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Original Article

# Correlation between leg extensor torque and the degree of sway

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**Abstract.** [Purpose] The purpose of this study was to examine the correlation between leg extensor torque and the degree of sway. [Participants and Methods] We recruited 31 male and 22 female healthy adults. Strength Ergo 240 was used to measure leg extensor torque. A body pressure measurement system was used to measure the degree of sway. After the measurement, the correlation between these factors was investigated according to sex. [Results] In the males, a significant negative correlation was observed between leg extensor torque and the degree of sway. [Conclusion] In cases where therapists actively performed muscle strengthening and standing-up exercises to reduce the degree of sway in the males, the possibility that such efforts could increase leg extensor torque was observed.

**Key words:** Closed motion linkage, Leg extensor torque, Degree of sway

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## INTRODUCTION

As exercise therapy for patients with difficulty in standing or walking, many cases have focused on the involvement of quadriceps in actions that extend the knee joint in open motion linkage[1)]. However, in exercise patterns with closed motion linkage such as standing up and walking, extensor torque of the lower limb as a whole, which is the combination of the thigh, knee, and ankle joints, is needed[2)]. Moreover, leg extensor torque is manifest as a combination of the thigh, knee, and ankle joint, and is considered to have correlation with degree of sway (DOS)[3, 4)]. There are many opportunities for physical therapists to address leg extensor torque in leg muscle strengthening exercise and standing and walking exercise. In rehabilitation field, the Strength Ergo 240 is used to measure leg extensor torque, and the Body Pressure Measurement System is used to measure degree of sway. Reliability of measurement of leg extensor torque by Strength Ergo 240 is high, and its correlation with isokinetic strength has been recognized used BIODEX[5, 6)]. Moreover, switching to the Body Pressure Measurement System has been reported to be easier than to a three-dimensional motion analysis system, and can be developed for use in clinical research[7)].

In addition, maximum muscle strength varies between men and women[8)], so the relation in each of men and women are needed to be considered. If a reduction in DOS can be expected by increasing leg extensor torque, usability of methods to increase leg extensor torque through leg muscle strengthening exercise and standing exercise is higher. However, there are few studies on the correlation between leg extensor torque and degree of sway. Consequently, the purpose of this study is to examine the correlation between leg extensor torque measured by Strength Ergo 240, and DOS measured by Body Pressure Measurement System.

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## PARTICIPANTS AND METHODS

Fifty-three healthy adults with no leg problems (31 males/average age 21.4 ± 4.2 years, and 22 females/average age 21.6 ± 4.8 years) were recruited. The purpose of this study, measurement methods, handling method of the results, presentation of the study results, anonymity of personal names during presentations and deletion of data after the study were thoroughly explained in accordance with the ethical standards of the Declaration of Helsinki. Only persons who signed the consent form were set as study participants. In addition, this study was carried out with the approval of the ethical committee of Fukuoka Wajiro Rehabilitation College (Approval No. FW-20-08).

The Strength Ergo 240 by Mitsubishi Electric Engineering Company Limited was used for leg extensor torque, and measurement was carried out five times continuous drive at a speed of 50 rotation/min. Peak torque by the body weight for both the left and right sides during leg extension motion (Nm/kg) was measured. Here, body position during measurement was set as sitting, and the angle of the backrest was set at 110°. Seat position was set as the knee joint at 30° in the flexed position, ankle joint 0° dorsiflex posture, at bottom dead center (greatest extension of the leg), which is the transition point between left and right pedaling. Leg extensor torque was measured three times and the average value was calculated. A 30 second break was taken between each operation.

Regarding DOS, total trajectory length (cm) and outer peripheral area ($cm^2$) were calculated according to the foot pressure central distribution using Body Pressure Measurement System by Nitta Corporation. Measurement body position was set as standing on one leg with eyes open and bare feet, and the thigh and knee joints were set to be in the slightly bent position. Moreover, both upper limbs slightly touched on the body side, and were observed at the same height and line of vision 2 m in front. The time to stand on one leg was set as 30 seconds, for both the right and left leg, and measurement was taken two times for each leg. The value with less sway was set as the representative value. A 30 second break was taken between each operation. Furthermore, regarding measurement methods for leg extensor torque and degree of sway, previous studies were consulted[9, 10].

For statistical analysis, the difference between genders was considered, as well as the calculation of the interclass correlation coefficients (ICC) for each measurement. Next, the correlation between leg extensor torque and DOS was considered by gender using Spearman's rank correlation coefficient. Furthermore, SPSS Statistics V22.0 was used for statistical analysis, and significant difference was set at 5%.

## RESULTS

Measurement results of leg extensor torque and degree of sway for males and females are as shown in Table 1. Regarding left and right leg extensor torque between genders, a significantly large difference was observed for males. Regarding degree of sway, no significant difference was observed.

Correlation of leg extensor torque and degree of sway is shown in Table 2. A significant negative correlation between left

**Table 1.** Measurement results of leg extensor torque and degree of sway

| | | Males | Females |
|---|---|---|---|
| Leg extensor torque (nm/kg) | (Right) | 2.4 ± 0.4**, 0.93 | 1.9 ± 0.3**, 0.98 |
| | (Left) | 2.4 ± 0.5**, 0.97 | 1.9 ± 0.3**, 0.98 |
| Total trajectory length (cm) | (Right) | 65.1 ± 16.6, 0.92 | 59.4 ± 7.3, 0.97 |
| | (Left) | 56.9 ± 13.9, 0.90 | 64.6 ± 9.0, 0.89 |
| Outer peripheral area ($cm^2$) | (Right) | 2.6 ± 1.6, 0.70 | 2.2 ± 1.1, 0.92 |
| | (Left) | 2.4 ± 1.4, 0.74 | 2.5 ± 1.1, 0.75 |

Mean ± standard deviation, interclass correlation coefficients (ICC) of leg extensor torque and total trajectory length, outer peripheral area for males and females. **p<0.01.

**Table 2.** Correlation between leg extensor torque and degree of sway

| | | Leg extensor torque (Nm/kg) | | | |
|---|---|---|---|---|---|
| | | Males | | Females | |
| | | (Right) | (Left) | (Right) | (Left) |
| Total trajectory length (cm) | (Right) | −0.53* | - | 0.22 | - |
| | (Left) | - | −0.43* | - | 0.23 |
| Outer peripheral area ($cm^2$) | (Right) | −0.54** | - | −0.01 | - |
| | (Left) | - | −0.42* | - | 0.22 |

Correlation between leg extensor torque and total trajectory length, outer peripheral area for males and females, *p<0.05, **p<0.01.

and right leg extensor torque, trajectory length and outer circumference area was observed in males. No correlation between left and right leg extensor torque, trajectory length and outer circumference area was observed in females.

## DISCUSSION

This study considered the correlation between extensor torque and DOS. ICC (1.3) for each measurement in this study was 0.70–0.98. Hence, for measurement of leg extensor torque and DOS carried out in this study, all matters are considered to have reliability. As a result of this study, a significant difference in leg extensor torque between genders was observed. Moreover, regarding leg extensor torque, relative muscle strength of females as shown by body weight ratio of isokinetic leg press is reported to be 74% of males[11]. This result was roughly the same in this study also.

Moreover, a significant negative correlation between left and right leg extensor torque, trajectory length and outer circumference area were observed in males. Leg extensor torque is manifest as a combination of the thigh, knee, and ankle joint, and is strongly connected to muscle strength of each joint of the lower limb. Furthermore, in the movement form of closed motion linkage, not only the knee joint extensor but also hip flexors and extensor and knee joint flexors are involved[12, 13]. Moreover, DOS is an indicator of instability in the upright position, and is strongly connected to muscle strength of each joint of the lower limb[3, 4]. Previous studies have indicated that weakening leg muscle strength leads to worsened proprioceptor activity and increased degree of sway[3, 4]. Consequently, both leg extensor torque and degree of sway have a strong correlation with muscle strength in each joint of the lower limb. Since a negative correlation in leg extension torque and degree of sway was observed, increasing muscle strength of each joint of the lower limb is considered to increase leg extensor torque, and as a result, contribute to a reduction in DOS. Physical therapy addressing DOS is usually performed in the upright position. Is such case, there is always the risk of falling, causing concern and anxiety to both the patient and the physical therapist. On the other hand, muscle strengthening exercises for the lower limb can be sufficiently performed in both the lying and sitting position, and with hardly any risk of falling. Furthermore, muscle strengthening exercises in the lying and sitting position are also easier to teach for self-training. Sinaki et al.[14] stated that muscle strengthening exercises for each site in the sitting position and while lying on a bed are recommended as exercises which can avoid falls. In addition, Storer et al.[15] stated that positive results were observed when self-training to strengthen leg muscles were introduced. In addition, leg extension torque has a strong correlation with standing movement[12]. In many cases, physical therapists provide instruction for standing movement prior to upright and walking movement. Hence, according to the results of this study, the possibility that efforts by physical therapists may increase leg extensor torque by actively performing muscle strengthening exercises and standing exercises for each joint of the lower limbs of males, in order to reduce DOS. On the other hand, no correlation between leg extensor torque and DOS was observed in females. This is considered to be connected to the motor unit at muscle exertion and hormone related. Females have a lower motor unit than males, and as a result, the muscle strength which can be exerted is considered to be reduced[16, 17]. In addition, male hormone influences the promotion of protein synthesis and increases calcium in muscle cells[18]. Compared to males, females have approx. 5–10% male hormone, and as a result, muscle strength which can be exerted is considered reduced[19]. Consequently, as a neurological approach, clearly explaining the purpose and goal in the guidance on motor skills and exercise therapy such as how to use the body is recommended. In addition, promoting spontaneous muscle activities is considered effective. Staron et al.[20] stated that hypertrophy of type I and type II fibers occurred in females who participated in strength training. Moreover, Marx et al.[21] stated that six months of resistance training increased serum testosterone in females. However, a consideration of the details as a future task is desired.

Regarding the limitations of this study, participants were healthy adults. In the future, a similar study targeting elderly persons and post-surgical patients is desired.

### *Conflicts of interest*

None.

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