



## Original Article

## The Effect of Kinesio Taping of Quadriceps Muscle on the Balance of Non-Elite Football Players After a Local Fatigue Induced Protocol

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### ARTICLE INFO

#### Article History:

Received: 28/12/2015

Revised: 19/4/2016

Accepted: 28/4/2016

#### Keywords:

Fatigue  
Kinesio taping  
Balance  
Postural control

### ABSTRACT

**Background:** Previous studies have shown detrimental effects of muscle fatigue on balance. Also they have reported the effects of kinesio taping (KT) on postural control, joint support, and muscle function. However, no studies have been conducted so far to assess the immediate effects of KT after local muscle fatigue on balance. Therefore, the aim of this study was to determine whether KT improves the Y-balance test scores after quadriceps fatigue.

**Methods:** Fifty healthy male athletes (18-35 years old) participated in this quasi-experimental study and were randomly allocated to one of the two groups. The control group received only a fatigue protocol and the KT group received both quadriceps KT and the fatigue protocol. The balance of the subjects was assessed by a Y-balance test before and after the interventions.

**Results:** The results revealed a significant decrease in Y-balance test scores after interventions in both groups. The KT group showed better scores in Y-balance test in all directions compared to the control.

**Conclusion:** The study confirmed the positive effect of KT on balance after a fatigue protocol in athletes. We conclude that the application of KT can be an effective intervention for improving balance after induced fatigue in athletes.

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### Introduction

Balance is the ability to maintain the center of gravity in the supporting surface. When the sensory information becomes corrupted, postural control would be impaired. Manipulation of different sources of sensory information (skin, musculotendinous, skin temperature, auditory and visual), disturbs the information integration and postural control [1].

It is suggested that the injury risk in athletes is positively associated with muscular fatigue and injuries often occur in the last minutes of the game [2,3]. A number of studies support the hypothesis that localized fatigue reduces the

neuromuscular and sensorimotor control and therefore may lead to increasing lower extremity injury and risk [4-6]. Fatigue means difficulty in initiating or maintaining voluntary activities or progressive reduction in maximum voluntary force produced by one or a group of muscles [7]. It seems that the most important effect of fatigue is the reduction of proprioception due to the change in muscle spindle receptors [8]. Other changes include reduced muscle strength and activity, and kinematics [9,10]. There is a relationship between fatigue and changes in neuromuscular control [11]. Fatigue changes muscle activity condition and slows the transmission of afferent inputs leading to slowing efferent outputs and influences the ability to efficient production of compensatory motion [12]. With deficit in afferent inputs, postural control is impaired and the body is susceptible to injury [13].

There are two common types of taping including KT and

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athletic taping. Athletic tape is structurally supportive whereas KT may have therapeutic benefits. This approach is widely used in athletes to prevent and treat injuries [14,15]. The therapeutic effects of using taping involve minimizing pain, increasing muscle strength, improving walking pattern and increasing patients' performance results with sport injury, and patellofemoral pain syndrome [15-18]. Tape may increase or decrease muscle strength. Many researchers have explained its process containing neural facilitation and inhibition mechanisms and have explained the relationship between cutaneous afferent stimulation and motor unit firing [19-23]. Researchers reported that following the application of KT on pectoralis major muscles and gastrocnemius muscles, blood supply was improved [24]. Thus, by improving blood flow, oxygen-delivery to the muscle improves its resistance to fatigue. Furthermore, KT improves lymphatic drainage [25] and therefore it can facilitate the removal of metabolites. Studies have shown that the use of KT on the knee improves EMG activity of vastus medialis oblique (VMO) muscles which subsequently increases the sense of stability and reduces the amount of pain [26]. Current evidences mostly applied the KT on the ankle region and have been evaluated the static standing balance. Given the importance of fatigue in sports injuries and the needs for interventions to reduce the impact of fatigue on sports injuries, more researches were necessary in this area. To date there is no study that investigates the effect of KT after local fatigue on dynamic balance in athletes. Accordingly, the aim of present study was to determine the simultaneous influence of the KT application and fatigue on quadriceps muscle on dynamic postural control in healthy non-elite football players. We hypothesized that KT could improve negative effects of fatigue on postural control.

## Methods

A convenience sampling of forty healthy male athletes was participated in this quasi experimental study. The sample size calculation was based on data in previous study [27] with considering the significance level of 0.05 and power of 80%. The participants were healthy male non-elite football players that aged between 18-35 years old (Mean±SD: age, 19.0±0.0 years; height, 170.1±6.2cm; Weight, 70.4±0.9kg) and they should participate in sports activity at least 1 hour during 3 days of week. Participants were excluded according to the following criteria: a history of systemic disease or a history of lower-extremity injury or neurologic deficits that might interfere with sensory input and/or balance disturbances, visual impairments that not corrected by glasses. The other exclusion criteria were the vestibular or neuromuscular disorders, history of ankle sprain, lower extremity or spinal fracture and a history of application of tape in two late weeks. After that the volunteers were randomly assigned to control and KT groups using a computer random number generator. Before fatigue intervention, demographic and balance tests were measured and after that, the control group received a quadriceps fatigue protocol, while the KT

group received KT and quadriceps fatigue protocol. Finally the balance tests were measured again by the same examiner.

Before participation, all subjects signed a consent form, approved by the Shiraz University of Medical Sciences Ethics Committee (CT-9379-7299).

Initial testing included all demographic and anthropometric assessments of height, weight, and limb length. The subjects were assessed by Y-balance test immediately after both interventions. Each subject completed a Y-balance test modeled according to the methodology described by Plisky et al. [28]. The subjects stood on dominant leg, with the most distal aspect of their great toe on the center of the grid (Figure 1). The dominant leg was determined based on kick test [29]. The subjects were then asked to reach the farthest distance with non-dominant leg in the anterior, posteromedial, and posterolateral directions with no rest between trials. The mean of the three reaches in each direction was recorded.



**Figure 1:** The Y-balance test, posterolateral direction

The subjects repeated the testing trial after 5 minute rest if they were unable to complete the task in 6 trials. Then the data were normalized to each lower limb length. The leg length was determined while the subjects were supine and the distance between anterior superior iliac spine and medial malleolus was measured. Before the fatigue protocol, subjects performed 6 practices of Y-balance to familiarize with the task and after 5 minutes rest, the balance test was measured.

After testing the balance, the maximum isometric quadriceps contraction in the dominant leg was assessed using a hand held dynamometer (DSI®-Iran).

For measuring the isometric Maximum Voluntary Contraction (MVC) of quadriceps, the subjects sat on a chair with hips and knees flexed at 90 degree. The thigh fixed with a strap and upper limb crossed on the chest with resistance applied above the ankle joint. Before assessing by the dynamometer, each participant's performed three submaximal (30% MVC) isometric contractions for warm up to familiarize with the task. After 5 minutes rest maximum isometric quadriceps contraction was measured. Then the fatigue protocol includes constant quadriceps contraction in 75% of MVC. The criterion for exhaustion was receiving to lower than 50% MVC and remaining for 5 seconds [30]. The subjects were instructed to hold the contraction in 75% MVC based on number demonstrated by dynamometer. Immediately after protocol each participants were assessed again by the Y-balance test [30].

After the initial measurements, the KT group received a 30 minutes of KT (Kinesio® Tape-South Korea) on quadriceps muscle and after that they received the fatigue protocol. The tape was applied while the subjects sat in a relaxed position and the tape was stretched with approximately 40% of initial length for the aim of proprioceptive facilitation [31]. Three heads from four heads of quadriceps muscle including rectus femoris, vastus medialis and vastus lateralis were taped (Figure 2) [32]. For the rectus femoris muscle, the tape was applied from distal to the anterior inferior iliac spine (that was found by palpating the anterior superior iliac spine) to the superior border of the patella while holding the knee in full flexion. For the vastus medialis, the tape was applied from distal and anterior to the greater trochanter to the medial and superior aspect of the patella while holding the knee in flexion. Finally for the vastus lateralis muscle, the tape was applied from the anterior of the greater trochanter of the femur (intertrochanteric line) to



**Figure 2:** KT of vastus lateralis, vastus medialis and rectus femoris

the lateral and superior aspect of the patella while holding the knee in flexion [33].

### Statistical Analysis

Demographic characteristics of the subjects were shown by descriptive statistics. Baseline comparisons between the two groups were analysed using independent sample t-test. The Kolmogorov–Smirnov test showed a normal distribution ( $P>0.05$ ) for all variables, and therefore an independent sample t-test was used for comparison between KT and control groups. The level of significance was considered as  $P<0.05$  and the SPSS software, version 22 (SPSS, Chicago, IL, USA) was used for analysis.

### Results

Comparison of the baseline characteristics of 40 subjects between the KT (15 subjects) and control (15 subjects) groups revealed no significant differences in all of variables (Table 1).

After the fatigue protocol the results of mean group difference comparisons showed significant differences in Y-balance test scores in anterior and posterolateral directions between groups ( $P<0.05$ ) (Table 2). Improvement in the Y-balance test scores was found for all directions in both KT and control groups (Table 2).

### Discussion

The aim of present study was to determine the effects of the KT application on dynamic postural control after quadriceps induced fatigue in healthy non-elite football players. We observed significant differences in Y-balance test scores in anterior and posterolateral directions between the groups. Also significant improvements in the Y-balance test scores were observed in all directions in both KT and control groups. Although the postromedial direction showed improvement in performance and was consistent with other directions, but it was not significant which could be due to the small sample size.

Considering that a similar protocol applied between the two groups and the same conditions of groups, this difference in performance can be attributed to use of KT in the second group.

The results of this study regarding the effect of fatigue on loss of balance were in consistent with the findings of studies that have been already conducted in this area [1,8,34-36]. In fact, these studies have justified the effects of fatigue on loss of balance through these mechanisms.

**Table 1:** Comparison of baseline characteristics of KT and control groups

Variable	KT Group (Mean±SD) n=20	Control Group (Mean±SD) n=20	P value <sup>†</sup>
Age	19.0±0.00	19.0±0.00	0.59
Height	172.15±7.30	168.05±5.10	0.91
Weight	69.40±9.46	71.50±9.16	0.43
YBT: Anterior	106.28±13.57	102.33±12.27	0.28
YBT Posteromedial	102.85±9.74	98.19±9.16	0.88
YBT Posterolateral	92.34±11.12	93.00±10.63	0.83

\* $P<0.05$  was considered as a significant level; †YBT=Y-balance test



**Table 2:** Results of within and between-group comparisons for balance tests in KT and control groups

	KT Group (Mean±SD) n=20		Control Group (Mean±SD) n=20		Mean Group Difference (95% CI)	P value*
	Before	After	Before	After		
YBT <sup>1</sup> Anterior	106.28±13.57	103.74±13.84**	102.33±12.27	91.83±12.32**	-7.95 (-10.39;-5.51)	<0.001
YBT Posteromedial	102.85±9.74	94.68±9.45**	98.19±9.16	87.39±12.20**	-5.58 (-7.03;-4.13)	0.138
YBT Posterolateral	92.34±11.12	89.92±11.57**	93.00±10.63	85.00±9.07**	-2.64 (-6.15;0.88)	<0.001

\*\*\*Significantly different (P<0.05) after intervention for between group comparisons based on independent sample t-test; \*\*Significantly different (P<0.001) from baseline for within group comparisons based on paired t-test; <sup>1</sup>YBT=Y-balance test

Results of this study are consistent with the other similar study that showed significant effect of KT is not observed without fatigue [37]. Thus, studies have shown that fatigue is one of the factors that affect the balance [34,36,38] and on the other hand, studies have also shown the advantages of KT in improvement of balance [39,40]. According to the results of this study, it can be concluded that KT can help to improve balance by reducing the effects of fatigue. Determining the exact mechanism of KT on balance improvement by reducing the effects of fatigue is beyond the scope of this study and more research is needed in this area.

Fatigue can occur at any point of the routes involved in the contraction process. It causes changes in the brain messages, lower motor neuron stimulation capacity and the excitability of the motor neuron based on the physiological mechanism. Fatigue can also change the neuromuscular junction message transmission quality, the intensity of muscle membrane excitability and excitation-contraction relationship [41].

Muscle fatigue impairs both the central and peripheral proprioceptive system [42]. In local muscle fatigue due to intense muscular activity, metabolic substances are released such as bradykinin, Arachnoid acid, lactic acid and prostaglandin [43]. Inflammatory substances and metabolites have direct effects on the pattern of muscle discharge and impairment of proprioceptive afferents which is the peripheral part of fatigue [44,45].

Cortical and supraspinal motor pathways are also involved in the process of fatigue. It is demonstrated that firing rate of cortical neurons was reduced by fatigue which confirms the reduction of cortical efferent activity due to fatigue [46]. It seems that the most important effects of fatigue in reduced proprioception are because of the change in muscle spindle receptors [8].

The results of this research are consistent with findings of previous studies on the effect of KT to improve the balance [33,37,47-49] and these studies have justified their results as below.

Tape may increase or decrease muscle strength [19]. Fatigue can also affect the proprioceptive stimulation. According to available evidences, the use of KT on the knee improves muscle EMG activity of vastus medialis oblique followed by increasing the sense of stability and reducing the amount of pain [26]. On the basis of a study conducted by Kase, it was shown that following the use of KT on pectoralis major and gastrocnemius the ratio of

blood supply was improved. It is thought that KT triggers the autonomic nervous system and leads to vasodilatation as well as increasing blood supply below the tape which this issue shows greater different in patients [24]. Thus, by improving blood flow, oxygen supply to the muscles increases and improves muscle resistance to fatigue. KT also improves lymphatic discharge [25]. So the removal of metabolites can be facilitated.

It has been shown that stimulation of the skin caused by KT provides an important sensory flow to understand and awareness of movements and helps the central nervous system (CNS) to determine which joint is in motion [50]. Tape which is apply as perpendicular to the axis of joint movements improves the sense of kinesthesia and proprioception. The elasticity of the skin around the tape application area increases because of limited movements under adhesive tape and this makes faster possibility of reaching to threshold of cutaneous discharge [51].

The results of this study are in contrast with the findings of some previous similar studies [52-54]. These differences can be caused by differences in interventions that were not the same. Also, subjects were not under the effect of fatigue that can lead us to conclude that KT might be able to reduce the effects of fatigue to help improve of balance.

A similar work in this regard is a study that investigated the effects of KT on the knee joint repositioning error after quadriceps muscle fatigue, the results of this study demonstrated that fatigue can increase the level of joint error and in return the use of KT can help the joint position sense by reducing the effects of fatigue [33].

The subjects of this study were male and there are likely to observe different results in women. The other limitation is evaluating the immediate effect of KT on balance after fatigue, and the long term effects may be different. The examiners and subjects of both groups were not blinded to treatments and data of other group and these may be the source of bias.

However we conclude that application of KT can reduces the detrimental effect of fatigue on dynamic balance of athletes and this intervention can be used in prevention and treatment of athletes in rehabilitation.

#### Acknowledgement

This study was funded in 2015 by Shiraz University of Medical Sciences, Iran.

**Conflict of Interest:** None declared.

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