Movement velocity in the chair squat is associated with measures of functional capacity and cognition in elderly people: Measurement with a smartphone (#24957)

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Movement velocity in the chair squat is associated with measures of functional capacity and cognition in elderly people: Measurement with a smartphone

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Background. The purpose of this study was to analyze the relationships between muscular performance in a simple test consisting on a single repetition on the chair squat exercise (CSQ) and different measures of functional performance, balance, quality of life and cognitive status in older adults. **Methods.** 40 participants (N=40; 22 women, 18 men; Age=72.2±4.9 yrs.) joined the investigation. Muscular performance was assessed by measuring movement velocity in the CSQ using a validated smartphone application. Additionally, functional capacity, balance, quality of life and cognitive statues were evaluated using the hand-grip test (HGS), the Berg-scale, the EuroQol 5D (EQ-5D) and the Mini mental state examination questionnaire (MMSE). Finally, participants were divided into two subgroups according to their velocity in the chair squat exercise. **Results**. Positive and significant ($p<0.05$) correlations between movement velocity in the CSQ and HGS ($r=0.763$), the Berg-scale ($r=0.649$), the EQ-5D ($r=0.340$) and the MMSE ($r=0.364$). Participants in the fastest subgroup showed very likely higher scores in the Berg-scale and the HGS, as well as likely higher scores in the MMSE scale (ES=0.69-1.79). **Discussion**. These findings highlight the positive relationship between muscular performance (measured with a smartphone application) and other measures of functional capacity and mental cognition in older adults.

AUTHOR COVER PAGE

MOVEMENT VELOCITY IN THE CHAIR SQUAT IS ASSOCIATED WITH MEASURES OF FUNCTIONAL CAPACITY AND COGNITION IN ELDERLY PEOPLE

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ABSTRACT

Background. The purpose of this study was to analyze the relationships between muscular performance ~~in a simple test~~ consisting on a single repetition on the chair squat exercise (CSQ) and different measures of functional performance, balance, quality of life and cognitive status in older adults.

Methods. 40 participants (N=40; 22 women, 18 men; Age=72.2±4.9 yrs.) ~~joined the investigation.~~ Muscular performance was assessed by measuring movement velocity in the CSQ using a validated smartphone application. Additionally, functional capacity, balance, quality of life and cognitive statues were evaluated using the hand-grip test (HGS), the Berg-scale, the EuroQol 5D (EQ-5D) and the Mini mental state examination questionnaire (MMSE). Finally, participants were divided in two subgroups according to their velocity in the chair squat exercise.

Results. Positive ~~and significant~~ ($p<0.05$) correlations between movement velocity in the CSQ and HGS ($r=0.763$; the Berg-scale 0.649), the EQ-5D ($r=0.340$) and the MMSE ($r=0.364$). Participants in the fastest subgroup showed very likely higher scores in the Berg-scale and the HGS, as well as likely higher scores in the MMSE scale (ES=0.69-1.79).

Discussion. These findings highlight the positive relationship between muscular performance ~~(measured with a smartphone application)~~ and other measures of functional capacity and mental cognition in older adults.

Key words: older adults; performance; testing; health; technology

INTRODUCTION

Aging can produce a remarkable decrement on muscle mass, exercise performance and bone mineral density, along many other health-related variables [1–3]. Specifically, muscular performance has been associated with the risk of suffering falls, which is a strong factor that leads to morbidity or mortality in the elderly [4,5]. Resistance training has shown to be a very effective intervention to increase functional capacity, i.e., the ability to perform daily life tasks such as standing up from a chair or walking with proper balance [5–7] . Specifically, the increases in muscle strength and power following a resistance training program are believed to be one of the most important factors that prevent falls and reduces frailty in the elderly [6,8,9]. Moreover, studies have even shown that progressive resistance training can improve cognitive function in older adults with mild cognitive impairment [10]

Several investigations have used different testing protocols to objectively quantify the balance, functional and mental capacities in older adults (like the handgrip strength test, the Berg-scale, the 30-s. chair test or the EuroQol questionnaire), in order to develop strategies to prevent falls, reduce frailty and improve the quality of life [9,11]. However, these methodologies are often time-consuming or require expensive instrumental like dynamometers, which might prevent its use in less resourceful nursing centers. Solving this limitations, smartphone apps have shown to provide accurate measures for different health and performance-related variables in comparison with more expensive laboratory equipment [12–14]. Finally, during the last decade, the measurement of movement velocity in exercises like the squat has been proposed as a reliable method to

accurately quantify the maximal strength capacities of the subjects; moreover, it is known that, for a certain mass, higher movement velocity results in greater force production [15,16] . However, to the best of our knowledge, no studies have analyzed movement ~~velocity in exercises~~ like the chair squat in older adults, nor have investigated its potential correlations with measures of balance, functional capacity and cognition.

For this, the aim of this study was to analyze if a time-efficient test, consisting on the measurement of the movement velocity of a single repetition on the chair squat exercise using a validated smartphone app, related to other widespread balance, functional and cognitive tests. Our hypothesis is that movement velocity in the chair squat will be related with several measures of strength, balance and cognition.

MATHERIAL & METHODS

Experimental approach to the problem

This investigation is a correlational study with parallel groups comparison. Performance in functional capacity tests ~~(i.e., the Berg scale and the hand grip test)~~ as well as scores in cognition and mental questionnaires were correlated with movement velocity in the chair squat exercise. Also, participants were divided into two groups based on their performance in the chair squat test for comparison purposes.

Subjects

We recruited forty participants (N = 40; 22 women, 18 men; Age = 72.2 ± 4.9 yrs.; Body mass index = 27.8 ± 3.3 kg/m^2) from a nursing home for this study. The Spanish version of the Yale

149 Physical Activity Questionnaire –Y-PAQ– [17] was administered to evaluate participant's levels of
150 physical activity, who scored 52.7 ± 23.2 points. According to this questionnaire, participants with
151 a score of 51 points or less are categorized as *sedentary*.
152 The study protocol complied with the Declaration of Helsinki for Human Experimentation and
153 was approved by the ethics committee at the institutional review board (CSEULS-PI-059/2015).
154 Written informed consent was obtained from each subject before participation.
155
156
157 *Procedures*
158 During a single morning of testing conducted in their nursing home, participants performed
159 several tasks to test their balance and functional capacities. First, the hand grip strength (HGS, in
160 kg) was tested with a dynamometer (Lafayette Instrument Evaluation, USA) as reported in the
161 literature. Two attempts were conducted with each hand, and the final score was calculated as
162 the average value of the best attempt of each hand. Second, the Berg-scale was calculated as the
163 sum of scores of 14 different balance and functional tasks as described elsewhere [19,20]. Scores in
164 the Berg-scale were categorized as follows: high risk of falling (0-20), moderate risk (21-40) and
165 low risk (>41) [19].
166
167 Third, we asked the participants to perform a chair squat (CSQ), i.e., a variant of the squat
168 exercise which starts with the participant sat in a chair. We instructed the participants to keep their
169 arms crossed in their chest and to stand up as fast as possible until the knees were fully extended
170 and the trunk was in an upright position. We measured mean velocity (in m/s) of 4 attempts
171 (separated by 10 seconds of passive rest) using a validated app (PowerLift for iOS, v.5.4) [14]

installed on an iPhone 6 running iOS 10.3.3 (Apple Inc., USA). To measure mean velocity, *PowerLift* uses the well-known Newtonian equation (1):

$$v = d/t \quad (1)$$

where v is the mean velocity (in m/s), d (in m) the range of motion of the movement (in this case, the difference between the height of the participants standing and sitting on a chair) and t the time (in ms.) of the lift, which was calculated by the app as the time between two frames selected by the user. The beginning of the lift was considered as the first frame in which the participant took-off the chair, and the end of the task was considered as the first frame in which the knees were completely extended. To record the videos, a researcher held the iPhone on his hand in portrait position and recorded each lift from the side of the participant at 1.5m from the chair in order to see the full ~~ROM~~ close as possible. The height of the participants, both in the standing and sitting position, was measured using a wall-mounted stadiometer (Seca, Germany). The best of the four attempts was used for the calculations.

Finally, the Yale Physical Activity (Y-PAQ) [17], the EuroQol (EQ-5D component) and the Mini mental state examination (MMSE) [21] questionnaires were administrated to evaluate levels of daily physical activity, quality of life and cognitive status, respectively. We divided the participants in two groups based on their performance in the CSQ: ~~G1~~ included the half who reached higher velocities in the test, while ~~G2~~ included the other half of participants.

Statistical analyses

We used the Pearson's product-moment correlation coefficient with N = 1000 bootstrapping to calculate the association between movement velocity in the CSQ and the functional measures, with 95% confidence intervals. To compare G1 to G2, we used standardized mean differences (SMD) with the corresponding 90% confidence interval. The criteria for interpreting the magnitude of the SMD were: trivial (<0.2), small (0.2–0.6), moderate (0.6–1.2), large (1.2–2.0), and extremely large (>2.0). Quantitative chances of better or worse scores were assessed qualitatively as follows: <1%, almost certainly not; 1–5%, very unlikely; 5–25%, unlikely; 25–75%, possible; 75–95%, likely; 95–99%, very likely; and >99%, almost certain. If the changes of better or worse were both >5%, the true difference was assessed as unclear.

RESULTS

Correlation between variables

The mean velocity in the chair squat was positively and significantly correlated with the HGS (r = 0.761, 95%CI = [0.652,0.853]), the Berg-scale (r = 0.649, 95%CI = [0.483,0.776]), the Y-PAQ (r = 0.342, 95%CI = [0.052,0.583], p< 0.05), the EQ-5D (r = 0.340, 95%CI = [0.010,0.614], p< 0.05) and the MMSE scale (r = 0.364, 95%CI = [0.056,0.540], p< 0.05). See Figure 1 for more details.

Difference between groups

Participants in G1 showed very likely higher scores in the Berg-scale (99/1/0; SMD = 1.15, 90% CI = 0.51-1.18) and the HGS (100/0/0; SMD = 1.79, 90% CI = 0.98-2.59), as well as likely higher scores in the MMSE scale (87/10/3; SMD = 0.69, 90% CI = -0.04-1.42, p < 0.05) and the Y-PAQ

(93/5/1; SMD = 0.87, 90% CI = 0.13-1.61, p < 0.01). No other variable showed meaningful, statistically significant differences between G1 and G2. See Figure 2 for more details.

DISCUSSION

Results showed moderate to large positive correlations between mean velocity in the chair squat and both the hand grip strength and the Berg-scale. These results are in line with previous research that showed remarkable associations between the 30-s. chair test (i.e., completing as many chair squat repetitions as possible within 30 s.) and other measures of functional capacity [11,22]. Moreover, we observed moderate to large differences between groups for both the hand grip strength and the Berg-scale, with participants in the strong group (G1) having likely to very likely higher scores than their counterparts from G2. Muscular strength seems to be an extremely important factor to prevent falls and increase functional capacity in the elderly, and recent studies have even shown that there is an inverse relationship between strength and mortality [4,6,8,9,23]. During the last decade, movement velocity in resistance exercises (such as the back squat) has been proposed to be a very reliable metric to monitor muscular strength since, for a certain load, higher movement velocity means having higher maximal strength [16,24,25]. However, its use among elder populations is still poorly investigated. Thus, to the best of our knowledge, this is the first study analyzing mean velocity in the chair squat exercise as a mean to monitor muscular performance in a geriatric population.

Moreover, our results showed a significant correlation between the MMSE cognition test and movement velocity in the chair squat exercise, as well as likely moderate higher scores in the MMSE in the strongest group of participants (G1). Recent research has observed that muscular

strength has a positive effect on cognition as, for example, it has been showed that a progressive resistance training program produces a significant improvement in cognitive function in individuals with mild cognitive impairment [10]. Therefore, our results are consistent with previous research and highlights the relationship between muscular performance and cognition in elders.

However, this study has two main limitations that should be considered when trying to replicate it: first, the average age of the participants was about 72 yrs. and, therefore, conclusions should not be generalized to older geriatric populations. Finally, participants in our study had a mean score in the Berg-scale of 53.3 points, which is considered as "low risk" of falling. Again, conclusions should be taken with precaution as other geriatric populations at higher risks of having falls were not studied in our investigation. These results might help strength and conditioning coaches and physical therapists working with elder populations to monitor muscular performance in a time-efficient, effort-less, affordable way within their fall-prevention protocols.

CONCLUSIONS

This study showed that a simple test (i.e., the chair squat exercise) which can be conducted with just a smartphone app is related to measures of functional performance, balance and cognition in elders.

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FIGURES CAPTIONS

Figure 1. Correlation between mean velocity (in m/s) in the chair squat exercise and A) the Mini mental state examination test (MMSE, black dots) and the Yale Physical Activity Questionnaire (Y-PAQ, white diamonds), and B) the hand grip strength (HGS, black dots) and the Berg-scale (white diamonds).

Figure 2. Standardized mean differences (with 90% CI) between scores for the hand grip strength (HGS), the EQ-5D scale, the Yale Physical Activity Questionnaire (Y-PAQ), the Mini mental state examination (MMSE) and the Berg scale from the strongest (G1) and weaker (G2) participants.

355

Figure 1

Figure 1

Correlation between mean velocity (in m/s) in the chair squat exercise and A) the Mini mental state examination test (MMSE, black dots) and the Yale Physical Activity Questionnaire (Y-PAQ, white diamonds), and B) the hand grip strength (HGS, black dots) and the Berg-scale (white diamonds).

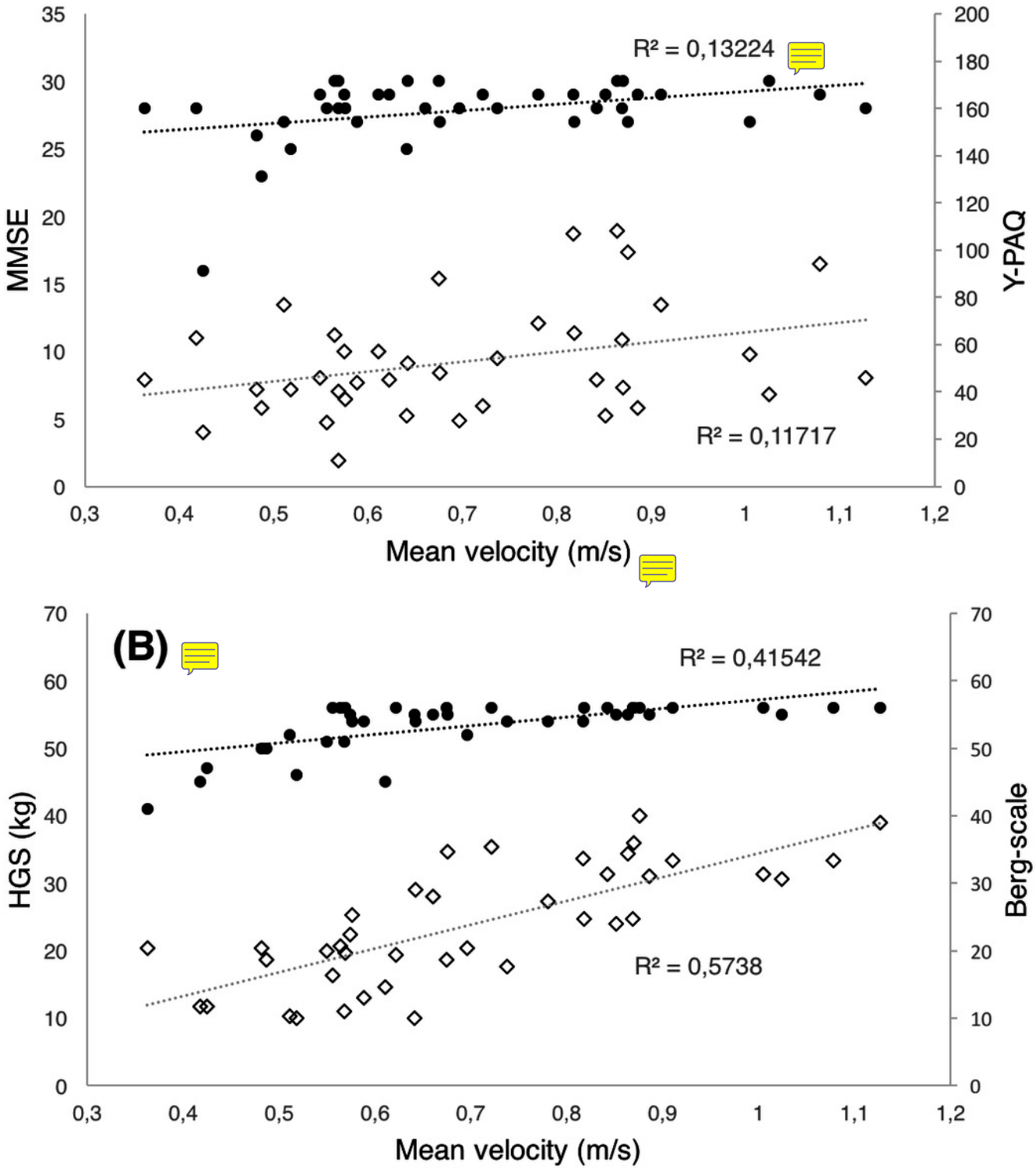
R² = 0,13224
R² = 0,11717
MMSE
Y-PAQ
Mean velocity (m/s)
(B)
R² = 0,41542
R² = 0,5738
HGS (kg)
Berg-scale
Mean velocity (m/s)

Figure 2

Figure 2

Standardized mean differences (with 90% CI) between scores for the hand grip strength (HGS), the EQ-5D scale, the Yale Physical Activity Questionnaire (Y-PAQ), the Mini mental state examination (MMSE) and the Berg scale from the strongest (G1) and weaker (G2) participants.