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RESEARCH ARTICLE

THE INFLUENCE OF KNEE INJURIES ON ANKLE PLANTARFLEXION AND DORSIFLEXION STRENGTH

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ABSTRACT

Purpose: Knee joint injuries may affect the function of the adjacent ankle joint. The strength of ankle dorsiflexion and plantarflexion of the affected leg, was compared to the unaffected leg, to assess the influence of different knee injuries on ankle movement strength.

Methods: Sixteen healthy, young adult males with a mean age of 34 years, and a unilateral knee injury (either the menisci, the ligaments, or both) were examined To measure the dorsiflexion strength, the Elgin ankle exercise machine was used, and for measuring the plantarflexion strength, heel raise exercises with full body weight was performed by the participants. The one repetition maximum (1RM) of both the injured and non-injured legs, was calculated through the Epley equation using the repetition until fatigue method.

Results: There was no evident difference found in the strength of dorsiflexion between the injured and non-injured legs. However, there was a significant difference among the plantar flexion strength of the injured and non-injured legs.

Conclusion: Injury at the knee joint affects the strength of the muscles at the adjacent ankle joint, especially the plantarflexion. Therapists treating these types of patients, must attend to the ankle deficits caused as a result of knee.

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INTRODUCTION

Kneeinjuries are highly prevalent in developed countries; many recent studies suggest that the prevalence of knee injury ranges between 10% - 25%, with somestudies reporting higher percentages (Louw, 2008). The knee joint was the most frequently injured site amongst both men and women, and accounted for 19–23% of all injuries (Macaluso *et al.*, 2018). Among the different types of knee injuries, ligament damage to the knee was themost common (Brown, 2016). Knee injuries are common reasons for temporary inabilityto continue playingsports (Harmer, 2005), and can incur long-term disabilities that could impede future participation in sports, daily activities, and other occupational requirements (Kujala *et al.*, 1995).

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Evidence suggests that injuries to the knee may precipitate ankle joint impairment and cause muscle weakness (Thomas, 2013). The ankle joint is functionally connected to the knee joint. Moreover, after knee injuries, a surgery can widely influence ankle muscle strength, leading to weakness in plantar and dorsiflexion motions (Thomas, 2013). Several methods can be employed to evaluate maximal muscle strength of the ankleafter knee injuries, to determine the influence of the knee on the ankle joint. These methods include isometric and isokinetic dynamometers, however these two methods require sophisticated laboratory equipment and trainedpersonnel (DiStasio, 2014). The one-repetition maximum (1RM) method is another method that can be used to determine muscle strength, defined as the maximal weight that can be lifted once. This method is comparatively simple and requires inexpensive non-laboratory equipment (Levinger, 2007). In addition, the 1RM measurement is considered one of the most accurate methods of assessing muscular strength (DiStasio, Thomas, 2014).

Thus, the purpose of this study is twofold; the first is to determine the influence of knee injuries on ankle plantar flexion and dorsiflexion strength. The second is to comparethe affected side to the non-affected side of the lower extremities, using the 1RM method.

METHODS AND PARTICIPANTS

Sixteen male subjects volunteered in the study. All the participants were patients at our physical therapy clinic, and were healthy and independent in their daily life activities. The subjects signed a consent form at the time of the data collection, and were excluded from the study if they had any neurological disorders or unstable cardio respiratory conditions. The patients were also removed from the study if they had any ankle deficits, bilateral knee injuries, or unilateral injuries other than the menisci and ligament impairments. The included subjects all had a history of knee injuryinone leg, whether it was a meniscal injury (medial or lateral), or a ligament us injury (ACL, PCL, MCL, LCL), or both.

Subjects characteristics (shown as mean ± standard deviation) are in the following table (1.1):

	Mean	Standard Deviation
Age	34.2 Years	± 2.5
Height	172.5 Cm	± 1.6
Weight	84.2 Kg	± 5

Gender (16 Male Subjects)

To measure the impact of each individuals knee injury on ankle joint strength, the participants were subjected to ankle exercises to reach the maximum muscle strength. Then, the results were calculated by an equation to predict their one-repetition maximum (1RM). The 1RM test has several equations, but for the purpose of this study the Epley formula was chosen due to its accuracy and reasonability to measure the strength of the given muscle[9].

1RM = weight x (1 + (reps / 30))

During the first therapy session, subjects were asked to answer a log sheet of questions to determine whether the patient's are eligible to participate in the study. The 1RM ankle test was executed at the beginning of the physical therapy treatment program of the second visit. The devices used was: the Elgin ankle exerciser, and the quad bench. The reliability of the selected exercises being performed on these similar devices was found to be high[10]. After a 5-minutewarm-up routine on a treadmill, The subjects sat on the quad bench with all the mechanical parts taken out, to imitate a normal exercise bench, with the Elgin ankle exerciser beneath it. The dorsiflexion strength measurements were recorded on the Elgin Ankle Exercise Machine, which allowed plate loading on the foot's anterior and posterior aspects. In a seated position with the knee at 90° flexion, the foot was moved from a neutral position at the ankle joint, and weights were added accordinglyhe plantarflexion strength was measured by asking each individual to fully raise their heels and stand on their toesas many timesas possible until fatigue. The side tested first (injured vs. non-injured) was randomly chosen. Three trials for each subject was done, and the average of the 3 tests was taken. The other side was tested using the same protocol To calculate the 1RM, the repetition until fatigue method was used, with weights for dorsiflexion, and body weight for plantar flexion; the results were then applied to the Epley equation to compute the 1RM.

Statistical Analysis: All values are expressed as the mean (±SD). Paired t-tests were used to evaluate the differences between plantar flexion and dorsiflexion 1RMs of the affected and non-affected sides. All statistical calculations were performed using IBM SPSS 22.0 (IBM Corporation, Armonk, NY), and statistical significance was set at $p < 0.05$.

RESULTS

When comparing the dorsiflexion strength of the affected and the non-affected sides, there were no significant differences ($p=0.214$), meaning that whether there a was a knee injury or not made no differencein the dorsiflexion strength between the affected and non-affected side. However, when comparing the plantarflexion of the affected and non-affected side, there was a significant difference ($p<0.05$), which means knee injuries had an impact on plantar flexion strength between the affected and non-affected sides, with a mean difference of 13 kg ±4.39(SD).

DISCUSSION

The major findings of this study suggests that knee injuries, especially injuries at the menisci and ligament regions, do not have a large impact onankle dorsiflexion strength, when the affected and non-affected legs were compared. Even though, the range of dorsiflexion motion has been reduced in individuals with knee injuries[11].However, the planter flexion strength was significantly different between the affected and non-affected sides, as there was an apparent difference due to knee injuries on the affected leg. The plantarflexion motion is more powerful than the dorsiflexion motion[12,13], because the calf muscles have a significantly vaster cross-section as compared to the dorsiflexion muscles[14].Due to the difference in strength of these muscle groups, there was a need for a suitableplantarflexion technique to adequately exercise the calf muscles. The plantarflexion exercise used was heel raises in order to utilize the body weight, due to the limitation of the Elgin device being unable to bear heavy weights.Approximately25 repetitions of standing heel raises account for the normal strength of plantarflexionmuscles[15].However,in this study the duration to maintain the heel in its raised position, was also used to account for the strength of the muscle. Plantar flexion becomes weak after a knee injury on the same side, but strength is usually gained after knee reconstruction followed byrehabilitation[17].To our knowledge and according to the findings of this study, there is a direct impact on the ankle joint muscles after an injury to the ipsilateral knee, if sufficient rehabilitation is not done in a timely manner. This goes back to the fact that there is a strong interrelated relationship between the muscles of the knee joint and ankle joint[6]. Resistance training is the most appropriate exercise technique to enhance muscle strength[16].Yet, an accurate determination of muscle strength to evaluate the efficacy of the training routine is essential. Thus, the 1RM calculation method is considered an accurate strategy to measure muscular strength[7].In addition, The 1RM measurement is a reliable, low-cost, and simple tool for assessing maximal strength for subjects, when compared to

costly laboratory equipment's, such as isometric and is kinetic dynamometers[8]. The Epley 1RM equation was used in our study, which is considered one of the most accurate formulas to predict the 1RM for an individual[7,18,9].The use of sub maximal loading till fatigue, as was used in our study, is preferred than the maximal strength testing procedure, because it allows for early recovery from fatigue[7,19]. A limitation of this study is that the sample included only 16 male participants. Thus, the relatively decreased number of subjects and the utilization of only one gender, confines the generalizability of our results.

CONCLUSION

Knee injuries generally have an effect onankle joints, whether the type of injury is ligamentous, meniscalor both. Besides the influence of the knee on the ankle joint, the plantarflexion strength was seemingly more affected at the same side of the affected knee, causing significant muscle strength decreases when compared to the non-affected leg, whereas the ankle dorsiflexion strength was only slightly affected at the 1RM test. It is recommended that the treating therapists make note of this difference, and screen the ankle for any muscular imbalances when attending to patients with knee joint related injuries, as there is an evident connection between the musculature of both joints[20].

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