Effect of Fatigue on Kinesthetic Acuity of Healthy Ankle

Tomar, Akansha[1], Jagga, V[2].

[1] Department of Physiotherapy, Prem Physiotherapy & Rehabilitation College, Panipat, Haryana India. Email: tomarakki@gmail.com
[2] Head, Department of Physiotherapy, Prem Physiotherapy & Rehabilitation College, Panipat, Haryana) India. Email: jaggavinay@yahoo.co.in

Abstract

The purpose of this study was to determine the effect of fatigue on kinesthetic acuity of (Ankle) the gastrocnemius through a dynamic fatiguing protocol in dorsiflexion and plantar flexion of the ankle. Participants: 100 healthy college students volunteered for the study. Subjects meeting any of the following exclusion criteria were excluded from the study: (1) prior history of multiple ankle sprains, (2) an ankle sprain or ankle injury within the last six months, (3) any knee or ankle surgery within the past year, (4) any neurological or central nervous system deficits (5) taking any medication which might affect the nervous system. Main Outcome Measures: The researchers expected that there would be a significant difference in absolute error between the non-fatigued and fatigued condition at both 10º of dorsiflexion and 20º of plantar flexion. Results: There was significant main effect of fatigue on kinesthetic of healthy ankle. Conclusion: The results of this study indicated that there was significant difference between the non-fatigued and fatigued conditions at 10º of dorsiflexion and 20º of plantar flexion measurements.

Key Words: Kinesthetic Acuity; Fatigue; Ankle; Dorsiflexion; Planter flexion

Introduction

Kinesthetic acuity is defined as ability of perception of one's own body part, weight and movement or the ability of a person to sense by which position, weight and movement are perceived *(Mosby, 2009)*. Proprioception is defined as the awareness of posture, movement, and changes in equilibrium and the knowledge of position, weight and resistance of objects in relation to the body. It is derived from a complex array of information arriving at the brain from several different sources including the muscle spindle, joint capsule, joint ligaments, skin, fat pads, and possibly the joint cartilage and/or subchondral bone. The individual contributions of the various components of proprioception are not well understood, although historically the joint capsule and ligaments were thought to be the major contributors. If indeed the joint capsule and ligaments are the principle contributors to proprioceptive input, it might be expected that persons with damage to their joint capsules or ligaments might have proprioceptive deficits. Joint position sense is a vital component of proprioception. Joint position sense is the body's conscious awareness of joint position and movement resulting from the proprioceptive input to the central nervous system *(Docherty et al, 1999)*. Joint position sense is determined by muscle spindles and skin receptors (*Forestier et al, 2002)*. There have been numerous studies measuring joint position sense in

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the lower *(Hertel et al, 1996; Bernier & Perrin, 1998; Forestier et al, 2002)* and upper extremity *(Johnston et al, 1998; Hertel, 2000)* using a dynamometer. These studies have indicated that joint position sense may be affected by anesthetic injection (*Bernier & Perrin, 1998)* and muscle fatigue in the lower *(Forestier et al, 2002)* and upper *(Myers et al, 1999)* extremities. Fatigue can be defined as undergoing both a metabolic and a neuromotor process. The neuromuscular component of fatigue is dependent on many factors, including stimulation parameters such as frequency, duty cycle, and activation pattern *(Ding et al, 2002)*. There are two types of neuromotor fatigue, central fatigue and peripheral fatigue *(Bernier & Perrin, 1998. Ding et al, 2002)*. Central fatigue is associated with reduced recruitment of new motor units or decreased firing frequency of the active units, or both *(Bernier & Perrin, 1998. Ding et al, 2002)*. Peripheral fatigue results from a decrease in the efficiency of the contractile units of the muscle Neuromuscular fatigue may involve a decrease in motoneuron output or desensitization of type III and type IV muscular afferents *(Yaggie & McGregor, 2002)*.

Materials & Methods

A convenient sample was taken from Prem Institute of Medical Sciences, Panipat. 100 subjects were taken which were equally divided into two groups with 50 males and 50 females in each group which were young group of non sports activity. The subjects were explained about the procedure (fatigue protocol) and then allowed a practice for time of 5 minutes. Both groups followed the same procedure. During the practice time, as in the test time, subjects removed their shoes and socks. The dominant leg was determined by asking the subject which leg they preferred to kick a soccer ball as done in many earlier studies *(Ochsendorf et al, 2000; Sekizawa et al, 2001; Forestier et al, 2002)*. The subjects were then tested for degrees of movement using Baseline Electric goniometer at 20° of plantar flexion and 10° of dorsiflexion in the non-fatigued state. Intermediate range of motion for plantar flexion and dorsiflexion were selected rather than the end range of motion. For our study Golgi Tendon Organs and muscle mechanoreceptors, which are activated at the intermediate range of motion, are of more concern rather than the articular receptors which are activated at the end ranges of motion. Subjects were then allowed a five-minute break prior to starting the fatiguing protocol in which the subjects were allowed to stretch their gastrocnemius if they so desired. The subjects were then asked to stand on their tiptoes until they could no longer hold such a position. When fatigue was reached the subjects underwent a fatigued state kinesthetic acuity test using the same test angles in the same order. The amount of time from the end of the fatigue protocol to the beginning of joint position sense measurement was not greater than 60 seconds. Each test angle was tested only once in the fatigued and non-fatigued state.

Results & Discussion

The results demonstrate that there is significant effect of fatigue on kinesthetic acuity of healthy ankle. There is a

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significant effect of fatigue on kinesthetic acuity of healthy ankle in the Female group which demonstrated a change in dorsiflexion and plantar flexion range of motion after fatigue protocol i.e. non fatigue ankle dorsiflexion range of motion was 9.26 and fatigue ankle dorsiflexion range of motion was 9.28 whereas Non fatigue ankle plantar-flexion range of motion was observed to be 20.00 and fatigue ankle plantar flexion range of motion was 20.00. There was also a significant effect of fatigue on kinesthetic acuity of healthy ankle in the Male group which demonstrated a change in dorsiflexion and plantar flexion range of motion after fatigue protocol i.e. non fatigue ankle dorsiflexion range of motion was found to be 9.86 and fatigue ankle dorsiflexion range of motion was 9.88 whereas Non fatigue ankle plantar-flexion range of motion was 20.00 and fatigue ankle plantar flexion range of motion was 20.00. It was further found that there was greater magnitude of significant effect of fatigue on kinesthetic acuity in males as compared to females i.e. fatigue dorsiflexion range of motion of ankle of males is 9.88 and fatigue dorsiflexion range of motion of ankle of females is 9.28.

Table 1: Comparison of Mean values of non fatigue & fatigue ankle dorsiflexion

Groups	Mean ± SD	t-value	P value
Non Fatigue Ankle DF	9.26±1.07	-1.00	<0.05
Fatigue Ankle DF	9.28±0.83		
Non Fatigue Ankle DF	9.86±0.34	-1.00	<0.05
Fatigue Ankle DF	9.88±0.34		

Yaggie & McGregor (2002) used a Cybex dynamometer in their protocol and fatigued the ankle in all four directions, inversion, eversion, plantar flexion and dorsiflexion. They were observing the effects of isokinetic ankle fatigue on the maintenance of balance and postural limits. The speed was set at 60° per second and fatigue was achieved when three consecutive repetitions fell below 50% of maximum joint torque *(Wilkerson & Nitz, 1994)*. It was concluded that isokinetic fatigue of ankle plantar flexors and dorsi flexors significantly influences sway parameters and ranges of postural control in healthy young men. These perturbations are transient, and recovery occurs within 20 minutes *(Wilkerson & Nitz, 1994)*. *Forestier, et al (2002)* used a dynamometer and subjects hold at least 70% of their maximum voluntary contraction for 40 seconds followed by 40 seconds rest. Subjects were considered fatigued when they could no longer produce 70% of their maximum voluntary contraction for 15 seconds or more. In this study the results indicated that the acuity of the position sense at the ankle is reduced subsequent to a fatigue protocol. With fatigue, subjects produced ankle movements characterized by greater absolute errors for movements of large amplitude in dorsiflexion and for movements of small amplitude in plantarflexion.

Table 2: Comparison of Mean values of non fatigue & fatigue ankle plantar flexion

Groups	Mean ± SD	t-value	P value
Non Fatigue Ankle PF	20.00±000	0.00	<0.05
Fatigue Ankle PF	20.00±000		
Non Fatigue Ankle PF	20.00±000	0.00	<0.05
Fatigue Ankle PF	20.00±000		

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SJIF IMPACT FACTOR 2013=4.65

However, in our study fatigue was determined by the subjects. Therefore, a perceived fatigue may have occurred and not an actual fatigue. The technique, when performed correctly, was reliable in inducing a real state of fatigue. In previous studies using this protocol it was stated that in order to ensure a real fatigued state the testing protocol must begin within one minute of fatigue *(Vuillerme et al, 2001; 2002)*. In the protocol actually took place in under 40 seconds of fatigue. However, not all subjects may have been experiencing a real state of fatigue. Some may have perceived that they were fatigued, when in fact they might have only been experiencing minor discomfort. Previous studies have indicated the use of repeated bouts of this protocol due to multiple trials of their testing procedure *(Vuillerme et al, 2001; 2002)*. The subjects in this study only performed one trial of this fatiguing protocol based on our procedures perhaps the protocol did induce a real state of fatigue, but since subjects were healthy one can only speculate that the muscle mechanoreceptors were not affected. The angles that were tested may play an important role in determining significance. The angles of 10º of dorsiflexion and 20º of plantar flexion were near the midpoint of the normal physiological ranges of motion for the ankle. Using angles that are at the mid-range or just past the mid-range may yield significant results. The mechanoreceptors that are located in the muscles and tendons have shown to be most effective at determining conscious awareness of joint position sense at the mid-range of motion *(Wilkerson & Nitz, 1994; Luttgens & Hamilton, 1997; Vuillerme et al, 2002)*. It has been reported that there is no evidence that articulator (joint) receptors of any joint are important in the conscious awareness of joint position sense *(Wilkerson & Nitz, 1994)*. Muscle spindles are believed to be the best suited for conveying conscious awareness of joint position sense. Therefore, if the angles selected were closer to the mid ranges of motion it may be assumed that significant results may have been found. The failure of anesthesia of the joint and cutaneous afferents disrupting conscious kinesthesia and joint position sense provides further support for the importance of muscle receptors in conscious proprioception (*(Wilkerson & Nitz, 1994)*. In this study the mid ranges of motion were tested to eliminate the cutaneous receptors that are activated at the beginning ranges of motion. Through testing the intermediate range of motion proprioceptive input from type III and IV joint receptors, that detect joint movement and joint position sense at the end range of motion, was eliminated (*Luttgens & Hamilton, 1997)*. We further eliminated cutaneous receptor activity by covering the foot with an elastic foam strap *(Docherty et al, 1999).*

Conclusion: The study was on the effect of fatigue on kinesthetic acuity on the healthy ankle the results of our study conclude that there is significant change in absolute error in an active angle reproduction test at 10º of dorsiflexion a non-fatigued and fatigued condition but there is no significant change in absolute error in an angle reproduction test at 20° of plantar flexion. There are many other variables that can affect joint position sense in the lower extremity. Those

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subjects with chronic ankle instability have impaired joint position sense due to the disruption of joint mechanoreceptors while healthy subjects have no such impairment. In our study only the mid-range of the physiological range of motion was tested. This is the range of motion in which joint position sense is detected by muscle mechanoreceptors.

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