BIOMECHANICAL ANALYSIS OF MOVEMENT TRANSFORMATION BY THE KNEE SUPPORTER WEARING

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The purpose of this study was to clarify the effect of the soft knee brace, “ knee supporter ” in continuous squat motion under the fatigue condition. The results were summarized as follows; 1) the influence of knee supporter to the squat motion was different according to the subjects' characteristics, but in Wear condition, almost all subjects was getting to be improved the stability of knee flexion-extension motion. 2) In Wear condition, the stability of the hip joint was decreased gradually while fatigued, because the hip joint was the compensation of knee flexion-extension motion. 3) In the variation of the changes in the knee joint flexion-extension motion from the 1st set to 10th set, the subjects could be divided into three types.

KEY WORDS: injury prevention, fatigue condition, standard deviation, kinematics.

INTRODUCTION: Many athletes, who have injury experiences of the knee joint, wear knee braces, knee supporters and taping during the rehabilitation activities and sports activities in order to prevent the repeating knee injury. The flexion limit of sports knee supporter is smaller than the others because it is made of soft materials to prevent injuries during sports activities. Furthermore, knee supporter is easy to wear and total cost is low in comparison with taping. Therefore, the athletes prefer the knee supporter rather than taping. In the sports field, the athlete wearing the knee supporters always repeat continuous movement with a high exercise intensity. However, the target motion of previous studies (Lin et al. ,2008; DeVita et al. ,1998) are focused on a singly motion such as stop jump or low intensity such as walking. Because knee injury often occurs under the fatigue condition, the effect of knee supporter is needed to be verified with a continuous motion and under fatigue condition. The purpose of this study was to clarify the effect of knee supporter in continuous squat motion under the fatigue condition.

METHODS: Eleven male university student (height 1.76±0.07m, body mass 69.9±8.43kg) volunteered in this study. We asked the subjects to do the continuous squat in one tempo to two seconds. One set consisted of twenty squats. Two Conditions were following; wearing knee supporters (Japan SIGMAX, ZAMST ZK-7) on the knee joints of both legs (Figure1) (Wear condition) and not wearing (Non-wear condition). Rest time between sets was thirty seconds. We asked the subjects to do a total of ten sets. In order to unity the experiment trial, we attached the rubber cord at the lowest position in the squat (Figure2). In addition, we

Figure 1 Knee supporters that was used in this study.

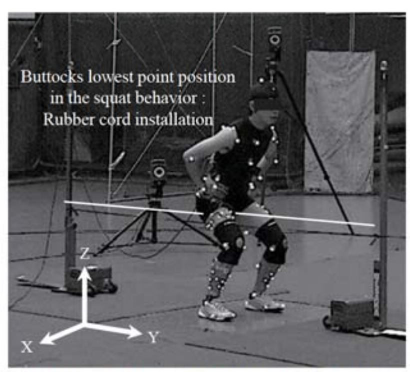

Figure 2 Experimental set up 1.

instructed the subjects as follows: 1) stand with feet shoulder-width apart and direct your toes and knee joints forward, 2) look at ahead, 3) put your hands on your waist, 4) don't bend your trunk forward. To be free of the fatigue, the experiments of two conditions were set with a rest of one week or longer. The global coordinate system was defined as follows: the Y (anteroposterior)-axis was horizontally toward the front from the back of the subject, the Z (longitudinal)-axis was the vertical axis, and the X (mediolateral)-axis crossed with the Y- and Z-axes. Ground reaction forces (GRFs) of both legs were obtained with 2 force platforms (9287B, 9287C, Kistler) at 1000 Hz. Three-dimensional (3D) coordinates of 47 reflective markers on a body were collected using a motion analysis system (Vicon MX+, Vicon) at 250 Hz. GRFs and 3D coordinates were time-synchronized by the motion analysis system. 3D coordinates of the markers were smoothened by a fourth-order Butterworth low-pass-digital-filter at cut-off frequencies based on the residual method of Wells and Winter (1980). In this study, we calculated the kinematics and kinetics parameters at maximum knee joint flexion (MKF). Therefore, we extracted 20 data from one set, and totally 200 data in one experimental condition.

RESULTS AND DISCUSSION

1. The tendency of all subjects in the viewpoint of the standard deviation of each joint angle.
Figure3 (a) showed the standard deviation of the knee joint angle at MKF. In the first set, the scatter ranges of all subjects were 1.5 - 4.8 deg in the Non-wear condition and 1.6 - 3.2 deg in the Wear condition. The scatter range in the Wear condition was less than that in the Non-wear condition. In the 10th set, the scatter ranges of all subjects were 1.2 - 4.2 deg in the Non-wear condition and 1.2 - 3.0 deg in the Wear condition. The scatter range in the Wear condition was also less than that in the Non-wear condition. Furthermore, the scatter ranges in the 10th set in both conditions was less than in 1st set. Figure3 (b) showed the standard deviation of the ankle joint angle at MKF. The standard deviation of the ankle joint was less than the knee joint regardless of both the conditions and the sets. Figure3 (c) showed the standard deviation of the hip joint angle at the MKF. In the first set, the scatter ranges of all subjects were 1.4 - 4.7 deg in the Non-wear condition and 2.0 - 3.3 deg in the Wear condition. The scatter range in the Wear condition was less than that in the Non-wear condition. In the 10th set, the scatter ranges of all subjects were 1.4 - 3.7 deg in the Non-wear condition and 1.8 - 3.1 deg in the Wear condition. The scatter range in the Wear condition was less than the Non-wear condition in the both sets. Focused on the individuals, most of subjects had the less standard deviation in the Wear condition than that in the Non-wear condition in the 1st set. On the other hand, in the 10th set, most of subjects had the larger standard deviation in the Wear

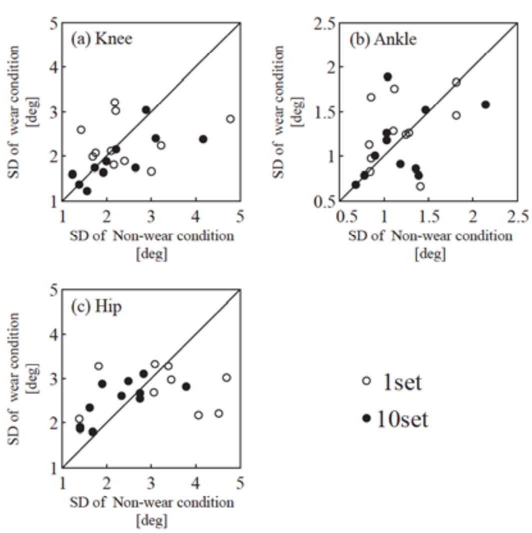

Figure 4 The standard deviation of each joint angle in the knee joint maximum flexion.

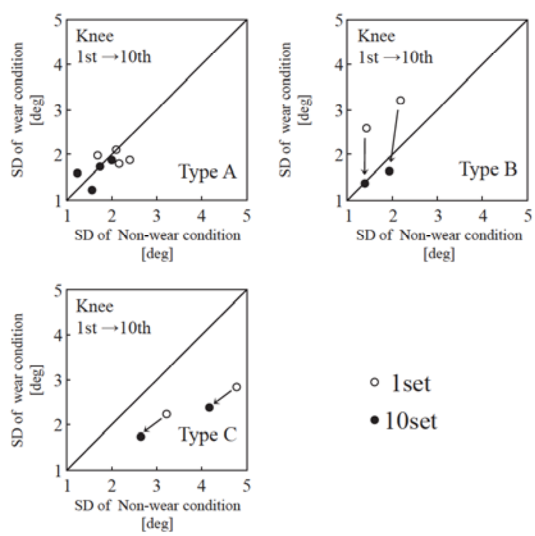

Figure 5 Election of typical example.

condition than that in the Non-wear condition. In summary, by wearing the knee supporters, the stability of the knee joint in the squat under the fatigue condition was improved. On the other hand, the stability of the hip joint was reduced because hip joint compensates the fatigue of knee joint.

2. The tendency of each type in the viewpoint of the standard deviation of the knee joint angle. According to the result of this study, it was possible to divide the subjects into three types based on the standard deviation of the knee joint angle at MKF (Figure 6). Figure4 (a) showed 4 subjects of Type A. Regardless of the conditions and sets, the knee joint angle of Type A at MKF was stable (1st set: Wear condition 1.79-2.10deg, Non-wear condition 1.76-2.42deg. 10th set: Wear condition 1.22-1.88 deg, Non-wear condition 1.59-2.00deg.). It was considered that the subjects of Type A were able to perform the similar knee flexion motion in the both conditions. Figure4 (b) showed 2 subjects of Type B. In the first set, the standard deviation of knee joint of Type B was larger in the Wear condition than in the Non-wear condition(1st set: Wear condition 2.57-3.21deg, Non-wear condition 1.45-2.21deg.). In this result, the knee supporter might reduce the knee stability for the subjects who were able to perform the knee flexion stably without the knee supporters. In this case, we must be careful to injury of the other joints or muscles near the knee joint because the subjects may alter their natural motion with the knee supporters into the clumsy motion. Figure4 (c) showed one subject of Type C. In both the 1st set and 10th set, the standard deviation of knee joint in the Wear condition was less than that in the Non-wear condition(10th set: Wear condition 2.37-2.39deg, Non-wear condition 3.12-4.19deg.). In this result, the athlete who had injury experience with the worse stability might improve the stability of the knee joint motion by wearing knee supporters. The knee supporters used in this study is for rehabilitation activities and returning to sport activities. The knee supporter is made of soft materials to prevent injury during sports activities. The flexion limit of the knee supporters is less than the others. We inferred that this kind of supporters influenced the results of each subject differently because of individual physical strength and muscular strength and the characteristics of the knee supporters mentioned above. We considered that it is needed to improve the knee supporter that can protect other joints and muscles. This study could examine the effect of knee supporter from the performance. We could not, however, examine the stability of inside around bone and ligament with the knee supporter. In the future research, we must examine the influence to the inside of inner knee joint wearing knee supporters.

CONCLUSIONS: The purpose of this study was to clarify the effect of the knee supporter in the continuous squat motion under the fatigue condition. The results were summarized as follows; 1) the influence of knee supporter to the squat motion was different according to the subjects' characteristics, but in Wear condition, almost all subjects was getting to be improved the stability of knee flexion-extension motion. 2) In Wear condition, the stability of the hip joint was decreased gradually while fatigued, because the hip joint was the compensation of knee flexion-extension motion. 3) In the variation of the changes in the knee joint flexion-extension motion from the 1st set to 10th set, the subjects could be divided into three types. Further researches with competitive athletes as subjects are needed in order to consider whether an athlete should wear supports.

	SD of 1st set	SD of 10th set
Type A	Wear ≒ Non-wear	Wear ≒ Non-wear
Type B	Wear > Non-wear	Wear ≒ Non-wear
Type C	Wear < Non-wear	Wear < Non-wear

Figure 6 The tendency of each type in the viewpoint of the standard deviation of the knee joint angle.

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