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Full Length Article

Electromiography comparison of distal and proximal lower limb muscle activity patterns during external perturbation in subjects with and without functional ankle instability

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ABSTRACT

Ankle sprain is one of the most common injuries among athletes and the general population. Most ankle injuries commonly affect the lateral ligament complex. Changes in postural sway and hip abductor muscle strength may be generated after inversion ankle sprain. Therefore, the consequences of ankle injury may affect proximal structures of the lower limb. The aim is to describe and compare the activity patterns of distal and proximal lower limb muscles following external perturbation in individuals with and without functional ankle instability. The sample consisted of 16 women with functional ankle instability and 18 healthy women were recruited to participate in this research. The external perturbation via body jacket using surface electromyography, amplitude and onset of muscle activity of gluteus maximums, gluteus medius, tibialis anterior, and peroneus longus was recorded and analyzed during external perturbation. There were differences between the onset of muscles activity due to perturbation direction in the two groups (healthy and functional ankle instability). In the healthy group, there were statistically significant differences in amplitude of proximal muscle activity with distal muscle activity during front perturbation with eyes open and closed. In the functional ankle instability group; there were statistically significant differences in amplitude of proximal muscle activity with distal muscle activity during perturbation of the front and back with eyes open. There were statistically significant differences in the onset of muscle activity and amplitude of muscle activity, with-in and between groups ($P < 0.05$). Therefore, in the presence of functional ankle instability, activation patterns of the lower limb proximal muscles may be altered.

1. Introduction

Ankle sprain is one of the most common injuries among athletes and general the population (Gribble & Robinson, 2009). Excessive plantar flexion and inversion are the most common causes of injury of lateral ligament complex (Brown & Mynark, 2007; Clark & Burden, 2005). About 80% of the people will experience ankle sprain during their life span (Akhbari, Ebrahimi Takamjani,

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Salavati, & Ali Sanjari, 2007; Gribble & Robinson, 2009; Webster & Gribble, 2013). About 73% of athletes who had an ankle sprain, report the recurrence and 59% of them had long-term disability (Hopkins, Coglianese, Glasgow, Reese, & Seeley, 2012). A clear definition of functional ankle sprain is recurrent ankle sprain and periods of giving way with or without ligamentous laxity (Wikstrom & Hass, 2012). Functional ankle instability is a complex syndrome that involves functional and neuromuscular structures (Nawata, Nishihara, Hayashi, & Teshima, 2005). Effects of ankle injury are not just restricted to the ankle structure (Beckman & Buchanan, 1995). Functional ankle instability is associated with deficiency of dynamic stability and neuromuscular changes in proximal joints (Akhbari et al., 2007). After inversion ankle sprain, the changes of postural sway and the strength of hip abductor muscles suggest that the consequences of ankle injury manifest in structures proximal to the ankle in addition to local structures (Beckman & Buchanan, 1995). In recent years, researchers have found that in case of ankle instability, the kinematic patterns of the hip and knee joints will be change (Gribble & Robinson, 2009). Because of closed kinematic change in lower extremity during weight bearing, the ankle sprain or lower extremity injury lead to changes in proximal muscle activity patterns (Lehman, 2006). Most previous studies have shown muscle activity during distal perturbation in ankle sprain and most have evaluated distal muscles. Few studies have evaluated proximal muscles and muscular activity during isolated movement. We aimed to investigate the distal and proximal lower limb muscles activity patterns after external perturbation of the proximal lower limb region between individuals with and without functional ankle instability.

2. Methods

2.1. Participants

16 women with functional ankle instability (FAI) and 18 healthy control women participated in this study. To be characterized as functionally unstable, the women should have the following criteria: (a) lateral (inversion) ankle sprain, within the last year, (b) no ankle fracture, (c) no ankle instability or "giving way", (d) no formal or informal rehabilitation of the unstable ankle and (e) no evidence of mechanical instability as assessed by anterior drawer and Talar tilt tests. Participants were excluded if they had any current lower extremity injuries, previous surgical procedures that caused major structural change in the lower extremities, were pregnant, lower extremity pain by activity or had concussions or any other neurological conditions that may have altered their muscle activity and movement patterns within the last six months (Gribble & Robinson, 2009). Patients in the FAI group were matched to healthy controls with respect to age, body mass index, and lower limb dominance (Finch E & Stratford PW, 2002) (Table 1).

2.2. Ethical approval statement

The study was approved by the Human Ethics Committee of the University of Social Welfare and Rehabilitation Sciences, Tehran, Iran (Ethics Code: USWR.REC.1393.148). The rights of all participants were protected in the study. Before participation in the study, all participants signed a consent form.

2.3. Instrumentation and testing procedure

2.3.1. Perturbation device

From a relaxed standing position, sudden ventral or dorsal loading was applied to the trunk as proximal perturbation by a molded plastic vest strapped to the torso (Cresswell, Oddsson, & Thorstensson, 1994). A non-elastic string with a 5-kg load was attached to horizontal bars that extended 12 cm ventrally and dorsally from the vest respectively. Perturbations were delivered by dropping the weight 25 cm prior to the string tightening. "Frontal-loading" was achieved by unexpectedly dropping the weight ventrally; "back-loading" was unexpected dorsal loading.

Perturbation was produced in the sagittal plane in four directions: frontal direction with open eyes, frontal direction with closed eyes, back direction with open eyes, back direction with closed eyes (Cresswell et al., 1994).

Table 1
Subject Demographic and clinical characteristics of the sample population.

Group	Healthy (n = 18) P-Value Mean ± SD	FAI (n = 16) P-Value Mean ± SD
Age (Year)	24.5 ± 3.32 0.67	24.5 ± 3.75 0.56
Weight (kg)	56.52 ± 8.18 0.99	61.25 ± 6.49 0.91
Height (cm)	1.63 ± 0.60 0.95	1.65 ± 0.62 0.97
BMI (kg/m^2)	21.20 ± 2.94 0.92	22.49 ± 1.96 0.97

Abbreviations: BMI, body mass index; SD, standard deviation, FAI, Functional Ankle Instability. In all the analyses, $P < 0.05$ (with a 95% confidence interval) was considered statistically significant.