

## The Effects Kinesiotaping® and Proprioceptive Exercises in Rehabilitation Management of Volleyball Players with Chronic Ankle Instability

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### Abstract

#### Introduction:

Chronic ankle instability (CAI) resulting from repetitive sprains can influence the performance in volleyball players. So, conservative strategies are important to manage such conditions. The present study aimed to investigate the effects of strengthening/proprioceptive exercises (SPE) and Kinesiotaping® (KT) on volleyball players with CAI.

#### Materials and Methods:

Thirty-eight volleyball players (Mean±SD, Age: 23.0±2.7 years; Playing years: 5.6±2.2 years) were divided into three groups including SPE (N=13), KT (N=13), and control (N=12). The Thera-Band was used for strengthening exercises and proprioceptive exercises were followed in closed kinetic chain exercises for 8 weeks. The KT method was administrated for peroneus muscles and also tibiofibular ligament. The participants were evaluated by Foot and Ankle Ability Measure, Single-leg Hopping test, and Heel raise test at baseline and after completing the interventions.

#### Results:

Both the SPE and KT can significantly increase foot and ankle ability and improve performance in volleyball players with CAI (P<0.001). However, a combination method of treatment is more effective compared to using exercise therapy alone.

#### Conclusion:

A combination method involving the SPE and KT can be beneficial to improve the ability and performance and achieving favorable results in volleyball players with CAI.

**Keywords:** Chronic ankle instability; Kinesiotaping; Exercise therapy; Performance; Volleyball

### Intruoduction

The ankle is the most prone-to-injury joint in team sports such as handball, football, volleyball, and basketball (1-3). The most common ankle injury is lateral ankle sprain that occurs in people participating in sports activities which might lead to their physical disability (2, 3). A lateral ankle sprain can be a separate injury or part of an injury

process that will lead to functional ankle instability (FAI) (4). Available evidence indicates that about 40% of ankle sprains can lead to chronic ankle instability (1, 5). The overall prevalence of chronic ankle instability in men and women is reported 1.1% and 0.7%, respectively (6). Tanen et al. (2014) reported the prevalence of this

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disease among high school athletes as 23% (7).

Ankle instability symptoms include giving way feeling, pain, swelling, resprain, and limitations in daily activities and sports (6). Chronic ankle instability might develop due to many reasons such as mechanical disorders (joint laxity, changes in motion pattern, degenerative or synovial changes in talocrural joint cartilage) or functional disorders (defects in proprioception, muscle strength or control) (8).

A conservative treatment is the first treatment option for these patients. However, the best therapeutic approaches are still unknown. Previous studies suggested using ankle mobilization techniques to treat ankle instability symptoms (9, 10). However, it appears that proprioceptive and neuromuscular therapy interventions are considered the most appropriate tool for this condition. In a review article, De Vries (2011) concluded that neuromuscular training in a short term was effective for people with chronic ankle instability compared to no exercise program (11). Another review article determined that the use of a training program had better results than no training in improving the performance and reducing pain and recurrent ankle sprains for those with chronic ankle instability. However, the clinical evidence level in this study was limited to moderate (12).

Volleyball is a popular and also risky sport. Evidence show that the prevalence of injuries in this sport is from 1.7 to 4.2 per 1,000 hours of competition (13) and it is considered the fourth high-risk sport vulnerable to many injuries (14). Ankle sprain is the most common acute injury in volleyball (13). Studies show that the prevalence of injuries in volleyball is less than other team sports such as basketball and soccer (13-15), which is due to its non-contact nature. However, it is reported that the prevalence of ankle sprain in it is 0.9 per 1000 hours of competition which is comparable with the prevalence of the same

injury in other contact sports such as soccer and basketball (15, 16).

Many athletes and coaches believe that the ankle brace and taping are very important in acute and chronic injuries since they believe that ankle support improves their performance. The effects of ankle taping on functional performance are studied in both injured and healthy subjects. However, there is no comprehensive agreement on whether the ankle support interferes with a person's normal performance or not. According to previous studies, the vertical jump in athletes who used different types of ankle support reduced by 3 to 5 percent (17, 18), while no significant effects have been reported from using this method in some other studies (19-21). There was a significant reduction in performance of healthy subjects using ankle support in agility tests (22), while other studies showed no significant difference in using or not using ankle supports (23, 24).

Among the methods of ankle support, Kinesio Taping (KT) is proposed as a new method. The tape used in KT is different from traditional athletic tapes. The first distinction is that it has elasticity in one direction and can be stretched to 140% of its original length before applying to skin (25), which provides a constant pulling (shear) force to the skin. The second distinction is that the Kinesio tape is air permeable and water resistant and can be used for several days without removal. The KT is used after injury and during the rehabilitation (26). Athletic tapes are structurally supportive whereas KT might have a therapeutic role (2). The effectiveness mechanisms of KT include: 1. Altered muscle function by the effects of the tape on weakened muscles, 2. Improved circulation of blood and lymph by eliminating tissue fluid or bleeding beneath the skin, 3. Decreased pain through neurological suppression, and 4. Repositioning of subluxed joints by relieving abnormal muscle tension, and helping to affect the function of fascia and muscle (25, 27).

Therefore, neuromuscular training has a special place in the rehabilitation of patients with chronic ankle instability. On the other hand, studies on ankle support for these people had contradicting results and less attention was paid to KT as a supportive method. As a result, the present study was conducted to answer the question of whether adding KT to proprioceptive exercises is effective in rehabilitation programs for people with chronic ankle instability or not.

### Materials and Methods

This quasi-experimental study was conducted in March 2014 in Tehran, Iran. The studied population was Tehran volleyball players suffering from chronic ankle instability. A total of 45 athletes volunteered to enter the study. The inclusion criteria were: (1) Aged between 18 and 30; (2) a history of ankle resprains (at least three times); (3) At least one ankle giving way during the last 6 months; (4) an over 3 degrees of pain in the ankle according to the 11-point numerical pain rate scale; and (5) score of 25 or less in the

Cumberland Ankle Instability Tool scale. The exclusion criteria were: (1) fractures of the lower extremity; (2) lower extremity surgery; (3) any other lower extremity disorders or diseases such as osteoarthritis or anterior cruciate ligament injury; (4) regular use of medication; (5) history of physiotherapy for the lower extremity during last 6 months; and (6) any neurological disorders (28, 29). According to inclusion and exclusion criteria, 2 subjects because of meniscus injury of the knee, 1 subject because of anterior cruciate ligament reconstruction surgery, and 4 subjects because of medication consumption as directed by the doctor to reduce symptoms (total 7 subjects) were excluded and finally 38 patients were enrolled (demographic data presented in Table 1). The necessary explanations about the purpose and process of the study including the administration of the tests and the type of interventions intended for the subjects were provided by the researchers. After a thorough familiarity of the subjects with the study, a written informed consent to participate in the study was obtained.

Table 1: Demographic characteristics of the subjects

Variable (measure)	Groups			P value
	Exercise Group (N = 13)	Exercise and KT group (N = 13)	Control group (N = 12)	
Age (years)	22.6±2.7	23.2±2.9	23.1±2.8	P=0.833; F=0.184
Height (cm)	194.0±4.8	193.6±4.3	192.7±4.5	P=0.784; F=0.246
Weight (kg)	90.4±6.0	91.5±3.3	91.7±4.1	P=0.739; F=0.305
BMI (Kg/m <sup>2</sup> )	23.9±0.9	24.4±0.4	24.7±0.6	P=0.108; F=3.1
History of sport activities (years)	6.2±1.8	5.9±2.2	4.6±2.3	P=0.179; F=1.8
Symptom duration (months)	14.7±4.0	16.1±4.6	13.9±3.7	P=0.403; F=0.934
Pain level (0-10)	5.8±1.5	6.3±1.7	6.1±1.4	P=0.689; F=0.377
Cumberland Ankle Instability Tool	16.8±3.6	18.3±4.2	16.8±3.5	P=0.539; F=0.630

(Data are reported as Mean ± SD).

The variables were measured as follows: First, the Foot and Ankle Ability Measure

(FAAM) was measured. In a review in 2013, it found that FAAM is the most

common performance evaluation tool in the lower extremities (30). This scale consists of 29 questions that are divided into two parts: 1. Activities of daily living, including 21 items; and 2. Sports including 8 items. Each item is scored according to a 5-point Likert scale (from 0 to 4) indicating different levels of difficulty. The scores are summed up to calculate the score of each section. The activities of daily living section have 84 points and the sports section has 32 points (31). Each score is converted to a percentage to calculate the final score for each section. Higher scores indicate higher abilities. The test-retest reliability for activities of daily living and sports was reported as 0.89 and 0.87, respectively. In fact, it appears that the FAAM scale is valid for patients with ankle instability (32). It is suggested that the Minimal Clinically Important Difference for activities of daily living and sports are 8 and 9, respectively (31).

The subjects' performance was assessed by Single Leg Hopping and Standing Heel Raise tests. The Hopping test assessed agility and movement control of a limb on uneven surfaces. In this test, four flat squares and four squares with 15 degrees of tilt in different directions were considered. The subjects were asked to practice hopping between/on the squares and finish the test correctly in the fastest time possible. Every time their foot was out of the squares or they used the other leg, one second was added to their final time (33). The validity of the Single Leg Hopping test was 0.93 (34).

The Standing Heel Rise test assessed the isotonic strength of ankle plantar flexors. For this test, the subjects stood in front of a wall and they were allowed to put their fingers on the wall to help them maintain balance. Then they had to bend one leg at the knee and were asked to lift the heel of the other leg off the floor while keeping their toes on the floor. The heel was raised up to 5 cm from the floor. Then the subjects had to maintain this situation. The period of time that they could maintain this situation

before getting tired and returning to the normal situation was measured and recorded as their score. The test-retest reliability of this test was reported 0.78 to 0.96 for healthy people (34).

The above-mentioned assessments were repeated similarly after the implementation of therapeutic interventions. The person in charge of the evaluation was unaware of the type of treatment received by patients and grouping of the subjects. After pre-test evaluations, patients were randomly divided into three groups: exercise therapy, exercise therapy and KT, and control. The control group was asked not to receive any rehabilitation treatment or medication, and also have no exercises and merely follow their routine daily lives during the interventions. In addition, in order to maintain ethical principles, the participants in the control group also received their exercise therapy after recording the post-test scores and finishing the study. The interventions used in the intervention groups were as follows:

Results from a systematic review of studies suggest that proprioceptive exercise program is normally administered for 10 minutes to one hour, 1 to 7 times a week for a period of 6 weeks (34). On the other hand, some researchers believe that proprioceptive exercise programs should be used for a longer period of time, at least 8 weeks, to achieve the desired effects (35). Hence, the present study considered an 8-week duration for the exercise intervention period. Kim et al. (2014) stated that combining strengthening and proprioceptive exercises is more effective for the treatment of ankle instability than doing strengthening exercises alone (36).

The strengthening programs included the use of exercise band (Thera-Bands) according to the method introduced by Kaminsky et al (2003) (37). In this method, the subject would sit on the floor and one end of the exercise band would be tied to a bed and the other end to the metatarsals of the unhealthy foot. The knee was in full extension and the exercise band was pulled

up to 170% of its original length, regardless of its color (resistance). Strengthening exercises included all ankle motions. In order to advance the exercise, the number of sets (1 to 3 sets of 8 to 10 repetitions for each motion) was increased, or the imposed resistance was increased every week based on individual's symptoms and conditions (38).

The proprioceptive exercise program consisted of several closed kinetic chain exercises in the weight-bearing status (Figure 1). The exercises were performed first on two legs and then on one leg for program advancement. Applied exercises include semisquats and standing on one leg with open or closed eyes on a stable surface. During the first two weeks, three sets of 10 repetitions were considered for each exercise. In the third and fourth weeks, the exercises continued on unstable surfaces. In the last 4 weeks (weeks 5 to 8) some perturbations was added by the therapist. All these exercises focused on motor control of eccentric contractions of foot muscles in order to increase the ability of these muscles to stabilize the ankle (39).

The KT technique was also used in the other intervention groups in addition to the above-mentioned exercises. That is, the subjects used KT during exercises. They also benefited from KT on the days of the week without training. The KT tapes were changed at every training session (twice a week) to maintain their adhesiveness. The TemTex Kinesiology Tape made in South Korea was used in this study. The width of this type of tape is 5 cm with a thickness of 5 mm. KT was applied by a qualified physiotherapist on the tibiofibular ligament and peroneal muscles with a supporting technique. In order to apply Kinesio tape on the peroneus longus muscle, the subjects sat

in a supine position or sat with legs stretched (long sitting). One end of the Kinesio tape was stuck to the first part of the plantar base of the first metatarsal. Then the ankle was placed in plantar flexion and inversion position to increase tissue tension and the Kinesio tape was drawn on the peroneus longus tendon route, so that it crossed behind the outer ankle and finally stuck to the end of fibula bone. Peroneus brevis muscle KT application was different from that of the peroneus longus. The ankle was in dorsiflexion and inversion position to increase tissue tension. The rest of the tape was stuck on the route of peroneal muscles to the fibula end. In order to tape the tibiofibular ligament to support it, the subjects' knee was in an extension position and the ankle was in a dorsiflexion position. Then one end of the tape was stuck on the inner ankle. After ensuring the fixation of tape on the inner ankle, Kinesio taping continued by the mild tension of 25% towards the outer ankle (on the anterior part of the ankle) and its end was attached to the outer ankle without tension (Fig. 2). This type of Kinesio taping covers the anterior and posterior ligaments (29, 40).

After collecting the information, data was entered in the SPSS version 19 statistical software. The central tendency measures were evaluated by descriptive statistical tests. The Shapiro-Wilk was used for evaluation of the normal distribution of data. The differences between pre- and post-scores of the dependent variables were measured and the ANOVA test was used for the comparison of mean changes of the variables among the three groups. In cases where there was a significant difference between the groups, Scheffe post hoc test was used for dual comparison.



Figure 1: An example of strengthening/proprioception exercises



Figure 2: Ankle Kinesio Taping (The purple tape is on peroneus brevis muscle, the orange tape is on the peroneus longus muscle, and the red tape is on the tibiofibular ligaments).

## Results

Table 1 shows that the demographic variables and basic indicators had a normal distribution ( $P > 0.05$ ).

Table 2 shows the results of pre- and post-test scores obtained by the subjects.

According to Table 2, the intra-group comparison shows that all four variables had significant changes before and after the intervention in both intervention groups ( $P < 0.001$ ). The changes in the FAAM scale in the activities of daily living section in the pre-test was not significant compared to the post-test in the control group ( $P > 0.05$ ), while FAAM variable in the sports section and test scores of subjects' performance reduced significantly in this group ( $P < 0.05$ ).

Table 3 shows the statistical characteristics of the dependent variables and their inter-groups comparison.

Table 3 shows a significant difference between the mean change of all four dependent variables among the three groups ( $P < 0.001$ ). Accordingly, Scheffe post-hoc test was used for dual comparison of the groups. The results showed that the mean change in the FAAM scale in the activities of daily living and sports sections in both intervention groups was significantly higher compared to the control group ( $P < 0.001$ ). The comparison between the intervention groups also showed that patients treated with the combined method had more significant changes in these variables compared to the

strengthening/proprioception exercises alone ( $P<0.01$ ). The mean score changes of Single Leg Hopping and Standing Heel Raise tests in the intervention groups were significantly higher compared to the control group ( $P<0.001$ ); while the combined

exercise therapy and KT group had significantly greater mean score changes in the two variables related to the functional performance compared to the exercise therapy group ( $P<0.01$ ).

Table 2 : Dependent variables scores and their comparison among the three groups (mean  $\pm$  SD)

Variable	Group	Pre-test	Post-test	P value
FAAM (Activities of daily living)	Exercise Group	77.2 $\pm$ 8.4	82.8 $\pm$ 7.0	* <0.001
	Combined Group	73.0 $\pm$ 8.7	84.1 $\pm$ 6.3	* <0.001
	Control group	76.3 $\pm$ 11.0	74.5 $\pm$ 10.2	0.195
FAAM (Sport activities)	Exercise Group	72.6 $\pm$ 6.6	80.8 $\pm$ 6.3	* <0.001
	Combined Group	69.2 $\pm$ 6.5	80.8 $\pm$ 6.2	* <0.001
	Control group	69.5 $\pm$ 10.6	65.7 $\pm$ 10.5	**<0.01
Test scores Single Leg Hopping	Exercise Group	7.5 $\pm$ 0.7	6.2 $\pm$ 0.8	* <0.001
	Combined Group	7.4 $\pm$ 0.8	5.3 $\pm$ 0.8	* <0.001
	Control group	7.4 $\pm$ 0.6	8.1 $\pm$ 0.6	**<0.01
Test scores Standing Heel Raise	Exercise Group	27.8 $\pm$ 6.5	29.9 $\pm$ 6.4	* <0.001
	Combined Group	25.4 $\pm$ 6.6	32.7 $\pm$ 6.4	* <0.001
	Control group	26.0 $\pm$ 6.0	24.3 $\pm$ 5.8	***<0.05

\* Significant  $P<0.001$

\*\* Significant  $P<0.01$

\*\*\* Significant  $P<0.05$

Table 3: The statistical characteristics of the dependent variables

Dependent Variable		Sum of squares	Degrees of freedom	Mean square	F	P value
FAAM changes (Activities of daily living)	Inter-group	1042.6	2	521.3	48.3	* <0.001
	Intra-group	377.0	35	10.7		
	Total	1419.7	37			
FAAM changes (Sport)	Inter-group	1604.2	2	802.1	118.4	* <0.001
	Intra-group	237.0	35	6.7		
	Total	1841.2	37			
Changes in Single Leg Hopping test scores	Inter-group	50.4	2	25.2	75.8	* <0.001
	Intra-group	11.6	35	0.3		
	Total	62.1	37			
Changes in Standing Heel Raise test scores	Inter-group	414.1	2	207.0	86.6	* <0.001
	Intra-group	83.6	35	2.3		
	Total	497.7	37			

\* Significant difference

## Discussion

The present study was conducted to investigate the effects of adding KT to normal exercises of athletes with chronic ankle instability. The statistical analysis results showed that the foot and ankle ability and functional performance of

volleyball players with this problem improved by using a combination of KT and strengthening/proprioception exercises compared to only using strengthening/proprioception exercises.

Chronic ankle instability results from neurological mechanisms (proprioception, reflexes, and muscle reaction timing), muscular mechanisms (power, strength, and endurance), and mechanical mechanisms (ligaments laxity) (14, 25). The proprioceptive deficits including motion perception in these patients have received attention from researchers. Plantar flexion is an important part of ankle supination motion, and patients' increased ability to detect the angle of the ankle, especially in the plantar flexion motion, may help them reduce recurrence of the problem (41). Delay in peroneal muscles response is another problem of patients with chronic ankle instability (42). This problem raises the importance of ankle muscles overture and suggests that dysfunction of these muscles can worsen chronic ankle instability. In this study, the exercise program in both groups focused on ankle motions, including ankle plantar flexion and eversion motions. The exercises in this study were progressive. That is, standing on the foot, doing the exercises with eyes closed, using unstable surfaces, and applying perturbations by the therapist were used during the last three weeks as ways to improve proprioception exercises. It appears that by changing the somatosensory and visual feedback, the athlete must replace constant motion patterns with variable feedbacks. When the body reacts in different ways to the applied perturbations (feedforward reaction against feedback), the sensory input is received from all parts of the body and transmitted by the afferents to the central nervous system. Thus, conscious and unconscious reactions are necessary to protect the joint stability. Proprioception is useful for injury prevention in slow, almost fast and even very fast activities; however, it might not be enough to deal with the forces that challenge the neuromuscular system at the highest levels (38, 41, 43). Although, ankle proprioception and muscle activity (such as peroneal muscles) were not examined in this study, the authors believe that the use

of exercise therapy in strengthening and proprioceptive exercises pattern can reduce ankle plantar flexion recovery error and decrease peroneal muscles reaction delay, which has improved functional performance of the participants in this study.

The results suggested that doing strengthening/ proprioception exercises along with KT had better effects in improving the performance of subjects with chronic ankle instability. Findings from other studies in this area are in line with these results (44, 45). In these studies, the therapeutic interventions solely focused on the individual use of ankle supporting methods such as KT and brace, while we used strengthening/ proprioception exercises and KT together. A review of previous studies indicated the fact that the use of such combined methods in the form of an exercise therapy and KT was used for the first time in this study.

The Hopping test is one of the most common and useful tools to assess the functional performance because the use of various factors such as muscle strength, neuromuscular coordination, and joint stability are required on the part of the subjects (29, 33, 46). Another assessment was on the isotonic strength of ankle plantar flexor muscles conducted in the form of the Standing Heel Rise test. Madeley et al. (2007) argue that although the test basically evaluates the gastrocnemius and soleus muscle function as ankle plantar flexors, the effect of other foot muscles on ankle plantar flexion should not be ignored (47).

In this study, KT was applied according to the role of peroneal muscles and tibiofibular ligaments, because the results from previous studies have shown a delay in the reaction of these muscles and tibiofibular ligament malfunction that led to ankle instability (12, 42, 48). Among the interventions used for chronic ankle instability, Salom-Moreno (2015) used a combined therapy of strengthening/ proprioception exercises and dry needling technique for myofascial trigger points in

the peroneal muscles and concluded that the use of the combined therapy had better effects on pain intensity and the ability of people with chronic ankle instability compared to using exercises alone (49). They found that the use of the dry needling technique for peroneal muscles before strengthening/proprioception exercises can improve the motor output of the muscle. In this regard, the positive impact mechanism of KT in the present study can be attributed to the fact that applying KT on peroneus longus and brevis muscles resulted in their activation through skin stimulations, reducing the delay in activation of the muscles, and resulting in better performance of the subjects in the two tests. On the other hand, it appears that applying KT on the tibiofemoral ligament and creating a proprioception feedback and thus supporting the ankle can be another possible reason for the better effects of the combined method of exercise therapy and KT. That is because the subjects in this group benefited KT during the exercises which can lead to a reduction in the fear of resprains and an increase in the performance of the subjects. Therefore, it appears that the subjects in this group followed the exercises more effectively

because of KT which in turn led to their better performance in the functional tests.

### Conclusion

Both exercise therapy and KT and their combination can improve functional ability and performance of volleyball players with chronic ankle sprain, although the effect of the combined method including strengthening/proprioception exercises and KT was more on the variables.

### Limitations

One of the limitations of this study was the few number of the subjects which was in part due to the long period of the study and lack of subjects' cooperation. Another limitation was that only male subjects entered the study due to ethical issues; hence the results cannot be extended to female volleyball players with a chronic ankle sprain.

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### Conflict of Interest

The authors declare no conflicts of interest.

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