Functionally Unstable Ankle Effect on Eccentric Peak Torque at Two Different Angular Velocities

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ABSTRACT

The purpose of this study was to examine the eccentric torque measures of the ankle musculature in participants with stable ankles and participants with functional ankle instability (FAI) at two angular velocities 30 and 90^o/sec. The study included fifty untrained participants(31 male,19 female, age ranged from 19-34 year) divided into two groups; the first group consisted of twenty five subjects suffering from FAI, the second group consisted of twenty five subjects with no prior history of ankle injury as control group. Eccentric peak torque of invertor, evertor, plantar-flexor and dorsiflexor muscles was recorded for each participant at angular velocities 30 and 90^o/sec at the isokinetic lab. Of the faulty of physical therapy. Analysis of variance (ANOVA) was used to compare between the two groups at angular velocities 30 and 90^o/sec, revealed that there was a significant deficit for eccentric inversion, eversion, and plantarflexion peak torques between FAI group and control group at both angular velocities. Moreover, no significant difference was identified for eccentric dorsiflexion peak torque at both angular velocities. Therefore, eccentric inversion, eversion, and plantarflexion strength is an important factor during rehabilitation protocols of functional unstable ankle.

Keywords: *eccentric contraction; inversion; eversion; plantarflexion; dorsiflexion; functional ankle instability.*

INTRODUCTION

Ankle injuries result in a significant amount of time loss from work and sport activity. The ankle is the most commonly injured joint in the body and 85% of those ankle injuries are inversion sprains[1]. The mechanism of a lateral ankle sprain is typically a violent inversion/hypersupination of the ankle complex[2]. Given the high prevalence of this injury, and the large proportion of sufferers who continue to experience related functional disability, it is important to identify impairments that contribute to functional ankle instability (FAI). The most common complications following ankle sprain are mechanical and functional instability[3].

Mechanical ankle instability (MAI) is defined as ankle movement beyond the physiologic limit of the ankle's range of motion. The term "laxity" is often used synonymously with MAI. FAI is defined as the subjective feeling of ankle instability or recurrent, symptomatic ankle sprains (or both) due to proprioceptive and neuromuscular deficits. The subtalar joint is critical to the mechanics of ankle instability. It acts functionally as a mitered hinge, allowing the leg to rotate on the weight-bearing foot. Biomechanically, the reaction force from the ground acts on the foot to create a moment acting on the subtalar joint[4].

Postural corrections taking place at the ankle during walking and running; these primarily occur through corrective motions of inversion and eversion in an effort to keep the foot stable underneath the center of gravity (COG). If postural correction takes place, no shear forces are produced, and any forces on the foot are counteracted by forces acting through the COG[4]. Due to the importance of the ankle joint as the main shock absorber in locomotion, it is imperative to reduce the debilitating effects of ankle instability. Consequently, a more complete understanding of neuromuscular function surrounding the ankle joint is vital[2].

Peroneal muscle weakness has been theorized to cause diminished dynamic stability and, therefore, contribute to FAI[5]. However, the previous literature related to the presence of peroneal deficits in individuals with functionally unstable ankles is conflicting. Hartsell and Spauling[6] and Tropp[7] have identified both concentric and eccentric eversion torque deficits; whereas others have concluded that no eversion deficit exists, regardless of mode or speed of contraction[8].

Additionally, while the evertor muscles can counter a varus force[6], proper dynamic stabilization of the ankle can only be achieved through a coordinated effort of all the surrounding muscles[9]. Efficient function and protection of the joints would, at times, involve cocontractions for stability as well as the commonly recognized agonist-antagonist activity in order to facilitate reciprocal planar motion. Significant torque deficits have been noted during eccentric muscle contractions[6,8], whereas (McKnight and Armstrong[10] and Baumhauer et al.,[11] found no significant invertor deficits. Termansen et al.,[12] studying the plantar-flexors reported concentric torque deficits in participants with a history of a lateral ankle sprain; McKnight and Armstrong[10] found no significant difference in plantarflexion or dorsiflexion torque between FAI and control participants.

So, there are discrepancies in the inversion and eversion literature and the lack of research on the plantar-flexors and dorsiflexors, additional studies evaluating isokinetic ankle torque values are necessary. Additionally, eccentric muscle contraction could be considered a critical component of ankle control during virtually all ankle joint movements[13]. Furthermore, eccentric muscle actions are more representative of dynamic ankle stabilization mechanisms[2]. Therefore, the purpose of the present study was to examine differences in eccentric inversion, eversion, plantarflexion and dorsiflexion peak torque in normal and functionally unstable ankles.

MATERIALS AND METHODS

Subjects

Fifty subjects participated in this research. Group (A) the healthy group consisted of twenty five participant (14 male and 11 female, age range 19-34 years, mean height = 174.9 ± 5.5 cm, mean weight = 73.33 ± 7.76 kg) with no prior history of pathology to any of lower extremity. Group (B) the FAI consisted of twenty five participant (17 male and 8 female, age range 19-31 years, mean height= 176.13 ± 6.6 cm, mean weight = 74.13 ± 6.77 kg) who had sustained at least one moderate sprains to the same ankle which required medical intervention and who complained of repeated episodes of "giving way". No subjects had suffered from injury to the unstable ankle for at least six months before testing, were not undergoing rehabilitation of the ankle, nor had any complaints of pain, swelling, or functional limitations. Active range of motion plantarflexion/dorsiflexion and inversion/eversion was measured using a standard goniometer were observed to be within normal limits (±2^{o}).

All subjects were not involved in any physical activity or exercise training. Written consent was obtained from each subject before testing, and all subjects were screened to ensure that no lower extremity neuromuscular or musculoskeletal problems or contraindications for isokinetic testing, after being informed about the study and test procedures, and any possible risks and discomfort that might ensue.

Testing Procedures

The subject have warmed up for 5 min on a stationary bicycle at a comfortable pace between 60 and 70 revolutions per minute and 5 min of stretching exercise for invertors, evertors, plantar-flexors and dorsiflexors. For the participants' ankles were then tested in both inversion-eversion and plantarflexion-dorsiflexion movements using the Biodex multi joint system 3 isokinetic dynamometer (Biodex Medical Systems, Inc, Shirley, NY, USA). The test angular velocities were 30 and 90°/sec for all movement patterns inversion/eversion and plantarflexion/dorsiflexion. It has been established through Kaminski and Hartsell[9] quadratic trend that 90°/sec was the optimal testing speed for eversion movements. Moreover, Buckley et al.,[14] stated that during eccentric muscle performance must use the low-medium range of velocity spectrum, because using high velocities is not risk free. Each subject was seated on the biodex chair, with the angle of hip 80° flexion (0° neutral position). In ankle plantarflexion/dorsiflexion test and inversion/eversion a knee pad was placed under distal femur and secure with a strap allowing for approximately 20° to 30° of knee flexion, also ensure that the subjects's lower leg is parallel to the floor, this also diminished the potential for dynamic hamstring activity falsely contributing to the generated torque[15], the foot and ankle were positioned into either the inversion/eversion or plantarflexion/dorsiflexion attachment with straps to secure the foot. Once positioned, the participant's active range of motion was used to determine the start and stop angles. For each testing motion, a warm-up of 10 repetitions at 30 and 90°/sec was performed for familiarization of the speed of movement and the eccentric mode of testing. This was followed by 5 continuous repetitions throughout the range of motion. Kaminski and Dover[16] used similar testing procedures in their reliability testing, and a two-minute rest was permitted between the test for inversion, eversion, plantarflexion and dorsiflexion to prevent the buildup of fatigue[17].

Statistical analysis

The peak toque (expressed in Nm) of the ankle joint muscles at 30 and 90°/sec was recorded. The highest value of each bout of repetitions was used. Data were analyzed by using a Statistical Package for Social Sciences (SPSS version 16) Analysis of variance (ANOVA) was used to compare between normal and FAI group at angular velocities 30 and 90°/sec. Level of significance was set at 0.05 for all statistical tests.

RESULTS

Descriptive statistics for ankle joint muscles peak torque (Nm) for normal and FAI groups at 30 and 90°/sec are presented in table (1) and shown in figure (1).

Table (1): The mean values of peak torque (±SD) for the ankle joint muscles for the normal and FAI at angular velocities 30 and 90°/sec.

Groups	Degree	Plantarflexion (Mean±SD)	Dorsiflexion (Mean±SD)	Inversion (Mean±SD)	Eversion (Mean±SD)
Normal	30°/sec	78.56 ± 2.35	41.64 ± 2.48	28.48 ± 3.38	25.36 ± 2.96
	90°/sec	81.08 ± 3.03	43.84 ± 3.68	31.16 ± 4.17	27.56 ± 3.18
FAI	30°/sec	76.32 ± 3.51	40.32 ± 4.53	25.56 ± 4.57	23.60 ± 1.60
	90°/sec	78.72 ± 4.05	43.12 ± 3.81	27.84 ± 3.86	25.24 ± 1.94

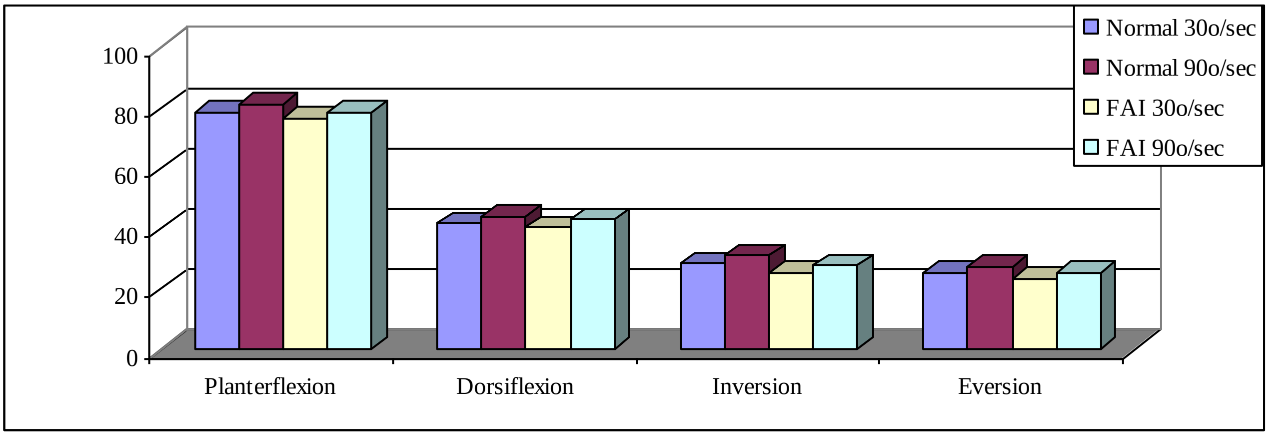

Fig. (1): Mean values of the eccentric peak torque (Nm) for plantar-flexors, dorsiflexors, invertors and evertors.

Effect of FAI on eccentric peak torque

For the plantar-flexor muscles there was a significant difference between the normal and FAI eccentric peak torque values at angular velocity of 30°/sec as well as at 90°/sec, P = 0.018 and 0.013 respectively. However, for the dorsiflexor muscles there was no significant difference between the normal and FAI eccentric peak torque values at angular velocities of 30 and 90°/sec, P = 0.210 and 0.493 respectively.

Considering the invertor muscles there was a significant difference between the normal and FAI eccentric peak torque values at angular velocities 30 and 90°/sec, P = 0.012 and 0.004 respectively. For eccentric contraction of evertor muscles there was a significant difference between the normal and FAI eccentric peak torque values at angular velocities 30 and 90°/sec, P = 0.015 and 0.001 respectively.

Effect of angular velocity on eccentric peak torque

The plantar-flexor muscles eccentric torque significantly increased when the angular velocity increased from 30°/sec to 90°/sec for normal and FAI group, p = 0.008 and 0.011 respectively. The dorsiflexor muscles eccentric torque significantly increased when the angular velocity increased from 30°/sec to 90°/sec for normal and FAI group, p = 0.038 and 0.009 respectively.

The invertor muscles eccentric torque significantly increased when the angular velocity increased from 30°/sec to 90°/sec for normal and FAI group, p = 0.020 and 0.048 respectively. The evertor muscles eccentric torque significantly increased when the angular velocity increased from 30°/sec to 90°/sec for normal and FAI group, p = 0.002 and 0.023 respectively.

DISCUSSIONS

The testing procedure of the current study conducted on the eccentric mode of muscle contraction and didn't include concentric contraction that is due to Dvir[17] stated that it is not advisable to draw comparisons between concentric and eccentric values. In order to achieve a certain force, lower levels of motor-unit activity are required with eccentric actions. Consequently, additional units not being used are available and can provide higher increments than with concentric contractions. For the same test velocity, eccentric strength is greater than concentric strength, and the order of strength depends on contraction mode (eccentric, isometric, concentric).

Moreover, Dvir[17] maximal moment developed concentrically by the muscle decreases concurrently with increments in test velocity, whereas for eccentric actions, the tension generated by the muscle remains similar, regardless of test velocity which is not supported the results of the present study, the results of plantar-flexor, dorsiflexor, invertor and evertor muscles proved that as the angular velocity increased the eccentric peak torque of both group increased.

Some studies showed no deficit in eccentric evertor muscle strength in FAI[8,18]. However, Hartsell et al.,[19] established eccentric evertor muscle weakness comparing patients with normal subjects, which is coincident with the results of the present study. Eccentric evertor strength weakness might be explained as follows, biomechanical changes around the ankle joint caused by unstable ankle deficiency might affect eccentric activity to a greater degree than healthy ankle joints. In addition, evertor muscle atrophy might affect eccentric activity at the cellular level[20].

Conversely, the more recent study did not identify any significant eversion torque deficits in FAI participants[21]. These authors reported that ankles with FAI perform the same as uninjured ankles during eversion movements, regardless of the type of contraction (concentric and eccentric) or velocity. Therefore, they concluded that the isokinetic eversion torque deficits are not a major contributing factor to residual symptoms of giving way, which is against the result of current study that may be due to the sample of their study was athletes which is physically and mechanically differs than the sample of present study that was nonathletic group.

Additionally, McKnight, and Armstrong[10], Baumhauer et al.,[11], Fox et al.,[21] did not find a significant difference in eccentric invertor torque between the FAI, and uninjured subjects, which is against the result of the current study. Their results contradict previous findings of Hartsell and Spaulding[6] who found invertor deficits in participants with FAI. One potential reason for these discrepancies is the mode and speed of testing. Testing speeds of previous investigations ranged from 30 to 240°/sec[8,10,11] and mode of testing included both eccentric[8] and concentric contractions[10,11,22]. All these variety in testing procedures makes it difficult to interpret and compare previous findings.

Nitz et al.,[23] have provided evidence that the deep peroneal nerve may be compressed after lateral ankle sprain. Ryan[22] theorized that the inversion deficits might have resulted from selective inhibition or deep peroneal nerve dysfunction as a result of overstretching the peroneal nerve. Moreover he speculated that lateral ankle sprain renders the invertor motor-neuron pool less excitable, while the evertor motor-neuron pool is not affected as much, which could be the reason for invertor weakness in lateral ankle sprain.

Fox et al.,[21] proved that there is a decrease in plantar-flexor torque at angular velocities 30 and 90^o/sec which is concurred with the findings of the current study, that could be the result of several different factors. First, the deficit could be the result of damage to the gastrocnemius-soleus complex during the initial injury. Hertel[24] identified damage to both the ligamentous and musculotendinous structures after a lateral ankle sprain. The gastrocnemius-soleus complex crosses the talocrural joint, so this complex could be damaged by a severe inversion stress. Second, reduced motor unit excitability could occur after an initial ankle sprain and lead to decreased plantarflexion torque. McVey et al.,[25] identified arthrogenic muscle inhibition of the soleus muscle in participants with unilateral FAI. The authors suggested that changes in afferent feedback could contribute to both muscle inhibition and FAI. Finally, little is known about the muscle-fascia interfaces and their relationship to injury. The formation of fibrous tissue in the myofascial interface would theoretically lead to inhibition of the muscle's ability to lengthen during activity Fox et al.,[21]. The results of dorsiflexion torque of participants with a history of FAI did not have deficits at angular velocities 30 and 90^o/sec, this results agree with the results of the previous studies[10,11,21,26] regardless of population, mode of testing, or type of contraction.

This study was limited by the following: First, the sample study was untrained subjects. So, the reader must be careful during application of these results on physically active subjects or athletes. Second, the study was restricted for FAI which is mechanically differs than chronic ankle instability. Third, this study utilized a relatively young sample. Therefore, the results of the present study will be more suitable for similar age group and further research evaluate the effect of FAI on the eccentric peak torque of ankle musculature in other age groups would be interested especially elder subjects. Finally, the angular velocities used during conduction of this study were 30 and 90^o/sec which considered slow and moderate velocities. So, further research can be conducted at fast angular velocities.

Conclusion

This study evaluated the eccentric peak torque of invertor, evertor, plantar-flexor and dorsiflexor of functionally unstable ankles and found a deficit in inversion, eversion, and plantarflexion eccentric peak torque at angular velocities 30 and 90^o/sec. No deficit identified for dorsiflexion eccentric peak torque at both angular velocities. So, Eccentric training of invertors, evertors, and plantar-flexors lead to more effective rehabilitation programs of subjects suffering from functionally unstable ankle and prevent the incidence of recurrent ankle sprain.

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الملخص العربى

تاثير عدم ثبات مفصل الكعب على العزم الإنبساطى لعضلات الكعب على سرعتين مختلفتين

الهدف من الدراسة هو إختبار العزم الإنبساطى عضلات الكعب فى حالات عدم ثبات مفصل الكعب وذلك عند سرعتين مختلفتين (30 و90/ ثانية) ، الدراسة تحتوى على خمسين شخص لايمارسون أى نوع من الرياضة مقسمين لمجموعتين المجموعة الأولى خمسة وعشرون شخص مصابين بعدم ثبات مفصل الكعب ، والمجموعة الثانية خمسة وعشرون شخص لا يعانون من أى إصابة بمفصل الكعب. وتم قياس العزم الإنبساطى لجميع عضلات الكعب على السرعتين (30 و90/ ثانية) . وأثبتت نتائج البحث وجود ضعف فى عضلات القدم القابضات ، وموجهات القدم للداخل ، وموجهات القدم للخارج للمجموعة المصابة بعدم ثبات مفصل الكعب عند مقارنتها بالمجموعة الغير مصابة ، وعدم وجود أى ضعف فى عضلات القدم الباسطات عند مقارنة المجموعة المصابة بالمجموعة السليمة ، وذلك فى السرعتين السابق ذكرهم . وبناءاً عليه فإنه يجب مراعاة ذلك فى برامج تأهيل المصابين بتمزق برباط الكعب الخارجى وذلك عن طريق تقوية عضلات الفدم القابضات ، وموجهات القدم للداخل ، وموجهات القدم للخارج .