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Original Article

Effects of visibility and types of the ground surface on the muscle activities of the vastus medialis oblique and vastus lateralis

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Abstract. [Purpose] The purpose of this study was to compare the effects of visibility and types of ground surface (stable and unstable) during the performance of squats on the muscle activities of the vastus medialis oblique (VMO) and vastus lateralis (VL). [Subjects and Methods] The subjects were 25 healthy adults in their 20s. They performed squats under four conditions: stable ground surface (SGS) with vision-allowed; unstable ground surface (UGS) with vision-allowed; SGS with vision-blocked; and UGS with vision-blocked. The different conditions were performed on different days. Surface electromyogram (EMG) values were recorded. [Results] The most significant difference in the activity of the VMO and VL was observed when the subjects performed squats on the UGS, with their vision blocked. [Conclusion] For the selective activation of the VMO, performing squats on an UGS was effective, and it was more effective when subjects' vision was blocked.
Key words: Vision, Unstable, VMO

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INTRODUCTION

Patellofemoral pain syndrome (PFPS), a luxating patella, and subluxation increase knee joint instability and pain[1)]. The vastus medialis oblique (VMO) of the musculus quadriceps femoris influences the stability of the coxofemoral joint[2)]. In particular, an imbalance between the VMO and vastus lateralis (VL) can cause PFPS or other knee joint diseases[3)].

A previous study reported that the VMO is contracted in PFPS[4)]. To activate the musculus quadriceps femoris, that study also suggested using open kinetic chain exercises and closed kinetic chain exercises. Among closed kinetic chain exercises, squats are known to selectively strengthen the VMO[5)]. Various types of squats have been described, and squats on an unstable ground surface (UGS) induce muscle activation because they increase joint movement and proprioceptive feedback[6)].

Squats affect a subject's balance control. They rely on vestibular function, visual information, proprioception, the musculoskeletal system, and cognitive ability[7)]. Vision is one of the most used of the sensory inputs in postural control[8)], and inhibition of vestibular function by blocking a subject's vision increases antigravity muscle activation[9)]. Kuo et al.[10)] conducted a study of the balancing ability of teenagers with idiopathic scoliosis who were divided into a vision-blocked group and a vision-allowed group. Their results show that the muscle activities of the multifidus and gluteus medius were higher in the vision-blocked group than in the vision-allowed group. In a study of children, Smith et al. reported that exercising on a UGS with the eyes closed was more effective at stabilizing posture than exercising on the same surface with the eyes open[11)].

A recent study compared the muscle activities of the VMO and VL in the squat position with and without isometric hip adduction. However, no studies of squat exercises have considered the impact of vision on the muscle activities of the VMO and VL. Therefore, this study investigated the effect of vision on changes in the muscle activities of the VMO and VL in a squat position on stable and unstable support surfaces. The aim of this study was to identify effective methods for the rehabilitation of PFPS or other knee diseases.

SUBJECTS AND METHODS

Subjects

The subjects were healthy male and female adults (males: n=12, females: n=13; age: 25.19±2.48 years; height=166.62±7.88 cm; weight=62.86±13.52 kg) who were residents of D Metropolitan City. All the subjects had

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Table 1. Muscle activities of the vastus medialis oblique and vastus lateralis during squats performed on stable and unstable surfaces, with the eyes open and closed (n=25)

	VMO			VL		
	SGS	UGS		SGS	UGS	
Vision Allowed	35.75±17.72[a]	41.21±17.92	*	45.0±21.83	53.49±23.15	*
Vision Blocked	39.38±18.07	71.46±24.43	**	50.15±22.40	47.98±16.96	
	*	**		*		

[a]: Mean (%RMS) ± SD.
*: $p<0.05$, **: $p<0.001$
VMO: vastus medialis oblique, VL: vastus lateralis, SGS: stable ground surface, UGS: unstable ground surface

a normal joint range of motion. The subjects were fully informed about the study and voluntarily signed a written consent form voluntarily. The study was approved by the Research Ethics Committee of Sunmoon University. Exclusion criteria were neurological, orthopedic, psychological, and cardiovascular diseases in the past 3 months, as these could have affected the study's results.

Methods

The subjects performed squats under four conditions: SGS with vision-allowed; UGS with vision-allowed; SGS with vision-blocked and UGS with vision-blocked. On the first day, the subjects performed squats on the SGS with vision allowed. The subjects stood with their feet 120% of their shoulder width apart, and the locations of their feet were marked with a foot-shaped sticker. The knee joint angle was measured using an electrogoniometer (DatalLOG, Biometrics, USA). When performing the squats, the subjects straightened their trunk, with their arms bent and hands on their hips. They were instructed to look straight ahead. They started bending their knees upon the verbal order of "start", and they stopped upon hearing the verbal order "stop" when their knee joints were at 60 degrees. They then maintained that position for 5 sec. They performed the squats 3 times with a 10 min break between each trial. On the second day, they performed the same exercise on the UGS, which was a foam pad (40 × 47 × 7 cm, balance-pad Elite, Germany), at the same time of the day. On the third day, they performed the same exercise on the SGS with their vision blocked. On the fourth day, they performed the same exercise on the UGS with their vision blocked.

An electromyograph (Noraxon Inc., Myotrace 400) was used to measure the activity of each muscle, and the collected data were analyzed using Myoresearch XP master 1.07. The sampling rate was 1,000 Hz, and the frequency bandwidth was 80–250 Hz. The subjects wore comfortable shorts. The areas where the electrodes were placed were shaved and cleaned with alcohol-soaked cotton. To detect the activity of the VL, a surface electrode was attached at 2/3 the distance between the lateral part of the knee bone and the anterior superior iliac spine are connected. To assess the activity of the VMO, a surface electrode was attached at the 4/5 the distance between the upper inner part of the knee bone and the anterior superior iliac spine[6]. The electrode for the VMO was 45 degrees from the shaft of the femur, and that for the VL was 15 degrees from the shaft of the femur. The muscle activity measured during the squats was integrated and averaged for comparative analysis.

The paired-samples t-test was conducted to compare the muscle activities of the VMO and VL among the SGS and UGS, with and without vision. SPSS Ver. 20.0 was used for the statistical analysis, with a significance level of $p=0.05$.

RESULTS

When performing the squats with vision allowed, the activities of the VMO and VL were significantly different between the two ground surfaces ($p<0.05$). When vision was blocked, the activity of only the VMO was significantly different on both ground surfaces ($p<0.05$) (Table 1).

DISCUSSION

Frontal knee pain has become more common as increasing numbers of people engage in a range of sports. Such pain is particularly common among young people and athletes. Frontal knee pain occurs due to abnormal movement of the knee bones when the knee is bent[1, 2]. Abnormal movement occurs when the ratio of activity of the VMO to that of the VL (knee-controlling muscles) is far less than 1. The purpose of the present study was to observe the changes in the muscle activities of the VMO and VL of healthy young adults on different types of surfaces, with vision blocked and vision allowed, to identify effective rehabilitation strategies for PFPS and other knee diseases.

In a study by Kang and Hyong, the activity ratio of the VMO and VL was significantly different as the ground surface became more unstable[6]. This result is similar to that of our present study, which detected the biggest difference on the UGS, with vision blocked.

In a study of 33 healthy subjects, Kushion et al.[12] verified that the ratio of the VMO/VL in healthy adults was 0.99–1.0. When the subjects performed a leg lift in a supine position, the ratio was between 0.99 and 1. In the present study, the ratio of the VMO/VL on the SGS during the squats with vision allowed was 0.92, and it was 1.40 during the squats with vision blocked on the UGS. This result indicates that squatting on the UGS with vision blocked is more effective at activating the VMO than leg lifting in a supine position, and selective activation training of the VMO would be helpful for increasing a decreased VMO/VL ratio.

Previous studies that have sought to improve the activ-

ity of the VMO by focusing on the ratio of the VMO/VL. However, this study focused on differences in muscle activity between with and without vision and between stable and unstable ground surfaces. With this approach, it was easier to observe the changes in the activity of each muscle. The activity of the VMO was significantly different, dependent on vision and the type of ground surface, whereas that of the VL was not significantly different. Thus, it can be inferred that the VL acts as an antigravity muscle and that vision and the type of ground surface have less of an effect on this muscle than on the VMO.

The subjects of this study were young adults who could easily adapt to a vision-controlled situation. As this study included only young adults as study subjects, it is difficult to generalize the results. However, the results suggest that controlling vision during squats could form the basis of future studies aimed at strengthening the VMO.

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