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# The Effect of a Proprioceptive Balance Board Training Program for the Prevention of Ankle Sprains

## A Prospective Controlled Trial

Evert Verhagen,* Allard van der Beek,*† Jos Twisk,* Lex Bouter,* Roald Bahr,‡ and Willem van Mechelen*†§

*From the *EMGO-Institute, Amsterdam, the Netherlands, †Body@Work, Amsterdam, the Netherlands, and the ‡Oslo Sports Trauma Research Center, Oslo, Norway*

**Background:** Ankle sprains are the most common injuries in a variety of sports.

**Hypothesis:** A proprioceptive balance board program is effective for prevention of ankle sprains in volleyball players.

**Study Design:** Prospective controlled study.

**Methods:** There were 116 male and female volleyball teams followed prospectively during the 2001-2002 season. Teams were randomized by 4 geographical regions to an intervention group (66 teams, 641 players) and control group (50 teams, 486 players). Intervention teams followed a prescribed balance board training program; control teams followed their normal training routine. The coaches recorded exposure on a weekly basis for each player. Injuries were registered by the players within 1 week after onset.

**Results:** Significantly fewer ankle sprains in the intervention group were found compared to the control group (risk difference = 0.4/1000 playing hours; 95% confidence interval, 0.1-0.7). A significant reduction in ankle sprain risk was found only for players with a history of ankle sprains. The incidence of overuse knee injuries for players with history of knee injury was increased in the intervention group. History of knee injury may be a contraindication for proprioceptive balance board training.

**Conclusions:** Use of proprioceptive balance board program is effective for prevention of ankle sprain recurrences.

**Keywords:** prevention; ankle sprains; volleyball; proprioception; prospective

Ankle injuries are the most common injuries across a wide variety of sports.[6,12,14,16,22] Athletes who suffer from ankle sprains are more likely to reinjure the same ankle,[2,5,10,17] which can result in disability and can lead to chronic pain or instability in 20% to 50% of these cases.[13] Of all sports, volleyball has a relatively high incidence of sprains considering the noncontact nature of this game.[2] This high incidence of ankle sprains in volleyball and their negative consequences for future sports participation call for preventive measures.

Braces and tape are widely used measures to prevent ankle sprains. It is known from previous research that use of braces reduces incidence of ankle sprain,[1,6,12,14,16] and it is argued that tape also has a preventive effect because the working mechanism is thought to be similar to braces. However, both measures have negative side effects[19]; for example, whereas braces can be irritating if not fitted properly and are argued to negatively affect performance, tape loosens during play, needs to be applied by qualified personnel, and can cause skin irritation.

Proprioceptive balance board training is another measure, presumably as effective as braces and tape but without the above-mentioned negative side effects.[3,17,20] This measure is already used in the rehabilitation following ankle sprain to restrengthen muscles and ligaments and to restore proprioception of the damaged structures around the ankle.[7-9] Proprioceptive balance board training has also been suggested as an alternative to taping or bracing in the prevention of ankle sprains. Previous studies

§Address correspondence to Willem van Mechelen, EMGO-Institute, VU Medisch Centrum, Van der Boechorststraat 7, 1081 BT Amsterdam, the Netherlands (e-mail: w.vanmechelen@vumc.nl).

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showed that this method is promising in doing so.[3,17,21] However, these previous studies failed to show a significant reduction of ankle sprains, presumably because of low sample size and/or inadequate study design.

The aim of the present study was to study the effect of a proprioceptive balance board training program on the incidence of ankle sprains in volleyball players, in a prospective controlled trial.

## MATERIALS AND METHODS

### Population

All 288 teams from the second and third Dutch volleyball divisions were invited to participate in this study (Figure 1). At the time of invitation, coaches did not know whether they were assigned to the control or intervention group. A total of 116 teams (49 male, 67 female) consisting of 1127 players agreed to participate, and coaches of all participating teams were informed face to face of the purpose of the study, the procedures of the study, and their study group allocation. None of the participating teams followed any additional ankle-strengthening programs.

The study was approved by the Medical Ethics Committee of the VU University Medical Center, Amsterdam, the Netherlands, and each participating player gave written informed consent.

### Randomization

The second and third Dutch volleyball divisions are spread roughly over 4 different geographical regions. Within these regions, second and third division teams compete against each other in regional competitions. For practical reasons, we chose to randomize the teams by these 4 geographical regions. This was done to avoid spillover of the intervention between teams in the same regional competition and between teams of the same club playing in different divisions and/or competitions but within the same region. It was also expected that coaches would be more inclined to participate if the group allocation would not differ between teams in 1 competition, thereby avoiding the argument of inherent different training and playing conditions between teams during the competition. This method of randomization by geographical regions resulted in an n = 4 trial with an intervention group of 66 teams (29 male, 37 female) and a control group of 50 teams (20 male, 30 female) (Figure 1).

### Training Program

At the start of the season, coaches of intervention teams were educated in the use of the prescribed balance board training program by a sports physician or physical therapist. Each intervention team was provided with 5 balance boards, an instructional booklet, and an instructional videotape. In the videotape, players of the Dutch national under 21 team served as a role model to enhance credibility of the intervention. Halfway during the season, all intervention teams were visited by a sports physician or physical therapist to check compliance and ensure proper use of the training program.

The training program was designed in collaboration with sports physicians of the Dutch Volleyball Association (NeVoBo) and the Dutch National Olympic Committee (NOC*NSF). The training program consisted of 14 basic exercises on and off the balance board, with variations on each exercise (Table 1). The program provided the coach each week with 4 prescribed exercises: (1) 1 exercise without any material, (2) 1 exercise with a ball only, (3) 1 exercise with a balance board only, and (4) 1 exercise with a ball and a balance board. Each week, all 4 prescribed exercises were of similar difficulty and intensity, with a gradual increase in difficulty and intensity during the 36-week volleyball season. During each warm-up, the coach chose 1 of the 4 prescribed exercises to carry out. The total duration of 1 exercise, in which both ankles were trained, was approximately 5 minutes. Once an exercise was carried out, it could not be chosen again during the same week. This program was pretested for feasibility in 4 teams prior to the start of the intervention.

### Design and Measurements

At the start of the season (September 2001), all participating players completed a questionnaire on demographic variables, sports participation (volleyball and other sports), use of preventive measures, and previous injuries. This questionnaire was repeated in January 2002 (follow-up 1) and again at the end of the season (May 2002, follow-up 2).

Exposure was recorded by the coach on an exposure form. Coaches noted the total duration time of each training session and match as well as the participation of each player (full, three quarters, one half, one quarter, or no participation). If the player did not participate fully, the coach noted the reason, that is, being injured, ill, or absent for other reasons. Completed exposure forms were returned on a weekly basis. If data were missing on the exposure forms, the coach was contacted to inquire on the missing data.

Injuries were registered on an injury registration form by means of self-report by the injured player. The injury registration form was specifically designed for this cause in cooperation with 2 sports physicians of the Dutch Volleyball Association. On this form, the players were asked to choose from a given list the injury location, injury type, diagnosis of the injury, direct cause of the injury, preventive measures used at time of injury, first aid given, and subsequent medical treatment. Also, players were asked to explain in their own words the direct cause and events leading to the injury, as well as the physical symptoms resulting from the injury.

In case of injury, the coach provided the injured player with an injury registration form, which had to be completed within 1 week after the onset. If an injury was noted on the exposure form and no injury registration form had been received within 2 weeks after the injury was logged, the coach was contacted and urged to get the player to complete the injury registration form.

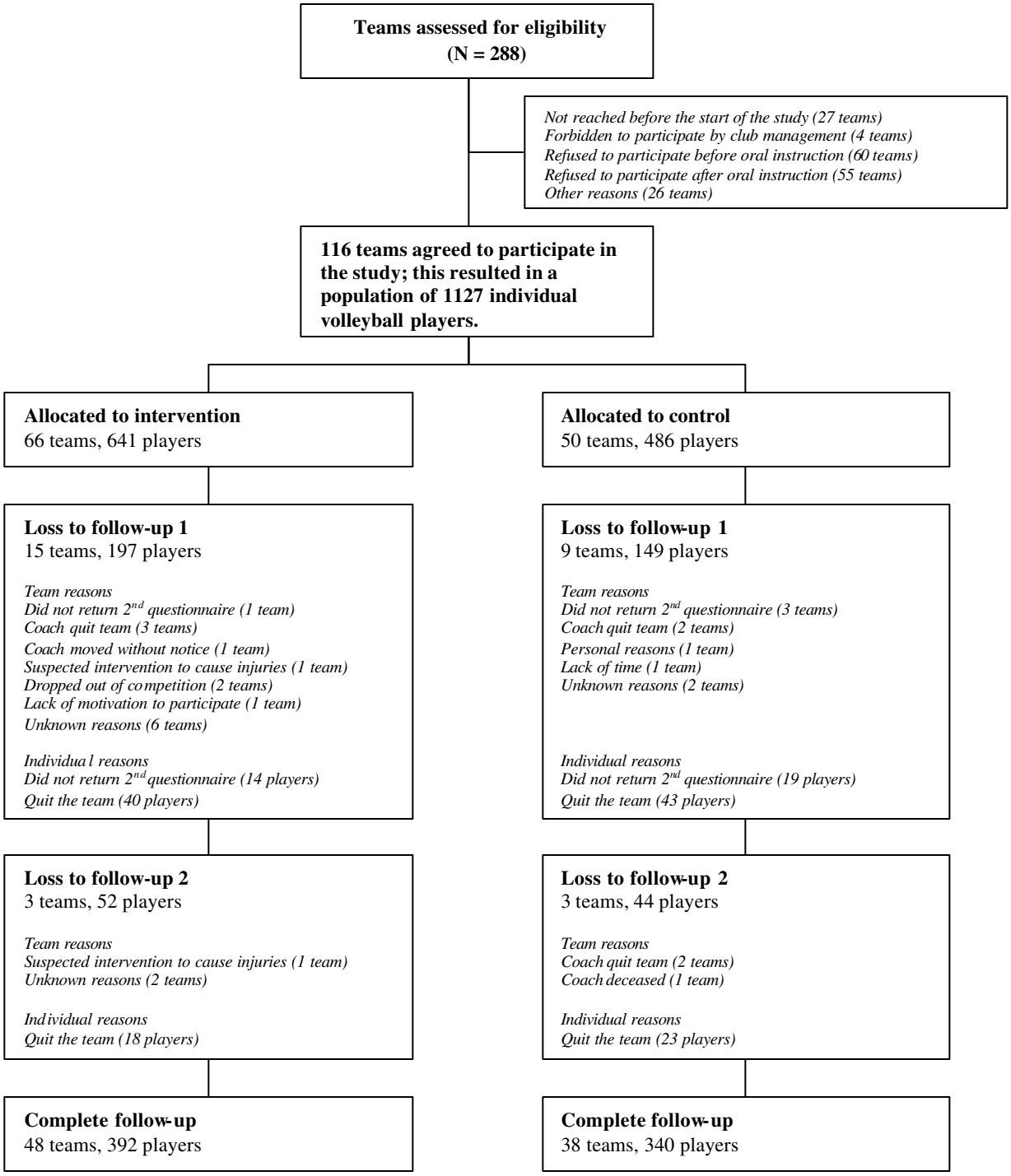



**Figure 1.** Flowchart of the prospective intervention trial.

## Injury Definition

An injury was defined as an event that caused the subject to stop his or her volleyball activity or caused the subject to not fully participate in the next planned volleyball activity. All recorded injuries were blinded for group assignment and independently determined as being either acute (ie, resulting from a sudden event during organized volleyball) or overuse (ie, resulting from volleyball but without a sudden event leading to injury) by 2 sports physicians of the Dutch Volleyball Association, using the injury registration forms. In addition, both physicians diagnosed all injuries to the ankle as either acute lateral ankle ligament sprains or other ankle injuries. In a consensus meeting,

TABLE 1
The Exercises of the 36-Week Balance Board Training Program

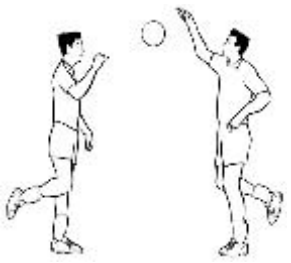
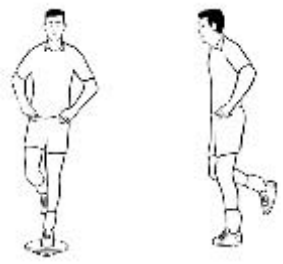
| No Material | Ball | Balance Board | Ball & Balance Board |
|---|---|---|---|
| **Exercise 1**<br>One-legged stance with the knee flexed. Step-out on the other leg with the knee flexed and keep balance for 5 seconds. Repeat 10 times for both legs.<br><br>**Variations** 1 2 3 4 | **Exercise 3**<br>Make pairs. Both stand in one-legged stance with the knee flexed. Keep a distance of 5 meters. Throw and/or catch a ball 5 times while maintaining balance. Repeat 10 times for both legs.<br><br>**Variations** 1 2 | **Exercise 5**<br>One legged stance on the balance board with the knee flexed. Maintain balance for 30 seconds and change stance leg. Repeat twice for both legs.<br><br>**Variations** 1 2 3 4 | **Exercise 7**<br>Make pairs. One stands with both feet on the balance board. Throw and/or catch a ball 10 times with one hand while maintaining balance. Repeat twice for both players on the balance board. |
| **Exercise 2**<br>One-legged stance with the hip and the knee flexed. Step-out on the other leg with the hip and knee flexed, and keep balance for 5 seconds. Repeat 10 times for both legs.<br><br>**Variations** 1 2 3 4 | **Exercise 4**<br>Make pairs. Stand both in one-legged stance with the hip and knee flexed. Keep a distance of 5 meters. Throw and/or catch a ball 5 times while maintaining balance. Repeat 10 times for both legs.<br><br>**Variations** 1 2 | **Exercise 6**<br>One-legged stance on the balance board with the hip and knee flexed. Maintain balance for 30 seconds and change stance leg. Repeat twice for both legs.<br><br>**Variations** 1 2 3 4 | **Exercise 8**<br>Make pairs. One stands in one-legged stance with the knee flexed on the balance board, the other has the same position on the floor. Throw and/or catch a ball 10 times with one hand while maintaining balance. Repeat twice for both legs and for both players on the balance board.<br><br>**Variations** 1 2 |
|  |  | **Exercise 10**<br>Step slowly over the balance board with one foot on the balance board. Maintain the balance board in a horizontal position while stepping over. Repeat 10 times for both legs. | **Exercise 9**<br>Make pairs. One stands in one-legged stance with the hip and knee flexed on the balance board, the other has the same position on the floor. Throw and/or catch a ball 10 times with one hand while maintaining balance. Repeat twice for both legs and for both players on the balance board.<br><br>**Variations** 1 2 |
|  |  | **Exercise 11**<br>Stand with both feet on the balance board. Make 10 knee flexions while maintaining balance. | **Exercise 13**<br>Make pairs. One stands with both feet on the balance board. Play the ball with an upper hand technique 10 times while maintaining balance. Repeat twice for both legs and for both players on the balance board.<br><br>**Variations** 5 6 7 8 |
| **Variations on basic exercises:**<br>1 The standing leg is stretched<br>2 The standing leg is flexed<br>3 The standing is stretched & the eyes are closed<br>4 The standing leg is flexed & the eyes are closed<br>5 The standing leg is stretched & upper hand technique<br>6 The standing leg is flexed & upper hand technique<br>7 The standing leg is stretched & lower hand technique<br>8 The standing leg is flexed & lower hand technique | | **Exercise 12**<br>One-legged stance on the balance board with the knee flexed. Make 10 knee flexions while maintaining balance. Repeat twice for both legs. | **Exercise 14**<br>Make pairs. One stands in one-legged stance with the knee flexed on the balance board, the other has the same position on the floor. Play the ball with an upper hand technique 10 times while maintaining balance. Repeat twice for both legs and for both players on the balance board.<br><br>**Variations** 5 6 7 8 |

TABLE 2
Subject Characteristics, Given as Mean (SD) or Percentage

| Characteristic | Intervention | Control |
|---|---|---|
| n | 641 (men = 286; women = 355) | 486 (men = 197; women = 289) |
| Age, y | 24.4 (2.8) | 24.2 (2.5) |
| Weight, kg | 74.3 (6.3) | 73.6 (6.7) |
| Height, cm | 183.2 (5.8) | 182.4 (6.7) |
| Experience, y | 13.3 (2.3) | 12.8 (1.9) |
| Ankle protective devices | | |
| Brace | 97 (15.1%) | 74 (15.2%) |
| Tape | 78 (12.2%) | 62 (12.8%) |
| Previous injury | | |
| Ankle | 419 (65.4%) | 339 (69.8%) |
| Knee | 278 (43.4%) | 198 (40.7%) |

both physicians tried to reach agreement on injuries that they had determined/diagnosed differently. If no accord was reached, a third sports physician would make the final decision. This latter situation, however, did not occur.

### Analyses

For each nonparticipating team, the number of players; their gender, ages, and volleyball experience; and the number of registered players in the club were tracked through the Dutch Volleyball Association for a nonresponse analysis.

Injury incidence was calculated for total volleyball participation, and separately for training and matches, as the number of injuries reported per 1000 hours of play (total, match, or training, as appropriate), using exposure time of each individual player until the first injury. For each specific injury type—for example, ankle sprains—injury incidence was calculated using exposure time of each individual player until the first injury of this type. Risk difference (RD) and corresponding 95% confidence interval (CI) were calculated for the intervention group compared to the control group for total injuries and for each specific injury type.

Mean weeks of absence from volleyball due to injury and SD were calculated for the intervention group and the control group. Absence was not normally distributed: few players had a long absence, and most players were absent from volleyball for a short period of time because of their injury. Therefore, differences in absence between groups were tested using a Mann-Whitney test.

Cox regression analysis was used to compare ankle injury risk between the intervention and control groups, using a significance level of $P < .05$. It was decided a priori to adjust for age, gender, player function, and previous injury because these factors are believed to influence ankle injury risk.[2,10] Other variables were checked for confounding and/or interaction, but none were found.

Recorded exposure and injury data of players without complete follow-up were included in the analyses until they dropped out of the study.

Match exposure data were missing for 23 intervention and 6 control teams. Because baseline variables of these 29 teams did not differ from the other teams, it was decided to estimate the missing match exposure. For teams with missing match exposure, the total duration of each individual match was traced by cross-referencing to the match exposure of the corresponding opposing team.

## RESULTS

### Population

The nonresponse analysis showed that significantly more male than female teams did not participate in the study. For the other variables (ie, number of players, age, volleyball experience, and the number of registered players in the club), no differences were found (data not shown). The participating 66 intervention teams and 50 control teams consisted of 641 and 486 players, respectively (Table 2). At baseline, no significant differences were found between groups.

### Injury Incidence

In the intervention group, a total exposure of 62 477 playing hours was reported throughout the 36-week season, during which a total of 132 injuries occurred. In the control group, a total number of 102 injuries occurred during a reported exposure of 42 960 playing hours. The overall injury incidences in the intervention and control groups were 2.1 per 1000 playing hours (95% CI, 1.8-2.5) and 2.4 per 1000 playing hours (95% CI, 1.9-2.8), respectively. The overall risk of injuries was not different between both groups (RD = 0.3; 95% CI, –0.3-0.9). The overall mean absence from volleyball after injury was 4.2 ± 5.7 (SD) weeks in the intervention group and 4.0 ± 4.5 weeks in the control group (difference not significant, Mann-Whitney).

### Acute Injuries

The overall acute injury incidence was 1.4 (95% CI, 1.0-1.7) per 1000 playing hours in the intervention group and 1.8

TABLE 3
Number of Acute Injuries, Injury Incidence, and Absence From Volleyball Due to Injury, Given by Injury Location[a]

| | Control | | | | | Intervention | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Incidence | | Absence, wk | | | Incidence | | Absence, wk | | 95% CI | | |
| | Injuries, n | n/1000 Hours | 95% CI | Mean | SD | Injuries, n | n/1000 Hours | 95% CI | Mean | SD | RD | Lower | Upper |
| Ankle | 41 | 0.9 | 0.6-1.2 | 4.5 | 3.6 | 29 | 0.5 | 0.3-0.6 | 3.8 | 3.3 | 0.4 | 0.1 | 0.7 |
| Knee | 5 | 0.1 | 0.0-0.2 | 4.0 | 2.6 | 14 | 0.2 | 0.1-0.3 | 8.8 | 8.8 | –0.1 | –0.3 | 0.0 |
| Other lower extremity | 19 | 0.4 | 0.2-0.6 | 3.2 | 4.0 | 17 | 0.3 | 0.1-0.4 | 2.4 | 1.4 | 0.1 | –0.1 | 0.3 |
| Back | 6 | 0.1 | 0.0-0.2 | 2.2 | 1.6 | 6 | 0.1 | 0.0-0.2 | 2.0 | 1.0 | 0.0 | –0.1 | 0.2 |
| Shoulder | 2 | 0.0 | 0.0-0.1 | 9.5 | 12.0 | 6 | 0.1 | 0.0-0.2 | 2.8 | 2.2 | –0.1 | –0.1 | 0.0 |
| Other upper extremity | 9 | 0.2 | 0.0-0.3 | 2.6 | 1.9 | 16 | 0.3 | 0.1-0.4 | 4.6 | 7.0 | –0.1 | –0.2 | 0.1 |
| Training | 48 | 1.4 | 1.0-1.7 | 3.6 | 3.5 | 49 | 1.1 | 0.8-1.4 | 3.4 | 3.2 | 0.3 | –0.2 | 0.8 |
| Match | 34 | 2.9 | 1.9-3.9 | 4.7 | 4.2 | 39 | 2.3 | 1.6-3.0 | 5.2 | 6.6 | 0.6 | –0.6 | 1.8 |
| Total | 82 | 1.8 | 1.4-2.2 | 4.0 | 3.8 | 88 | 1.4 | 1.0-1.7 | 4.6 | 5.7 | 0.4 | –0.1 | 0.9 |

[a]CI, confidence interval; RD, risk difference between the intervention and control groups.

(95% CI, 1.4-2.2) in the control group. No differences between the intervention and control groups were found for total, training, and match acute injury incidence (Table 3). For the intervention and control groups, the overall mean absence after an acute injury was 4.6 ± 5.7 (SD) weeks and 4.0 ± 3.8 weeks, respectively (difference not significant, Mann-Whitney).

In both the intervention and the control groups, the ankle (all sprains) was the most frequently injured body part. The ankle sprain incidence was 0.5 (95% CI, 0.3-0.6) per 1000 playing hours in the intervention group and 0.9 (95% CI, 0.6-1.2) in the control group. The ankle injury incidence in the intervention group was with an RD of 0.4 per 1000 playing hours (95% CI, 0.1-0.7), significantly lower than in the control group. No differences between groups were found for the other acute injury categories, that is, knee, other lower extremity, back, shoulder, and other upper extremity.

Cox regression analysis adjusted for gender, age, player function, and history of ankle sprains also showed that the incidence of ankle sprains was lower in the intervention group (relative risk [RR] = 0.5; 95% CI, 0.3-0.9). A subgroup analysis for players with a history of ankle sprains also showed a lower risk of ankle sprains in favor of the intervention group (RR = 0.4; 95% CI, 0.2-0.8). No difference was observed for players without a history of ankle sprains (Figure 2). The mean absence from volleyball after an ankle sprain was 3.8 ± 3.3 weeks in the intervention group and 4.5 ± 3.6 weeks in the control group (difference not significant, Mann-Whitney).

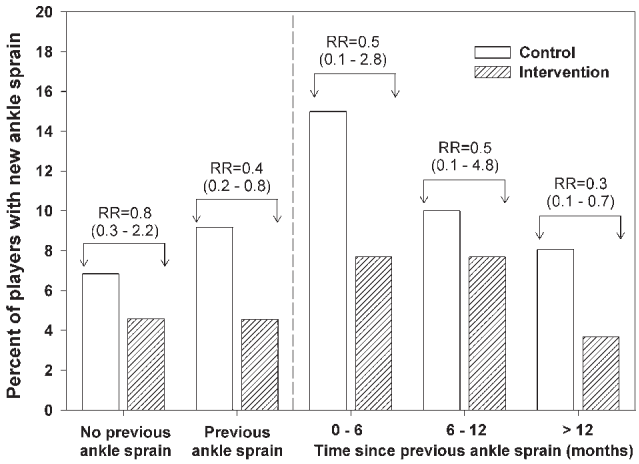



**Figure 2.** Risk of recurrent ankle sprains shown as a percentage of players with ankle sprains within each category. Relative risks and 95% confidence intervals are calculated using Cox regression analysis adjusted for age, gender, and player function.

## Overuse Injuries

The incidence of overuse injury was 0.8 (95% CI, 0.6-1.0) per 1000 player hours in the intervention group and 0.5 (95% CI, 0.3-0.8) in the control group (Table 4). The RD of overuse injuries between control and intervention was –0.2 per 1000 playing hours (95% CI, –0.6-0.1). The incidence of overuse knee injuries was significantly higher in the intervention group than in the control group (RD = –0.2 per 1000 playing hours; 95% CI, –0.4 to –0.0). No differences between groups were found for the other overuse injury categories, that is, ankle, other lower extremity, back, shoulder, and other upper extremity.

A Cox regression analysis adjusted for gender, age, player function, and history of knee injuries did not show an increased risk of overuse knee injuries in the intervention group. However, a subgroup analysis for players with a history of knee injuries showed a higher risk of overuse knee injuries in the intervention group (RR = 5.0; 95% CI, 1.1-

TABLE 4
Number of Overuse Injuries, Injury Incidence, and Absence From Volleyball Due to Injury, Given by Injury Location[a]

| | Control | | | | | Intervention | | | | | 95% CI | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Incidence | | Absence, wk | | | Incidence | | Absence, wk | | | | |
| | Injuries, n | n/1000 Hours | 95% CI | Mean | SD | Injuries, n | n/1000 Hours | 95% CI | Mean | SD | RD | Lower | Upper |
| Ankle | 0 | | | | | 0 | | | | | | | |
| Knee | 5 | 0.1 | 0.0-0.2 | 2.9 | 1.8 | 19 | 0.3 | 0.2-0.4 | 4.6 | 7.3 | –0.2 | –0.4 | –0.0 |
| Other lower extremity | 4 | 0.1 | 0.0-0.2 | 1.8 | 1.1 | 8 | 0.1 | 0.0-0.2 | 1.9 | 1.0 | 0.0 | –0.2 | 0.1 |
| Back | 8 | 0.2 | 0.0-0.3 | 2.4 | 1.2 | 14 | 0.2 | 0.1-0.3 | 2.9 | 4.2 | –0.1 | –0.2 | 0.1 |
| Shoulder | 9 | 0.2 | 0.0-0.3 | 6.2 | 9.4 | 7 | 0.1 | 0.0-0.2 | 1.8 | 2.4 | 0.1 | –0.1 | 0.2 |
| Other upper extremity | 0 | | | | | 1 | 0.0 | 0.0-0.1 | 0.5 | — | 0.0 | –0.1 | 0.0 |
| Total | 26 | 0.5 | 0.3-0.8 | 4.0 | 6.2 | 49 | 0.8 | 0.6-1.0 | 3.1 | 5.1 | –0.2 | –0.6 | 0.1 |

[a]CI, confidence interval; RD, risk difference between the intervention and control groups.

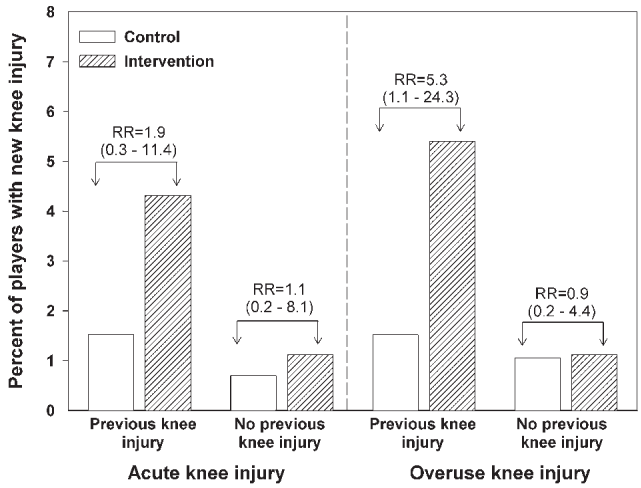



**Figure 3.** Risk of recurrent knee injuries shown as a percentage of players with knee injury within each category. Relative risks and 95% confidence intervals are calculated using Cox regression analysis adjusted for age, gender, and player function.

24.3). No difference was observed for players without a history of knee injuries (Figure 3).

## DISCUSSION

The main findings in this intervention study were that after the systematic introduction of a proprioceptive balance board training program, (1) the incidence of acute lateral ankle ligament injuries (ie, ankle sprains) for players with a history of ankle sprains was lower in the intervention group than in the control group, and (2) the incidence of overuse knee injuries for players with a history of knee injury was higher in the intervention group than in the control group.

### Ankle Injuries

Regarding ankle sprains, the results of our study contradict the results of Söderman et al,[15] who found no effect of balance board training on the incidence of ankle sprains. However, their study was carried out in female soccer players. In contrast, other studies[3,17,21] have suggested a preventive effect of a proprioceptive balance board training program on the risk of sustaining ankle sprains. In accordance with the studies of Bahr et al[3] and Tropp et al,[17] the effect of the intervention was greater for players with a history of ankle sprains. It is known from the literature that proprioceptive function at the ankle joint is reduced in athletes after injury, which is suggested to lead to the high risk of reinjury after an initial injury.[8,9,18] This impaired proprioceptive function can be restored with a balance board training program.[7] This might suggest that in our study, as in the previous studies on balance board training,[3,17] we are not looking at a primary preventive effect of the balance board training program but at a rehabilitative effect.

### Knee Injuries

Although a significant difference between groups was found for overuse knee injuries, this could be a random occurrence due to the fact that in total 12 comparisons were made and because an increase in overuse knee injuries was not part of the original hypothesis. Furthermore, previous trials on the preventive effect of balance board training[15,21] showed no effect on knee injury incidence. From other trials,[3,17] it is not known what the effect of the program was on knee injuries because ankle sprain incidence was the only parameter measured. A balance board training program was associated with a 50%

reduction of acute ACL injuries in soccer players.[4] Moreover, balance board exercises are commonly used in rehabilitating a traumatic knee injury. Add to this the fact that the presently used training program consisted only of a maximum of 4 exercises each week lasting no more than 5 minutes, which makes it unlikely that the balance board training program itself can be linked to the observed increase in overuse knee injuries in the intervention group.

One possible explanation for our finding could be that although we are preventing ankle sprains, we are also shifting the weakest link in the injury chain up to the knee joint. When forces are acting on an ankle and no ankle sprain occurs because the ankle has been trained to withstand external forces, the knee joint could be stressed abnormally, leading to injury. A similar shift in traumatic injury pattern has been seen previously in alpine skiing, in which the rigid coupling of the ski to the skier has reduced the number of lower leg injuries but increased the number of knee injuries.[11] However, the same reasoning should be valid for the use of tape or brace, and from previous intervention trials on these preventive measures,[1,6,12,14,16] it is not known whether there has been an increase in overuse knee injuries concurrent with a decrease in ankle sprains. Therefore, this line of reasoning should be followed with care, and the effect of proprioceptive balance board training on overuse knee injuries requires further study and reconfirmation.

## Methodological Considerations

Intervention studies in a sports setting do have some inherent limitations, that is, compliance, injury awareness, and contamination. We do not have concrete information on how the coaches and players complied with the intervention program. Direct contact with the coaches and the teams was limited to an instructional meeting at baseline and a visit by a sports physician at follow-up 1. In addition, during the course of the study, all coaches were contacted by phone at baseline, follow-up 1, and follow-up 2 by the principal investigators to keep the coaches motivated. The team visits and phone calls gave the impression that coaches were well motivated, and coaches believed the training program to be effective. From this, it might be concluded that compliance with the program was reasonably high in the present study.

Injury awareness is believed to be a major confounding factor in sports injury research because it causes players to adjust their sports behavior. In the present study, the effect of injury awareness was minimized by giving at baseline the intervention and control teams exactly the same information on the background and procedures of the study. The only difference in information between both groups was the instruction on the balance board training program; this information was kept from control teams. Therefore, injury awareness is considered to be similar in the intervention and control groups, ascribing observed differences to the program only.

Contamination was reduced by means of the randomization procedure. Randomization by player or team would have greatly reduced control over contamination (and compliance) and would have imposed practical logistical problems. Randomization by geographical region resulted in control teams not meeting intervention teams during the study, minimizing contamination.

It should be noted that in the present study, injuries were registered by means of self-report, including the registration of previous injuries and the registration of injuries during the study. Data on previous injuries were obtained through the baseline questionnaire. Before completion of the baseline questionnaire, all players were thoroughly informed on the cause and symptoms of the requested injuries and, thus, were believed to have the proper knowledge to self-register previous injuries. However, there is still a chance of recall bias. There is also a chance of misclassification of injuries sustained during the study as being acute or overuse, or a faulty diagnosis of acute lateral ankle ligament sprains. Such errors have been minimized by designing the injury registration forms in cooperation with 2 board-certified sports physicians of the Dutch Volleyball Association. Nevertheless, it should be taken into account that some of the reporting of injury history and injury occurrence could be subject to error due to the methods employed.

Because randomization in the present study took place at the level of 4 geographical regions, the possibility of regional bias needs to be taken into account. Analysis by a cluster-sampling method gives the opportunity to analyze the data while taking a region-specific risk into account. Unfortunately, the number of geographical regions (N = 4) is too low for proper analysis by means of cluster sampling. However, because in the Netherlands volleyball is a competitive sport nationwide and because dropout and nonresponse were divided equally over the 4 regions, regional bias is most likely minimal.

Nonresponse in the present study was high. Only 116 teams of all 288 eligible teams agreed to participate and returned the baseline questionnaire. Significantly more male than female teams did not participate in the study. For the other nonresponse variables (ie, number of players, age, volleyball experience, and the number of registered players in the club), no differences were found. However, gender did not have a significant relation with the effect of the intervention. Therefore, selection bias due to nonresponse is believed to be limited in this study. Nevertheless, the actual reasons for nonparticipation of refusing teams remain unknown. Teams could have declined participation because of, for instance, a low motivation or a disbelief in the effect of a balance board program. This might have resulted in, to some extent, overpositive results of the balance board program. Therefore, one may argue that the preventive effect of a balance board program may be somewhat lower in the general volleyball population.

Loss to follow-up should be considered with care in the present study. At follow-up 1, for instance, in the intervention group 3 coaches switched teams, resulting in a loss of about 30 individual players for reasons not related to this

study. Baseline variables of players who were lost to follow-up did not differ from the other players. Therefore, bias due to a selective dropout is believed to be limited in this study.

## CONCLUSIONS

The present study showed that a proprioceptive balance board program was effective in preventing recurrence of ankle sprains. However, there seemed to be an increase in recurrence of overuse knee injuries. Even so, the use of such a program in volleyball is recommended for players with a history of ankle sprains because in volleyball the risk of ankle sprains outweighs the risk of knee injuries. So far, players currently suffering from an overuse knee injury are advised to refrain from a proprioceptive balance board training program.

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