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Is Proprioceptive Training Effective in Reducing the Recurrence of Ankle Sprains among Athletes?

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ABSTRACT

OBJECTIVE: The objective of this systematic review is to determine whether or not proprioceptive training is effective in reducing the recurrence of ankle sprains among athletes.

STUDY DESIGN: Review of three English language primary studies published in 2004, 2006, and 2007.

DATA SOURCES: Prospective randomized, controlled trials comparing proprioceptive training to a strength and conditioning program.

OUTCOME MEASURED: The incidence of recurrent ankle sprain in athletes participating in proprioceptive training versus strength and conditioning exercises.

RESULTS: All three RCT's included in this review found that the athletes participating in proprioceptive training experienced a significantly lower incidence of recurrent ankle sprains than the control group participating in strength and conditioning exercises.

CONCLUSIONS: The results of the RCT's reviewed demonstrate that proprioceptive treatment is effective in reducing the incidence of recurrent ankle sprains among athletes. Further research is needed to determine the regimen necessary for maximum benefit. It will also be helpful to determine if proprioceptive training can be used to prevent primary injuries.

KEY WORDS: Ankle injuries, proprioception

INTRODUCTION

Worldwide, ankle sprains are the most common musculoskeletal injuries that occur among athletes.[1,3] Sports that register the highest incidence of ankle sprains are those requiring sudden stops and pivoting, such as soccer, volleyball, and basketball. These specific movements often result in ankle inversion during plantar flexion, which is the most common type of ankle sprain.[2] Research has shown that 25%-40% of athletes who suffer from an ankle sprain will experience a recurrent sprain due to acquired instability.[1,6] Therefore, it has been postulated that strengthening the evertor muscles, which provide support to the lateral ligaments of the ankle, will prevent recurrent ankle inversion injuries.[5]

However, more recent research points to the importance of restoring proprioception to the damaged muscles and ligaments following an ankle sprain.[1,2,3,5] Proprioception refers to the inborn sense of relative positioning of the body in order to execute kinesthetic movements.[2,5] Proprioception involves elements of muscle memory and coordination believed to be regulated by sensory neurons located in the inner ear and stretch receptors located in joint-supporting muscles and ligaments. In order to perform an athletic movement such as kicking a soccer ball, these specific nerve receptors, called proprioceptors, coordinate the timing, bodily position, spatial relationship, and force needed for the foot to strike the ball. With repetitive training, the elements of proprioception become automatic, enabling an athlete to concentrate on other aspects of performance such as executing an offensive play.

Physician assistants working in hospital emergency departments and emergency care settings treat ankle sprains frequently. In fact, 10% of emergency department visits are due to ankle injuries and 75% of these injuries are sprains.[6,7] As a result, the enormous amount of resources devoted to treating ankle sprains makes this a major health concern for all medical

professionals, including physican assistants working on the front-line of healthcare. Physician assistants are needed to administer proper care and encourage prevention, as up to 50% of recurrent ankle sprains lead to disability and chronic pain.[3]

In an acute care setting, the recommended treatment for a sprained ankle follows the acronym R.I.C.E., which stands for rest, ice, compression, and elevation. Ankle sprains are graded on a 1-3 scale depending on severity, with a grade 3 sprain being most severe and usually requiring about 4-6 weeks for recovery. Once an athlete is medically cleared for physical activity, however, there are a variety of supportive braces and rehabilitation exercises used to prevent recurrent injury.

External support can be achieved by means of orthoses or athletic tape, but can cause irritation if not fitted properly and may need to be applied by qualified personnel. Furthermore, some research suggests that the use of othoses may cause athletes to develop a physiological and psychological dependence on the external support during athletic performance.[3] Strength and conditioning training using resistance bands and isometric exercises are also commonly used to prevent recurrent ankle sprains. These exercises aim to increase the strength of the ankle joint muscles, thus preventing excessive inversion or eversion. Although strength and conditioning is an effective preventative measure in short-term studies, there is no evidence that the long-term incidence of recurrent ankle sprains is diminished.[2]

Previous studies have found that patients with a history of recurrent ankle sprains have a deficit in ankle position sense.[5,8] It is believed that the decrease in ankle joint proprioception results in a delayed activation of muscles within the ankle joint causing a failure to correct excessive ankle positions.[2] Proprioceptive training is the only method of rehabilitation that specifically focuses on the regeneration of proprioceptors within the injured muscle and

ligament. Therefore, it seems likely that this training regimen should prove successful in the long-term prevention of recurrent ankle sprains.

OBJECTIVE

The objective of this systematic review is to determine whether or not proprioceptive training is effective in reducing the recurrence of ankle sprains among athletes. Recent studies have determined the importance of restoring proprioception to a sprained ankle, setting the stage for further research on the topic.

METHODS

The author completed a detailed search using search engines MEDLINE and Cochrane Databases. The key words "ankle injuries" and "proprioception" were used in combination to search for English articles, and all of the resulting articles were published in peer-reviewed journals from 2000 to 2010. Articles were selected based on the importance of outcomes to the patient (Patient-Oriented Evidence that Matters, or POEMS). Included studies were those that were randomized, controlled, prospective, and based on a patient oriented outcome. The studies excluded were ones in which the athletes had previously participated in a proprioceptive treatment program. Randomized controlled trials (RCTs) were searched for those in which the patient population had been previously diagnosed with an ankle sprain, as well as those whose treatment intervention included a proprioceptive treatment regimen. In addition, only those articles that compared a proprioceptive treatment group to a strength and conditioning group were considered.

Under these criteria, three randomized, controlled clinical trials were identified and included in this review. In all three studies, an ankle sprain was defined as a disruption to the ligaments of the ankle occurring during a coach-directed competition or practice that causes the

player to miss the next scheduled competition or practice. The strength and conditioning control group participated in isometric exercises, use of ankle weights, and dynamic resistance exercises using resistance bands. All three studies assessed the number of athletes who sustained recurrent ankle sprains in the proprioceptive intervention group versus the number of athletes who sustained recurrent sprains in the strength and conditioning control group. Statistics were generated using the chi square test and reported as *p*-values. Table 1 includes the demographics of the included studies.

Table 1. Characteristics of Studies Included for Analysis of the Effectiveness of Proprioceptive Training in Reducing the Recurrence of Ankle Sprains Among Athletes

Study	Type	NE *	Age (yrs)	Inclusion Criteria	Exclusion Criteria	W/D	Interventions
McGuine and Keene, USA, 2006	RCT	765	14-18	Interscholastic male and female basketball and soccer players from 12 high schools	Inability to fully participate the first day of preseason	11	Proprioceptive training program vs standard conditioning exercises
Mohammadi Iran, 2007	RCT	80	21-27	Male soccer players in the first division of a men's league with history of previous ankle sprain	Players with a history of other lower extremity injuries	0	Proprioceptive training, strength training program, or sport stirrup orthosis
Verhagen et al., the Netherlands, Norway, 2004	RCT	732	>18	Players in the second and third Dutch volleyball divisions	Teams that previously followed any ankle strengthening programs	395	Proprioceptive training vs standard conditioning exercises

NE* = Number of participants analyzed in the study after participant withdraw/dropout (W/D).

OUTCOMES MEASURED

Outcomes were measured based on the incidence of recurrent ankle sprains with regard to the number of injury exposures. In all three studies, injury exposures were described as any practice or competition in which a player participates. The data from the studies was presented in an intention-to-treat analysis with exception of participants who withdrew or were lost to follow-up. In the study conducted by McGuine and Keene, participants in the intervention group performed a 5-phase balance training program consisting of 5 exercise sessions per week before the start of the season and a maintenance phase consisting of 3 times per week for 10 minutes throughout the season. The exercises were performed on both legs and included a single leg stance with eyes closed, while dribbling a ball, and on a balance board. The schools' athletic trainers recorded information regarding previous and recurrent ankle sprains on standardized forms.

Verhagen et al. provided teams with 5 balance boards, an instructional booklet, and videotape. For the first 5 minutes of every practice throughout the season, players performed an exercise with a ball only, a balance board only, or with a ball and balance board in the same exercise. Coaches were responsible for recording each athlete's injury exposures and the players submitted a detailed report of an ankle sprain under supervision of a team physician.

Mohammadi's study instructed athletes to engage in a single leg stance on the injured ankle for 30 minutes. Participants gradually advanced to a single leg stance on an unbalanced disk while shifting his or her weight, which caused the disk's edge to follow a continuous circular path. Athletes were instructed to move from eyes open to eyes closed and from hard surfaces to soft surfaces once progress had been made. Mohammadi collected information from

each player at the start and end of the season, and medical practitioners evaluated all subjects within 1 hour of an injury.

Certain secondary outcome measures differed in each of the three studies. McGuine and Keene measured the mean number of days lost after an ankle sprain suggestive of the severity of each injury. Their study also examined whether proprioceptive training was equally effective in reducing the rate of ankle sprains in athletes without a history of an ankle sprain. Mohammadi included a third intervention group to investigate the effectiveness of orthoses as a means of recurrent ankle sprain prevention. Verhagen et al. noted the incidence of overuse knee injuries for athletes with a history of knee injury participating in the intervention group. All of the secondary outcomes are patient-oriented evidence that matters.

RESULTS

The results pertaining to the primary outcome were presented as dichotomous data in all three studies. The data from the studies was presented as intention to treat analysis for participants having been diagnosed with a recurrent ankle sprain.

Both McGuine and Keene and Verhagen et al. had a significantly larger study population than Mohammadi. McGuine and Keene's study initially started out with 765 participants but 11 athletes dropped out of the study after quitting their interscholastic sports team and 34 intervention subjects were classified as noncompliant due to four missed balance board sessions. However, the 45 athletes who left the study were still included in the analysis for the duration of the time that they participated. The study conducted by Verhagen et al. initially had 1127 participants but ended up with 732 participants. Reasons for the high number of drop-outs included, but were not limited to, lack of time, coaches and players quitting their respective

teams, and failure to follow up. Mohammadi did not report any loss of the original 80 participants in his study.

Participants in all three studies were randomly assigned to either an intervention group participating in proprioceptive training or a control group participating in strength and conditioning exercises. Mohammadi's study also allocated participants to an additional two groups - one using orthoses and another refraining from any preventative activity. In all three studies, the "experimental event rate" (EER), or incidence of recurrent ankle sprains in the intervention group, and the "control event rate" (CER), or incidence of recurrent ankle sprains in the control group, was determined. McGuine and Keene reported that the CER and EER was 10% and 6% respectively. The rate of ankle sprains in the intervention group was significantly lower than those in the control group (P=.04). Mohammadi also reported that the EER was significantly lower than the CER (95% CI 0.003-0.93; P=.02). The incidence of recurrent ankle sprains in the control group was 40% versus 5% in the intervention group. Verhagen et al. reported that the EER was significantly lower than the CER (95% CI 0.1-0.7). The CER was 12% and the EER was 7%, which was significant although the p-value was not reported (See Table 2).

Table 2. Analysis of CER and EER in the control group vs. intervention group

	***p*-value**	Control Participants	Control Number of Sprains	**CER**	Intervention Participants	Intervention Number of Sprains	**EER**
McGuine and Keene	0.04	392	39	.1	373	23	.06
Mohammadi	0.02	20	8	.4	20	1	.05
Verhagen et al.	NR	340	41	.12	392	29	.07

Using the CER and EER, an Absolute Risk Reduction (ARR) was calculated, which shows the decrease in recurrent ankle sprains of the intervention group compared to the control group. The Relative Risk Reduction (RRR) was also be calculated by dividing the Absolute Risk Reduction (ARR) by the CER. This statistic is even more useful than the ARR because it accounts not only for the effectiveness of the proprioceptive treatment, but also for the relative likelihood of experiencing a recurrent ankle sprain if only strength and conditioning exercises were performed. The Numbers Needed to Treat (NNT) of patients who underwent proprioceptive training to prevent a recurrent ankle sprain was determined by using the inverse result of the ARR. The calculated analysis of outcomes and numbers needed to treat can be seen in Table 3.

Table 3. Analysis of outcomes and NNT in order to determine whether proprioceptive treatment is effective in preventing the recurrence of ankle sprains

	ARR EER - CER	**RRR** $\frac{\text{EER – CER}}{\text{CER}}$	**NNT** 1/ARR
McGuine and Keene	-4%	-40%	-25
Mohammadi	-35%	-87.5%	1 (-.285)
Verhagen et al.	-5%	-41%	-20

ARR= Absolute Risk Reduction, RRR = Relative Risk Reduction, NNT = Number Needed to Treat, NR = Not Reported
*Since outcome measured was recurrent ankle sprain incidence, the negative value for NNT indicates that for every 25/1/20 participants in the proprioceptive training group, there was one fewer incidence of recurrent ankle sprains than in the group of participants in the strength and conditioning control group

As can be seen in the table above, the RRR is quite pronounced in the Mohammadi study (87.5%), however the McGuine and Keene and Verhagen et al. studies did not show a similar reduction in symptoms (40% and 41% respectively). It is likely that the small sample size of Mohammadi's study impacted the outcome and would have been more reliable with a greater

number of participants. As a result, the NNT for the McGuine and Verhagen studies are much greater than the Mohammadi study.

Unfavorable side effects were only reported by Verhagen et al. In that study participants with a history of knee injuries had a significantly increased incidence of overuse injury in the intervention group than in the control group. Over 4% of the participants in the intervention group with a history of previous knee injury experienced a recurrent overuse knee injury versus 1.5% of the participants in the control group.

As mentioned above, McGuine and Keene also investigated the incidence of ankle sprains in participants without a prior history of ankle injury. The study found that 7.7% of the control group and 4.2% of the intervention group sustain an ankle sprain. Although proprioceptive training seemed to reduce the incidence of ankle sprains, these results were not significant (P=.059).

DISCUSSION

The Randomized Controlled Trials in this review achieved statistically significant results supporting proprioceptive treatment as a means of preventing recurrent ankle sprains. Proprioceptive treatment after an ankle sprain allows for the regeneration of damaged sensory and motor nerves in the muscles, ligaments, and tendons surrounding the ankle, which restores the body's awareness of position and movement in space. Although proprioceptive training is being used in fitness training and rehabilitation, it is not recommended for elderly individuals and those under 16 years old because the central nervous system is no longer or not yet functioning optimally. In addition, obese individuals should take caution while participating in balance exercises due to an increased risk for injury.

The studies chosen for this review did have certain limitations. Lack of continuous monitoring in the Verhagen et al. study and Mohammadi study allowed for participants to deviate from the training protocol. This lack of supervision made it possible for participants to skip training sessions or perform exercises incorrectly. McGuine and Keene were able to avoid this problem by having athletic trainers and coaches continuously monitor the participants for the entire duration of the study.

In addition, there was a lack of blinding in all three studies. Subjects performing the intervention knew they were doing so to prevent recurrent ankle sprains. Over 35% of the participants in study conducted by Verhagen et al. and five percept of the participants in McGuine and Keene's study dropped out or were lost to follow-up, which may have affected the significance of the results. Finally, Mohammadi and Verhagen et al. relied on participant self-reports for previous injuries, which subjects the data to recall bias.

CONCLUSIONS

Despite the limitations previously described, the studies reviewed demonstrate that proprioceptive treatment significantly reduces the incidence of recurrent ankle sprains. In all three studies, the incidence of a recurrent ankle sprain in the intervention group receiving proprioceptive training is significantly lower than in the control group participating in strength and conditioning exercises. Future research should be designed so that athletes are monitored closely throughout the entire length of the study to ensure that all protocols are met. In addition, it would be useful to conduct a prospective study allocating participants without a history of ankle sprain to the intervention or control group once sustaining a sprain. Therefore, all aspects of the participants' ankle injuries would fall under the supervision of a healthcare professional affiliated with the study. This would prevent recall bias concerning the original ankle sprain, but

may require a larger participant pool and a longer period of time in order to conduct the study. Results of future studies will help guide physical therapists, physician assistants, and all other healthcare professionals towards the most efficient treatment for the prevention of recurrent ankle sprains. In the future, this information may also provide insight into the prevention of primary injuries as well.

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