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Effect of Ankle Taping and Brief Exercise on Lower Extremity Kinematics of Healthy Adults During Vertical Drop Landing

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국문요약

수직착지시 발목관절의 운동형상학적(kinematic) 분석

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이 연구의 목적은 발목에 테이핑을 한 후 40 ㎝의 높이에서 한 발로 수직착지를 할 때 발목관절에서의 테이핑 효과를 분석하는 것이었다. 대상자는 20대의 건강한 성인 14명 (남자 4명, 여자 10명) 이었다. 대상자에게 적용한 조건은 테이핑 전, 테이핑 적용, 30분 동안 트레드밀에서 걷기, 테이핑 제거상태 이었고 맥리플렉스(MacReflex)를 이용하여 발끝이 지면에 닿은 상태에서 발목이 최대 배측굴곡(dorsiflexion) 되기까지 걸린 시간, 발목관절 각도변화, 각속도를 측정한 후 반복측정에 의한 분산분석으로 비교하였다. 그 결과 네 개의 조건간에는 통계학적으로 유의한 차이가 없었다($p>.05$). 따라서 발목 테이핑은 수직착지시 발목의 배측굴곡을 제한하는 효과는 없다고 판단된다.

핵심단어: 발목 테이핑; 수직착지; 운동형상학적 분석.

Introduction

Ankle sprains are the most frequently reported injury in sport. The sport with the highest prevalence of ankle injuries is basketball, with over 50% of players having ankle joint problems that have

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resulted from ligament injuries (Brynnon and Renstrom, 1991). The lateral ligaments of the ankle are the most common site of injury in netball (Hopper, 1986; Hopper et al, 1999). Due to the high incidence of acute ankle sprain and sprain reoccurrence, many physicians, physical therapists, and athletic trainers attempt to prevent ankle injuries through the use of various taping/strapping techniques or ankle orthoses. Several studies have examined the effects of prophylactic bracing/taping on the incidence of ankle sprains in basketball (Garrick, 1977; MacKean et al, 1995; McCaw and Cerullo, 1999; Miller and Hergenroeder, 1990). To decrease the risk of an inversion sprain, traditional ankle taping or various commercially available ankle stabilizers have been used to provide functional stabilization to the joint. Ankle taping has become the principal means of preventing ankle sprains in sport.

On the other hand, landing has been studied extensively in biomechanics (Skelly and DeVita, 1996). The studies on biomechanical behaviors of the lower extremity in landing have been focused on prediction of impact forces (Defek and Bates, 1990), comparison of landing techniques (DeVita and Skelly, 1992), effects of landing velocities (McNitt-Gray, 1991), fatigue (Nyland et al 1999), skilled versus unskilled (McKinley and Peodotti, 1992), landing surfaces (Dufek and Bates, 1991), manipulations of landing distances, and heights and techniques (McNitt-Gray, 1991; Zhang et al, 2000). Landing after vertical or vertical -horizontal fall and the collision of the human body with the ground is a frequent occurrence in human locomotion. Landing from a jump is a task that is important to many sports. Previous studies have examined the effects of landing surfaces (Gross and Bunch, 1989), the manipulation of stiffness (DeVita and Skelly, 1992; Dufek and Bates, 1990; Mizarahi and Susak, 1982), or elastic energy storage, utilization and coordination (Dufek and Bates, 1990) on lower extremity joint kinetics.

The purpose of this study, therefore, was to determine the kinematics of the ankle for four different conditions (pretaped, taped, walking on the treadmill, removal of taping) during drop landing.

Methods

Subjects

The study consisted of 14 healthy adult (four males: age, 25.7±2 yrs; height, 177±7 ㎝; weight, 74.0±2 ㎏; and ten females: age, 23.8±2 yrs; height, 164±5 ㎝; weight, 54.7±7 ㎏) volunteers with ages ranging from 22~28 years. Each participant was asked to provide age, height, weight, and previous injury history. Individuals were excluded if they reported previous injury or current orthopedic problems in their backs, hips, knees, or ankles. The age, height, and weight characteristics of the subjects are summarized in Table 1.

No subject had orthopedic or neurological problems or has had an ankle injury during the past 5 years.

Instruments

Materials utilized for the taping were one and a half inch tape, foam prewrap[1],

1) Johnson & Johnson Products, Inc. USA

Table 1. Age, height, and weight characteristics of the subjects (N=14)

Variable	Male	Female
Age (yrs)	25.7±2*	23.8±2
Height (㎝)	177±7	164±5
Weight (㎏)	74.0±2	54.7±7

*Mean±SD

and adherent spray[2].

One force plate was embedded in a level walkway (10 m in length and 1.22 m in width). Reflective markers were placed on the lateral mid-thigh, knee joint, lateral malleolus, and the fifth metatarsal. Knee and ankle sagittal plane motion of the tested limb was recorded using the MacReflex video analysis system[3] at a rate of 50 ㎐. The distance between the camera and the subject was 3.7 m, measured from the center of the force platform.

Procedures

Subjects were asked to complete four tasks on one occasion. First, subjects stood on their dominant limb on a 40 ㎝ high platform that was placed 20 ㎝ from the edge of the force plate. The force plate was placed at where the subject was expected to land on from the hop. Subjects were asked to hop down in the way that they landed safely without the need to readjust the landing leg. Subjects completed 3 practice trials followed by 3 experimental trials. The arms were not constrained during the landings, but were generally held up in front of the subjects for balance. The ankle of the dominant limb was then taped by a certified athletic trainer. The taping configuration involved two circumferential anchor strips applied at the fore foot region and proximally at the lower 1/3 part of tibia. Three stirrups and horseshoes were applied in a basketweave configuration. Circulars were applied to fill in the gaps, followed by two heel locks. The taping methods were applied with the ankle in neutral, inversion-eversion, and dorsiflexion. The subject then repeated 3 hopping trials. The subject then walked for 30 minutes on a treadmill at a comfortable self-selected speed. Following a 5 minute rest, the subject again repeated the 3 hopping trials. After removal of ankle taping, 3 hopping trials were performed. Joint angular position and velocity were calculated from the kinematic data.

Statistical Analysis

One-way analysis of variance with repeated measures was used to examine the differences between the independent (initial hopping, hopping following taping, hopping following exercise, and hopping following removal of taping) and dependent variables of kinematic variables. A level of significance was set at $p<.05$.

2) Tuf-skin, Cramer Products, Inc., Gardner, Kansas 55030, USA.
3) Qualisys Inc, Glastonbury, CT, USA.

Table 2. Time from toe-impact to maximum ankle dorsiflexion

Conditions	Mean±SD	Range	p
Pre-taped	.17±.06	.09～.26	
Taped	.16±.05	.12～.27	.06
Exercise with taping	.16±.04	.10～.22	
Removal of tape	.14±.04	.10～.22	

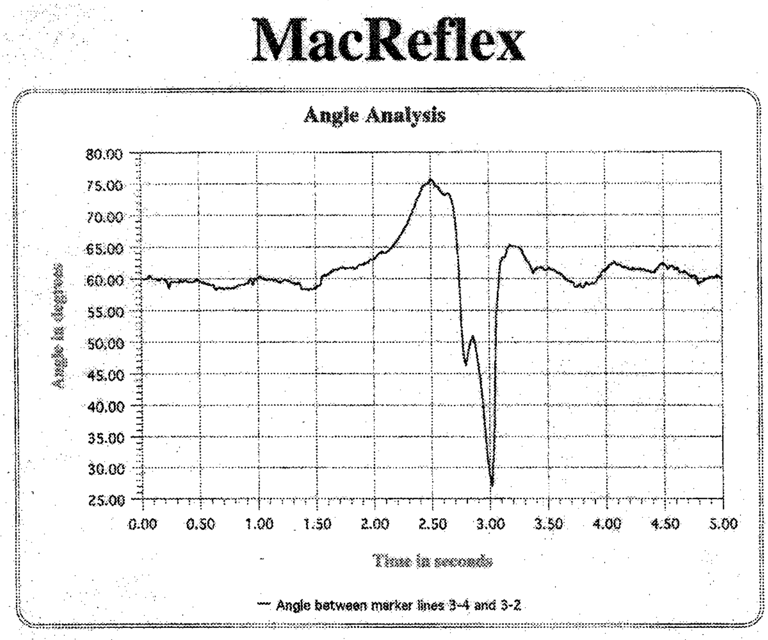

Fig 1. MacReflex record of the angle at ankle

Results

From the toe impact to maximum ankle dorsiflexion, the time was the shortest in the removal of tape condition. However, there were no statistically significant differences among 4 conditions (Table 2).

Figure 1 shows the ankle angle during the vertical drop landing.

From the toe impact to maximum ankle dorsiflexion, the degree of angle change was the shortest in the taped condition. However, there were no statistically significant differences among the conditions (Table 3).

Figure 2 shows the ankle angle velocity during the vertical drop landing from 40 ㎝ high platform.

Measuring the angular velocity at ankle from the toe impact to maximum dorsiflexion, the angular velocity was compared across the conditions. The degree of angular velocity change was the shortest in the taped condition, also. However, no

Table 3. Ankle angle among 4 conditions from impact to maximum dorsiflexion

Conditions	Mean±SD	Range	p
Pre-taped	24.95±9.27	11.85~44.54	
Taped	21.56±5.89	12.98~37.60	.60
Exercise with taping	23.32±5.84	10.00~30.09	
Removal of tape	23.46±5.11	16.62~31.75	

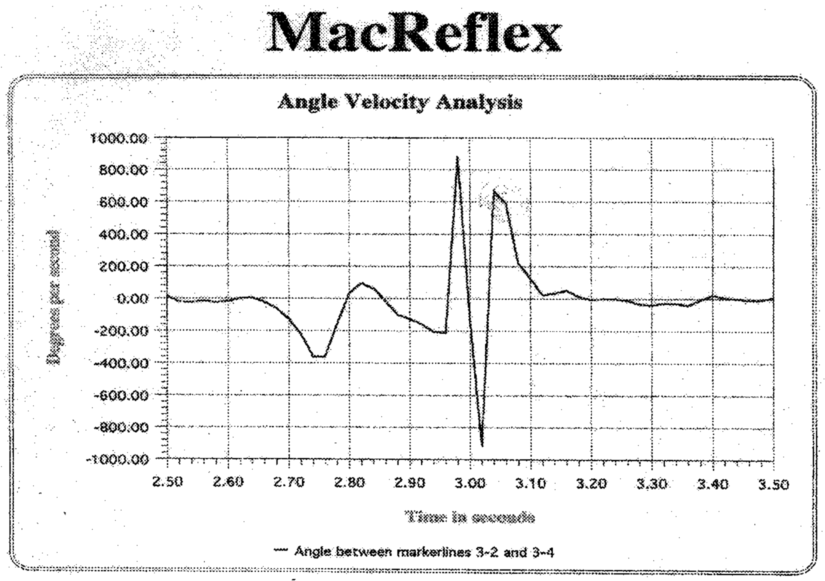

Fig 2. MacReflex record of the angular velocity at ankle

statistically significant differences in the angular velocity values were revealed among the conditions (Table 4).

Discussion

Ankle taping is commonly used by athletic trainers or sports physical therapists to protect ankle and to maximize its function during sporting activities (Firer, 1990). Nevertheless, the recommendations for or against the use of taping are sometimes

Table 4. Angular velocity among 4 conditions

Conditions	Mean±SD	Range	p
Pre-taped	154.24±46.73	100.96~249.18	
Taped	143.16±40.46	89.89~234.98	.59
Exercise with taping	151.29±46.44	83.33~237.61	
Removal of tape	163.36±60.27	99.98~317.47	

confusing and not so clear, ranging from prophylactic external stabilization of both ankle joints during all exercise, to refusal due to the assumed risk or adverse effect of ankle injury caused by restriction of joint movement (Hume and Gerrard, 1998). The positive effect of taping, therefore, is not so conclusive and the effect on lower limb kinetics and kinematics after exercise with ankle taping has not been widely studied (Shapiro et al, 1994).

Whereas taping was once thought to stabilize the ankle mechanically, this seems unlikely considering reports that show no measurable stabilizing effect of tape after as little as 20 minutes of exercise (Perlman et al, 1987). Presumably humans use kinasesthetic sense of information in anticipation of foot contact with a surface either to position the plantar surface before the support phase to attenuate forces causing inversion, or to command muscle support to sustain these forces, thereby preventing ligament loading, or both. By this reasoning, ankle sprains are caused by impaired foot position awareness resulting in inadequate use of these anticipatory maneuvers under conditions such as sports, when there is insufficient time to respond to the actual loading event (Robbins and Waked, 1998).

At the moment of toe impact, the time to peak ground reaction force was the shortest in taped condition and at the moment of heel impact, the time to peak ground reaction force of the taped condition was the shortest, also. This means, that in taped condition, the ankle joint has the shortest time to absorb the reaction force from the ground (Yi, 2001). From the toe impact to maximum ankle dorsiflexion, the time was the shortest in the removal of tape condition. However, there were no statistically significant differences among 4 conditions (Table 2). In the taped condition, the degree of angle change was the shortest, however there were no statistically significant differences among the conditions (Table 3). In addition, the degree of angular velocity change was also the shortest in the taped condition. However, no statistically significant differences in angular velocity values were revealed among the conditions (Table 4). This means that ankle taping doesn't provide sufficient stabilization to ankle dorsiflexion motion during the performance of drop landing.

The information mentioned above is of interest not only for athletes to improve training exercises but also for clinicians including physical therapists, because of the wide application of ankle taping in different types of sports and the dearth of study on landing impact to ankle with taping. The results of this study will provide useful information for physical therapists, athletic trainers, and other professionals related to sports to judge the injury prevention effect of ankle taping.

Limitations of this study were the small subject sample size, and a possible learning effect occurring during the performance of landing. Measures to exclude the order effects could not be applied in this study. Thus, claims based on this study should be interpreted with caution.

Conclusion

The results of this study suggest that ankle taping might provide insufficient mechanical restriction to ankle dorsiflexion motion during vertical drop landing.

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