

Gender differences in hand grip power in the elderly

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Any correspondence should be directed to me at the following address:

Please address correspondence to Hiroki Aoki, Kanazawa University Graduate School of Natural Science and Technology, Kakuma, Kanazawa, Ishikawa 920-1192, Japan,

E-mail: hiroki.a@ed.kanazawa-u.ac.jp

Tel: +81-76-264-2643

Fax: +81-76-234-4120

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Original Article

Title:

Gender differences in hand grip power in the elderly.

Shinichi Demura, Hiroki Aoki, Hiroki Sugiura

Kanazawa University Graduate School of Natural Science and Technology,
Kakuma, Kanazawa, Ishikawa 920-1192, Japan

*Corresponding author:

Phone: +(81-76)-264-2643

Fax: +(81-76)-234-4120

E-mail: hiroki.a@ed.kanazawa-u.ac.jp

Abstract

This study aimed to clarify the difference in hand grip power in elderly males and females. The subjects were 15 elderly males (mean age 65.6 ± 2.5 yr, mean height 165.7 ± 6.0 cm, mean mass 63.9 ± 5.5 kg) and 15 elderly females (mean age 65.0 ± 2.6 yr, mean height 155.2 ± 5.3 cm, mean mass 56.5 ± 7.3 kg). Peak velocity was measured by the dominant hand with loads of 30, 40 and 50% of maximum voluntary contraction (MVC). The MVC was significantly greater in males than in females. The peak velocity and the required time to reach peak velocity in all loads showed insignificant differences between both groups. Hand grip power was significantly greater in males than in females in all loads.

In conclusion, elderly males have superior hand grip power compared to elderly females and this gender difference depends largely on MVC. The decrease in muscle contraction velocity in those main muscle groups related to hand grip movement accompanied by age may be greater in males than in females.

Keywords: Muscle power, Muscle strength, The elderly

1. Introduction

Recently, greater attention has been paid to muscle power in the upper limbs of the elderly (Valour et al., 2003, Toji and Kaneko, 2004, Toji and Kaneko, 2007). Valour et al. (2003) examined the force-velocity relationship of elbow flexion movements in the elderly and reported that males are superior to females in flexion velocity under no-load conditions, but that force and velocity show a hyperbola relationship in both males and females. Aoki and Demura (2008), who examined the force-velocity relationship of hand grip movement in the young, found that males are superior to females in MVC and moving velocity, but that moving velocity decreases

with loads in a linear relationship in both males and females. On the other hand, because elderly males have greater maximum hand grip movement strength than elderly females, it is assumed that the former have superior hand grip power. In addition, the hand grip movement is different from the elbow flexion movement in that it requires multiple joint movements and also has a small range of motion. It is possible that, in the elderly, the force-velocity relationship in the hand grip movement may differ from that of the elbow flexion movement.

Muscle power is decided by both factors of force and contraction velocity, and the size of loads used in a power test greatly affects them. In short, muscle power depends strongly on the muscle contraction velocity when using light loads and on maximal muscle strength when using heavy loads (Perrine and Edgerton, 1978). Kaneko (1988), who examined gender differences in elbow flexion power in the young, found that males had significantly greater elbow flexion power than females, and that this perceived gender influence increases with heavier loads. The ratio of fast muscle fibers is higher in males than in females (Saltin, 1977) and selective atrophy of these fibers occurs with age (Lexell et al., 1988). According to Yassierli et al. (2007), the above becomes more marked in males in old age. Hence, it is thought that the gender differences observed in the fast-twitch muscle fiber ratio and muscle contraction velocity decrease with age. However, the maximum upper limb strength is greater in males than in females in the elderly (Valour et al., 2003). Therefore, this gender difference may be greater under heavy load conditions related closely to maximal muscle strength.

This study aimed to clarify the gender difference of hand grip power in the elderly.

2. Methods

2.1. Subjects

The subjects were 15 elderly males (mean age 65.6 ± 2.5 yr, mean height 165.7 ± 6.0 cm, mean mass 63.9 ± 5.5 kg) and 15 elderly females (mean age 65.0 ± 2.6 yr, mean height 155.2 ± 5.3 cm, mean mass 56.5 ± 7.3 kg). Before an experiment, all subjects were judged to be right-handed by a Demura et al. (2009) handedness inquiry. We explained the experimental purpose, methods, and risks to the subjects, and obtained their consent. The protocol for this study obtained approval from Kanazawa University Department of Education Ethical Review Board.

2.2. Experiment device

Maximum hand grip strength (MVC) and the moving velocity of the loads used to calculate hand grip power were measured by the dynamometry device (YH100, YAGAMI, Japan). This device consists of a rotary encoder attached to a fixed pulley and a recording device. The encoder can measure the rotational angle at a sampling frequency of 100 Hz via an analog-to-digital interface. The resolution of the Rotary Encoder was 1200 pulses / turn. In short, a pulse occurs every 0.3 degree and the angle of rotation degree ($0.3 \times \text{pulses}$) is calculated by counting the number of pulses. The rotational angle was converted to the moving velocity of the load in the recording device.

2.3. Experimental procedure

Measurement of MVC: Subjects sat in an adjustable ergometric chair, and the arm, supported by an armrest, was in a sagittal and horizontal position, with the forearm vertical and the hand in a semi-prone position. The grip width could be arbitrarily adjusted for each individual by a dial to achieve a 90 degree angle with the proximal-middle phalanges. Subjects attached their palm to the fixed bar and

grasped the handle with four fingers except for the thumb. The subjects performed the MVC test twice.

Measurement of moving velocity of loads: as with the measurement of MVC, the subjects grasped the handle with four fingers and exerted maximal force as fast and forcefully as possible immediately after hearing a beeping sound from the device. The loads were pulled up with this hand grip movement. The order of each load used was random for every subject. Each subject performed each test twice on the same day and the larger value was used for analysis.

2.4. Relative load and evaluation parameters

The relative loads of 30, 40 and 50% MVC were selected based on a previous study (Ikemoto et al., 2006). MVC, peak velocity, required time to reach peak velocity and peak power were selected as evaluation parameters. The grip muscle powers in 30, 40 and 50% MVC were calculated by submitting peak velocity to the following equation.

$$\text{peak power (W)} = \text{peak velocity (m/sec)} \times 9.8 \times \text{load (kg)}$$

This study defined peak power in hand grip movements as hand grip power.

*** Figure 1 near here ***

2.5. Statistical analysis

The intra-class correlation coefficient (ICC) for each test was calculated to examine trial-to-trial reliability. The t-test was used to reveal the mean difference of MVC. Two way ANOVA (gender and loads) was used to reveal the mean differences of each parameter. Tukey's HSD method was used for multiple comparisons. The level of significance was set a priori to be 0.05.

3. Results

The ICC's of evaluation parameters were very high (0.84~0.93) in both males and females. The MVC was greater in males ($36.7 \pm 4.9\text{kg}$) than in females ($22.5 \pm 3.1\text{kg}$).

Table 1 shows results of two way ANOVA (gender \times loads) for peak velocity. Insignificant interaction was found. Significant main effect was found in load factor and a multiple comparison showed that the peak velocity was faster in the order of 30, 40 and 50 % MVC in males and females.

*** Table 1, 2 near here ***

Table 2 shows results of two-way ANOVA for required time to reach peak velocity. Insignificant interaction was found. Significant main effect was found in load factor and multiple comparison showed that the required time to reach peak velocity was longer in the order of 50, 40 and 30 %MVC in males and females.

Table 3 shows results of two way ANOVA (gender \times loads) for hand grip power. Insignificant interaction was found. Significant main effect was found in gender factor and a multiple comparison showed that the hand grip power was larger in males in all loads.

*** Table 3 near here ***

4. Discussion

The MVC was significantly greater in males. Valour et al. (2003) reported that

maximum elbow flexion strength is greater in males than in females. Aoki and Demura (2008) reported that males have superior maximum hand grip strength compared to females in the young. It was reported that muscle volume either decreases with age (Frontera et al., 1991) or does not change (Toji and Kaneko, 2004). Regardless of a change in muscle volume with age, it is thought that males also have superior hand grip strength relative to females in the elderly.

The peak velocity and the required time to reach peak velocity at all loads showed insignificant differences between males and females at all loads. Because fast muscle fibers have fast muscle contraction velocity (Kaneko, 1988), it is thought that muscle groups with a high ratio of these fibers also have high muscle contraction velocity and are very quick in moving the loads. Yassierli et al. (2007) suggested that selective atrophy of fast muscle fibers with age becomes more marked in males than females in old age. Krivickas et al. (2001) reported that an age-level difference was found in muscle contraction velocity in lateral great muscles in males, but not in females. From the above, the load velocity in the young during the hand grip movement is faster in males than in females (Aoki and Demura, 2008). However, because the selective atrophy of fast muscle fibers is more marked in males in old age, it is inferred that a gender difference was not found in the peak velocity and required time to reach peak velocity. Valour et al., (2003) reported that the maximum elbow flexion velocity is faster in males in the elderly. The arthrosis and muscle groups related to both movements are considerably different. These differences may influence characteristics of both muscle powers.

Average velocity (average moving velocity of the load) and required time to reach peak velocity showed an insignificant relationship in both males and females. Ikemoto et al. (2006) reported that the average velocity correlated moderately and significantly with arrival time of peak velocity in 20,30,40 and 50% MVC ($r=-0.63\sim$

-0.87) in young males and in 50% MVC ($r=-0.56$) in young females, which is considerably different from the present results. This may be due to the influence of age. In the future, further study will be necessary using the same conditions.

Males had superior hand grip power with all loads. The MVC was superior in males, but the peak velocity in all loads showed insignificant differences between males and females. Hence, a gender difference in hand grip power when using loads may depend on an age-level difference of MVC than moving velocity. In addition, because the ratios of hand grip power of males to females were almost the same in all loads (159.4%-166.5%), females may have inferior hand grip power of about 60-70%, regardless of load size.

Hand grip power showed an insignificant difference among 30% MVC, 40% MVC and 50% MVC in males and females. Toji and Kaneko (2007) reported that the greatest elbow flexion power occurred at about 30% MVC in elderly males. Aoki and Demura (2008) suggested that the maximum elbow flexion power was produced at about 50% MVC in the young. From the present results, the maximum hand grip power may be produced at 30~50% MVC in the elderly regardless of gender.

5. Conclusion

Hand grip power in the elderly shows gender differences between males and females in all loads (30, 40 and 50% MVC). However, the peak velocity shows little a gender difference and is faster in light loads. The required time to reach peak velocity does not show a gender difference in all loads, and is longer at 50% MVC than at 30 and 40% MVC in males and females. Differences in hand grip power with relative loads due to gender depend largely on MVC rather than velocity in the elderly.

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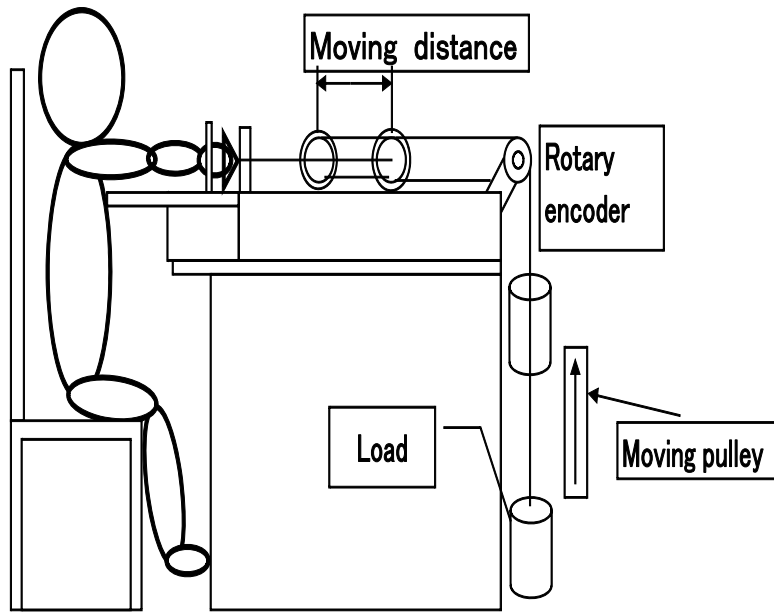


Figure1. Scheme of measurement device. The device consists of grip handle, rotary encoder attached at the fixed pulley, and variable load. These connect by moving pulley and wire. The rotary encoder can measure the rotational angle when the load was pulled up by hand grip movement.

Table1. Peak velocity by gender and loads, mean \pm S.D.

	Male		Female		F-value	Post-hoc
	Mean	SD	Mean	SD		
30%MVC	0.31	0.04	0.31	0.07	F1: 0.02	
40%MVC	0.24	0.04	0.21	0.08	F2:92.67*	F2:M, F:30>40>50
50%MVC	0.20	0.05	0.20	0.06	F3: 0.14	

Notes: Unit: m/s, F1: gender difference, F2: load difference, F3: interaction, 30: 30%MVC, 40: 40% MVC, 50: 50% MVC.

* $p < 0.05$.

Table 2. Required time to reach peak velocity by gender and loads, mean \pm SD.

	Male		Female		F-value	Post-hoc
	Mean	SD	Mean	SD		
30%MVC	0.20	0.04	0.20	0.04	F1: 0.09	
40%MVC	0.23	0.04	0.24	0.04	F2:23.40*	F2:M, F:30>40>50
50%MVC	0.27	0.08	0.27	0.05	F3: 0.38	

Notes: Unit: m/s, F1: gender difference, F2: load difference, F3: interaction, 30: 30% MVC, 40: 40% MVC, 50: 50% MVC.

* p < 0.05.

Table 3. Hand grip power by gender and loads, mean \pm S.D.

	Male		Female		F-value	Post-hoc
	Mean	SD	Mean	SD		
30%MVC	33.3	5.8	20.5	6.7	F1:28.27*	F1:30,40,50 M>F
40%MVC	34.9	6.4	21.9	9.0	F2: 1.15	
50%MVC	35.3	9.1	21.2	7.1	F3: 0.38	

Notes:Unit: w, F1: gender difference, F2: load difference, F3: interaction, 30: 30% MVC, 40:40% MVC, 50: 50% MVC.