ORIGINAL ARTICLE

Effect of Attention Focus on Acquisition and Retention of Postural Control Following Ankle Sprain

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ABSTRACT. Laufer Y, Rotem-Lehrer N, Ronen Z, Khayutin G, Rozenberg I. Effect of attention focus on acquisition and retention of postural control following ankle sprain. Arch Phys Med Rehabil 2007;88:105-8.

Objective: To examine the effect of attentional focus instructions and dynamic balance training on ankle sprain recovery.

Design: Randomized controlled trial.

Setting: Outpatient physical therapy department.

Participants: Forty volunteers (age range, 19–33y) referred to treatment within 4 months after sustaining a grade 1 or 2 ankle sprain with no concurrent impairments. Participants were randomly allocated to 1 of 2 groups differing in training instructions.

Intervention: Postural control training consisted of ten 20-second trials, performed on 3 consecutive days, at 2 stability levels of the Biodex Stability System (BSS). Training instructions directed the participants to either an internal or an external focus of attention. Assessments were conducted on the BSS pre- and post-training, and 48 hours after the last session (retention test).

Main Outcome Measures: Overall stability as indicated by variance in platform displacement in all directions; anteroposterior (AP) variance of platform displacement; and mediolateral variance of platform displacement.

Results: Increases in overall and AP stability were observed immediately following training in both groups and were maintained at the retention test. Interaction effect indicates greater improvement in the external-focus group.

Conclusions: Our results suggest that external focus of attention is advantageous for the learning of a postural control task following an ankle injury.

Key Words: Ankle injuries; Attention; Balance; Learning; Posture; Rehabilitation.

MOTOR LEARNING RESEARCH focuses on the principles underlying the acquisition and retention of motor skills, thereby enhancing our understanding of how motor performance is affected by practice variables. Current research indicates that focus of attention during practice may play a role in skill acquisition and retention. When teaching motor tasks, instructors usually provide information related to the learner's body movements, thus emphasizing an internal focus of attention (IFA). However, multiple studies of subjects with no known impairment suggest that instructions directing subjects to focus on the effect of the movement (EFA), rather than on the movement itself, may be more effective in promoting skill learning.[1-7] Some of the studies regarding preferential focus of attention used a dynamic balance task that required participants to balance on a platform and to minimize deviations of the platform from the horizontal.[1,2,6] In these studies, EFA was achieved by instructing the participants to focus on stabilizing the platform, while IFA was achieved by instructing them to focus on stabilizing the body. Participants repeatedly demonstrated enhanced learning of the balance task when directed to utilize EFA rather than IFA. To account for the observed benefit of external focus, it is proposed that focusing on the body movements may interfere with the automatic control processes, while focusing on the outcome of the movement may allow unconscious processes to take over and control the movements.[1,6]

Balance tasks entail constant control processes that involve the sensory, musculoskeletal, and central nervous systems.[8] A disease or injury to any of these systems often results in impaired balance requiring rehabilitative intervention. Based on the research with nonimpaired subjects, using EFA is assumed to be applicable in rehabilitation following a disease or injury in which balance is impaired. A recent study has demonstrated that the balance of subjects with idiopathic Parkinson's disease can be enhanced by instructing them to adopt an external focus.[9] However, this assumption has yet to be tested in populations with impaired postural control due to orthopedic injuries.

Lateral ankle sprain is a common musculoskeletal injury in which balance control is impaired. Ankle injuries constitute 25% of all sports-related injuries,[10,11] with high prevalence among athletes and soldiers.[12] Impaired postural control is a major cause of chronic instability of the ankle, a common and serious residual impairment following such an injury.[13-16] Several authors have examined the effect of treatment on postural control following ankle sprains. Holme et al[17] reported reduced postural control at 6 weeks after lateral ankle sprain, which was normalized at 4 months following participation in a program with an emphasis on balance training. In a study on injured dancers, Leanderson et al[14] reported that postural stability was impaired for several weeks after the ankle sprain, but gradually improved during the course of rehabilitation and even after professional dancing had resumed.

Various methods have been proposed to improve postural control following lateral ankle sprain, including specific exercises and training on unstable surfaces.[18-20] These methods might be further improved with the application of recent findings in motor learning research regarding the effect of focus of attention on skill acquisition. Thus, the objective of this study was to examine preferential focus of attention in learning a balance task following ankle ligament injury. The hypothesis of this research was that EFA may be more effective than IFA in learning a postural control task following lateral ankle sprain injury.

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METHODS

Participants

Participants were 40 volunteers (36 men, 4 women; age range, 19–33y) who were referred to a military outpatient physical therapy department following an ankle sprain. Participants were eligible if they were diagnosed with a first or recurrent lateral ankle sprain at grade 1 or 2, had sustained their injury less than 4 months earlier, were able to bear full weight on the injured leg, presented no evidence of concomitant additional injury, had no history of prior surgical procedures in the lower extremities, had no neurologic or vestibular disorders, and had no previous training on a stabilometer. All participants gave written consent to participate in the study, and the study was approved by the Medical Corps Ethical Review Board. Eligible participants were randomly assigned to the EFA or the IFA group.

Procedure

Balance assessment and training were carried out using the Biodex Stability System (BSS).[a] The BSS is comprised of an unstable support platform that allows up to 20° of multiaxial surface deflection, thus challenging both the anteroposterior (AP) and mediolateral (ML) component of stability. The unstable support platform of the BSS can be placed at 8 levels of stability settings, with a setting of 8 being the most stable foot platform setting and a setting of 1 being the least stable setting.

The participants were required to attend 4 meetings, with the first 3 meetings held on consecutive days, and a fourth and final meeting held 48 hours later. The first meeting included an initial assessment (pretraining) and a training session; the second meeting consisted of only a training session; and the third meeting included a training session and a post-training assessment (post-training) to measure gains in the acquisition phase. At the fourth meeting, a final assessment was conducted to measure change in the retention phase. All assessment and practice trials involved single-leg support stance on the injured ankle. All balance testing was conducted by a physical therapist (NR-L) who was blind to the subjects' group allocation.

Three measures of postural stability were obtained at stability level 6 followed by level 4: (1) Overall Stability Index (OSI)—the variance of foot platform displacement in degrees in all directions (the higher the number, the greater the movement during a test); (2) Anterior/Posterior Stability Index (APSI)—the variance of foot platform displacement in degrees for motion in the sagittal plane; and (3) Medial/Lateral Stability Index (MLSI)—the variance of foot platform displacement in degrees on any given level for motion in the frontal plane.

Assessment consisted of 2 practice trials followed by 2 test trials performed on each of the tested levels. Each trial was 20 seconds long, with 30-second rest periods between trials. We performed all tests with the participants standing barefooted in single-limb stance. A standardized position was used in which the posterior aspect of the calcaneus was placed midway over the ML midline of the platform grid, with the second ray pointing 5° lateral to midline. Reliability of this protocol has been previously determined for OSI (r=.92), APSI (r=.89), and MLSI (r=.93).[21] During the testing sessions, we asked the participants to maintain balance without any instructions as to focus of attention.

The same foot position used in the test trials was maintained during training. Training at each of the stability levels 6 and 4 consisted of ten 20-second trials with 30 seconds of rest between each trial. Before the beginning of each training session, the testers gave the participants in the 2 groups different instructions in regard to their focus of attention. Whereas the EFA group was instructed to "keep your balance by stabilizing the platform," the IFA group was told to "keep your balance by stabilizing your body." Both groups participated in 3 training sessions.

Statistical Analysis

We used t tests and chi-square tests to compare parametric and nonparametric characteristics of the groups. We calculated means and standard deviations (SDs) of test trials at each stability level and at each of the testing periods for the OSI, APSI, and MLSI. We utilized separate mixed-model 2-way (2×3) repeated-measures analyses of variance (ANOVAs) for each variable at stability levels 6 and 4. Subjects constituted a random factor nested within the subject group, and the 2 independent fixed factors were group (IFA, EFA) and time (pretraining, post-training, retention). We used adjusted Tukey-Kramer tests to determine specific time-related effects. Alpha error level was set at P less than .05. Statistical analysis was performed using SAS.[b]

RESULTS

We found no significant differences between groups in terms of age (IFA group, 21.1±3.3y; EFA group, 20.5±1.8y), or time since injury (IFA group, 4.3±3.1wk; EFA group, 4.7±2.8wk). There was a statistical difference between groups in terms of sex, with 4 female participants present in the IFA group and none in the EFA group. Table 1 presents the stability results for levels 6 and 4 by group.

Table 1: Stability Results at Levels 6 and 4

	Internal Focus of Attention (n=20)			External Focus of Attention (n=20)		
Variable	Pretest	Post-Test	Retention	Pretest	Post-Test	Retention
Level 6						
OSI	6.42±2.84	7.09±4.34	6.12±3.81	8.10±4.37	5.70±2.25	5.88±2.27
APSI	4.55±2.41	4.06±2.59	3.50±2.28	5.92±4.14	2.70±1.34	2.90±1.50
MLSI	4.43±2.05	5.53±4.05	4.96±3.30	5.21±2.50	5.01±2.17	5.12±2.06
Level 4						
OSI	9.02±4.21	8.00±4.99	8.83±5.09	10.31±4.86	7.42±2.92	7.41±3.40
APSI	6.24±2.65	4.75±3.02	5.04±2.72	7.16±4.42	3.67±1.98	4.27±2.43
MLSI	6.49±3.62	6.21±4.58	7.17±4.57	7.25±2.93	6.36±2.73	6.07±2.78

NOTE. Values are mean degrees ± SD.

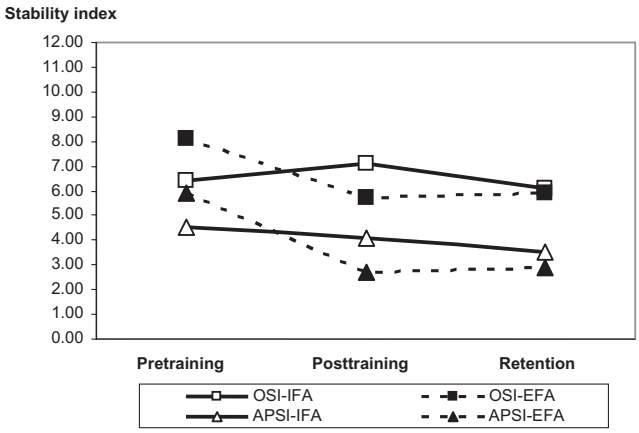

Fig 1. Overall stability and AP stability at level 6 by group.

Stability Indices at Level 6

ANOVA indicated a main effect of time ($F_{2,76}=10.72$, $P<.001$) for APSI at level 6. No such effect was found for OSI or for MLSI at this level. We found no group effect for any of the stability indices at level 6. However, we found a significant interaction between group and time for OSI ($F_{2,76}=3.67$, $P=.030$) and APSI ($F_{2,76}=4.2$, $P=.019$) (fig 1). While Tukey-Kramer post hoc tests revealed no significant difference between groups at any of the 3 testing periods, the Tukey-Kramer tests indicated that only the EFA group experienced a significant decrease in OSI ($P=.030$) and in APSI ($P<.001$) between pretraining and post-training. There was no significant difference between post-training and retention for any of the stability indices in either group, indicating that differences achieved between pretraining and post-training were maintained.

Stability Indices at Level 4

ANOVA indicated a main effect of time for OSI ($F_{2,76}=4.92$, $P=.010$) and for APSI ($F_{2,76}=16.08$, $P<.001$) at level 4, indicating a significant improvement over the study period in both groups. We found no such effect for MLSI at this level. Tukey-Kramer post hoc tests revealed that an improvement was made during the acquisition phase in OSI ($P=.011$) and in APSI ($P<.001$), with no significant change found during the retention phase (fig 2). We found no group effect or interaction effect at level 4 for any of the stability indices. However, there was a trend toward significant interaction between time and group ($F_{2,76}=2.63$, $P=.078$) for APSI, with the EFA group showing greater improvement over time.

DISCUSSION

At the most stable position (level 6), changes over time were determined for both groups only for APSI. Yet, the observed interaction effects between group and time indicated a greater reduction in the acquisition phase in the group utilizing an EFA. This increased efficacy of EFA was observed in both the APSI and the OSI variables. There was no significant change found in the retention phase, indicating that changes observed in the acquisition phase were maintained in the retention phase. At the lower level of stability (level 4), improvements were noted during the acquisition phase in the APSI and the OSI of both groups, with the gains achieved maintained in the retention test. While there was no significant difference found between the groups, analysis indicated a trend toward a greater mean reduction in APSI in the EFA group. Similar to level 6, there was no change found in the MLSI in either group at either phase.

The results showing superior improvement in the EFA group during the practice phase are consistent with numerous studies that determined the effectiveness of EFA on balance performance in individuals with no known impairment by using a variety of dynamic tasks, such as riding a pedalo (wheeled platform),[4] balancing on a stabilometer,[6] and performing ski-type movements on a ski simulator.[5] While these studies all used balance tasks, the positive effect of EFA during the acquisition phase was also shown in other tasks, such as golf shots.[22]

However, the present results, which demonstrate an advantage of EFA only in the acquisition phase, with gains maintained over the retention period, differ from those of some previous studies utilizing balance tasks that particularly showed advantages of EFA in the retention phase.[1,5,22] These differences may be explained by differences in testing procedures. In the present study, four 20-second trials were administered at each level, and retention was tested following 48 hours without practice. In contrast, some of the previous studies involved multiple repetitions in the testing procedure, possibly elevating improvement over the course of the test itself. This effect was demonstrated in a study utilizing 4 and seven 90-second trials to assess retention, with some improvement found across the test trials.[1,23] Moreover, in previous studies,[1,5,22,23] retention was tested on the day immediately following the final practice session, while in the present study the duration of time between the end of training and retesting was longer.

In regard to the effect of training in the ML direction, the literature reveals inconsistent results. Some studies show no effect and are in agreement with the present research,[24] while others show improvement in both planes following balance training.[25] Outcome differences may be related to differences in assessment methods, subject characteristics, and training procedures. In the present study, the lack of change in the ML plane may be the result of the subjects' reluctance to stress the injured ligaments by movements of the joint needed to control ML movement. As such, a stiffening strategy in this plane would be related to the characteristics of the injury rather than to a specific motor learning effect. While apprehension of movement and altered strategies can be influenced by training, the limited training in this study may not have been sufficient to induce changes. Future studies should target the ML component of instability following a lateral ankle sprain and assess the contribution of attentional focus on this aspect of balance recovery.

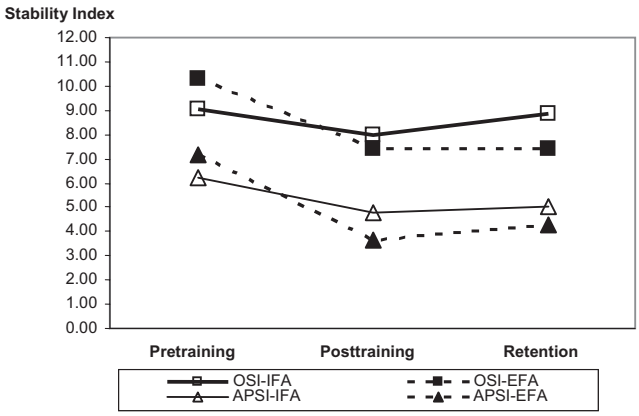

Fig 2. Overall stability and AP stability at level 4 by group.

Study Limitations

Despite randomization, a significant difference in sex distribution occurred between groups, with the IFA group composed only of men, while the EFA group included 4 (of 20) women. Although there is some evidence of sex differences in neuromuscular control[26] and in the performance of cognitive tasks,[27] there is no evidence of an equivalent difference in motor learning abilities, nor is there evidence for sex-related differences in recovery pattern after lateral ankle sprain. However, further studies are needed to establish that sex indeed does not affect recovery and learning of postural control.

It is difficult to discern whether the differences between groups have any clinical significance. The differences in OSI at level 6 between pretraining and retention represented a 27.3% improvement for the EFA group and only a 4.7% improvement for the IFA group. The differences in OSI at level 4 for this same period were 28.1% for the EFA group and 2.1% for the IFA group. The APSI differences were larger than the OSI differences at all times and stability levels. Although the differences between participants in the EFA group over the course of 1 week's training might seem to be clinically meaningful, the amount of improvement in postural control that significantly influences function or is clinically significant has yet to be established and requires further study.

Furthermore, the present study examined only the short-term effect of training. Typically, rehabilitation following an ankle sprain is of relatively short duration, with return to activity expected between 4 and 8 weeks after the injury.[28] Therefore short-term training is of relevance in this condition. However, physical therapy will usually be continued for a few more weeks in order to further improve ability. Thus, future studies are necessary to determine the differential effect of focus of attention following longer training periods as well as its effect on return to function.

CONCLUSIONS

The results of this study indicate that 3 sessions of balance training on a dynamic stabilometer can improve the balance capabilities of subjects with a lateral ankle sprain. Improvement was noted primarily in the sagittal plane, with no concurrent change in the frontal plane. EFA was found to be preferential to IFA during the acquisition phase, particularly for the less challenging stance position. Gains made immediately following training were retained 2 days following the completion of training. The present study demonstrates the feasibility and relevance of applying specific principles of motor learning to basic activities engaged in during the rehabilitation process, thereby facilitating recovery following a typical orthopedic or sports injury.

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Suppliers

a. Biodex Medical Systems Inc, 20 Ramsay Rd, Shirley, NY 11967-4704.
b. Version 6.09; SAS Institute Inc, 100 SAS Campus Dr, Cary, NC 27513.