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ORIGINAL ARTICLE

Prevalence of sarcopenic obesity in Germany using established definitions

Baseline data of the FORMOsA study

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Abstract
Summary The prevalence of sarcopenic obesity in community-dwelling women 70 years and older according to established sarcopenia and obesity definitions averaged between 0 and 2.3 % and can thus be considered as relatively low. However, the converse argument that sarcopenic obesity was incompatible with an independent life cannot be confirmed.
Introduction The primary aim of the study was to determine the prevalence of sarcopenic obesity (SO) in community-dwelling (CD) older females in Germany. The secondary aim was to assess whether these females really live independently and autonomously.
Methods A total of 1325 CD females 70 years and older living in the area of Erlangen-Nürnberg, Germany were assessed. Sarcopenia as defined by (a) the European Working Group on Sarcopenia in older people (EWGSOP) and (b) the International working group on Sarcopenia (IWGS) combined with obesity defined as (a) BMI≥30 kg/m^2 (NIH) or (b) body-fat≥35 % (WHO) was determined. In participants with SO, Barthel Index, care level and social network were retrospectively evaluated via personal interview.
Results Based on anthropometric data, family, education and social status, lifestyle, number and distribution of diseases and medication, the present cohort is representative for the corresponding German population. Sarcopenia prevalence was 4.5 % according to EWGSOP and 3.3 % according to the IWGS criteria. Obesity prevalence in our cohort averaged 19.8 % (BMI, NIH) and 63.8 % (body fat, WHO). The overlap between both factors (i.e. SO) ranged from 0 % (EWGSOP + NIH criteria) to 2.3 % (EWGSOP + WHO criteria). Factors that may represent limited autonomy or independence were very rarely identified in this SO cohort.
Conclusion The prevalence of sarcopenic obesity in the CD (female) German population 70 years + is relatively low. With respect to our second research aim, the hypothesis that SO was incompatible with independent life was rejected. However, the latter finding should be addressed with more dedicated study designs.

Keyword BMI · Body fat · EWGSOP · IWGS · Sarcopenia obesity

Introduction

Sarcopenic Obesity (SO) is the combination of low muscle mass and -function (sarcopenia) and high fat mass (obesity) that affect subjects' health and independence through various interactions of musculoskeletal, cardiometabolic and functional parameters [1, 2]. Thus, the progressively increasing cohort of older people with SO are at particular risk of negative health impact such as loss of independence, disability and increased morbidity and mortality [2]. Although the relevance of this "geriatric syndrome" is considered to be high, its prevalence in older persons living in the community is unclear and may depend on different Sarcopenia and Sarcopenic Obesity definitions and approaches [1, 3].

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Independently of these considerations, the prevalence of Sarcopenia and Sarcopenic Obesity in community-dwelling people has not been established in Germany yet. Thus, the aim of our study was to determine the prevalence of SO for the relevant cohort of females 70 years and older.

Due to our assumption that SO collide with "independent living" in the community, our hypothesis was that the prevalence of Sarcopenic Obesity is less than 5 % for community-dwelling (CD) older females. Our secondary hypothesis was that the vast majority of corresponding CD females with SO do not live autonomously, but were intensively supported by ambulatory nursing services or family members.

Methods

The "Bavarian Research Foundation - Sarcopenia and Osteoporosis" (FORMOsA) project is part of a comprehensive network that addresses Sarcopenia and Osteoporosis. Our research group focuses primarily on Sarcopenia and Sarcopenic Obesity in older CD females. Data presented are based on screening project data determined in Northern Bavaria from February to November 2014. The Institute of Medical Physics and the Institute of Biomedicine of Aging, University of Erlangen-Nürnberg (FAU) Germany initiated the study that was approved by the University Ethics Committee (Ethikantrag 905, 4209, 4914 B). After detailed information, all study participants gave written informed consent. The FORMoSA trial was registered under www.clinicaltrials.gov (NCT02356016).

Study endpoint

Sarcopenic obesity

Sarcopenia as defined by (a) the European Working Group on Sarcopenia in older people (EWGSOP) [4] and (b) the International working group on Sarcopenia (IWGS)([5]) combined with Obesity defined as BMI≥30 kg/m^2 [6] or body fat≥35 % [7].

Participants

Reference cohort of young women

In order to generate T-Score based cut-off values (Teschler Score, [8]), 689 Caucasian females 18-35 years old living in Northern Bavaria were assessed between February and August 2014 and served as a young reference cohort. With respect to anthropometric (e.g. BMI, body fat) and demographic (e.g. family and educational status, lifestyle) factors, this cohort can be considered representative for young Bavarian [9] or German females [10].

Women 70 years and older

Using citizen registration records provided by the municipality, in batches of 500 personal letters, in total 7,908 females 70 years and older, living community-dwelling in the area of Erlangen-Nürnberg, Germany were contacted. Letters included detailed study information with the most relevant eligibility criteria for the study. After verification of our eligibility criteria: (a) female, 70 years and older (b) living in the community, 1,343 of the responding 1,401 women matched these criteria and were included in the screening process. In order to exclude a possible effect of ethnic origin on Sarcopenia or SO, only white (Caucasian) people were included in the analysis (n=1325). Table 1 shows the characteristics of the eligible participants.

Measurements

Assessment of sarcopenia

We determined the prevalence of Sarcopenia according to the European Working Group on Sarcopenia in Older People (EWGSOP) [4] and the International working group on Sarcopenia [5]. Both definitions include "low muscle mass" and "low gait speed". Cut-off values for gait speed are≤0.8 m/s for the EWGSOP and≤1.0 m/s for the IWGS criteria. Additionally, the EWGSOP algorithm includes low handgrip strength at<20 kg for women [4, 11]. Low muscle mass is not consistently defined by both definitions. Generally the EWGSOP definition uses the T-score based cut-off for appendicular skeletal muscle mass index (ASMI: ≤ 5.45 kg/m^2) proposed by Baumgartner [12]. The IWGS group, on the other hand, suggests using the cut-offs defined by Newman et al. [13] which are generated by including only those subjects who fall into the lowest quintile of its ASMI distribution. It is important to note that both methods are DXA-based. In our study obesity prevalence was based on (a) a BMI cut-off of≥ 30 kg/m^2 [6] and (b) a body fat of≥35 % [7, 14].

Assessment of anthropometry and body composition parameter

Body mass and composition (i.e. total and regional fat and fat-free body mass) was determined using multi-frequency Bio Impedance Analysis (BIA; InBody 770, Biospace Ltd, Seoul, Korea) that separately measured trunk, arms and legs using a tetrapolar eight-point tactile electrode system by means of six different frequencies (1, 5, 50, 250, 500 and 1000 kHz). Body height was assessed by a calibrated stadiometer. Body mass

Table 1 Characteristics of the study participants (n=1325). P values represent differences between the subgroups (70–79 vs≥80 years)

Variable	Total cohort (n=1325)	70–79 years (n=1022)	80–95 years (n=303)	p
Age [years]	76.4±4.9	74.2±2.6	83.8±3.5	<.001
Body height [cm]	160.3±6.5	161.0±6.4	157.8±6.4	<.001
Body weight [kg]	68.5±11.9	69.2±12.0	66.0±11.3	<.001
Number of diseases [n]	2.31±1.10	2.20±1.08	2.64±1.09	<.001
Multimorbidity (≥2 diseases) [%]	79.9	77.8	87.1	<.001
CVD [%][a]	68.8	66.1	71.4	<.001
Diabetes mellitus type II [%]	18.8	18.2	21.0	<.001
Low-trauma fractures [%]	26.3	25.0	32.9	<.001
Glucocorticoids>5 mg/day [%]	3.3	3.3	3.4	.762
Physical activity [index][b]	4.38±1.30	4.40±1.29	4.29±1.36	.258
Physical fitness [index][b]	4.46±1.34	4.53±1.31	4.22±1.42	.001
No sports or exercise [%][c]	53.8	40.5	36.6	<.001

[a] Cardiovascular heart diseases according to ICD 10, I00-I99, incl. E78

[b] >5 mg/d during the last year as assessed by physical activity (PA) questionnaire [42] and interview. Index: scale from 1 (very low) to 7 (very high)

[c] ≤1 session/month during the last year

index was calculated as body mass (kg) / body height (m^2). Appendicular skeletal muscle mass (ASMM) was generated by summing the lean body mass of upper and lower limbs. An ASMM Index (ASMI) was calculated by dividing ASMM (kg) by height squared (m^2). Applying a -2 T-Score criterion (i.e. a decrease of 2 SD relative to a young reference cohort) the ASMI cut-off value for Sarcopenia was≤5.66 kg/m^2; using the "lowest ASMI quintile of the cohort" approach resulted in a considerably higher ASMI cut-off value of≤ 5.99 kg/m^2 for this cohort of females 79 years and older.

Assessment of functional sarcopenia parameters

Muscle strength

Using a Jamar hand dynamometer (Sammons Preston Inc, Bollington, USA) handgrip strength of the dominant and non-dominant hand was measured. The width of the dynamometer grip was individually adjusted to the participants' hand size. Tests were performed arms down by the side in an upright standing position. Two test trials each for the dominant and non-dominant were performed; the best trial was included in the analysis. Calibration of the device was checked prior to the study.

Gait speed

The 10 m test protocol of Fritz and Lusardi [15] was used to assess habitual gait speed. Two trials with a rest period of 30 s between the trials were conducted without any walking targets. Participants were requested to walk 14 m in their usual gait speed using their regular shoes. Participants started 2 m before the first photo sensors (HL 2-31, TagHeuer, La Chaux-de-Fonds, Switzerland) walked 10 m in their habitual gait speed and stopped 2 m after the second photocell.

General characteristics, covariates, comorbidity

Questionnaires and short interviews were conducted to determine not only general characteristics (e.g. family and educational status, occupational career) but also medication, diseases and lifestyle and physical activity and fitness. In order to generate completeness and accuracy, participants were requested to list their medication and diseases at home prior to the interviews. In participants with SO personal interviews were conducted to address the degree of independence and autonomy via the Barthel Index [16], family status, social network, grade of care intensity I-III (i.e. "Pflegestufe" [17]), and use of ambulatory nursing services.

Statistical analysis

Mean values with standard deviation (MV ± SD) and proportions (%) describes characteristics and key parameters of the study cohort. Differences between age groups (70-79 vs. ≥ 80 years) were consistently calculated using Welch T-Test for continuous and chi-square test for categorical variables.

All tests were two-sided with a p-value of less than 0.05 considered as statistically significant. SPSS 21.0 (SPSS Inc, Chicago, IL) was used for all statistical procedures.

Results

Apart from participation in sports and exercise activities, which was higher in our cohort (59.5 % vs. 50.8 %), anthropometric data, family, education and social status, lifestyle, number and distribution of diseases and medication among our study participants (Table 1) were identical or comparable to data given for German females 70 years and older [10, 18]. Additionally the age distribution within our cohort was identical to German data for females 70 years and older living in the community [10]. Thus, we assumed that our group was highly representative of the corresponding population of Germany.

Prevalence of sarcopenic obesity

Parameters that constituted "sarcopenia" [4, 5] and "obesity" [6, 7] for all participants (n=1325), for women 70–79 (n=1022) and for women 80 years and older (n=303) are listed in Table 2. Differences between the groups (<80 vs. ≥ 80 years) with respect to sarcopenia parameters (all p<.001) were much more pronounced compared with differences of obesity parameters (.028 to .452).

Table 3 gives the prevalence of "sarcopenia", "obesity" or "sarcopenic obesity" in our cohort. In summary, sarcopenic obesity applying the different combinations (EWGSOP, IWGS, NIH, WHO) varied from 0 to 2.3 % for the complete cohort, from 0 to 1.7 % for women 70–79 years old and from 0 to 5 % for the older subgroup (80+). To underscore this finding further, none of the 59 participants with sarcopenia according to EWGSOP had a BMI≥30 kg/m^2 (IWGS: n=1). However, largely independent of the sarcopenia definition (EWGSOP or IWGS), about 50 % of these women were obese according to the WHO of body fat >35 % definition.

Thus, our hypothesis that the prevalence of sarcopenic obesity was relatively low (<5 %) in CD women 70 years and older was confirmed.

Although the categorization according to the EWGSOP and IWGS approach was roughly comparable, only 20 women were sarcopenic according to both the EWGSOP (n=59) and the IWGS (n=43) criteria. Correspondingly, eight females fulfilled the criteria of sarcopenic obesity according to the EWGSOP (n=30) *and* the IWGS +>35 % body fat (n=24) approach. Of importance is the fact that no relevant differences between the age groups were determined for this issue.

With respect to our secondary research question, we had to reject our hypothesis that most people with SO did not live autonomously but were intensively supported by ambulatory nursing services or family members. In summary, 18 out of the 46 participants with SO (IWGS or EWGSOP and body fat> 35 %) reported living alone; 17 women said they lived in their own households with their husband or a partner of the same age. Only about one quarter live in their children's households. Further, only one woman reported a care category of level I. This lowest German care category address subjects in need of (1) personal hygiene, (2) nutrition or (3) mobility (at least two out of three limitations), with support of at least 90 min per day on average. Two participants, one with musculoskeletal limitation and the other with increasing dementia, used ambulatory nursing services. With respect to the Barthel Index (BI) [16], only one woman with SO showed a BI of less than 95 points (95–100: no or slight motoric limitations). All minor limitations were related to "bathing" and "showering" or more precisely "hair care".

Discussion

To our best knowledge, this is the first article to address the prevalence of sarcopenic obesity (SO) in a cohort that can be widely considered as representative for German community-dwelling (CD) older females. In summary, the prevalence of SO (≤2.3 %) was rather low both in the younger subgroup (70–79 years, ≤ 1.7 %) and in their elderly peers (≥80 years, ≤ 5.0 %). It is difficult to compare our data with other published prevalence rates because the sarcopenia and obesity definitions, criteria and assessments vary considerably among studies. With one exception [14], all the published data on SO prevalence [12, 19–24] were based on "low muscle mass" as the sole criterion for sarcopenia. Unfortunately, this early definition is obsolete and may contribute to the high sarcopenia prevalence rates of 19.9–35.8 % in CD females 65–80 years old reported by corresponding studies (e.g. [12, 19, 21, 24–27]). However, even when using more recent sarcopenia

Table 2 Sarcopenic obesity parameters of the study cohort of community-dwelling females 70 years and older. *P* values show differences between the subgroups (70–79 vs ≥80 years)

Variable	Total cohort (n=1325)	70-79 years (n=1022)	≥80 years (n=303)	p
BMI [kg/m^2]	26.7±4.3	26.7±4.4	26.5±4.5	.452
Body fat [%]	36.9±7.2	36.6±7.3	37.6±6.9	.028
Appendicular Skeletal Muscle Mass Index [kg/m^2]	6.59±0.73	6.65±0.71	6.38±0.76	<.001
Gait speed [m/s]	1.26±0.21	1.31±0.22	1.11±0.26	<.001
Hand grip strength [kg]	23.4±5.0	24.2±4.9	20.8±4.5	<.001

Table 3 Prevalence of sarcopenia, obesity and sarcopenic obesity according to EWGSOP, IWGS and NIH, WHO criteria in all women and women 70–79 vs. 80 years and older

Sarcopenia [%]	Total cohort (n=1325)	70–79 years (n=1022)	80–95 years (n=303)
Model 1: T-score based [4, 11, 12]: walking speed≤0.8 m/s or grip strength<20 kg and ASMI≤5.66 kg/m^2	4.5 %	2.8 %	9.9 %
Model 2: lowest quintile of the cohort: [5, 13] ASMI: ≤ 5.99 kg/m^2 and walking speed<1.0 m/s	3.3 %	1.2 %	10.3 %
Obesity [%]			
BMI≥30 kg/m^2 [6]	19.8 %	20.2 %	18.7 %
Body fat>35 % [7]	63.6 %	62.1 %	68.5 %
Sarcopenic obesity [%]			
Model 1 [4] and BMI≥30 kg/m^2	0 %	0 %	0 %
Model 1 [4] and body fat>35 %	2.3	1.7	4.3
Model 2 [5] and BMI≥30 kg/m^2	0.1 %	0.1 %	0 %
Model 2 [5] and body fat >35 %	1.8 %	0.9 %	5.0 %

definitions that include muscle strength and/or physical performance criteria [4, 5], prevalence rates of sarcopenia still vary considerably (e.g. from 0.9 % [28] to 30.1 % [29]) in CD female 70 years and older. One main reason for this variation is definitely the ambiguity on how to define "low muscle mass". Although with a few exceptions (e.g. biceps circumference [29]), most studies reliably assessed total (SMM) or/and appendicular muscle mass (ASMM) with modern multi-frequency BIA or DXA devices; the calculation and generation of sarcopenia cutoff values nonetheless differed considerably [30]. Usually SMM or ASMM was normalized for body height (e.g. [12]), body mass (e.g. [31]) or body height and fat (e.g. [25]) in order to generate "relative muscle mass". Corresponding cutoffs are typically based on T-score concepts or a low fraction within the distribution of the given cohort (e.g. lowest quartile or quintile of the cohort). However, application of these different approaches to our cohort would result in SO prevalence rates between 2.9 and 51.5 %.

In addition, although "obesity" is clearly operationalized by high BMI [6] or high total body fat (TBF, [7]), some studies used waist circumference [20, 21, 23, 32] or visceral fat as determined by computed tomography [22] to determine (abdominal) obesity. Further, with respect to TBF, the "cutoffs" of 28 % (males) and 35 % (females) suggested by the WHO [7] were rarely applied [14]. On the contrary, in the majority of studies, obesity cutoffs were based on the TBF distribution of the given cohort, i.e. > median TBF [12] or highest two TBF quintiles [19, 20, 24]. Applying absolute cutoffs determined by these studies (31.7 % [20] to 42.9 % TBF [24]) to our cohort, for example, would result in obesity prevalence rates of 24.1 % (TBF 42.7 %) to 78.5 % (TBF 31.7 %).

In order to overcome some of the problems in studies aimed at determining the prevalence of sarcopenic obesity, we strictly applied widely accepted consensus definitions and criteria of sarcopenia and obesity. With respect to sarcopenia prevalence, the application of the EWGSOP [4] and the IWGS [5] concepts resulted in roughly comparable rates (4.5 vs 3.3 %); however, only 1.5 % of the subjects were sarcopenic according to both definitions. This finding can be partially explained by the different implementations of "walking speed". While a gait speed faster than 1 m/s is a "killer criterion" in the IWSG definition, a higher velocity than the EWGSOP cutoff (0.8 m/s) did not result in exclusion but led to the application of an additional grip strength test. However, at least in our cohort, only a minority of participants were slower than 0.8 m/s (4.2 % or 1.0 m/s—12.8 %), while the cutoff for grip strength (<20 kg) was in the range of normative data given for the Jamar dynamometer (females 70+: 21±5 kg) [33, 34], with corresponding impact on prevalence rates of "low grip strength" (20.6 %). This methodology helps to explain the higher prevalence rates determined by the EWGSOP approach despite its stricter cutoffs for "low muscle mass" (i.e. 5.66 vs. IWGS 5.99 kg/m^2) *and* walking speed (0.8 m/s vs. IWGS 1.0 m/s). Addressing "sarcopenic obesity", the very low prevalence rate in our cohort when applying BMI (≤0.1 %) was due to the fact that the presently favored

approaches [4, 5] of adjusting total or appendicular muscle mass to height (and not weight) resulted in a significant underrepresentation of subjects with high BMI [13]. As an example, applying an ASMI cutoff 5.67 kg/m^2 comparable to the present study, Newman et al [13] identified 52 % of his 70–79-year-old females with BMI<25 as sarcopenic, compared with a rate of 7.1 and 0 % in the subgroups with overweight (25–30 kg/m^2) or obesity (>30 kg/m^2). This finding did not agree, however, with the "relative muscle mass" concept of sarcopenia initially proposed by Baumgartner [12].

Interestingly, only a minority (<5 %) of women with SO needed relevant assistance in daily activities (ADL). This was in contrast to our hypothesis, which suggested that negative consequences of sarcopenia *and* obesity synergistically and additively impacted on functional and metabolic risk factors (review in [2, 35, 36]) and ultimately prevented truly "independent and autonomous life" in the community. This finding should be further verified by studies with more dedicated study protocols,.

Limitations

Some features, procedures and limitations of this study may prevent a proper comparison with other studies in this field: (1) Although the time- and cost-effective application of (segmental) multi-frequency BIA technique is a promising one for determining body composition in larger cohorts, some authors (e.g. [3]) reported a systematic overestimation of muscle mass when compared with DXA. However, others and we [37–39] do not share this position. Particularly, Ling et al. [37] reported an "excellent agreement" of BIA (InBody 720, Biospace Ltd, Seoul, Korea) and DXA (QDR 4500a; Hologic, Bedford, USA).[1] Nevertheless, because our cutoff for "low muscle mass" is based on either a young reference cohort (≤2 SD T-score) or the distribution (lowest quintile) within the own cohort as assessed with the same BIA device, prevalence rates should not be affected. (2) Another particularity of the study was the considerably higher gait speed (1.26 vs. 1.07 to 1.19 m/s) compared with other studies (n=27) of females 70–79 years old (review in [40]). We attribute this finding to two causes: (a) There is some evidence that the 10 m walking test conducted in this study may result in significantly higher gait speed compared with the shorter distances (4 m) [41] used in most other studies [40]; and (b) the high level of sports and exercise participation in our cohort (59.5 %) with corresponding positive consequences for gait speed. (3) Finally, the assessment of parameters related to independence and autonomy was carried out retrospectively and only for participants with SO (n=46) but should have been conducted initially for the complete study cohort. As mentioned above, more dedicated studies should further address this relevant issue.

[1] We used the identical DXA scanner and the succeeding model of their BIA device (i.e. InBody 770).

Conclusion

Using established definitions of sarcopenia and obesity, the prevalence of sarcopenic obesity ranges between 0 and 2.3 % in German females 70+ years old and can thus be considered as rather low. Although sarcopenia prevalence rates derived by the EWGSOP and IWGS approaches were comparable, the overlap of correspondingly identified females was small, indicating that increased emphasis should be placed on generating a more consistent consensus definition of this "geriatric syndrome". Finally, our hypothesis that sarcopenic obesity was incompatible with an independent life could not be confirmed; however, this study was not optimally designed to address this issue.

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Conflicts of interest None.

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