EDUCATION, OCCUPATION AND OPERATIONAL MEASURES OF SARCOPENIA: SIX YEARS OF AUSTRALIAN DATA

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MeSH Key Words: functional health status; economic status; epidemiology; health disparities

CONFLICT OF INTEREST

S.L.B-O. has received speaker fees from Amgen Australia and Pfizer Australia. D.S. has received speaker fees from Amgen Australia and consulting fees from Pfizer US. G.D. has received speaker fees from Amgen Australia, Eli Lilly, and Abbott, and consulting fees from Amgen Australia, Eli Lilly and Theramex.

ACKNOWLEDGEMENTS

This work was supported by the National Health and Medical Research Council (NHMRC) of Australia (Project Number 302204; Early Career Fellowship number 1158661 to F.W.; Career Development Fellowship number 1107510 to S.L.B-O., and number 1123014 to D.S.); Arthritis Foundation of Australia (MRI06161); Tasmanian Community Fund (D0015018); and University of Tasmania Institutional Research Grants Scheme (D0015019). S.L.B-O was also supported by a Research Fellowship from the Faculty of Medicine, Dentistry and Health Sciences, University of Melbourne. We gratefully acknowledge the efforts of the TasOAC participants and staff, particularly study coordinator Catrina Boon. We thank Darci Green, University of Melbourne, for her administrative support directly related to this manuscript.

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Article type : Research Article

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ABSTRACT:

Objectives: To examine associations of education and occupation with handgrip strength (HGS), lower limb strength (LLS), and appendicular lean mass (ALM).

Methods: Measures of HGS, LLS, and ALM (dual-energy X-ray absorptiometry) were ascertained at baseline in 1,090 adults (50-80yrs, 51% women), ~3yrs and 5yrs. Education and occupation were self-reported, the latter categorised as high-skilled white-collar (HSWC), low-skilled white-collar (LSWC), or blue-collar. Separate general estimating equations models were performed.

Results: The highest education group had greater HGS than the middle (0.33psi) and lowest (0.48psi) education groups, and 0.34kg greater ALM than the lowest education group. HGS was 0.46psi greater for HSWC than LSWC groups. Compared to LSWC groups, LLS was 5.38kg and 7.08kg greater in HSWC and blue-collar groups. Blue-collar and HSWC groups each had ~0.60-0.80kg greater ALM than LSWC.

Conclusion: Progressive muscle loss can be prevented by targeted intervention thus we suggest clinical attention be directed toward specific social groups.

KEYWORDS: functional health status; economic status; epidemiology; health disparities

WORD COUNT: Manuscript: 3000, Abstract: 150

INTRODUCTION:

The global population is ageing, yet, increased longevity does not always signify extra years lived in good health. Rather, some individuals appear to be living longer with declining physical capacities [1]. A healthy musculoskeletal system is an important determinant in the maintenance of functional capacity across the lifecourse. In 2016, sarcopenia was allocated an International Classification of Diseases, Tenth Revision, Clinical Modification (ICD-10-CM) code (M62.84) [2]. Sarcopenia results in an increase in physical disability, falls, fractures, and mortality [3, 4]. Whilst an international consensus regarding the operational definition of sarcopenia is, as yet, non-existent [3, 5], the diagnostic criteria for sarcopenia include a combination of low muscle mass, strength and physical performance [6, 7]. Regardless of the definition applied and populations examined [5], sarcopenia prevalence is suggested to be approximately 30% [7].

The impact of socioeconomic status on sarcopenia prevalence is not well understood and it is not clear whether sarcopenia prevalence, like other disease, has a social gradient [8]. Yet, there are data suggesting such a gradient might exist. In a pooled study of 18,363 adults aged ≥65 years from Finland, Poland, Spain, China, Ghana, India, Mexico and China, lower socioeconomic status (SES) was consistently associated with an increased risk of sarcopenia [9] defined by using indirect population equations to estimate skeletal muscle mass. However, much of the available literature has conflicting results from predominantly cross-sectional data. For instance, cross-sectionally, lower educational attainment was associated with a greater likelihood of sarcopenia in 730 Italian community-dwelling adults aged ≥65 years [10], but not in 70 Quilombola persons aged ≥60 years from Brazil [11].

Lower household income and lower educational attainment may predispose populations to lower skilled occupations, which includes manual labour and repetitive exposures; however, lower functional capacity would increase the difficulty of performing job requirements with ease, and without injury. Should socially disadvantaged individuals be at a disproportionately greater risk of sarcopenia, this would also have significant implications for primary prevention, diagnosis and management. Indeed, the revised European Consensus regarding sarcopenia identified that, in clinical practice, low handgrip strength may be enough to trigger assessment, and potentially interventions, for sarcopenia [7], which is indicative of an increasing focus on muscle strength and function rather than muscle mass as a key determinant of sarcopenia [7, 12-14]. Given that a prompt identification of sarcopenia in clinical settings would be facilitated by ascertaining measures of operational sarcopenia quickly and cost-effectively [15], we aimed to examine associations between education and occupation with operational measures of sarcopenia (handgrip strength, lower limb strength, and appendicular lean mass [ALM]) across six years in a population-based sample of adults.

METHODS:

Participants

The Tasmanian Older Adult Cohort Study (TasOAC) is a prospective study of community-dwelling men and women resident in Southern Tasmania, Australia. Participants were randomly selected from the Commonwealth electoral rolls for southern Tasmania, with equal numbers of men to women (57% participation). Phase 1 (baseline) measures for TasOAC were ascertained in 1,090 adults (51% women; 50-80 years; 98% Caucasian) from March 2002 to September 2004, Phase 2 measures were collected September 2004 to June 2007 (n=873; 49% women), and Phase 3 measures were ascertained October 2007 to June 2009 (n=762; 50% women); notably, 70% of the sample had completed all visits. All participants in the TasOAC provided informed written consent. Approval for the study was obtained from the Southern Tasmania Health and Medical Human Research Ethics Committee (H1040).

Operational measures of sarcopenia (commonly used in sarcopenia diagnoses)

All measures were performed at each phase. Handgrip strength was measured by trained staff using a pneumatic dynamometer (psi) and lower limb strength was simultaneously measured in both legs to the nearest kilogram using a dynamometer (TTM Muscular Meter, Tokyo, Japan). An average of two measures for each was calculated. Participants underwent a whole-body scan, performed by a Hologic dual energy X-ray absorptiometry (DXA) scanner (Hologic Corp., Waltham, Massachusetts, USA), from which measures of appendicular lean mass (ALM; sum of lean mass in the arms and legs) were ascertained.

Education, occupation, and area-level disadvantage

The highest level of educational attainment self-reported at baseline was categorised in the three groups of having; (i) not completed secondary/high school, (ii) completed secondary/high school, or (iii) completed tertiary education.

The longest-held occupation, self-reported at baseline, was categorised using two different methods. First, we used the International Standard Classification of Occupations (ISCO-88) coding system to classify occupations according to the hierarchical dimensions of skill-level and specialisation [16]. Occupations were categorised into the ten major hierarchical groups, and further collapsed into four groups for analyses. Second, also based on the ISCO coding system, occupations were grouped into high-skilled white-collar (HSWC), low-skilled white-collar (LSWC), or blue-collar groups, according to the classification standards employed by the European Foundation for the Improvement of Living and Working Conditions [17].

Area-level disadvantage was ascertained by matching the baseline residential address of each TasOAC participant to the corresponding Australian Bureau of Statistics (ABS) Census Collection District for 2001, after which ABS software was used to determine the Socio-Economic Indexes for Areas (SEIFA) value, as previously reported [18]. SEIFA is a collection of four separate indexes, derived from Australian Census data and constructed from different variables. The variables characterise subjects within an area, thereby providing a single measure to rank the level of disadvantage or advantage at the area level, not of the individual subject. The indexes are: Index of Relative Socioeconomic Disadvantage (IRSD), the Index of Relative Socioeconomic Advantage (IRSAD), the Index of Education and Occupation (IEO) and the Index of Economic Resources (IER). For these analyses we employed the IRSAD, which accounts for high and low area-based income and occupation types including unskilled employment to professional positions, among other variables. A low score as measured by the IRSAD represents a more disadvantaged area, while a high score represents a more advantaged area [19]. Participants were assigned to a category of social disadvantage according to quartile cut-points for SEIFA values were based on population values of the study region of Southern Tasmania, Australia [19].

Anthropometrics, and lifestyle and behavioural exposures

Weight, with shoes, socks and bulky clothing removed, was measured using a single pair of calibrated electronic scales (Seca Delta Model 707, Hamburg, Germany). Height, with shoes and socks removed, was measured by trained staff to the nearest ±0.1cm using a single calibrated stadiometer. Body mass index (BMI) was subsequently calculated as kg/m^2.

Self-reported lifestyle and behavioural exposures were obtained by questionnaire at the time of baseline DXA measures. Dietary protein intake (grams) was assessed using the self-reported Cancer Council of Victoria Food Frequency Questionnaire (CCV-FFQ) [20], which estimates intake over the previous 12 months from 101 food items. This validated tool includes both a frequency component and portion size of food items from which food intake is calculated as grams per day. For analyses, we investigated dietary protein intake as (i) a continuous measure, and (ii) consuming at least 1.2 grams per kg of body weight per day [21, 22]. Smoking was defined as current at the time of DXA measures, or as any lifetime history of smoking. A lifetime history of stroke and/or diabetes was ascertained by self-report, as was the incidence of hip fracture or major osteoporotic fracture (at the skeletal site of hip, wrist or spine), or having sustained an incident fracture at any skeletal site.

Statistical analyses

Descriptive characteristics were calculated and presented as mean and standard deviation (±SD) (continuous variables) or frequency and percentage (categorical variables). The association of education and occupation on handgrip strength, lower limb strength, ALM (kg), ALM divided by BMI ($kg[kg/m^2]$) (ALM_{BMI}), and ALM divided by height squared (kg/m^2) ($ALM/height^2$) were evaluated using general estimating equations separately for each exposure and outcome. The following confounders were considered and evaluated for inclusion in final models: age, sex, weight (except for ALM models), height, BMI, IRSAD quartiles, smoking (ever or current), dietary protein intake (continuous, and consuming above recommended dietary intake of 1.2g/kg/day), a history of stroke and/or diabetes, and incident hip fractures, major osteoporotic fractures (hip, wrist, or spine), or fractures occurring at any skeletal site. The effect of each exposure on the change in the outcome was tested (entered as an interaction with time). Significance was set at $p<0.05$, and all statistical analyses were performed using Stata (StataCorp, Release 15, College Station, TX).

RESULTS:

Table 1 presents descriptive characteristics of the study population at baseline and each of the follow-up Phases. Mean age at baseline was 63.0 ± 7.5 years. Mean handgrip strength ranged between 10-12 psi across the three timepoints, mean lower limb strength ranged between 91.4-96.5kg, and mean ALM ranged between 23.5-24.8 kg. The greatest proportions of this study population had completed a tertiary education (46.9%), held a HS white-collar occupation (42.9%), were a manager/professional/technician (49.7%), and lived in the most advantaged quartile of area-level SES (60.0%) (all proportions shown are at Phase 3).

Education and operational measures of sarcopenia

Table 2 presents the best fitting model for associations between education groups and the outcomes of handgrip strength, lower limb strength, ALM, ALM_{BMI}, and ALM/height^2. After adjustment for age, sex, and height, those with a tertiary degree had 4.1% (0.48 psi, 95% CI 0.20-0.76) greater handgrip strength compared to those that had not completed secondary or high school, and 0.33 psi (95%CI 0.01-0.65) greater handgrip strength compared to those that had completed secondary or high school. For ALM, and after adjustment for age, sex and height, those with a tertiary degree had 1.4% greater lean mass than those that had not completed secondary/high school (0.34kg, 95%CI 0.01-0.67). In those who completed tertiary education, ALM_{BMI} was 3.3% (0.03kg/(kg/m^2), 95%CI 0.01-0.04) higher than those who had not completed secondary school, after adjusting for sex and baseline current smoking. In sex-adjusted models, those who completed tertiary education had 0.13kg (95%CI 0.01, 0.25) higher ALM/height^2 compared to those that had not completed secondary school. There were no interactions between education and time for any outcome. No further differences were observed.

Occupation and operational measures of sarcopenia

Table 3 presents the best fitting models for associations between occupation groups of HSWC, LSWC, and blue-collar and the outcomes of handgrip strength, lower limb strength, ALM, ALM_{BMI}, and ALM/height^2. After adjustment was made for significant confounders of sex, weight, height and IRSAD, those working in a HSWC occupation had 4% (0.46 psi, 95% CI 0.15-0.78) greater handgrip strength compared to those working in LSWC occupations. No differences in handgrip strength were observed across hierarchical ISCO-defined occupation groups [16] (data not shown). After adjustment for significant confounders of sex, weight and height, those in the HSWC or blue-collar groups had 5.38kg (95%CI 1.17-9.58) and 7.08kg (95%CI 1.69-12.49) greater leg strength compared to those in the LSWC group (7.7% greater), respectively. After adjustment for sex, height, IRSAD, and any lifetime history of smoking, HSWC and blue-collar workers both had greater ALM compared to LSWC workers (0.56kg, 95%CI 0.21-0.92, and 0.79kg, 95%CI 0.34-1.24, respectively). In models adjusted for sex and any prior fracture, HSWC and blue-collar workers also had greater ALM/height2 compared to LSWC workers (0.20kg, 95%CI 0.07-0.034, and 0.35kg, 95%CI 0.18-0.53, respectively). No differences were observed for any measures of ALM across hierarchical ISCO-defined occupation groups [16], and IRSAD was not a significant confounder in any models (data not shown). There were no interactions between occupation and time for any outcome.

DISCUSSION:

Ours is the first study to investigate the association between social factors and operational measures of sarcopenia across multiple follow ups, in which measures of muscle mass were ascertained reproducibly from DXA. We report that, independent of age and other covariates, those with greater educational attainment were more likely to have stronger handgrip and more muscle mass. Holding a HSWC occupation was associated with a stronger handgrip, more muscle mass and greater leg strength than holding a LSWC occupation, and those with blue-collar jobs had more muscle mass and greater leg strength that their LSWC counterparts. The magnitude of ~8% difference in leg strength observed between occupation groups could be functionally and clinically important. The effect of SES-related variables did not vary over time thus no cumulative effect was observed; however, that we observed some clinically and functionally important differences in LLS, and some smaller differences in HGS and ALM, between social groups suggests that sarcopenia could be added to the list of diseases affected by social factors, and thus add impetus to the need to address the social determinants of health. As such, these results indicate that those who have not completed secondary/high school, or who are involved in LSWC occupations, may potentially have greater risk for sarcopenia onset, and/or those holding blue-collar occupations may potentially be protected due to the physical activity needs of their work.

There are few studies with which we can compare our findings regarding educational attainment and operational measures of sarcopenia, however, we report similar associations with ALM to those observed in a Swedish study of 185 participants with type 2 diabetes [23]. In order to compare our findings against other studies, we may also consider the inextricable link between education and income, whereby higher educational attainment is associated with increased capacity for income. In this context, a study of 2,091 adults from Baltimore, USA, in which the sampling frame for recruitment crossed age, sex, race (African American and Caucasian) and SES [24], reported a positive association between income and handgrip strength, however it was only observed for men, and not women [24].

In our study, holding a HSWC and blue-collar occupations were both beneficially associated with all sarcopenia measures except ALM/height^2 and HGS (for blue-collar occupations), with largest effect sizes seen in the blue-collar group. Our findings aligned with those of the Hertfordshire Cohort Study, in which no evidence was found for an association between physically demanding occupations and handgrip strength in 1,418 adult men who had worked for at least 20 years [25]. For ALM, our findings differed from those observed in the Korea National Health and Nutrition Examination Survey [26]. In that study of 679 Korean men, in which a calculated skeletal muscle mass index (SMMI) was employed to determine sarcopenia, the highest mean SMMI was observed for men with a lifetime occupation in agribusiness, fishing or low-level laborers compared to those in white-, blue- or pink-collar occupations (the latter group was similar to, although not fully aligned with, our LSWC definition). Given that we grouped all manual occupations into the blue-collar group, it is likely that our findings of greater ALM in the blue-collar group are comparable to the findings reported in Korean blue-collar group. However, we also observed greater ALM in the HSWC group, which was not seen in the Korean HSWC population. In context of a paucity of data in this field, lower SES across the lifetime has been associated with lower lean mass in women, and a contemporaneous association between household income and lean mass has been reported for men [27]. Whilst little is known about the role of social factors on lower limb strength, given the associations we observed with ALM, our findings are consistent.

Speculation exists as to why parameters of SES such as education and occupation may influence operational measures of sarcopenia. First, there are common familial and peer-related environmental influences between higher education and measures of body habitus such as obesity [28], and thus plausibly ALM and related strength measures. In addition to the direct biological effects exerted on ALM by lifestyle factors, it is possible that, similar to bone health [29], inflammatory dysregulation may have considerable relevance for the field of sarcopenia. Psycho-social environments that are characterised by chronic stress, a situation well-documented as more common for those of lower SES, may result in a chronically heightened inflammatory state that places disadvantaged individuals at greater risk of muscle loss. However, although sensitivity to the social environment is supported by data pertaining to the link between neural, endocrine and immune function [30], there exist few data specifically investigating these complex relationships in sarcopenia.

While lean mass variables differed in several comparisons between education and occupation, muscle strength also differed for the same comparisons. This suggests that the low-cost and simple muscle strength tests may be sufficient to detect education- and occupation-related differences in sarcopenia status. Debate continues regarding the value of including DXA-assessed lean mass in definitions of sarcopenia, with a bias toward agreement for muscle strength assessments being a key component.

Our study has some limitations. These data are from a community-dwelling and generally Caucasian population resident in Southern Tasmania, Australia, and thus we highlight that our findings may have limited generalisability for populations of other ethnicity or locations. Our population was biased toward having higher education, holding higher-skilled occupations, and residing in more advantaged areas; however, this may suggest that the differences we observed between social groups are conservative. Finally, given that our measures of handgrip strength, lower limb strength and ALM varied randomly across the three time-points, we cannot rule out that this may be partly explained by loss to follow up, which was somewhat higher in those with lower education, or held a LSWC, particularly between Phase 1 and 2. This study also has strengths. Ours is the first to investigate associations between social factors and operational measures of sarcopenia across multiple follow ups, in which measures of muscle mass were ascertained reproducibly from DXA. Furthermore, given the paucity of data in this field of enquiry, we provide further evidence for differences between educational and occupational groups in operational measures of sarcopenia.

CONCLUSION:

In the context of a scant literature base regarding whether a social gradient of sarcopenia exists, these data support the possibility of such a gradient. Considering the functional and clinical importance of the ~8% difference in leg strength that we observed between occupation groups, we suggest sarcopenia should be added to the list of chronic diseases that are affected by social factors, adding impetus to calls to address social determinants of health. Given the emerging evidence that progressive muscle loss can be prevented by targeted intervention, our data will inform public health promotion and clinical attention toward those most at risk.

Policy Impact Statement

We observed a functionally important difference of ~8% in leg strength between occupation groups. We suggest sarcopenia should be added to the list of chronic diseases that are affected by social factors, adding impetus to calls to address social determinants of health.

Practice Impact Statement

We observed a functionally and clinically important difference of ~8% in leg strength between occupation groups, adding impetus to calls to address social determinants of health within clinical settings. Emerging evidence indicates that progressive muscle loss can be prevented by targeted intervention, thus directing clinical attention toward specific social groups.

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Table 1: Characteristics of the study population at baseline (Phase 1) and each follow up Phase, presented as mean (± standard deviation [SD]), or n (%).

Characteristic	**Phase 1, n=1,090**	**Phase 2, n=873**	**Phase 3, n=762**
Age (years)	63.0 (±7.5)	65.2 (±7.3)	67.1 (±7.0)
Women	558 (51.2%)	430 (49.3%)	380 (49.9%)
Handgrip strength (psi)	12.0 (±3.0)	10.0 (±3.0)	11.3 (±4.3)
Lower limb strength (kg)[a]	92.5 (±48.9)	96.4 (±50.3)	91.0 (±49.9)
Appendicular Lean Mass (ALM) (kg)	24.4 (±5.3)	23.5 (±5.0)	24.8 (±5.3)

ALM_{BMI} (kg/[kg/m^2])	0.9 (±0.2)	0.9 (±0.2)	0.9 (±0.2)
ALM/height^2 (kg/m^2)	8.7 (±1.3)	8.3 (±1.2)	8.9 (±1.3)
Baseline education			
Not completed secondary/high school	396 (36.3%)	293 (33.6%)	250 (32.8%)
Completed secondary/high school	220 (20.2%)	176 (20.2%)	155 (20.3%)
Completed tertiary education	474 (43.5%)	404 (46.3%)	357 (46.9%)
Baseline collar occupation groups			
High-skilled white-collar	430 (39.4%)	369 (42.3%)	327 (42.9%)
Low-skilled white-collar	401 (36.8%)	304 (34.8%)	264 (34.6%)
Blue-collar	251 (23.0%)	194 (22.2%)	166 (21.8%)
Armed forces	8 (0.7%)	6 (0.7%)	5 (0.7%)
Baseline Hierarchical occupation groups			
Managers/professionals/technicians	518 (47.5)	430 (49.3)	379 (49.7)
Clerical/services/agricultural	379 (34.8)	295 (33.8)	257 (33.7)
Craft/machine operators/elementary	152 (13.9)	118 (13.5)	102 (13.4)
Armed Forces	41 (3.8)	30 (3.4)	24 (3.1)
Anthropometric measures			
Height (cm)	166.9 (±9.0)	167.0 (±9.0)	166.6 (±9.0)
Weight (kg)	77.7 (±14.7)	78.1 (±14.8)	78.1 (±14.8)
Body Mass Index (kg/m^2)	27.8 (±4.6)	28.0 (±4.8)	28.1 (±4.8)
Lifestyle exposures			
Currently smoking	129 (11.8%)	91 (10.4%)	71 (9.3%)
Any lifetime history of smoking	550 (50.5%)	429 (49.1%)	373 (49.0%)
Protein intake (gm)	87.2 (±36.0)	86.9 (±33.2)	86.3 (±36.3)
Protein intake (>1.2g/kg/day) [b]	389 (35.7%)	313 (35.9%)	252 (33.1%)
History of specific comorbid conditions			
Prevalent stroke and/or diabetes	70 (6.4%)	71 (8.1%)	73 (9.6%)
Incident hip fracture	[c]	5 (0.6%)	1 (0.1%)
Incident major osteoporotic fracture [d]	[c]	21 (2.4%)	20 (2.6%)
Incident fracture at any skeletal site	[c]	53 (6.1%)	51 (6.7%)
Baseline IRSAD quartiles			
Quartile 1 (most disadvantaged)	86 (7.9%)	63 (7.2%)	53 (7.0%)
Quartile 2	146 (13.4%)	112 (12.8%)	96 (12.6%)

Quartile 3	233 (21.4%)	183 (21.0%)	156 (20.5%)
Quartile 4 (most advantaged)	625 (57.3%)	515 (59.0%)	457 (60.0%)

Note. IRSAD=Index of Relative Socioeconomic Advantage and Disadvantage; [a] missing data: Phase 1, n=44, Phase 2, n=46, Phase 3, n=57; [b] met recommended intake of 1.2 grams per kg of body weight per day; [c] data not collected; [d] includes hip, wrist or spine.

Table 2: Multivariable (best) models showing the mean difference and 95% confidence intervals (95%CI), with p value, between education groups and the outcomes of handgrip strength, lower limb strength, ALM, ALM_{BMI}, and ALM/height^2

Outcome (confounders adjusted for)	Completed vs not completed secondary/high school [a]		Tertiary vs not completed secondary/high school [a]		Tertiary vs completed secondary/high school [a]	
	Mean difference (95% CI)	p	Mean difference (95% CI)	p	Mean difference (95% CI)	p
Handgrip strength (psi)						
(Age, sex, height)	0.15 (-0.18, 0.48)	0.36	**0.48 (0.20, 0.76)**	**0.001**	**0.33 (0.01, 0.65)**	**0.04**
Lower limb strength (kg)						
(Age, sex, weight, height)	2.78 (-1.91, 7.47)	0.25	1.76 (-2.11, 5.63)	0.37	-1.03 (-5.78, 3.72)	0.67
ALM (kg)						
(Age, sex, height)	0.03 (-0.36, 0.43)	0.88	**0.34 (0.01, 0.67)**	**0.04**	0.31 (-0.08, 0.70)	0.12
ALM_{BMI} (kg/[kg/m^2])						
(Sex, current smoking at baseline)	0.02 (-0.01, 0.04)	0.06	**0.03 (0.01, 0.04)**	**0.001**	0.01 (-0.01, 0.03)	0.33
ALM/height^2 (kg/m^2)						
(Sex)	0.00 (-0.14, 0.15)	0.99	**0.13 (0.01, 0.25)**	**0.04**	0.13 (-0.01, 0.27)	0.08

Note. Bolded data indicates statistical significance; ALM=appendicular lean mass; BMI=body mass index; [a] Referent group is italicised.

Table 3: Multivariable (best) models showing the mean difference and 95% confidence intervals (95%CI), with p value, between occupation groups and the outcomes of handgrip strength, lower limb strength, ALM, ALM_{BMI}, and ALM/height^2

Outcome (confounders adjusted for)	HSWC vs LSWC [a]		Blue-collar vs LSWC [a]		Blue-collar vs HSWC [a]	
	Mean difference	p	Mean difference	p	Mean difference	p

Handgrip strength (psi)						
(Sex, weight, height, IRSAD)	**0.46 (0.15, 0.78)**	**0.004**	0.36 (-0.06, 0.77)	0.10	-0.11 (-0.50, 0.28)	0.59
Lower limb strength (kg)						
(Sex, weight, height)	**5.38 (1.17, 9.58)**	**0.01**	**7.08 (1.69, 12.49)**	**0.01**	1.71 (-3.63, 7.05)	0.53
ALM (kg)						
(Sex, height, IRSAD, smoking [b])	**0.56 (0.21, 0.92)**	**0.002**	**0.79 (0.34, 1.24)**	**0.001**	0.23 (-0.19, 0.64)	0.28
ALM$_{BMI}$ (kg/[kg/m^2])						
(Sex)	0.02 (-0.00, 0.03)	0.05	-0.02 (-0.04, 0.00)	0.103	-0.03 (-0.05, -0.01)	0.001
ALM/height^2 (kg/m^2)						
(Sex, any fracture [c])	**0.20 (0.07, 0.34)**	**0.004**	**0.35 (0.18, 0.53)**	**<0.001**	0.15 (-0.01, 0.31)	0.06

Note. Bolded data indicates statistical significance; ALM=appendicular lean mass; BMI=body mass index; HSWC=high-skilled white-collar; IRSAD=Index of Relative Socioeconomic Advantage and Disadvantage; LSWC=low-skilled white collar; [a] Referent group is italicised; [b] any lifetime history of smoking; [c] incident fracture that occurred at any skeletal site.