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Handgrip explosive force is correlated with mobility in the elderly women

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The analysis of explosive force, through rate of force development (RFD) and contractile impulse (CI), from handgrip strength data seems to be useful and promising information to study the aging of musculoskeletal system and health status. We aimed to test the hypothesis that, in elderly women, the handgrip explosive force could be better associated to the functional mobility than maximum handgrip strength. Handgrip strength and the performance of Timed Up & Go Test (TUG) were measured from sixty-five community-dwelling healthy elderly women. The average slope of the moment–time curve (Δ moment/Δ time) over the time interval of 0–200 ms relative to the onset of contraction was calculated to provide the RFD and CI. The highest strength achieved during the isometric contraction was used as maximum handgrip strength. Pearson correlations were used to assess the strength of the relationship between the handgrip strength parameters (Maximum strength and explosive force from 0–200 ms) and TUG test performance from older women. The correlation analysis showed that the TUG test performance was inversely correlated to the handgrip strength parameters, with better relationship with explosive force parameters. The handgrip explosive force seems to be a promising predictor of functional mobility of elderly women, since it showed a better relationship with functional mobility than maximum handgrip strength.

Key words: *aging, mobility, maximum muscle strength*

1. Introduction

It is described that the aging is associated to the skeletal muscle function decay, which is dramatically evident by the sixth decade and onward [4]–[7]. This deterioration is known to be caused to a great extent by morphological changes, like decreased muscle mass, both due to a loss of muscle fibers and a decrease in the individual muscle fiber size [4]–[10]. A neurological change is also associated to the muscle function decay, affecting maximum voluntary strength production [4]–[8], and specially the capacity for rapid muscle strength production (i.e., contractile rate of force development (RFD) [14]–[17].

Numerous types of motor actions are characterized by a limited time to develop strength (0–200 ms), which is considerably less time than it takes to achieve a maximal strength (400–600 ms) [1]. Thereby, during such time-restricted contraction conditions (200 ms), the ability to develop a rapid rise in muscle strength (i.e., a high RFD moment/time and contractile impulse, called explosive force) may become more important than maximal muscle strength, especially for elderlies, because the explosive force may be influenced by the level of neural activation [1]–[5], muscle size, and fiber-type (Myosin Heavy Chain

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isoform) composition [6], which are modified during the aging process. Additionally, during fall events, the balance restoration is dependent of explosive force [1].

It is well-known that maximum isometric strength (i.e., maximum strength) declines with age [9], as well as the ability to develop a high RFD [4], but this decline may vary among muscle groups. Several studies focus on lower extremity muscle groups, especially when the RFD is studied [2]–[16], despite of the strong evidence in the literature that maximum handgrip strength is a strong predictor of mobility, disability and mortality [9]–[13].

The Timed Up & Go Test (TUG) is commonly used to examine functional mobility in community-dwelling and frail older adults [11]–[18]. Additionally, the TUG is a simple screening test that is a sensitive and specific measure of probability for falls among older adults [15]–[18].

As the analysis of explosive force (i.e., RFD and contractile impulse) can assess better the neuromuscular system than maximum strength, we hypothesized that, in elderly women, the handgrip explosive force could be better associated to the functional mobility than maximum handgrip strength. Then, we tested our hypothesis correlating the handgrip strength parameters (i.e., Maximum strength and explosive force from 0–200 ms) with the TUG test performance from elderly women.

2. Material and methods

2.1. Subjects

Sixty-five community-dwelling healthy elderly women (age: 68.9 ± 8.0 [50 to 86] years, height: 150.9 ± 6.1 cm, weight: 66.7 ± 14.3 kg) volunteered to take part in the study.

Volunteers were not engaged in structured physical exercise programs for at least one year before the study. Before the study beginning, an extensive health questionnaire was conducted by one of the researchers. Subjects were excluded if they presented any orthopedic, neurological, cardiac, vestibular, visual or psychiatric impairment which would not allow them to perform all the tasks in the study. Written informed consent was obtained from all subjects, and the university ethics committee gave approval for the study. All subjects underwent testing under the same instructions and conditions.

2.2. Maximal isometric handgrip contraction

Handgrip moment/time curves were measured using a custom-made strain gauge-based force trans-

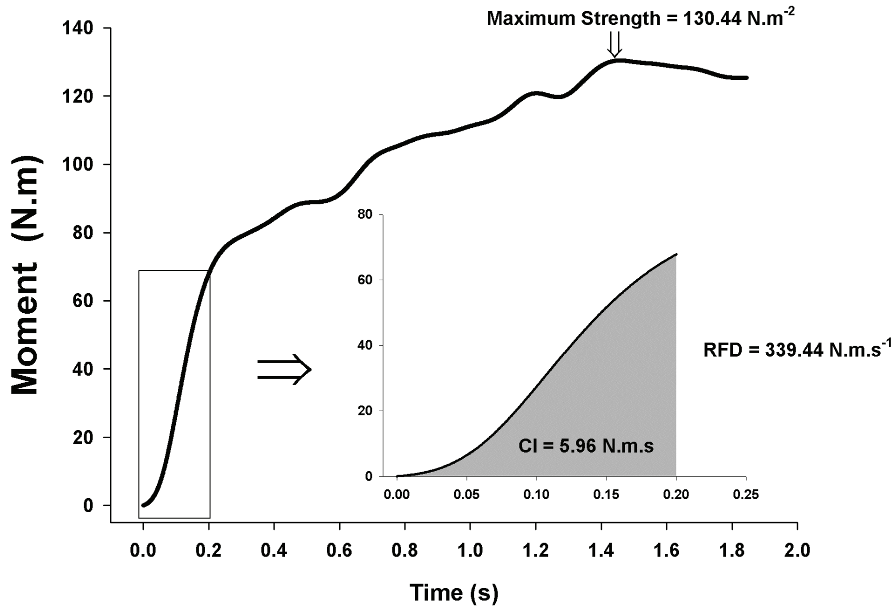

Fig. 1. Handgrip moment-time curve from a volunteer, emphasizing the maximum strength, rate of force development (RFD), calculated as the average slope of the moment–time curve (Δ moment/Δ time) over the time interval of 0–200 ms relative to the onset of contraction and contractile impulse (CI), calculated through the accumulated area under the moment–time curve over the time interval of 0–200 ms (i.e., integrating the area under the moment–time curve)

ducer (EMG System Brazil, São José dos Campos, SP) with the recordings sampled at 2 KHz, as previously described by [14]. Subjects stood with their arms hanging relaxed at the sides of their body. Then, they were instructed to position their dominant arm at 90° of elbow flexion and with their forearm in the neutral position. The device's handle was fit into their palm with the fingers at 90° flexion at the proximal and distal interphalangeal joints with the thumb in 90° abduction. Two maximal isometric handgrip attempts with an inter-attempt rest interval of 1 min were performed and the maximum handgrip strength of each trial identified. Subjects were carefully instructed to contract "as fast and forcefully as possible" after the command "go", sustaining the contraction for 3 seconds, when the command "stop" was given. The subjects were naive to the experimental procedures in order to mitigate a potential "learning effect". The greatest maximum handgrip strength among trials was used for analysis.

The strain-gauge signal was smoothed by a digital fourth-order, zero-lag Butterworth filter, with a cutoff frequency of 15 Hz [1], and the capacity to increase strength in short–time periods was determined as the area under the moment–time curve in time interval of 0–200 ms relative to the onset of contraction. The cumulated area under the moment–time curve reflected the entire time history of the contraction(s) and can be called contractile impulse (CI) [1]. The average slope of the moment-time curve (Δ moment/Δtime) over the time interval of 0–200 ms relative to the onset of contraction was calculated, and is representative of RFD [1]. Despite the fact that both CI and RFD measure explosive force, they use different, but complementary ways. The CI measures accumulated area under the moment–time curve, which reflects the entire time history of contraction, including the overall influence of the various time-related RFD parameters [1] (Fig. 1).

Onset of muscle contraction was defined as the time point at which the moment-time curve exceeded baseline by 2.5% of the difference between baseline moment and the maximum voluntary contraction (i.e., maximum handgrip strength), as proposed by [1]. All analyses were conducted using specific algorithms developed in MatLab®.

2.3. Timed Up & Go Test (TUG)

Mobility was determined by the TUG test. To perform the TUG test, subjects were given verbal instructions to stand up from a chair, walk 3 m as quickly and as safely as possible, cross a line marked on the floor, turn around, walk back, and sit down [11]–[15]. Subjects were asked to complete 2 trials of the TUG test with 3 minutes rest-interval and the best performance (i.e., the trial with the smallest Time taken to complete the test) was used for statistical analysis.

2.4. Statistical analyses

Pearson correlations were used to assess the strength of the relationship between the handgrip strength parameters (Maximum strength and explosive force from 0–200 ms) and TUG test performance from older women (50–86 years old). All statistical procedures were carried out using SPSS v.18.0 (SPSS Inc., Chicago, IL) and a significance level of $p < 0.05$ was used to identify statistical significance.

3. Results

The correlation analysis showed that the time to stand up, walk 3 m, turn, walk back, and sit down was

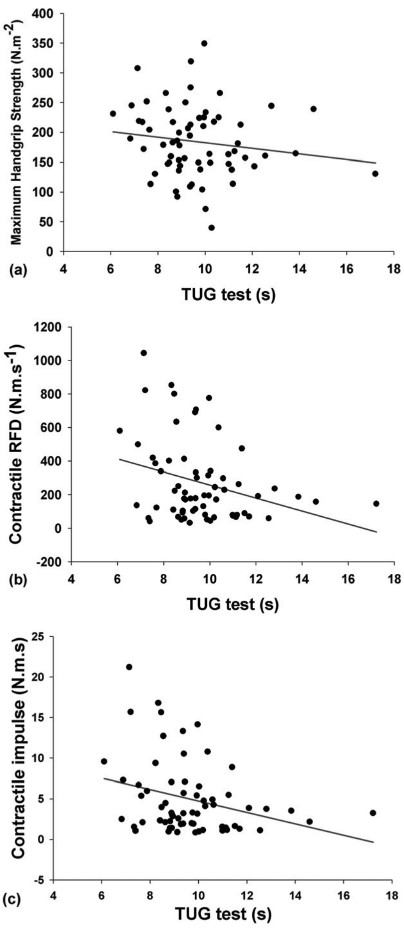

Fig. 2. Correlation between handgrip strength parameters ((a) Maximum strength, (b) contractile RFD at 200 ms, (c) contractile impulse at 200 ms and TUG test performance from older women (50–86 years old)

inversely correlated to the handgrip strength parameters, with better relationship with explosive force parameters (i.e., RFD and contractile impulse at the first 200 ms) ($p < 0.05$) than maximum strength ($p > 0.05$) (Fig. 2 and Table 1).

Table 1. Correlation coefficient
between handgrip strength parameters
and TUG test performance from older women (50–86 years old)

		MHS	RFD 200 ms	CI 200 ms
TUG test	*r* (value)	–0.147	–0.340	–0.332
	p (value)	0.244	0.006	0.007

MHS – Maximum Handgrip Strength; RFD – Rate of Force Development; CI – Contractle Impulse.

All explosive force parameters were significantly correlated to the TUG test performance, while maximum strength was not significantly correlated as shown in Table 1. The greatest correlation coefficients values were observed for RFD at 0–200 ms and for CI at 0–200 ms.

4. Discussion

The goal of this study was to test the hypothesis that the handgrip explosive force could be better associated to the functional mobility than maximum handgrip strength in the elderly women. The results confirmed the proposed hypothesis showing that handgrip explosive force has a better relationship with TUG test performance than maximum handgrip strength.

The aging process is also associated with muscle function decay, affecting maximum voluntary strength production [4]–[8], and specifically the capacity for rapid muscle strength production (i.e., explosive force) [14]–[18]. Watanabe et al. [18] and Schettino et al. [14], showed that during the aging process, the handgrip RFD is impacted greater than maximum handgrip strength. However, it is not known how the maximum handgrip strength and handgrip explosive force are relate to functional mobility from elderly people.

Maximum handgrip strength is known to be associated with muscular functioning in other muscle groups [9], and with activities of daily living (ADL) functioning, besides to be considered a predictor for disabilities and incidents as falls [3]. The TUG test is strongly correlated to level of functional mobility and falls risk [15], which is dependent of muscle strength. Then, the relationship between muscle strength and functional mobility seems to be quite evident. Interestingly, our results demonstrated that the handgrip explosive force is a better marker of functional mobility than the maximum handgrip strength.

Aagaard et al. [1], stated that in the elderly individual, the ability to exert a rapid rise in muscle strength may reduce the incidence of falls related to the impaired control of postural balance. It is important to note that many types of motor responses, such as fall prevention, are characterized by a limited time to develop strength (0–200 ms), which is considerably less time than it takes to achieve maximal contraction strength (400–600 ms) [1]. Thus, during daily situations where the time-restricted contraction (200 ms) are primordial, as in fall events, the ability to develop a rapid rise in muscle strength (i.e., explosive force) may be more important than maximal muscle strength alone.

Considering that the maximum handgrip strength is significantly associated to functional disabilities and fall events in elderly people [3], our results pointed a promising tool to predicts functional mobility, since the handgrip explosive force showed a better relationship with functional mobility than maximum handgrip strength. Despite this promising result, our finding should be verified in a longitudinal study.

5. Conclusion

The handgrip explosive force seems to be a promising predictor of functional mobility of elderly women, since it showed a better relationship with functional mobility than maximum handgrip strength.

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