Put To The Test
Oscillatory devices accelerate proprioception training

BioMechanics, May 2001 By Robert A. Schulte, PT, MBA, and Cory Warner, MPT

The shoulder is an inherently unstable joint based on the anatomical relationship of the glenoid and the humeral head. Static stability is primarily a function of the labrum, capsular ligaments, capsule, and bony articulation.1 A high degree of the joint?s stability depends on the dynamic stabilizers, which include the rotator cuff, long head of the biceps, and the scapulothoracic musculature working together to provide adequate neuromuscular control.2 Neuromuscular control of the dynamic stabilizers comes in part from proprioceptors located within the joint capsule and musculotendinous unit.3-6 Proprioception contributes to the muscle reflex by providing dynamic joint stability, and also contributes to motor programming for the neuromuscular control required for precision movements.7 Proprioception has been defined as the specialized variation of the sensory modality of touch that encompasses joint position sense and sensation of joint movement (kinesthesia).7 Several authors have discussed the effect of joint injury and proprioceptive deficits.7-13 Smith and Brunolli11 reported that shoulder kinesthesia was significantly affected after anterior glenohumeral dislocation. Lephart et al13 observed individuals with chronic, traumatic anterior shoulder instability deal with significant deficits in proprioception. They suggested that proprioception deficits caused by partial deafferentiation resulted when capsuloligamentous structures were damaged. According to Davies and Dickoff-Hoffman,14 coordinated function of joints is essential for athletic function, and when kinesthetic awareness is inhibited, the shoulder becomes dysfunctional.

Davies and Dickoff-Hoffman14 reported that muscle conditioning enhances joint position sense and central peripheral control can be associated with ?coactivation exercises? that require the reciprocal recruitment of the agonist and antagonist musculature in a synergistic manner. Clinical kinesthetic/proprioceptive rehabilitation devices include Plyoback, Impulse Inertial Exercise System, and Pro Fitter. Various manual techniques are also used. In recent years, several new oscillatory devices have been introduced into the rehabilitation environment, along with manufacturer claims that they enhance proprioception of the joint. B.O.I.N.G. (body oscillation integrates neuromuscular gain) and the Bodyblade are frequently used by patients undergoing rehabilitative/proprioceptive training following injuries. Davies and Dickoff-Hoffman14 have discussed several methods for testing shoulder kinesthesia and treatment intervention techniques employed to improve proprioception and kinesthesia. However, a limited number of studies on shoulder kinesthesia/proprioception exist and few have provided easily applicable testing and interpretation.15-18 The need for this study became apparent when we realized the lack of controlled research studies assessing the efficacy of these proprioceptive training devices. Establishing a connection between therapeutic exercise devices and enhancement of joint proprioception helps justify the use of proprioceptive training during rehabilitation.

Methods

Forty collegiate athletes (25 males and 15 females) between the ages of 18 and 23 (x = 19.28 ± 1.24) from the baseball and softball teams at a National Association of Intercollegiate Athletics university voluntarily participated in this study. All subjects were informed about the experimental procedures and the role of proprioception, and signed informed consent forms approved by the institutional review board. Subjects also completed a questionnaire clearing them of upper extremity injury and designating their dominant hand with their preference for throwing a ball.

Fifteen subjects were randomly assigned to the control group (13 males and two females), 13 to the B.O.I.N.G. group (eight males and five females), and 12 to the Bodyblade group (four males and eight females). All subjects were allowed to participate in spring practice, but no additional sport enhancement programs outside the respective sports programs were permitted. To be included in the results, subjects in both experimental groups had to complete nine out of the 12 workout sessions (x attendance = 11.04). Four experimental group subjects (two from each group) were dropped from the results because they didn?t meet this criterion. A fifth subject, from the Bodyblade group, was eliminated because of illness during the final testing.

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Proprioception Training

Subjects assigned to the B.O.I.N.G. group completed the training regimen using the B.O.I.N.G. device. Proper techniques and safety considerations of the B.O.I.N.G. were taken from the instruction manual.19

Subjects assigned to the Bodyblade group completed the training regimen using the Bodyblade device. Proper techniques and safety considerations of the Bodyblade were taken from the instruction manual.20

The training regimen consisted of reciprocal contraction of the agonist and antagonist shoulder musculature with the respective oscillatory devices. Three primary motions were utilized: internal and external rotation (IR/ER), flexion and extension (FLEX/EXT), and abduction and adduction (ABD/ADD). The starting position during the first week limited shoulder elevation to less than 45° to allow for more control in the early phases of training. Shoulder elevation was progressed over the next three weeks as coordination with the devices improved. The training intensity was set at a 1:3 work:rest ratio. The ratio remained the same while the duration of the elements (work, rest) increased over the four weeks as the sets decreased (Table 2).

Facilitators mediated the workout sessions. They followed the training protocol (Table 2), ensured proper use of the devices, arranged workout sessions, and promoted compliance.

The experimental group subjects trained their dominant upper extremity only. A proprioceptive training protocol using oscillatory devices was followed, consisting of three workouts a week for four weeks. A rest period of 24 hours was required between every workout session.

The control group did not perform any proprioceptive training during the four weeks. Furthermore, no subjects (control or exercise) were allowed to participate in other athlete enhancement activities outside of normal practice parameters during the course of the study

Proprioception Testing

Proprioception testing was performed twice. Baseline measures were taken before training and taken again post-training.

All shoulder proprioception testing was recorded with a Cybex Electronic Digital Inclinometer 320 (EDI 320). Proper subject and Cybex EDI 320 positions were derived from the Cybex EDI 320 operations manual (Table 1).21 Prior to testing, all subjects performed a five-minute warm-up on the same AirDyne. Investigator one explained the testing procedures and was responsible for the Cybex EDI 320 and subject positioning. Subjects were blindfolded before the testing commenced. Investigator one actively assisted each subject?s upper extremity to the target position (noting the Cybex EDI 320 reading), and held it there for three seconds while instructing the subject to remember the target position. The subject?s extremity was brought back down until the Cybex EDI 320 read zero. Subjects were then instructed to actively replicate that position. The subjects did not see their values until after post-training testing was completed.

Subjects were tested bilaterally for the following seven shoulder motions: external rotation <45°, external rotation >45°, internal rotation, flexion <90°, flexion >90°, abduction <90°, and abduction >90°. Post-training testing was performed four weeks after baseline measurements were taken.

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Results

The paired-sample t-test was used to determine whether a difference occurred within the groups before and after training over a four-week period. The Bodyblade and B.O.I.N.G. groups were analyzed together because they were both subjected to the same independent variable (oscillatory training protocol). The purpose of the study was to determine the effect of an oscillatory training protocol on healthy male and female baseball and softball players respectively. We did, however, run an ANOVA (ANalysis Of VAriance between groups), which did not demonstrate any difference in effect between the two devices. Therefore, the paired t-test was used to determine within-group differences of two groups; the control group and the exercise (Bodyblade and B.O.I.N.G.) group.

A paired-sample t-test22 was performed on the proprioceptive parameters of an angular shoulder position replication index (in degrees) of three rotator measurements (external rotation <45°, external rotation >45°, and internal rotation) to determine whether differences occurred before and after training. The shoulder position replication index is calculated by averaging the three recorded degree errors (absolute value). The three rotator measurement index was analyzed exclusively, with abduction and flexion measurements omitted because of difficulty controlling for postural sway of the blindfolded subjects when standing.

In addition, a paired-sample t-test was performed on the replication index of three rotator measurements to determine whether significant proprioceptive changes were in fact limited to the dominant extremity. A paired-sample t-test was also performed on the replication index of the three measurements to determine if the results could be correlated with gender.

No significant difference was found involving the index of three rotator measurements between the dominant and nondominant extremities of the control and experimental subjects after baseline testing ($p > 0.05$). However, a significant difference ($p = 0.008$) was observed between the pre- and post-training scores for the exercise group.

No significant difference ($p > 0.05$) was noted between the dominant and nondominant extremities of the control subjects after post-training testing. A significant difference ($p = 0.018$) was observed in exercise group subjects between dominant and nondominant extremities after training.

No significant difference was found involving an index of three rotator measurements for genders after baseline and post-training testing ($p > 0.05$); the subjects were relatively homogenous in respect to proprioception. The proprioceptive scores started at the same point and improved at the same magnitude regardless of gender. The mean value scores in degrees from baseline to post-training testing and standard deviations are shown in Figures 1 and 2.

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Discussion

This study suggests that proprioception can be enhanced with oscillatory training devices and a proprioception training protocol in conjunction with normal practice parameters involving healthy collegiate male and female throwing athletes. This study has established an effective proprioceptive training protocol emphasizing conditioning principles of strength, endurance, and specificity training. The protocol was built on specific adaptation to implied demands (SAID), as illustrated by the limb progression involving position and duration. Using the oscillatory training devices may have had an effect on proprioception enhancement by improving neuromuscular control and motor learning. To use the B.O.I.N.G. and Bodyblade devices, precise motor execution refinements in addition to gross muscular strength and coordination are required. Both oscillatory devices require a rhythmic pattern of alternating contractions between the agonist and antagonist muscles used in the desired motion. Therefore, we hypothesized that the neuromuscular control and proprioceptive feedback required to operate the oscillatory devices, along with the training protocol, significantly improved the exercise subjects? ability to replicate joint position. Which adaptations of the receptors and neurological pathways bring about improvement in proprioception is not entirely clear.7,13,23-26 Intuitively, we suspect that this proprioceptive improvement could allow these athletes to have better neuromuscular control, and prevent injury by maintaining proper joint congruency.

This study also reported that no significant proprioceptive difference existed between the dominant and nondominant extremity before training. Conversely, after training in which only the dominant extremity was trained, significance was reported. Since no significant difference was found in the control group (no proprioceptive training) before and after training, but was found in the experimental group, the use of oscillatory training devices for improving proprioception in the subject population is supported. Even though the proprioceptive training protocol need two particular devices to facilitate the training, the results don?t support the use of these two devices specifically, just proprioceptive training in general. Using other oscillatory training devices (e.g., punch-ball, manual techniques including rhythmic stabilization) with a similar training protocol may benefit other athletes as well.

This study did have some limitations due to uneven gender distribution in the control and exercise groups. However, the subjects were randomly distributed to avoid any bias. The fact that there was no significant difference involving gender before or after training supports the premise that gender was not a factor that could have contributed to greater proprioception gains in the exercise groups. Pre- and post-intervention strength measurements with a dynamometer would also have added to the outcome data; however this variable was beyond the scope of the study design.

The results of this study provide the clinician with valuable information regarding proprioception training. Specifically, they document the efficacy of a proprioception training protocol using oscillatory training devices for proprioception enhancement. Even though the subjects in this study were healthy collegiate athletes without reported injury, it could be theorized that proprioception training could also improve proprioception sense in individuals with proprioception deficits (e.g., injury or instability). Further investigation involving effects of proprioception training on injured shoulders is warranted.

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