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Short communication

Muscle strength and cognition in ageing men and women: The DR's EXTRA study

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1. Introduction

Handgrip strength (HS) has been widely used as a measure of muscle strength in prospective studies examining the association between strength and cognitive impairment [1–10]. Lower HS has been independently associated with deeper decline in cognition over time [1–7] but contradictory results also exist [8–10]. HS is simple and quick to measure but caution is required when generalising HS as a predictor of the global muscle strength [11].

To the best of our knowledge, the association between extensively (i.e. from multiple muscle groups) measured muscle strength and cognition has been explored in only one study [6], in which a higher muscle strength was related to a lower risk of developing Alzheimer's disease (AD). It is still unclear, however, whether the association between muscle strength and cognition is adequately characterised by gauging HS strength as a measure of overall muscle strength; or whether extensively measured muscle strength still reflects global muscle strength more appropriately, hence strengthening the association between muscle strength and cognition.

We studied the association between muscle strength and cognition in ageing men and women with special reference to the effect of various measures of strength (HS as well as extensive muscle strength measurement from lower body [LB] and upper body [UB]) to the magnitude of association.

2. Material and methods

We used the baseline data of the Dose-Responses to Exercise Training (DR's EXTRA) Study (ISRCTN45977199, http://www.isrctn.org) [12]. The subjects were a representative sample from target population consisting of all men and women aged 55–74 years who lived in the city of Kuopio in Finland in 2002. Altogether, 1410 men and women were randomised into one of the five intervention groups (aerobic exercise, resistance exercise, diet, aerobic exercise + diet or resistance exercise + diet) or the reference group [12]. In this study we used the baseline data from resistance exercise ($n = 236$) and resistance exercise + diet ($n = 234$) groups which were combined into a single group for analysis. After excluding individuals with missing or insufficient data on muscle strength ($n = 130$) or cognition ($n = 2$), the present study included 168 men and 170 women aged 57–78 years at baseline in 2005–2006. The main reason for incomplete muscle strength measurements were various musculoskeletal complaints (i.e. arthrosis, arthritis etc.) common in this age group. Musculoskeletal complaints became evident mostly in knee extension and chest press. The study protocol was approved by the local ethics committee. All participants gave a written informed consent.

2.1. Muscle strength

Muscle strength (kg) was tested with air resistance equipment (Hur Ltd., Finland), which replaces the weight plates traditionally used in weight stack machines with a pneumatic system of

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resistance. Strength of the main muscle groups of LB and UB was tested with three (leg extension, leg flexion, leg press) and two (chest press, seated row) exercises, respectively. For each of five exercises the aim was to find the maximum load with which a subject was able to perform 3–5 repetitions. From these loads measured separately the expected 1 repetition maximum for each exercise was estimated [13]. Measurements were made by one limb at a time and a mean value was used in analyses. In that case the value of either limb was missing, available value was used. HS was measured two times from the dominant hand using the handheld Jamar dynamometer and a mean of the two scores was used in analyses.

2.2. Cognition

Cognitive function was assessed using the Consortium to Establish a Registry for Alzheimer's Disease (CERAD) neuropsychological test battery [14] previously described in detail [15]. The CERAD total score (CERAD-TS) was calculated by summing up the six individual subtests [16], a higher score indicating a better performance.

2.3. Statistical analyses

Independent samples *t*-test was used to compare muscle strength and cognition between men and women. Sum scores for LB and UB muscle strength were calculated as follows: leg extension + leg flexion + leg press for LB-index; chest press + seated row for UB-index. Sum scores were then standardised by calculating gender-specific *z*-scores, which were pooled together to enable the analysis of both sexes in the same model for each index. Similar standardising procedure was made for the HS scores as well.

Linear regression analysis was used to examine separately the association of HS, LB muscle strength and UB muscle strength with CERAD-TS adjusted for age. To explore the association between muscle strength and CERAD-TS three models were created: HS, age (Model 1), HS, age and LB-index (Model 2), HS, age, LB-index and UB-index (Model 3). The change in global goodness-of-fit was used to explore whether the stepwise addition of new variable improved the model fit when expanding the Models from 1 to 3. The change in global goodness-of-fit was calculated using the log-likelihood ratio (LR) Chi^2 (χ^2) statistic. Statistical analyses were performed using the IBM SPSS statistics for Windows, version 21.0 (IBM Corporation) and R version 2.11.1. P-value < 0.05 was defined as statistically significant.

3. Results

The mean age of the subjects was 66.1 (SD 5.3) years. Men had higher muscle strength in all measurements compared to women ($P < 0.001$) but there was no difference in cognition ($P = 0.11$) between sexes (Table 1). The LB ($\beta = 0.16$, $P = 0.007$) and the UB ($\beta = 0.18$, $P = 0.001$) muscle strength was positively associated with CERAD-TS but no association was observed between HS and CERAD-TS ($\beta = 0.04$, $P = 0.46$) adjusted for age.

The global goodness-of-fit of various models reflecting muscle strength are presented in Table 2. A model 2 fitted significantly better compared to the model 1 (the change in LR χ^2 statistic 6.84, df = 1, $P = 0.009$) indicating that the addition of LB-index to a model improved it. Furthermore, model 3 fitted significantly better than model 2 ($\chi^2 = 4.40$, df = 1, $P = 0.004$) indicating that the addition of UB-index to a model further improved it. Finally, we reduced HS from the model and tested whether addition of the UB-index to a model including LB-index and age improves the model. The addition of the UB-index improved the fit of a model, albeit not statistically significantly ($\chi^2 = 3.61$, df = 1, $P = 0.06$).

Table 1
Muscle strength and cognition of the subjects.

	Men (n = 168)	Women (n = 170)	All (n = 338)
Handgrip strength, kg	41.8 (8.1)	22.7 (6.4)	32.2 (12.0)
Leg press, kg	111.1 (25.9)	89.2 (19.4)	100.1 (25.3)
Leg extension, kg	28.1 (6.7)	17.0 (5.3)	22.6 (8.2)
Leg flexion, kg	32.8 (7.2)	19.4 (4.0)	26.0 (8.8)
Chest press, kg	36.5 (8.9)	18.2 (4.9)	27.3 (11.6)
Seated row, kg	38.9 (7.0)	18.5 (4.0)	28.7 (11.7)
CERAD total score, points	82.1 (9.1)	83.6 (8.9)	82.9 (9.0)

Values are presented as mean (SD).

Table 2
The association between muscle strength and CERAD total score (n = 338).

Model	Log-likelihood ratio	P-value
1	−1216.9	
2	−1213.5	0.009
3	−1211.3	0.004

P-value for the change in log-likelihood ratio after adding a new variable. Model 1: handgrip strength, age; Model 2: handgrip strength, age, lower body index (leg press + leg extension + leg flexion); Model 3: handgrip strength, age, lower body index, upper body index (chest press + seated row).

4. Discussion

An association between higher muscle strength and better global cognition was observed in ageing men and women. However, this association was found only between extensively measured muscle strength and cognition. These results indicate that instead of measuring only HS, it may be rational to perform more extensive but relatively effortless measurements of muscle strength.

Our results are in line with the previous study [6] in that extensively measured muscle strength is positively associated with cognition. In our sample, however, LB and UB muscle strength were independently associated with global cognition, which differs from the previous results [6] that only axial muscle strength was individually associated with the risk of AD. Furthermore, previously [6] subjects were approximately 14 years older and an isometric testing was used to measure muscle strength, which makes it difficult to compare the results with the present study.

HS was positively associated with cognition in some previous studies [1–7]. Subjects in these studies were older than in our study, and cognition was assessed using either Mini-Mental Status Examination (MMSE), a rough measurement of global cognition [1,3,4,7], or incident AD [2,5,6] as an outcome. In a cohort over 2000 ageing individuals [5], poor HS was associated with increased risk of dementia over six years follow-up only among participants with possible mild cognitive impairment. Interestingly, among participants without cognitive impairment, other factors like gate slowing and poor balance were associated with the increased dementia risk [5]. Extensively measured muscle strength may indicate the association of muscle strength with cognition in participants without cognitive impairment, whereas the association between HS and cognition may occur with older and more cognitively impaired subjects.

The main strength of the study is a large population based sample of ageing men and women with wide age range. We measured muscle strength of several muscle groups, which enabled us to evaluate LB and UB musculature separately. The CERAD battery is a sensitive measure of cognitive domains that are vulnerable in early and preclinical stages of AD [14]. Furthermore, CERAD-TS was previously found to be superior to the MMSE, or any single CERAD subtest in discriminating cognitively intact subjects from subjects with mild cognitive impairment [17]. There are also some limitations in our study. A relatively high number of subjects were excluded due to musculoskeletal complaints preventing reliable measurement of muscle strength. The application of isometric strength testing instead of dynamic testing would probably have decreased the amount of excluded subjects. However, we included subjects who were able to perform strength testing in a given exercise with either limb.

We conclude that muscle strength is associated with cognition in ageing men and women. Extensive measurement of muscle strength may be more convenient than HS alone in studies investigating the association between muscle strength and cognition.

Ethical statement

The DR's EXTRA study protocol was approved by the joint Ethics Committee of the Kuopio University and University Hospital and conducted according to Declaraton of Helsinki. All participants gave a written informed consent. The DR's EXTRA Study has been registered (ISRCTN45977199, http://www.isrctn.org).

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Disclosure of interest

The authors declare that they have no competing interest.

References

[1] Alfaro-Acha A, Al Snih S, Raji MA, Kuo YF, Markides KS, Ottenbacher KJ. Handgrip strength and cognitive decline in older Mexican Americans. J Gerontol A Biol Sci Med Sci 2006;61:859–65.

[2] Buchman AS, Wilson RS, Boyle PA, Bienias JL, Bennett DA. Grip strength and the risk of incident Alzheimer's disease. Neuroepidemiology 2007;29:66–73.

[3] Auyeung TW, Lee JS, Kwok T, Woo J. Physical frailty predicts future cognitive decline – a four-year prospective study in 2737 cognitively normal older adults. J Nutr Health Aging 2011;15:690–4.

[4] Gallucci M, Mazzuco S, Ongaro F, Di Giorgi E, Mecocci P, Cesari M, et al. Body mass index, lifestyles, physical performance and cognitive decline: the "Treviso Longeva (TRELONG)" study. J Nutr Health Aging 2013;17:378–84.

[5] Wang L, Larson EB, Bowen JD, van Belle G. Performance-based physical function and future dementia in older people. Arch Intern Med 2006; 166:1115–20.

[6] Boyle PA, Buchman AS, Wilson RS, Leurgans SE, Bennett DA. Association of muscle strength with the risk of Alzheimer disease and the rate of cognitive decline in community-dwelling older persons. Arch Neurol 2009;66:1339–44.

[7] Taekema DG, Ling CHY, Kurrle SE, Cameron ID, Meskers CGM, Blauw GJ, et al. Temporal relationship between handgrip strength and cognitive performance in oldest old people. Age Ageing 2012;41:506–12.

[8] Atkinson HH, Rapp SR, Williamson JD, Lovato J, Absher JR, Gass M, et al. The relationship between cognitive function and physical performance in older women: results from the women's health initiative memory study. J Gerontol A Biol Sci Med Sci 2010;65:300–6.

[9] Gray SL, Anderson ML, Hubbard RA, LaCroix A, Crane PK, McCormick W, et al. Frailty and incident dementia. J Gerontol A Biol Sci Med Sci 2013;68:1083–90.

[10] Veronese N, Stubbs B, Trevisan C, Bolzetta F, De Rui M, Solmi M, et al. What physical performance measures predict incident cognitive decline among intact older adults? A 4.4-year follow up study. Exp Gerontol 2016; 81:110–8.

[11] Felicio DC, Pereira DS, Assumpção AM, de Jesus-Moraleida FR, de Queiroz BZ, da Silva JP, et al. Poor correlation between handgrip strength and isokinetic performance of knee flexor and extensor muscles in community-dwelling elderly women. Geriatr Gerontol Int 2014;14:185–9.

[12] Komulainen P, Kivipelto M, Lakka TA, Savonen K, Hassinen M, Kiviniemi V, et al. Exercise, fitness and cognition – A randomised controlled trial in older individuals: the DR's EXTRA study. Eur Geriatr Med 2010;1:266–72.

[13] Bompa TO. Periodization of strength. Toronto, ON: Veritas Publishing Inc; 1993. p. 72.

[14] Morris J, Heyman A, Mohs R, Hughes J, van Belle G, Fillenbaum G, et al. The Consortium to establish a registry for Alzheimer's disease (CERAD). Part I. Clinical and neuropsychological assessment of Alzheimer's disease. Neurology 1989;39:1159–65.

[15] Mannikko R, Komulainen P, Schwab U, Heikkila HM, Savonen K, Hassinen M, et al. The Nordic diet and cognition – The DR's EXTRA study. Br J Nutr 2015;114:231–9.

[16] Chandler MJ, Lacritz LH, Hynan LS, Barnard HD, Allen G, Deschner M, et al. A total score for the CERAD neuropsychological battery. Neurology 2005; 65:102–6.

[17] Paajanen T, Hanninen T, Tunnard C, Mecocci P, Sobow T, Tsolaki M, et al. CERAD neuropsychological battery total score in multinational mild cognitive impairment and control populations: the AddNeuroMed study. J Alzheimers Dis 2010;22:1089–97.

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