Effect of Focus of Attention on Transfer of a Postural Control Task Following an Ankle Sprain

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Effect of Focus of Attention on Transfer of a Postural Control Task Following an Ankle Sprain

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This study was approved by the Israel Defense Force Medical Corps Ethical Review Board

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Study Design: Randomized clinical trial.

Objective: to examine the effect of attentional focus instructions during training on the transfer of a learned balance capability to a more challenging condition among subjects with ankle ligament injury.

Background: Current evidence suggests that instructions inducing an external focus of attention may be more effective at promoting learning than instructions inducing an internal focus of attention. The effect of attentional direction on transfer has not been tested in populations following a disease or injury, such as lateral ankle sprain, in which postural control is impaired.

Methods and Measures: Participants were 36 male volunteers (mean age 20.9, range 19-33 years) who were referred to physical therapy following a grade 1 or 2 ankle sprain. The patients were randomly allocated to 1 of 2 groups, which were instructed to focus attention either internally or externally during postural control training. Three training sessions were conducted on consecutive days and consisted of ten 20-second trials at 2 stability levels, using the Biodex Stability System (BSS). Postural control at an untrained, less stable level was assessed before the initial training session and 48 hours following the last session, using the BSS. Three measures of stability were used: overall stability, as indicated by the variance in platform displacement in all directions; anterior/posterior variance of platform displacement; and medial/lateral variance of platform displacement.

Results: Participants utilizing an external focus of attention improved significantly over the study period in all 3 stability indices while those utilizing internal focus of attention did not improve significantly.

Conclusions: Our results suggest that an external focus of attention is advantageous for the transfer of learning of a postural control task following an ankle
injury. Furthermore, they indicate that using an external focus of attention when training under moderately unstable conditions can significantly improve postural control under less stable conditions.

**Key words:** ankle injuries, attention, learning, postural balance, rehabilitation
INTRODUCTION

Ankle sprains are the most common musculoskeletal injuries that occur among athletes. Ankle injuries constitute 25% of all sports-related injuries \(^{26,28}\) and are particularly prevalent in sports that require jumping and landing on 1 foot.\(^{8,21,37,38}\) Ankle injuries are also prevalent in the military, with one-third of all West Point cadets sustaining an ankle sprain during their 4 year tenure.\(^{18}\) Similarly, an 18% incidence of lateral ankle sprain (LAS) was reported in a population of 390 male Israeli infantry recruits during their period of basic training.\(^{34}\)

Ankle sprains often result in long-term disability and significant time loss from sports participation, with a major impact on health care costs and resources.\(^{9,61}\) More than 40% of ankle sprains have the potential to cause chronic problems,\(^{2,39}\) and impaired postural control has frequently been demonstrated in individuals after an acute ankle sprain.\(^{3,10,23,18,36}\) It has been suggested that impaired postural control contributes to functional instability following LAS,\(^{7,12}\) which is an important factor in long-term chronic problems following an ankle sprain.\(^{61}\)

Postural control tasks entail constant processes that involve the sensory, musculoskeletal, and central nervous systems,\(^{42}\) and a disease or injury to any of these systems might impair balance. Balanced stance requires the ability to shift weight in the medio-lateral (ML) and anterior-posterior (AP) directions and to make flexible movements in the vertical direction.\(^{52}\) Experience is the basis for improving postural control and is gained by repeated exposure in which individuals can learn and refine their movement strategies. Training can improve adjustments in postural control by optimizing the efficiency of individuals’ reactions\(^{1,15-17}\) and by minimizing the effects of external perturbations.\(^{29,42}\)
Several authors have examined the effect of treatment on balance control following ankle sprains. In 1 study, reduced postural control was evident 6 weeks after LAS, but it normalized at 4 months following participation in a program with an emphasis on balance training. In a study on injured dancers, postural stability was impaired for several weeks after an ankle sprain, but gradually improved during the course of rehabilitation and even after professional dancing had resumed. A comparison of the progress of 2 groups of injured participants who differed in the practice of balance exercises in 1-legged stance during rehabilitation showed that at 8 weeks following their injury, no postural deficit was found for the injured limb of the subjects who received balance training.

Various methods have been proposed to improve postural control following LAS, including specific exercises and training on unstable surfaces. These methods might be further improved with the application of recent findings in motor learning research, which focuses on the principles underlying the acquisition of motor skills. Motor learning is defined as a “set of processes associated with practice or experience leading to relatively permanent changes in the capability for responding. Several aspects of training have been found to influence learning, including type, frequency, and timing of feedback; number of training sessions and their distribution; amount of practice time and length of delay between practice sessions; presence of contextual interference; and timing and context of instructions.

One such variable which has been shown to affect learning is the direction of focus of attention. When teaching motor tasks, instructors typically provide information related to the learner’s body movements, thus emphasizing an internal focus of attention (IFA). However, current evidence suggests that instructions
directing subjects to focus on the effect of the movement, rather than on the movement itself, thus inducing an external focus of attention (EFA), may be more effective in promoting skill acquisition.\textsuperscript{32,33,45,53,58,59}

The effect of focus of attention was initially tested with healthy participants in the learning of sports skills, such as a ball-throwing task,\textsuperscript{43} golf,\textsuperscript{53} tennis,\textsuperscript{57} and soccer skills.\textsuperscript{54} Other studies used a dynamic balance task that required participants to balance on a platform and to minimize deviations of the platform from the horizontal.\textsuperscript{31,32,55,60} In these studies, EFA was achieved by having the participants 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.

The advantages of EFA at the neuromuscular level have been shown in studies of upper limb motion\textsuperscript{46} and sports skill,\textsuperscript{62} in which not only the outcomes of the practiced skills were superior, but muscular efforts (based on electromyographic signal) was also lower, indicating more efficient movement. The disadvantages of IFA were highlighted in a study of postural control demonstrating that IFA required increased neuromuscular activity to ensure standing control.\textsuperscript{47} This represents a less efficient task- and context-adaptation of neuromuscular control around the ankle. The researchers proposed that the effect of attentional focus imposed by instructions may be larger when the tasks require greater accuracy or are more difficult to perform.\textsuperscript{47}

To account for the observed benefit of external focus, it is proposed that focusing on 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.\textsuperscript{56,58}
Other studies have examined the effect of an important aspect of learning termed “transfer,” which refers to the impact of previous experiences on the performance of a skill in a new context, or of performance of a variation of the practiced skill. Variations studied in the literature include throwing at targets set at a different distance than experienced in acquisition, or performance at different inclinations of walking surface. A study of the effect of focus of attention on transfer of a balance task used multiple variations including riding a dynamic apparatus under speed constraints, riding backward instead of forward, and riding with additional attentional demands. As in acquisition, EFA was found to be effective in promoting transfer.

Although there is extensive evidence regarding the effect of focus of attention on several aspects of motor learning, most research was conducted with non-impaired subjects. Recently, the positive effect of EFA was demonstrated among impaired subjects with a diagnosis of Parkinson’s disease and in a study examining acquisition of a balance task with impaired subjects following ankle sprain. The objective of this study was to further explore the effect of focus of attention on learning a balance task following ankle sprain by examining its effect on the process of transfer.

METHOD

Subjects

Participants were 36 male volunteers, with a mean age of 20.9 years (range 19-33) who were referred to a military outpatient physical therapy department following an ankle sprain. Participants were included in the study if they (a) had a first or recurrent grade 1 or 2 lateral ankle sprain, as diagnosed by a physician or a physical therapist using clinical examination and the anterior drawer test in accordance to the
classifications described by Crichton et al; (b) were less than 4 months since injury; and (c) were able to apply full weight bearing on the injured lower extremity with no more than mild discomfort. Exclusion criteria were (a) evidence of a concomitant additional injury, such as a bony injury or significant muscular/tendon injury; (b) previous ankle surgery or other pathological conditions or surgical procedures in either lower extremities; (c) neurological disorders; (d) vestibular dysfunction or any other balance disorders; or (e) previous training on any stabilometers. Participants self-reported their previous lower extremity injuries and absence of neurological or vestibular disorders. All participants gave written consent to participate in the study, and the study was approved by the Israel Defense Force Medical Corps Ethical Review Board. Eligible participants were randomly assigned to the EFA or the IFA group.

Assessment

Balance assessment and training were carried out using the Biodex Stability System (BSS) (Biodex Medical Systems Inc., Shirley, NY, USA). The BSS is comprised of an unstable support platform that allows up to 20° of multi-axial surface deflection. The BSS can be set at 8 levels of stability, with a setting of 8 being the most stable foot platform setting and a setting of 1 being the least stable setting.

Prior to the intervention program, 3 measures of postural stability were obtained at stability level 2: a) Overall Stability Index (OSI) – the variance of foot platform displacement in degrees in all directions (the higher the number, the greater the amount of movement during a test); b) Anterior/Posterior Stability Index (APSI) – the variance of foot platform displacement in degrees for motion in the sagittal plane; and c) Medial/Lateral Stability Index (MLSI) – the variance of foot platform displacement in degrees on any given level for motion in the frontal plane.
The reliability of the BSS has been previously established, with an internal consistency coefficient (ICC) ranging from 0.72 to 0.81. Another study recommended a testing protocol consisting of 2 practice trials followed by 2 test trials. The reliability scores for Trials 3 and 4 were $r = 0.90; 0.86$; and 0.76 for OSI, APSI, and MLSI respectively. Replication of this 4-trial protocol with a separate group resulted in reliability estimates of $r = 0.92; 0.89$; and 0.93 for OSI, APSI and MLSI respectively.

Assessment was performed before the initial training session (pre-training) and 2 days following completion of the last training session (post-training). The assessment procedure consisted of 4 20-second-long trials, with a 30-second rest period between trials at the levels using for training (levels 6 and 4) and at level 2, which was not used for training. Order of testing was the same in all tests, starting with the most stable (level 6) and ending with the least stable (level 2). Results for level 4 and 6 were obtained to measure effect of attentional focus on acquisition which has been previously reported.

The results for OSI, APSI, and MLSI obtained for trials 3 and 4 for Level 2 were averaged for use in the data analysis. Assessment was performed by a researcher who was blind to the participants’ group assignment.

During the testing sessions, the participants were asked to maintain balance while standing on the injured lower extremity, without any directions as to focus of attention. The BSS screen was covered so that no feedback was available during tests and training. The dynamic balance testing was performed with the participants standing in single-limb stance, barefooted, in a standardized foot position in which the posterior aspect of the calcaneus was placed midway over the mediolateral midline of the platform grid, with the second ray pointing 5° lateral to midline.
Participants were instructed to hold the unsupported limb in a comfortable position so as not to contact the test limb or the test platform.

**Training**

Both groups participated in 3 training sessions, held on 3 consecutive days, each of which included 10 practice trials at stability levels 6 and 4, for a total of 20 practice trials. Each practice trial was 20 seconds in duration, with a 30-second rest period between trials. If needed, participants were allowed to rest for longer periods during the training sessions. This option was seldom used, as the 30-second resting time was adequate.

Following the initial assessment, participants were randomly assigned to the IFA and EFA groups. Before the beginning of each training session, the participants in the 2 groups received different instructions about where to focus their attention. The EFA group was given the instruction to “keep your balance by stabilizing the platform,” whereas the IFA group was told to “keep your balance by stabilizing your body.” During training, participants were required to assume the same foot placement that was used in the assessment.

The instructions and supervision of training were performed by 2 qualified physical therapists on staff at the facility, both of whom were blind to the participants’ initial assessment results. The physical therapists who were supervising the training were provided with a training manual that included the exact phrasing of instructions to participants.

**Data Analysis**

Independent T-tests were used to determine any significant differences between groups in for age, body mass, height, and time elapsed since the ankle sprain.
Descriptive statistics (mean, SD, and change scores) were used to describe OSI, APSI, and MLSI performance of both groups pre and post-training.

Separate mixed-design 2-way (2X2) analyses of variance (ANOVAs) were utilized for each variable to determine transfer of skill to the untrained level 2, with group (IFA/EFA) and time (pre-training / post-training) as the 2 factors. Significant results were followed by Tukey HSD pairwise comparisons post-hoc analyses. Results were regarded as significant at p<.05. Statistical analysis was performed using JMP software (SAS Institute, NC, U.S.A.).

RESULTS

Characteristics of the subjects are shown in Table 1. There was no significant difference between groups for age, height, body mass, and time from injury between groups (P>.05).

Mean, standard deviations, and change scores of the stability indexes of both groups pre and post training are presented in Table 2. For all 3 outcome measures (OSI, APSI, MLSI), the ANOVA indicated a statistically significant group by time interaction (F(1,34)=12.10, p=0.001; F(1,34)=4.95, p=0.03); and F(1,34)=6.92, p=0.01), respectively, (Figures 1-3). Post hoc Tukey HSD pairwise comparisons, for each of the outcome measures, indicated no significant difference between the groups either pre or post training. While change over time for the IFA group was not significant, the EFA group demonstrated significant difference between the pre and post training scores (p=0.05), indicating that training led to a significant improvement in all stability measures only in the EFA group.
DISCUSSION

In this study, we show that following an ankle sprain, the use of EFA in the training of postural control on moderately unstable surfaces improves postural control on an untrained, less stable surface. These results are especially important in rehabilitation following injury, where there is typically a gradual increase in difficulty of training in accordance with the constraints induced by the injury. The results indicate that utilizing EFA in the early stages of rehabilitation, when training is limited to less demanding tasks, has the potential to positively affect the recovery of postural control in more highly demanding tasks normally addressed in later stages.

The advantage of EFA in transfer that was demonstrated with impaired participants in this study is consistent with the results of previous studies using a dynamic balance task,45 in which healthy participants practiced riding a Pedalo, as well as with research examining the effect of attentional focus on supra-postural tasks and balance learning.60

While the results demonstrate the advantage of IFA, the changes were not sufficient to demonstrate differences between the groups post training.

Further research is necessary to examine whether changes in the training protocol (for example the number of repetitions or length of trials), will result in greater differences between the post training performance of the groups.

Results of the present study are consistent with a previous study we performed, which examined the effect of focus of attention in acquisition and retention, rather than transfer, of a postural control task following ankle sprain.22 EFA was found to be more effective in those phases as well, but, it was not preferential for all stability measures. In the present study we used a less stable, and therefore more difficult, task than in the previous study. This could account for the seemingly more
pronounced effect of instructions as it has been suggested that IFA was specifically less effective in more challenging tasks.47

As in this study, most studies on training and learning and the application of motor learning principles report short-term effects. These are important in orthopedic and sports physical therapy insofar as the expediency of return to full function is often a significant component of the rehabilitation goals. Typically, rehabilitation following an ankle sprain is of relatively short duration, with return to activity expected between 4 and 8 weeks after the injury.27 Within such a time frame, the results of even 3 days training seem to have some importance. Furthermore, there is also some evidence for a long-term effect on postural control following even short term practice.44 Yet, the significance of preferential focus of attention and the effect on long-term results and early return to function should be determined by future research with longer intervention periods and follow up.

As is often the case in studies that measure postural control, it is difficult to discern whether the differences in improvement between groups have clinical significance. In the present study, the EFA group improved by 35% in OSI, 41% in APSI, and 29% in MLSI, while the IFA group improved only by 12%, 17%, and 7% for the same variables, respectively. Although the differences found among participants in the EFA group over the course of 3 days of training were more substantial as compared to the IFA group, the amount of improvement in postural control that significantly influences function or is clinically significant has yet to be established.

Results show that, unlike the EFA group, the IFA group did not significantly improve overtime. This could be a result of the short training period, or it could imply that IFA is not effective during the early phase of learning a balance task. Further investigation of different phases of rehabilitation, specific instructions, and possibly a
combination of instructions (EFA and IFA) are warranted to establish preferential focus of attention in learning a postural control task throughout the rehabilitation process.

All participants in this study were male. Although there is some evidence of gender differences in neuromuscular control\textsuperscript{11} and in the performance of cognitive tasks,\textsuperscript{49} there is no evidence of an equivalent difference in motor learning abilities, nor is there evidence for gender-related differences in recovery patterns following LAS. However, further studies are needed to establish that gender indeed does not affect recovery and learning of postural control.

Conclusions

The results of this study indicate that focusing attention externally during the acquisition of a postural skill over a 3 day period significantly improved the ability to maintain balance for an untrained more challenging conditions. A similar training program using an internal focus of attention did not result in a significant improvement. Applying principles of motor learning to what is usually termed orthopedic or sports physical therapy may facilitate skill acquisition.
REFERENCES


### TABLE 1. Participants’ characteristics (mean ± SD).

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<th>Characteristics</th>
<th>IFA Group n=20</th>
<th>EFA Group n=16</th>
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<tr>
<td>Age (years)</td>
<td>21.1 ±3.3</td>
<td>20.6 ±1.9</td>
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<tr>
<td>Body mass (kg)</td>
<td>73.0 ±12.8</td>
<td>74.3 ±5.8</td>
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<tr>
<td>Height (cm)</td>
<td>175.7 ±8.9</td>
<td>178.9 ±5.2</td>
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<tr>
<td>Time from injury (weeks)</td>
<td>4.3 ±3.1</td>
<td>4.1 ±2.4</td>
</tr>
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</table>

Abbreviations: IFA = Internal focus of attention; EFA = External focus of attention. There was no statistically significant difference between groups (P > .05)
### TABLE 2. Mean (SD) of pre and post training stability indices, change score, and 95% confidence Intervals of the change scores.

<table>
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<tr>
<th>Group/ Stabilty Index</th>
<th><strong>Internal Focus of Attention Group (n=20)</strong></th>
<th><strong>External Focus of Attention Group (n=16)</strong></th>
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<tr>
<td>Pre-training</td>
<td>Post-training</td>
<td>Pre-training</td>
</tr>
<tr>
<td>Overall</td>
<td>13.5 (4.1)</td>
<td>15.7 (3.3)</td>
</tr>
<tr>
<td></td>
<td>11.9 (5.5)</td>
<td>10.2 (3.5)</td>
</tr>
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<td>Change score [95% CI]*</td>
<td>-1.59 [-3.13 – (-0.05)]</td>
<td>-5.45 [-6.92 – (-3.97)]</td>
</tr>
<tr>
<td>Anterior-Posterior</td>
<td>8.3 (3.2)</td>
<td>10.1 (3.4)</td>
</tr>
<tr>
<td></td>
<td>6.8 (3.2)</td>
<td>6.00 (2.0)</td>
</tr>
<tr>
<td></td>
<td>-1.43 [-3.13 – 0.28]</td>
<td>-4.14 [-5.75 – (-2.54)]</td>
</tr>
<tr>
<td>Medio-Lateral</td>
<td>10.3 (4.2)</td>
<td>11.5 (2.6)</td>
</tr>
<tr>
<td></td>
<td>9.6 (5.1)</td>
<td>8.2 (3.4)</td>
</tr>
<tr>
<td></td>
<td>-0.69 [-1.99 – 0.61]</td>
<td>-3.36 [-4.88 – (-1.84)]</td>
</tr>
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</table>

* Determined by the mean change score ±1.96 SE.
Mean Overall Stability Index and standard deviation pre and post training of the IFA and EFA groups. A significant group by time interaction was present \( F(1,34) = 12.10, p=0.001 \). Post hoc Tukey HSD pairwise comparisons indicated a significant pre-post difference for the EFA group, no significant pre-post difference for the IFA group, and no significant difference between groups either pre or post intervention. IFA = Internal focus of attention; EFA = External focus of attention.
FIGURE 2. Mean Anterior-posterior Stability Index and standard deviation pre and post training for the IFA and EFA groups. A significant group by time interaction was present \((F(1,34) = 4.95, p = 0.03)\). Post hoc Tukey HSD pairwise comparisons indicated a significant pre-post difference for the EFA group, no significant pre-post difference for the IFA group, and no significant difference between groups either pre or post intervention.

IFA = Internal focus of attention; EFA = External focus of attention.
FIGURE 3. Mean Medial-lateral Stability Index and standard deviation pre and post training for the IFA and EFA groups. A significant group by time interaction was present ($F(1,34) = 6.92$, $p=0.01$). Post hoc Tukey HSD pairwise comparisons indicated a significant pre-post difference for the EFA group, no significant pre-post difference for the IFA group, and no significant difference between groups either pre or post intervention.

IFA = Internal focus of attention; EFA = external focus of attention.