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Research Article

Muscle Quality and Muscle Fat Infiltration in Relation to Incident Mobility Disability and Gait Speed Decline: the Age, Gene/Environment Susceptibility-Reykjavik Study

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Abstract

Background. Aging is associated with increased risk of reduced mobility. However, data on muscle components in relation to subjective and objective indicators of disability is limited.
Methods. Data were from 2,725 participants (43% men) aged 74.8±4.7 years from the AGES-Reykjavik Study. At baseline, maximal isometric thigh strength (dynamometer chair), and midthigh muscle area and muscle fat infiltration were assessed with computed tomography. Usual 6 m gait speed and mobility disability were assessed at baseline and after 5.2±0.3 years. Incident mobility disability was defined as having much difficulty or unable to walk 500 m or climb-up 10 steps. A decrease of ≥0.1 m/s in gait speed was considered clinically relevant.
Results. Greater strength and area were protective for mobility disability risk and gait speed decline. After adjustment for other muscle components, greater strength was independently associated with lower mobility disability risk in women odds ratios (OR) 0.78 (95% CI 0.62, 0.99), and lower decline in gait speed risk among both men OR 0.64 (0.54, 0.76), and women OR 0.72 (0.62, 0.82). Larger muscle area was independently associated with lower mobility disability risk in women OR 0.67 (0.52, 0.87) and lower decline in gait speed risk in men OR 0.74 (0.61, 0.91).
Conclusions. Greater muscle strength and area were independently associated with 15–30% decreased risk of mobility disability in women and gait speed decline in men. Among

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women, greater muscle strength was also associated with lower risk of gait speed decline. Interventions aimed at maintaining muscle strength and area in old age might delay functional decline.

Key Words: Epidemiology—Functional performance—Muscle—Imaging—Gait

Aging is associated with loss of muscle strength and muscle mass and greater muscle fat infiltration (1–5). A recent meta-analysis showed that low muscle strength was strongly associated with functional decline. However, low muscle mass was weakly related to functional decline, reflecting inconsistent results across individual studies (6) for reasons that are unclear. It is possible that more precise measures of muscle like computed tomography (CT) imaging that also measure the physical and biochemical composition of the muscle, ie attenuation in Hounsfield Units (HU) of muscle and intermuscular adipose tissue area can provide insight into relationships between muscle components and function.

Muscle fat infiltration has been associated with poorer performance (7) and lower muscle strength (5) in cross-sectional studies among older adults. Muscle fat infiltration was also associated with increased risk of incident mobility limitation, independent of muscle mass, and strength (8). The latter is the only study till date that investigated associations between muscle fat infiltration and subsequent development of self-reported mobility disability. Investigating these associations in a different study population and with objective measures of physical function measures is important. Gait speed is one such measure. Slow gait speed probably represents disturbances in multiple organ systems and even small declines in gait speed are predictive of mortality (9) suggesting that gait speed may be a sensitive indicator of early functional decline.

Given the multidimensional nature of age-related changes in function, we used a comprehensive approach to examine associations between muscle strength, muscle area, muscle quality (strength/area), and two measures of muscle fat infiltration with incident mobility disability and gait speed decline over 5 years of follow-up in a large cohort of older adults. We hypothesized that participants with greater muscle strength, area and quality, and lower muscle fat infiltration would have lower odds of incident mobility disability and decline in gait speed.

Methods

Study Population

We used data from the Age, Gene/Environment Susceptibility-Reykjavik Study (AGES-Reykjavik) Study, a single-center, prospective, ongoing population study of survivors from the Reykjavik Study (10,11). Details of the study design are previously published (12). Baseline data collection among 5,764 men and women took place from 2002 to 2006. Follow-up took place between 2007 and 2011 in 3,316 participants (mean follow up; 5.2 ± 0.3 years) reflecting losses due to death (n = 1,039), and study attrition (n = 1,409).

All participants provided written informed consent. The study was approved (VSN 00-063) by the National Bioethics Committee in Iceland and the Institutional Review Board of the National Institute on Aging, Intramural Research Program.

Measures

Computed tomography

CT imaging of the midthigh was performed with a 4-row detector system Sensation; Siemens Medical Systems, Erlangen, Germany) (13). Thigh cross-sectional area (cm^2) was determined from a single 10 mm thick transaxial section (14). Muscle cross-sectional area was segmented using the outline along the fascial plane between the muscle and subcutaneous fat. Muscle fat infiltration represents intermuscular adipose tissue (IMAT) and muscle attenuation. IMAT (cm^2) is the visible fat within the fascia surrounding skeletal muscles (4); lakes of adipose between and within muscle were determined as the number of pixels with HU between −200 and −50 multiplied by the area of a pixel. Muscle attenuation was calculated as the mean attenuation coefficient (HU) of the muscle area after subtraction of IMAT. The HU of distilled water is 0 and of air is −1000 HU, lower HU indicates less dense muscle and greater fat infiltration (15) and is inversely associated with muscle strength (5). An operator used a manual contouring program to draw the contours of the hamstring, sartorius, and quadriceps muscles of the thigh as well as the contours of the total muscle bundle with the thigh. Within each region, a threshold was chosen to select voxels with a CT density greater than the maximal density of fat, as documented in Lang and associates. (16). The lean muscle cross-sectional area of each region was calculated as the number of voxels above the threshold, and the lean tissue attenuation was the mean CT density of the thresholded voxels. Twenty-six randomly selected participants underwent a second CT scan after repositioning. The coefficient of variation was 3.5% for thigh muscle cross-sectional area. There was no significant difference between the repeated measurements (14).

The average of the mean values for the left and right leg was used; if one leg was missing or incomplete, then the nonmissing thigh was used. The ratio of muscle strength and muscle area was calculated as an indicator of muscle quality (17).

Maximal isometric knee extension strength

Maximal isometric muscle strength of the dominant side of the thigh was measured according to a standardized protocol in a sitting position in an adjustable dynamometer chair (Good Strength, Metitur, Palokka, Finland) (14,18). Knee extension strength was measured with the knee angle at 60° from flexion toward full extension. The ankle was fastened by a belt to a strain-gauge system and with the participant's hands gripping the edge of the seat. Before the measurement participants completed one trial to ensure they understood the standardized instructions. Three maximal efforts, separated by 30-seconds rest, were conducted. During the measurements, participants were encouraged verbally to produce at their maximal capacity, and the highest value was used (14). Previous studies have shown high reliability for the strength chair in older individuals (19,20).

Self-reported mobility disability

Self-reported mobility disability was assessed at baseline and follow-up. Mobility disability was defined as having much difficulty or unable to walk 500 m and/or climb 10 steps. Participants with prevalent mobility disability at baseline were excluded (see description of analytical cohort below).

Gait speed

Gait speed was used as an objective measure of physical performance. Gait speed (m/s) was assessed at both baseline and follow-up

over a 6-m long course according to a standardized protocol (21). A stopwatch was used to measure the time. It took the participant to complete the 6 m walk. Participants were instructed to walk at their usual walking pace. Change in gait speed over time was calculated. A decline of ≥ 0.1 m/s in gait speed was used as a clinically meaningful change (9) and is herein referred to as decline in gait speed.

Confounding variables

All confounders were assessed at baseline. Body mass index (BMI) (kg/m^2) was calculated from measured height and weight, and waist circumference (cm) was measured using standardized protocols (12). Education (primary, secondary, college, and university education), smoking status (never, former, and current), and physical activity (frequency of moderate to vigorous activity) were assessed by questionnaire. Blood pressure was assessed from the mean value of two measurements with a large-cuff mercury sphygmomanometer. Medical conditions (hypertension, diabetes, congestive heart failure, coronary heart disease, myocardial infarction, stroke, disease of the lungs, disease of the kidneys, and cancer) were determined from self-report, medications, and clinical assessments.

Analytical cohort

The number of participants included in the analyses differed by physical function measure. Regarding mobility disability, we only included participants with complete data at baseline and follow-up (n = 3,228). As the primary outcome was incident mobility disability, participants who reported much difficulty (n = 91) or were unable (n = 69) to walk 500 m, and/or had much difficulty (n = 65) or were unable (n = 9) to walk up 10 steps at baseline were excluded. Participants without muscle strength, CT imaging data or covariates (n = 266) were excluded, resulting in 2,728 participants with complete data for muscle measures in relation to incident mobility disability. Regarding change in gait speed, 3,139 participants had baseline and follow-up gait speed. Exclusion of participants without muscle strength and/or CT imaging data or covariates (n = 280) resulted in 2,859 participants for the gait speed analyses.

Statistical Analysis

Baseline characteristics are presented according to incident mobility disability and decline in gait speed. Two-sided t-tests were performed for continuous variables and chi-square tests for categorical variables. Correlations between muscle parameters were examined using the Spearman correlation coefficient (r).

Multiple logistic regression analyses were performed to determine associations between baseline muscle strength, muscle area, muscle quality, and muscle fat infiltration with incident mobility disability and decline in gait speed. Effect estimates were expressed as odds ratios (OR) and 95% confidence intervals (CI). Men and women differ with regard to body composition (22) and physical performance (23). Analyses were therefore stratified by sex and modeled per sex-specific standard deviations (SD) of muscle parameters. Two models were fitted; Model 1 was adjusted for age, BMI, and education. Model 2 was additionally adjusted for waist circumference, smoking status, hypertension, diabetes, coronary heart disease, stroke, lung disease, kidney disease, and physical activity. All models of gait speed decline were adjusted for baseline gait speed.

To investigate which muscle measures (muscle strength, muscle area, and muscle fat infiltration) were independently associated with mobility disability and gait speed decline, we mutually adjusted a model for each muscle measure with the exception of muscle attenuation and IMAT which are collinear. Collinearity assessment within models revealed mean variance inflation factors <1.2. All p values are two-tailed (α = 0.05) and data were analyzed with STATA version 12.1 (StataCorp, College Station, TX).

Results

Mean age was 74.7 ± 4.7 years, varying slightly depending on the outcome measures (ie 74.8 ± 4.7 years for mobility disability, 74.8 ± 4.8 years for decline in gait speed). Differences between participants' characteristics with or without mobility disability or decline in gait speed are shown in Supplementary Table 1. Excluded participants, were older, had larger waist circumference, were more likely to be current smoker, were less educated, less physically active, and were more likely to have comorbidities than the analytical sample (p < .05). Excluded participants also had lower muscle strength, lower muscle area, lower muscle attenuation, and greater muscle fat infiltration compared with participants who were included (p < .001).

Muscle strength was positively correlated with muscle area, quality, and muscle attenuation. Muscle area was negatively correlated with quality, but positively correlated with IMAT. Quality was positively correlated with muscle attenuation, and IMAT was negatively correlated with both quality and muscle attenuation (Supplementary Table 2).

Muscle Measures in Relation to Mobility Disability

At follow-up, 52 (4.4%) men and 105 (6.8%) women reported having much difficulty or unable to walk 500 m. In addition, 42 (3.5%) men and 66 (4.3%) women reported having much difficulty or unable to climb 10 steps at follow-up. Of those participants reporting having difficulty/unable to perform those two tasks, 20 men and 29 women reported both and 216 (7.9 %) participants were classified as having mobility disability.

Associations between SD increments in muscle measures with risk of mobility disability are presented in Table 1. Greater muscle strength and larger muscle area were both associated with a lower risk of mobility disability in both men and women in a model that was adjusted for age, BMI, and education (Model 1). With additional adjustment for covariates (Model 2), muscle strength and muscle area remained associated with lower risk of mobility disability in men OR 0.67 (0.50, 0.90) and 0.66 (0.46, 0.95), respectively, and in women OR 0.67 (0.54, 0.82), OR 0.57 (0.45, 0.73), respectively. Higher muscle quality (greater strength per unit muscle area) was associated with lower mobility disability risk in women OR 0.81 (0.67, 0.99), but not in men OR 0.81 (0.62, 1.07), although the results were still suggestive of a protective association (Model 2). Higher values of muscle attenuation (HU) among women were associated with lower risk of mobility disability in Model 1; OR 0.81 (0.67, 0.97), but further adjustments for covariates attenuated the associations and became nonsignificant; OR 0.85 (0.71, 1.03) (Model 2). Muscle attenuation (HU) was not associated with mobility disability in men. IMAT (cm^2) was not associated with risk of mobility disability in men or women.

Muscle Measures in Relation to Decline in Gait Speed

Usual 6 m gait speed at baseline was 1.04 ± 0.18 m/s for men, and 0.97 ± 0.19 m/s for women. At the follow-up measurement, both men and women had a slower gait speed compared to the baseline examination: 0.96 ± 0.20 and 0.89 ± 0.20 m/s, respectively. Of

Table 1. Muscle Measures in Relation to Incident Mobility Disability and Decline in Gait Speed over 5 Years of Follow-Up

	Mobility Disability				Decline in Gait Speed			
	n at Risk	*n* Events	Model 1 (OR (95% CI))	Model 2 (OR (95% CI))	*n* at Risk	*n* Events	Model 1 (OR (95% CI))	Model 2 (OR (95% CI))
Men								
Muscle strength (N)	1,190	74	0.61 (0.46, 0.80)‡	0.67 (0.50, 0.90)†	1,208	504	0.55 (0.48, 0.64)‡	0.57 (0.49, 0.66)‡
Muscle area (cm²)	1,190	74	0.55 (0.39, 0.77)‡	0.66 (0.46, 0.95)*	1,208	504	0.57 (0.48, 0.68)‡	0.62 (0.52, 0.75)‡
Muscle quality (strength/area)	1,190	74	0.79 (0.61, 1.02)	0.81 (0.62, 1.07)	1,208	504	0.72 (0.63, 0.82)‡	0.71 (0.62, 0.81)‡
Muscle attenuation (HU)	1,190	74	0.84 (0.66, 1.09)	0.88 (0.68, 1.15)	1,208	504	0.83 (0.72, 0.95)†	0.86 (0.74, 0.99)*
IMAT (cm²)	1,190	74	1.17 (0.90, 1.52)	1.08 (0.81, 1.42)	1,208	504	1.10 (0.94, 1.28)	1.05 (0.90, 1.23)
Women								
Muscle strength (N)	1,538	142	0.64 (0.52, 0.78)‡	0.67 (0.54, 0.82)‡	1,651	710	0.67 (0.59, 0.76)‡	0.68 (0.60, 0.77)‡
Muscle area (cm²)	1,538	142	0.56 (0.45, 0.71)‡	0.57 (0.45, 0.73)‡	1,651	710	0.85 (0.74, 0.97)*	0.86 (0.75, 0.99)*
Muscle quality (strength/area)	1,538	142	0.79 (0.65, 0.96)*	0.81 (0.67, 0.99)*	1,651	710	0.72 (0.64, 0.81)‡	0.73 (0.64, 0.82)‡
Muscle attenuation (HU)	1,538	142	0.81 (0.67, 0.97)*	0.85 (0.71, 1.03)	1,651	710	0.90 (0.81, 1.01)	0.92 (0.82, 1.04)
IMAT (cm²)	1,538	142	1.08 (0.90, 1.28)	1.03 (0.86, 1.23)	1,651	710	1.08 (0.96, 1.21)	1.07 (0.95, 1.20)

Notes: Logistic regression analyses were used to compute odds ratios (OR) and 95% confidence intervals (CI). Model 1 was adjusted for age, BMI, and education. Model 2 was additionally adjusted for waist circumference, smoking status, hypertension, diabetes, coronary heart diseases, stroke, lung diseases, kidney diseases, and physical activity. Models of gait speed decline were additionally adjusted for baseline gait speed. HU = Hounsfield Units, IMAT; intermuscular adipose tissue, N = Newton.

*$p < .05$, †$p < .01$, ‡$P<0.001$.

those participants, decline in gait speed (≥ 0.1 m/s) occurred for 704 (41.7%) men and 710 (43.0%) women.

Table 1 also shows the association between muscle measures and decline in gait speed. Greater muscle strength, area, and quality were all associated with lower risk of decline in gait speed among men and women (Model 2). The strongest associations were observed for muscle strength among both men and women; OR 0.57 (0.49, 0.66) and OR 0.68 (0.60, 0.77), respectively. With regards to muscle attenuation (HU) among men was inversely associated with risk of decline in gait speed; OR 0.86 (0.74, 0.99) (Model 2). IMAT was not significantly associated with the risk of decline in gait speed.

Associations between all muscle measures and incident mobility disability or decline in gait speed using mutually adjusted models are shown in Table 2. Higher muscle strength and muscle area were independently associated with lower risk of mobility disability in women OR 0.78 (0.62, 0.99), and OR 0.67 (0.52, 0.87), respectively, but not in men. In men, adjustment for muscle strength attenuated the association between muscle area with mobility disability OR 0.68 (0.44, 1.04). In both men and women, adjustment for muscle attenuation did not appreciably change associations between muscle strength and muscle area with mobility disability nor was muscle fat infiltration associated with mobility disability. With regard to decline in gait speed, muscle strength remained associated with decreased risk, even after adjustment for other muscle measures in both men OR 0.64 (0.54, 0.76) and women OR 0.72 (0.62, 0.82). Muscle area was also inversely associated with decline in gait speed independent of other muscle measures, but only in men OR 0.74 (0.61, 0.91). In both genders, muscle attenuation and IMAT were not significantly associated with gait speed decline.

Discussion

This study investigated associations between multiple muscle measures and subsequent development of incident mobility disability and gait speed decline. We confirm prior findings of Visser and colleagues (8); greater thigh muscle strength and muscle area were independently associated with decreased risk of mobility disability in men and women. We further showed that among men and women muscle strength was associated with gait speed decline independent of muscle area and muscle attenuation. Among men muscle area remained associated with lower odds of gait speed decline after adjustments for muscle strength and muscle attenuation. Interestingly, muscle fat infiltration was not associated with either mobility disability or decline in gait speed.

The associations for muscle strength and muscle area with both of measures of physical function suggest that greater muscle strength and larger muscle area are independent predictors of less functional decline. Our results are supported by the Health, Aging, and Body Composition Study (Health ABC) (8,24) and other studies. Within the Cardiovascular Health Study and NHANES, low muscle mass was associated with greater risk of developing disability (25,26). In addition, low muscle strength was strongly associated with inability to walk 1 km and low walking speed among InCHIANTI participants (27). In contrast, low skeletal muscle mass was not cross-sectionally associated with self-reported physical disability among participants from the Framingham Heart Study (28). However, muscle was assessed with DXA which is less precise than CT and the study population was primarily healthy older people.

Although our study is observational and does not show causation, several clinical trials illustrate the effect of modifying muscle parameters and strength on function. Result from a randomized controlled trial in older men and women showed that a moderate-intensity physical activity program compared with education reduced the risk of major mobility disability over 2.6 years (29). A randomized controlled trial of physical activity and weight loss in overweight/obese older adults showed reduction in body fat and increase in lean mass, which in turn was associated with improved mobility (30). Others have shown that regular physical activity prevents age-associated loss of muscle strength and increase of muscle fat infiltration in older adults with moderate functional limitations (31). Combined, this evidence illustrates the importance of muscle mass and muscle strength in old age to maintain physical function, which is also recognized in sarcopenia definitions (32).

Despite prior indications of associations between muscle fat infiltration and incident mobility limitation (8), and decline in gait speed

Table 2. Muscle Measures in Relation to Incident Mobility Disability and Decline in Gait Speed Over 5 Years of Follow-Up in Mutually Adjusted Models

n (events)	Mobility Disability		Decline in Gait Speed	
	Men 1,093 (62)	Women 1,366 (129)	Men 1,155 (477)	Women 1,495 (635)
	OR (95% CI)	OR (95% CI)	OR (95% CI)	OR (95% CI)
Muscle strength (*N*)				
Model 2	0.83 (0.60, 1.16)	0.68 (0.55, 0.84)‡	0.59 (0.51, 0.69)‡	0.71 (0.63, 0.81)‡
Model 2 + muscle area	0.94 (0.66, 1.34)	0.77 (0.61, 0.97)*	0.64 (0.54, 0.76)‡	0.72 (0.62, 0.82)‡
Model 2 + muscle attenuation	0.86 (0.62, 1.21)	0.69 (0.55, 0.86)‡	0.69 (0.51, 0.70)‡	0.71 (0.62, 0.81)‡
Model 2 + IMAT	0.84 (0.60, 1.17)	0.68 (0.55, 0.84)‡	0.59 (0.50, 0.69)‡	0.71 (0.63, 0.81)‡
Model 2 + all	0.98 (0.68, 1.40)	0.78 (0.62, 0.99)*	0.64 (0.54, 0.76)‡	0.72 (0.62, 0.82)‡
Muscle area (cm^2)				
Model 2	0.66 (0.45, 0.98)*	0.61 (0.48, 0.78)‡	0.62 (0.51, 0.75)‡	0.87 (0.75, 1.00)
Model 2 + muscle strength	0.68 (0.44, 1.04)	0.68 (0.52, 0.88)†	0.74 (0.61, 0.91)†	0.98 (0.84, 1.15)
Model 2 + muscle attenuation	0.67 (0.45, 0.99)*	0.61 (0.48, 0.78)‡	0.62 (0.52, 0.76)‡	0.87 (0.75, 1.00)
Model 2 + IMAT	0.67 (0.45, 0.99)*	0.61 (0.48, 0.78)‡	0.61 (0.50, 0.74)‡	0.87 (0.75, 1.00)
Model 2 + all	0.68 (0.44, 1.04)	0.67 (0.52, 0.87)†	0.74 (0.61, 0.91)†	0.98 (0.84, 1.15)
Muscle attenuation (HU)				
Model 2	0.83 (0.62, 1.11)	0.88 (0.72, 1.06)	0.89 (0.77, 1.02)	0.96 (0.84, 1.08)
Model 2 + muscle strength	0.86 (0.64, 1.15)	0.94 (0.77, 1.15)	0.98 (0.84, 1.14)	1.01 (0.89, 1.14)
Model 2 + muscle area	0.85 (0.64, 1.14)	0.88 (0.72, 1.07)	0.92 (0.79, 1.06)	0.96 (0.85, 1.08)
Model 2 + all	0.86 (0.64, 1.15)	0.92 (0.75, 1.12)	0.99 (0.85, 1.15)	1.01 (0.89, 1.14)
IMAT (cm^2)				
Model 2	1.14 (0.84, 1.54)	1.00 (0.82, 1.20)	1.02 (0.87, 1.20)	1.08 (0.96, 1.22)
Model 2 + muscle strength	1.13 (0.83, 1.52)	0.99 (0.82, 1.20)	0.96 (0.81, 1.13)	1.08 (0.96, 1.23)
Model 2 + muscle area	1.09 (0.81, 1.47)	1.01 (0.83, 1.22)	0.94 (0.80, 1.11)	1.08 (0.96, 1.22)
Model 2 + all	1.09 (0.80, 1.47)	1.00 (0.82, 1.22)	0.92 (0.78, 1.09)	1.08 (0.96, 1.23)

Notes: Logistic regression analyses were used to compute odds ratios (OR) and 95% confidence intervals (CI). Models were adjusted for age, BMI, education, waist circumference, smoking status, hypertension, diabetes, coronary heart disease, stroke, lung disease, kidney disease, physical activity + different muscle components, or strength. Models of gait speed decline were additionally adjusted for baseline gait speed. BMI = body mass index; HU = Hounsfield Units, IMAT = intermuscular adipose tissue, N = Newton.

*$p < .05$, †$p < .01$, ‡$p < .001$.

(24), our study found no evidence of similar associations. These inconsistent findings raise the question whether muscle fat infiltration influences physical function. The previous mentioned associations (8,24) were observed among participants from the HABC study. It is possible that the lack of associations in our study population might be a true finding or reflects important population differences. For example muscle fat infiltration is lower in AGES-Reykjavik than Health ABC, however, direct comparison is limited due to the use of different CT scanners and methodology. The age range is wider (66–92 years) in AGES-Reykjavik than Health ABC (70–79 years), ethnic backgrounds differ (Health ABC included blacks and whites), as do diet and baseline physical function. In our analyses, 21.8% of the participants reported some difficulty in walking 500 m, and/or walking up 10 steps at baseline, whereas Health ABC participants were selected to be initially well functioning. Restricting our study population to participants who were well functioning using the Health ABC definition ($n = 2,108$) still resulted in no significant associations between muscle fat infiltration and risk of mobility disability or gait speed decline (data not shown). Further studies are needed to clarify the role of muscle fat infiltration in physical function.

In our study population, the incidence of mobility disability (7.9%) was low compared to the incidence of gait speed decline (42.6%). This difference might be related to elderly being more likely to give disproportionately positive health assessments compared to younger adults (33,34). Older adults also tend to overestimate their physical function (35). Another explanation might be that decline in gait speed occurs before people perceive this decline. Previously gait speed has been shown to be a sensitive and informative measure of physical function (9,36). Despite the difference in incidence, associations between muscle measures and measures of physical function were generally consistent.

Strengths and Limitations

Strengths of our study include the large sample size and the detailed body composition measures from CT imaging, including two measures of muscle fat infiltration which has seldom been reported. Physical function was assessed using both self-reported and objectively measured mobility. Our analytic sample for incident mobility disability was restricted to participants who reported no or some mobility disability at baseline, which minimizes the possibility of reverse causation.

Some limitations of the study need to be addressed. Like all observational studies, it precludes any conclusions on causality. Participants who did not have complete data at follow-up were older at baseline, had higher prevalence of comorbidities, and had lower gait speed at baseline, therefore, survival bias cannot be excluded. No muscle biopsies were available to directly measure the muscle fat infiltration, however, CT provides accurate images of the muscle and previous research has shown good correlations between CT and muscle biopsies (15,37).The external validity of our findings may be limited to older white adults since our study only included individuals of European ancestry.

In summary, this study shows that greater thigh muscle strength and muscle area were associated with lower odds of mobility disability and decline in gait speed among an older population after 5 years of follow-up. In view of global ageing and the considerable prevalence of older persons with functional limitations, interventions aimed at maintaining both muscle strength and area in old age might be important to prevent functional decline. Of note, muscle strength can be assessed in the clinic and may be a particularly important clinical risk factor for functional decline in older adults.

Supplementary Material

Supplementary material can be found at: http://biomedgerontology.oxfordjournals.org/

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