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doi:10.1093/ageing/afn151
Published electronically 29 July 2008

Relationship between customary physical activity, muscle strength and physical performance in older men and women: findings from the Hertfordshire Cohort Study

Sir—Maintenance of muscle strength and physical performance in later life is an important component of healthy ageing [1–4]. Reported influences include age, gender, size and physical activity [5–7]. Older age has been linked to lower strength [8, 9], but these studies have not considered how age-related decline in activity levels may contribute to these changes. A study of grip strength in older people found that it declined by 20% per decade but only 11% of this decline could be attributed to age alone [10].

Older people are encouraged to maintain levels of physical activity, but most evidence considers the benefits of exercise and strength training intervention programmes [11–13]. It is important to quantify activity levels corresponding to levels of benefit in general, as well as defining specific outcomes related to particular activities in both men and women. Epidemiological studies suggest that increased customary physical activity is associated with improved muscle strength and physical performance, but it is unclear whether men and women derive similar benefit [14–17]. For example Bassey *et al.* found a positive association between usual physical activity and muscle strength in both men and women [18], whereas Rantanen's study of everyday physical activity in older people showed the importance of activities such as housework, walking and gardening in maintaining independence for women [19].

The objective of this study was to investigate the relationship between customary physical activity, muscle strength and physical performance in older men and women.

Methods

This study was based on the previously described Hertfordshire Cohort Study [20]. We received general practitioner permission to contact 647 women and 792 men resident in West Hertfordshire. A total of 321 (50%) women and 396 (50%) men agreed to a home interview, and 280 (87%) women and 349 (88%) men subsequently attended a clinic for investigations including anthropometry [21], hand grip strength using a Jamar dynamometer (Promedics, Blackburn, UK) [22] and a short physical performance battery [23] (comprising tests of 3 m customary walking pace, 5 sit-stand chair rises time and timed one-legged balance). In addition, 275 women and 229 men completed a 69-item validated self-administered questionnaire [Hertfordshire Physical Activity Questionnaire (HPAQ)] based on the Minnesota instrument which assessed activity over the previous 12 months [24, 25]. Respondents indicated whether they participated in each activity (yes/no), and if yes, ticked the months during which they did it and gave the typical duration of time spent doing it (in hours and minutes). Intra- and interobserver variability studies were carried out for all physical performance measures at regular intervals during the fieldwork to ensure comparability of measurements within and between observers. In all cases, the fieldwork team measured similarly to one another and repeatably within themselves. The study had ethical approval from the Hertfordshire and Bedfordshire Local Research Ethics Committee, and participants gave written informed consent.

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Statistical Methods

Physical activity was characterised by organising the 69 items of the questionnaire into 12 activity groups, including gardening which was used as representative of customary activity in subsequent analyses owing to its high overall level of participation in combination with a wide range of levels of energy expenditure (the other 11 groups were: walking, cycling, conditioning exercises, water activity, winter activity, sport, golf, home activities, DIY/repair, fishing/hunting or other). Rather than simply dichotomising men and women as participants in gardening (yes or no), and to reflect the wide range of frequencies with which this activity was reported, first the energy expended on gardening was calculated by multiplying time spent on gardening by its metabolic cost (MET.h/mth) obtained from an activity compendium [26], and secondly, this was converted into an ordinal variable [27].

In addition to the novel 'representative activity' approach, cluster analysis was used to summarise activity participation. This classified men into three types reflecting 'keep fit', 'indoors' and 'less active' men. Among women, two groups were identified reflecting 'keep fit' and 'indoors' types of women. The 'keep fit' men and women participated in more sports, water activities, and golf; the 'indoors' groups did more home-based activities, e.g. housework, DIY; and the 'inactive' group of men did generally less of everything [25] (see Appendix 1 at *Age and Ageing* online for a full description of the clusters, and see Appendix 2 at *Age and Ageing* online for technical details).

For statistical coding of the physical performance variables see Appendix 2 at *Age and Ageing* online. Relationships between muscle strength and physical performance, and the physical activity clusters were explored using analysis of variance (ANOVA) or Fisher's exact test. Relationships with the ordinal gardening variable were explored using linear or logistic regression.

Results

The characteristics of the study participants are described in Appendix 3 at *Age and Ageing* online. Median-estimated total energy expenditure per month was 665.3 MET.h/mth for women and 482.7 for men. Eighty-six point nine per cent of women and 96.1% of men participated in gardening.

The relationships between muscle strength, physical performance and energy expended on gardening are shown in Figure 1. In women, increasing gardening activity was associated with stronger grip strength, quicker 3-m walk, and chair rises test times and better balance. There were no significant associations in men (Figure 1).

Table 1 shows the relationships between muscle strength and physical performance and the physical activity clusters. Women in the 'keep fit' cluster had significantly stronger grip strength than those in the 'indoors' cluster, and were quicker at the 3-m walk and chair rises tests, and a lower proportion had poor balance. There were no significant differences among men.

Discussion

Higher levels of customary physical activity were associated with significantly higher muscle strength and better physical performance among women but not men. Other studies have also noted these gender differences. Bassey *et al.* reported that muscle strength was significantly associated with leisure activity in women but not men [18]. Brach *et al.* noted that moderately intensive activities on most week days in men and women equated to better physical performance in comparison with those who were less active. However, among less active people, higher proportions of women had poorer physical performance than men [28]. Findings from studies considering exercise may differ from those considering customary physical activity. For example, the Jerusalem Longitudinal Study found that regular exercise at the age of 70 was significantly associated with ease of performance of daily living tasks in women (odds ratio 8.5, 95% CI 2.0, 36.2) and men (odds ratio 4.3, 95% CI 1.1, 17.1) [29].

The gender differences in this study could arise from differences in reporting of physical activity. Unexpectedly, women had significantly higher median total energy expenditure than men (665.3 versus 482.7 MET.h/mth) with walking and home activity driving this difference. Difficulties with reporting of everyday activities have been noted previously [18, 27, 30]. Wareham *et al.* have suggested that questionnaires should be used to quantify levels of specific categories of activity rather than deriving overall energy expenditure [27, 30].

To allow for possible over-reporting of physical activities in women, analyses focussed on a single activity, i.e. gardening, which did not appear to be affected by this bias with the benefit of its high overall level of participation (87% women and 96% men) and wide range of energy expenditure (thereby allowing creation of a discriminating ordinal variable). We suggest this a novel approach for characterisation of an individual's customary level of physical activity and that the selected activity is particularly appropriate for studies of older people. Cluster analysis also addressed this possible bias by focussing on binary outcomes of whether people did a particular activity; these variables should suffer less from reporting bias than reports of amount or intensity of activity. The associations between lower physical activity participation and poorer physical performance were only seen in women irrespective of analysis approach, suggesting that gender differences were not explained by over-reporting of physical activity in women.

Other explanations for the gender difference are possible. First, gender differences in body composition may provide an explanation with average percentage body fat in this sample being 28% in men and 39% in women. Women have a higher fat-to-muscle ratio and may gain more benefit from physical activity with regard to strength and physical performance. Secondly, a threshold effect may have influenced our results. Men have greater muscle

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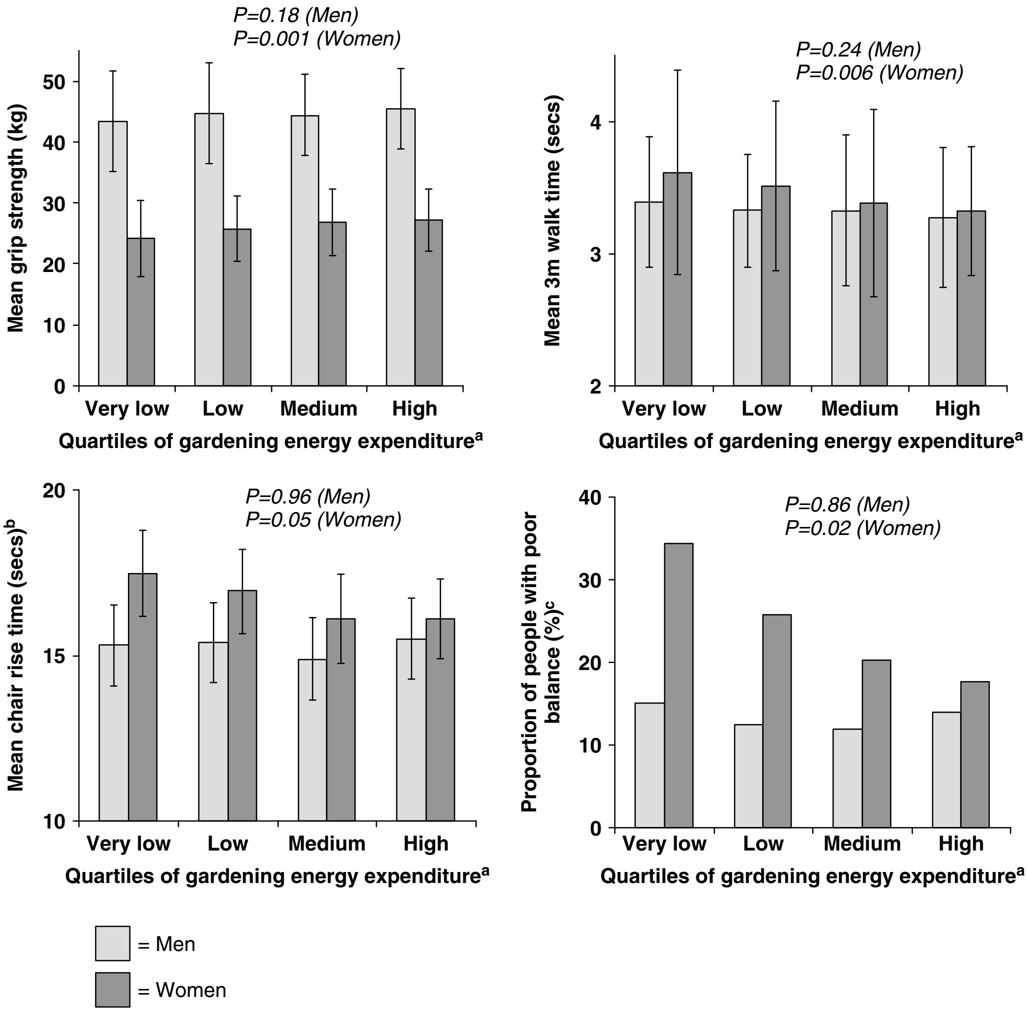

Figure 1. Relationships between muscle strength and physical performance and gardening activity by gender. [a] Men: very low < 15.1 to 45.6; medium 45.7–106.9 and high ^{3}107.0 MET.h/mth. Women: very low <5.0; low 5.1–24.0; medium 24.1–66.5 and high ^{3}66.6 MET.h/mth. [b] Geometric mean and SD (standard deviation). [c] Poor balance defined as people who lost balance in first 5 seconds.

P values generated from regression analysis (or logistic regression for balance time) testing for a statistically significant difference in muscle strength or physical performance for each increasing band of gardening activity. Results were as follows:

Average change (95% confidence interval [CI] in grip per increased band of gardening activity: 0.59 kg (−0.28, 1.47) $P = 0.18$ for men; 1.02 kg (0.43, 1.61) $P = 0.001$ for women.

Average change (95% CI) in 3 m walk time per increased band of gardening activity: −0.04 sec (−0.10, 0.02) $P = 0.24$ for men; −0.10 (−0.17, −0.03) $P = 0.006$ for women.

Average change (95% CI) in chair rises time per increased band of gardening activity: −0.00 SD units (−0.12, 0.12) $P = 0.96$ for men; −0.11 SD units (−0.22, 0.00) $P = 0.05$ for women.

Odds ratio (95% CI) for poor balance per increased band of gardening activity: 0.97 (0.69, 1.37) $P = 0.86$ for men; 0.74 (0.57, 0.95) $P = 0.02$ for women).

bulk than women; to show differences in physical activity relative to physical performance among men, a wider range and greater intensity of physical activity may be needed. Physical activity questionnaires are limited in their ability to reflect activity at the higher end of the spectrum, which is differentially likely to affect men. The threshold for observing the association between levels of customary activity and physical performance may have been reached in women but not men. Finally, our physical performance assessments involved fairly low-intensity exercise; the same argument for differential threshold effects applies.

In conclusion, higher levels of customary physical activity are associated with better muscle strength and physical performance in older women but not men. Maintenance of muscle strength and physical performance in later life is an important component of healthy ageing and is an important area for future research.

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Table 1. Relationships between patterns of physical activity, muscle strength and physical performance

	Physical activity cluster									
	Women				Men					
Mean (SD) by cluster	'Keep fit' (n = 85)		'Indoors' (n = 190)		'Keep fit' (n = 117)		'Indoors' (n = 36)		'Less active' (n = 76)	
Grip strength (kg)	27.8	(4.9)	25.2	(5.7)	44.4	(6.8)	44.2	(6.9)	44.6	(8.7)
	$P = 0.0003$				$P = 0.96$					
3-m walk (s)	3.22	(0.50)	3.55	(0.70)	3.3	(0.5)	3.3	(0.4)	3.4	(0.6)
	$P = 0.0001$				$P = 0.62$					
Chair rises (SDS)	−0.36	(0.76)	0.17	(1.05)	−0.03	(0.9)	0.01	(1.0)	0.04	(1.1)
	$P = 0.0001$				$P = 0.88$					
Balance lost in <5 s[a]	14	(16.5)	51	(28.0)	16	(13.7)	3	(8.8)	11	(14.9)
	$P = 0.05$				$P = 0.77$					

SDS, standard deviation score; s, seconds; SD, standard deviation.
[a] Number and percentage with poor balance time. P-values for differences in muscle strength or physical performance between physical activity clusters were obtained from analysis of variance (ANOVA) for grip strength, 3-m walk and chair rises test times, and from Fisher's exact test for balance performance.

Key points

- Maintenance of muscle strength and physical performance in later life is an important component of healthy ageing.
- Higher levels of customary physical activity are associated with better muscle strength and physical performance in older women but not men.
- The reason for the observed gender difference is not known, but women, with a higher fat-to-muscle ratio, may gain more with regard to strength and physical performance from the beneficial effects of physical activity.
- This is an important area for future research.

Acknowledgements

This work was supported by the Medical Research Council and the University of Southampton.

Conflicts of interest

None.

Supplementary data

Supplementary data for this article are available online at http://ageing.oxfordjournals.org.

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doi:10.1093/ageing/afn148
Published electronically 29 July 2008

A Mini-Mental Status Examination for the hearing impaired

SIR—The Folstein Mini-Mental State Examination (MMSE), developed in 1975 as a bedside test of cognitive function, has been extensively used in clinical practice and research and is widely accepted as a clinical tool for diagnosing and monitoring dementia [1]. Despite its low sensitivity and specificity (0.56 and 0.73, respectively, in one recent study) [2], comparable tools, including the Modified MMSE of Teng and Chui [3] have not received such widespread acceptance.

It contains 11 questions that test orientation, registration, attention, calculation, recall, language and visuospatial functioning, with a maximum score of 30. It takes minutes to administer and is practical for routine clinical use. Most questions are administered verbally. Hearing loss reduces performance on the verbal parts of the examination even in cognitively intact patients, with potential diagnostic error and alteration of management [4]. This is of concern, as hearing impairment affects over one-fourth of people over 65 years of age, and half of those over 75 years in most industrialised nations [5].

Uhlmann [6] tested 71 Alzheimer's disease subjects with varying levels of hearing, using both written and standard versions of the MMSE. Paradoxically, they found that hearing-impaired subjects scored higher in the standard than the written version, while subjects with normal hearing performed better using the written version, although these findings were not statistically significant.

We (M.M.) developed a written version of the MMSE, found it clinically useful, and report here an evaluation of its performance in a hospital-based population of older people.

Methods

Subjects

The study population consisted of subjects over the age of 65 years with a range of cognitive function and normal, moderately or severely impaired hearing. Subjects with profound hearing loss or inability to read or comprehend instructions were excluded. Subjects were recruited from the geriatric, neurological and audiometry departments at

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