



Original Article

## Differences of quadriceps activity during inline lunge by using FMS assessment

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**Abstract.** [Purpose] This study assessed the exercise capacity of healthy adults while performing the inline lunge exercise by using Functional Movement Screen (FMS). Compared the difference in muscle activity of the quadriceps according to the exercise capacity. [Participants and Methods] Thirty two healthy participants (12 males, 20 females) participated in this study. The surface electromyography (sEMG) was used to measure the electrical activities for the vastus medialis (VM), rectus femoris (RF), vastus lateralis (VL) of quadriceps. [Results] Both groups had significant difference when sitting up and getting up during the inline lunge. In scores 3 group, vastus medialis showed higher muscle activity than vastus lateralis. On contrary, in scores 2 group, vastus lateralis had higher muscle activity than vastus medialis. [Conclusion] Therefore, this study suggests that inline lunge can help to strengthen the quadriceps effectively by showing the difference of quadriceps activity according to exercise capacity.

**Key words:** Inline lunge, Muscle activity, Functional movement screen

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### INTRODUCTION

Lunge refers to body movement technique which pushes the body ahead in the starting point and coming back to the original place. This exercise uses one side of the leg for intensive training of specific muscle and it helps balanced muscle development to prevent muscle injury<sup>1)</sup>. Especially, inline lunge movement pattern requires much more left–right movement and adjustment compared to existing lunge pattern. During inline lunge, the upper limbs and lower limbs are placed in an asymmetric position in a narrow floor<sup>2)</sup>. Inline lung is the only movement which has its basis on spinal stabilization and it requires the balance using the mutual complement of upper and lower limbs<sup>3)</sup>. If the likelihood of potential injury is ignored without improvement, the body is continuously exposed to likelihood of injury. However, it is difficult to find the appropriate preliminary evaluation kit for movement. Recently, Functional Movement Screen (FMS) kit has been introduced and it evaluates the asymmetry of body and defect in functional exercise<sup>4)</sup>. There are seven movements: deep squat, hurdle step, in-line lunge, shoulder mobility, active straight leg raise, trunk stability push up, and rotary stability. Then, FMS prevents the injury based on the examination result<sup>5)</sup>. FMS evaluation kit is widely used in fields related to sports injury based on its high reliability and validity<sup>6)</sup>. Also, FMS can identify weak or imbalanced muscle and find the risk factors that people are not aware of in their daily life. Thus, FMS can be used as the fundamental reference data in rehabilitation program<sup>7)</sup>. Until now, studies on lunge movements have been widely conducted, but studies on movements based on FMS kits are insufficient. In this study, the purpose of this study was to evaluate the exercise ability using the FMS kit during in-line lunge exercise in normal adults, and to analyze and investigate the reason by comparing the muscle activity of the quadriceps muscles according to the exercise ability.

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## PARTICIPANTS AND METHODS

The participants of this study were composed of 32 healthy adults (12 males, 20 females) at D University. Among the participants, people who had lower than 41 points in BBS or people who had BMI lower or higher than 20–24 kg/m<sup>2</sup> were excluded from the participants as such factors may change the test result for balance in comparing the lunge exercise capacity. In regard to criteria for dominant leg of the participants, the participants who preferred to use right leg in kicking movement were included in the participants<sup>8</sup>). The participants were provided a written informed consent according to the ethical standards of the Declaration of Helsinki, and all of them agreed to participate in current study voluntarily (approval number: CUIRB-2016-0046).

To compare the muscle activity of vastus medialis (VM), rectus femoris (RF), vastus lateralis (VL) muscle, this study used 8-channel wireless surface EMG, WEMG-8 (LXM5308, LAXTHA, USA). Also, this study used Functional Movement Screen (FMS™) test kit to identify the exercise capacity of participants during inline lunge movement.

This study used maximum voluntary isometric contraction (MVIC) and standardized the EMG signal for each muscle for standardizing the action potential of the muscle during inline lunge movement<sup>9</sup>). All electrodes (Ag/AgCl 2223, 3M, Korea) were placed on the participants by the same experimenter. The MVIC value used the average root mean square (RMS) of three trials. The data was collected for 5 seconds and the data value was processed with RMS. Also, this signal analyzed the average EMG signal amount for middle 3 seconds to reduce the error in the start and the end part<sup>10</sup>). The sampling rate was 1,024 Hz and EMG signals were filtered at 10–450 Hz by finite impulse response bandpass and 60 Hz, 120 Hz, 180 Hz filters and infinite impulse response rejector and the rectification. Before the test, the length of tibia was measured by measuring the length from the floor to the participant's tibial tuberosity and the big toe of the participant's left foot was placed on the starting line of Functional Movement Screen (FMS™) test kit. The participant's right foot was placed on the indicated mark on the kit based on the measured tibia length and participants were told to stick the heel of the right foot on the kit. Then, the participants were told to place two feet on FMS kit and the feet were placed on the straight line so that big toes of the both sides would face forward. After placing the feet, the participants were instructed to touch the stick with head, thoracic vertebra, and sacrum. The right hand holding the stick was placed on the cervical vertebra and the left hand was placed on the lumbar vertebra. Also, participants were told to keep touching the stick and the participants were instructed to maintain the vertical angle with the stick while performing the movements of sitting and standing up. For the movements which may influence the scores, the experimenter gave explanations again instead of correcting the position. During the test, the participants touched the heel of the right foot with their left knee and went back to the starting position. The participants performed the movements repeatedly for 3 times. Then, this study classified the participants into scores 3 group (S3G, n=16) and scores 2 group (S2G, n=16) based on the result of FMS assessment tool. The participants who kept touching the stick and maintaining the vertical angle without moving the trunk and participants who's left knee touched the heel of the right foot was defined as the S3G (Fig. 1a, b). On the other hand, participants who failed in touching the stick or maintaining the vertical angle with stick, participants who performed movements but had compensatory action, or participants who failed in touching the kit with their left knee were defined as S2G (Fig. 1c, d). Both two groups repeatedly performed inline lunge for total of 10 times with 5 times for each set in the speed they felt comfortable with. To minimize the accumulation of muscle fatigue, the participants were given sufficient break between each set.

Both S3G and S2G were analyzed using descriptive statistics and results are reported as means and standard deviations. The collected data was processed with commonly used program, SPSS ver 20.0 PASW Statistics for Window and this study conducted comparative analysis on average and standard deviation of each variable. To identify the muscle activity of quadriceps based on the capacity to perform inline lunge movement, this study used repeated one-way ANOVA and used Bonferroni's adjustment for post-hoc test. The statistical significance level was set to  $\alpha < 0.05$ .

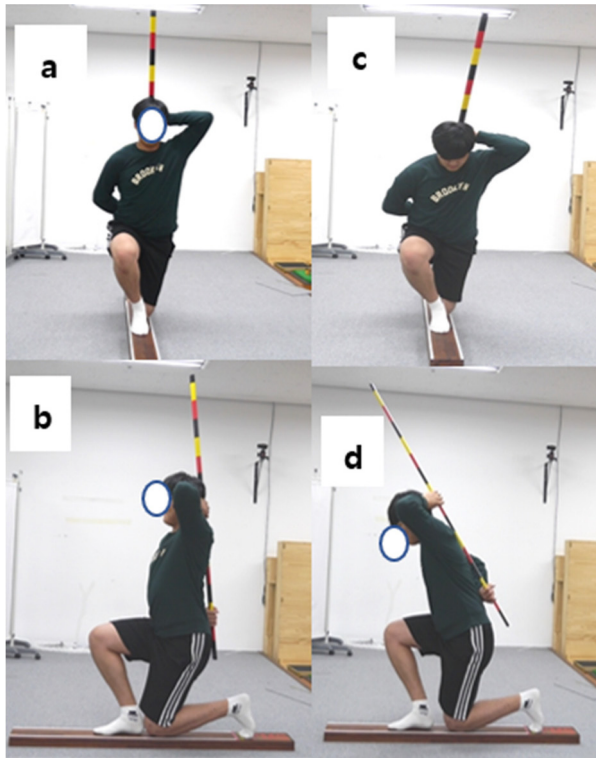
## RESULTS

The general characteristics of the participants are presented in Table 1.

Both S3G and S2G had significant difference when down and up during the inline lunge ( $p < 0.05$ ). In scores 3 group, vastus medialis (VM) showed higher muscle activity than vastus lateralis (VL). On contrary, in scores 2 group, vastus lateralis (VL) had higher muscle activity than vastus medialis (VM) (Table 2).

## DISCUSSION

Among the muscles around knee joint, quadriceps are the most important muscles and they allow stretching of the new joint and they play essential role in standing position, lower limbs stability, and overall body balance<sup>11</sup>). Also vastus medialis pulls patella inward while vastus lateralis pulls patella outward to stabilize the knee joint<sup>12</sup>). According to the research, it is reported that strengthening of quadriceps can prevent the worsening of knee joint structure effectively<sup>13</sup>). Inline lunge exercise is one of the closed-chain exercises performed to strengthen the muscular strength of quadriceps and it is helpful in activity and training of muscular tissues in leg for specific functional requirements<sup>14</sup>). It is also used as a strength exercise, but



**Fig. 1.** (a, b) scores 3 group and (c, d) scores 2 group for inline lunge.

**Table 1.** General characteristics of the participants (n=32)

Gender (male/female)	12/20
Age (years)	22.6 ± 1.4
Height (cm)	167.7 ± 7.8
Weight (kg)	63.7 ± 11.4
BMI (kg/m <sup>2</sup> )	22.5 ± 2.7
BBS	55.7 ± 0.4

Values are means ± SD. BMI: Body mass index; BBS: Berg balance scale.

**Table 2.** The comparison of quadriceps muscle EMG according to %MVIC during inline lunge

Group	Condition	Muscle			F	p
		VM	RF	VL		
S3G (n=16)	Down	69.3 ± 23.6†	51.1 ± 18.3	59.4 ± 15.3	7.0	0.0*
	Up	77.1 ± 24.3†	58.9 ± 17.3	68.5 ± 11.3	13.3	0.0*
S2G (n=16)	Down	59.5 ± 16.1	40.7 ± 16.8	61.6 ± 24.1†	8.9	0.0*
	Up	68.5 ± 21.2	48.0 ± 22.1	70.8 ± 21.7†	12.5	0.0*

Values are means ± SD. S3G: Score 3 group; S2G: Score 2 group; VM: Vastus medialis; RF: Rectus femoris; VL: Vastus lateralis.

\*p<0.05, †p<0.05: Significant difference among the muscles within each group.

can be used as an evaluation index. Preliminary evaluation is significant in prevention of injury. Also, there are many people who cannot perform movements effectively during the measurement even though they don't have issue in daily life. Thus, it is necessary to evaluate the functions instead of checking the status of musculoskeletal malfunction.

FMS evaluates the functional problems of the body in relatively simple method and it is a great measurement tool which can be used not only in rehabilitation for exercise injury but also in prevention of exercise injury. As FMS does not require highly-developed body techniques or special instrument, people in all ages can easily perform easily.

This study had the participants to perform inline lunge, one of the FMS movements. As a result in both groups had significant difference in sitting up and getting up motion and showed significant difference in relationship among the muscles in post-hoc test (p<0.05). In quadriceps, each muscle applies biomechanical stress on different parts of patella. As each muscle have the same controlling nerves, each part of quadriceps cannot contract independently. However, action of vastus medialis is important in developing appropriate tracking of patella. Although it cannot contract independently, the line pulling the constituents of the quadriceps influence on tracking of patella and acts directly on contraction of vastus medialis during the quadriceps activity<sup>14</sup>. While vastus lateralis has the widest horizontal cross-sectional area, vastus medialis pulls patella in diagonal direction and such diagonal pull is significant in stabilization and direction of patella when it slides through intercondylar groove<sup>15</sup>. Thus, action of vastus medialis is regarded significant in quadriceps.

The study result showed that S3G had higher muscle activity in vastus medialis than vastus lateralis. On the other hand, S2G had higher muscle activity in vastus lateralis than vastus medialis. Such result suggests appropriate training for people.

Clinically, in the FMS assessment, the S3G can train to strengthen overall quadriceps strength based on exercises focused on vastus medialis. It is possible to suggest a rehabilitation program that does not use compensation for instability by minimizing the activity of vastus lateralis to those who exhibit the S2G pattern. Also, this study would be the foothold for predicting the frequency of muscle activity in quadriceps fragmentarily based on the capacity to perform inline lunge movement. Furthermore, this study is expected to suggest dynamic training for each muscle in unstable and narrow ground as one of the selective muscle training method of vastus medialis, rectus femoris, and vastus lateralis.

In consequence, inline lunge selectively promotes muscle activity of each muscle in quadriceps for physical stability and for improving mobility. Also, evaluation of exercise capacity using FMS kit is expected to be helpful in precise diagnosis during the rehabilitation. In addition, the comparative study on muscle activity of quadriceps based on exercise capacity for inline lunge is expected to be useful in rehabilitation or in the training for strengthening quadriceps in preventing the future injury. However, in this research paper, although the experiment was conducted with a small number of 32 people, there is a limit. In addition, since the experiment was conducted on university students of University D, it is expected that research on ages with a slightly wider deviation will be required.

### *Conflict of interest*

None.

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