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Is grip strength associated with health-related quality of life? Findings from the Hertfordshire Cohort Study

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Abstract

Objective: to investigate the relationship between grip strength and health-related quality of life (HRQoL).
Design: cross-sectional survey within a cohort study design.
Setting: the county of Hertfordshire in the UK.
Participants: a total of 2,987 community-dwelling men and women aged 59–73 years of age.
Measurements: grip strength was used as a marker of sarcopaenia and measured using a Jamar dynamometer. HRQoL was assessed using the eight domain scores of the Short Form-36 (SF-36) questionnaire, and subjects in the lowest sex-specific fifth of the distribution were classified as having 'poor' status for each domain.
Results: men and women with lower grip strength were significantly more likely to report a poor as opposed to excellent to fair overall opinion of their general health (GH) [odds ratio (OR) per kilogram decrease in grip strength = 1.13, 95% CI = 1.06–1.19, $P<0.001$ in men, 1.13, 95% CI = 1.07–1.20, $P<0.001$ in women]. Among men, after adjustment for age, size, physical activity and known co-morbidity, decreased grip strength was associated with increased prevalence of poor SF-36 scores for the physical functioning (PF) (OR per kilogram decrease in grip strength = 1.03, 95% CI = 1.01–1.06, $P = 0.007$) and GH domains (OR = 1.03, 95% CI = 1.01–1.05, $P = 0.01$). Similar associations were seen in women.
Conclusions: our findings suggest that lower grip strength is associated with reduced HRQoL in older men and women. This does not appear to be explained by age, size, physical activity or co-morbidity and may reflect the link between sarcopaenia and generalised frailty. Individuals with sarcopaenia may benefit from interventions to improve muscle mass and strength before the onset of chronic disorders usually associated with impaired HRQoL.

Keywords: *grip strength, sarcopaenia, frailty, quality of life, SF-36, elderly*

Introduction

There is an increasing recognition of the serious health consequences of loss of muscle strength both in terms of disability [1], morbidity [2] and mortality [3] and in terms of significant healthcare costs [4]. It is one of the major risk factors for falls [5], and a number of studies have demonstrated that people with a history of falls have lower health-related quality of life (HRQoL) [6, 7]. One study has reported an association between low muscle mass and lower general health (GH) score [8]; however, there have been no studies to date linking loss of muscle strength with GH. A relationship between muscle strength and HRQoL may be important in identifying individuals who would benefit from early intervention to prevent sarcopaenia—the loss of muscle mass and strength with age [9].

There is a wide range of questionnaire-based tools designed to ascertain HRQoL in older people. The Short Form-36 (SF-36) has gained widespread acceptance as a HRQoL measure and has been recommended as the optimum outcome measure across a range of ages, participant characteristics and illness conditions [10, 11]. Its use is now extending beyond people with specific disease states, to determine HRQoL in those with functional impairment or disabilities. For example, the SF-36 for veterans was utilised in a recent study reported in *Journal of the American Geriatrics Society* demonstrating an association between difficulties in activities of daily living and lower physical and mental component summary scores in the Veterans' Quality of Life Study [12]. We investigated the relationship between loss of muscle strength and HRQoL in 2,987 men and women aged 59–73 years of age who participated in the Hertfordshire Cohort Study (HCS).

Methods

Study population

The HCS has been described previously [13]. In brief, from 1911 to 1948, midwives collected detailed records, including information on birthweight and weight at 1 year, on infants born in the county of Hertfordshire, UK. The records for people born in the period 1911–30 have been used in a series of studies linking early growth to health in later life. In 1998, a younger cohort was recruited to participate in studies examining the interactions between early life, diet, adult lifestyle and genetic factors as determinants of adult disease. A total of 3,822 men and 3,284 women born in Hertfordshire between 1931 and 1939 and still living in the county were traced with the aid of the NHS central registry in Southport and confirmed as currently registered with a general practitioner in Hertfordshire.

Permission to contact 3,126 (82%) men and 2,973 (91%) women was obtained from their general practitioners because home addresses for direct approach were not available from the tracing procedure. A total of 1,684 (54%) men and 1,541 (52%) women agreed to take part in a home interview where trained nurses collected information including self-reported walking speed [14], smoking history, alcohol intake, social class, medical history (including the Rose chest pain questionnaire, existing diagnosis of diabetes, history of cerebrovascular disease and symptoms of bronchitis as well as falls history in a subgroup) and self-assessed HRQoL using the SF-36 questionnaire [15]. The SF-36 is an established and widely used measure of HRQoL. An individual's responses to its 36 questions are mapped to eight domain scores to provide a profile of HRQoL; the SF-36 does not yield a single overall summary score [16, 17].

One thousand five hundred and seventy-nine (94%) of these men and 1,418 (92%) of these women subsequently attended a clinic for a number of investigations. Height was measured to the nearest 0.1 cm using a Harpenden pocket stadiometer (Chasmors Ltd, London, UK) and weight to the nearest 0.1 kg on a seca floor scale (Chasmors Ltd). Grip strength was measured three times on each side, alternating between right and left hands, for 1,572 (99.6%) of the men and 1,415 (99.8%) of the women using a Jamar handgrip dynamometer (Promedics, Blackburn, UK). Participants were given standardised encouragement to squeeze the dynamometer as hard as possible. The repeat measures allowed both practice and tiring effects to be apparent for an individual. The dynamometers were calibrated at the start of the study, and intraobserver and interobserver studies were carried out at regular intervals during the fieldwork to ensure comparability of measurements within and between observers [18].

Clinical examination was used to assess presence of hand osteoarthritis [19]. Subjects, who had not reported an existing diagnosis of diabetes, attended the morning clinics fasting; an oral glucose tolerance test (OGTT) was performed using 75 g anhydrous glucose, with blood samples obtained at baseline, 30 min and 120 min. Plasma venous glucose was assayed on an Advia 1650 autoanalyser (Bayer Diagnostics, Newbury, UK), and diabetes mellitus and impaired glucose tolerance were classified according to WHO criteria [20]. Blood pressure was recorded as the mean of three measurements taken with a Dinamap Model 8101 (GE Medical Systems, Slough, UK) after the subject had been seated for 5 min. An ECG was also performed, and graded for ischaemic changes, according to the Minnesota protocol [21]. The study had ethical approval from the Hertfordshire and Bedfordshire Local Research Ethics Committee, and all subjects gave written informed consent.

Statistical methods

The best of the six grip measurements was used to characterise maximum muscle strength [22, 23].

The SF-36 questionnaire data were mapped to the eight recommended domain scores (lower scores implied poorer status); physical functioning (PF), role physical (RP), role emotional (RE), social functioning (SF), mental health (MH), vitality (VT), bodily pain (BP) and GH perception [15]. In general, subjects with scores in the lowest sex-specific fifth of the distribution were classified as having 'poor' status for each domain. However, the lowest sex-specific tenth was used to define 'poor' RE status owing to a substantial 'ceiling effect' for this domain; that is, a high proportion of participants obtained the maximal score for RE.

To gauge participants' overall opinion of their health, we considered their response to the following question (which is one of the five items comprising the SF-36 GH domain): 'In general how would you say your health is?' (response options: excellent; very good; good; fair; poor).

Logistic regression modelling was used to estimate odds ratios (ORs) for (i) a poor as opposed to excellent to fair overall opinion of health according to the single item described above and (ii) poor status for each domain per kilogram decrease in grip strength. Analyses for the eight domains were conducted without and with adjustment for the potential confounding influences of age, height, weight, walking speed, smoking, alcohol intake, current social class and co-morbidity [diabetes mellitus (previously known or newly diagnosed by OGTT), high blood pressure (systolic pressure $\geq$ 160 mmHg or diastolic $\geq$ 100 mmHg or anti-hypertensive medication), ischaemic heart disease (ECG q-waves or Rose questionnaire typical angina or coronary artery bypass graft or angioplasty), cerebrovascular disease, bronchitis (productive cough on most days for at least 3 months of the year) and hand osteoarthritis (Heberden's or Bouchard's nodes, or squaring at the thumb base, upon clinical examination)]. The effect of adjustment for falls history (any fall in the last year) in a subgroup was also investigated.

Height and weight were highly correlated (r = 0.45, P<0.001 for men; r = 0.32, P<0.001 for women); to avoid multi-collinearity problems, we calculated a sex-specific standardised residual of weight-adjusted-for-height for inclusion with height in the logistic regression models. Grip strength was principally analysed as a continuously distributed variable, but it was also classified into sex-specific quintiles for presentational purposes only. All analyses were conducted for men and women separately using the Stata 8 statistical software package, release 8.0 (Stata Corporation, College Station, Texas, 2003).

Results

Summary characteristics

The characteristics of the study population are summarised in Table 1.

Grip strength in relation to overall self-reported GH

Men and women with lower grip strength were significantly more likely to report a poor as opposed to excellent to fair overall opinion of their GH (OR per kilogram decrease in grip strength = 1.13, 95% CI = 1.06–1.19, P<0.001 in men; 1.13, CI = 1.07–1.20, P<0.001 in women).

Relationships between co-morbidities and SF-36 scores

Co-morbidities were common (Table 1) and, with the exception of hand osteoarthritis, were strongly associated with poorer SF-36 scores in men and women. Among men, previously or newly diagnosed diabetes mellitus was associated with poorer scores for all domains besides SF, MH and BP (OR = 1.9–3.4, P-values = 0.02 to <0.001). Hypertension was associated with poorer scores for all domains (OR = 1.4–2.4, P-values = 0.02 to <0.001, respectively), as was ischaemic heart disease (OR = 1.6–2.7, P-values = 0.006 to <0.001). A history of cerebrovascular disease was associated with poorer scores for all domains other than VT (OR = 1.7–2.7, P-values = 0.03 to <0.001). Finally, a history of bronchitis was associated with poorer scores for all of the SF-36 domains other than BP (OR for poor scores ranging from 2.0 to 2.5, P-values = 0.02 to <0.001).

Table 1. Summary characteristics of study participants

	Males (n = 1572)	Females (n = 1415)
Age (years) [mean (SD)]	65.7 (2.9)	66.6 (2.7)
Weight (kg)[a] [mean (SD)]	81.5 (1.2)	70.2 (1.2)
Height (cm) [mean (SD)]	174.2 (6.5)	160.8 (5.9)
Grip strength (kg) [mean (SD)]	44.0 (7.5)	26.5 (5.8)
Current manual social class (IIIM-V)[b] [n (%)]	906 (57.6)	824 (58.2)
Current smoker [n (%)]	238 (15.1)	139 (9.8)
Men >21/women >14 units alcohol per week [n (%)]	338 (21.5)	68 (4.8)
Walking speed: very slow/stroll at easy pace [n (%)]	449 (28.6)	380 (26.9)
Walking speed: normal [n (%)]	622 (39.6)	637 (45.0)
Walking speed: fairly brisk/fast [n (%)]	499 (31.7)	398 (28.1)
SF-36 domain scores: median (20th, 25th, 75th and 80th percentiles)		
Physical function (PF)	90 (76, 80, 95, 100)	85 (60, 65, 95, 95)
Role physical (RP)	100 (75, 100, 100, 100)	100 (50, 75,100, 100)
Role emotional (RE)	100 (100, 100, 100, 100)	100 (100, 100, 100, 100)
Social functioning (SF)	100 (88, 100, 100, 100)	100 (75, 88, 100, 100)
Mental health (MH)	88 (72, 76,92, 96)	80 (64, 68, 88, 92)
Vitality (VT)	75 (55, 60, 80, 85)	65 (50, 55, 80, 80)
Bodily pain (BP)	84 (61, 62, 100, 100)	72 (51, 51, 100, 100)
General health (GH)	77 (60, 62, 87, 87)	77 (57, 62, 87, 87)
SF-36 self-reported GH		
Poor [n (%)]	20 (1.3)	21 (1.5)
Fair [n (%)]	160 (10.2)	193 (13.6)
Good [n (%)]	598 (38.0)	620 (43.8)
Very good [n (%)]	590 (37.5)	455 (32.2)
Excellent [n (%)]	202 (12.9)	120 (8.5)
Co-morbidities		
Bronchitis [n (%)]	92 (5.9)	69 (4.9)
Ischaemic heart disease [n (%)]	223 (14.2)	126 (8.9)
Previously diagnosed diabetes mellitus [n (%)]	108 (6.9)	74 (5.2)
Newly diagnosed diabetes mellitus [n (%)]	123 (7.8)	125 (8.8)
High blood pressure [n (%)]	626 (39.8)	575 (40.6)
Cerebrovascular accident [n (%)]	78 (5.0)	39 (2.8)
Hand osteoarthritis [n (%)]	389 (24.8)	740 (52.3)

[a]Geometric mean and SD.

[b]IIIM-V denotes classes three (manual) to five of the 1990 Standard Occupational Classification scheme (OPCS) for occupation and social class. Social class was identified on the basis of own current or most recent full-time occupation for men and never-married women but on the basis of the husband's occupation for ever-married women.

Among women, previously or newly diagnosed diabetes mellitus was associated with poorer scores for the PF, VT, BP and GH domains of the SF-36 (OR = 1.8–3.5, *P*-values = 0.02 to <0.001). Hypertension was associated with poorer scores for all domains other than MH (OR = 1.3–2.1, *P*-values = 0.04 to <0.001). Ischaemic heart disease was associated with poorer scores for all domains other than MH and RE (OR = 1.5–3.3, *P*-values = 0.04 to <0.001). A history of cerebrovascular disease was associated with poorer scores for all domains other than MH, BP and RE (OR = 2.1–2.7, *P*-values = 0.03–0.003). Finally, a history of bronchitis was associated with poorer scores for all of the SF-36 domains other than MH and RE (ORs for poor scores ranging from 1.7 to 3.6, *P*-values = 0.05 to <0.001). Subsequent analyses therefore assessed the impact of adjustment for co-morbidities on the relationships between grip strength and SF-36 scores.

Relationships between falls history and SF-36 scores

Falls history was only available in 864 men and 1,279 women. The prevalence of falls was 14.4 and 22.6%, respectively. Falls history was significantly associated with poorer scores for all of the SF-36 domains in men but only with RP in women (data not shown). However, final adjustment of the multivariate model for falls history was only possible in this subgroup.

Relationships between adult size and SF-36 scores and grip strength: Is adult size a potential confounder of grip strength *vs* SF-36 associations?

Adult size was related to SF-36 scores and to grip strength. Higher weight was associated with poorer PF, RP, VT, BP and RE in men [ORs for poor SF-36 scores per standard deviation (SD) increase in weight ranged from 1.2 to 1.3, *P*-values = 0.01 to <0.001] and with poorer scores for all domains other than MH in women (ORs ranging from 1.2 to 1.8, *P*-values = 0.02 to <0.001). Shorter height was associated with increased likelihood of having poor GH scores among men (OR for poor GH score: 1.1 per SD increase in height, $P = 0.02$) and increased likelihood of having poor PF, VT and GH scores in women (OR = 1.1 for all, $P = 0.03$, $P = 0.02$ and $P = 0.02$). In addition, weight and height were positively correlated with grip strength in men (Pearson correlations and *P*-values: $r = 0.24$, $P<0.001$ for weight; $r = 0.40$, $P<0.0001$ for height) and women ($r = 0.08$, $P = 0.003$ for weight; $r = 0.28$, $P<0.0001$ for height). Hence, weight had the potential to mask (i.e. to negatively confound) any relationship between lower grip strength and poorer SF-36 scores, and height had the potential to accentuate (i.e. to positively confound) any such relationship. Subsequent analyses therefore accounted for the potential confounding effects of adult size by including both height and weight-adjusted-for-height in the logistic regression models for grip strength in relation to SF-36 scores.

Relationships between grip strength and SF-36 scores

Table 2 and Figure 1 present the relationships between grip strength and SF-36 scores. Simple unadjusted analyses demonstrated that for men, and for women, lower grip strength was associated with increased prevalence of having poor scores for all of the SF-36 domains (Figure 1 and Table 2 unadjusted ORs). However, among men, after adjustment for age, height, weight-adjusted-for-height, self-reported walking speed, social class, smoking, alcohol consumption and known co-morbidity, decreased grip strength was only associated with increased prevalence of poor SF-36 scores for the PF (OR per kilogram decrease in grip strength = 1.03, 95% CI = 1.01–1.06, $P = 0.007$) and GH domains (OR = 1.03, 95% CI = 1.01–1.05, $P = 0.01$) (Table 2). These relationships were consistent among women (adjusted OR for PF = 1.09, 95% CI = 1.05–1.12, $P<0.001$; adjusted OR for GH = 1.08, 95% CI = 1.05–1.11, $P<0.001$), and lower grip strength among women was also associated with increased prevalence of poor RP, VT and BP scores in adjusted analyses [adjusted OR for RP = 1.04, 95% CI = 1.01–1.06, $P = 0.003$; adjusted OR for VT = 1.04, 95% CI = 1.02–1.07, $P = 0.001$; adjusted OR for BP = 1.06, 95% CI = 1.03–1.08, $P<0.001$ (Table 2)]. The relationship between lower grip strength and increased prevalence of poor PF and GH was not explained by falls history in the men or women.

Discussion

We have shown that lower grip strength is associated with reduced HRQoL in older men and women. In particular, men with lower grip strength were more likely to report overall poor GH and have low SF-36 scores for the PF and GH domains. The findings for the women were similar, but additionally those with lower grip strength were more likely to have low SF-36 scores for the RP, VT and BP domains. These results are consistent with a previous report linking low muscle mass with poor GH [8].

Co-morbidity is a possible explanation for the associations observed. Specific disease states such as type 2 diabetes and cerebrovascular disease have been associated with both weaker muscle strength and lower HRQoL [2, 24]. However, our findings were robust to adjustment for the presence of type 2 diabetes, hypertension, ischaemic heart disease, cerebrovascular disease and bronchitis. Furthermore, the relationship was not explained by history of falls in the last year or level of physical activity in the men or women.

There is an increasing recognition that grip strength is a useful clinical marker of sarcopaenia, and recent work has validated this approach demonstrating that grip strength is more strongly associated with age and is a better predictor of poor mobility than other potential markers of sarcopaenia such as calf muscle area [25]. Grip strength has also been proposed as a useful single marker of generalised frailty and biological ageing [26]. It is associated with ageing in a wide range of body systems and may be a good marker of underlying ageing processes because of the rarity of muscle-specific diseases contributing to change in muscle function. The relationship between loss of muscle strength and HRQoL may reflect this association with frailty and appears to be important in both men and women, with an effect in women beyond the PF and GH domains.

Table 2. Odds ratios for poor score each SF-36 domain per kilogram decrease in grip strength

	Men		Women	
	Odds ratio[a] (95% CI)	P value	Odds ratio[a] (95% CI)	P value
Physical functioning (PF)				
Unadjusted	1.06 (1.04–1.07)	<0.001	1.13 (1.10–1.15)	<0.001
Adjusted[b]	1.03 (1.01–1.06)	0.007	1.09 (1.05–1.12)	<0.001
Role physical (RP)				
Unadjusted	1.02 (1.00–1.03)	0.03	1.08 (1.05–1.10)	<0.001
Adjusted[b]	1.00 (0.98–1.02)	0.74	1.04 (1.01–1.06)	0.003
Role emotional (RE)				
Unadjusted	1.03 (1.00–1.05)	0.03	1.03 (1.01–1.06)	0.01
Adjusted[b]	1.01 (0.98–1.03)	0.60	1.02 (0.99–1.05)	0.11
Social functioning (SF)				
Unadjusted	1.02 (1.00–1.03)	0.04	1.04 (1.02–1.07)	<0.001
Adjusted[b]	1.00 (0.98–1.02)	0.94	1.02 (1.00–1.05)	0.12
Mental health (MH)				
Unadjusted	1.02 (1.00–1.03)	0.05	1.04 (1.02–1.06)	<0.001
Adjusted[b]	1.01 (0.99–1.03)	0.20	1.03 (1.00–1.05)	0.05
Vitality (VT)				
Unadjusted	1.03 (1.01–1.04)	0.002	1.08 (1.06–1.10)	<0.001
Adjusted[b]	1.01 (0.99–1.04)	0.19	1.04 (1.02–1.07)	0.001
Bodily pain (BP)				
Unadjusted	1.02 (1.01–1.04)	0.005	1.08 (1.06–1.10)	<0.001
Adjusted[b]	1.01 (0.99–1.03)	0.27	1.06 (1.03–1.08)	<0.001
General health (GH)				
Unadjusted	1.05 (1.03–1.07)	<0.001	1.11 (1.09–1.14)	<0.001
Adjusted[b]	1.03 (1.01–1.05)	0.004	1.08 (1.05–1.11)	<0.001

[a]Odds ratios for having a poor score for each SF-36 domain (i.e. a score within the lowest sex-specific fifth of the distribution) per kilogram decrease in grip strength.
[b]Adjusted for age, height, weight-adjusted-for-height, walking speed, social class, cigarette and alcohol consumption and co-morbidities (bronchitis, ischaemic heart disease, diabetes mellitus, high blood pressure, cerebrovascular accident and hand osteoarthritis).

The major limitation of the study lies in the cross-sectional nature of the data. It is not possible to ascertain cause and effect in the relationship between grip strength and HRQoL, and it is plausible that poor quality of life could lead to inactivity and loss of muscle function. However, the association was independent of physical activity, as characterised by usual walking speed, suggesting that this is a less likely explanation. Longitudinal data are required to address this issue in more detail, and follow-up of the cohort currently underway will allow us to examine the relationship between grip strength at baseline and subsequent HRQoL.

These findings have clinical relevance because they suggest that older people with lower grip strength have reduced HRQoL in the absence of major co-morbidity and independently of recent falls history. We suggest that the relationship reflects the link between sarcopaenia and generalised frailty. Individuals with sarcopaenia may benefit from intervention to improve muscle mass and strength before the onset of chronic disorders usually associated with impaired HRQoL.

Key points

- There is an increasing recognition of the serious health consequences of loss of muscle mass and strength (sarcopaenia) both in terms of disability, morbidity and mortality and in terms of significant healthcare costs. The relationship with health-related quality of life (HRQoL) is less clear.
- The objective of this study was to investigate the relationship between grip strength, as a marker of sarcopaenia, and Short Form-36 (SF-36) score, as a marker of HRQoL, in a community-dwelling population of older people participating in the Hertfordshire Cohort Study (HCS).
- Men and women with lower grip strength were significantly more likely to report poor general health (GH) even after allowing for age, size, physical activity and known co-morbidity.
- These findings suggest that lower grip strength is associated with reduced HRQoL in older men and women and may reflect a link between sarcopaenia and generalised frailty.
- Individuals with sarcopaenia may benefit from interventions to improve muscle mass and strength before the onset of chronic disorders usually associated with impaired HRQoL.

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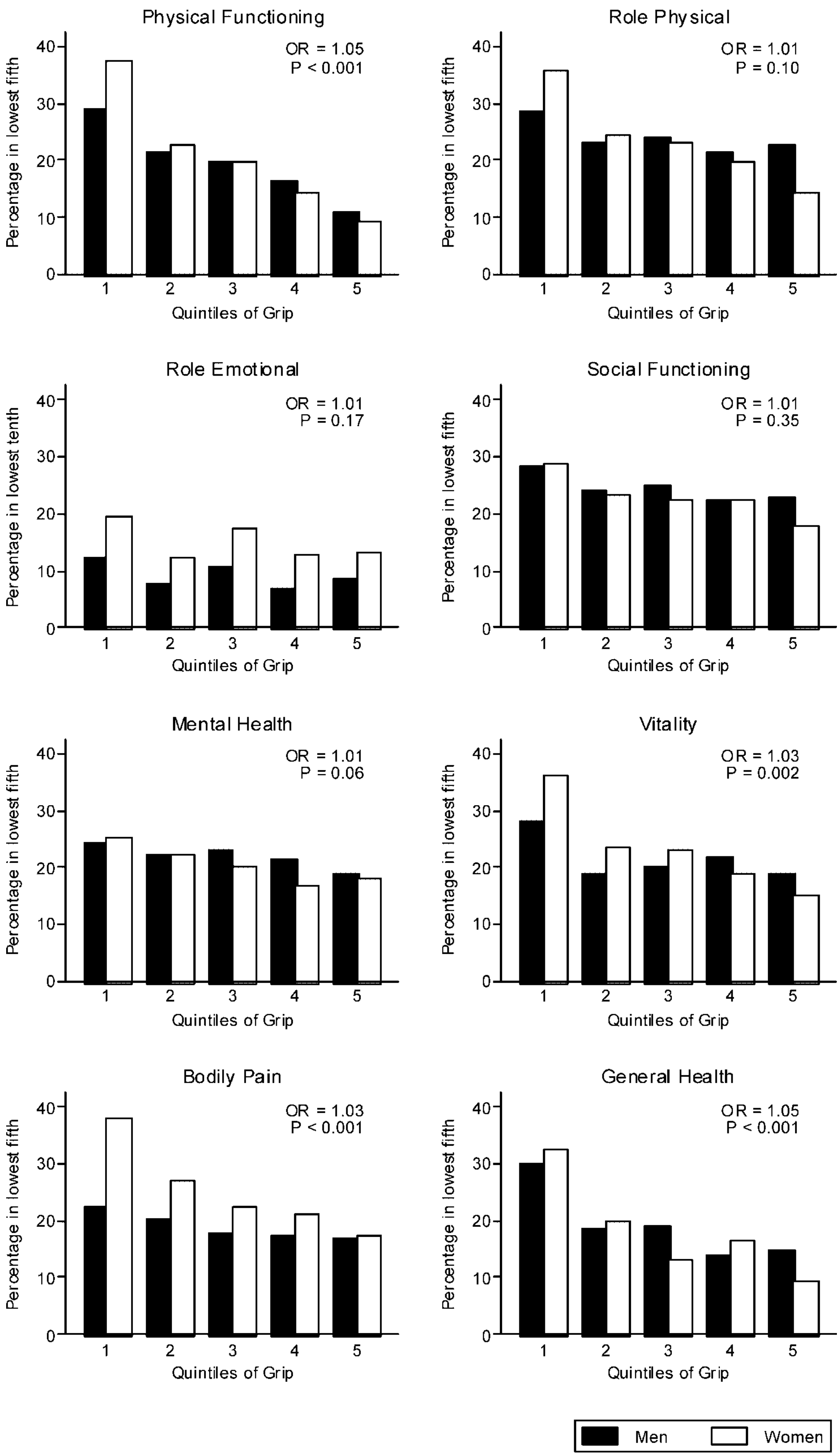

Figure 1. Relationships between grip strength and SF-36 scores. Odds ratios (ORs) are per kilogram decrease in grip strength for men and women combined, adjusted for gender, age, height, weight-adjusted-for-height, walking speed, social class, cigarette and alcohol consumption and co-morbidities. Quintiles of grip (kg) defined as follows: men ≤38, –42, –46, –50 and ≥51; women ≤22, –26, –28, –31 and ≥32.

UK. All authors contributed to the study concept, design, fieldwork and preparation of the manuscript.

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Conflict of interest

The authors have no conflict of interest.

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