



Original Article

## Comparison of the hamstring/quadriceps ratio in females during squat exercise using various foot wedges

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**Abstract.** [Purpose] This study compared the hamstring/quadriceps ratio in females during squat exercise using various foot wedges. [Subjects and Methods] Nine females participated in this study. Surface electrodes measurements were taken over the hamstring and quadriceps under 3 squat exercise conditions, and the hamstring/quadriceps ratio was calculated. [Results] The hamstring/quadriceps ratio was significantly increased during squat exercise in inclined wedge condition ( $7.4 \pm 1.8$ ), compared to the declined wedge condition ( $5.3 \pm 2.2$ ) and no wedge condition ( $6.4 \pm 3.2$ ). [Conclusion] This study suggests that squat exercise in the inclined wedge condition may be effective for increasing the hamstring/quadriceps ratio in females.

**Key words:** Females, H/Q ratio, Wedge

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### INTRODUCTION

Female athletes are reported to be much more likely to sustain an anterior cruciate ligament (ACL) injury than male athletes<sup>1)</sup>. Hamstring muscle strength, however, is relatively preserved because the hamstring can be facilitated or activated in response to an ACL tear<sup>2)</sup>. A high incidence of ACL injury has been reported in pivoting sports such as soccer, basketball, and handball, and the incidence is 3 to 5 times higher among women than men<sup>2)</sup>. A decreased hamstring/quadriceps (H/Q) ratio may increase the stress on the anterior cruciate ligament (ACL), with increased risk of knee injury<sup>1, 2)</sup>. Therefore, this study compared the H/Q ratio in females during squat exercise using various foot wedges.

### SUBJECTS AND METHODS

This study was performed in 9 asymptomatic females aged  $27.2 \pm 2.2$  years (mean  $\pm$  SD); their average height and weight were  $174 \pm 3.1$  cm and  $67.9 \pm 4.3$  kg, respectively. The study purpose and methods were explained to the subjects, who provided informed consent according to the principles of the Declaration of Helsinki before participating. Electromyography (EMG) signals were sent to the data acquisition unit of an MP150 system (BIOPAC Systems, Santa Barbara, CA, USA). The EMG data were analyzed using a program created with the AcqKnowledge software (version 3.9.1) and expressed as the maximum voluntary contraction (MVC). Surface electrodes were attached over the hamstring (medial part) and quadriceps (rectus femoris) and then the H/Q ratio was calculated. The squat exercise involved descending to  $90^\circ$  of knee flexion, and ascending to the initial position at the individual's natural speed. The  $90^\circ$  of knee flexion angle was controlled by a guide bar in the habitual usual-speed squat exercise. The trunk posture was defined as anterior rotation of the pelvis for neutral lumbar lordosis, and relaxation of the thorax with an upright head posture. The experimental protocol specified 3 squat exercise conditions: condition 1 applied no foot wedge board; condition 2 applied an inclined wedge board to the foot; condition 3

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applied a declined wedge board to the foot. The angle of the wedge was 20° (L×W×H: 30 × 30×15 cm). To test for differences in H/Q ratio among the various foot wedge board conditions, repeated-measures analysis of variance was used to determine if there was a significant effect of the muscles and ratio. For the significant main effect, Bonferroni's correction was performed to identify the specific mean differences. Differences were defined as significant at  $p < 0.05$ .

## RESULTS

The H/Q ratio was significantly increased during squat exercise in inclined wedge condition ( $7.4 \pm 1.8$ ) compared to the declined wedge condition ( $5.3 \pm 2.2$ ) and no wedge condition ( $6.4 \pm 3.2$ ).

## DISCUSSION

The squat exercise in inclined wedge condition resulted in a much greater increase in the H/Q ratio. This may be because gastrocnemius muscle tension decreased due to the declined board. Thus, the gastrocnemius muscle acted more on knee extension, thereby relatively reducing the activity of the quadriceps muscles<sup>3</sup>). Declined wedge squat exercise was more effective in activating the quadriceps than the same exercise on the ground because it minimized the effect of the gastrocnemius muscle. On the other hand, gastrocnemius muscle tension increased due to the inclined board. Thus, the gastrocnemius muscle acted more on knee extension, thereby relatively reducing the activity of the quadriceps muscles. Finally, these changes increased the H/Q ratio. Studies suggested that a decreased H/Q ratio was thought to contribute to the higher incidence of ACL injuries in women<sup>1, 2</sup>), and that the development of preventive strategies in women was needed<sup>4</sup>). Further research on risk factors and preventive strategies for the female ACL is needed, because the cause of the disparity in injury rates remains equivocal and controversial. Individualized treatment for the injured knee is necessary<sup>1</sup>). Kim et al.<sup>5</sup>) presented the kinematic differences in landing motions between male and female college students and reported that the valgus angles of women were more increased than those of men during vertical landing motion. They suggested future studies to measure activities of the muscles that are used for landing motions and the evaluation of the imbalance of these muscles<sup>4</sup>). The balance between quadriceps and hamstring muscle strength is usually assessed as the H/Q ratio. Therefore, this study suggests that squat exercise in inclined wedge condition may be effective for increasing the H/Q ratio in females.

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