The Incorporation of Balancing Board Exercises in the Management of Plantar Fasciitis

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ABSTRACT

Background: *Foot problems have been identified as falls risk factor. In particular, painful feet are associated with an increased risk of falling and decreased mobility and quality of life. Therefore, balance control, are disturbed in cases of plantar fasciitis by several factors including: abnormal foot position, deficient muscle function of the ankle and foot, t^{0}he direct effect of pain associated with weight bearing on pressure exerted beneath the calcaneous and forefoot 39- which is decreased in such a manner that can affect the sensory cues from the plantar mechanoreceptors and medial calcaneal nerve neuropathy associated with chronic plantar fasciitis. Therefore, the purpose of this study was to assess the effect of adding balancing board exercises on stability and functional disability in patients with chronic unilateral plantar fasciitis.* ***Materials and Methods:*** *Twenty-eight (18 females, 10 males) suffering from unilateral plantar fasciitis, their age ranged from 28 to 60 years old participated in the study. Patients were randomly assigned to receive either conventional physical therapy and balancing board exercises (CPTB) or a program of conventional physical therapy (CPT) only. All subjects completed a single-leg static balance assessment on a Biodex Stability System (Shirley, NY 11967) at stability level 8 (the most stable) over a period of 20 seconds. The test was performed twice with eye-openned and eye-closed conditions. The overall stability index (OSI) was used for analysis. Foot pain and functional limitations were assessed by the use of Manchester Foot Pain and disability Index (MFPDI).* ***Results:*** *Following the 4 weeks of treatment intervention, a significant improvement was found in the balance group in the overall stability indices during stance leg with the eye openned (SLEO) ($P<0.006$) and in the stance leg with the eye closed (SLEC) conditions ($P<0.05$). The conventional group showed no significant changes in the overall stability indices in the two test conditions. The mean value of FDQ score for both the conventional and balance groups significantly decreased after the treatment period indicating an improvement of function ($P<0.05$). Comparing the mean differences of the score achieved revealed a higher improvement in balance group than in the conventional group.* ***Conclusion:*** *The incorporation of balance-training with conventional physiotherapy program in the treatment of plantar fasciitis could improve balance, pain and function more than implementing the conventional program alone.*
Key words*: Plantar fasciitis, Balance, function.*

INTRODUCTION

Plantar Fasciitis is one of the most common causes of heel and foot pain in athletes as well as those not involved in sports[17]. It is common in runners as an incidence of approximately 10% has been reported. It has also seen in nonathletic persons who are obese, who spend most of the day on their feet, or who have limited ankle dorsiflexion[33]. Men and women appear to be equally affected[6]. The condition occurs over a wide age range and peaks in people between the ages of 40 to 60 years, in the general population, and in younger people among runners[12,33].

Plantar Fasciitis was defined by Voloshin et al. (2002)[39] as a painful inflammation of fascia in the plantar area of the heel. Plantar fasciitis is considered to be an overuse syndrome as it develops over time and is a result of repeated stress that exceeds the body's inherent capacity to repair and adapt; which eventually leads to failure of the ligaments, bone and muscles. It has been associated with biomechanical disorders such as pescavus, pesplanus, and tight achilles tendon. Repeated stress to plantar fascia origin leads to micro tears and chronic inflammatory changes (necrosis, fibrosis, chondroid metaplasia). The normally resilient fascia becomes stiffened, prone to re-injury, and thus setting up a vicious circle of persistent pain[16].

Patient with plantar fasciitis typically present with intense focal pain at the medial tubercle of the calcaneus upon taking the first steps out of bed in the morning. They often have a temporary limp, and symptoms may recur during the day when taking the first steps

after any prolonged sitting. Symptoms often subside after walking for a short time, but they may worsen at the end of the day after prolonged standing, walking or running. The onset of pain is usually gradual without any antecedent trauma[39].

The conventional physical therapy treatment for plantar fasciitis includes physical agents such as ice and ultrasound to reduce pain and assist the natural healing process of the involved tissues[9]. The restoration of flexibility to the involved tissues is an important component of the overall treatment program. Stretching of the calf muscles, achilles tendon and plantar fascia itself is most frequently recommended in the literature[2,12,39]. Strengthening exercises for the extrinsic and intrinsic muscles should also be included[23,44].

Foot problems have been identified as falls risk factor and in particular, painful feet are associated with an increased risk of falling and decreased mobility and quality of life. Older people with foot pain and plantar hyperkeratosis performed significantly worse in balance and functional ability tests[26]. Other study conducted by Yaqci et al. (2007)[43] proved that chronic musculoskeletal pain in the lower body affects negatively the balance ability in the healthy adults. Other foot problem identified to impair proprioceptive inputs and producing when standing with eyes closed is peripheral neuropathy[27,30]. In addition, different foot types (cavus, rectus, or planus; supinated or pronated foot) have been found to affect postural control during single leg stance[10,18].

Accordingly, somatosensory input, and therefore balance control, are disturbed in cases of plantar fasciitis by several factors. These factors include: (1) abnormal foot position[2,44], (2) deficient muscle function of the ankle and foot[1], (3) the direct effect of pain associated with weight bearing on pressure exerted beneath the calcaneous and forefoot[40], which is decreased in such a manner that can affect the sensory cues from the plantar mechanoreceptors, and (4) medial calcaneal nerve neuropathy associated with chronic plantar fasciitis[3,8,34].

The addition of balance training exercises to the rehabilitation program for patients with plantar fasciitis is recommended[31,42].

To our knowledge, no published report has evaluated an integrated physical therapy program with balancing exercises in treatment of plantar fasciitis. Therefore, the purpose of this study was to assess the effects of adding balancing board exercises on stability and functional disability in patients with chronic unilateral plantar fasciitis.

MATERIALS AND METHODS

Subjects

Thirty-eight consecutive patients diagnosed with plantar fasciitis were referred to the outpatient orthopaedic physical therapy clinic. They were evaluated for eligibility to be enrolled in the study. Twenty-eight subjects (18 females, 10 males) who met the following inclusion criteria participated in the study: (1) suffering from unilateral plantar fasciitis (2) pain complain exists for more than 6 weeks, and (3) their age ranged from 28 to 60 years old. Subjects were excluded from the study if they had neurological problems interfering with balance control, systemic inflammatory diseases, herniated intervertebral disc of the lumbar spine and any other causes of ankle or foot pain as ankle sprains, ankle arthritis, gouty arthritis, fat pad inflammation, tarsal tunnel syndrome, and tendonitis. Ten patients were excluded because 2 had a recent history of vestibular neuritis, 4 had gout arthritis and 4 refused to participate.

Prior to participation, all patients signed an informed consent, and the study was approved by the institutional review board of our faculty and was conducted in the outpatient clinic for orthopedic physical therapy and balance assessment lab for balance evaluation. Patients were randomly assigned to receive either conventional physical therapy and balancing board exercises (CPTB) or a program of conventional physical therapy (CPT) only. For this purpose randomization was done by allocating subjects with odd number to group (CPTB) and even number to group (CPT).

Balance assessment

Prior to and following the treatment program, all subjects completed a single-leg

static balance assessment on Biodex Stability System (Shirley, NY 11967) by a researcher blinded to the patient's group assignment. The Biodex Stability system (fig.1) consists of a movable balance platform which provides up to 20 degrees of surface tilt in a 360 degrees range, and is interfaced with microprocessor based actuator. The actuator controls the manually preset degree of surface instability; which ranges from a completely firm surface (level 8) to a very unstable surface (level 1). A multi-plane test is used to quantify the ability of a patient to maintain unilateral or bilateral postural stability on an unstable surface[24].

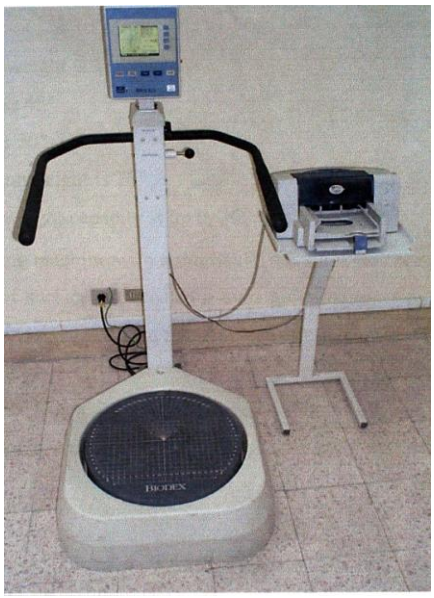

Fig. (1): The Biodex stability system.

During postural stability testing, the patient's ability to control the platform's angle tilt is quantified as a variance from center. A large variance is indicative of poor stability control. The outcome from tests include the Overall Stability Index (OSI), medial-lateral stability index (MLSI) and anterior-posterior stability index (APSI). The OSI score is believed to be the best indicator of the overall ability of the patient to balance the platform[20].

The reliability of the Biodex Stability System has been established with intraclass correlation coefficients (ICC) ranging from 0.6 to 0.95[29]. Specifically, the ICCs for a single-leg stance at stability level 8 (a stable platform) are 0.95 and 0.78 for the dominant and non dominant limbs respectively.

In this study, subjects performed a single leg stance test at stability level 8 (the most stable) over a period of 20 seconds. The test was performed twice with eye open and eye-closed conditions. Patient's centering procedure was performed prior to the test and was recorded in order to maintain foot position constant throughout the test sessions. This procedure enables the patient to adjust his foot position on an unstable platform, until reaching the most relaxed foot position that he could best control the platform. In addition, the system provides visual feedback screen that assisted patients to achieve this most adequate position. The grid mesh drawn on the surface of the platform was used to identify the x and y axes of patient's heel, taken from the central point of the heel, and the foot angle taken parallel to the longitudinal axis of the second toe (Fig. 2).

Test started when the visual feedback screen that consisted of four quadrants and four intrinsic circular zones, where the inner most indicated the higher stability, appeared. The patient was instructed to maintain the cursor in the inner mostzone for 20 seconds while standing on one foot with the contralateral leg held in a flexed position and the arms placed at the side (Fig. 3 and Fig. 4). The system recorded participant's sway with its direction and extent. Results were expressed as overall balance index, anterior/posterior balance index, and medial/lateral balance index from which the OSI was used for analysis.

Fig. (2): Biodex platform coordinates grid mesh to identify foot coordinates and angles.

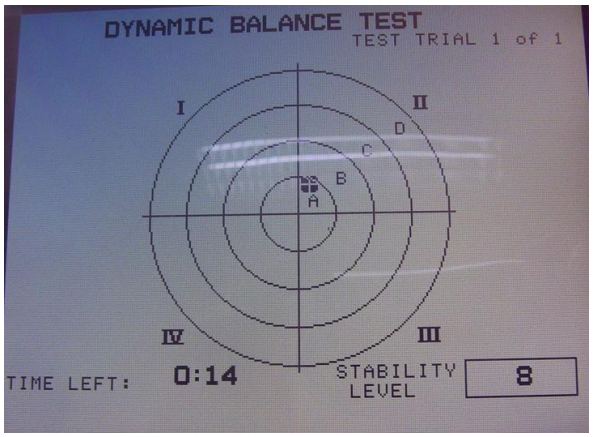

Fig. (3): Balance test screen that consisted of four quadrants and four intrinsic circular zones, where the cursor in the inner most indicated the higher stability.

Fig. (4): Patient position on the Biodex stability system. Patient stood on one leg with the contralateral leg held in a flexed position with the arms at side.

Foot pain and functional limitation assessment

Foot pain and functional limitations were assessed by the use of Manchester Foot Pain and disability Index (MFPDI)[15]. It consists of 19 items, preceded by the phrase "because of my foot pain". They cover activities of daily living and recreational activities including standing, walking and running. Each item has three possible responses: none of the time=1, in some days=2, or on most / every day(s)=3. Higher scores indicate higher levels of disability. The MFPDI has good content validity and strong internal consistency with Cronbach's alpha of 0.99. Item-total correlation was between 0.25 and 0.62 indicating moderate correlations[15].

Treatments Procedures

All treatments were delivered, three times per week, for 4 weeks by the same physio therapist. All subjects in both groups received ultrasound, stretching exercises for calf muscles and plantar fascia and strengthening exercises for dosrsiflexors, plantar flexors and intrinsic muscles of the foot. Ultrasound was applied at a continuous wave frequency of 1 MHz, and intensity of $1W/cm^2$ over the plantar aspect of the affected heel for a period of 5 minutes 41-. Then stretching exercise for calf muscles was applied from supine lying position with the knee extended. The investigator applied slow intermittent stretch for calf muscles that was held for 20 sec, for a total of 3 minutes as recommended in the clinical practice guidelines of plantar fasciitis[25].

Stretching exercise for plantar fascia was done by the same physiotherapist who placed the fingers across the base of the toes on the bottom of the foot (distal to the metatarsophalangeal joints) and pulled the toes back toward the shin until he felt a stretch in the arch of the foot by palpating the tension in the plantar fascia with the contralateral hand while performing the stretching. The position was maintained for 20 second for a period of 3 minutes[13].

Strengthening exercises of ankle dorsiflexors, plantar flexors, and intrinsic muscles of the foot (toe flexors) were applied from the same supine lying position, with the foot outside the edge of the bed. Stabilization, just above the ankle joint, was provided by the therapist hand and resistance was applied on the dorsum of the foot by the other hand just below toes for ankle dorsiflexors. For plantar flexion, the patient heel was cupped on the therapist hand, and resistance was applied by therapist forearm. For toes flexors, stabilization was just proximal to the toes, and resistance was applied on the plantar surface of the toes. Each exercise was done in three

sets; each set 10 repetitions, with rest in between sets[21,24]. CPTB group received balance exercises, in addition to the previously described exercises, using a rocking board which is a rectangular wooden platform (30 cm x 60 cm) with two half's of circles situated parallel on the bottom and separated from each other by 20 cm. It allows anteroposterior, and mediolatearal rolling movements. The patient was instructed that the platform should not touch the ground all over the exercise movement, the first two exercises movement should be continued for 15 sec with a rest of 10 sec and 10 repetitions for each exercise. The first exercise was anteroposterior rolling movement from standing position with feet parallel on the board. The second exercise was side to side rolling movement from standing with feet parallel on the board. The third one was a single leg stance with the affected foot on the board and the patient try to keep the board horizontal for 7 seconds. This exercise was repeated five times. All exercises were performed first with eyes open then with eyes closed[24,41].

Data Analysis

To determine similarity between the groups at baseline, subjects' age, height, and body weight were compared using independent t tests. Descriptive statistics on gender, was compared using chi square tests for homogeneity. The functional limitations and pain intensity subscales of Manchester foot pain and disability questionnaire score, and the difference (post-pre) in balance assessment parameters were analyzed using independent t test. Statistical significance was defined as $p < 0.05$. For statistical analyses, SPSS 18 software was used.

RESULTS

Subjects

Demographic data for the 28 subjects who completed the study are presented in

Table. There was no significant difference between subjects in both groups concerning age, weight, height and gender ($P > 0.05$).

Table (1): Comparison of Subject Characteristics at Baseline by Group.

Characteristic		CPT	CPTB	P value
Age (y) *		49±10.3	46.5±9.8	0.518†
Gender	Female	9	8	0.244‡
	Male	6	7	0.240‡
Weight(Kg)*		85.4±13.9	81.5±9.65	0.395†
Height(cm) *		156.71±8.55	160.86±9.63	0.240†

*Mean ± SD; † Independent t test; ‡Chi-square test

Balance data

Table (2) shows the baseline, the final results and the mean difference of the two test conditions (single leg eye open (SLEO) and single leg eye closed (SLEC) for both groups.

Following the 4 weeks of treatment intervention, a significant improvement was found in the CPTB group in the overall stability indices in SLEO ($P=0.006$) and in SLEC conditions ($P<0.05$). The conventional group showed no significant changes in the overall stability indices in the two test conditions (Fig. 5 and Fig. 6).

Table (2): Overall stability indices obtained at the two tests conditions.

	Conventional group (n=14)	Balance group (n=14)	P-value
Pretreatment	53.43±3.08	52±5.9	0.003**
Post treatment	34.71±4.91	23.57±7.19	
Mean Difference	18.71±6.24	28.43±8.89	
P-value	0.0001**	0.0001**	

*Indicates significant mean difference ($p<0.05$) when compared with that of the other group.

** Indicates significant difference when compared with that of the pretreatment value of the same group.

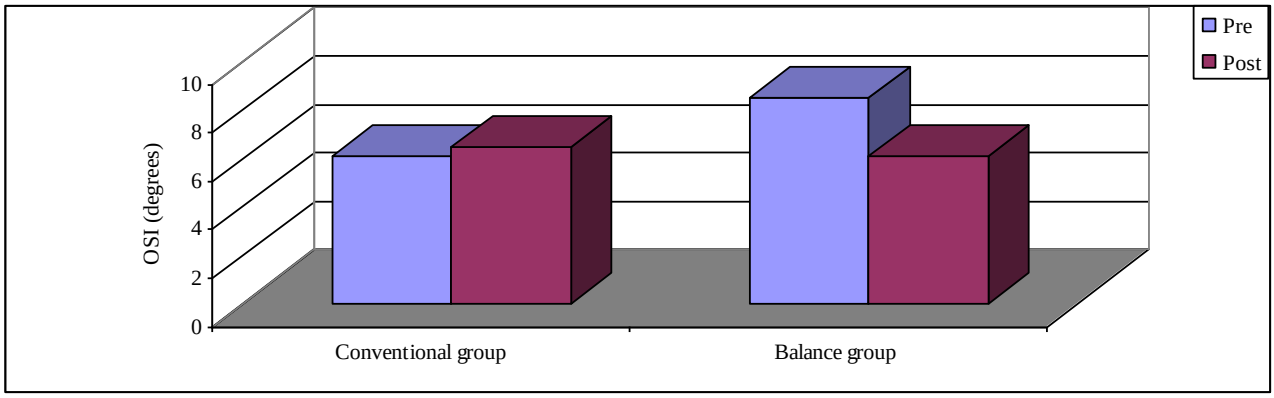

Fig. (5): OSI with eyes open for both conventional and balance group pre and post treatment.

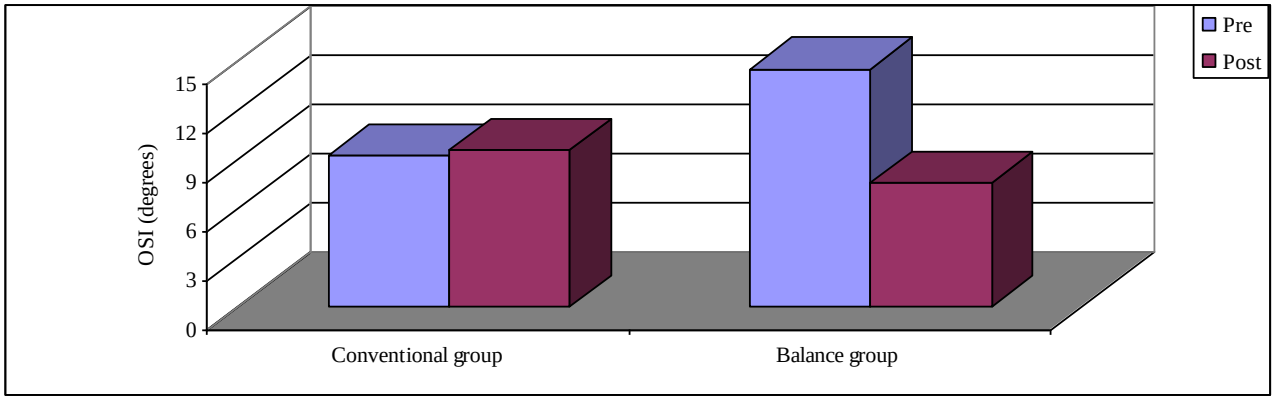

Fig. (6): OSI with eyes closed for both conventional and balance group pre and post treatment.

Foot disability questionnaire

The mean value of FDQ score for both the conventional group and balance group was significantly decreased after the treatment period indicating improvement of function ($P<0.05$). Comparing the mean difference of the score achieved revealed a higher improvement in balance group than in the conventional group (Table 2).

Table (3): Mean ± Standard Deviation for (FDQ) score in both groups pre and post intervention.

	Conventional group (n=14)	Balance group (n=14)	P-value
Pretreatment	53.43±3.08	52±5.9	
Post treatment	34.71±4.91	23.57±7.19	
Mean Difference	18.71±6.24	28.43±8.89	0.003**
P-value	0.0001**	0.0001**	

** Indicates significant difference with P <.05

DISCUSSION

Analysis of the results showed that there were significant improvements in all test conditions (SLEO and SLEC) of overall stability index in the balance group. But the conventional group didn't demonstrate improvement in the measured parameter of balance. For foot disability questionnaire, there was significant improvement in both groups, with a greater decrease of the foot disability in the balance group than the conventional group.

Balance

Improvements of postural stability in the current study in the group that received balance exercises as compared with the group that received conventional program only might be attributed to sufficient stimulation of proprioceptors and activation of proprioceptive system[11] and also to the stimulation of centrally mediated neuromuscular control

mechanisms responsible for the maintenance of balance and posture[35].

Hu and woollacott, (1994)[19] suggested that general exercise program are less effective than programs that target a specific system (e.g. visual, vestibular, and somatosensory) that functions to maintain balance. This explains why the conventional group didn't demonstrated an improvement in balance as the exercises they received were only stretching and strengthening which didn't target balance system directly.

Bologun et al. (1992)[5] reported that balance board training could be a very efficient tool in rehabilitation because it targets the proprioceptive system and actually produces greater lower extremity strength gains than did a series of isotonic exercises.

The work of Madureira et al. (2007)[22] was in agreement with the results of this study as they compared the effects of balance exercises with different exercise modalities and concluded that balance exercises are more effective in improving balance than aerobic, muscular strength, or flexibility exercises. Another randomized controlled study conducted by Schlicht et al. (2001)[36] suggested that strength training alone does not appear to enhance standing balance or sit-to-stand performance in active, community-dwelling older adults but that it may improve maximal walking speed. Many authors concluded that balance training using a wobble board is effective in improving static and dynamic balance and reducing sports-related injuries among healthy adolescents and in prevention of ankle sprain recurrences[14,38].

Also the results of this study support the previous findings of Rozzi et al. (1999)[35] who proved that 4- weeks of balance training program is a sufficient time to promote reflex muscle activation patterns necessary for the maintenance of posture and balance.

Functional Disability

The functional disability is one of the most common problems that encounter patients who complain from chronic plantar fasciitis. Improvements of functional disability in both the conventional group and balance group are supported by the findings of many previous researches. The results of studies conducted by Pfeffer et al. (1999)[28] and DiGiovanni et al. (2003)[12] showed improvements of pain and functional disability in groups of patients treated with stretching exercises of plantar fascia and planter flexors.

The greater improvement in functional outcome of the balance group might be the result of the improvement of dynamic stabilization by the synergistic and synchronous working of the muscle groups and the increased coordination between muscle groups and the response to the sensorial information[11].

Sharma et al. (1997)[37] showed that impaired proprioceptive sense had negative effects on functional parameters such as impairment in walking rhythm, shortened distance of step, and decrease speed of walking, so it is suggested that improvement of proprioception will improve the overall functional performance.

The restoration of balance and mobility skills is a fundamental part of many aspects of physiotherapy, as effective balance is related to mobility, activities of daily living and prevention of falls[4,7].

Conclusion

The balance-training combined with conventional physiotherapy program used in the current study improved patient balance, function and reduced pain. It is also a simple program that uses non sophisticated equipment, which is available in most physiotherapy departments. Therefore, the adoption of this regimen into clinical practice could be readily feasible.

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الملخص العربي

إضافة تمارين الاتزان في علاج حالات التهاب اللفافة الأخمصية

الغرض : تعتبر مشاكل القدم مرتبطة بخطر السقوط و فقدان الاتزان . على وجه الخصوص،القدم المؤلمة تزيد من مخاطر فقد الاتزان .لذلك، اضطراب الاتزان، في حالات التهاب اللفافة الأخمصية له العديد من العوامل بما في ذلك: وضع القدم الغير طبيعي، ونقص وظيفة العضلات في الكاحل والقدم، والتأثير المباشر من الألم الذي يصاحب تحميل الوزن على المسقبلات المكانيكية واعتلال العصب المرتبط بالتهاب اللفافة الأخمصية المزمنة .ولذلك، كان الغرض من هذه الدراسة تقييم تأثير إضافة تمارين التوازن على الثبات ووظيفة القدم في المرضى الذين يعانون من التهاب اللفافة الأخمصية المزمن . **طريقة التجربة** : ثمانية وعشرون (18 إناث و 10 ذكور) الذين يعانون من التهاب اللفافة الأخمصية من جانب واحد، وتراوحت أعمارهم 28-60 سنة شاركوا في الدراسة. تم تقسيم المرضى عشوائيا لتلقي إما العلاج الطبيعي والتمارين التقليدية بالاضافة الى تمارين الاتزان أو برنامج العلاج الطبيعي التقليدي فقط .تم تقييم الاتزان وقد أجري الاختبار مرتين مع ظروف العين مفتوحة والعين مغلقة .تم تقييم الألم في القدم والقيود الوظيفية عن طريق استخدام مؤشر مانشستر لألم القدم والعجز. .**النتائج:** بعد 4 أسابيع من العلاج اثبتت نتائج الدراسة وجود تحسن ذو دلالة احصائية بالنسبة للاتزان فى المجموعة المضاف لها تمارين الاتزان وكذلك تحسن ذو دلالة احصائية بالنسبة لمؤشر مانشستر لألم القدم والعجز فى المجموعتين و كان التحسن لصالح مجموعة الاتزان اكثر. **الخلاصة** : إن بدمج لتدريب على التوازن مع برنامج العلاج الطبيعي التقليدي في علاج التهاب اللفافة الأخمصية يمكن تحسين التوازن والألم أكثر من تنفيذالبرنامج التقليدي وحده.

الكلمات الدالة: التهاب اللفافة الأخمصية، الاتزان ، وظيفة القدم