to clinically diagnose. Current body composition measurement tools (DEXA, computed tomography (CT) scan, magnetic resonance imaging (MRI)), although used in specific clinical and research settings, are not widely available for use with the general population. Further, as evidenced by the current study, such measurements may not be regularly included in population health studies, and the most-preferred measures of functionality, hand grip strength and gait speed, were not available in the NHANES dataset at all. It is thus critical to develop effective health screening tools to identify sarcopenia and SO, as well as develop early intervention strategies to help prevent progression of these serious conditions.

The recently established ICD-10 code for sarcopenia can potentially drive towards routine body composition measurements, as well as development of clinically-viable tools that can be used in community healthcare settings, as practitioners seek ways to identify sarcopenia. For such tools to become more commonplace, healthcare professionals need to be educated on the importance of sarcopenia and SO and how to incorporate routine screening and intervention for these conditions into their clinical practice. For example, screening for sarcopenia could be included as part of the Welcome to Medicare and annual Medicare wellness preventive exams using simple screening tools such as the SARC-F screen for sarcopenia [46].

Indeed, screening for sarcopenia and SO fits well within the care management model which has emerged as a "leading practice-based strategy for managing the health of populations" [47]. Key care management recommendations include "use multiple metrics to identify patients with modifiable risks" and "develop risk-based approaches to identify patients most in need of care management services" [47]. Sarcopenia and SO are important conditions for care management because they are modifiable risks and have potential significant impact on functionality and health outcomes. Project Leonardo demonstrated that care management is feasible and very effective in increasing patient health knowledge, self-management skills, and readiness to make changes in health behaviors [48]. Such an approach to sarcopenia and SO is critical because the conditions cannot be mitigated without patient engagement.

When developing the care management approach for sarcopenia and SO, early intervention strategies that include exercise and optimized nutrition are warranted to help mitigate progression of mobility-disability and loss of independent living. Resistance exercise is particularly effective in helping preserve muscle mass and strength in older adults, although there appears to be some variability in the dose-response relationship reported in the literature [49,50]. The LIFE study demonstrated the benefit of long term intervention with a structured physical activity program (aerobic, resistance training and flexibility activities) as compared to a health education program in preventing mobility-disability in older adults [51].

Nutritional approaches towards preventing muscle decline should include increasing protein intake to achieve at least 1.0-1.2g/kg body weight/day in older adults [52,53]. In addition, there is emerging evidence showing benefits of supplementation with specific nutrients such as Vitamin D, branch chain amino acids and their metabolites, and omega-3 fatty acids on muscle health [7,54]. High-protein oral nutritional supplements have been shown to improve strength outcomes in malnourished older adults with sarcopenia and enhance resistance training-induced skeletal muscle mass and function [56,49]. The same early intervention strategies (physical activity and nutrition) apply to the SO population along with calorie restriction, although higher protein intakes are recommended (at least 1.2 g/kg body weight or 1.9g/kg fat free mass per day), to preserve muscle mass during the weight loss period [56]. As the science on body composition and conditions such as sarcopenia and SO continues to evolve, so to must the data collection instruments, screening tools, care management approaches, and evidence-based intervention strategies. This will help ensure that there are ample opportunities to quantify the prevalence, screen and identify those at risk and intervene early through care management, to prevent mobility-disability and loss of independence.

Limitations

As a retrospective analysis, this study had several limitations, which could limit the application of the results compared to a prospective study. First, the research could only identify associations and not causation. This study was also constrained by the survey design of NHANES. Ethnic and racial populations were limited to the categories presented in the NHANES demographics questionnaire, which prevented analysis of more specific populations, such as Asian or Native Americans. Another limitation of the study was that the data were collected from 1999-2004, which were the most recent years in which DEXA measurements of appendicular lean and fat mass

were reported. Today's racial/ethnic populations may have different rates of sarcopenia and SO, which could challenge the inferences drawn from this study. In addition, there was a potential of selection bias, for example DEXA measurements of body composition were only available for participants who physically fit into the scanning table, (<300 pounds and <6 feet 5 inches in height), limiting inclusion of individuals who were morbidly obese. Further, examination from this survey period did not include measurements of hand grip strength or gait speed, two of the more preferable measurements of functionality in older adults [6]. Another study constraint was potential recall bias in the functional limitation data collected through a self-reported questionnaire. Despite these limitations, this study provides useful insights on the association between obesity and sarcopenia, and on the variation in prevalence of SO among different racial/ethnic, age, and sex groups.

Conclusion

The aging population (age 65 years and older) in the U.S. is projected to double by the year 2050 and to become increasingly racially and ethnically diverse [1]. The burgeoning size of the older adult population has increased the importance of understanding factors impacting health disparities, promoting healthy aging, and focusing on conditions that may impact independent living such as saracopenia and SO. Thus, there is a need to examine and collect data on the prevalence of sarcopenia and SO, especially among racial/ethnic groups, who have typically been less-studied. The prevalence of sarcopenia and SO increase with age and differ by sex and racial/ethnic groups, with Hispanics having the highest prevalence and NH Blacks the lowest. Further investigation is needed to better understand the characteristics influencing differences in the development of sarcopenia and SO and potential health disparities among racial/ethnic groups. In addition, given the importance of body composition and maintaining muscle strength for successful functional and health outcomes in older adults, screening and intervention for sarcopenia and SO should be included as part the basic education for those healthcare professionals working with older adults so they can become aware of the screening tools available and how to use these tools as part of routine wellness exams. Sarcopenia and SO are also important conditions for care management and can benefit from effective patient engagement. With the new recognition of sarcopenia as a CDC reportable condition and the assignment of an ICD-10 CM code for the condition, now is the time for researchers, healthcare practitioners and care managers, and policy makers to work together in developing guidelines and public health policies for preventing, identifying, managing, and treating sarcopenia and SO among older adults, particularly vulnerable racial/ethnic groups.

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