CONSTRUCTING A SYSTEM TO EVALUATE EFFECTS OF SUPPORT TAPING FOR ANKLE INVERSION SPRAIN USING 3-D MOTION AND PLANTER PRESSURE

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Abstract: In the field of sports science, support taping for ankle inversion sprain has often been used. The motion of ankle joint would be limited with support taping for ankle inversion. In order to clarify the effects of the ankle taping and to examine characteristics of the taping, we had constructed a system to measure the distance between the metatarsus first head and the floor with 3D motion analysis system, and to measure the planter pressure patterns during the ankle inversion with pressure monitoring system. When the eight subjects were instructed to inverse their ankles as much as possible with and without taping, there was a difference in the distances between taping and no taping.

1 INTRODUCTION

In the field of sports and clinical medicine, support taping for ankle inversion sprain has been often used in case the ankle was unstable. (Morrison and Kaminski, 2007).

First, not only medical techniques but also engineering science techniques, there are various reports in order to evaluate the ankle inversion sprain mechanism. Chan and coworker studied that they had instructed subjects to stand at the two rotatable plates. (Chan et al, 2008). And then, they had measured subject's foot angles of extension and flexion at the each plate angle. Wei-Hsiu and coworker studied unilateral ankle strength ratio of inversion and eversion. (Wei-Hsiu et al, 2009). Wright and coworker used muscle model with computer simulations in order to evaluate the mechanism of ankle sprain occurrences and the relationship between ankle sprain occurrence and foot position at touch-down phase. (Wright et al, 2000). On the other hand, Willems and coworker studied gait patterns and foot biomechanics with 3-D analysis and planter pressure distribution, and indicated that it was necessary to pay the special attention to gait patterns and foot biomechanics for effective prevention and rehabilitation of ankle sprain. (Willems et al, 2005).

To turn to the next point, there were researches about ankle taping to prevent the ankle inversion sprain. O'Sullivan and coworker had studied how the ankle taping effects the planter pressure in walking. (O'Sullivan et al, 2008). Recurrence of ankle sprain was common among athletes. Even though ankle taping reduces the risk of injury, its mechanism remains unclear. Sawkins and coworker studied placebo effects of the ankle taping. (Sawkins et al, 2007).

A purpose of taping is to limit the ankle movement. We are to evaluate the effects of support taping for ankle inversion sprain in the static position. To begin with, in this study, we decided to evaluate the effects of support taping for ankle inversion sprain in the static position. We developed methods with which to measure and analyze the degree of ankle inversion, the planter pressure, and the foot contact area.

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2 METHOD

[Measurement equipment system] Fig. 1 shows the system which evaluated the effects of ankle taping. This system consisted of 3-D motion capture system (OPTOTRAK CERTUS, Northern Digital Inc.), planter pressure measuring system (BIG-MAT, Nitta Corporation), and analyzing system. On calculation, we used MATLAB (Version 7.2.0.232 (R2006a)).

Kinematic data was acquired using an OPTOTRAK motion analysis system. This system helps to calculate skin marker positions. The coordinate system in the OPTOTRAK was explained: The direction that moves from the left to the right is x axis. A vertical direction to ground is y axis. The direction going directly to x axis and y axis is z axis. In this system, we were able to calculate the distance between the light source of OPTOTRAK and markers. In that case, if the OPTOTRAK was located on vertical position to the ground, the marker was sometimes not recognized, so the OPTOTRAK was placed at slope.

Markers were positioned on four points (A,B,C,D) in the floor plane, right and left coracoides (E,F) measuring the shake of the body, 10 cm under the centre of patella measuring the movement of the knee joint (G), the middle point of medial malleolus and lateral malleolus which measured the shake of foot joint (H), metatarsus-fourth head (J) and metatarsus-first head (I) which marker helped us to evaluate the degree of ankle inversion.

3D motion data was collected at 50 Hz for 10 sec while the subject was performing the instructed motion. BIG-MAT data was collected at a frequency of 50 Hz. Spatial resolution was 10×10 mm.

On the planter pressure system, we used sensor mat which consisted of 1929 × 880 pressure detecting cells, and measured the pressure during the subjects were standing and doing the ankle inversion. Measurement range was from 0.3 mgf to 3.0 kgf, and the resolution was 0.0140 kgf. Planter contact areas were the areas which were the right side of the foot detected with planter pressure system, and then the planter pressure was this right side pressure. We made the function which extracted the planter pressure of the right foot using the mask processing.

【Taping】
The taping method is described as follows: underwrap (70 mm wide), cotton tape (38 mm wide), and elastic tape (50 mm wide) were used.

The order of taping is described as follows: underwrap taping, anchor, star up, anchor, horseshoe, circular, heel lock, figure of eight, anchor, and overlap were applied. Taping was applied only to their right foot.

【Measurement method】
Eight healthy right-handed subjects volunteered to participate in this study. Subjects were obtained informed consent. Subjects with an adverse skin reaction, with a lower limb injury in the past six months were excluded. Measurement time was 10 sec. The subjects were performing the instructed motion. The things which we instructed the subjects are described as follows:

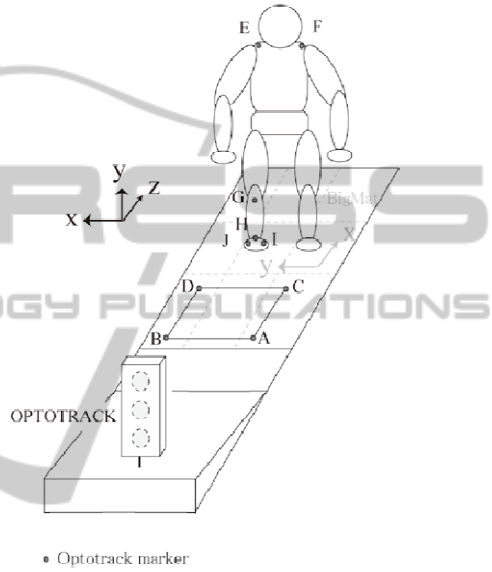

Figure 1: Outline of measurement apparatus.

(1) The subject performed first 3 cycles with taping and next 3 cycles without taping. The subjects were instructed to expand their foot at the breadth of their shoulders level in standing position, and look at a distant to prevent them from looking down at the floor.
(2) They inverse the ankle as far as they can, and they keep this position until the end of measurement.

Needing to know the time when subjects inverted their ankle as far as they could at first, we calculated this time with differential and smoothing filters (Xu and Xiao, 2000).

3 RESULTS

The distance from the metatarsus first head to the floor using the way we developed is shown in Fig. 2. The line was observed without taping, the dot line

was observed with taping. At 0-2 s the distance was almost constant, because the subject kept their standing position. After 2 s, the more he inversed the inversion, the more the distance increased. About 3 s he felt that it was difficult for him to increase the degree of the ankle inversion so he kept this position until the end of measurement. That was why the angle was almost constant. On this result, the threshold time without taping was 3.36 sec, and that time with taping was 3.66 sec.

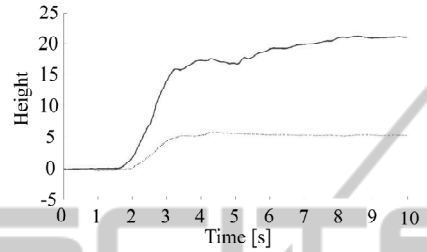

Figure 2: Distance from the metatarsus first head to the floor.

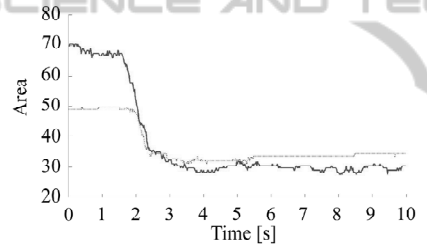

Figure 3: Contact areas of right foot.

Contact areas of right foot with ankle inversion were shown in Fig. 3. We normalized the foot contact areas of the right foot dividing by the foot contact areas of both right and left sides at their static position. Solid line shows the foot contact areas without taping, and the dot line shows the areas with taping. At the start of the experiment, the foot

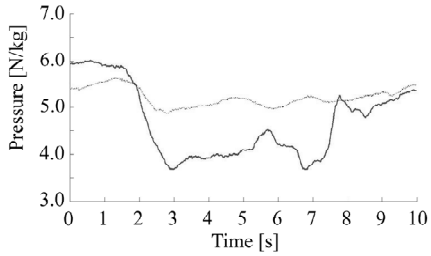

Figure 4: Planter pressure of right foot.

contact areas with taping were smaller than the areas without taping. The subject kept their standing position at first, so the foot contact areas without taping were almost constant. After that, the more he increased the degree of the ankle inversion, the more foot contact areas with and without taping were decreased.

About 3 sec, he realized that it was difficult for him to more increase the degree of ankle inversion. So after that the foot contact areas were almost constant.

In this study, we normalized planter pressure dividing by their weight (Fig. 4). Solid line shows the foot contact area without taping, the dot line shows the area with taping. The subject keeping their standing position and didn't move at 0-2 s, the planter pressure wasn't constant. Without taping, the more the degree of ankle inversion increased, the more the planter pressure decreased. After 3 s the subject wasn't used to try to increase the degree at first, so the pressure was constant until the 7th s. Then, he got used to increase the angle. There was almost no planter pressure difference between with or without taping.

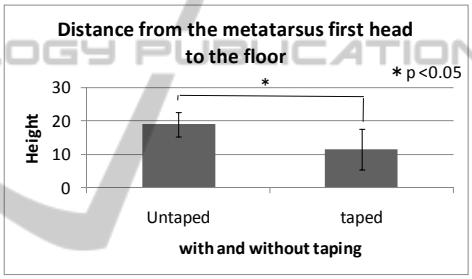

Figure 5: Distance from the metatarsus first head to the floor for taped and untapped conditions.

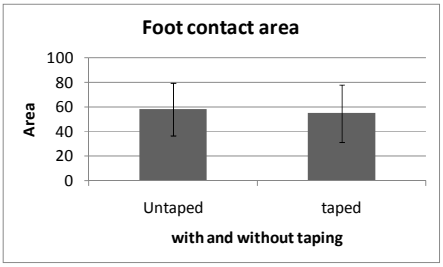

Figure 6: Foot contact area for taped and untapped conditions.

We show the distance from the threshold time to the end of the measurement in Fig. 5. Average distance of eight subjects without taping was 18.92, and the standard deviation was 3.64. Average distance of eight subjects with taping was 11.59, and the standard deviation was 6.12.

The distance from the metatarsus first head to the floor without taping group (18.92 ± 3.64) was significantly larger than that for the taping groups (11.59 ± 6.12, respectively, $p < 0.05$).

In Fig. 6, we calculated the foot area. The average area without taping was 57.65, and standard deviation was 21.41. The average area with taping was 54.53, and standard deviation was 23.31.

Broadly speaking, there seemed to be difference. Thought, we didn't have 5 % significant difference between no taping and taping with t-test.

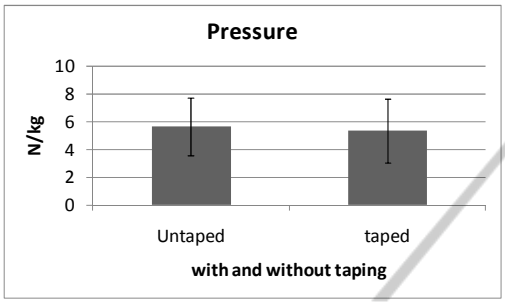

Figure 7: Pressure for taped and untapped conditions.

In Fig. 7, we calculated the pressure of eight subjects. The average pressure without taping was 5.65 [N/kg], and standard deviation was 2.10 [N/kg]. The average pressure with taping was 5.34 [N/kg], and standard deviation was 2.28 [N/kg]. We didn't have 5 % significant difference between no taping and taping with t-test.

4 DISCUSSION

Results suggested that the time length from the start time of ankle inversion to the threshold time depended on their feelings of insecurity, and the more subjects felt insecurity of their ankle inversion, the more their pressure was decreased.

In Fig. 3, strange to say, the degree of the ankle inversion has little to do with the foot contact area. That must be why at the maximum inversed potion, right side of the right foot contacted at the floor.

The result of Fig. 4 indicated that the planter pressure began to increase at 6-7 s. This indicated that at first he couldn't help being feared and kept the inversed position for a few seconds, which made him feel like reducing the fear.

5 CONCLUSIONS

1) In this study, we develop methods to evaluate the effects of support taping for ankle inversion sprain in the static position. Analysing the degree of ankle inversion, we calculated the distance from metatarsus first head to the floor, the planter pressure, and the foot contact areas with eight subjects.

2) Average distance of eight subjects without taping was 18.92, and the standard deviation was 3.64. Average distance of eight subjects with taping was 11.59, and the standard deviation was 6.12.

The distance from the metatarsus first head to the floor without taping group (18.92 ± 3.64) was significantly larger than that for the taping groups (11.59 ± 6.12, respectively, $p < 0.05$).

The average area without taping was 57.65, and standard deviation was 21.41. The average area with taping was 54.53, and standard deviation was 23.31.

The average pressure without taping was 5.65 [N/kg], and standard deviation was 2.10 [N/kg]. The average pressure with taping was 5.34 [N/kg], and standard deviation was 2.28 [N/kg].

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