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Grip Strength and Impact on Cognitive Function in Healthy Kitchen Workers

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ABSTRACT

Background: Hand grip strength is often considered may predict cognitive functioning and has been established as associates of cognitive performance with individual differences in some particular cross-sectional studies. However, little is known about hand grip strength and cognitive performance in the elderly individuals, and it is not known whether changes in hand grip strength may be associated with preservation/decline in cognitive functioning.
Objectives: We have studied the impact of hand grip strength on cognition function in healthy kitchen workers.
Methods: Participants ($n = 90$, age range: 25–40 years) randomly assigned in to two groups according to their nature of work: Group I-Control group ($n = 47$) - workers recruited for simple work such as dusting, cleaning dining tables and floor. Group II-Study group ($n = 43$) - workers recruited for firm work such as cooking large quantity of food, kneading dough, rolling chapattis, cut and sauté the vegetables and dish washing. For the analyses, we used at dominant and non-dominant hand; hand grip strength (HGS), reaction time task, sensory disability test (SDT) and cognitive function test (CFT) among both the groups.
Result: We observed that visual reaction time (VRT) and auditory reaction time (ART) were significantly improved in dominant hand of study group, when compare to control group; however it was comparable in non-dominant hand among both the groups. In addition to; among all control and study group female workers there was significant positive correlation between VRT & ART and significant negative correlation between at dominant hand HGS & VRT as well as between at dominant hand HGS & ART. We also observed that dominant hand HGS was a significant predictor of VRT and ART and however there was no any significant variation in body mass index (BMI), sensory disability test (SDT) and cognitive function test (CFT) among both groups.
Conclusion: We found that muscle strength (as measured by hand grip strength) was associated with improved reaction time. Hence by using a simple muscle strength test; is one way of obtaining useful information for the development of nerve-muscle coordination. Increased handgrip strength would be associated with preservation of cognitive function.

Introduction

Handgrip strength (HGS) is a noninvasive measure of physical health and usually assessed in different clinical settings as an indicator of over-all health status and upper limb strength (Bonitch-Góngora et al., 2013; Nicolay and Walker, 2005; Schlüssel

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et al., 2008). Some cross-sectional studies have shown associations between muscle strength and physical fitness (Hasegawa et al., 2008; Jeune et al., 2006; Lauretani et al., 2003; Takata et al., 2008). HGS is not only used for muscle strength, but also for changes in biological functioning (Bohannon, 2008). Measures of HGS may be viewed as a general indicator of the integrity of the central nervous system related to cognitive variables (Alfaro-Acha et al., 2006; Raji et al., 2005; Taekema et al., 2010). On the other hand; conflicting results have been reported when data from longitudinal studies have been analyzed to determine whether handgrip strength was a predictor of cognitive decline (Christensen et al., 1999; MacDonald et al., 2004). Although there is substantial evidence that HGS and cognitive performance are associated with individual differences in some particular cross-sectional studies (Anstey and Smith, 1999; Nourhashémi et al., 2002) and longitudinal studies (Clouston et al., 2013; Deary et al., 2011; Kuh et al., 2009).

Most studies are reported on the relations between HGS and mental fitness or cognition in older individuals (Alfaro-Acha et al., 2006; Buchman et al., 2007; Christensen et al., 2000). However, to our knowledge studies reported in young adults are still lacking. Henceforth, the nature of the association between muscle strength and cognition is still uncertain in young adults. The identification of cognitive changes would be of practical benefit, particularly if these were identifiable early in adult life. Thus we hypothesized that change in handgrip strength would be associated with preservation/decline of cognitive function by examining the relationships between both these variables in young adults. So we have studied the impact of hand grip strength on cognition function in healthy kitchen workers.

Methods

Inclusion and Exclusion Criteria for Participants

Varying as a function of age, the highest grip strength scores occur between the ages of 24 and 39 years (Mathiowetz et al., 1985). Hence in our study we have restricted the participant age between 25 and 40 years to evaluate the association with cognition. The participants were female's workers working for more than five years in People's University college kitchen, hospital kitchen and hostels kitchen were recruited for the study. All participants were screened for medications and had no history of respiratory or cardiac diseases. Moreover, there were exclusion criteria for participants such as: self-reported chronic long-term musculoskeletal disease, progressive psychological or neurological disease, diagnosed cardiovascular or metabolic disease with regular medication and pregnant women. The 26 participants were excluded, because of older age, early employment, pregnancy and medical factor.

Ethic Declaration

This cross-sectional and prospective study was approved by the Institutional Review Board of Peoples University and committee of ethics in research involving human participation (PCMS/OD/2015/1069). All participants provided written informed consent to participate. The selected 90 participants who met the inclusion criteria were randomly assigned in to two groups according to their nature of work:

- Group I-Control group (n = 47) - workers recruited for simple work such as dusting, cleaning dining tables and floor.
- Group II- Study group (n = 43) - workers recruited for firm work such as cooking large quantity of food, kneading dough, rolling chapattis, cut and sauté the vegetables and dish washing.

The data were collected under natural environmental conditions in the morning (between 8 am and12 noon) to avoid diurnal variation.

Study Protocol

Body Mass Index (BMI) Measurements (on the Basis of Asian Population)

This was done in the orthostatic position. Weight and height were measured without shoes and with light clothing. The BMI was calculated by dividing the body weight by the squared height (Klein et al., 2007; Snehalatha et al., 2003).

Determination of HGS

HGS was determined by using Smedley hand grip dynamometer which measures the force exerted in kilograms; as the maximum voluntary contraction (kg) sustained for at least 3 s. Each subject was given the verbal instruction and demonstration before being tested and further instructions are provided at the time of test. Subject stand upright holding the dynamometer in both dominant and non-dominant hand, with the shoulder abducted and elbow in full extension and will be encouraged to exert the maximal grip such as squeeze fingers and thumb together as hard as possible. The participant made six attempts (three with each hand) (Coldham et al., 2006). Three trials with brief pauses of 10–20 s were allowed and the highest score (in kg) was considered as the participant's grip strength score.

Reaction Time Task

This measured time (in milli-sec) responds to right or left light and sound signal with a right or left button press by both dominant and non-dominant hand; as previously explained by our research group (Choudhary et al., 2016). It consisted of two units, a device for stimuli settings and another for stimuli response, along with an electronic chronometer for measuring the reaction time in

Table 1
The comparison of body mass index (BMI); among control and study groups.

	Control group(n = 47)	Study group (n = 43)
Age (years)	24.25 ± 4.47	27.68 ± 5.40
Height (cm)	172.38 ± 10.66	169.24 ± 13.84
Weight (Kg)	62.72 ± 7.54.	60.30 ± 10.23
BMI (kg/m^2)	20.89 ± 2.73	19.55 ± 2.42

milliseconds. During each examination procedure, each subject was communicated regarding stimulus (sound/light) to respond. The subjects were instructed to place index fingers over these buttons, such as left index finger goes over the left button and right index finger goes over the right button and were seated in front of a desk with the responding device placed on top of it. The task was to press the appropriate button as soon as the stimulus appeared. Six practice trials were then given for each subject. In order to avoid the anticipation of a stimulus, the examiner varied the intervals between successive stimuli. Each experimental situation consisted of three trials, from which the arithmetic mean was calculated and represented as an individual reaction time expressed in milliseconds.

Cognitive Function Test (CFT)

Cognitive function was evaluated with the Mini Mental State Examination (MMSE) (Bird et al., 1987; Folstein et al., 1975). Scores have a potential range of 0 to 30, with the highest scores indicating indicative of healthier cognitive ability.

Sensory Disability Test (SDT)

This was measured in both dominant and non-dominant hand by a scale measuring sensory disability based on 12 items (Christensen et al., 2000) where 10 of were self-rated and 2 of were rated by the interviewer and the maximum score on the scale was 27, with the highest scores indicating healthier sensory functioning.

Statistical Analysis

Data are expressed as mean ± standard deviation (SD). All data were analyzed with the SPSS for windows statistical package (version 20.0, SPSS Institute Inc., Cary, North Carolina). Statistical significance between the different groups was determined by the independent student '*t*-test' and the significance level was fixed at $p \leq 0.05$. Finally, Pearson correlation and linear regression was used between two variables.

Result

The Comparison of BMI among Control and Study Groups

The data are summarized in (Table 1) with mean ± SD. Among workers in control group and study group, there were no any significant variation in body mass index (BMI) and their age groups.

Table 2
The comparison of HGS, RT, SDT, CT; among control and study groups.

	Control group(n = 47)	Study group (n = 43)
HGS(kg)		
Dominant hand	18.67 ± 2.73	25.38 ± 3.13*
Non-dominant hand	17.20 ± 2.32	19.38 ± 2.56
VRT(milli-sec)		
Dominant hand	415 ± 28	342 ± 37*
Non-dominant hand	428 ± 33	405 ± 30
ART(milli-sec)		
Dominant hand	265 ± 15	213 ± 20*
Non-dominant hand	285 ± 17	270 ± 18
SDT		
Dominant hand	23.25 ± 3.18	24.16 ± 2.86
Non-dominant hand	22.80 ± 2.63	23.80 ± 2.39
CFT		
MMSE score	25.66 ± 3.58	26.25 ± 3.80

* Significance change ($p \leq 0.05$) compared with control group; hand grip strength (HGS), visual reaction time (VRT), auditory reaction time (ART), sensory disability test (SDT), cognitive function test (CFT).

The Comparison of HGS among Control and Study Groups

The data are summarized in (Table 2) with mean ± SD. The study group female workers showed significant increase in HGS at dominant hand, when compare to control group females. However HGS at non-dominant hand was comparable among both the groups.

The Comparison of Visual Reaction Time (VRT) & Auditory Reaction Time (ART) among Control and Study Groups

The data are summarized in (Table 2) with mean ± SD. The VRT and ART were significantly improved in dominant hand of study group, when compare to control group; however it was comparable in non-dominant hand among both the groups. In addition to among all control and study group female workers there was significant positive correlation between VRT & ART (Fig. 1) [$r(88) = 0.87; P = 0.01$] and significant negative correlation between at dominant hand HGS & VRT(Fig. 2) [$r(88) = 0.78; P = 0.01$] as well as between at dominant hand HGS & ART(Fig. 3) [$r(88) = 0.81; P = 0.01$]. We also observed that dominant hand HGS was a significant predictor of VRT [$\beta = -0.78, t(88) = 43.25$; $F(1,88) = 136$, $P = 0.01$, $R^2 = 0.60$] and ART [$\beta = -0.81, t(88) = 45.00$; $F(1,88) = 171$, $P = 0.01$, $R^2 = 0.66$].

The Comparison of SDT & CFT among Control and Study Groups

The data are summarized in (Table 2) with mean ± SD. Among workers in control group and study group; SDT at both dominant and non-dominant was comparable as well as there was no any significant variation in CFT in between control and study group.

Discussion

The human hand is unique to perform motor task and also capable of relaying sensory perception to the brain (Günther et al., 2008). Hand-eye coordination, is closely involved in the coordination of the voluntary movement (Gribble et al., 2002). HGS is greatly affected by daily life pattern (Pijnappels et al., 2008).

In the present study, the dominant hand displayed maximal handgrip strength and improved reaction time than that of the non-dominant hand. The dominant hand is superior than non-dominant hand as the individual habitually favors one hand in daily life (Aoki and Demura, 2008; Aoki and Demura, 2009). In addition to, lateral dominance appears in motor tasks which demand dexterity of the hands, fingers and upper limbs and hence it confirms that laterality exists in each body part with bilateral symmetry in humans (Kubota and Demura, 2011; Noguchi et al., 2009).

The relationship between measures of non-cognitive markers such as HGS and motor control (reaction time) has been established. The researcher has found that reaction time was closely related to grip strength (as measured by HGS) than whichever physical or

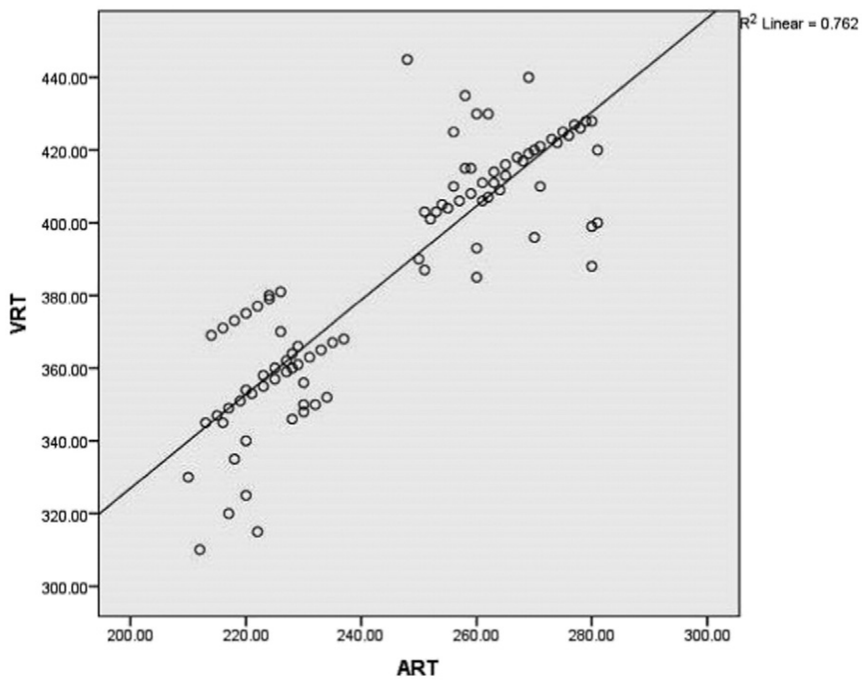

Fig. 1. Positive correlation between visual reaction time (VRT), and auditory reaction time (ART) at dominant hand among control and study groups.

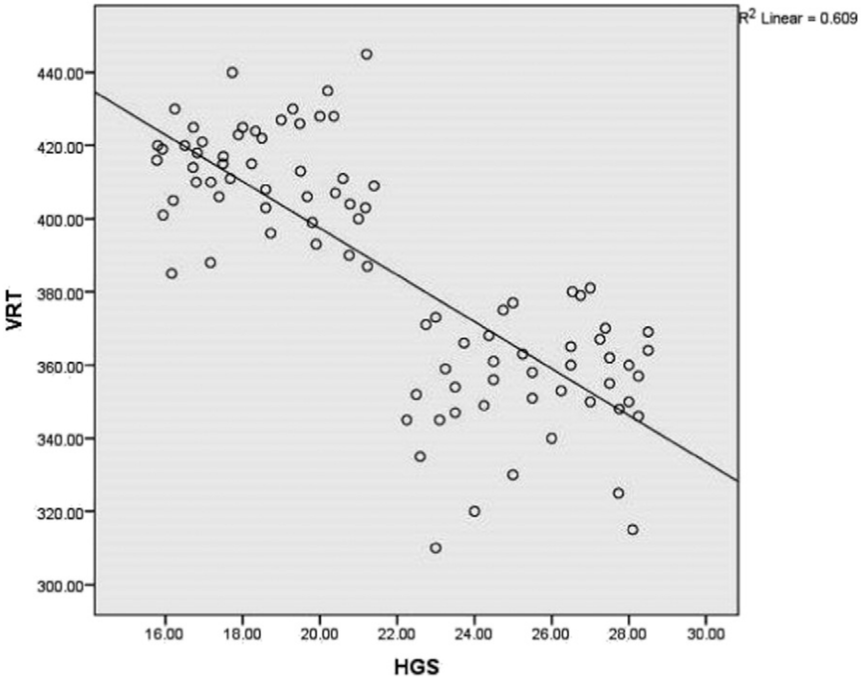

Fig. 2. Negative correlation between at dominant hand grip strength (HGS) and visual reaction time (VRT) among control and study groups.

mental health (Anstey et al., 2005; Lord et al., 2002). Our findings in this study; such as maximal HGS and improved reaction time are similar to the results from previous studies where HGS and reaction time are correlated (Lord et al., 2002; Proctor et al., 2006).

The proposed mechanisms for the relationship between grip strength and cognition in healthy adults are brain-aging processes, such as the functioning of the central nervous system or changes in white matter integrity (Baltes & Lindenberger, 1997; Christensen et al., 2001). The area of the brain often associated with motor control (reaction time) and mental attention is the anterior portion of the internal capsule (Zaborszky et al., 1999). Some studies recommend that measurements of brain health as measured by cerebral

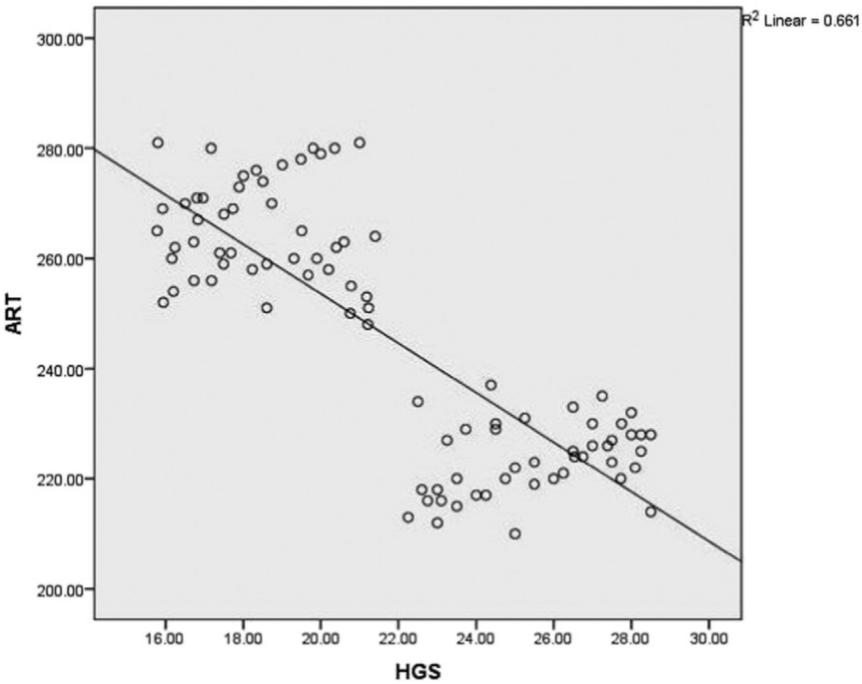

Fig. 3. Negative correlation between at dominant hand grip strength (HGS) and auditory reaction time (ART) among control and study groups.

white matter integrity; established a relationship existed between grip strength, reaction time and cerebral white matter integrity in the internal capsule (Lindberg et al., 2007; Madden et al., 2004). But the mechanisms intended are not completely understood. This suggests that improved reaction time in this study may associate with greater cerebral white matter integrity and may be hemispheric specific in the left side of the anterior internal capsule for predominately right handed individuals or vice versa.

We didn't observe any significant change in cognitive function and sensory disability test among both groups. These results are consistent with earlier findings and suggesting a relationship between HGS and cognitive function; such as an increased physical activity that improves muscle strength might help to prevent cognitive decline (Hassmén and Koivula, 1997; Williams and Lord, 1997). Conversely; low handgrip strength might accelerate cognitive decline (Alfaro-Acha et al., 2006; Buchman et al., 2007; Christensen et al., 2000). Briefly, speed of processing has been regarded as a major determinant of cognitive efficiency and faster nervous system activity may responsible for efficient cognition (Paas et al., 2003).

Limitation of the Study

Future studies with more number of participants may help to add further data on this finding and results were controlled for by gender, and not analyzed with regard to gender differences. Such differences exist in both grip strength and cognition (De Frias et al., 2006), and to get a better understanding of gender differences in underlying mechanisms, would be a natural continuation of this study. In addition we were not able to examine the biomarkers that incorporate blood sample; which may further add a new dimension to explore this outcome.

Conclusion

In this cross sectional study, we can conclude that our results are consistent with hypothesis. We found that muscle strength (as measured by hand grip strength) was associated with improved reaction time. Hence by using a simple muscle strength test; is one way of obtaining useful information for the development of nerve-muscle coordination. Increased handgrip strength would be associated with preservation of cognitive function. Hence it's recommended to promote adoption of proper diets to enhance muscle strength, particularly among those who have lower grip strength in young individuals and some more research work should evaluate these bidirectional connections underlying between both grip strength and cognitive abilities.

Conflict of Interest

The authors declared no conflict of interest.

Acknowledgement

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References

Alfaro-Acha, A., Al Snih, S., Raji, M.A., Kuo, Y.-F., Markides, K.S., Ottenbacher, K.J., 2006. Handgrip strength and cognitive decline in older Mexican Americans. J. Gerontol. Ser. A Biol. Med. Sci. 61 (8), 859–865.

Anstey, K.J., Smith, G.A., 1999. Interrelationships among biological markers of aging, health, activity, acculturation, and cognitive performance in late adulthood. Psychol. Aging 14 (4), 605.

Anstey, K.J., Dear, K., Christensen, H., Jorm, A.F., 2005. Biomarkers, health, lifestyle, and demographic variables as correlates of reaction time performance in early, middle, and late adulthood. Q. J. Exp. Psychol. A 58 (1), 5–21.

Aoki, H., Demura, S., 2008. The effect of gender and lateral dominance on gripping muscle power in young adults. Sport Sci. Health 3 (1–2), 1–6.

Aoki, H., Demura, S., 2009. Laterality of hand grip and elbow flexion power in right hand–dominant individuals. Int. J. Sports Physiol. Perform. 4, 355–366.

Bird, H.R., Canino, G., Stipec, M.R., Shrout, P., 1987. Use of the mini-mental state examination in a probability sample of a Hispanic population. J. Nerv. Ment. Dis. 175 (12), 731–737.

Bohannon, R.W., 2008. Hand-grip dynamometry predicts future outcomes in aging adults. J. Geriatr. Phys. Ther. 31 (1), 3–10.

Bonitch-Góngora, J.G., Almeida, F., Padial Puche, P., Bonitch-Domínguez, J.G., Feriche, B., 2013. Maximal Isometric Handgrip Strength and Endurance Differences between Elite and Non-Elite Young Judo Athletes.

Buchman, A.S., Wilson, R.S., Boyle, P.A., Bienias, J.L., Bennett, D.A., 2007. Grip strength and the risk of incident Alzheimer's disease. Neuroepidemiology 29 (1–2), 66–73.

Choudhary, A.K., Alam, T., Jiwane, R., Kishanrao, S.S., 2016. A comparative analysis of dietary habits on sensory motor association and heart rate variability during menstrual cycle. J. Clin. Diagn. Res. 10 (1), CC04.

Christensen, H., Mackinnon, A., Korten, A., Jorm, A., Henderson, A., Jacomb, P., et al., 1999. An analysis of diversity in the cognitive performance of elderly community dwellers: individual differences in change scores as a function of age. Psychol. Aging 14 (3), 365.

Christensen, H., Korten, A., Mackinnon, A., Jorm, A.F., Henderson, A.S., Rodgers, B., 2000. Are changes in sensory disability, reaction time, and grip strength associated with changes in memory and crystallized intelligence? Gerontology 46 (5), 276–292.

Clouston, S.A., Brewster, P., Kuh, D., Richards, M., Cooper, R., Hardy, R., et al., 2013. The dynamic relationship between physical function and cognition in longitudinal aging cohorts. Epidemiol. Rev. 35 (1), 33–50.

Coldham, F., Lewis, J., Lee, H., 2006. The reliability of one vs. three grip trials in symptomatic and asymptomatic subjects. J. Hand Ther. 19 (3), 318–327.

De Frias, C.M., Nilsson, L.-G., Herlitz, A., 2006. Sex differences in cognition are stable over a 10-year period in adulthood and old age. Aging Neuropsychol. Cognit. 13 (3–4), 574–587.

Deary, I.J., Johnson, W., Gow, A.J., Pattie, A., Brett, C.E., Bates, T.C., et al., 2011. Losing one's grip: a bivariate growth curve model of grip strength and nonverbal reasoning from age 79 to 87 years in the Lothian birth cohort 1921. J. Gerontol. Ser. B Psychol. Sci. Soc. Sci., gbr 059

Folstein, M.F., Folstein, S.E., McHugh, P.R., 1975. "Mini-mental state": a practical method for grading the cognitive state of patients for the clinician. J. Psychiatr. Res. 12 (3), 189–198.

Gribble, P.L., Everling, S., Ford, K., Mattar, A., 2002. Hand-eye coordination for rapid pointing movements. Exp. Brain Res. 145 (3), 372–382.

Günther, C.M., Bürger, A., Rickert, M., Crispin, A., Schulz, C.U., 2008. Grip strength in healthy caucasian adults: reference values. J. Hand Surg. 33 (4), 558–565.
Hasegawa, R., Islam, M.M., Lee, S.C., Koizumi, D., Rogers, M.E., Takeshima, N., 2008. Threshold of lower body muscular strength necessary to perform ADL independently in community-dwelling older adults. Clin. Rehabil. 22 (10–11), 902–910.
Hassmén, P., Koivula, N., 1997. Mood, physical working capacity and cognitive performance in the elderly as related to physical activity. Aging Clin. Exp. Res. 9 (1–2), 136–142.
Jeune, B., Skytthe, A., Cournil, A., Greco, V., Gampe, J., Berardelli, M., et al., 2006. Handgrip strength among nonagenarians and centenarians in three European regions. J. Gerontol. Ser. A Biol. Med. Sci. 61 (7), 707–712.
Klein, S., Allison, D.B., Heymsfield, S.B., Kelley, D.E., Leibel, R.L., Nonas, C., et al., 2007. Waist circumference and cardiometabolic risk: a consensus statement from shaping America's health: Association for Weight Management and Obesity Prevention; NAASO, the Obesity Society; the American Society for Nutrition; and the American Diabetes Association. Obesity 15 (5), 1061–1067.
Kubota, H., Demura, S., 2011. Gender differences and laterality in maximal handgrip strength and controlled force exertion in young adults. Health 3 (11), 684.
Kuh, D., Cooper, R., Hardy, R., Guralnik, J., Richards, M., Team, M.S., 2009. Lifetime cognitive performance is associated with midlife physical performance in a prospective national birth cohort study. Psychosom. Med. 71 (1), 38.
Lauretani, F., Russo, C.R., Bandinelli, S., Bartali, B., Cavazzini, C., Di Iorio, A., et al., 2003. Age-associated changes in skeletal muscles and their effect on mobility: an operational diagnosis of sarcopenia. J. Appl. Physiol. 95 (5), 1851–1860.
Lindberg, P.G., Skejø, P.H., Rounis, E., Nagy, Z., Schmitz, C., Wernegren, H., et al., 2007. Wallerian degeneration of the corticofugal tracts in chronic stroke: a pilot study relating diffusion tensor imaging, transcranial magnetic stimulation, and hand function. Neurorehabil. Neural Repair.
Lord, S.R., Murray, S.M., Chapman, K., Munro, B., Tiedemann, A., 2002. Sit-to-stand performance depends on sensation, speed, balance, and psychological status in addition to strength in older people. J. Gerontol. Ser. A Biol. Med. Sci. 57 (8), M539-M43.
MacDonald, S.W., Dixon, R.A., Cohen, A.-L., Hazlitt, J.E., 2004. Biological age and 12-year cognitive change in older adults: findings from the Victoria longitudinal study. Gerontology 50 (2), 64–81.
Madden, D.J., Whiting, W.L., Huettel, S.A., White, L.E., MacFall, J.R., Provenzale, J.M., 2004. Diffusion tensor imaging of adult age differences in cerebral white matter: relation to response time. NeuroImage 21 (3), 1174–1181.
Mathiowetz, V., Kashman, N., Volland, G., Weber, K., Dowe, M., Rogers, S., 1985. Grip and pinch strength: normative data for adults. Arch. Phys. Med. Rehabil. 66 (2), 69–74.
Nicolay, C.W., Walker, A.L., 2005. Grip strength and endurance: influences of anthropometric variation, hand dominance, and gender. Int. J. Ind. Ergon. 35 (7), 605–618.
Noguchi, T., Demura, S., Aoki, H., 2009. Superiority of the dominant and nondominant hands in static strength and controlled force exertion. Percept. Mot. Skills 109 (2), 339–346.
Nourhashémi, F., Andrieu, S., Gillette-Guyonnet, S., Reynish, E., Albarède, J.L., Grandjean, H., et al., 2002. Is there a relationship between fat-free soft tissue mass and low cognitive function? Results from a study of 7, 105 women. J. Am. Geriatr. Soc. 50 (11), 1796–1801.
Paas, F., Tuovinen, J.E., Tabbers, H., Van Gerven, P.W., 2003. Cognitive load measurement as a means to advance cognitive load theory. Educ. Psychol. 38 (1), 63–71.
Pijnappels, M., Reeves, N.D., van Dieën, J.H., 2008. Identification of elderly fallers by muscle strength measures. Eur. J. Appl. Physiol. 102 (5), 585–592.
Proctor, D.N., Fauth, E.B., Hoffman, L., Hofer, S.M., McClearn, G.E., Berg, S., et al., 2006. Longitudinal changes in physical functional performance among the oldest old: insight from a study of Swedish twins. Aging Clin. Exp. Res. 18 (6), 517–530.
Raji, M.A., Kuo, Y.F., Snih, S.A., Markides, K.S., Kristen Peek, M., Ottenbacher, K.J., 2005. Cognitive status, muscle strength, and subsequent disability in older Mexican Americans. J. Am. Geriatr. Soc. 53 (9), 1462–1468.
Schlüssel, M.M., dos Anjos, L.A., de Vasconcellos, M.T.L., Kac, G., 2008. Reference values of handgrip dynamometry of healthy adults: a population-based study. Clin. Nutr. 27 (4), 601–607.
Snehalatha, C., Viswanathan, V., Ramachandran, A., 2003. Cutoff values for normal anthropometric variables in Asian Indian adults. Diabetes Care 26 (5), 1380–1384.
Taekema, D.G., Gussekloo, J., Maier, A.B., Westendorp, R.G., de Craen, A.J., 2010. Handgrip strength as a predictor of functional, psychological and social health. A prospective population-based study among the oldest old. Age Ageing 39 (3), 331–337.
Takata, Y., Ansai, T., Soh, I., Kimura, Y., Yoshitake, Y., Sonoki, K., et al., 2008. Physical fitness and cognitive function in an 85-year-old community-dwelling population. Gerontology 54 (6), 354–360.
Williams, P., Lord, S.R., 1997. Effects of group exercise on cognitive functioning and mood in older women. Aust. N. Z. J. Public Health 21 (1), 45–52.
Zaborszky, L., Pang, K., Somogyi, J., Nadasdy, Z., Kallo, I., 1999. The basal forebrain corticopetal system revisited. Ann. N. Y. Acad. Sci. 877 (1), 339–367.