# A Cross-sectional Study on Females' Torque Strengths of the Hip Joint Muscle

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## Abstract

The purpose of this study is to extract relations of the hip-joint adductor and abductor muscle strengths among female in standing and sitting postures respectively from standpoint of cross-sectional age stages. Seven items were measured; height, weight, age, hip joint adductor strengths, hip joint abductor strengths, hip joint flexion strengths, and hip joint extension strengths. Two types of patented torque meters were used to measure hip joint flexion and extension strengths in standing postures, and to measure hip joint adductor and abductor strengths in sitting posture.

Seventy-six female participants volunteered with the informed consent. Mean age, weight, and height were 43.9 ±15.8 years old, 52.4 ±7.3 Kg, and 157.8 ±5.6 cm, respectively. The strongest muscle power was obtained in the right leg extension that reflected dominant leg, and the weakest one was the right leg flexion. Muscle strengths between hip joint flexion and extension strengths in standing posture showed statistical significance by ANOVA, but no significance among the age stages was obtained.

The abduction strengths of hip joint gradually increase with aging, on the other hand, the adduction strengths gradually decrease with a peak around 30's and 40's. The abduction strengths were significantly stronger than adduction strengths in all age groups. However, no significance was observed among age groups. The ANOVA results showed that abduction strengths were significantly stronger than adduction strengths in all age groups. However, no significance was obtained among age groups, and no significant interaction was obtained. It is inevitable to shift central gravity toward one leg in walking, and this causes or generate outward power moment. So getting older has an effect to make the outward rotation muscles strengthen for maintaining stable upright posture in walking.

**Keywords: Torque strength; Hip-joint; Psoas major; Adductor; Abductor**

## Introduction

To lift up the lower limbs forward and to extend down backward is very important for walking and running. The movement of hip-joint adductor and abductor muscles is inevitably important for maintaining a posture of halfway of bending both knees, some kind of exercising postures, rolling over in sleeping, or directional changes while sitting on a chair. To move the lower limbs has deep relations with the psoas major muscle. To measure and clarify characteristics of these hip-joint adductor and abductor muscle strengths is contributable for assessing athletes training effects, elderly walking abilities, rehabilitation effects of those with disabilities, and people's daily activities. Motor ability, moving ranges of hip joints, and their muscle strengths are significant factors in athletic exercising and walking.

Kuno (2000) found out that running faster had strong relation with psoas major in case of having measured of Japanese Olympic sprinters. This finding induced many studies on characteristics of psoas major in Japan (e.g. Kinugasa, 2001; Yamamoto, 2003; Hoshikawa, 2006; Takahashi, 2006; Asaka, 2008). These findings made clear that the psoas major area has gender difference and decreases with aging. However, the strength of psoas major can measure indirectly, so that strength of the psoas major applies a correlation method.

Among studies on the strength of psoas major, Yamamoto et al. (2004, 2005) reported that there were gender differences of the hip adductor and abductor strengths. Yamamoto et al. (2008) also reported that there was relation between the strength of psoas major muscles and bone density, and the psoas major muscles and exercising period. There were studies on the psoas major muscles by use of MRI (Magnetic Resonance Imaging) technique (e.g. Laura E. Gibbons et Al., 1997; Juha E. Peltonen et al. 1998; W. S. Marras, 2001).

Katoh et al. (2008) reported that there were a positive partial correlation coefficient between right psoas major area and inward rotation hip-joint muscle from multiple regression analysis, and a negative one between left psoas major and outward rotation hip-joint muscle by MRI (Magnetic Resonance Imaging) cross-sectional area of the psoas major muscles. On the other hand, Kita et al. (2009) derived a positive relation between right and left psoas major area and adductor strength. The above ambivalent results come from number of participants, their attributes, and so on. Relations between the psoas major area and hip-joint muscle powers have obtained confusing results.

However, there are a few research conducted in the area of cross-sectional measurements on torque strengths of the psoas major muscles and hip-joint muscle strengths among different age stages of female.

The purpose of this study is to extract relations of the hip-joint adductor and abductor muscle strengths among female in standing and sitting postures respectively from standpoint of cross-sectional age stages.

## Method

1) Volunteered participants

Seventy-six female students volunteered with informed consent. These students were enrolled in "Health and Physical Arts" course at the university. Ages ranged from 18 to 78 years old.

2) Measured items

Totally seven items were measured; height, weight, age, hip joint adductor strengths, hip joint abductor strengths, hip joint flexion strengths, and hip joint extension strengths.

3) Devices used

Two types of patented torque meters were used to measure hip joint flexion and extension strengths in standing postures （Photo.1; Yamamoto et al. 2009）, and to measure hip joint adductor and abductor strengths in sitting posture (Photo.2; Yamamoto et al. 2005). Subjects were requested to rotate their thighs inward and outward for adductor and abductor strengths of the hip joint.

Phot 1. Patented torque meter 1 to measure flexion and extension muscle strengths of both legs in standing posture.

### Results

**1) Overview of participants**

Totally, seventy-six female participants volunteered with the informed consent. Mean age, weight, and height were 43.9 ±15.8 years old, 52.4 ±7.3 Kg, and 157.8 ±5.6 cm, respectively. These participants were divided into five age groups. Sample size of each age group was as follows; a group of 20-29 years-old was 21 participants with averaging 23.6, 30-39 years-old was 11 with averaging 35.7, 40-49 years-old was 12 with averaging 45.0, 50-59 was 19 with averaging 55.2, and over 60 was 13 with averaging 66.2, respectively. Dominant of all participants' leg was right one.

**2) Hip-joint muscle strengths in standing posture**

Each flexion and extension of muscle strengths of both legs in standing posture was measured. In addition, each data obtained was corrected with participant's height. This is a reason why a joint torque is a product of moment arm and tendinous tension to which synthesized tension by related each muscle fibers are transmitted ( Fukunaga, 2002). Its unit is Nm (Newton meter).

The strongest muscle power was obtained in the right leg extension that reflected dominant leg, and the next was the left leg flexion. The weakest one was the right leg flexion (**Tab.1**).

Tab.1 Mean values of measured items in function of age group

| | | Age | Height | Weight | Nm | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| n | Age Group | years old | cm | kg | right leg flexion | right leg extension | left leg flexion | left leg extension | inward rotation of hip-joint | outward rotation of hip-joint |
| | | | | | Sitting Posture | | | | Standing Posture | |
| 21 | 20~29 | 23.6 | 158.2 | 50.1 | 43.4 | 52.7 | 46.7 | 45.5 | 18.7 | 20.5 |
| 11 | 30~39 | 35.7 | 159.7 | 52.4 | 45.7 | 56.2 | 53.3 | 48.7 | 20.5 | 22.3 |
| 12 | 40~49 | 45.0 | 159.6 | 53.0 | 43.0 | 55.3 | 50.1 | 47.3 | 20.7 | 23.0 |
| 19 | 50~59 | 55.0 | 158.2 | 52.6 | 44.8 | 57.2 | 51.8 | 47.1 | 20.7 | 23.4 |
| 13 | above 60 | 66.2 | 153.2 | 52.4 | 40.9 | 53.6 | 48.9 | 45.2 | 20.1 | 24.9 |
| 76 | Mean→ | 45.1 | 157.8 | 52.1 | 43.6 | 54.9 | 49.8 | 46.6 | 20.0 | 22.6 |

Relations among flexion and extension muscle strengths of the both legs are shown in Fig. 1 to Fig. 4 with regression line and correlation coefficient. The highest relation was between the right leg flexion and extension (Fig. 1), the next was a relation between the right leg flexion and the left leg flexion (Fig.2).

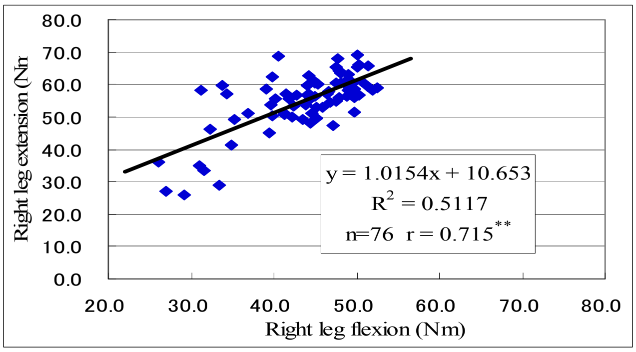


Fig 1. Scatter graph of relation between flexion and extension of right leg.

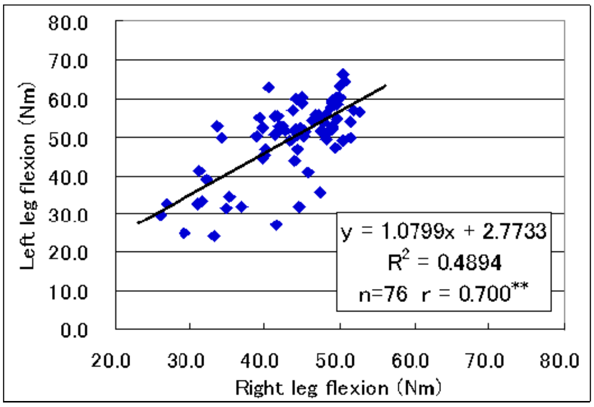


Fig 2. Scatter graph of relation between flexion and extension of both legs

On the other hand, a relation between the left leg flexion and extension was the lowest (Fig.3). The most important relation among the above is in Fig.4, which reflected a muscle coordination of the right leg extension and the left leg flexion for walking and running. These results mean that the right leg has been used for driving force from the point of dominant leg. Mean values of muscle strengths of both flexion and extension in function of age group was in Fig. 5.

The within- participant model of the two-factor (age group x muscle strengths) ANOVA was applied to hip joint flexion and extension strengths in standing posture. Muscle strengths as a main factor showed statistically significance ($F=63.43$, $df=3/213$, $p<0.01$). No significance was observed among age groups ($F=1.03$, $df=4/71$, ns) and interaction.

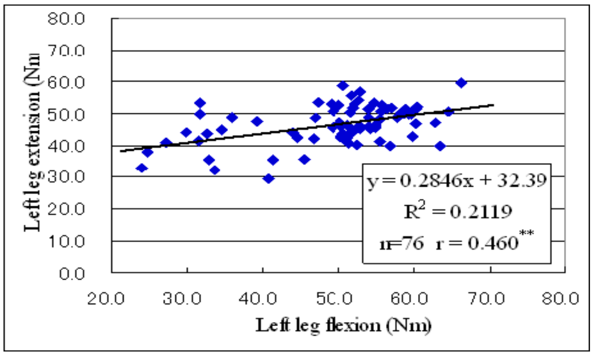


Fig 3. Scatter graph of relation between flexion and extension of left leg.

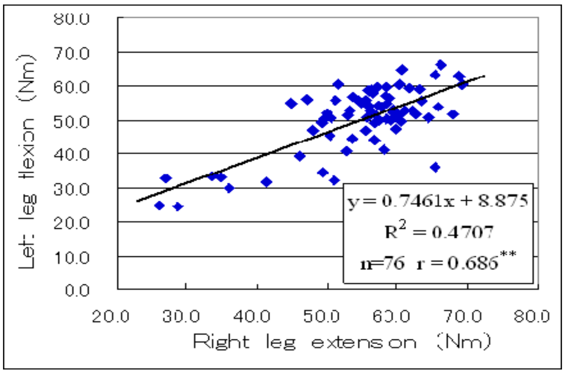


Fig 4. Scatter graph of relation between right leg extension and flexion of left leg.

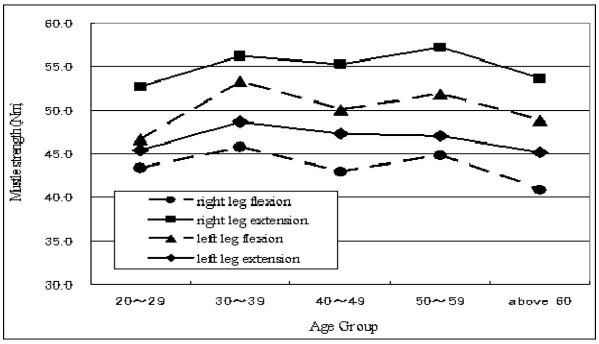


Fig 5. Mean values of muscle strengths of both flexion and extension in function of age group.

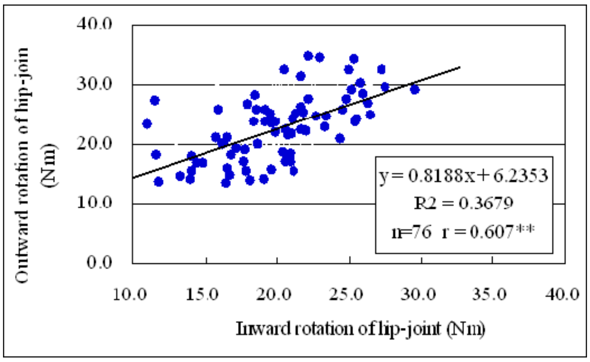


Fig 6. A scatter graphic relation of muscle strengths between inward and outward rotation

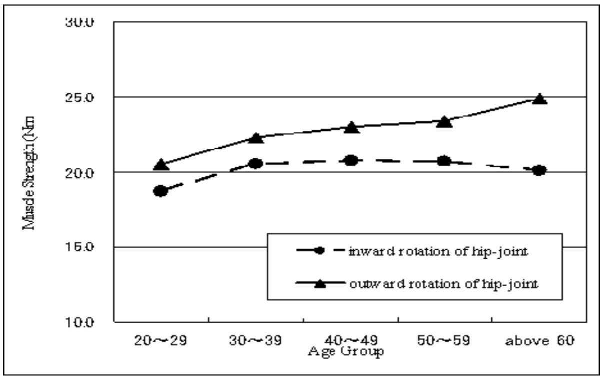


Fig 7. Mean values of the rotation muscle strengths in function of age groups.

**3) Hip-joint strengths in sitting posture**

Both adductor and abductor strengths of the hip joint in sitting posture were measured by the torque meter. These data were also corrected with participant's height.

A scatter graphic relation of muscle strengths between inward and outward rotation showed relatively high (Fig. 6). Mean values of the rotation muscle strengths in function of age groups were in Fig. 7. It showed that the abduction strengths of hip joint gradually increase with aging. On the other hand, the adduction strengths gradually decrease with a peak around 30's and 40's ages. A correlation coefficient between adduction and abduction strengths of the hip joint was 0.607 (n=74, $P<0.01$). The within-participant model of the two-factor (age group x muscle strengths) ANOVA was performed. Results showed that abduction strengths were significantly stronger than adduction strengths in all age groups ($F=24.81$, $df=1/71$, $p<0.01$). However, no significance was obtained among age groups ($F=0.91$, $df=4/71$, ns), and no significant interaction was obtained.

## Discussion

No clear difference among age groups in hip-joint muscle strengths was obtained because of participants attribute, only female group who had no daily physical exercises. From the findings that the psoas major area decreased with aging, the hip-joint muscle strengths expect to decrease with aging hypothetically. This is why hip-joint muscle strengths seem to correlate deeply with the psoas major area. However, there was no significant difference in the inward and outward rotation of muscle strengths by age groups. This finding accords with Juho E. Peltonen et Al. (1997). Namely, athletes have a strong correlation between the psoas major area and hip-joint muscle power, but non-athletes have no such correlation. Why does not such correlation show in non-athletes? This seems to reflect that elderly or non-athletes female tend to weaken their physical balance in walking. They intend to keep their balance with widening width of both legs to prevent falling down. This causes abduction muscle strength stronger than adduction strength. For non-athletes person, walking ways on balance beam is not good to prevent falling down, but walking on two parallel bars is good to prevent falling. This kind of walking gives a positive view to understand why the outward rotation muscle strength was significantly stronger than the inward rotation one. Moreover, this is also the reason why the outward rotation strength and difference between outward and inward rotation strengths tended to increase in function of aging. It is inevitable to shift central gravity toward one leg in walking, and this causes or generate outward power moment. So getting older has an effect to make the outward rotation muscles strengthen for maintaining stable upright posture in walking.

In walking and/or physical exercises, muscle power of flexion and extension of dominant legs is for driving force with coordination of muscle strengths of the other leg antagonistically. Especially, coordinating muscle powers between one leg extension and the other leg flexion needs for efficient and stable walks.

Figure 8 shows a normalized scatter gram based on data in figure 4. This coordinating muscle power of both flexion and extension of dominant legs can use to understand female's relative position. For example, such people with muscle power of both flexion and extension of dominant legs under $-1.0\sigma$ ( right leg :45.8 Nm, left leg:40.0 Nm) expect to have physical exercises for maintaining stable walking ability. Accordingly, Figure 8 can be able to utilize female's estimation of walking ability, and effect of physical exercises.

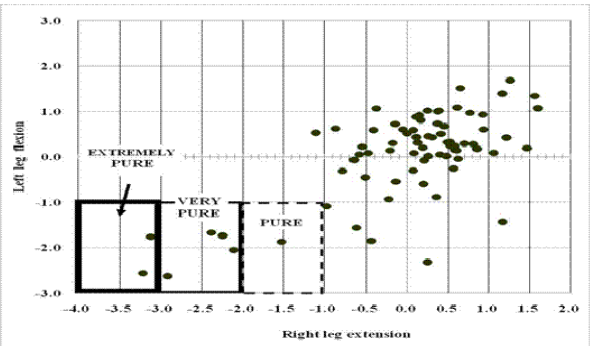


Fig 8. Normalized scatter graph to judge a relative position of leg muscle power.

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