KINEMATIC ANALYSIS OF AN ANKLE INVERSION SPRAIN
— A NEW EVALUATION TECHNIQUE —

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Abstract

The purpose of this study was to measure and analyze peroneus longus reaction time (PRT) as well as ankle movement during ankle sprain simulation. PRT was measured for six control ankles and six unstable ankles with an inversion ankle sprain (1 male and 5 females per group, respectively) using an ankle inverting platform and high speed camera. The unstable group showed a significantly slower PRT (58.8±8.7 ms) than the control group (46.5±8.1 ms). The inversion angular velocity was significantly faster in the unstable group (152.8±62.6 d/s) than the control group (83.2±38.4 d/s). There was no significant difference between the two groups regarding ankle eversion time. Our results indicate that it is important to lead an unstable ankle to reduce inversion angular velocity to prevent recurrent inversion ankle sprain.

(key word: Ankle sprain, peroneus longus muscle, kinematics, simulation, sports)

Introduction

Ankle sprains are one of the most common athletic injuries1,2. Sprains can lead to an unstable ankle, which is related to the latency of the peroneus longus reaction time (PRT). Lofvenberg et al.3 showed that the PRT in patients with functional ankle instability was significantly prolonged. Moreover, Osborne et al.3,4 found that while ankle disk training reduced PRT, there were no significant differences between unstable ankles and control ankles in the reduction of PRT with training. Ishii et al.1 reported that functional training did not significantly reduce the PRT of unstable ankles. On the other hand, ankle disk training has been found to decrease reinjury rates in patients with unstable ankles. These studies suggest that PRT does not adequately evaluate instability after ankle sprain.

Few studies have performed ankle kinematic analysis of simulated ankle inversion sprains, and comparison of unstable and stable ankle movements during simulated ankle inversion sprain is therefore necessary. The purpose of this study is to measure and analyze PRT as well as ankle movement during ankle sprain simulation of an unstable ankle group and control group, and to suggest a new evaluation technique for preventing recurrent ankle sprains.

Methods

Subjects:

Twelve subjects (mean age: 24.0±1.9 years, height: 160.9±7.2 cm, weight: 53.3±7.0 kg) participated in this study. Six were included in the control group and six with inversion sprains in the chronic unstable ankle group (1 male and 5 females per group, respectively.) An unstable ankle was defined as at least one significant ankle inversion sprain, followed by repeated sprains and a subjective feeling of the ankle giving way. The testing procedures were explained to all subjects at the beginning of the testing session.

Procedures:

An ankle inverting platform was constructed to simulate an ankle inversion sprain. By turning off a switch, the platform can be suddenly tilted in an inverted direction to an angle of 30° with ankle plan-

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Fig. 1. The ankle inverting platform. By turning of a switch, the platform is suddenly tilted in an inverted direction to an angle of 30° with ankle plantar flexion of 10°.

Fig. 2. The experimental setup. The leg to be tested was placed on the platform with the medial aspect of the foot in line with the center of the rotation of the platform. Reflecting marks were placed on the posterior surface of the ankle to measure the changing leg heel angle.

Fig. 3. Measurement of the peroneus longus reaction time (PRT). PRT was defined as the time from tilting of the inverting platform to the time when the magnitude of the EMG signal reached or exceeded a level three standard deviations above the baseline activity.

tar flexion of 10° (Fig. 1). Kinematic data was recorded using a Has-200 high-speed camera (Detect Co., Japan) and was analyzed with software (Fig. 2). Reflecting marks were placed on the posterior surface of the ankle to measure the changing leg heel angle (LHA). Inversion angular velocity was then calculated using the LHA. The PRT, i.e., the time until the peroneus longus muscle started to respond after platform tilting, was measured with an electromyographic system (EMG). EMG signals were sampled at 1000 Hz and filtered with a band-pass filter of 20 to 500 Hz. PRT was defined as the time from tilting of the inverting platform to the time when the magnitude of the EMG signal reached or exceeded a level three standard deviations above the baseline activity; the signal had to last for at least 100 ms (Fig. 3).

Statistical analysis:

PRT, inversion angular velocity and eversion time were evaluated with a t-test between the control and unstable ankle group.
Results

The unstable group showed a significantly slower PRT (58.8 ± 8.7 ms) than the control group (46.5 ± 8.1 ms) (Fig. 4). The inversion angular velocity was significantly faster in the unstable group (152.8 ± 62.6 d/s) than the control group (83.2 ± 38.4 d/s) (Fig. 5). However, regarding the time when eversion started, the unstable group (154.2 ± 20.8 ms) was almost equal to the control group (142.5 ± 5.8 ms) (Fig. 6).

Discussion

This study showed that the PRT in patients with an unstable ankle is significantly more prolonged than in those with a stable ankle, supporting the above-mentioned previous studies. On the whole, the PRT in this study was shorter than in previous studies (60–80 ms). The reason for this was thought to be related to the ankle position on the platform, which in this study was 10° plantar flexed; an ankle joint placed at this position will easily suffer an ankle inversion sprain. Another reason for this was thought to be the distribution of the body weight on the platform. Some studies used an experimental set-up with on both feet equally distributed body weight. In this study, almost full weight bearing of

Fig. 5. Mean inversion angular velocities of the unstable and control groups. The inversion angular velocity was significantly faster in the unstable group than the control group.

Fig. 6. Mean ankle eversion times of the unstable and control groups. There was no significant difference between the two groups. * n.s.: not significant.

Fig. 4. Mean peroneus reaction times (PRT) of the unstable and control groups. The unstable group showed a significantly slower PRT than the control group.
the measured leg was considered to simulate the inversion ankle sprain more realistic than the body weight equally distributed on both legs. The unstable ankle group showed a higher inversion angular velocity during sudden fall compared to the control group. Fung et al.\textsuperscript{5)} suggested that the tensile strength of the ligament is related to the stretched velocity of the ligament. We found that patients with unstable ankles easily injure their lateral ankle ligaments. Following that ankle inversion arised on the platform tilting, ankle eversion arised after ankle inversion was finished. However, regarding the time when eversion started, the unstable group was not significantly different from the control group (Fig. 7). Therefore, it is suggested that a high inversion angular velocity causes recurrent ankle inversion sprain in process of ankle inversion sprain occurrence. To prevent ankle inversion sprain, it might therefore be important to lead an unstable ankle to reduce inversion angular velocity.

It was previously reported that not only is PRT improved by ankle disk training, but so too is the re-injury rate in patients with unstable ankles. An important factor in preventing recurrent ankle sprain during tilting is therefore the ankle inversion angular velocity as well as the PRT. Accordingly, we suggest that kinematic analysis of simulated ankle sprains is important. In the future, we plan to analyze ankle movements at an angle lower than 30° to accurately determine the safest platform angle.

The findings will help reflect ankle functional instability during simulated inversion ankle sprains and be useful in kinematic evaluations.

**Conclusion**

This study supported the delayed PRT with unstable ankles suggested in previous studies. Despite instability, the ankle eversion time was the same in both the unstable and control groups. The unstable ankle group showed a higher inversion angular velocity during sudden fall compared to the control group. We concluded that kinematic analysis, as well as PRT analysis, of simulated ankle sprains might be important.

**References**