Knee Surg, Sports Traumatol, Arthrosc
(2000) 8 : 356–363

DOI 10.1007/s001670000147

K. Söderman
S. Werner
T. Pietilä
B. Engström
H. Alfredson

Balance board training: prevention of traumatic injuries of the lower extremities in female soccer players?

A prospective randomized intervention study

Received: 5 March 2000
Accepted: 11 August 2000
Published online: 19 October 2000

K. Söderman (✉) · T. Pietilä
H. Alfredson
Department of Surgical
and Perioperative Science,
Umeå University,
90187 Umeå, Sweden
e-mail:
kerstin.soderman@rehabmed.umu.se,
Tel.: +46-90-7853951,
Fax: +46-90-135692

K. Söderman
Department of Community Medicine
and Rehabilitation, Physiotherapy,
Umeå University, 90187 Umeå, Sweden

S. Werner · B. Engström
Section of Sports Medicine,
Department of Surgical Science,
Karolinska Institutet, Stockholm, Sweden

S. Werner
Department of Physical Therapy,
Karolinska Institutet, Stockholm, Sweden

H. Alfredson
Center for Musculoskeletal Research,
National Institute for Working Life,
Umeå, Sweden

Abstract This prospective randomized intervention investigated whether training on a balance board could reduce the amount of traumatic injuries of the lower extremities in female soccer players. A total of 221 female soccer players from 13 different teams playing in the second and third Swedish divisions volunteered to participate in the study. Seven teams (n=121) were randomized to an intervention group and six teams (n=100) to a control group and were followed during one outdoor season (April–October). Before and after the season muscle flexibility and balance/postural sway of the lower extremities were measured in the players. There were no significant differences in age, height, weight, muscle flexibility and balance/postural sway of the lower extremities between the intervention and the control group. During the season the players in the intervention group performed a special training program consisting of 10–15 min of balance board training in addition to their standard soccer practice and games. After a 37% drop-out the intervention group consisted of 62 players and the control group of 78 players. The results showed no significant differences between the groups with respect either to the number, incidence, or type of traumatic injuries of the lower extremities. The incidence rate of "major" injuries was higher in the intervention group than in the control group. Four of five anterior cruciate ligament injuries occurred in the intervention group, which means that we could not prevent severe knee injuries in female soccer players with balance board training. However, among the players who had been injured during the 3-month period prior to this investigation there were significantly more players from the control group than from the intervention group who sustained new injuries during the study period.

Keywords Balance board training · Female · Injury · Intervention · Prevention · Soccer

Introduction

Soccer is the most popular sport worldwide [14, 15], with approximately 200 million active players, according to the International Football Federation. In Sweden it is the most popular female team sport [10]. Of 198,532 licensed Swedish soccer players, 38,189 are women, according to the Swedish Football Association Players Register (1999).

Soccer is a contact sport associated with a large number of injuries in both male and female players [10, 16, 20]. Engström et al. [10] found the injury incidence in upper-level (first and second Swedish divisions) female soccer players to be 24/1000 game hours and 7/1000 training hours. Several previous studies [2, 5, 10, 18, 21] have reported that ankle sprains are the most common injury in both adolescent and adult female and male soccer players. Engström et al. [10] reported knee ligament injuries and meniscal tears to be the most frequent major injuries sustained by female soccer players.

The effect of programs designed to reduce the risk of injuries of the lower extremities in athletes has been studied previously. Ekstrand et al. [7] found that a prophylactic program including special warm-up, stretching exercises, use of leg guards, ankle taping, and controlled rehabilitation significantly reduced the number of injuries of the lower extremities in male soccer players. Several studies [3, 6, 22, 23] report a decrease in the amount of injuries of the lower extremities after balance board training. Caraffa et al. [6] demonstrated a marked reduction in the incidence of anterior cruciate ligament (ACL) injuries in male soccer players after a proprioceptive training program on a balance board.

Since soccer attracts many participants and leads to a substantial number of injuries, especially of the lower extremities [12, 15], it is important to study possibilities for injury prevention. However, to our knowledge, there have been no previous investigations studying injury prevention among female soccer players. Therefore the aim of the present investigation was to study whether training on a balance board could reduce the amount of traumatic injuries of the lower extremities in female soccer players.

Material and methods

This was a Swedish bicenter study with collaboration between the Sports Medicine Unit, Umeå University in Umeå, and the Section of Sports Medicine, Karolinska Institutet in Stockholm. The investigation was approved by both local ethics committees.

Subjects

A total of 221 female soccer players from 13 different teams playing in the second and third Swedish divisions volunteered to participate in the study, 96 from Umeå and 125 from Stockholm. Seven teams (n=121) were randomized to an intervention group and six teams (n=100) to a control group. Approximately the same number of players from the second and third Swedish soccer divisions were represented in each group. The players were followed during one out-door season (April–October 1998).

At the start of the study all subjects answered a questionnaire assessing age, years in soccer training, amount of physical training hours, and former and present injuries. Weight and height were measured using standardized equipment. No significant differences were found in age, height, weight, muscle flexibility, balance/postural sway of the lower extremities, or the number of years in soccer training between the intervention and control groups at the start of the study. The basic data concerning the players are presented in Table 1.

We regarded as "external" drop-outs the 32 who ceased playing soccer during the season (17 from the intervention group and 15 from the control group) and another 22 who did not complete the study for other reasons (15 from the intervention group and 7 from the control group; pregnancy, n=3; moving to another part of the country, n=8; decided not to complete the study, n=11). We regarded as "internal" drop-outs the 27 participants from the intervention group who were excluded from the study for not carrying out the balance board training as prescribed (performing fewer than 35 balance board training sessions). All together, the internal

Table 1 Participants' characteristics (M±SD) at the start of the study (*dom* dominant leg, *nondom* nondominant leg)

	Intervention group (n=62)	Control group (n=78)
Age (years)	20.4±4.6	20.5±5.4
Height (cm)	165.4±5.7	167.0±4.7
Weight (kg)	59.9±5.9	61.4±6.6
Ankle dorsiflexion, dom (°)	32.8±6.5	33.2±5.6
Ankle dorsiflexion, nondom (°)	32.7±6.0	32.7±6.1
Hip flexion, dom (°)	84.3±10.7	83.7±9.7
Hip flexion, nondom (°)	82.4±9.8	82.6±9.2
Hip abduction, dom (°)	40.0±5.6	41.0±6.9
Hip abduction, nondom (°)	40.5±5.6	41.0±6.7
Years in soccer training	11.7±4.2	11.6±5.0

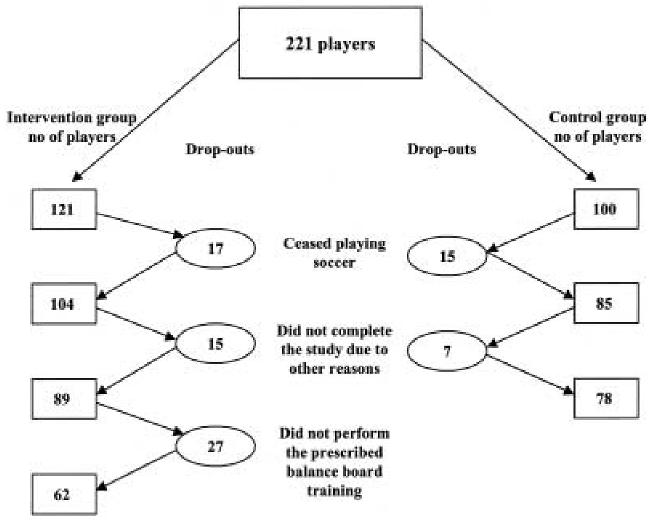

Fig. 1 Drop-out in the intervention group (59/121) and control group (22/100)

and external drop-out frequency was 37% (Fig. 1). Excluding drop-outs, the intervention group consisted of 62 players and the control group of 78 players.

Clinical test methods

In the present study the kicking leg was defined as the dominant leg and the supporting leg as the nondominant leg.

Range of movement and muscle flexibility

A flexometer ("Myrin," Follo, Norway) was used to measure ankle dorsiflexion [8] and hamstring flexibility [4, 8] in the Umeå players (n=73) and a goniometer [13, 19] in the Stockholm players (n=67). To compare the values between these two instruments, measurements (ankle dorsiflexion and hamstring flexibility) were performed on nine healthy subjects (not participating in the intervention study) in Stockholm and Umeå with both instruments, and the results demonstrated high ICC values ranging from r= 0.87–0.99 in Umeå and in Stockholm. The following mean differences for the dominant leg were demonstrated: ankle dorsiflexion, Umeå –1.9±2.7°, Stockholm –0.9±0.8°; hamstring flexibility: Umeå 0.3±3.5°; Stockholm 0.3±1.1°.

Ankle dorsiflexion was measured standing with the knee in a flexed position. The flexibility of the hamstring muscle group was measured in supine position. The subject's leg was slowly raised as high as possible with the knee kept in extension while the opposite leg was fixed to the bench to stabilize the pelvis. The flexibility of the hip adductors (range of motion in hip abduction) was measured with a goniometer both in Umeå and in Stockholm [13, 19]. The measurement was performed in supine position. The examiner slowly abducted the subject's leg with the hip kept in a neutral position, while the opposite leg was fixed to the bench to stabilize the pelvis. Since muscle flexibility testing was performed manually, a difference of 5° or less was not considered to be relevant.

Balance/postural sway

The Kinesthetic Ability Trainer 2000 (KAT 2000; BREG, Calif., USA) was used to measure balance/postural sway of the lower extremities. The KAT 2000 consists of an electronic moveable platform supported at its central point by a small pivot. The stability of the platform is controlled by varying the pressure in a circular pneumatic bladder between the platform and the base of the unit. High pressure indicates an inflated platform (stable) and low pressure a deflated platform (unstable). The platform is connected with a computer through a tilt sensor that at a rate of 18.2 times/s registers the deviation of the platform from the reference position, during a test period of 20 s. Each registration period measures the distance from the center of the platform to the reference position, and the sum of these distances yields a score, a balance index. A low balance index indicates a low postural sway and thus a good balance of the lower extremity [17].

Postural sway of both legs was measured according to the following standardized procedure. The subjects were standing on one leg with their arms folded across the chest facing a spot on the wall 3 m in front of them. They were carefully instructed to try to keep the movable platform as still as possible in a horizontal position. While looking at the display on the computer each subject was initially (at the preseason test occasion) given approximately 5 min in order to find an individual suitable foot position on the platform. This position was then used during all measurements at both the preseason and postseason test occasions. Three reference points at the subjects foot (the longitudinal line of the second toe, a self-chosen point at the lateral side of the foot and the center of the calcaneus) were adapted to the reference lines on the platform. The distance from the self-chosen point at the lateral side of the foot to the base of the fifth metatarsus was measured (in centimeters) to ensure that the same position was used during all the repeated measures.

The subjects performed six measurements per leg, three with the knee in an extended position (0°) and three with the knee in a flexed position (approximately 20°). The order of the different test variables (dominant/nondominant leg and extended/flexed knee) was randomized for all subjects at the preseason test occasion, and the same individual order was then used during the postseason test occasion. The best trial per test variable was used for statistical evaluation.

Injury protocol

All traumatic injuries associated with soccer and resulting in absence from at least one scheduled practice session or game were recorded by the players in cooperation with their coaches. A modification of the protocol used by Ekstrand [7] was used to record the injuries. The date of injury, injury mechanism, injury localization, type of injury, duration of injury, and previous injuries at the same site were recorded. The player was defined as injured until she was able to return to full activity in games and/or practice sessions. Injuries were classified into the following three categories according to their severity: minor (absence from training/games <7 days), moderate (absence from 7 to 30 days), and major (absence >30 days) [7, 10]. The injuries were diagnosed by the authors (K.S. and S.W.). The players who sustained major injuries were also examined by experienced sports orthopedic surgeons.

During the season the authors (K.S. and S.W.) had regular contacts with the coaches and the players by both personal visits and telephone calls to collect injury forms and answer questions.

Practice and game recording

The number of practice and game hours was collected from diaries filled in by the players and their coaches. In the case of missing information an average value from the diaries of the current team was used. These average values were then corrected for time of absence from practice and game due to injuries of that player.

Balance board training

The players in the intervention group received a special training program devised by one of the authors (T.P.). All the players were given their own balance board and were provided with a printed handout presenting the training program (Fig. 2). They were also carefully instructed by one of the authors (K.S. or S.W.) how to perform the balance board training program. The program consisted of 10–15 min of training on a balance board in addition to their standard physical training. The program contained five exercises with progressively increasing degree of difficulty. The height of the balance board could be elevated to increase the degree of difficulty. The players were standing on one leg at a time with their knee in a slightly flexed position. The exercises were carried out for 3×15 s on each leg. The players were told to perform the training program at home, initially each day for 30 days and then three times per week during the rest of the season. The players recorded the amount of balance board training in a special protocol.

Statistics

SPSS for personal computer was used for the statistical analysis. Descriptive information of the injuries was based on information gathered from the injury protocols. Mean ± standard deviation is used to describe continuous data, and frequency tables are used with categorical variables. Differences between the intervention and the control groups, and the different types of drop-outs (external and internal) in continuous variables were tested using the Mann-Whitney test. For categorical variables Fisher's exact test and the Mann-Whitney test were used. For both of these tests the SPSS exact routine was used. A Kaplan-Meier survival analysis and the log rank test were used to analyze the time to first injury. Injury incidence rates were calculated according to the formula $I=A/R$, where A was the number of traumatic injuries during the study period and R was the sum of exposure time expressed in 1000 h of soccer, in game and in practice hours. The injury incidence rates in the intervention and control groups were compared using the ratio of the incidence rates with 95% confidence intervals [1]. The Wilcoxon signed ranks test (SPSS exact routine) was used to investigate differences in balance index before and after the balance board training period in both groups. To compare possible changes in balance/postural sway of the lower extremities between the groups before and after the study period, the balance variables were divided into three categories: improved (a decreased balance

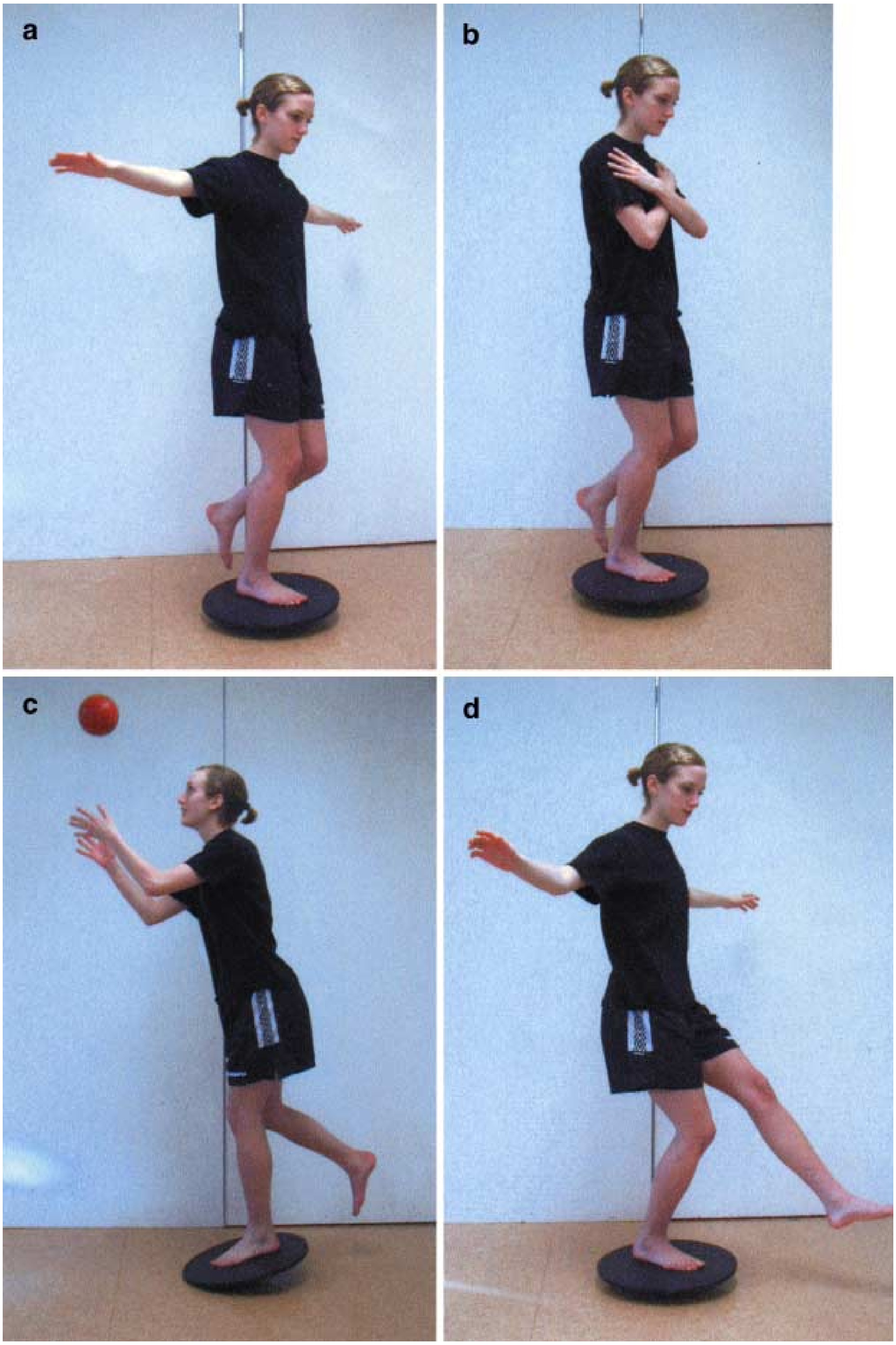

Fig. 2a–d Balance board training program with gradual increasing difficulty. **a**,**b** Standing on one leg with arms in different positions. **c** Standing on one leg on the balance board, bouncing the ball against the floor, or throwing the ball in the air. **d** Standing on one leg "drawing figures" in the air with the opposite leg

index of ≥100), unchanged and impaired (increased balance index of ≥100). The Mann-Whitney test (SPSS exact routine) was then used to test the difference between the groups. A P value of 0.05 or less was considered as significant. All P values are two-tailed.

Results

The intervention group performed the balance board training program on an average 65±19 times (range 36–97). During the study period the intervention group had signif-

Table 2 Balance index (M±SD) in the intervention and control groups before and after the study period (*dom* dominant leg, *nondom* non-dominant leg)

	Intervention group (n=62)			Control group (n=78)			
	Before	After	*P*	Before	After	*P*	P^a
Knee extended, dom	653±394	655±306	0.80	690±306	735±330	0.39	0.79
Knee extended, nondom	892±442	755±280	0.04	801±317	786±312	0.98	0.06
Knee flexed, dom	700±374	642±285	0.47	700±350	723±332	0.32	0.44
Knee flexed, nondom	866±507	757±332	0.20	745±354	753±327	0.97	0.93

[a]Difference between groups

Table 3 Injury incidence rates (injuries/1000 h) and ratio of incidence rates (*RR*), 95% confidence intervals (*CI*)

	Intervention group (n=62)	Control group (n=78)	RR	95% CI
Soccer	4.75	3.83	1.24	0.74–2.06
Practice	1.82	1.47	1.24	0.45–3.41
Game	10.23	8.72	1.17	0.65–2.12
Minor injuries, soccer	2.03	1.97	1.03	0.49–2.17
Moderate injuries, soccer	1.36	1.73	0.78	0.33–1.86
Major injuries, soccer	1.36	0.12	10.96	2.10–57.3

icantly improved their balance index standing on the non-dominant leg with extended knee (P=0.04; Table 2). No other significant changes in balance index were found in either of the two groups, nor was a significant difference found regarding changes in balance/postural sway of the lower extremities before and after the training period. There were no significant differences in the incidence rates of traumatic injuries during practice or game between the two groups (Table 3). Most of the injuries in both groups were game related. The type and localization of the injuries are presented in Table 4. There were also no significant differences regarding the number of injured players (23 in intervention group, 37%; 25 in control group, 32%) and the number and types of injuries, nor did the time to first injury of the lower extremities differ significantly between the groups. Reinjuries accounted for 36% of the injuries in the intervention group and 45% in the control group. Ankle sprain was the most common reinjury in both groups. However, there was no significant difference between the groups in the number of reinjuries, including the number of recurrent ankle sprains.

There was a significant difference in the distribution of injury severity (minor, moderate, and major) between the intervention and the control groups (P=0.02; Fig. 3). There were no significant differences between the groups concerning the incidence rates of either minor or moderate injuries. However, the intervention group had a significantly higher incidence rate of major injuries than the control group (Table 3). To determine whether the extent of balance board training was related to the number of traumatic injuries and injured players, the intervention group was divided into two subgroups: those who performed at least 70 training sessions (n=27) and those who trained between 35 and 69 times (n=35). No significant difference was found in the number of traumatic injuries or injured players between these two subgroups.

Table 4 Localization, number, and type of traumatic injuries (*ACL* anterior cruciate ligament injury, *MCL* medial collateral ligament injury, *LCL* lateral collateral ligament injury)

Type of injury	Intervention group (n=62)	Control group (n=78)
Foot		
Contusion	1	–
Partial rupture plantar aponeurosis	–	1
Ankle		
Sprain	13	14
Calf		
Contusion	1	1
Knee		
ACL	3	1
ACL+MCL	1	–
MCL	1	1
LCL	2	–
Contusion	1	4
Thigh		
Contusion	2	2
Hamstring strain	1	7
Quadriceps strain	1	–
Groin		
Strain	1	
Total	28	31

During the 3 months preceding this investigation (January–March 1998) 14 players in the intervention group and 14 in the control group reported absence from game or practice because of injury. These players, however, were free of symptoms and had returned to play soccer at the time of the preseason test and were therefore included in the study. Significantly more of these players in the

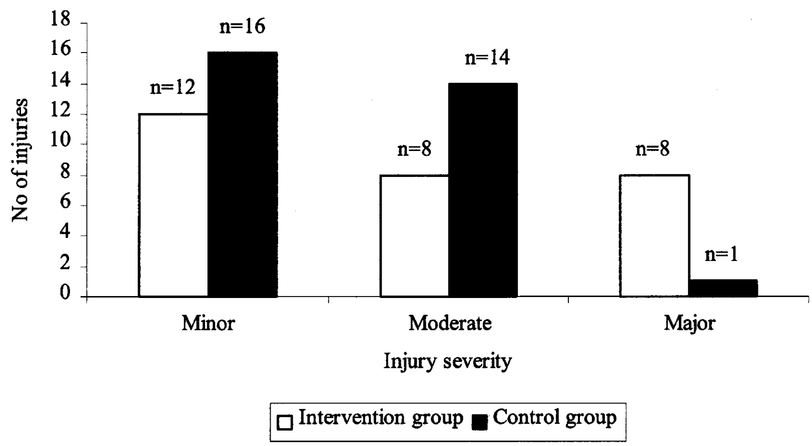

Fig. 3 Severity of traumatic injuries in the intervention group (*n*=62) and in the control group (*n*=78)

control group (9/14, 64%) than in the intervention group (3/14, 21%; *P*=0.05) subsequently sustained injuries during the investigation period (April–October 1998).

External drop-outs in the intervention group (*n*=32) were significantly older (22.5 vs. 20.4 years) and taller (169 vs. 165 cm) than the players who continued to play soccer throughout the season (*n*=62; *P*=0.01). Other parameters such as weight, muscle flexibility, balance/postural sway of the lower extremities, number of years in soccer training, and amount of time spent in soccer playing showed no significant differences between the external drop-outs and those who continued to play throughout the season. In the control group there were no significant differences in any of the above parameters between external drop-outs (*n*=22) and those who continued to play (*n*=78). Among internal drop-outs there were no significant differences in any of the parameters between the players who completed the balance board training (*n*=62) and those who did not perform the prescribed balance board training (*n*=27).

Discussion

In this prospective randomized intervention study we found no effect of balance board training on the number, incidence, or type of traumatic injuries of the lower extremities in female soccer players. This finding contradicts that of Caraffa et al. [6], who reported a considerable decrease in the incidence of ACL injuries after proprioceptive training on a balance board in male soccer players, and that of Wedderkopp et al. [23] who found a reduction in traumatic injuries among female handball players after balance board training in combination with a thorough warm-up program.

Several important factors must be considered in performing intervention studies. Prior to the study a statistical power analysis must be carried out to determine the sample size needed to detect a certain reduction in the injury frequency. In the present investigation a statistical power analysis indicated the need for a sample size of 95 players in each group to detect a reduction in injury frequency from 30% to 15% to achieve a power of 80%. The proportion of drop-outs in our study was more than expected. However, the remaining number of players in the two groups was enough to make it possible to detect a reduction in injury frequency from 30% to 12%. Another important aspect in this type of intervention study is to know how well the subjects have complied with the intervention program. The players in our intervention group performed the balance board training indoors at home because it is difficult to use the balance board equipment properly outdoors on surfaces such as grass and gravel. For information about how well the players had performed the balance board training they were asked to record this carefully in a special protocol. Furthermore, it might be difficult to motivate the subjects to perform the training as prescribed and to maintain their motivation at a high level throughout the entire study period. Therefore in this investigation the authors (K.S. and S.W.) were in regular contact with the players to try to keep them motivated to perform the balance board training as prescribed.

In the present study we did not find any significant differences between the intervention and control groups regarding either minor or moderate injuries. However, the intervention group showed a significantly higher incidence rate of major injuries than the controls. Most of the major injuries were knee sprains and four of five ACL ruptures occurred among the players in the intervention group. ACL ruptures have been demonstrated to be common in soccer and more frequent in women than in men [11]. The 3 years intervention study by Caraffa et al. [6] on male soccer players reported proprioceptive training on a balance board to considerably prevent ACL ruptures. We cannot explain the contradictory results between their investigation and ours, but the difference in gender, playing division, and/or total exposure time for training on a balance board may have played a role.

Similar to the results in our study, several authors [2, 5, 7, 10, 18, 21] have found ankle sprain to be the most common injury among soccer players. In contrast to Wedderkopp et al. [23], who studied female handball players, we were not able to prevent ankle sprains with balance board training. Whether this depends on the different characteristics of the games, playing surfaces, and equipment (shoes) is unclear. However, we cannot exclude the possibility that the special warm-up program added in the study by Wedderkopp et al. [23] had an injury-preventing role. In fact, Ekstrand et al. [9] reported that a special warm-up program in combination with other preventive strategies significantly reduced injuries in male soccer players.

Ekstrand [7] reported both acute and recurrent ankle sprains to be common in soccer. Tropp et al. [22] were successful in decreasing the incidence of recurrent ankle sprains with balance board training. However, in the present study we could not prevent recurrence of ankle sprains with balance board training. This may have been due to our players being trained standing on the balance board with the knee in a flexed position, which may not influence on stabilization of the ankle joint. The players in the study by Tropp et al. [22] performed their balance board training with the knee extended, which may be better for training ankle stabilization. Another reason could be that the number of players with recurrent ankle sprains in our study was too low.

Among the players who had been injured during the 3-month period prior to this investigation, significantly more players from the control group than from the intervention group, were ingured during the study period. Their injuries, however, were not necessarily of the same type as their previous ones. A player having recovered from one injury might be more prone to sustain another injury. This means that even if a player is free of symptoms from the previous injury, it may not be completely healed. Keller et al. [15] reported that, for example, leg muscle weakness following a previous injury to be a factor associated with soccer injuries. Furthermore, Garrett [12] and Ekstrand [7] reported that a minor injury predisposes to a more serious one. Therefore it is important to ensure that the player is not only free of symptoms from the injury but also has regained full physical fitness before returning to play soccer.

Within the intervention group we found no difference in injuries between players who trained as prescribed (≥70 training sessions) and players who trained less (35–69 training sessions). The amount of balance board training also did not appear to affect the frequency of traumatic injuries of the lower extremities.

A movable platform device, the KAT 2000, was used to measure balance/postural sway of the lower extremities. This device gives a rough measurement of one leg standing balance of the lower extremities and is comparable to standing on the balance board that we used for balance training in our investigation. However, to improve the method of using the KAT 2000 we performed a carefully standardized measurement procedure. In assessing possible changes in balance/postural sway of the lower extremities between intervention and control groups we divided the balance variables into three categories: improved, unchanged, and impaired. In a previous study on male and female soccer and volleyball players we found a 27% higher risk of sustaining an ankle sprain when there was a side-to-side balance index difference of 100 as measured by the KAT 2000 (unpublished data). In the present investigation a balance index of 100 or higher was therefore chosen to reflect a true change in balance/postural sway of the lower extremities. Surprisingly, the only significant improvement in balance/postural sway of the lower extremities among the players in the intervention group was found in the nondominant leg with extended knee. Possible explanations for this are that the time of training performed in each session (10–15 min) was not long enough, that our 7-month period of balance board training was too short to improve balance/postural sway of the lower extremities, and/or that the KAT 2000 is not sensitive enough to detect possible changes.

In conclusion, one season of balance board training thus did not prevent primary traumatic injuries of the lower extremities in female soccer players in the second and third Swedish divisions. We found no significant differences between the groups with respect to either the number of injured players or the number, incidence rate, or type of traumatic injuries of the lower extremities. However, among players who had been injured during the 3 months prior to this investigation significantly more controls than players from the intervention group sustained further injuries during the study period. No significant difference was shown between the two groups regarding either minor or moderate injuries, but the incidence rate of major injuries was higher in the intervention group than in the control group. Four of five ACL injuries occurred in the intervention group. Balance board training therefore did not prevent ACL injuries in female soccer players.

Acknowledgements This study was supported by grants from the Swedish National Center for Research in Sports. We thank Hans Stenlund from the Department of Public Health and Clinical Medicine, Epidemiology, for valuable help with the statistics.

References

1. Ahlbom A, Norell S (1987) Grunderna i epidemiologi [Basics in epidemiology]. Studentlitteratur, Lund
2. Backous DD, Friedl KE, Smith NJ, Parr TJ, Carpine WD (1988) Soccer injuries and their relation to physical maturity. Am J Dis Child 142:839–842
3. Bahr R, Lian Ø, Bahr IA (1997) A twofold reduction in the incidence of acute ankle sprains in volleyball after the introduction of an injury prevention program: a prospective cohort study. Scand J Med Sci Sports 7:172–177
4. Barnekow-Bergkvist M, Hedberg G, Janlert U, Jansson E (1996) Development of muscular endurance and strength from adolescence to adulthood and level of physical capacity in men and women at the age of 34 years. Scand J Med Sci Sports 6:145–155
5. Brynhildsen J, Ekstrand J, Jeppson A, Tropp H (1990) Previous injuries and persisting symptoms in female soccer players. Int J Sports Med 11:489–492
6. Caraffa A, Cerulli G, Projetti M, Aisa G, Rizzo A (1996) Prevention of anterior cruciate ligament injuries in soccer. A prospective controlled study of proprioceptive training. Knee Surg Sports Traumatol Arthrosc 4:19–21
7. Ekstrand J (1982) Soccer injuries and their prevention. Thesis. Linköping University
8. Ekstrand J, Wiktorsson M, Öberg B, Gillquist J (1982) Lower extremity goniometric measurements: a study to determine their reliability. Arch Phys Med Rehabil 63:171–175
9. Ekstrand J, Gillquist J, Liljedahl SO (1983) Prevention of soccer injuries: Supervision by doctor or physiotherapist. Am J Sports Med 11:63–67
10. Engström B, Johansson C, Törnkvist H (1991) Soccer injuries among elite female players. Am J Sports Med 19:372–375
11. Folksam (1994) Idrottsskador [sports injuries] 1986–1990. A report from Folksam Insurance Company. Stockholm, Sweden
12. Garrett WE Jr (1996) Muscle strains. In: Garrett WE Jr, Kirkendall DT, Cintiguglia SR (eds) The U.S. soccer sports medicine book. Williams & Wilkins, Baltimore
13. Green WB, Heckman JD (eds) (1994) The clinical measurement of joint motion. American Academy of Orthopaedic Surgeons, Rosemont
14. Inklaar H (1994) Soccer injuries. I. Incidence and severity. Sports Med 18:55–73
15. Keller CS, Noyes FR, Buncher CR (1987) The medical aspects of soccer injury epidemiology. Am J Sports Med 15:230–237
16. Lüthje P, Nurmi I, Kataja M et al. (1996) Epidemiology and traumatology of injuries in elite soccer: a prospective study in Finland. Scand J Med Sci Sports 6:180–185
17. Mason JT, Mason BR, Howard ME (1990) Kinesthetic diagnostic and rehabilitation device. BREG, Vista
18. McCarroll JR, Meaney C, Sieber JM (1984) Profile of youth soccer injuries. Physician Sports Med 12:113–117
19. Möller M (1984) Athletic training and flexibility. A study on range of motion in the lower extremity. Thesis, Linköping University
20. Poulsen TD, Freund KG, Madsen F, Sandvej K (1991) Injuries in high-skilled and low-skilled soccer: a prospective study. Br J Sports Med 25:151–153
21. Sullivan JA, Gross RH, Grana WA, Garcia-Moral CA (1980) Evaluation of injuries in youth soccer. Am J Sports Med 8:325–327
22. Tropp H, Askling C, Gillquist J (1985) Prevention of ankle sprains. Am J Sports Med 13:259–261
23. Wedderkopp N, Kaltoft M, Lundgaard B, Rosendahl M, Froberg K (1999) Prevention of injuries in young female players in European team handball. A prospective intervention study. Scand J Med Sci Sports 9:41–47