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Original article

Sex differences in the association between dynapenic abdominal obesity and onset of disability in activities of daily living among adults aged ≥50 years: A prospective analysis of the Irish Longitudinal Study on Ageing

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ABSTRACT

Background: Sex differences in the longitudinal relationship between dynapenic abdominal obesity, i.e., impairment in muscle strength and high waist circumference, and disability in activities of daily living have not been investigated to date. Therefore, we aimed to examine sex differences in the longitudinal association between dynapenic abdominal obesity at baseline and the onset of disability in activities of daily living during a four-year follow-up period among Irish adults aged ≥50 years.

Methods: Data from Wave 1 (2009–2011) and Wave 3 (2014–2015) of the Irish Longitudinal Study on Ageing survey were analyzed. Dynapenia was defined as handgrip strength of <26 kg for men and <16 kg for women. Abdominal obesity was defined as waist circumference of >88 cm for women and >102 cm for men. Dynapenic abdominal obesity was defined as having both dynapenia and abdominal obesity. Disability was defined as having difficulty with at least one of six activities of daily living (dressing, walking, bathing, eating, getting in or out of bed, using the toilet). Multivariable logistic regression was conducted to assess associations.

Results: Data on 4471 individuals aged ≥50 years and free of disability at baseline were analyzed [mean (SD) age 62.3 (8.6) years; 48.3 % males]. In the overall sample, compared to no dynapenia and no abdominal obesity, dynapenic abdominal obesity was associated with 2.15 (95%CI = 1.17–3.93) times higher odds for incident disability at 4-year follow-up. This association was significant among men (OR = 3.78; 95%CI = 1.70–8.38) but not among women (OR = 1.34; 95%CI = 0.60–2.98).

Conclusions: Interventions to prevent or address dynapenic abdominal obesity may aid in the prevention of disability, especially among men.

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1. Introduction

Body composition changes as one ages, and this is characterized by an increase in total fat mass and decrease in lean mass and bone density [1]. In addition, ageing is associated with loss of muscle strength, known as dynapenia [2]. These age-related changes have been associated with disability or declines in functional ability in older adults. For example, a systematic review of eight cross-sectional studies indicated that being obese was associated with a 1.76 fold increase in the likelihood of limitations in the activities of daily living (ADL) [3]. Indeed, individuals with obesity are at higher risk for chronic conditions such as cardiovascular disease, hypertension, dyslipidaemia, diabetes and arthritis [4], and these conditions often underlie disability among these individuals [5]. Similarly, a recent systematic review including a large number of studies demonstrated that low muscle strength is associated with limitations in ADLs, possibly via decline in physical function associated with reduced muscle strength [6].

Currently, there is growing interest in the combination of abdominal obesity and low muscle strength, known as dynapenic abdominal obesity (DAO) [1], as a risk factor for adverse health outcomes including disability [7]. Waist circumference, which is strongly related to visceral fat, is considered a more reliable measure of obesity than body mass index (BMI) in older adults, due to age-related changes in body composition [8]. It is possible for DAO to have a more pronounced effect on physical function than dynapenia alone or abdominal obesity alone as fatty infiltration of muscle can cause low muscle strength, while it is possible for abdominal obesity to reduce muscle strength via endocrine and inflammatory mechanisms [9].

However, only a few studies have investigated the relationship between DAO and disability, and in particular ADL disability. For example, one study of the English Longitudinal Study of Ageing (n = 3723) showed that over an eight year period, DAO was associated with worsening ADL disability trajectories [7]. In another study including 93 men and 169 women aged between 66 and 78 years from Italy with 10 years of follow-up, it was observed that those with DAO are at higher risk of worsening disability than subjects with dynapenia or central fat distribution only [10]. Finally, in a sample of 370 men and 476 women aged between 65 and 95 years from Italy with 9 years of follow-up, participants with DAO were at higher risk of worsening disability compared to non-dynapenic and non-abdominal obese individuals [11].

The limitations of the previous studies on DAO and ADL disability are that they mainly focused on the trajectory or worsening of ADL disability, and they did not specifically estimate the risk for new onset of ADL disability among people who were free of ADL disability at baseline. Furthermore, another major limitation of these studies is that they did not assess sex differences in the association between DAO and ADL disability, despite the fact that previous research has suggested that sex differences may exist. For example, in a sample of 3875 older adults from the English Longitudinal Study of Ageing, it was observed that DAO was associated with a stronger decline in physical performance in males but not in females [12]. It is possible that DAO is more severe among males than females, as males are more likely to accumulate fat in the abdominal cavity than females, possibly due to bigger size and higher production of chylomicrons [13], while one study found that age-related declines in muscle strength were greater in individuals with abdominal obesity compared to those without, and that this association was only significant among men [14]. Thus, a sex-difference in the association between DAO and disability may exist, with this association being possibly more pronounced in males, as the decline in muscle strength coupled with abdominal obesity may greatly increase risk for ADL disability in males.

Therefore, the aim of this study was to examine the association between DAO at baseline and new onset ADL disability among middle-aged and older adults in Ireland who were free from ADL disability at baseline. A further aim was to assess the sex differences in this association.

2. Methods

2.1. Survey

We analyzed data from Wave 1 and Wave 3 of the Irish Longitudinal Study on Ageing (TILDA) survey. Data from Wave 2 was not used as data on ADL disability were not available. Full details of the survey, including its sampling methods, have been described in detail elsewhere [15–17]. Briefly, this was a community-based survey of middle-aged and older adults residing in Ireland conducted by Trinity College Dublin. The first wave (Wave 1) or the baseline survey was conducted between October 2009 and February 2011, and the third wave (Wave 3) was undertaken between March 2014 and October 2015. The target sample consisted of all individuals living in private households aged 50 years and over in Ireland. Clustered random sampling was used to obtain nationally representative samples. The first wave excluded institutionalized individuals, anyone with known dementia or anyone unable to personally provide written informed consent to participate due to severe cognitive impairment. Trained personnel conducted interviews with the use of Computer Assisted Personal Interviewing (CAPI). For sensitive questions (e.g., alcohol consumption), participants were asked to fill in a self-completion questionnaire (SCQ), which was returned after the interview. The response rate of Wave 1 was 62 %.

All respondents who completed the CAPI interview were invited to participate in a health assessment in one of two dedicated health centers in Dublin or Cork. Respondents who were unable and/or unwilling to attend a health assessment center were given the option of a shorter, home based assessment. Trained research nurses carried out all of the health assessments and the same procedures were followed in the health center and the home. A total of 5036 participants opted for a health center *assessment* and *861* underwent a *home assessment.* Sampling weights were generated with respect to age, sex, and educational attainment to the Quarterly National Household Survey 2010. Ethical approval for TILDA was obtained by the Faculty of Health Sciences Ethics Committee of Trinity College Dublin. Written informed consent was obtained from all participants.

2.2. ADL disability

Difficulties with six types of activities of daily living (ADL; dressing, walking, bathing, eating, getting in or out of bed, and using the toilet) were assessed by asking participants to indicate whether they had difficulty performing these activities due to a health or memory problem. The participant was asked to exclude any difficulties which are expected to last less than three months. ADL disability (dichotomous variable) was defined as having difficulty with at least one of these ADLs (code = 1). ADL disability was assessed in the exact same way in Wave 1 and Wave 3.

2.3. Dynapenia, abdominal obesity, and dynapenic abdominal obesity

Grip strength was measured with a Baseline (Fabrication Enterprises Inc., White Plains, NY, USA) hydraulic hand dynamometer. Respondents with swelling, inflammation, severe pain or recent injury to their hand/wrist, and those with surgery to their hand/wrist in the last 6 months were excluded. Dynapenia was defined as <26 kg for men and <16 kg for women [18], using the average value of the two handgrip measurements of the dominant hand. For waist circumference, the waist was defined as the point midway between the iliac crest and the costal margin (lower rib). The tape was kept horizontal and the measurement to the nearest mm was taken. Abdominal obesity was defined as a waist circumference of >88 cm for women and > 102 for men [19]. Participants were divided into four groups according to dynapenia and abdominal obesity status: No dynapenia and no abdominal obesity (code = 0), dynapenia alone (code = 1), abdominal obesity alone (code = 2), and dynapenia and abdominal obesity (i.e., DAO; code = 3). All

measurements were taken at Wave 1.

2.4. Control variables

The selection of the control variables was based on past literature [7,11], and included age, sex, education, smoking [never (code = 0), past (code = 1), current (code = 2)], physical activity, alcohol consumption [non-drinkers (code = 0), light/moderate drinkers (code = 1), heavy drinkers (code = 2)], and physical chronic conditions [20]. Education was classified as: primary (some primary/not complete, and primary or equivalent; code = 0); secondary (intermediate/ junior/ group certificate or equivalent, leaving certificate or equivalent; code = 1); and tertiary (diploma/certificate, primary degree, and postgraduate/ higher degree; code = 2). Physical activity was assessed with the short form of the IPAQ [21], and participants were classified as having low (code = 0), moderate (code = 1), or high (code = 2) levels of physical activity based on established criteria. Chronic physical conditions were assessed by the question "Has a doctor ever told you that you have any of the conditions on this card?" The total number of the following 14 conditions was summed: asthma, arthritis, cancer, chronic lung disease (chronic bronchitis or emphysema), cirrhosis, diabetes, eye disease (cataracts, glaucoma, age-related macular degeneration, or other eye disease), heart disease (angina, heart attack, congestive heart failure, heart murmur, abnormal heart rhythm, or other heart disease), high cholesterol, hypertension, osteoporosis, stomach ulcer, stroke, and varicose ulcer. The number of chronic conditions was categorized as 0 (code = 0), 1 (code = 1), and ≥2 (code = 2). The control variables were all assessed at Wave 1.

2.5. Statistical analysis

The analysis was done with Stata version 14.2 (Stata Corp LP, College Station, Texas, USA). A total of 8504 people aged ≥50 years (n = 8175) and their spouses or partners younger than 50 years (n = 329) participated in W1. Of these 8504 people, 6400 were followed at Wave 3. Our analytical sample consisted of: (a) participants aged ≥50 years at Wave 1 who had information on handgrip strength, waist circumference, and ADL disability at Wave 1; and (b) those who provided data on ADL disability at Wave 3. This restriction resulted in a total of 4819 participants. Furthermore, from this sample, we omitted those who had ADL disability at baseline, and this resulted in a final analytical sample of 4471 participants free of ADL disability at baseline. The flow chart of the participants can be found in Fig. 1. The difference in sample characteristics between the dynapenia/abdominal obesity groups at baseline was tested by Chi-squared tests and one-way ANOVA for categorical and continuous variables, respectively. Multivariable logistic regression analysis was conducted to assess the association between the four-category variable on dynapenia, abdominal obesity, or both (exposure) and new onset ADL disability at follow-up (outcome), with no dynapenia and no abdominal obesity being the reference category, while adjusting for age, sex, education, alcohol consumption, smoking, physical activity, and number of chronic physical conditions. Since our analytical sample consisted of people who had no ADL disability at baseline, the outcome referred to new cases of ADL disability (incident ADL disability) during a 4-year follow-up period. This method of analyzing a certain dichotomous outcome among those who did not have the outcome at baseline using logistic regression has been commonly employed when analyzing data from two waves of the TILDA survey [22–24]. The regression analysis was conducted using the overall sample, and sex-stratified samples as previous research showed that the effect of DAO on physical performance may differ by sex [12]. Among those included in the study, <0.87 % of the values for the variables used in this analysis were missing, except for alcohol consumption for which 12.4 % of the values were missing. We included a missing category for alcohol consumption so as not to exclude a large number of participants from the analysis. We conducted complete case analysis as the dataset did not include variables that can precisely predict the missing values, and also because we had no information on whether the data were missing at random [25]. The sample weighting and the complex study design including clustering within households were taken into account to obtain nationally representative estimates using the Stata *svy* command. Results are expressed as weighted odds ratios (ORs) and their 95 % confidence intervals (95%CIs). A two-side P-value <0.05 was considered to be statistically significant.

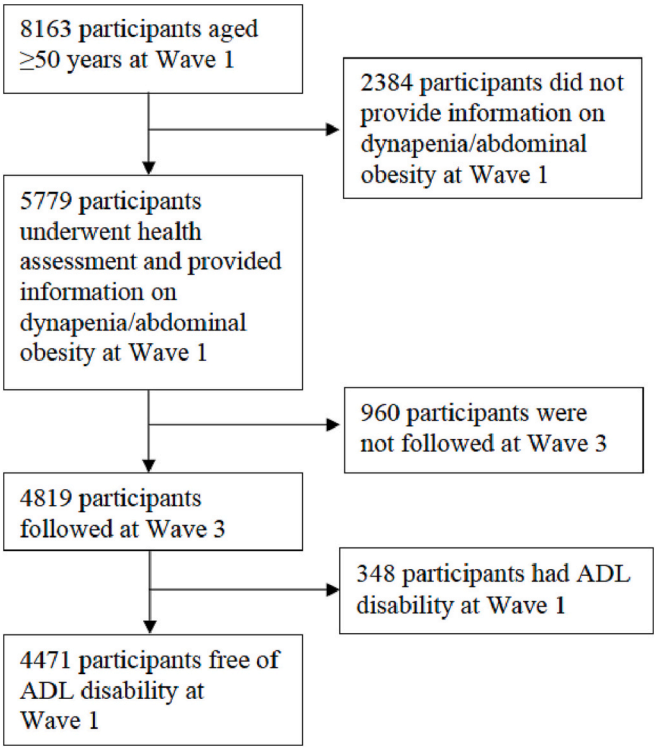

Fig. 1. Flow chart of the participants.

3. Results

The analytical sample consisted of 4471 individuals aged ≥50 years who were free of ADL disability at baseline. Of these people, 155 developed ADL disability during the 4-year follow-up, with this figure by dynapenia/abdominal obesity status at baseline being: no dynapenia and no abdominal obesity n = 35; dynapenia alone n = 22; abdominal obesity alone n = 64; and dynapenia and abdominal obesity n = 34. The prevalence of dynapenia alone, abdominal obesity alone, and dynapenic obesity were 9.7 %, 39.6 %, and 10.5 %, respectively. The baseline characteristics are provided in Table 1. The mean (SD) age was 62.3 (8.6) years and 48.3 % were males. Compared to other combinations of dynapenia and abdominal obesity, people with DAO were older and more likely to be females, have lower levels of education, be non-drinkers, never smokers, have lower levels of physical activity, and greater number of chronic physical conditions. The cumulative incidence of ADL disability was highest among those with DAO in the overall sample and in sex-stratified samples (Fig. 2). For example, in the overall sample, the cumulative incidence of ADL disability was 2.3 % among people without dynapenia or abdominal obesity but this figure increased to 10.1 % among those with DAO. After adjustment for potential confounders, in the overall sample, compared to no dynapenia and no abdominal obesity, DAO was associated with 2.15 (95%CI = 1.17–3.93) times higher odds for incident ADL disability at 4-year follow-up (Table 2). However, this association was mainly driven by males as no significant associations were observed for DAO, and also dynapenia alone and abdominal obesity alone in females. Among males,

Table 1
Baseline characteristics (overall and by dynapenia/abdominal obesity status).

Characteristic		Overall	D (−) AO (−)	D (+) AO (−)	D (−) AO (+)	D (+) AO (+)	P-value[a]
Age (years)	Mean (SD)	62.3 (8.6)	60.3 (8.0)	66.6 (8.9)	62.1 (8.0)	67.4 (9.0)	<0.001
Sex	Female	51.7	45.4	59.0	54.0	62.7	<0.001
	Male	48.3	54.6	41.0	46.0	37.3	
Education	Primary	33.3	25.7	40.7	36.5	46.6	<0.001
	Secondary	45.9	49.4	43.5	44.3	38.9	
	Tertiary	20.8	24.9	15.8	19.1	14.5	
Alcohol consumption	Non-drinkers	26.8	21.6	33.6	27.6	40.9	<0.001
	Light/moderate drinkers	44.4	47.0	46.4	42.4	39.4	
	Heavy drinkers	28.7	31.4	20.0	30.0	19.7	
Smoking	Never	45.2	44.8	47.9	44.9	46.0	0.026
	Quit	38.9	36.8	37.5	41.2	39.3	
	Current	15.9	18.4	14.6	14.0	14.7	
Physical activity	Low	27.3	21.5	30.0	29.5	40.8	<0.001
	Moderate	35.6	34.5	42.0	35.6	34.4	
	High	37.1	43.9	27.9	34.9	24.8	
No. of chronic conditions	0	20.9	27.5	16.2	17.4	10.5	<0.001
	1	27.8	31.1	27.5	26.3	19.9	
	≥2	51.3	41.4	56.3	56.3	69.6	

Abbreviation: SD Standard deviation; D Dynapenia; AO Abdominal obesity.
Data are weighted % (unweighted n/N) unless otherwise stated.
P-value was obtained by Chi-squared tests except for age (one-way ANOVA).

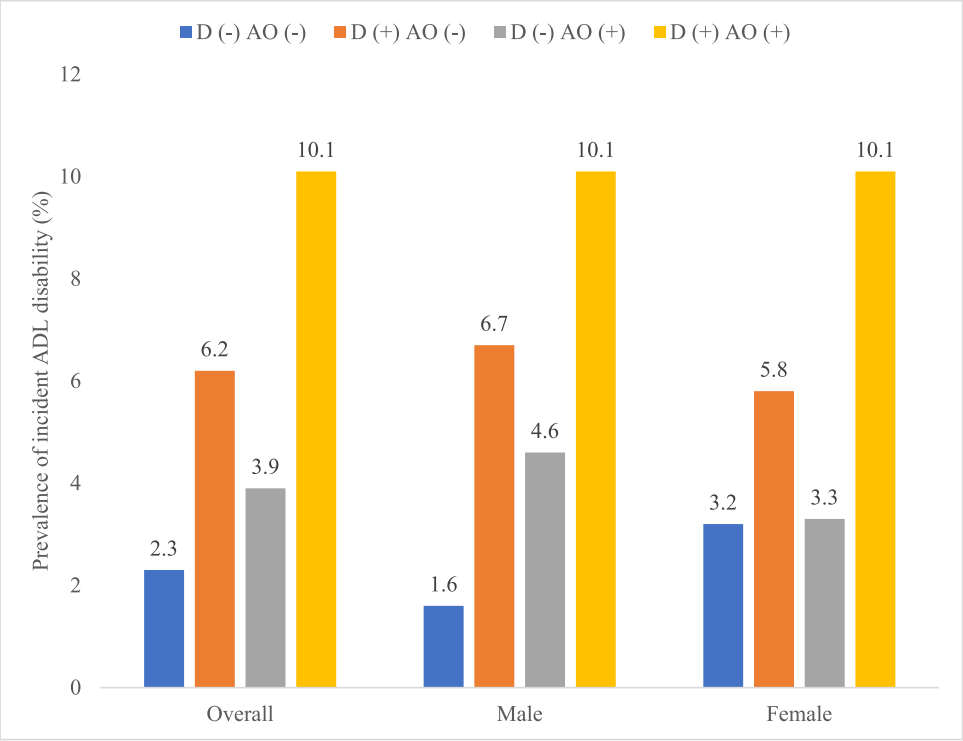

Fig. 2. Cumulative incidence of new onset ADL disability at 4-year follow-up by dynapenia/abdominal obesity status at baseline (overall and by sex).
Abbreviation: ADL Activities of daily living; D Dynapenia; AO Abdominal obesity.
New onset ADL disability referred to ADL disability at Wave 3 among those who did not have ADL disability at baseline (Wave 1). The estimates were calculated as the number of people who developed ADL disability at Wave 3 divided by the number of people who did not have ADL disability at baseline (at risk group at Wave 1).

dynapenia alone, abdominal obesity alone, and DAO were significantly associated with 2.77 (95%CI = 1.13–6.81), 2.35 (95%CI = 1.19–4.67), and 3.78 (95%CI = 1.70–8.38) times higher odds for new onset ADL disability, respectively.

4. Discussion

4.1. Main findings

In the present longitudinal study including a large representative sample of middle-aged to older adults from Ireland, in the overall sample, compared to no dynapenia and no abdominal obesity at baseline, DAO was associated with 2.15 (95%CI = 1.17–3.93) times higher odds for new onset ADL disability at 4-year follow-up. Importantly, among males, dynapenia alone, abdominal obesity alone, and DAO were all significantly associated with 2.77 (95%CI = 1.13–6.81), 2.35 (95%CI = 1.19–4.67), and 3.78 (95%CI = 1.70–8.38) times higher odds for new onset ADL disability, respectively. However, no significant associations were observed for females. To the best of our knowledge, this is the first study specifically on DAO and new onset ADL disability, while it is the first to show that there may be sex differences in this association.

4.2. Interpretation of the findings

Findings from the present study are in line with previous literature on this topic from the UK and Italy which found that DAO was associated

Table 2
Association between dynapenia, abdominal obesity, or both at baseline and incident ADL disability at 4-year follow up estimated by multivariable logistic regression.

Characteristic		Overall		Male		Female	
		OR	95%CI	OR	95%CI	OR	95%CI
Dynapenia & abodminal obesity status	D (−) AO (−)	1.00		1.00		1.00	
	D (+) AO (−)	1.50	[0.80,2.81]	2.77*	[1.13,6.81]	0.94	[0.41,2.15]
	D (−) AO (+)	1.24	[0.77,2.00]	2.35*	[1.19,4.67]	0.69	[0.35,1.33]
	D (+) AO (+)	2.15*	[1.17,3.93]	3.78**	[1.70,8.38]	1.34	[0.60,2.98]
Age (years)		1.06***	[1.03,1.09]	1.03	[1.00,1.06]	1.09***	[1.05,1.13]
Sex	Female	1.00					
	Male	1.18	[0.80,1.73]				
Education	Primary	1.00		1.00		1.00	
	Secondary	0.57*	[0.37,0.88]	0.55	[0.28,1.07]	0.63	[0.36,1.10]
	Tertiary	0.73	[0.46,1.16]	0.60	[0.31,1.16]	0.82	[0.43,1.56]
Alcohol consumption	Non-drinkers	1.00		1.00		1.00	
	Light/moderate drinkers	0.95	[0.58,1.55]	1.17	[0.57,2.42]	0.84	[0.44,1.61]
	Heavy drinkers	0.85	[0.44,1.64]	0.74	[0.31,1.78]	1.02	[0.39,2.70]
Smoking	Never	1.00		1.00		1.00	
	Quit	1.00	[0.65,1.53]	0.93	[0.49,1.76]	1.08	[0.60,1.95]
	Current	2.95***	[1.81,4.82]	1.98	[0.89,4.40]	4.26***	[2.25,8.06]
Physical activity	Low	1.00		1.00		1.00	
	Moderate	0.53**	[0.35,0.81]	0.57	[0.31,1.07]	0.51*	[0.29,0.90]
	High	0.41***	[0.26,0.65]	0.54	[0.28,1.02]	0.28***	[0.14,0.56]
No. of chronic physical conditions	0	1.00		1.00		1.00	
	1	1.57	[0.75,3.32]	0.82	[0.31,2.16]	5.34*	[1.01,28.17]
	≥2	2.65**	[1.35,5.20]	2.02	[0.93,4.36]	6.61*	[1.30,33.52]

Abbreviation: OR Odds ratio; CI Confidence interval; D Dynapenia; AO Abdominal obesity.
Models are adjusted for all variables in the respective columns.
* $p < 0.05$.
** $p < 0.01$.
*** $p < 0.001$.

with worse trajectories or worsening of ADL disability [7,10,11]. The increased risk of ADL disability among those with DAO may be explained by the conceptual model of disability proposed by Rivera and colleagues [26]. The model posits that an increased risk in disability among people with DAO may be explained by six main domains [central nervous system, peripheral nervous system, muscular system, osteo-articular system (bones and joints), perceptual system, energy production]. First, an excess of macronutrients in adipose tissues may stimulate the tissue to release inflammatory mediators, and reduces production of adiponectin, predisposing to a pro-inflammatory state and oxidative stress as well as increased muscle catabolic activity [9]. Moreover, abdominal adiposity may alter muscular anatomy, leading to impairment in its function by increasing the risk of intermuscular and intramuscular fat infiltration. These changes impact the functioning of the peripheral nervous system and muscular system [7]. Importantly, when the neuromuscular system is impaired, it may result in difficulties dealing with an overload in the osteoarticular system caused by abdominal obesity and can consequently result in limitations in ADL [7].

The finding that DAO was significantly associated with ADL disability only in men is interesting and of note. Such findings may be owing to the differences in fat deposition between men and women. For example, abdominal adiposity can either be subcutaneous or visceral fat with distinct proportions for men and women [27]. Men accumulate fat predominantly in the visceral abdominal region, which is strongly associated with elevated expression of proinflammatory cytokines [27] and insulin resistance [28]. These associations likely mediate the accelerated decline in muscle strength observed in abdominal obese men. Consequently, the elevated decline in muscle strength coupled with abdominal obesity may greatly increase males' risk of ADL disability. Furthermore, literature has shown that males with sarcopenic obesity (conceptually different but a similar concept to DAO) are more likely to suffer from osteoporosis compared to females [29]. In turn, osteoporosis has been found to be associated with worsening ADL [30].

4.3. Strengths and limitations

The large representative sample of middle-aged to older Irish adults with four years of follow-up is clear strengths of the present study. However, findings must be interpreted in light of the study limitations. First, some variables used in the study (including ADL disability) were based on self-report, and thus, reporting bias may exist. Second, those who were followed at Wave 3 were more likely to be younger and healthier than those who were lost to follow-up (details on the differences between those with and without follow-up are provided in Table S1 of the Appendix). Thus, some level of attrition bias may exist. Finally, information on DAO and other covariates were assessed at baseline. Thus, it is possible for some of this information to have changed during the four-year follow-up period.

4.4. Conclusion

DAO at baseline (vs. no dynapenia and no abdominal obesity) was significantly associated with a nearly four-times increased risk for new onset ADL disability at four-year follow-up among middle-aged and older males in Ireland but no significant associations were found for females. Findings from the present study suggest that interventions to prevent or address DAO may be appropriate to aid in the prevention of ADL disability, especially among men.

Supplementary data to this article can be found online at https://doi.org/10.1016/j.maturitas.2023.04.006.

Contributors

Lee Smith contributed to drafting and revision of the paper for important intellectual content.

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Ai Koyanagi contributed to drafting and revision of the paper for important intellectual content.

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Ethical approval

Ethical approval for TILDA was obtained by the Faculty of Health Sciences Ethics Committee of Trinity College Dublin. Written informed consent was obtained from all participants.

Provenance and peer review

This article was not commissioned and was externally peer reviewed.

Research data (data sharing and collaboration)

Researchers interested in using TILDA data may access the data for free from the following sites: Irish Social Science Data Archive (ISSDA) at University College Dublin http://www.ucd.ie/issda/data/tilda/; Interuniversity Consortium for Political and Social Research (ICPSR) at the University of Michigan (KENNY RA. The Irish Longitudinal Study on Ageing (TILDA), 2009–2011. Inter-university Consortium for Political and Social Research; 2018). TILDA (2019). *The Irish Longitudinal study on Ageing (TILDA) Wave 1, 2009–2011*. Version 1.8. Irish Social Science Data Archive. SN:0053-01. www.ucd.ie/issda/data/tilda/wave1; TILDA. (2019). *The Irish Longitudinal study on Ageing (TILDA) Wave 3, 2014–2015*. Version 3.1. Irish Social Science Data Archive. SN:0053-04. www.ucd.ie/issda/data/tilda/wave3.

Declaration of competing interest

The authors declare that they have no competing interest.

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