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Research Article

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The Comparison of Muscle Activation of Waist and Lower Limb during Lifting an Object from Floor according to Foot Position in Twenties Wearing a Skirt

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| Abstract |

PURPOSE: This study was aim to the change of muscle activities of lower extremity and waist during lifting a small object on the floor according to different foot position of women in their twenties wearing a skirt.

METHODS: 9 women in their twenties wearing a skirt were selected and were measured the muscle activities of medial gastrocnemius (MG), tibialis anterior (TA), vastus lateralis (VL) and iliocostalis (IC) when they lifted a small object on the floor. The two different foot position employed were "both feet posed straight side by side" (condition 1) and "both feet posed diagonally to 45 degree" (condition 2) used. The order of feet position was selected randomly and the subject took a rest for 30 min between tests to prevent muscle fatigue. We calculated the mean and standard deviation of muscle activities and used Mann-Whitney U test to compare the difference between the two foot positions with SPSS(IBM Korea)

RESULTS: The muscle activity of condition 2 was greater than that of condition 1 in right side of TA, VL, and IC and left side of TA, VL, MG and IC. The right side of TA, VL and left side VL were significant difference between condition 1 and condition 2($p<.05$).

CONCLUSION: We suggest "both feet posed straight side by side" position is better if a woman wearing a skirt lift the small object and it will help prevent the low back and lower limb problems in the future.

Key Words: Foot position, Lifting, Muscle activity

Ⅰ. Introduction

Women consider how dresses make them look elegant even though that has bad side. Some studies have reported the bad effects of the clothes on body (Mori et al 2002, Chan and Fan 2002). A woman wearing a skirt can feel more pressure on her thigh and walk with short and quick steps (Lee et al, 2004).

Squatting to pick up an object on the floor is the basic skill of daily living (Kuo et al, 2011). When performing functional task, wearing a tight skirt require substantially greater effort (Lee et al, 2004). Also, Squat position with different foot position causes the imbalance of muscle

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activity in vastus medialis oblique (VMO) and vastus lateralis (VL) (Yoo et al, 2004). Therefore, squat position to pick an object on the floor will cause asymmetric muscle activities. If a woman wear a skirt, it could make worsen squat position to pick up an object on the floor. The worsen squat position would induced by changing foot position due to clothes.

Muscle activities of hamstring and erector spinae were decreased (Hase et al, 2004, Fredericson and Power, 2002) and muscle activity of tibialis anterior (TA) was decreased during the initiation of squatting (Dionisio et al, 2008). Muscle activity of VL was significantly higher for knee push squat. The activation of muscle was determined by task pattern. The hip drive squat task emphasizes hip joint movement but the knee-push squat task emphasizes back and knee joint movement (Manabe et al, 2004). Most squatting studies focus on the weight of lifting not foot position and their studies focused on the low limbs while there was a few focus in the lumbar muscle (Yoo et al, 2004, Hase et al, 2004, Dionisio et al, 2008). Therefore we need to investigate the muscle activation by squatting to pick up an object on the floor.

Actions leading to low back pain(LBP) are pulling, pushing, lifting and putting down an object. Among those actions, lifting and putting down the object are reported the most common causes of LBP (Korea Industrial Safety Association, 2007).

Leg flexion or extension with different foot position changes the muscle activities of waist and lower extremity (Park and Lee, 2011). Especially, the muscle activation of lower extremity increases during static squat exercise with knee adduction (Choi, 2009). Moreover, It is reported that the more trunk is rotated, the higher electromyographic activity of erector spinae becomes when trunk is twisted unsymmetrically during lifting an object (Ki, 2006). Christian et al(2002) suggested that the activation of thoracic paraspinal muscle of subject with LBP was higher than subject without LBP during asymmetric lifting action.

Therefore, motion with unsymmetrical posture may cause LBP. If a women wearing a skirt pick up an object, It require asymmetrical posture and will induce the problem of lower limb and low back. However, the muscle activity by which a woman wearing a skirt requires and lower extremity and lumbar during lifting action to pick up an object on the floor is unknown.

For this reason, we investigate the electromyographic activity of lower extremity and waist when the subjects wearing skirt put up a small object with the state of “both feet pose straight by side” or “both feet posed diagonally to 45 degree”. Through this study, we want to propose a proper foot position for lifting thing in daily life. It was hypothesized that the muscle activation in state of “both feet posed diagonally to 45 degree” would be higher during lifting.

Ⅱ. Method

1. Subjects

9 women in their twenties who had national standard body character with right handed(mean age: 21.9±1.6 years ; mean height: 160.0±1cm; mean weight: 51.5±2.1kg) were recruited. The exclusion criteria were a history of nervous or musculoskeletal system problems and inability to maintain the lifting action. Prior to participation, all participants were informed about the aims and procedures of the study and then signed the consent as required by the local ethics committee.

2. Measurement

1) **EMG measurement**

We used the surface EMG (TeleMyo DTS, telementry system; Noraxon, USA) to measure and analyze the muscle activities according to feet positions. After cleaning the electrode sites with alcohol, the eight surface electrodes

were positioned bilaterally over the belly of medial gastrocnemius (MG), tibialis anterior (TA), vastus lateralis (VL) and iliocostalis (IC) when subjects lifted a small object on the floor wearing a skirt. All raw EMG signals were amplified with a total gain of 2000, band-pass filtered between 20 and 350 HZ, analog to digital converted. The sample frequency was 1024Hz and stored on a hard disk for later analysis.

2) **Procedure**

With regard to the starting position, subjects were required to stand on a fixed heel print to maintain the feet position. The two different feet position employed were "both feet posed straight side by side" (condition 1, Fig 1) and "both feet posed diagonally to 45 degree" (condition 2, Fig 2) used. The feet position was selected randomly and the subject took a rest for 30 min between tests to prevent muscle fatigue. We drawn the circle 5 cm in diameter at forward the 30 cm spot from base line. Verbal instruction to the subject were : lift the small object in a way you feel comfortable. After instructions were given, the subject was allowed to practice a task to find a comfortable lifting technique. After practice was given, the action with verbal instruction was performed and repeated 3 times each condition. When the verbal cue was given, the subject began to pick up the target object in front of her with her usual speed and self-selected squat depth. The order of feet position was selected randomly and the subject took a rest for 30 min between tests to prevent muscle fatigue.

Fig 1. Both feet posed straight side by side

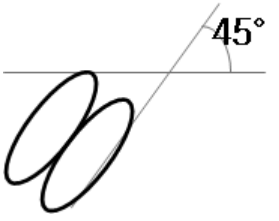

Fig 2. Both feet posed diagonally to 45 degree

3. Data analysis

We calculated the mean and standard deviation of muscle activities and used Mann-Whitney U test to compare the difference between the two feet positions with SPSS 18.0 (IBM Korea). The significant p-value was set below 0.05.

Ⅲ. Results

1. The muscle activity of TA

Muscle activity of right side of TA in condition 1 was 14.30±3.21 and in condition 2, it was 16.62±3.76. There was significant difference between condition 1 and condition 2 ($p<0.05$). Muscle activity of left side of TA was 15.43±3.66 and in condition 2, it was 16.21±2.76. There was no significant difference between condition 1 and condition 2 (Table 1).

2. The muscle activity of VL

Muscle activity of right side of VL in condition 1 was 21.41±2.52 and in condition 2, it was 25.70±2.97. There was significant difference in condition 1 and condition 2. Muscle activity of left side of VL in condition 1 was 21.17±2.02 and in condition 2, it was 24.61±3.64. There was significant difference in between condition 1 and condition 2 ($p<0.05$)(Table 1).

3. The muscle activity of MG

Muscle activity of right side of MG in condition 1 was 18.22±3.49 and in condition 2, it was 17.49±3.52. There was no significant difference between in condition 1 and condition 2. Muscle activity of left side of MG was 18.58±3.61 and in condition 2, it was 19.89±2.87. There was no significant difference between in condition 1 and condition 2 (Table 1).

Table 1. Comparison of muscle activity of condition 1 and condition 2

		condition 1 (n = 9)	condition 2 (n = 9)	P
Right	TA	14.30±3.21	16.62±3.76	0.000**
	VL	21.41±2.52	25.70±2.97	0.006**
	MG	18.22±3.49	17.49±3.52	0.566
	IC	22.23±3.40	24.21±5.70	0.200
Left	TA	15.43±3.66	16.21±2.76	0.596
	VL	21.17±2.02	24.61±3.64	0.038*
	MG	18.58±3.61	19.89±2.87	0.508
	IC	22.84±2.25	24.88±5.38	0.133

TA: Tibialis Anterior. VL: Vastus lateralis,
MG: Medial Gastrocnemius, IC(Iliocostalis)
condition 1. Both feet posed straight side by side
condition 2. Both feet posed diagonally to 45 degree

4. The muscle activity of IC

Muscle activity of right side of IC in condition 1 was 22.23±3.40 and in condition 2, it was 24.21±5.70. There was no between in condition 1 and condition 2. Muscle activity of left side of IC was 22.84±2.25 and in condition 2, it was 24.88±5.38. There was no significant difference between condition 1 and condition 2 (Table 1).

Ⅳ. DISCUSSION

Foot is located at the outermost part of body and it is very delicate organ that it is connected in concordance with muscles, tendons, nerves, vessels and so on. The unstable foot is more affected by core pressure than the stable foot. The position sense of unstable foot interrupts the balance control between the bottom of sloe and the contact surface of ground and it requires the usage of more proximal muscles to maintain upright trunk and balance (Hyung, 2008).

Human alignment can be changed according to the position of joint such as ankle, knee etc and this changes can possibly result dysfunction and disorder (Roh, 2011). An improper posture could cause not only decrease of body functions efficiency but severe changes of alignment caused by abnormal musculoskeletal system (The Korean Orthopeadic Association, 1998).

This study was to investigate the change of muscle activities of lower extremity and waist during lifting a small object on the floor according to different foot position which were “both feet posed straight side by side” and “both feet posed diagonally to 45 degree” in women in their twenties. The hypothesis stipulating that the muscle activity of “both feet pose diagonally to 45 degree” would increase through lifting action was accepted. The results revealed that the muscle activity of “both feet posed diagonally to 45 degree” was greater than that of “both feet posed straight side by side” about right side of TA, VL, and IC and left side of TA, VL, MG and IC. The right side of TA, VL and left side VL were significant difference between “both feet posed straight side by side” and “both feet posed diagonally to 45 degree”. This was not surprising that both VL was significantly increased in the state of “both feet posed diagonally to 45 degree”.

Choi(2009) analyzed the muscle activities of anterior tibialis, vastus lateralis, medial gastrocnemius, and erector spinae to investigate the changes of muscle activities of lumbar and lower extremity during squatting position. They found the muscle activities of VM and VL were increased in knee adduction and flexion position. In other ward, VM and VL was affected by knee adduction position.

This study showed that the muscle activities of both side VL and right side of TA in the state with “both feet posed diagonally to 45 degree” were higher than the muscle activities in the state with “both feet posed straight side by side”. And also, the muscle activities of VL with the state of “both feet posed diagonally to 45 degree” was higher than the muscle activities of VL with the state of “both feet posed straight side by side”. Especially, the muscle activity of right VL was higher than the left one. The results of this study are consistent with those from

a previous study that showed that TA, VL, Erector spinae were recruited during squatting (Choi 2009, Kuo, 2011)

The possibility reason of this result may be that the feet position affects knee adduction. Knee adduction during lifting action was increased by the state of "both feet posed diagonally to 45 degree". In additionally, they turned to left side to use their right hand and this motion induced to use the right VL more than the left side during the state of "both feet posed diagonally to 45 degree position"

Han and Kim(2012) investigated the Peak EMG amplitude of iliocostalis at two situations which were symmetrical and unsymmetrical situation. The symmetrical situation means a subject retains the center of gravity in the middle of body and the unsymmetrical situation means a subject moves the center of gravity to side by lifting an object horizontally. They reported that the value of Peak EMG of left and right iliocostalis in unsymmetrical situation was higher than symmetrical situation. Christian et al(2002) reported that the activation of thoracic paraspinal muscle of subject wih LBP increaased during asymmetric lifting action. The asymmetric lifting task was that subject lifted the object from floor to a shelf located at 90 degree on the right side of the subject. The asymmetrical position of their study was similar with the state of "both feet posed diagonally to 45 degree" in our study and the activation of muscles that related with low back pain increased.

We found the muscle activities of left and right iliocostalis in the state of "both feet posed diagonally to 45 degree" were higher than the muscle activities in the state of "both feet posed straight side by side". That result was similar with above study.

The first possible reason might be the increase of muscle activities to balance and control the posture by ankle rotation force which takes place when adapting to a new position after both feet was posed diagonally to 45 degree. The second one would be the shift of center of gravity. If the subject posed feet straight side by side, the center of gravity will stay on body but if the subject posed feet diagonally to 45 degree, it will partially stray from the center of body. Third one would be that the activity of iliocostalis was increased to prevent the body from falling forward.

Ryu(2008) studied about the relationship between the low back pain and the imbalance of hip abduction and adduction. He suggested that the imbalanced hip position will cause the low back pain. If the subject keeps the state of "hip posed side", the subject will stray from the neutral position of pelvic and the physiological curve of spine.

It will induce the low back pain. In our study, hip position at the state of "both feet posed diagonally to 45 degree" will induce the imbalance of hip position as Ryu's study. Also, it would produce more muscle activities of waist.

The limitation of this study was that we selected a small sample size and we focused only at twenties not various ages. Also, we did not consider the various other feet positions and various lumbar muscles and studied about only the subjects without low back pain not the subjects with low back pain.

Ⅴ. CONCLUSION

This study about feet position when a woman wearing a skirt lift a thing was conducted to investigate muscle activity of lower extremity and waist with "both feet posed straight side by side" and "both feet posed diagonally to 45 degree" position, using surface electromyography by attaching it to the right and left side of TA, MG, VL and IC.

We found the muscle activities of lower extremity and waist with "both feet posed straight side by side" is lower than the muscle activities of lower extremity and waist with "both feet posed diagonally to 45 degree" during picking up a small object on the floor. "both feet posed straight side by side" position is better if a woman wearing a skirt lift the small object and it will help prevent the

low back and lower limb problems in the future. Therefore, it is necessary to study various ages, feet positions and the subject with low back and lower limb problems in the future.

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