IMPROVING PELVIC MOVEMENTS DURING DIVING IN FOOTBALL GOALKEEPERS -EFFECTS OF HIP-LOCK TRAINING-

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The purpose of this study was to introduce Hip Rock to football goalkeepers and to investigate the differences in pelvic movement and lower limb joint torque exertion of the opposite leg before and after Hip Rock Training. All subjects in the training group improved the maximum value of hip extension torque in the opposite leg after training. The effect of the interaction was greater in the training group than in the control group in the demonstration of hip extension torque in the opposite leg. The stability of the pelvic musculature could be obtained, and the extension torque of the hip joint could be improved by gaining a sense of power to the ground. These results suggest that hip lock training and its application training can be useful for goalkeepers who are unable to lower their trunks in the direction of play or move their center of gravity smoothly.

KEYWORDS: joint torque, opposite leg, lock position

INTRODUCTION: In previous studies of diving motion of soccer goalkeepers, the lower limb joints have been studied. Numazu et al. (2018) showed that in a rightward diving motion, in the left leg (opposite leg) ground contact phase, the opposite leg hip abducted while exerting a moment of rightward tilt due to hip joint force. In the ground contact phase, the opposite leg exerted hip adduction torque and the opposite leg exerted hip abduction torque. In the rightward diving motion, it is important to exert adduction torque while abducting the opposite leg hip joint. It is stated that the rightward tilt of the trunk plays a role not only in maintaining the posture of the trunk but also in bringing the hand closer to the ball. Numazu et al. (2016) also described the support phase of the opposite leg; joint torque around the flexion-extension axis of the three lower limb joints of the opposite leg exerts an extension (or plantar flexion) torque, which plays an important role in generating hip joint forces that bring the trunk down in the direction of motion.

According to Frans Bosch (2010), running and jumping on one leg causes a strong force in the groin area. The locked position, the posture of using contraction to protect the groin during running and jumping, is created by raising the free leg side of the pelvis while standing on one leg, and slightly leaning forward and internally rotating the hip joint. This is accomplished by flexing the hip and knee of the free leg, while attempting to pull the heel toward the hamstrings. Hip lock training (hereinafter, this is called "HRT") is designed to master the locking position of the hip joint. Speed skater Nao Kodaira (Olympic gold medalist) demonstrates the effects of Hip Lock in her cornering posture. She stated that she wanted to push the ice more during cornering, and Hip Lock enabled her to push the ice more strongly with her outside leg by making her pelvis parallel to the ice. Frans Bosch (2010) also stated that as ground contact time decreases and exercise becomes more intense than jogging, the role of fixation receptors decreases and the role of co-contraction and stiffness becomes dominant. In other words, because diving is a higher-intensity exercise than jogging, it is important to train for cocontraction and stiffness.

Previous studies have shown that exerting torque in the opposite leg to the direction of play is important and affects the ability to bring the trunk down in the direction of movement. In the case of the opposite leg, the pelvis should be parallel to the ground until just before the opposite leg leaves the ground for better torque application in flexion and extension. HRT is said to be effective in demonstrating lower limb joint torque. Therefore, we thought that HRT could be applied to the diving motion of football goalkeepers.

The purpose of this study was to introduce HRT to football goalkeepers and to investigate the

differences in pelvic movement and lower limb joint torque exertion of the opposite leg before and after HRT.

METHODS: The subjects were eight goalkeepers from the football team of University of B [Male, age 21.13 ± 0.60 years, height 1.76 ± 0.05 m, weight 72.13 ± 5.40 kg, mean ± standard deviation (SD)]. Purpose and safety aspects of the study were explained to them, and their consent to participate in the study was obtained prior to the start of the study. There were 4 subjects in the training group and 4 subjects in the control group. A three-dimensional optical motion capture system (Oqus, Qualisys, Gothenburg, Sweden) was used, and 10 cameras were used for shooting. The shooting speed was 240 frames per second, and the shutter speed was 2000. Reflective markers were measured with 45 markers.
In the experimental test, the subjects were set up with one leg on each of two ground reaction force gauges, pre-jumping was allowed, and diving against a stopped ball was performed in the right direction. The training consisted of three HRT exercises. The HRT was used to activate the pelvic muscle group and to obtain a sense of power in exerting torque at the lower limb joints, and the HRT was applied to convert it into a diving motion.
The training was performed three times a week for four weeks(2 sets of 10 times 3 events), and then the movements were measured and the ground reaction force was taken again. The measurement items are extension (plantar flexion) torque of the hip, knee and ankle joints.
IBM SPSS statist opposite and version 25 package (IBM), were used for statistical processing. A two-factor analysis of variance was conducted, with a statistical significance level of less than 5%.

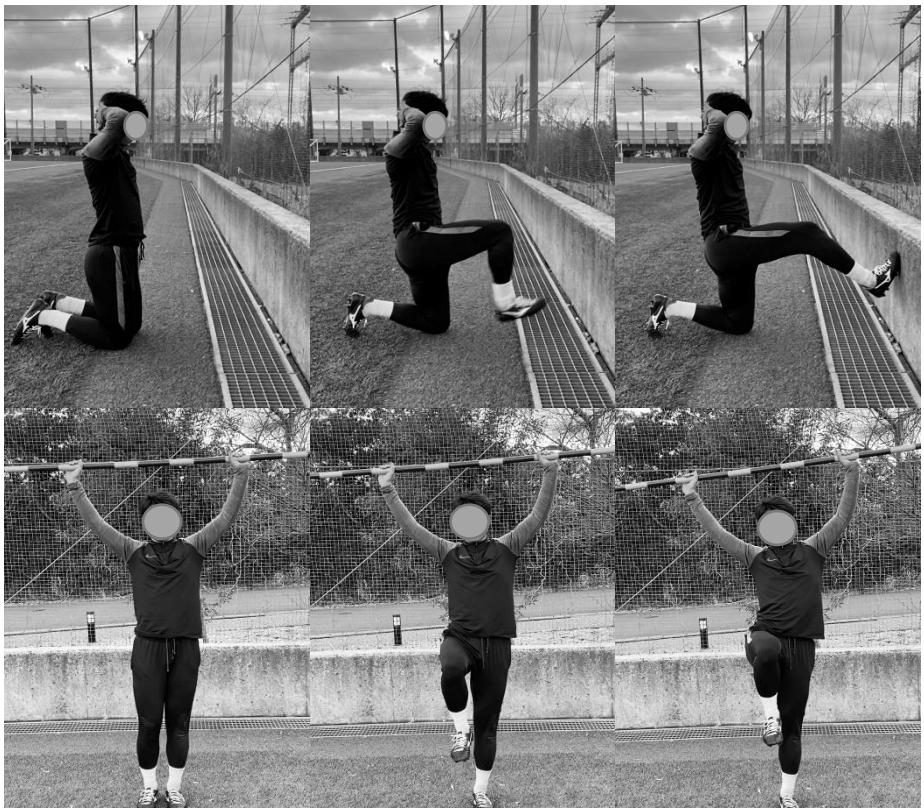

Figure1: Hip lock training.

RESULTS: Table 1 shows the maximum values of hip joint torque in the training and control groups. In the training group, four of the four subjects showed an increase in extension torque after training, with a maximum increase of 175.1 Nm. In the control group, only one person showed an increase, and the change was very small, 0.63 Nm.

Table 1 : Maximum values of opposite leg hip extension torque before and after training for the training group and the control group.

	Control				Training		
	pre	post	difference		pre	post	difference
A	159.66	151.82	-7.84	E	113.11	163.57	+50.46
B	112.72	113.35	+0.63	F	62.87	238.01	+175.13
C	209.13	176.4	-32.73	G	153.22	179.69	+26.48
D	101.03	87.31	-13.71	H	151.75	174.11	+22.36

There was no significant main effect between the two groups (pre/post (two levels): p=0.21, training group/control group: p=0.47). There was no significant interaction between the training group and the control group. However, the effect size of the interaction was large and there was a trend toward an interaction (p=3.88). A type2 error may have occurred due to the small sample size.

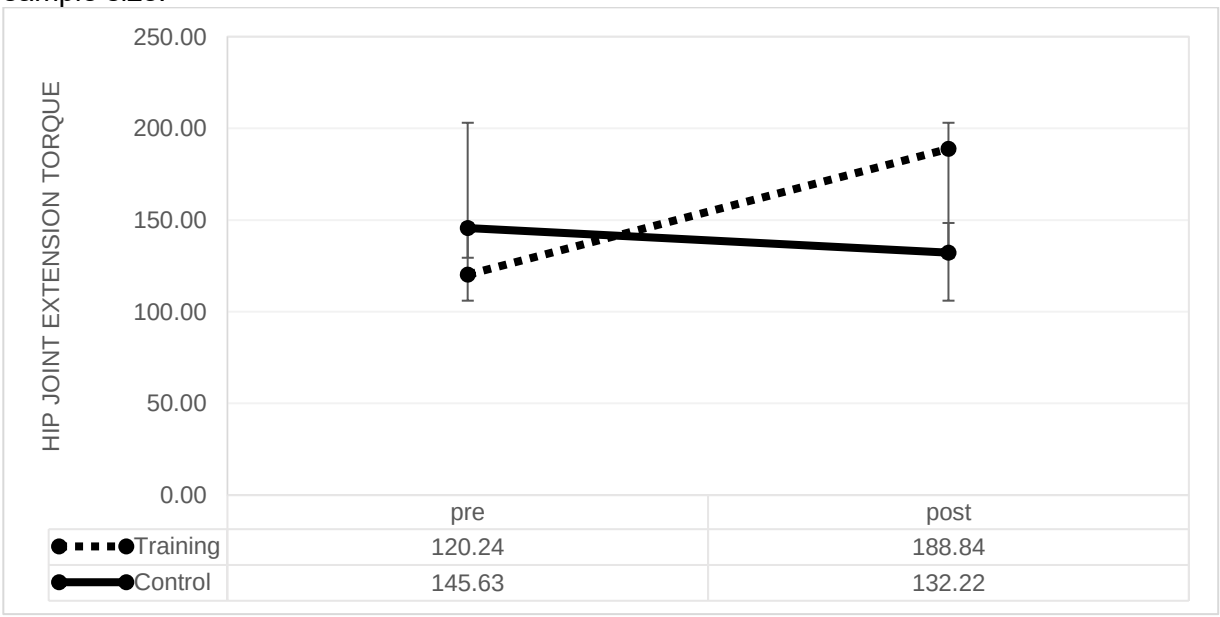

Figure 2: Results of analysis of variance of opposite leg hip extension torque before and after training in the training group and control group.

DISCUSSION: The results of this study showed that the effect size of the interaction was large before and after training for the training and control groups in hip extension torque exertion. This suggests that HRT may have some effect on the hypothesis of "improved lower limb joint extension torque exertion. Statistical significance could not be proven. However, an improvement was observed in each sample of the TR group. This suggests that type 2 error may have occurred due to the small sample size. Therefore, it is necessary to increase the sample size and reexamine the issue.

The effect of HRT on diving will be discussed. Numazu et al. (2016) showed that for the support phase of the opposite leg, the joint torque around the flexion-extension axis of the three lower leg joints of the opposite leg exerts an extension (or plantar flexion) torque. He states that it is important because it generates a hip force that brings the trunk down in the direction of motion. Frans Bosch (2010) stated that co-contraction and stiffness are dominant in high-intensity exercise. Therefore, it is important to train to increase co-contraction and stiffness when diving, and HRT is highly worth implementing in this regard. Frans Bosch (2010) also noted that training in the locked position can be applied to a wide range of low- to high-intensity training, such as rehabilitation. The HRT performed in this study could not be considered highly loaded due to the lack of weights or other means. Therefore, higher-intensity HRT had to be considered.

HRT may have a positive effect on the "torso tilt toward the ball," which is considered to be important in the diving motion. Also, by tilting the trunk with the three lower limb joints of the opposite leg capable of exerting extension torque until just before the opposite leg leaves the ground, it is possible that the center of gravity velocity is increased by adding a larger force product. In conclusion, HRT may have a positive effect on the diving motion of goalkeepers in this study, indicating that HRT can be applied to improve the diving motion.

CONCLUSION: The results of this study showed the following changes in the subjects.

(1) All subjects in the training group improved the maximum value of hip extension torque in the opposite leg after training.

(2) The effect of the interaction was greater in the training group than in the control group in the demonstration of hip extension torque in the opposite leg.

These results suggest that hip lock training have the following effects.

The stability of the pelvic musculature could be obtained, and the extension torque of the hip joint could be improved by gaining a sense of power to the ground.

These results suggest that hip lock training and its application training can be useful for goalkeepers who are unable to lower their trunks in the direction of play or move their center of gravity smoothly.

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