

Research on the treatment of ankle instability after inversion sprain

- Comparison between taping and application of ankle brace -

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Abstract:

【Objective】 Inversion sprain of ankle is one of the many inquiries caused by sports activities, and it is liable to repeat recurrence. This research aims to compare the effect of taping and applying brace for an increase of inversion sprain of ankle and delay in reaction time of peroneus muscle, both of which are caused by jumping side to side after inversion sprain of ankle. **【Method】** Subjects were 11 females with a history of inversion sprain (Average age: 15 ± 1.5 , Average height: 158.0 ± 2.5 cm, Average weight: 53.0 ± 4.2 kg). We let them do jumping side to side under three conditions of in bare feet, with brace, and with taping. We measured inversion angles of ankle and surface electromyogram of peroneus muscle in quick turn during jumping side to side. The inversion angle is the angle created by lower limb and the vertical axis of heel bone. To measure the reaction time of peroneus muscle, we set the time of standing in quick turn to 100% and normalized the time needed to start the activities of peroneus muscle. We conducted one-way analysis of variance and used Bonferroni method for multiple comparison analysis testing for three conditions of in bare feet, with brace, and with taping. The significance level was set at lower than 5%. **【Results】** The inversion degrees we got were 12.6 ± 1.8 degrees in bare feet, 5.8 ± 1.5 degrees with brace, and 5.0 ± 1.0 degrees with taping, indicating that degrees with brace and those with taping were significantly lower than those in bare feet. The reaction time of peroneus muscle was $53.1 \pm 1.5\%$ in bare feet, $44.4 \pm 1.5\%$ with brace, and $44.1 \pm 2.2\%$ with taping, indicating

that reaction time with brace and that with taping was significantly lower than that in bare feet. We did not observe any significant difference in inversion angle and reaction time of peroneal muscle between with brace and with taping. **【Conclusion】** Both brace and taping decreased the ankle inversion angle, and they consequently shortened the reaction time of peroneal muscle. This research successfully clarified that applying taping and brace is effective to decrease instability to a certain degree for people with established inversion sprain.

【Introduction】

Ankle sprain mostly occurs in sports activities. In particular, the occurrence rate of inversion sprain is as high as 67-85% of all sprains¹⁾. Moreover, injury of anterior talofibular ligament accounts for 75-73% of inversion sprain and reportedly yields a high frequency of ankle instability²⁾. In addition, some reports indicate that more than 80% of people will damage anterior talofibular ligament again once they damaged it in the past³⁾. We have so far reported on an increase of ankle inversion angle and a delay in the reaction time of peroneal muscle in sideways jumping⁴⁾. In the report that examined the braking force created by brace to improve ankle instability with the help of X-ray photography, we found that brace improved ankle bone inclination more than bare feet without brace did when ankle is inverted forcibly by external force⁵⁾. We clarified that taping improved both inversion angle of ankle and reaction time of peroneal muscle in repetitive sideways jumping⁶⁾. Our past research results clarified that both applying brace and taping are effective to improve ankle instability to a certain degree.

This research is intended to compare applying brace and taping to know how much

each of them can improve inversion angle of ankle and reaction time of peroneal muscle.

【Method】

1. Subjects

We studied 11 females who have established inversion sprain (Average age: 15.0 ± 1.5 years old, Average height: 158.0 ± 2.5 cm, Average weight: 53.0 ± 4.2 kg). For ethical considerations, we conducted the research in compliance with the Declaration of Helsinki, and we explained the objective and intent of the research to them in advance and obtained prior consent for participation from them.

2. Method

We let the subjects do repetitive sideways jumping in three conditions: in bare feet, with brace, and with taping. The brace we used was Exaid Ankle 3 made by Sigmax (Fig. 1), and we used three sizes of S, M, and L depending on the foot length of the subjects. We used 50 mm wide stretchy adhesive tape (NITREAT EB-50 tape made by Nitoms, Inc.) and applied two ways of figure 8 ankle taping and heel rock taping (Fig. 2) for taping. The method of doing sideways jumping complied with the Implementation Guidelines of the New Physical Fitness Test⁷⁾ by the Ministry of Education, Culture, Sports, Science and Technology. We drew a line and

two parallel lines on both sides in the position 100 meters away from the center line (Fig.3). Measurement time was 20 seconds. We asked the 11 subjects orally to land on their feet within the line stuck to the floor after quick turn because we wished them to land on feet at the same place as much as possible. In addition, we instructed them to make the angle of feet as close to 0° as possible and do repetitive sideways jumping at their maximum speed.

3. Measurement items

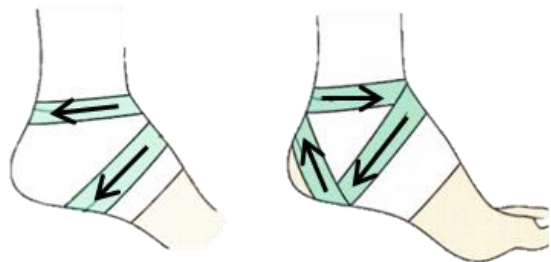
We measured two items: ankle inversion angles in quick turn and reaction times of peroneal muscle calculated from waveforms of surface electromyogram.

① Measurement of ankle inversion angles

We videotaped movements in quick turn during repetitive sideways jumping from the back with the help of a digital video camera (HDR-HC9 made by Sony Corporation). In compliance with the method developed by James et al⁸⁾, we measured the angle made by lower leg and vertical axis of heel bone, and designated inversion angle as positive and extroversion angle as negative. We applied taping on the vertical axis of lower legs and heel bones to measure inversion angles using videos we shot from behind. We used image processing software (Image J) to measure ankle inversion angles (Fig. 4).



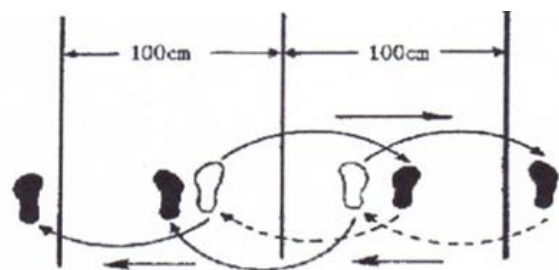
(Fig. 1) Exaid Ankle 3 made by Sigmax



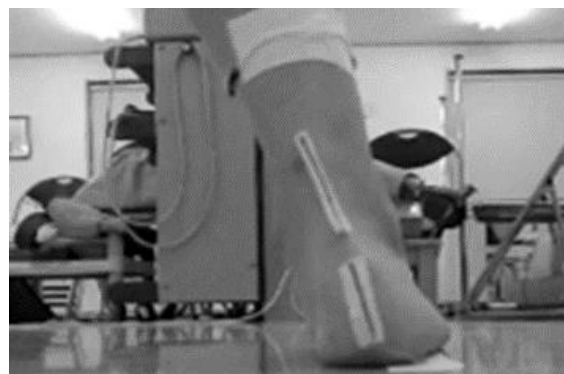
(Fig. 2) Taping method

Left : figure 8 taping

right : heel rock taping



(Fig. 3) repetitive sideways jumping



(Fig. 4) Measurement of ankle inversion angles

② Calculation of the reaction time of peroneal muscle

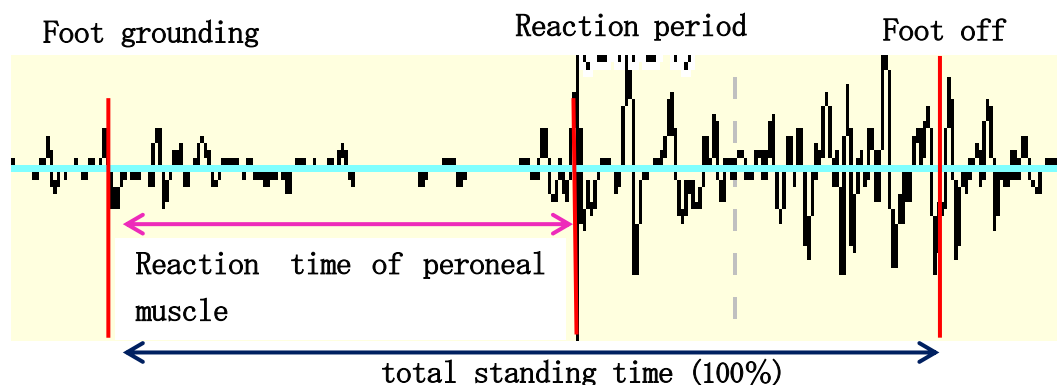
While measuring inversion angles, we simultaneously measured the electromyogram of peroneal muscle in quick turn during repetitive sideways jumping by synchronizing the electromyography (Vital Recorder 2, Version 2.6.1.908 made by Kissei Comtec Co., Ltd.) with the video camera. Following instructions by Aldo⁹⁾, we attached electrodes to the position three fingerbreadths away from peroneal muscle at 2 cm intervals. We confirmed the movements from landing to jump-up in quick turn from the video and designated the standing time as total standing time. We figured out the reaction time of peroneal muscle by normalizing the time before start-up of peroneal muscle activity on the condition that total standing time is 100% (Fig. 5).

The formula for computation is (Reaction time - landing of sole) / (Jumping from ground - landing of sole) x 100 = Time of peroneal muscle (%).

Furthermore, we used images and values of surface electromyogram whose toe out angles are close to 0° that we picked at random from all results of 20-second long repetitive sideways jumping.

4. Analytical method and statistical treatment

We used IBM SPSS Statistical ver. 25 (released by IBM Japan) for statistical analysis, and conducted one-way analysis of variance for each of in bare feet, with brace, and with taping. We used the Bonferroni method for multiple comparison tests and set the significance level at lower than 5%.



(Fig. 5) Calculation of the reaction time of peroneal muscle

(Table.1) Comparison between taping and application of ankle brace

	bare feet	brace	taping
inversion angle(°)	12.6±1.8	5.8±1.5 *	5.0±1.0 *
reaction time of peroneal muscle (%)	53.1±1.5	44.4±1.5 *	44.1±2.2 *

Numbers are mean and standard deviation

*P<0.05 Those with a significant difference from bare

【Research results】

The inversion angles were $12.6 \pm 1.8^\circ$ for in bare feet, $5.8 \pm 1.5^\circ$ for with brace, and $5.0 \pm 1.0^\circ$ for with taping. That is, with brace and with taping showed significantly lower values than in bare feet, showing that both with brace and with taping improved the inversion angle significantly.

Reaction times of peroneal muscle were $53.1 \pm 1.5\%$ for in bare feet, $44.4 \pm 1.5\%$ for with brace, and $44.1 \pm 2.2\%$ for with taping. That is, with brace and with taping gave significantly lower values than in bare feet, showing both with brace and with taping improved the delay in reaction time of peroneal muscle significantly. We did not observe any significant difference in inversion angle and reaction time of peroneal muscle between with brace and with taping.

【Discussions】

As we have already stated, we applied brace and taping to females who have established inversion sprain and let them do repetitive sideways jumping. Based on the results, we observed that both inversion angle and reaction time of peroneal muscle decreased significantly after they did sideways jumping and quick turn repetitively. In our past studies, taping decreased ankle inversion angle from $13.1 \pm 3.1^\circ$ to $5.5 \pm 1.8^\circ$ and decreased reaction time of in bare feet from $56.2 \pm 8.4\%$ to $47.0 \pm 4.6\%$. These values in our past studies are very close to those we obtained in this research, reconfirming the effect of taping⁶⁾. We also confirmed the effect of applying brace because we observed that with brace realized

a significant improvement as compared with in bare feet. We can indicate that taping is as effective as with brace because we did not observe significant differences between them in terms of efficacy.

Ankle instability can be discussed from two aspects of structural instability and functional instability. Structural instability is defined as the state where ankle deviates from the physiological range of joint motion because of damage on joint constituent and ankle instability remains because of increased accessory movements¹⁾. Inversion sprain of ankle is supposed to leave structural instability caused by relaxation and rupture of ligament because it is associated with a high incidence of ligament damage. Functional instability is defined as the state where ligament damage remains after inversion sprain of ankle regardless of whether or not structural instability exists¹⁾. Fukubayashi et al.¹⁾ indicate that a proprioceptive organ exists in the lateral ligament of ankle and that proprioceptive sensibility deteriorates because of ligament damage caused by inversion sprain of ankle. Ohnuma et al.¹⁰⁾ indicate that reaction time of peroneal muscle is delayed because of functional deterioration resulting from ligament damage caused by sprain of ankle, arthrochhalasis caused by inversion sprain of ankle, and muscular depression of peroneal muscle after inversion sprain of ankle. In general, damage of proprioceptive organ caused by ligament damage is supposed to be the major cause of ankle instability.

In this research, we evaluated structural instability from inversion angle and

functional instability from the reaction time of peroneal muscle. The inversion angles of ankle in bare feet that were $12.6 \pm 1.8^\circ$ in our past studies improved significantly to $5.8 \pm 1.5^\circ$ with brace and $5.0 \pm 1.0^\circ$ with taping. We compared $5.3 \pm 1.7^\circ$ ⁶⁾ that we obtained from inversion angles of healthy people in our past studies with the values we obtained in this research, and found that both with brace and with taping contributed to improving the instability to a certain degree. The reaction times of peroneal muscle improved significantly from $53.1 \pm 1.5\%$ in bare feet to $44.4 \pm 1.5\%$ with brace and to $44.1 \pm 2.2\%$ with taping. These values after improvement decreased at a faster pace than $49.9 \pm 5.0\%$ ⁶⁾ that we obtained from healthy people in our past studies.

Both brace and taping decreased the ankle inversion angle, and they consequently shortened the reaction time of peroneal muscle. This shows that improving structural instability can improve functional instability. That is, functional instability was not affected much by a decrease of afferent information because of damage on mechanoreceptor resulting from sprain. Rather, we suppose that abnormal positional relationship of ankle caused functional instability.

No past studies exist on the existence of damage caused by sprain and amount of its afferent information, and causes of functional instability are still unknown. However, this research indicates that normalizing the position of joints affects functional instability greatly. This research successfully clarified that

applying taping and brace is effective to decrease instability to a certain degree for people with established inversion sprain. The advantage of taping is the ability to adjust fixing strength and way of application in detail. However, it has a disadvantage, too. It is reported that taping decreased the control power by 18-40% in 10 minutes¹¹⁾. Therefore, detailed research is necessary on the effect of taping during exercise that lasts longer than 10 minutes. In addition, variation between individuals cannot be avoided because knowledge of kinds of tapes, experience in taping, and application technique of the therapist are critical for taping.

On the other hand, we can point out the advantage of applying brace. Because we use magic tape to adjust brace, it is possible to readjust the brace and increase its control power easily on the spot during long sports activities. On the other hand, applying brace has a disadvantage that adjusting strength of fixing and other factors cannot be done easily because off-the-shelf brace cannot be adjusted to the figure and size of foot of each person easily.

This research indicates that no difference exists between taping and applying brace, though each of them has both advantages and disadvantages. This means that it is advisable to choose easier way of application in consideration of various factors to obtain a desired effect.

【Summary】

• We compared the effectiveness between taping and applying brace for ankle

inversion angle and reaction time of peroneal muscle.

- Taping and applying brace significantly improved inversion angle and reaction time of peroneal muscle in quick turn during repetitive sideways jumping.

- It was clarified that applying brace is as effective as taping.

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