Ytfeldt et al., Physiother Rehabil 2018, 3:3
DOI: 10.4172/2573-0312.1000161

Journal of
Physiotherapy & Physical Rehabilitation

Research Article

Open Access

Functional Performance in Female Soccer Players Before and After Knee Injury Prevention Training

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Abstract

Objective: Female soccer players have an increased risk of knee injuries. Functional tests are used to evaluate global knee function after injury and/or surgery. The aims of this study were to characterize functional performance in female soccer players using four selected functional performance tests and to evaluate the effects of a specific injury prevention programme.

Methods: Ninety-nine female soccer players were divided into an intervention group (n=53) and controls (n=46). Both groups performed four functional performance tests at baseline and were retested at three months' follow-up. Only the intervention group was educated in knee injury prevention and given a prevention programme including three exercises recommended twice a week.

Results: At follow-up the intervention group had significantly better results in the single leg sit-to-stand test (right leg 27 ± 7.7 *vs.* 31 ± 7 .0; left leg 28 ± 7.0 *vs.* 30 ± 16.8) than the controls (right leg 25 ± 5.6 *vs.* 26 ± 6.6; left leg 24 ± 6.0 *vs.* 25±6.0); p=0.001; p<0.0001, respectively. The intervention group also had significantly improved results in single-leg hop for distance in both legs from baseline (right leg: 116 ± 15.2 cm; left leg: 118 ± 14.2 cm) to follow-up (right leg: 121 ± 14.4 cm; left leg: 122 ± 15.8 cm); p=0.03; p=0.02, respectively.

Conclusion: This brief injury prevention programme seemed to improve muscular strength and endurance in the lower extremities of female soccer players when performed for three months and evaluated on four selected functional tests.

Keywords: Female; Functional testing; Football; Injury prevention; Knee; Lower extremity; Soccer; Women

Introduction

Over the past decade, interest in women's soccer has grown. The number of female soccer players has increased and according to the International Federation of Football Association [1], there are today 29 million women and girls playing football worldwide. The game has become faster and more powerful over time, requiring players to become more athletic [2,3]. Injuries in female soccer players have become more common, with most involving the lower limbs [4,5] especially the ankles and knees [4,6,7].

Previous studies have shown that female athletes in sports involving twist and torque jumps have four to six times higher risks of serious knee injuries, such as anterior cruciate ligament (ACL) injuries, than male athletes in similar sports [8]. Female soccer players' risk of injury is highest during their post-pubertal years [9,10] and peaks slightly earlier than males'. Anterior cruciate ligament injuries are among the most serious in soccer [6] often requiring surgery and a long period of rehabilitation. The risk of developing early osteoarthritis increases with this type of injury, and an ACL injury may lead to high costs for both the athlete and society [8,11,12].

Usually, injuries in female soccer players occur without contact with other players during rapid deceleration, sudden change of direction, or a bad landing after a jump [4,9,12-14]. Female athletes have a movement pattern different to males, with less use of the knee flexor muscles and increased adduction and abduction moments at the knee when landing or cutting [8]. Excessive valgus movement of the knee is an indicated risk factor for ACL injury [8,15]. When testing strength and functional performance males have shown better results compared to females, however no differences in limb symmetry indexes (LSIs) were found between genders [16].

Several studies have shown that knee injuries among women athletes may be reduced by using neuromuscular training programmes, strength training, proprioception and balance training and plyometric training [8,17-23]. Multi-component preventive programs seem to be more effective than single-component programmes [24]. A Swedish preventive exercise programme was shown to reduce knee injuries in female soccer players by 77% [17] and a national prevention programme for knee injuries in Switzerland reduced injury rates in amateur soccer players and showed both social and economic cost-benefits [25].

Functional tests are often used by physiotherapists to assess knee function after injury and to obtain reliable measures of lower extremity performance and LSIs [26-30]. The prevention of sports injuries is not currently implemented in health care even though sports injuries represent a large proportion of particularly serious knee injuries. The prevention of knee injuries has mostly been studied and evaluated in group samples [10,17,18] and no consensus has been reached on which

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Received: July 04, 2018; **Accepted:** August 03, 2018; **Published:** August 09, 2018

Citation: Ytfeldt L, Skenk S, Månsson J, Grönlund MA (2018) Functional Performance in Female Soccer Players Before and After Knee Injury Prevention Training. Physiother Rehabil 3: 161. doi: 10.4172/2573-0312.1000161

specific parameters or key components truly explain the resulting reduction in injury rates. Better understanding of the mechanisms of prevention training programmes would benefit both athletes and society by increasing the use of prevention in primary care to avert sports injuries.

The aim of this study was to characterize functional performance in female soccer players using four selected functional performance tests and to evaluate the effects of a specific injury prevention programme on endurance, jumping and landing techniques, balance and explosive strength, and assess which mechanism that seems to be the most responsive one.

Materials and Methods

Study population

Of eight female soccer teams in the southwest of Sweden invited to take part in this prospective, controlled intervention study, six agreed to participate. Inclusion criteria were active female amateur soccer players over 13 years of age with no current injury and participating in fully in training and matches. The exclusion criterion was any lower limb injury lasting for more than three months during the past year. To prevent potential confounding the participating teams were strategically selected into an intervention group (IG) and a control group (CG) roughly matched for number of players, geographic location, and season of the year for performing the functional testing.

Procedure

Four functional tests measured endurance, jumping and landing techniques, balance and explosive strength:

1. The single leg sit-to-stand test;
2. The side hop test;
3. The standing on one leg eyes closed (SOLEC) balance test and
4. The single leg hop for distance test (Figures 1a-1d).

All tests were conducted by two physiotherapists (LY and SK). The physiotherapist gave standardized instructions before each test and refrained from encouraging participants during the test sessions. The participants were given a few minutes before each test for familiarization of the test. The tests were performed as follows:

Figure 1a: The functional performance tests used in the study: (1a) single leg sit-to-stand.

Figure 1b: The functional performance tests used in the study: (1b) side hop.

Figure 1c: The functional performance tests used in the study: (1c) standing on one leg eyes closed (balance).

The single leg sit-to-stand test

The participants were started sitting on a bench with arms crossed over their chest. They were instructed to rise from sitting to standing position on one leg as many times as possible in 60 seconds. They were not allowed to touch the floor with the other leg, which was held straight

Figure 1d: The functional performance tests used in the study: (1d) single leg hop (distance) test.

in front of them. The test was performed with full muscle control, i.e. the eccentric phase was carried out with constant speed, and the concentric phase without trunk and arm movements (Figure 1a). This test, with the exception of the time limit, was the test previously used by Thorstensson et al. [31]. It was used to evaluate strength and endurance in thigh muscles.

The side hop test

Two lines, 40 cm apart on the outer sides, were marked on the floor. Participants stood on one leg just outside one line, with their hands behind their back. On a signal they were to jump on one leg from one side to the other without touching the lines marked on the floor. The goal was to perform as many complete side hops as possible in 30 seconds (Figure 1b). One attempt was allowed for each leg. The side hop was used to evaluate jumping technique and endurance, and has been shown to have good reliability [32].

The SOLEC balance test

Participants stood on one leg in a circle 50 cm in diameter with arms folded over the chest. The free leg was held up with 90° flexion in both knee and hip. With eyes closed, the task was to maintain balance as long as possible within the circle to a maximum time of 60 seconds. Movements within the circle were allowed. The test was discontinued if the participant touched the circle (with the foot of the standing leg) or the floor (with foot of the free leg) (Figure 1c). Participants were allowed three attempts per leg, and the best result for each leg was recorded [26]. The SOLEC balance test was used to evaluate balance, and the test has good reliability [33] and may be appropriate for measuring change in balance at a group level [34].

The single-leg hop for distance test

Participants stood on one leg with their toes behind a line marked on the floor. Free leg swing with the other leg was allowed. Hands were placed behind the back. Participants were instructed to hop forward as far as possible while performing a controlled and balanced landing. The single leg hop for distance was measured in cm, from toe to heel (Figure 1d) [32,35]. Three attempts were documented for each leg and the longest successful jump was recorded. Single leg hop for distance was used to evaluate explosive strength and has a good reliability [35]. It has also proved to be a useful tool in identifying athletes at risk for low back or lower extremity injuries [36]. Both groups were tested twice, first at baseline and then at three months follow-up, using the same four functional tests at both sessions. The IG also performed an extra test, the drop jump test, at baseline. Participants were instructed to jump down from a box 30 cm high and to perform a maximal vertical jump directly after landing. They were instructed to try to land on both feet with knee alignment [27]. This was repeated three times for each person. The test was performed in front of a mirror to provide the participant with direct visual feedback, and the physiotherapist assessed the jumps subjectively and gave participants additional feedback. During the first session, participants in the IG were also given a lecture including information about knee anatomy, injury mechanisms, and the importance of prevention through training such as practicing good knee alignment and exaggerated hip and knee flexion on landing. They were further instructed to perform three exercises twice a week at home and record the training sessions in a training log (Table 1). The IG coaches were instructed orally and in writing about the following recommended exercises to include during soccer practice: running forward, running backwards side jumps, zigzag shuffles, long jumps (16 jumps × 3 sets), walking lunges (20 steps × 3 sets), square jumping (forward, to the side, backward , and to the other side; 5 repetitions × 2 sets), balance training (standing on one leg, in pairs of two, and the players try to push each other off balance; 30 s per leg × 2 sets). These exercises were recommended once or twice per week and suggested as a part of the warm-up.

The CG was tested at baseline on the same functional tests and in the same way as the IG, except they were not asked to do the drop jump test. The CG participants were not given any lecture or home exercise programme, nor were their coaches asked to alter their warm-up and training routines. CG participants were informed that they would receive the same information and training protocol as the IG after the study was finished. During the three months of the study, all participants in both groups self-reported any injury involving the lower extremities that was incurred during training or playing soccer and that prevented participation in training or playing for at least two consecutive days.

Statistical analysis

The statistical package, SPSS 20.0 (SPSS, IBM®) was used for

Exercises	Description	Repetitions
Walking lunges	Walking lunges with straight arms above head with a focus on postural control and knee stability.	16 steps (8 steps per leg) × 3 repetitions
"The Dragon"	Standing on one leg with light knee flexion and the trunk muscles activated. The back folds forward and the bottom are pushed back. The hips aim to be parallel to the horizontal plane. Flexion in the hip and the free leg is held extended behind the body. The back flips to horizontal where the rear leg is in line with the back. Then slowly return to starting position.	12 times (6 times per leg) × 3 repetitions
Horizontal and vertical jumps	Two horizontal jumps with both feet followed by a vertical jump with focus on landing technique. The knee in a good alignment and with an exaggerated flexion in hip, knee and trunk.	5 times × 2 repetitions

Table 1: Exercises, description, and repetitions of each exercise that female soccer players in the intervention group were instructed to perform at home twice a week.

statistical analysis. Means, standard deviations (SD), medians, and ranges were calculated for descriptive purposes. Paired t-test (continuous variables) was used for comparison between two occasions when separate analyses were performed for intervention participants and controls. Student's t-test was performed by comparing the means of two independent groups. For dichotomous variables, we used Fisher's exact test. Test results were considered significant at $p<0.05$.

The study was approved by the regional ethics committee in Stockholm, Sweden, No 2011/1213-31/2. The conduct of the study adhered to the tenets of the Helsinki declaration. Informed consent was obtained from all young adults from the age of 18 and the parents of all the children and younger adolescents participating in the study.

Results

In total, 137 subjects from six female soccer teams agreed to participate in the study. Eight players were excluded due to injury or illness and a total of 99 players (77%) completed the study. The final sample at follow-up consisted of 53 players with a mean age of 16.4 years (range 13.7-28.9 years) in the IG and 46 players with a mean age of 16.2 years (range 13.1-33.9 years) in the CG. The drop-out rate was 17/70 (24%) for the IG and 13/59 (22%) for the CG (Figure 2).

Test results at baseline and follow-up

Table 2 shows the results from the four selected functional performance tests at baseline and follow-up. Baseline test results were similar for the two groups, with no significant between-group differences except for the IG's higher score on the single leg sit-to-stand test for the left leg. In the IG, 46/53 (87%) players stood for 60 seconds on at least one leg in the SOLEC balance test; the corresponding figure for the CG was 40/46 (87%) players.

At three months follow-up significant differences were found between the groups. The IG had higher scores on single leg sit-to-stand

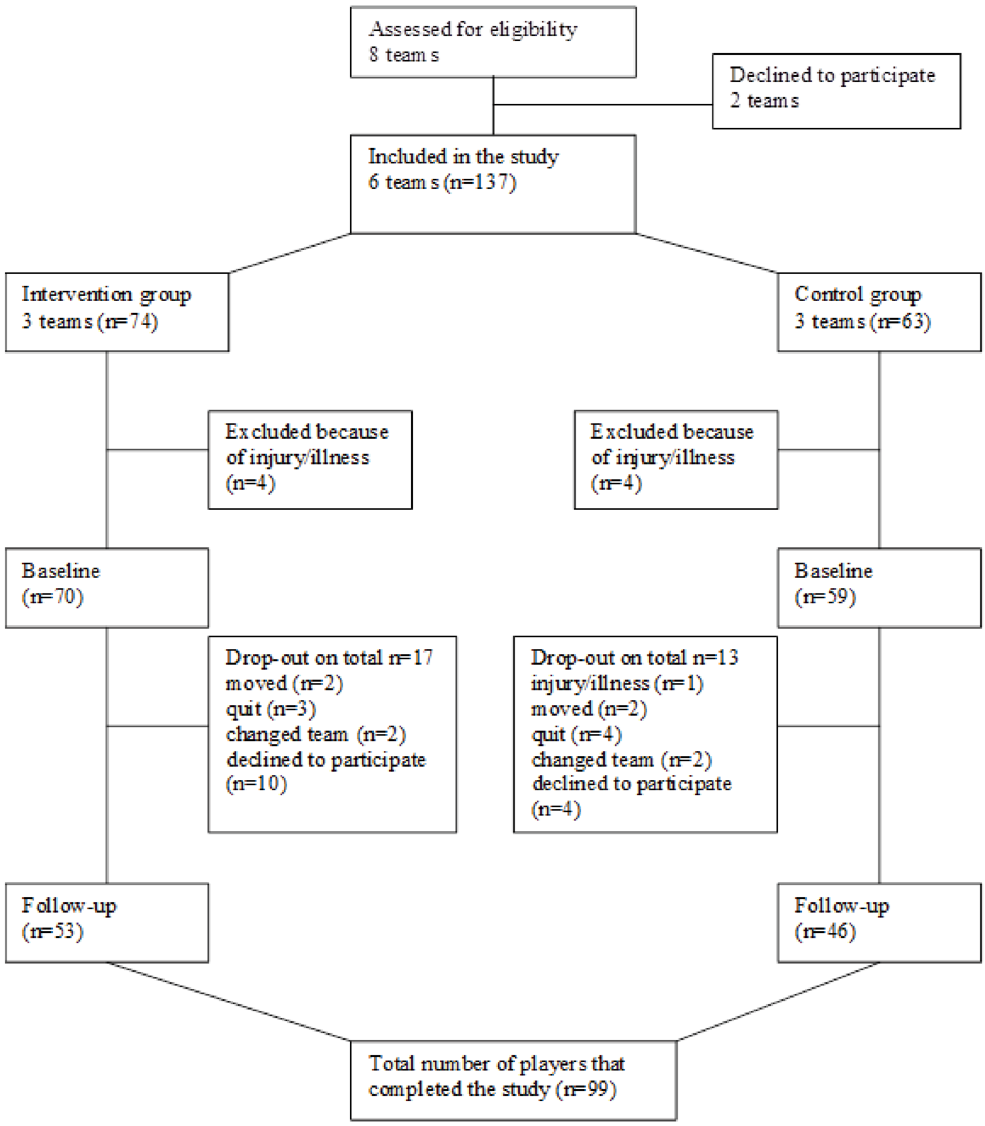

Figure 2: Flow chart showing the study design and study sample from invitation to completed study.

Tests	At Baseline Intervention group (n=53)* Mean (SD)	Control group (n=46) Mean (SD)	p-value	At Follow-up Intervention group (n=53)* Mean (SD)	Control group (n=46) Mean (SD)	p-value
Single leg sit-to-stand (n) right	27 (± 7.7)	25 (± 5.6)	0.12	31 (± 7.0) (n=52)	26 (± 6.6)	0.001
Single leg sit-to-stand (n) left	28 (± 7.0)	24 (± 6.0)	0.005	30 (± 6.8)	25 (± 6.3)	0.001
Side hop (n) right	36 (± 11.5) (n=52)	34 (± 12.3) (n=45)	0.47	38 (± 11.2) (n=52)	36 (± 12.6)	0.42
Side hop (n) left	36 (± 11.1) (n=51)	32 (± 11.8)	0.07	38 (± 11.1) (n=51)	34 (± 12.8)	0.07
SOLEC (s) right	51 (± 15.4)	56 (± 10.9)	0.09	54 (± 12.5)	56 (± 10.6)	0.31
SOLEC (s) left	53 (± 13.2)	56 (± 8.4)	0.18	54 (± 13.2)	59 (± 4.0)	0.02
Single leg hop for distance (cm) right	116 (± 15.2) (n=52)	118 (± 21.2)	0.62	121 (± 14.4) (n=52)	119 (± 14.7)	0.69
Single leg hop for distance (cm) left	118 (± 14.2)	119 (± 21.4)	0.94	122 (± 15.8)	119 (± 16.1)	0.4

*Where numbers differ from the total number of children in the group, they are given separately for each category.
cm=centimetres; n=number; s=seconds; SD=Standard Deviation; SOLEC=standing on one leg eyes closed.
P-values were obtained by Student's t-test.

Table 2: Results of functional testing at baseline and follow-up, comparing the intervention group and controls.

Tests: intervention group (n=53)	Change (%)	p-value	Tests: control group (n=46)	Change (%)	p-value
Single leg sit-to-stand (n) right	14	0.001	Single leg sit-to-stand (n) right	6	0.008
Single leg sit-to-stand (n) left	10	0.001	Single leg sit-to-stand (n) left	6	0.001
Side hop (n) right	6	0.16	Side hop (n) right	6	0.07
Side hop (n) left	6	0.19	Side hop (n) left	6	0.05
SOLEC (s) right	5	0.25	SOLEC (s) right	1	0.736
SOLEC (s) left	1	0.75	SOLEC (s) left	4	0.064
Single-leg hop for distance (cm) right	4	0.03	Single-leg hop for distance (cm) right	1	0.459
Single-leg hop for distance (cm) left	3	0.02	Single-leg hop for distance (cm) left	1	0.729

cm=centimetres; n=number; s=seconds; SOLEC=Standing on one leg eyes closed.
P-values were obtained by Paired t-test

Table 3: Relative change in test results from baseline to follow-up for the intervention group and the control group.

test for both right and left legs (p=0.001, respectively). There were also significant differences in the test results for the SOLEC balance test for the left leg (mean values), on which the CG had better results than the IG (p=0.015). In the IG 48/52 (92%) players were able to stand 60 seconds on at least one leg and the corresponding figure for the CG was 43/46 (93%) players. However, the median value for the IG was 60 seconds (range 13-60 s) for both right and left legs, and for the CG it was also 60 seconds for each leg (range 43-60 s).

Relative change from baseline to follow-up

Table 3 shows significantly improved results in the single-leg hop for distance test and the single leg sit-to-stand test for both legs in the IG. An improvement was also found in the CG on single leg sit-to-stand test for both legs. However, the improvement in the CG was not as great as it was in the IG (6% *vs.* 14% in the right leg and 6% *vs.* 10% in the left leg).

Self-reported data

Fifty-eight percent (31/53) of the players in the IG reported the number of exercise sessions they performed during the three-month follow-up. The median number of completed sessions was 15 (range 4-41). Eighty-three percent (44/53) of the participants in the IG reported the number of injuries compared with 37/46 (80%) in the CG. The number of players that self-reported injuries (n=18) during the follow-up were equally distributed, with 9 in both the IG (9/44; 20%) and the CG (9/37; 24%). The total number of injuries reported in the IG was 10 (foot n=3; thigh n=2; knee n=4; hip n=1). The equal number of injuries was reported in the CG (foot n=6; lower leg n=2; knee n=2). There was no significant difference between the groups regarding number of players injured during the study period (p=0.79, Fisher's exact test).

Discussion

The main findings of this study showed significantly better results in the IG than the CG on the single leg sit-to-stand test for both legs at the three-month follow-up. There were also statistically significant improvements in the IG from baseline to follow-up in single-leg hop for distance (both legs), which were not found in the CG. These improvements, indicating increased muscular strength and endurance in the lower extremities, were most certainly due to the effects of the injury prevention training programme.

The outcome of interest in the present study was improved functional performance after specific injury prevention training for lower limb, evaluated by four selected functional tests. Strength and endurance in lower extremity seems to be the most responsive mechanisms in this population of young female soccer players. Previous injury prevention studies in soccer players have mostly used injury rates as the outcome of interest [17,18,20,23,37]. Several studies have shown that the risk of injury among women athletes can be reduced by a preventive exercise programme [4,8,17,18,23]. In the present study the population was too small and the follow-up too short to draw any conclusions about the frequency of injury after the intervention period, although all injuries were reported.

A considerable amount of time was spent to educate and enforce awareness of injury mechanisms among the participants. For example, the Drop Jump test was performed in front of a mirror to increase understanding and compliance of the programme. Orr et al. [38] studied how well-known the effects of injury prevention training are in young female soccer players and their coaches and parents. They found that less than half of the players, 50% of the parents, and 62% of the coaches thought that it was possible to prevent knee injuries through specific injury prevention training. It is very important to inform young athletes, their coaches, and their parents about the benefits of prevention training. An interaction with a physical therapist during pre-season training would improve the identification of individual risk factors [39]. The prepubertal and pubertal years are very favorable for learning and practicing motor skills, techniques, and movement patterns [40] and it is easier to integrate injury prevention training as a part of soccer training when players are young [41]. Most subjects (n=57) in the present study were aged 13 to 15.

The total drop-out rate in the study was 30/129 (23%), and it was attributable to several causes. Many young athletes withdraw from sports during their teen years, and young female athletes are most likely to withdraw during their early teens [42]. The players in this study were given a diary to report their training sessions which is an obvious limitation. Furthermore, compliance with the injury prevention program was unsatisfying; only 58% of the players reported the number of exercise sessions they completed. Soligard et al. [41] have shown that players with a positive attitude towards injury prevention are correlated with high compliance and less risk of injury. The importance of understanding factors such as motivation that affect players and coaches has also been highlighted [25]. Educating coaches is fundamental and increases the adoption rate of prevention training programme during soccer practice [42,43]. Providing the players with easily accessible and up-to-date information and reminders *via* text messages or an interactive cell phone application would probably improve compliance by giving players additional motivation to continue the training. This is suggested as a complement to ordinary injury prevention training programmes.

A limitation of this study was the lack of standard preparation before each test session. Some of the players had had soccer practice earlier in the day and/or had played a match the day before. However, this chance was no different between groups or test sessions. The home exercise programme was instructed only once, at baseline. The effects of this programme depended on the subject's commitment and the quality with which the exercises were performed. There was no control or monitoring of how the participants performed the programme. The results of the study might have been different had a physiotherapist been present to supervise exercises during soccer training sessions.

The programme consisted of three exercises to allow participants to perform it twice a week without it taking too much time or effort. Players' ability to memorize the exercises also increased when the programme was not too long. To make the training programme easy to implement during soccer training, or even at home, all the exercises were performed in the standing position and required no additional equipment. Standing position is also more specific to soccer than, for example, supine or sitting positions. All components trained in the three selected exercises in this study-thigh and core strength, proprioception, and body control-have been shown to have a preventive effect on injuries [9,44]. Exercises for balance and jumping technique have also been reported to be effective for preventing knee injuries in particular [8].

Functional tests were used to measure physical performance and to increase the motivation of the participants to continue with the prevention training. Functional tests are more specific to particular sports than other measures such as laboratory tests [45]. The functional tests used in this study are frequently used for lower extremities by physiotherapists in everyday clinic. They are often used to evaluate whether full functional performance is regained after a period of rehabilitation. Unilateral testing should be used to identify deficits or asymmetries in performance [46]. Side hop test has high difficulty as it requires good knee stability while the muscle is fatigued [41] and this test gave a clear measurement of the participants' physical performance. Balance was evaluated to assess the combination of peripheral vestibular and visual properties [47]. Measuring balance in standing has been shown to have strong value for predicting sports injuries [48]. Steffen et al. [21] showed that injury prevention training improved functional balance and reduced injury risk in soccer players. In the present study the balance test, SOLEC, turned out to be too easy for the young female soccer players to provide a useful measurement. Too many of the participants were able to stand on one leg with eyes closed for 60 seconds. This test would have to be more difficult to provide a clearer result. The three allowed attempts for each subject gave further misleading results when there is obviously a difference between succeeding for 60 seconds on three attempts versus on only one attempt. A possible variation would be to calculate the mean value of the three attempts or to increase time limit for each test. We found that the single-leg sit to stand test was difficult to standardize with regard to how much arm and trunk movement was permitted. The height of the subject is also important as this test is performed standing from a bench of standard height. On the other hand, the individual's own test results between baseline and follow-up were studied, and the height of the bench would have no influence on those results. Physical performance is affected by a number of internal and external factors as well as gender [16]. Among other things, coordinative, physical, and psychological characteristics are all important to a player's performance [49].

Conclusion

The results in this study underline the importance to regularly conduct prevention training and especially strength training for lower extremities in female soccer players. The present study also indicate that functional testing may be a valid instrument for prevention training and a useful tool for screening for deficient physical performance in young female athletes.

At three months follow-up, there was a significant difference between the two groups, with the IG having better results on the single leg sit-to-stand test in both right and left leg, indicating improved strength and endurance in the thighs. A significant improvement was also found in the single-leg hop for distance test in the IG between baseline and follow-up, indicating increased explosive strength. This concise and modest preventive training programme, in combination with instructions and education regarding risk factors and injury prevention training, may improve physical performance with relatively little effort, and possibly, in the long run, be enough to reduce the risk of lower limb injury in female soccer players.

Acknowledgements

The authors would like to thank all the coaches and players who participate in the study. We would also like to thank Amir Baigi, M.D, Ph.D., Department of Research and Development Region of Halland, Sweden, for contributions to the statistical analyses and Ingela Ahlstrand for illustrations.

Financial Supports

The study was financially supported by Capio Health Care, Sweden.

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