Combination of dynapenia and abdominal obesity affects long-term physical performance trajectories in older adults: Sex differences

Short title: Dynapenic abdominal obesity and SPPB

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Abbreviations used: BMI, body mass index; CES-D, Center for Epidemiologic Studies Depression Scale; CI, confidence interval; D/AO, dynapenic/abdominal obesity; D/NAO, dynapenic/non-abdominal obesity; D/NO, dynapenia/non-obesity; D/O, dynapenia/obesity; ELSA, English Longitudinal Study of Ageing; GLMM, generalized linear mixed models; Health Survey for England, HSE; MREC, Multi-Centre Research and Ethics Committee; NVQ, National Vocational Qualifications; ND/AO, non-dynapenic/abdominal obesity; ND/NAO, non-dynapenic/non-abdominal obesity; ND/NO, non-dynapenia/non-obesity ND/O, non-dynapenia/obesity; SPPB, Short Physical Performance Battery.

Abstract

Background: There is little epidemiological evidence of sex differences in the association between dynapenic abdominal obesity and the decline in physical performance among older adults. **Objective:** The aims of the present study were to investigate whether the decline in physical performance is worse in individuals with dynapenic abdominal obese and whether there are sex differences in this association. **Methods:** Out of 6,183 individuals aged 60 years or older from the English Longitudinal Study of Ageing, 2,308 participants with missing data were excluded. Therefore, a longitudinal analysis was conducted with 3,875 older adults. Abdominal obesity was determined based on waist circumference (>102 cm for male and >88 cm for female) and dynapenia was based on grip strength (<26 kg for male <16 kg for female). The sample was divided into four groups: non-dynapenic/non-abdominal obesity (ND/NAO), non-dynapenic/abdominal obesity (ND/AO), dynapenic/non-abdominal obesity (D/NAO) and dynapenic/abdominal obesity (D/AO). Decline in physical performance in an eight-year follow-up period was analyzed using generalized linear mixed models. **Results:** At baseline, both male (-1.11 points; 95% CI: -1.58, -0.65; p <0.001) and female (-1.39 points; 95% CI: -1.76, -1.02; p <0.001) with D/AO had worse performances on the Short Physical Performance Battery (SPPB) than their counterparts in the ND/NAO group. Over the eight-year follow-up, male with D/AO had a faster rate of decline in the SPPB performance compared to male in the ND/NAO group (-0.11 points per year; 95% CI: -0.21, -0.01; p =0.03). **Conclusion:** D/AO is associated with a stronger decline in physical performance in male but not female. The identification and management of dynapenic abdominal obesity may be essential to avoiding the first signs of functional impairment in older male.

Keywords: waist circumference, grip strength, SPPB, physical performance, trajectories

Introduction

The decline in physical performance is commonly the first indicator of impaired function in older adults (1) and is considered a preclinical transition phase towards disability (2,3), predisposing these individuals to a greater risk of negative outcomes (1). Therefore, screening for this decline has been widely defended in the clinical geriatric setting (4).

Age-related changes in motor neuron function and muscle contractile properties lead to the loss of muscle strength, which is known as dynapenia (5). This process is faster in male despite their greater muscle mass and strength throughout life compared to female (6–8). Furthermore, fat distribution shifts from subcutaneous to abdominal deposits with aging, while fat mass tends to decrease or remain stable (9–12). This distribution occurs earlier in male and later in female due to menopause (12,13). The accumulation of abdominal fat exacerbates dynapenia (9,14–17), especially in male (17). This process is mediated by low-grade inflammation, which promotes insulin resistance and muscle catabolism and affects the repair of motor neurons (18,19). This way, dynapenic abdominal obesity (combination of dynapenia and abdominal obesity) could exert an impact on physical functioning differently between male and female.

Dynapenic abdominal obesity was related to gait speed decline over an eight-year follow-up in a previous study conducted by de Oliveira Máximo et al. (20) with 2,294 individuals aged 60 years or older free of mobility limitation at baseline. However, conflicting results are found when considering dynapenic obesity defined by the combination of dynapenia and general obesity. For example, exploring the cross-sectional relationship in older adults, Bouchard & Janssen (21) and Yang & collaborators (22) found that dynapenic obesity was associated with low gait speed. In a longitudinal study, on the other hand, Batsis & collaborators (23) found no decline in gait speed among individuals with dynapenic obesity over the four-year follow-up period.

The decline in physical performance is considered a component that precedes the onset of disability (2). Moreover, consistent evidence shows that dynapenic abdominal obesity is associated with disability regarding basic (24) and instrumental (25) activities of daily living. Therefore, the association between dynapenic abdominal obesity and the decline in physical performance needs to be investigated. For such, measures that incorporate a broader spectrum of functioning would be useful, such as the Short Physical Performance Battery (SPPB), which measures gait speed as well as balance, lower limb strength and endurance.

Therefore, the aims of the present study were to investigate whether the decline in physical performance is worse in individuals with dynapenic abdominal obesity and whether there are sex differences in this association. Our hypothesis are that the decline in physical performance is worse in individuals with dynapenic abdominal obesity compared to those with dynapenia or abdominal obesity alone and non-dynapenic/non-abdominal obesity and that male with dynapenic abdominal obesity have a worse physical performance than female.

Methods

Study population

The data used in this study were from the English Longitudinal Study of Ageing (ELSA), which is an ongoing panel study involving community-dwelling individuals in England aged 50 years or older. ELSA began in 2002 and the sample was composed of participants of the

Health Survey for England (HSE), which involved a nationally representative sample selected using a multi-stage stratified probability sampling design (26). Follow-up interviews in ELSA occur every two years and health examinations are performed by a nurse every four years. The first health examination occurred in 2004-2005. A detailed description of the study can be found in a previous publication (27).

The sample of the present study comprised 6,183 individuals aged 60 years or older in 2004, when anthropometric and physical performance data were collected for the first time. Among these individuals, 2,308 were excluded due to missing data on the SPPB, grip strength, waist circumference or other covariates, resulting in a final sample of 3,875 individuals at baseline (Supplementary Figure 1). These measures were not obtained for individuals who were incapable of 1) performing the walk tests without the use of a gait-assistance device; 2) standing up from a chair a single time without using the arms; 3) performing the standing balance tests; 4) performing the grip strength test; or 5) remaining in the standing position for the measurement of waist circumference. The participants were reevaluated after four (2008) and eight (2012) years.

Ethical approval and informed consent

Ethical approval and experimental protocols for ELSA were granted by the Multi-Centre Research and Ethics Committee (MREC/01/2/91). Respondents in ELSA gave their informed consent to participate in the study. The authors confirm that all research and methods were performed in accordance with approved guidelines and regulations.

Physical performance assessment

The SPPB is used to determine the physical performance of older adults through the combined assessment of static balance (feet side by side, semi-tandem and tandem), the 2.4-meter walk test and repeated chair stands (28). Each physical performance measure was categorized from 0 to 4 points, with 0 corresponding to the inability to perform the test and 4 corresponding to the highest level of performance. The complete battery ranges from 0 to 12 points, with higher scores denoting a better physical performance (28). In the present study, the outcome (SPPB score) was treated as a discrete variable.

Anthropometric measures and classification of groups

Grip strength was measured using a handgrip dynamometer (Smedley, range: 0 to 100 kg). During the test, the participant remained standing with the arm alongside the trunk and the elbow flexed at 90 degrees (29). Three maximum strength trials were performed with a one-minute rest period between readings and the highest value was considered for the analysis. Dynapenia was defined as grip strength <26 kg for male and <16 kg for female (30).

Waist circumference was measured using a metric tape at the midpoint between the lowest rib and the upper edge of the iliac crest. The measurement was made twice at the end of the expiratory phase of the respiratory cycle (29). A third measurement was performed if the difference between the first two measurements was greater than 3 cm. Abdominal obesity was defined as waist circumference >102 cm for male and >88 cm for female (31,32).

Four time-varying groups were created based on the absence/presence of abdominal obesity and dynapenia: non-dynapenic/non-abdominal obesity (ND/NAO); non-dynapenic/abdominal obesity (ND/AO); dynapenic/non-abdominal obesity (D/NAO); and dynapenic/abdominal obesity (D/AO) (25).

Covariates

The socioeconomic variables were sex, age was grouped into three 10-year categories, marital status (married vs. not married), total household wealth (quintiles) and level of education. The English three-way education system was qualified to a level lower than "O-level" or equivalent (0–11 years of schooling), a level lower than "A-level" or equivalent (12–13 years) and a higher qualification (more than 13 years) (25,33).

Smoking was determined by asking the participants whether they were non-smokers, ex-smokers or current smokers. Regarding alcohol intake, the participants were classified as non-drinkers or rare drinkers (up to once per week), frequent drinkers (two to six times per week) or daily drinkers (24). Physical activity level was determined using an instrument validated by the HSE (34), which considers the frequency of participation in vigorous, moderate and mild physical activities (more than once per week, once per week, one to three times per months or almost never). Lifestyle was classified as sedentary (no weekly physical activity) or active (mild, moderate or vigorous physical activity at least once per week) (25).

Health status was ascertained by self-reported medical diagnosis of diabetes, hypertension, stroke, heart disease, lung disease, cancer, osteoarthritis, osteoporosis and the occurrence of falls in the previous 12 months. Pain was assessed by asking the participants whether they were often troubled by pain in the hips, knees or feet when walking; this variables was dichotomized as no pain or pain (any degree) (35). Cognitive function was evaluated based on the global score of the immediate and delayed recall test (range: 0 to 20 words) (36). Depressive symptoms were determined using the Center for Epidemiologic Studies Depression Scale (CES-D), considering a cutoff of ≥4 points (37).

Weight (kg) was measured using a Tanita electronic scale with the participant barefoot and wearing light clothing. Height (m) was measured using a standardized Leicester portable stadiometer. Body mass index (BMI) was calculated by dividing weight in kilograms by height in meters squared (kg/m^2). BMI $\geq$ 30 kg/m^2 was considered indicative of obesity. Weight change was assessed by comparing baseline weight (kg) to weight at four-year and eight-year follow-up evaluations, as weight loss can affect the association between abdominal obesity and the decline in muscle strength. In comparison to weight at baseline, the individuals were categorized as having stable weight, weight loss equal to or greater than 5% and weight gain equal to or greater than 5% over follow-up. [(weight at four-year follow-up – weight at baseline) / weight at baseline x 100] and [(weight at eight-year follow-up – weight at baseline) / weight at baseline x 100] (38).

Statistical analysis

Differences in baseline characteristics between (a) included individuals and those excluded due to missing data on the SPPB, grip strength, waist circumference or other covariates and (b) the four groups classified according to abdominal obesity and dynapenia status were evaluated using the chi-squared test, analysis of variance (ANOVA) and Tukey's post hoc test. For all analyses, a p-value <0.05 was considered indicative of statistical significance.

Generalized linear mixed models (GLMM) stratified by sex were performed to estimate the trajectories of physical performance as a function of abdominal obesity and dynapenia status. We assumed normal distribution of the outcome and the XTMIXED procedure was used with an identity link and covariance structure maximum-likelihood estimates (mle) in Stata 14 SE (StataCorp, College Station, TX, USA) (39). GLMMs were chosen because such models are more appropriate for unbalanced data from studies with repeated measures and enable the statistical modeling of time-dependent changes in the outcome variable (SPPB) and in the magnitude of associations between variables (40,41). A full-model approach (42) was used with adjustment for a wide range of potential covariates defined *a priori* as being associated with the decline in physical performance (43). All covariates were treated as time-varying (i.e. when a variable changes over time for the subjects) (44).

In the GLMMs, the intercept represents differences in the mean SPPB score between the ND/AO, D/NAO and D/AO groups and the reference group (ND/NAO) at baseline. The coefficient for time represents SPPB performance decline in the reference group. Lastly, the coefficient for the interaction between time and ND/AO, D/NAO and D/AO represents differences in slope (the annual rate of decline in SPPB performance) between each of the three groups and the reference group. The results were reported as ß coefficient and 95% confidence interval (CI).

Three sensitivity analyses were performed. The first was to investigate whether abdominal obesity (yes/no) and dynapenia (yes/no), when analyzed separately, would be capable of modifying the associations found in the original models. The second was to investigate whether dynapenic obesity, defined using BMI ≥ 30 kg/m^2 rather than abdominal obesity, is associated with decline in physical performance. The third was to investigate whether the association between dynapenic abdominal obesity and decline in physical performance is modified when excluding individuals with a low SPPB score at baseline (≤ 8 points). Moreover, statistics to estimate average population parameters, such as the marginal average, were used from predictions of a previously fitted model.

Results

Among the 3,875 participants at baseline, 2,932 and 2,436 were reevaluated at the four-year and eight-year follow-up, respectively. Slightly more than 62.9% of the initial sample participated in the three waves and 75.7% participated in two waves of the study. The baseline characteristics according to abdominal obesity and dynapenia status stratified by sex are displayed in Table 1.

At baseline, the prevalence of D/AO and ND/AO was slightly higher in female than male (3.7%, [95% CI: 3.0, 4.6] versus 2.0% [95% CI: 1.4, 2.7] and 50.3% [95% CI: 48.2, 52.5] versus 42.3% [95% CI: 40.0, 44.6], respectively). No difference in the prevalence of D/NAO was found between sexes (3.3% [95% CI: 2.6, 4.3] versus 3.9% [95% CI: 3.2, 4.8]).

In the analysis comparing included and excluded individuals due to missing data, excluded individuals were mainly female, older and not married, had less schooling and income, smoked more, had a lower memory score, lower handgrip strength, higher waist circumference, higher BMI as well as more falls, sedentary behavior, depressive symptoms and greater frequencies of lung disease, heart disease, diabetes, hypertension, stroke, osteoarthritis, osteoporosis (see Supplementary Table 1).

Table 2 shows the estimated parameters of the generalized linear mixed models for the change in SPPB as a function of abdominal obesity and dynapenia status per sex in the eight-years of follow-up. The group with ND/NAO (both sexes) underwent significant decline in the performance on the SPPB over time. At baseline, both male (-1.11 points; 95% CI: -1.58, -0.65; p <0.001) and female (-1.39 points; 95% CI: -1.76, -1.02; p <0.001) with D/AO had worse performances on the SPPB than their counterparts in the ND/NAO group.

Over the eight-year follow-up, male with D/AO had a faster rate of decline in SPPB performance compared to male in the ND/NAO group. The estimated parameter for the difference in slope between the two groups was -0.11 points per year (95% CI: -0.21, -0.01; p =0.03) when all other covariates in the model were at zero or at average values, i.e., 60 years of age, total household wealth = 1st quintile, higher qualification, married, non-smokers, active, without hypertension, without diabetes, without lung disease, without heart disease, without stroke, without osteoarthritis, without osteoporosis, without falls, without joint pain, *CESD* <4 points, mean memory score = 20 and stable weight (Figure 1,Table 2 and Supplementary Table 2).

In clinical terms, male and female with D/AO had lower mean SPPB scores at baseline compared to their counterparts in the ND/NAO group (9.39 versus 10.50 for male and 8.63 versus 10.02 for female). However, male with D/AO exhibited a faster decline in the SPPB score at the end of the eight-year follow-up (-1.37 points) (Figure 1 and Supplementary Table 3), which is considered meaningful change (45). Female with D/AO had a mean decline in the SPPB score of 0.32 points in the same follow-up period (Figure 2 and Supplementary Table 3).

The first sensitivity analysis considering abdominal obesity and dynapenia as independent conditions showed significant intercept results. However, neither of the two conditions alone was associated with a greater SPPB decline based on their slope estimates (Table 3). This highlights the importance of the analytical approach adopted in the present study (considering the influence of combinations of abdominal obesity and dynapenia on the long-term decline in physical performance among older adults).

The second sensitivity analysis confirmed that dynapenic obesity (BMI ≥30 kg/m^2 and grip strength <26 kg for male and <16 kg for female) was not associated with SPPB decline over time (Table 4). The third sensitivity analysis, which excluded individuals with a low SPPB score (≤8 points) at baseline, demonstrated that male with D/AO had higher rates of decline in SPPB performance than those in the ND/NAO group (Supplementary Table 4 and Supplementary Figures 2 and 3).

Discussion

In this large nationally representative cohort, we demonstrated that older English male with dynapenic abdominal obesity have a stronger decline in physical performance. Moreover, when abdominal obesity and dynapenia were analyzed as independent conditions or when dynapenic obesity was defined by BMI ≥ 30 kg/m^2, neither was associated with a stronger decline in physical performance in either male or female, which highlights the importance of dynapenic abdominal obesity as a clinical condition.

Previous studies offer divergent findings regarding the association between dynapenic obesity and poorer physical performance in older adults. Cross-sectional studies conducted by Yang

& collaborators (22) involving 616 male and female aged 60 years or older (BMI ≥ 25 kg/m^2 and grip strength) and Bouchard & Janssen (21) involving 2,039 individuals aged 55 years or older (body fat mass and leg extensor strength) reported similar results, as individuals with dynapenic obesity had lower gait speed than those without either condition. In a four-year follow-up study of 2,025 individuals aged 60 years or older, on the other hand, Batsis & colleagues (23) found that the association between dynapenic obesity (BMI ≥ 30 kg/m^2 and knee extensor strength) and low gait speed at baseline in both sexes was not confirmed over time.

The most likely reason for the differences found between cross-sectional (21,22) and longitudinal (23) analyses seems to reside in how obesity is measured. General obesity indicators, such as BMI, are directly related to muscle strength in older people (14,17) and may not capture age-related changes in body fat distribution over time or differences between the sexes (12,14,46,47). Considering data on 8,441 participants aged 48 years or older from the European Prospective Investigation into Cancer-Norfolk, Keevil et al. (14) found that each 4.0-kg/m^2 increase in BMI corresponded to a 4.28-kg and 1.26-kg increase in grip strength in male and female, respectively, whereas each 10-cm increase in waist circumference corresponded to a 3.56-kg and 1.00-kg reduction in grip strength in male and female, respectively. Moreover, analyzing data on 5,181 older participants of the English Longitudinal Study of Aging, de Carvalho et al. (17) found that abdominal obesity was a risk factor for decline in grip strength trajectories in male but not in female in an eight-year follow-up period. Therefore, waist circumference seems to be more appropriate for this assessment in older adults, despite not being as accurate.

The decline in physical performance among older adults is complex and not fully understood. However, the accumulation of abdominal fat and the consequent low-grade inflammation has been associated with the stimulation of processes that exert a negative impact on muscle metabolism (18,19) and the repair of neurons (5). Thus, individuals with D/AO may experience faster decline in physical performance compared to ND/NAO, ND/AO and D/NAO groups.

The sex differences found in the present study may be explained by different age-related patterns of body fat distribution and muscle strength decline between male and female. Male exhibit more age-related loss of muscle strength (6,7) and accumulate abdominal fat earlier, with greater intensity and with a predisposition towards visceral fat deposition (12,13). Abdominal obesity is associated with a decline in a variety of neural and hormonal trophic aspects in muscles, given the link to chronic inflammation and the reduction in tolerance to glucose (18,19). Thus, evidence of the association between abdominal obesity and the exacerbation of the process of dynapenia exclusively in male (17) lends support to the stronger decline in physical performance in male with dynapenic abdominal obesity. In contrast, the buildup of central fat arises at an older age and in a subtler manner in female, occurring after menopause and with subcutaneous deposition (12,13). Thus, the milder production of inflammatory cytokines due to this alternate fat deposition (48) may attenuate the association between dynapenic abdominal obesity and the decline in physical performance in female over time.

The fact that both male and female with D/AO began the study with worse SPPB scores compared to their counterparts in the ND/NAO group highlights the importance of dynapenic abdominal obesity as a clinical condition that affects physical performance. However, the lack of an association between D/AO and a poorer SPPB performance in female over time may reflect the smaller effect of abdominal fat on the loss of muscle strength, which was milder in female than male with D/AO ($p < 0.01$, data not shown).

The sensitivity analyses showed that not combining abdominal obesity with dynapenia may lead to the overlooking of important associations between these conditions and the decline in physical performance, as abdominal obesity and dynapenia alone were not associated with SPPB decline over time (Table 3). This highlights the importance of the analytical approach adopted in the present study. The sensitivity analysis excluding individuals with low physical performance at baseline (≤ 8 points) revealed similar results to the main analysis. This finding seems to have an important clinical implication, with D/AO associated with faster rates of physical performance decline in both early and late phases in male.

This study has several strengths. The major strength is the use of a representative national sample of community-dwelling older adults in England, which enabled us to perform analyses stratified by sex. The use of objective measures of health and physical performance (waist circumference, grip strength and SPPB) is another strong point. Moreover, the analyses involved data from three waves and a long follow-up period, which enabled us to detect changes in physical performance over time. We also considered the influence of the regional redistribution of adipose tissue during the aging process and our models were adjusted by a wide range of important covariates associated with both the exposure and outcome.

The present study has also limitations that need to be considered. First, the losses to follow-up may be a source of bias, although this type of bias is inevitable in longitudinal studies involving community-dwelling older adults. Another potential source of bias relates to the generalization of the data due to the small number of individuals in the group with dynapenic abdominal obesity. However, this fact did not affect the association with the outcome in male. As the participants excluded from the analytical sample were poorer, had worse memory, sedentary behavior and a greater probability of chronic diseases, the trajectories estimated for these conditions may have been underestimated. Despite the differences between the included and excluded individuals, we were able to observe a stronger decline in the physical performance of male with dynapenic abdominal obesity. The lack of information on nutrition and the history of obesity (onset and duration) constitutes another limitation. Lastly, waist circumference does not provide a direct estimate of visceral adiposity, as achieved with computed tomography and magnetic resonance. However, it is a very useful screening tool in clinical practice.

Conclusion and implications

Dynapenic abdominal obesity is associated with a stronger decline in physical performance in older male. This finding highlights the clinical importance of including abdominal obesity and dynapenia in the evaluation of the risk of decline in physical performance, especially when these two conditions are found in the same patient. The identification and management of dynapenic abdominal obesity may be essential to avoiding the first signs of functional impairment in older male.

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CO, and TSA: are the guarantors of this work; and all authors: contributed to the interpretation of the results and revision of the manuscript and read and approved the final manuscript. The authors report no conflicts of interest.

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Table 1. Baseline characteristics of male and female from ELSA study (2004) according to abdominal obesity and dynapenia status.

	Male				Female			
	ND/NAO n = 933	**ND/AO n = 753**	**D/NAO n = 59**	**D/AO n = 35**	**ND/NAO n = 881**	**ND/AO n = 881**	**D/NAO n = 881**	**D/AO n = 881**
Age, years	69.5 ± 6.9	69.5 ± 6.5	79.3 ± 6.5[a,b]	75.9 ± 9.5[a,b]	69.5 ± 7.4	69.5 ± 6.6	77.8 ± 7.2[a,b]	74.2 ± 8.0[a,b,c]
60 - 69 years	55.4	52.2	8.4[a,b]	31.4[a,b]	57.5	54.5	14.6[a,b]	29.5[a,b]
70 - 79 years	35.2	39.6	42.4	31.5	30.1	37.5[a]	37.8	42.3
80 y or more	9.4	8.2	49.2[a,b]	37.1[a,b]	12.4	8.0[a]	47.6[a,b]	28.2[a,b]
Marital status (not married), (%)	22.0	20.6	40.7[a,b]	31.4	40.7*	39.7*	69.5*[a,b]	57.7[a,b]
Total household wealth in quintiles								
1st (highest)	29.6	23.2[a]	15.3	2.9[a,b]	27.2	19.1[a]	12.2[a]	10.3[a]
2nd	24.0	21.1	25.4	25.7	23.4	21.3	17.1	17.9
3rd	21.5	21.5	15.3	17.1	18.8	21.8	20.7	26.9
4th	14.3	19.8[a]	23.7	28.6	16.8	19.9	23.2	30.8[a]
5th (lowest)	9.7	13.1	20.3[a]	22.9[a]	12.6	16.7	26.8[a]	14.1
Not reported, (%)	0.9	1.3	0.0	2.8	1.2	1.2	0.0	0.0
Level of education, (%)								
Higher qualification	33.4	27.7	18.6	5.7[a,b]	21.8*	16.2[a*]	8.5[a]	9.0[a]
Level lower than "A level" or equivalent	23.8	21.0	13.6	17.1	23.3	19.9	15.9	17.9
Level lower than "O level" or equivalent	42.8	51.3[a]	67.8[a]	77.2[a,b]	54.9*	63.9[a*]	75.6[a]	73.1[a]
Smoking, (%)								
Non-smoker	30.6	24.4[a]	15.2[a]	17.1	47.2*	44.7*	50.0*	42.3
Ex-smoker	56.4	64.8	67.8[a]	74.3	41.1*	45.1*	40.2*	48.7
Smoker	13.0	10.8	17.0	8.6	11.7	10.2	9.8	9.0
Alcohol intake, (%)								
Non-drinker or rare drinker	10.1	11.5	8.5	5.7[b]	20.0*	23.9*	28.0*	30.8*
Frequent drinker	39.6	42.0	44.1	45.7	43.5	43.9	39.0	39.7
Daily drinker	42.3	38.5	23.7[a]	22.9	30.5*	23.6*	20.8	21.8
Did not answer	8.0	8.0	23.7[a,b]	25.7[a,b]	6.0	8.6	12.2	7.7
Sedentary behavior, (%)	2.5	2.1	5.1	2.9	1.7	2.9	7.3[a]	7.7[a]

Hypertension, (%)	36.3	52.6[a]	42.4	54.3	37.9	55.1[a]	45.1	64.1[a]
Diabetes, (%)	7.9	11.8	11.9	25.7[a]	2.3[*]	9.9[a]	4.9	14.1[a]
Cancer, (%)	7.1	9.8	8.5	8.6	9.8	9.6	13.4	9.0
Lung disease, (%)	14.7	16.6	13.6	28.6	16.8	20.5	17.1	24.4
Heart disease, (%)	25.8	26.0	32.2	34.3	20.5	20.9	28.0	28.2
Stroke, (%)	4.9	4.4	5.1	2.9	3.6	3.2	9.8[b]	5.1
Osteoarthritis, (%)	22.7	32.1[a]	44.1[a]	51.4[a]	36.5[*]	45.5[a*]	72.0[*a,b]	75.6[a,b]
Osteoporosis, (%)	1.2	1.7	3.4	8.6	13.1[*]	9.7[*]	15.9	15.4
Joint pain, (%)	15.8	22.4a	25.4	31.4a,b	21.0	30.9a	32.9	48.7
Falls in previous 12 months (mean ± SD)	0.4	0.5	0.7	1.0	0.6	0.7	0.8	1.1
Depressive symptoms, (%)	6.8	7.8	10.2	11.4	11.1[*]	15.5[*a]	24.4[a]	16.7
Memory Score, points (mean ± SD)	9.5 ± 3.2	9.3 ± 3.2	6.8 ± 3.4[a,b]	8.3 ± 3.7	10.3 ± 3.5[*]	10.0 ± 3.3[*]	8.0 ± 4.1[a,b]	8.7 ± 3.7[a,b]
Grip strength, kg (mean ± SD)	39.6 ± 7.4	40.6 ± 7.5[a]	21.0 ± 4.8[a,b]	22.5 ± 2.9[a,b]	24.4 ± 4.9[*]	24.7 ± 5.0[*]	12.8 ± 2.2[*a,b]	13.1 ± 2.6[*a,b]
Waist circumference, cm (mean ± SD)	93.7 ± 6.2	110.3 ± 7.0[a]	92.5 ± 7.0[b]	109.6 ± 5.6[a,c]	80.2 ± 5.6[*]	98.5 ± 8.3[*a]	79.4 ± 6.1[*b]	97.9 ± 8.2[*a,c]
Height, m (mean ± SD)	1.71 ± 0.7	1.71 ± 0.6[a]	1.65 ± 0.6[a,b]	1.65 ± 0.6[a,b]	1.60 ± 0.6[*]	1.60 ± 0.6[*a,b]	1.60 ± 0.7[*a,b]	1.50 ± 0.6[*a,b]
BMI ≥30 kg/m^2, (%)	1.9	51.7[a]	0.0	42.9[a]	1.6	51.4[a]	0.0	47.4[a]

Chi-squared test performed for categorical variables; analysis of variance (ANOVA) and Tukey's post hoc test performed for continuous variables to evaluate differences in baseline characteristics of four groups classified according to abdominal obesity and dynapenia status. Data expressed as percentage, mean and standard deviation (SD). *Significant sex difference in each group. [a] Significantly different from ND/NAO in each sex ; [b] Significantly different from ND/AO in each sex; [c] Significantly different from D/NAO in each sex. Statistical significance $p < 0.05$. Male, n = 1,780; female, n = 2,095. Abbreviations: D/AO, dynapenic/abdominal obesity; D/NAO, dynapenic/non-abdominal obesity; ND/AO, non-dynapenic/abdominal obesity; ND/NAO, non-dynapenic/non-abdominal obesity.

Table 2. Generalized linear mixed model estimated for SPPB scores as function of abdominal obesity and dynapenia status over eight-years of follow-up in older English male and female.

	Male		Female	
	Estimated Parameters		Estimated Parameters	
Time, years	-0.19	(-0.28, -0.10)**	-0.13	(-0.22, -0.04)*
Intercept Main effect				
ND/NAO	10.50†		10.02†	
ND/AO	-0.27	(-0.41, -0.13)**	-0.37	(-0.52, -0.22)**
D/NAO	-1.17	(-1.55, -0.79)**	-0.83	(-1.21, -0.46)**
D/AO	-1.11	(-1.58, -0.65)**	-1.39	(-1.76, -1.02)**
Slope Interaction effect				
Time x ND/NAO	10.44†		9.97†	
Time x ND/AO	-0.02	(-0.06, 0.02)	-0.01	(-0.05, 0.03)
Time x D/NAO	-0.01	(-0.10, 0.08)	0.01	(-0.07, 0.09)
Time x D/AO	-0.11	(-0.21, -0.01)*	0.01	(-0.06, 0.09)

Generalized linear mixed models performed to estimate beta coefficients (ß) and 95% confidence intervals (CI) for SPPB scores as function of abdominal obesity and dynapenia status in older adults. Model adjusted for age, total household wealth, years of schooling, marital status, smoking status, sedentary behavior, hypertension, diabetes, lung disease, heart disease, stroke, osteoarthritis, osteoporosis, falls, joint pain, depressive symptoms, mean memory score and change in weight. Intercept represents differences in mean SPPB score between ND/AO, D/NAO and D/AO and the reference group (ND/NAO) at baseline. Time represents SPPB performance decline in reference group. Slope represents estimated changes in SPPB scores per unit of time between group in question and reference. Significantly different from ND/NAO, * $p <0.05$; ** $p <0.001$. † indicates margins to reference group. Male, n = 1,780; female, n = 2,095. Abbreviations: D/AO, dynapenic/abdominal obesity; D/NAO, dynapenic/non-abdominal obesity; ND/AO, non-dynapenic/abdominal obesity; ND/NAO, non-dynapenic/non-abdominal obesity.

Table 3. Generalized linear mixed model estimated for SPPB scores as function of abdominal obesity and dynapenia analyzed as independent conditions over eight-years of follow-up in older English male and female – Sensitivity analysis.

	Male		**Female**	
	Estimated Parameters		**Estimated Parameters**	
Time, years	-0.19	(-0.28, -0.09)**	-0.13	(-0.22, -0.04)*
Intercept Main effect				
Without Abdominal Obesity	10.41†		9.93†	
Abdominal Obesity	-0.25	(-0.39, -0.11)**	-0.39	(-0.53, -0.24)**
Without Dynapenia	10.38†		9.81†	
Dynapenia	-1.04	(-1.34, -0.74)**	-0.93	(-1.20, -0.66)**
Slope Interaction effect				
Time x Without Abdominal Obesity	10.34†		9.88†	
Time x Abdominal Obesity	-0.03	(-0.07, 0.01)	-0.01	(-0.05, 0.03)
Time x Without Dynapenia	10.30†		9.75†	
Time x Dynapenia	-0.04	(-0.11, 0.03)	0.02	(-0.04, 0.07)

Generalized linear mixed models performed to estimate beta coefficients (ß) and 95% confidence intervals (CI) for SPPB scores as function of abdominal obesity and dynapenia analyzed as independent conditions in older adults. Model adjusted for age, total household wealth, years of schooling, marital status, smoking status, sedentary behavior, hypertension, diabetes, lung disease, heart disease, stroke, osteoarthritis, osteoporosis, falls, joint pain, depressive symptoms, mean memory score and change in weight. Intercept represents differences in mean SPPB score between abdominal obesity or dynapenia and reference group (without abdominal obesity or without dynapenia) at baseline. Time represents SPPB performance declines in reference group. Slope represents estimated changes in SPPB scores per unit of time between group in question and reference. Significantly different from without abdominal obesity or without dynapenia * $p < 0.05$; ** $p < 0.001$. † indicates margins to reference group. Male, n = 1,780; female, n = 2,095.

Table 4. Generalized linear mixed model estimated for SPPB scores as function of obesity (BMI ≥30 kg/m^2) and dynapenia status over eight-year follow-up in older English male and female – Sensitivity analysis.

	Male		Female	
	Estimated Parameters		**Estimated Parameters**	
Time, years	-0.17	(-0.26, -0.08)**	-0.15	(-0.25, -0.06)**
Intercept Main effect				
ND/NO	10.50†		10.08†	
ND/O	-0.11	(-0.31, 0.08)	-0.29	(-0.48, -0.10)*
D/NO	-1.08	(-1.41, -0.75)**	-0.98	(-1.29, -0.68)**
D/O	-0.95	(-1.64, -0.27)*	-1.13	(-1.66, -0.60)**
Slope Interaction effect				
Time x ND/NO	10.42†		9.99†	
Time x ND/O	0.02	(-0.03, 0.08)	0.01	(-0.04, 0.06)
Time x D/NO	-0.03	(-0.11, 0.04)	0.02	(-0.05, 0.08)
Time x D/O	-0.08	(-0.22, 0.07)	0.03	(-0.07, 0.13)

Generalized linear mixed models performed to estimate beta coefficients (ß) and 95% confidence intervals (CI) for SPPB scores as function of obesity (BMI ≥30 kg/m^2) and dynapenia status in older adults. Model adjusted for age, total household wealth, years of schooling, marital status, smoking status, sedentary behavior, hypertension, diabetes, lung disease, heart disease, stroke, osteoarthritis, osteoporosis, falls, joint pain, depressive symptoms, mean memory score and waist circumference. Intercept represents differences in mean SPPB score between the ND/O, D/NO and D/O and reference group (ND/NO) at baseline. Time represents SPPB performance decline in reference group. Slope represents estimated changes in SPPB scores per unit of time between group in question and reference. Significantly different from ND/NO, * p <0.05; ** p <0.001. † indicates margins to reference group. Male, n = 1,780; female, n = 2,095. Abbreviations: D/NO, dynapenia/non-obesity; D/O, dynapenia/obesity; ND/NO, non-dynapenia/non-obesity ND/O, non-dynapenia/obesity.

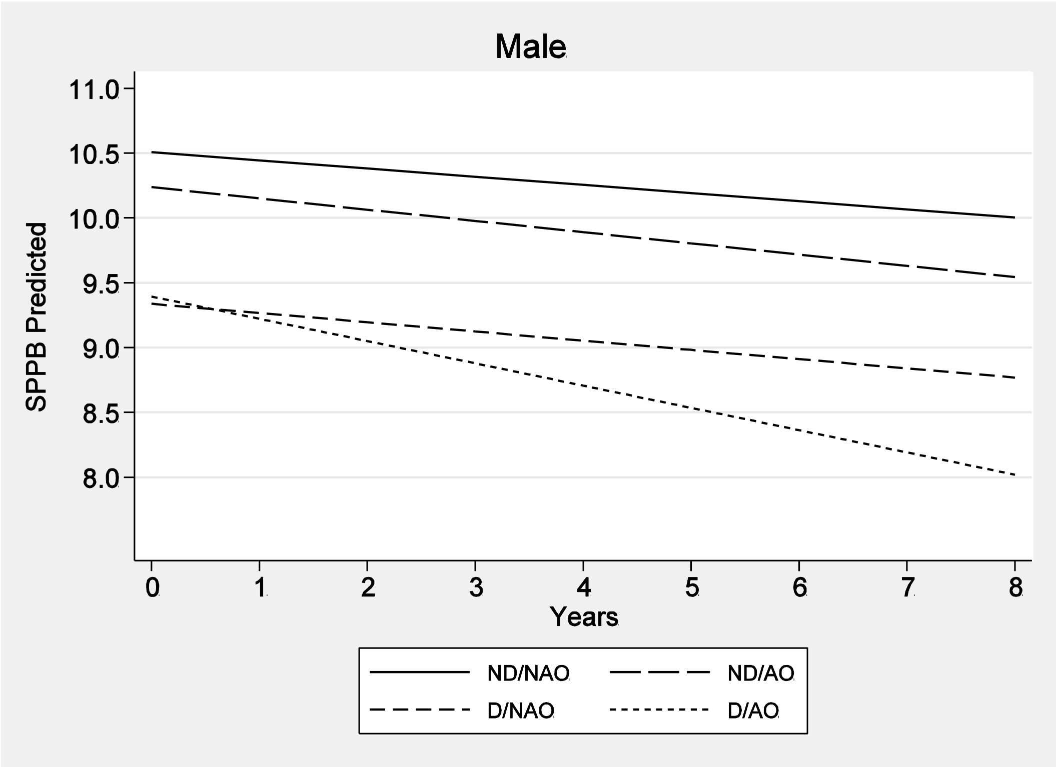

Figure 1. Trajectories of performance on SPPB for male according to abdominal obesity and dynapenia status – ELSA Study 2004-2012. Predictions for 60 years of age, male, total household wealth = 1st quintile, higher qualification, married, non-smokers, active, without hypertension, without diabetes, without lung disease, without heart disease, without stroke, without osteoarthritis, without osteoporosis, without falls, without joint pain, *CESD* <4 points, mean memory score = 20 and stable weight. Over the eight-year follow-up, only males with D/AO had a faster rate of decline in the SPPB performance compared to males in the ND/NAO group (-0.11 points per year; 95% CI: -0.21, -0.01; p =0.03). n = 1,780. Abbreviations: D/AO, dynapenic/abdominal obesity; D/NAO, dynapenic/non-abdominal obesity; ND/AO, non-dynapenic/abdominal obesity; ND/NAO, non-dynapenic/non-abdominal obesity. Figure created with STATA 14 (StataCorp. 2015. *Stata Statistical Software: Release 14.* College Station, TX: StataCorp LP) (39).

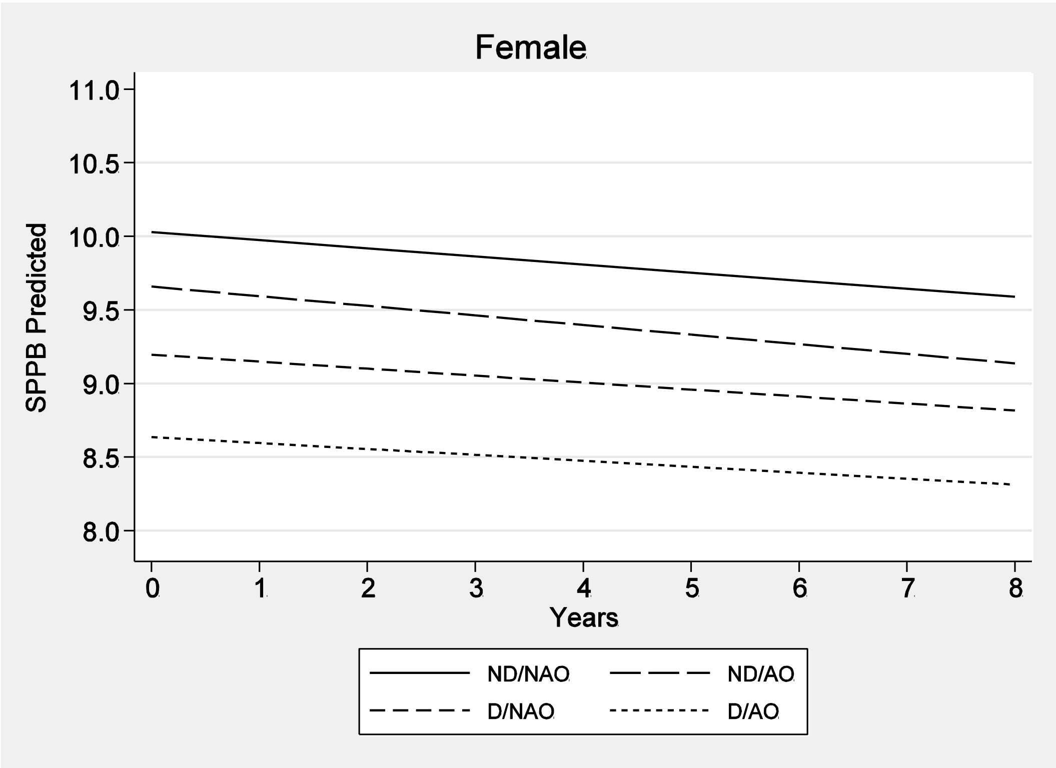

Figure 2. Trajectories of performance on SPPB for female according to abdominal obesity and dynapenia status – ELSA Study 2004-2012. Predictions for 60 years of age, female, total household wealth = 1st quintile, higher qualification, married, non-smokers, active, without hypertension, without diabetes, without lung disease, without heart disease, without stroke, without osteoarthritis, without osteoporosis, without falls, without joint pain, *CESD* <4 points, mean memory score = 20 and stable weight. Females with D/AO underwent no significant decline in the performance on the SPPB over time (0.01 points per year; 95% CI: -0.06, 0.09; p >0.71). n = 2,095. Abbreviations: D/AO, dynapenic/abdominal obesity; D/NAO, dynapenic/non-abdominal obesity; ND/AO, non-dynapenic/abdominal obesity; ND/NAO, non-dynapenic/non-abdominal obesity. Figure created with STATA 14 (StataCorp. 2015. *Stata Statistical Software: Release 14.* College Station, TX: StataCorp LP) (39).