

**A Biomechanical Study of The Stability
Among Athletes with Chronic Sprained
Ankle**

**Candy Wu, Elizebeth Leung
The Hong Kong Sports Institute
Ella Wai Yeung, Amy Fu, Aaron Leung
The Hong Kong Polytechnic University**

July 1997



香港康體發展局
HONG KONG
SPORTS DEVELOPMENT BOARD

Abstract

The objective of this study is to investigate the postural sway among athletes with chronic sprained ankle and the effect of external support on the postural sway. Thirteen subjects between the ages of 19 and 32 participated in this study. Subjects were recruited from the Hong Kong Sport Institutes, The Hong Kong Polytechnic University and The Hong Kong University. Subjects with a history of injury involving weight-bearing on an inverted leg resulting with pain over the lateral aspect of the ankle for three months or more were included. Subjects with bilateral ankle sprain, vestibular disease, and musculoskeletal injury affecting lower limb were excluded from the study. The study was carried out in the Locomotion Laboratory in The Hong Kong Polytechnic University. Subjects were tested on how still they could stand in single-leg stance position on a force-platform (AMTI) under the following situation; 1) injured-leg, eyes opened; 2) injured-leg, eyes closed ; 3) non-injured leg, eye open; 4) non-injured leg, eyes closed, 5) injured-leg with custom made elastic ankle support (Spenco), eye open 6) injured-leg with custom made elastic support (Spenco), eye closed, 7) injured-leg with basket-weave and heel-lock (1 1/2 " rigid tape, Strappal), eyes open, 8) injured-leg with basket-weave and heel lock (1 1/2 " rigid tape, Strappal), eye closed. During the trials, they were required to concentrate on keeping still on the force platform in stance position for 2 seconds and to correct their position as quickly as possible if a disturbance occurred during testing. The subjects performed each task four times consecutively before proceeding to the next task. The order of presentation of the tasks was randomised by drawing cards. Results of this study indicated that 54% of the subjects suffered from recurrent ankle sprain, 54% of them still suffered from chronic pain and had a sense of instability. Only 46% of them use external support, and only one subject used tape to protect his ankle during sport. Postural sway was significantly increased on the injured leg from 5.44 mm^2 to 7.96 mm^2 with eye closed ($t = -3.17, p < 0.05$). The postural sway was insignificant different between the injured and non-injured leg with eye opened. Taping had a significant effect in decreasing postural sway on the injured leg from 7.96 mm^2 to 5.9 mm^2 ($t = -2.5, p < 0.05$). However, bracing didn't shown any significant effect on postural sway. This study demonstrate that subjects having ankle sprains might use their eyes to compensate for the loss in proprioceptive sense due to ankle sprains. The substituting action of the other non-involved sensory sources makes it possible that disturbed proprioceptive system resulting with a normal postural sway. However, when the "other " sensory input is not allowed to contribute (eye closed), the disturbance on postural sway due to deficit on proprioceptive system is manifested. Unfortunately, during sporting activities, the sensory input from the visual system might be reduced. This happen when athletes use their eyes to follow the ball, their team-mate or their opponents. Co-ordination program is strongly suggested for subjects with ankle sprains. Our study also indicate that rigid tape provide more support than the elastic nature of Neoprene. It might due to a better confirm to the contour of the foot as well as a direct cling to the skin by the tape. However, taping is not as user friendly as the pull-up brace. Furthermore, tapes are expensive , not environmental friendly, and can cause skin allergy or irritation. The effect of brace on top of tape might be the best in a real sporting situation, especially during the healing phase after ankle sprain. However, the long term goal after ankle sprain is to have strengthening and proprioceptive training in stead of just rely on compensation or external support.

Title of Project :

A biomechanical study of the stability among athletes with chronic sprained ankle

Aims of the Project:

- (1) to measure the postural control in athletes who sustained a unilateral sprains to the lateral ligament of the ankle under stable and unstable conditions;**
- (2) to measure the effect of external support on postural control of these athletes;**

Introduction :

Ankle sprains are the most common joint injury in sports, especially among soccer, basketball and volleyball players. Garrick (1977) reported that 38-45% of all injures in men's and women's basket were ankle sprains. Nielsen and Yde (1989) found an incidence rate of 40% among soccer players. In Hong Kong, 73 % of athletes suffered from recurrent sprained ankle and 22% of them reported to have a recurrence of five or more (Yeung et al. 1994). After a sprain occurs, practice and playing time can be lost. If the injury happens while competition is taken place, the injured athlete is forced to leave the field. The same study from Yeung et al. indicated that 59% of the injured athletes had significant disability and residual symptoms which led to impairment of their athletic performance.

Treatment of athletes with chronic symptoms involve proprioceptive training, peroneal muscle strengthening and external support. Various methods have been utilized to assess postural control of athletes after inversion injury, ranging from visual observation to force platform evaluation. Goldie et al

(1994) used a force platform to assess postural control on 24 trained and 24 untrained subjects eight weeks post injury. The subjects were tested on the injured and noninjuries legs with eye closed and open. However, the greatest concern is the issue of whether these athletes can maintain postural control under unstable condition. The effect of this unstable condition on the postural control will be of immense interest.

In addition, the influence of external support on ankle postural control will be examined. Although external support has been used widely by athletes to prevent injury, the effectiveness of this support is not exactly clear. The effect of taping and brace on the influence of postural control will be analyzed, and thus assist to answer the question "does this external support, generally used by athletes for support after ankle sprain, will truly affect the postural control under stable and unstable condition? "

Methodology

Subjects

Thirteen subjects (10 male, 3 female) between the ages of 19 and 32 participated in this study. Subjects were recruited from The Hong Kong Sports Institute, The Hong Kong Polytechnic University and The Hong Kong University. Each subject was initially questioned concerning a history of unilateral inversion ankle sprains for three months or more. Subjects had experienced a substantial inversion injury using the following criteria : 1) the mechanism of injury involved weight-bearing on an inverted leg; 2) pain over the lateral aspect of the ankle was present in the first 24 hours post-injury; 3) weight-being on the injured leg was impaired in the first 24 hours; 4) the injury was considered serious enough to seek professional advice, and 5) external support to the ankle was applied following the injury.

Subjects with a history of bilateral ankle sprains, neurological deficit, vestibular disease and any musculoskeletal conditions affecting lower limbs were excluded from the study. The control group consisted of 5 persons (3 male, 2 female) without a history of an ankle sprain.

Apparatus

An Advanced Mechanic Technologies Industries (AMTI) force platform system was used to measure aspects of ground reaction forces. Out-put from the system included the three orthogonal component of the ground reaction force and two horizontal plane coordinates of the center of pressure. Signals were acquired using an analog to digital converter (ADC) and stored for adequate analysis on a IBM 486 computer. The area A (mm^2) was calculated, which was a measurement of the total sway amplitude, taking the two horizontal plane coordinates of center of pressure into account. Rigid tape of 11/2" (Strapal) was used to tape the injured ankle , Neoprene elastic support (Spenco) was used as ready made external support on the injured condition. A wobble board of size of 0.44m with a hemisphere of diameter of 0.16m was used to create an unstable surface for testing of postural sway under unstable situation.

Procedures

The study was carried out at the Locomotion Laboratory at the Hong Kong Polytechnic University. A consent form was signed following an explanation of the purpose and procedure of the experiment. The test consisted of two parts

Part I

Subjects were tested on how still they could stand in single-leg stance position under the following situation; 1) injured-leg, eyes opened; 2) injured-leg, eyes closed ; 3) non-injured leg, eye open; 4) non-injured leg, eyes closed, 5) injured-leg with custom made elastic ankle support, eye open 6) injured-leg with custom made elastic support, eye closed, 7) injured-leg with basket-weave and heel-lock, eyes open, 8) injured-leg with basket-weave and heel lock, eye closed. At the beginning of the trial, the non-supporting leg positioned approximately 5 cm off-center and 10 cm above this position, and hands positioned on both hips. During the trials, they were required to concentrate on keeping still on the force platform in stance position for 2 seconds and to correct their position as quickly as possible if a disturbance occurred during testing. The subjects performed each task four times consecutively before proceeding to the next task. Trials with touch down or step off the force platform were rejected. The order of presentation of the tasks was randomized by drawing cards. A rest of 5 minutes was allowed between each task.

Part II

Subjects were tested on how still they could maintain their posture on an unstable condition. A wobble board was placed on top of the force platform. They were tested under same situation as part I.

Statistical analysis

The area of sway of the last three trials were averaged to represent the performance score for each task. Paired t-test was used to assess differences between (L) and (R) of the controls, injured-leg and non-injured leg of the subjects under stable and unstable situation with eyes open and closed, and effect of taping and brace on the injured leg. The significant level was set at $p < 0.05$.

Results

Demographic data

The subjects consisted of 13 persons with unilateral ankle sprains for three months or more. Most of these subjects (90%) were recreational players. More than half (54%) suffered from recurrent ankle sprains (fig. 1). Chronic pain present in half of the subjects and swelling persisted on 38% of the subjects (fig. 2). About half (54%) of these subjects still had sense of instability, with one-third of them always have instability (fig. 3). Sixty-two percent of these subjects still suffered from having crepitations over their ankle, most of them were mild in nature. However, 25% of them reported to have severe crepitations over their ankle (Fig. 4). About half (46%) of them used protective device during their sporting activities. Majority (66%) used elastic support, only one subject used tape to protect his ankle during sport (fig. 5) .

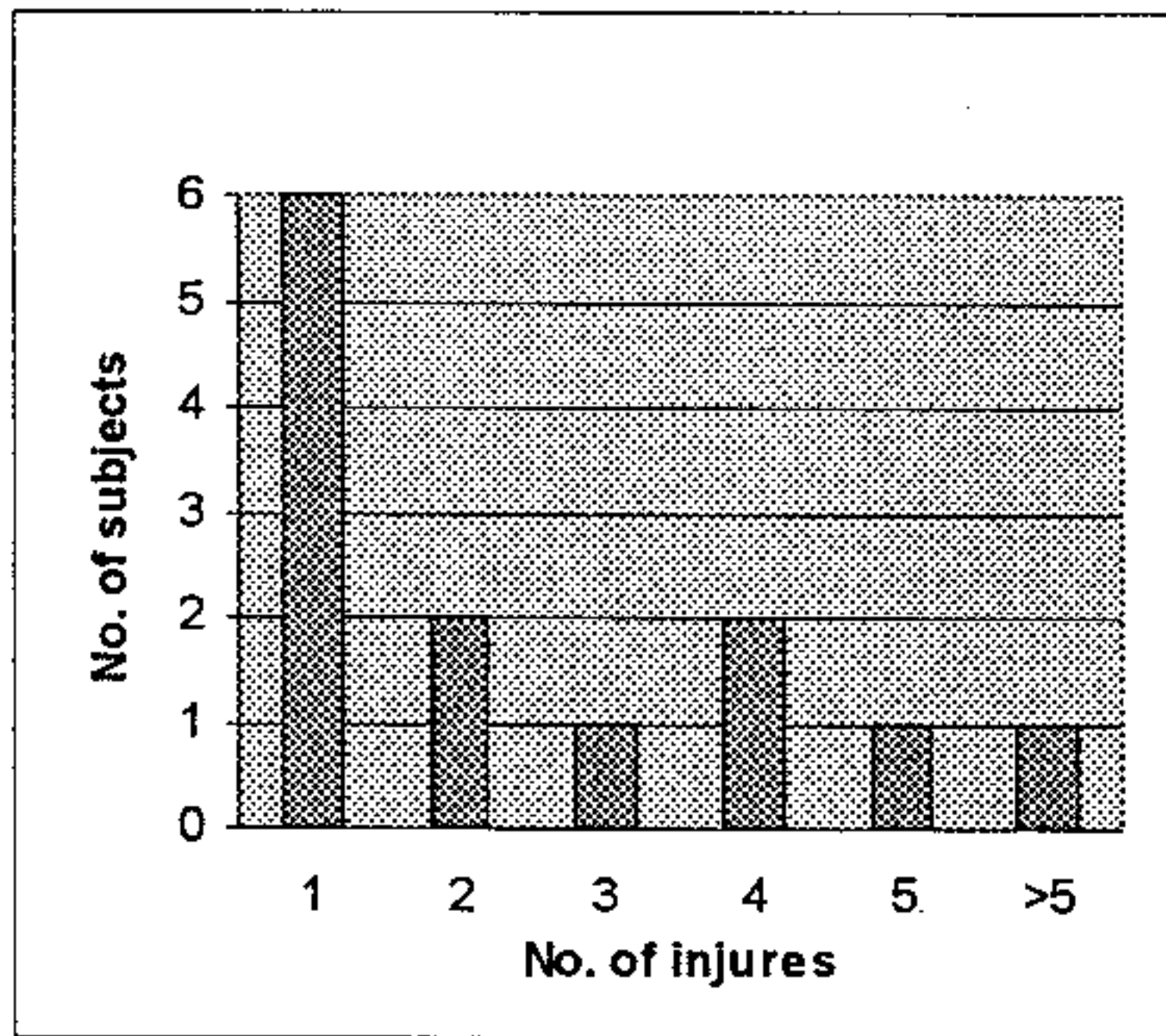


Fig. 1 number of injuries per subjects

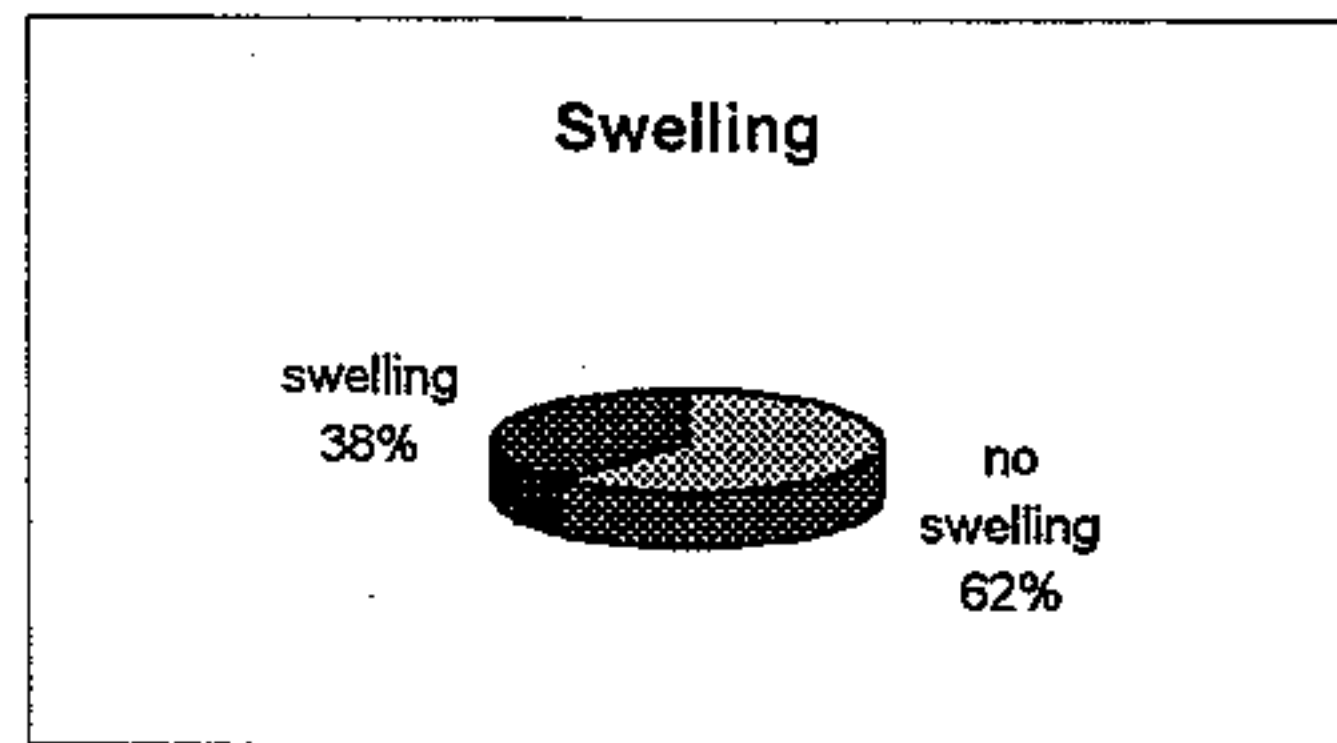
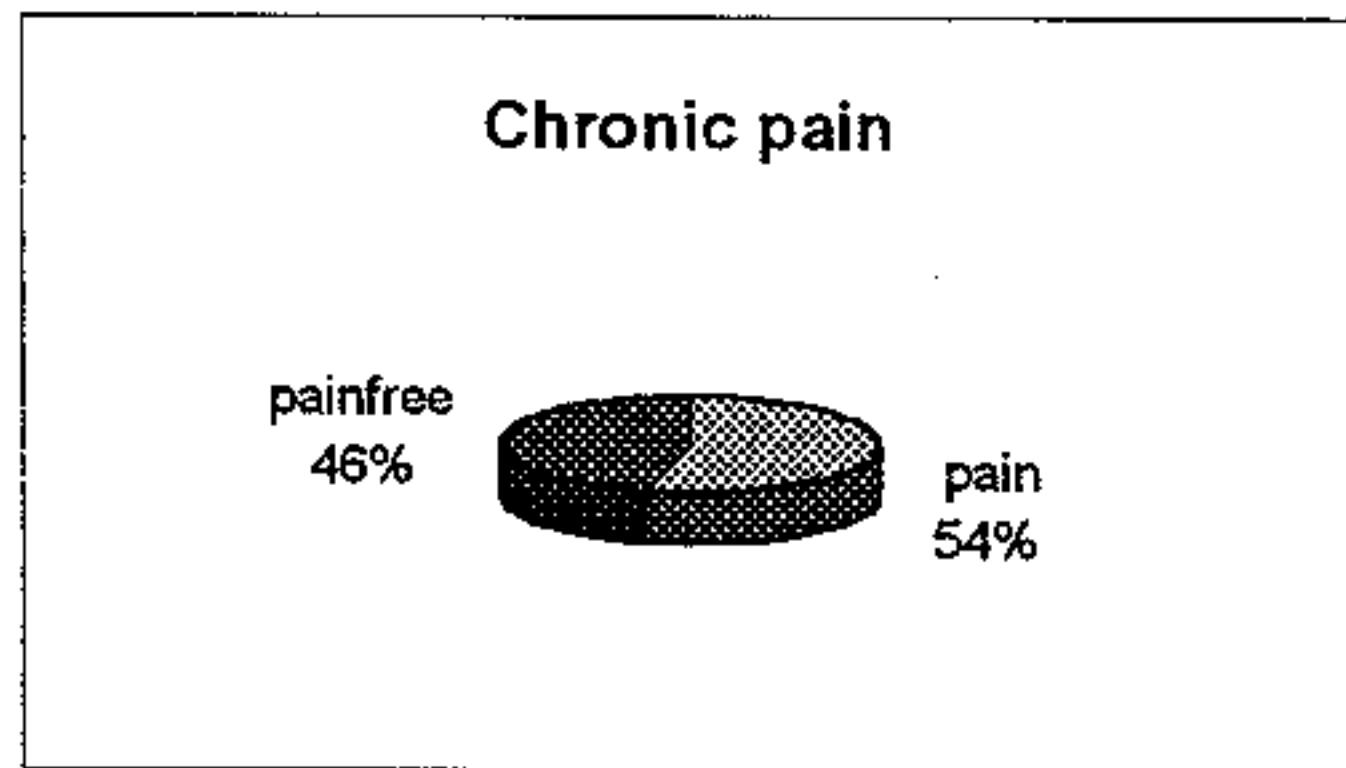


Fig. 2 a. presence of pain amongst subjects with ankle sprain. b. presence of swelling amongst subjects with ankle sprains

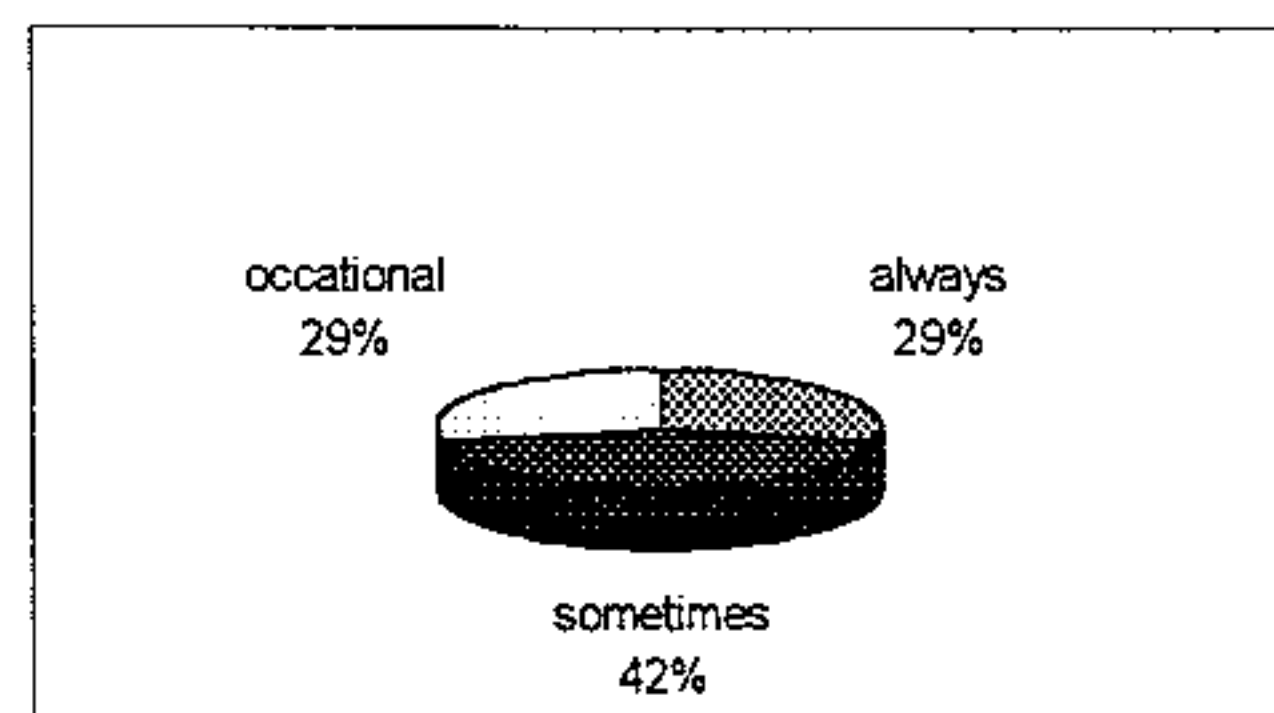
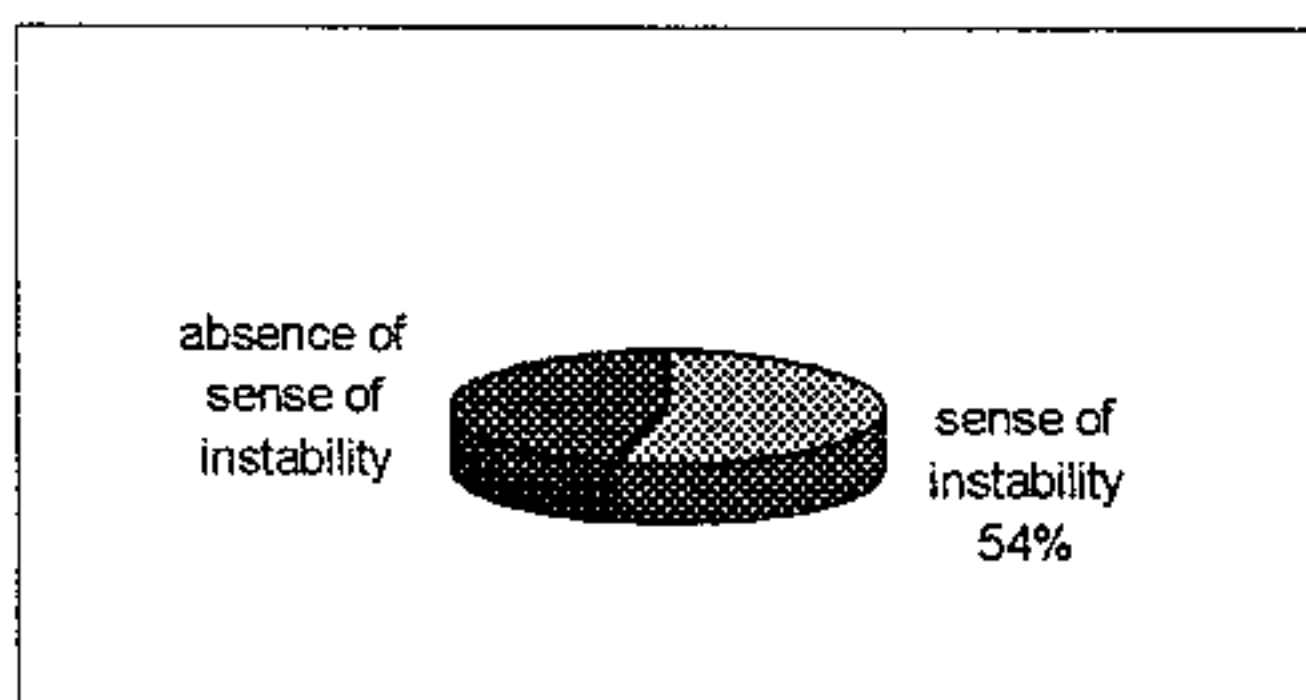


Fig. 3 a. sense of instability among subjects with ankle sprain. b. severity of instability.

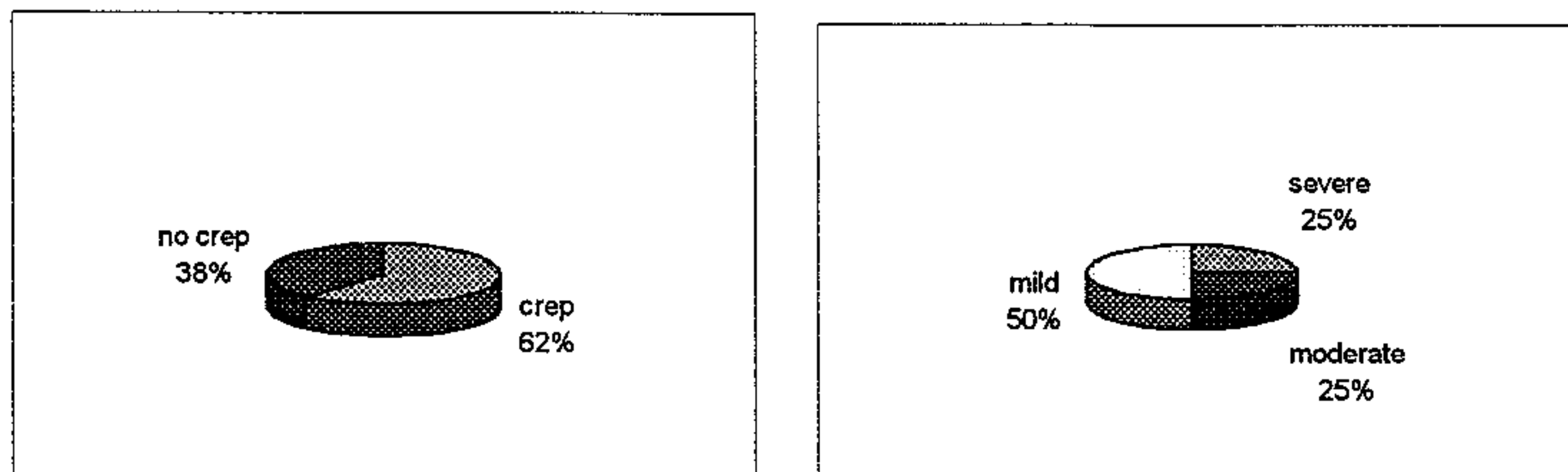


Fig. 4 a presence of crepitus on subjects with ankle sprain. b. severity of crepitus

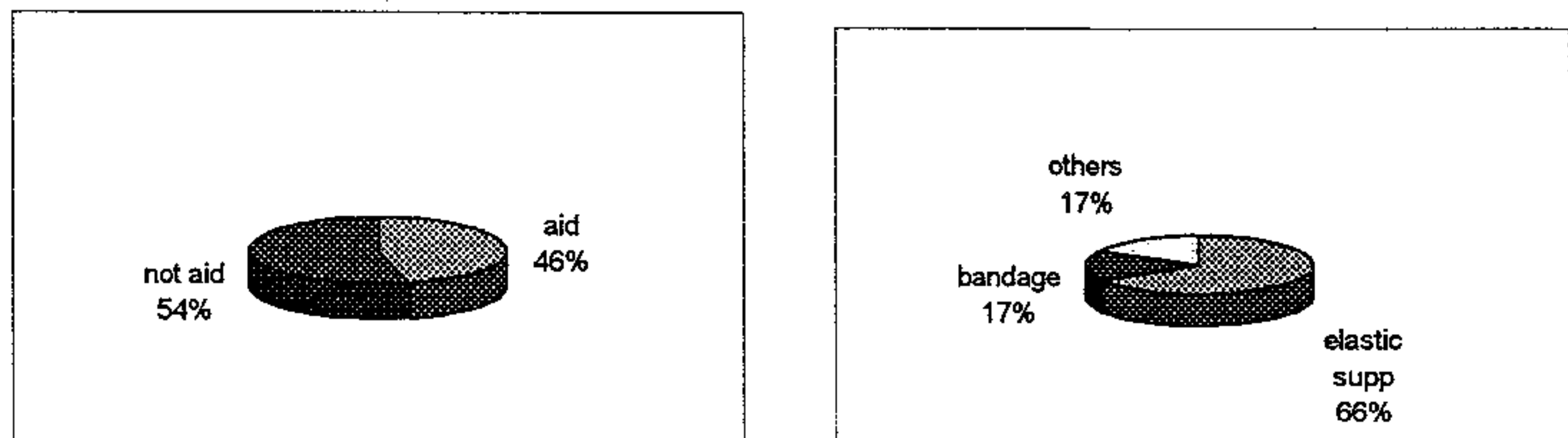


Fig. 5a use of external support on subjects, 5b types of external support used

Sway Amplitude

Results of postural sway indicated an insignificant difference between the left and right legs of the control subjects ($p > 0.05$). However, there was a significant ($p < 0.05$) increase in amplitude on the injured leg in the individuals with sprained ankles with eyes closed from 5.44mm^2 to 7.96mm^2 ($t = -3.17$, $p < 0.05$). Analysis of postural sway with eyes open, under stable and unstable conditions, indicated an insignificant difference between the injured and uninjured leg ($p > 0.05$). Table 1 shows the effect of injury on the amplitude of postural sway under the three conditions (stable/eyes closed, stable/eyes opened, unstable/eyes opened). Most of the injured subjects were unable to perform a stance on an unstable surface with eyes closed, so no analysis was done on this condition.

Table 1 : effect of injury on postural sway under eye closed and open during stable and unstable condition standard deviation in paraesthesia.

	eye open/stable (mm ²)	eye closed/ stable (mm ²)	eye open/unstable (mm ²)
Injured leg	2.75 (2.316)	7.96 (4.03)	4.92 (4.3)
Non-injured leg	2.3 (1.1)	5.44 (2.31)	5.16 (0.98)

Taping on injured ankles under stable/eye closed situation shows a significant decreased on amplitude of postural sway ($p < 0.05$) . However, there was no significant different on amplitude of postural sway with bracing on the injured ankle ($p > 0.05$). Figure 6 shows the effect of external supports on the injured ankle on the amplitude of postural sway under stable and eye closed condition.

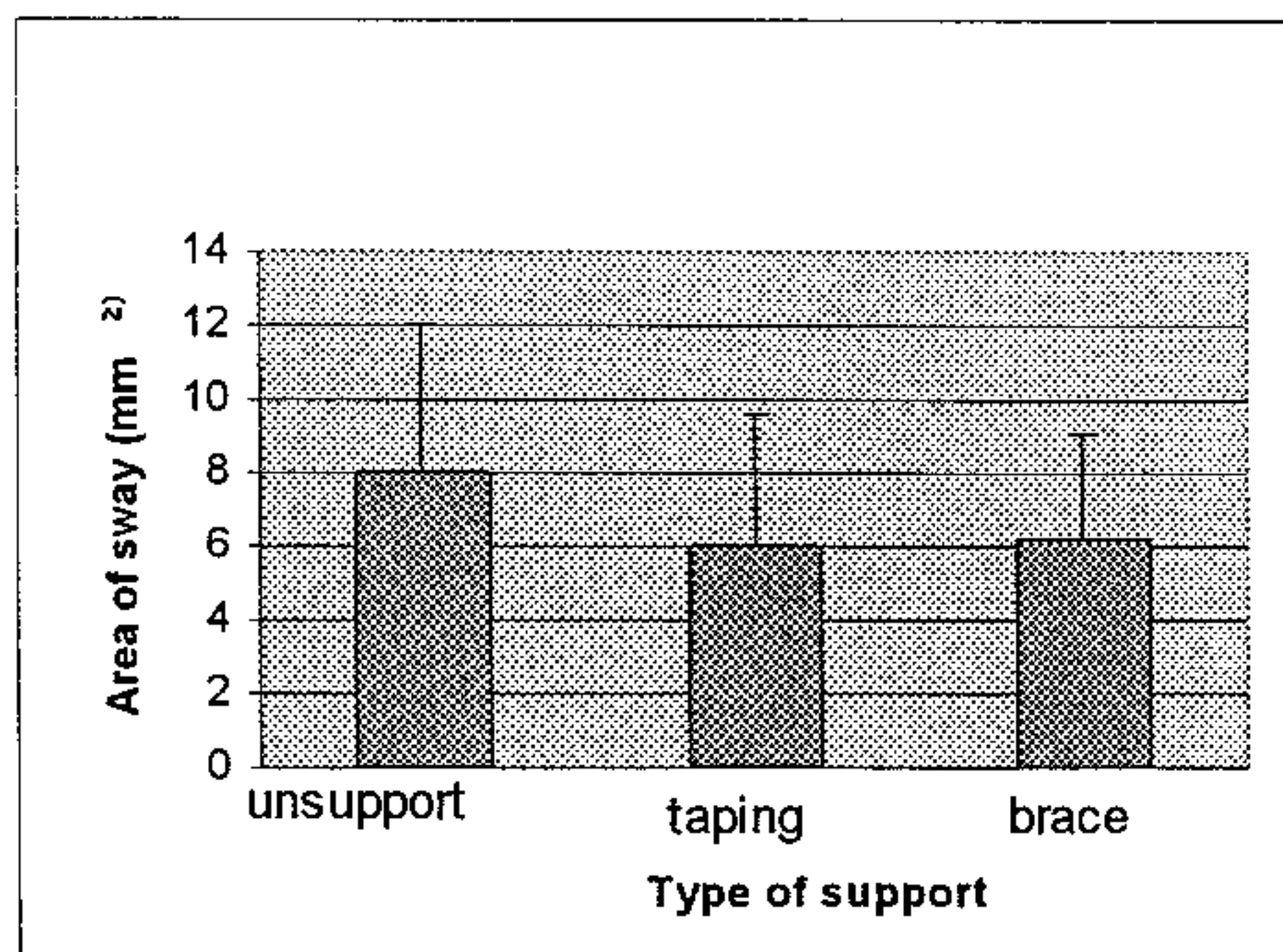


Fig. 6 effect of taping and brace on the injured leg during single-limb stance

Discussion

Ankle sprains is the most common sport-related injury among all athletes. Studies indicated that about 30-40% of them suffered from recurrent sprains. Our results shown that about half of them suffered from recurrent sprains. These data agree well with result from oversea, but much less than that from local study(Yeung et al 1994). It might due to the fact that majority of subjects for this study are recreational players, whereas subjects from previous study were mainly elite athletes. Similar to other reports, swelling, sense of instability and crepitus are the residue problems after ankle sprains. Half of the subjects from this study indicated that they still have the sense of instability, even though they all return to their sports after ankle sprains.

This study also demonstrates that subjects with a history of unilateral inversion ankle sprains are less stable in single-limb stance compared to the non-injured leg when subjects closed their eyes. There is no different between the injured and non-injured leg when their eyes are open. This demonstrate that subjects having ankle sprains might use their eyes to compensate for the loss in proprioceptive sense due to ankle sprains. According to the theory proposed by Freeman et al. (1965), subjects with ankle sprain might damage their mechanoreceptors over the ankle joint. The damage in the mechanoreceptors might cause an impairin proprioceptive sense, which is important to control the instantaneous and quantitatively precise contractions of ankle muscles and remain stable on ground. Freeman and Wyke (1965) suggest that these receptors project onto the fusimotor gamma motorneuron system, thus adjusting the muscle tone to different situations. It is well known that compensatory mechanisms are put into action in case of insufficiency in one system. Hence, the substituting action of the other non-involved sensory sources (in this case, the visual and vestibular system) makes it possible that disturbed proprioceptive system resulting with a normal postural sway. However, when

the "other " sensory input is not allowed to contribute (eye closed), the disturbance on postural sway due to deficit on proprioceptive system is manifested. Unfortunately, during sporting activities, the sensory input from the visual system might be reduced. This happen when athletes use their eyes to follow the ball, their teammate or their opponents.

Coordination program is strongly suggested for subjects with ankle sprains. Compensation from other system can provide a normal value on postural sway on standing. However, the compensation can be withdraw or misled during sporting activities. Freeman (1965) found that the feeling of "giving way" could be substantially reduced by treatment with coordinate exercises. Tropp (1984) demonstrated that practice once daily for six weeks on an ankle disc lead to a decreased in postural sway. They postulated that the effect of disc training might be a central tuning, re-education of an impaired position sense, as well as muscle strengthening. Further research is required on the mechanism of increased on postural sway after ankle sprains as well as the mechanism of disc training on subjects with ankle sprains. However, the adverse effect of ankle sprains on postural sway should be made known to the athletes, so that they are well aware that complete recovery after ankle sprains should include retraining on postural control, in stead of just pain.

Taping is an effective method to reduce postural sway on single-limb standing with eye closed. The rationale for external support is based on the assumption that by reinforcing the ligamentous structures of the ankle joint and restricting motion, ankle stability will be increased (Miller & Hergenroeder 1990). Adhesive taping may also improved Proprioception through exteroceptive information, and enhance stability. Garrick related the rate of ankle sprains to prophylactic ankle taping and shoe type in more than 2000 basketball players. He demonstrated that prophylactic taping reduced the incidence of reinsurance in players by about two thirds. Our study demonstrate the effect of taping on

improving stability during single-limb standing with eye closed. However, most of our subjects didn't know how to do taping. Only one subject tape his ankle occasionally during sport. Taping course to coaches and athletes is recommended to prevent reinjury after ankle sprain. Athletes should tape the ankle, especially during the period of rehabilitation, when the stability is still reduced.

Ready-made stabilizers are available in various shapes and materials. The elastic pull-on ankle brace (Spenco) cannot prove its effectiveness on improving stability during single-limb standing with eye-closed. The reason might be : 1) using brace of wrong size ; 2) reduced supporting property due to reused . The effect of bracing under unstable and eye closed condition cannot be tested since most of subjects cannot maintain their stance for 2 second. The combine effect of taping and brace received positive feedback from athletes, which is another area required further study.

Conclusion

From the result of this study, we conclude that subjects with ankle sprains have an increased in postural sway on single-limb standing on the injured leg . The visual system have strong compensation effect on these subjects. Clinically the results of this study reinforce the importance of coordination exercises after ankle sprains. Taping is recommended to used as external support, especially during period of rehabilitation. General education to athletes on the consequence of ankle sprains, and courses on taping to coaches and athletes are strongly recommended.

Reference :

Freeman MAR (1965). Treatment of rupture of the lateral ligaments of the ankle. J Bone Joint Surg. 47: 661.

Freeman MAR, Wyke B (1965). Articular reflexes at the ankle joint . An electromyography study of normal and abnormal influences of ankle joint mechanoreceptors upon reflex activity in the leg muscles. British Journ of Surg. 54 (12): 990-1001.

Goldie P, Evans OM, Bach TM. (1994). Postural control following inversion injures of the ankle. Arch Phys Med Rehab. 75: 969-75.

Garrick J (1977). The frequency of injury, Mechanisms of injury, and Epidemiology of Ankle Sprains. Am J Sports Med. 17: 291-292.

Miller EA, Hergenroeder AC (1990). Prophylactic ankle bracing. Sports Med. 57(5):1175-1185.

Nielsen AB, Ady J (1989). Epidemiology and traumatology of injures in soccer. Am J Sports Med. 17(6): 803-807.

Tropp H, Ekstrand J, Gillquist J (1984). Factors affecting stabilometry recordings of single limb stance. Am J Sports Med 12 :185-188.

Yeung MS, Chan KM, So CH, Yuan WY (1994). An epidemiological survey on ankle sprain. Br J Sp Med 28 (2) : 112-116.

CONSENT FORM

I, _____, freely and voluntarily agree to participate in the study, namely ; A biomechanical study of the stability among athletes with chronic sprained ankle conducted at The Hong Kong Polytechnic University.

The purpose and procedures of the study has been explained to me, and there will not be any possible risk to my health in this study.

I fully understand that the participation in this study is voluntary.

I authorise the research team to keep, preserve, use and dispose of the findings from this research with the provision that my name will not be associated with any of the results.

I have also have the right to ask any questions concerning the procedures to be used during the research and the right to terminate any involving at any time.

I have read and understand the content of this form and have received a copy.

Signature of participant

Signature of Witness

Name of participant

Name of Witness

Date

Date

A biomechanical study of the stability among athletes with chronic sprained ankle

Code: _____

A. Personal Particulars

Name: _____

Sex: Male / Female Age: _____

Tel.: _____

Main sporting activities: _____

Leg dominance: left / right

Level of participation: professional / sports club / recreational

Are you engaged in more than 10 hours of regular sporting activities each week? yes / no

Injured ankle: left / right

no. of times injured: _____

Last episode of injury: _____

B. Related ankle problems

I. Does your injured ankle affect your sporting activities? yes / no

- | | | |
|----|-------------------------|---------------------------------|
| 1. | Chronic swelling | yes / no |
| | If yes, | severe / moderate / mild |
| | If yes, sports related? | yes / no |
| 2. | Chronic pain | yes / no |
| | If yes, | severe / moderate / mild |
| | If yes, sports related? | yes / no |
| 3. | Sense of instability | yes / no |
| | If yes, | always / sometimes / occasional |
| | If yes, sports related? | yes / no |
| 5. | Stiffness | yes / no |
| | If yes, | severe / moderate / mild |
| | If yes, sports related? | yes / no |
| 6. | Crepitus | yes / no |
| | If yes, | severe / moderate / mild |

