Injury prevention in team sport athletes

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5

AN INTERVENTION STUDY TO DETERMINE THE EFFECT OF INTERNAL VERSUS EXTERNAL FOCUS INSTRUCTIONS TO REDUCE ACL INJURY RISK FACTORS IN FEMALE ATHLETES. A PILOT STUDY

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ABSTRACT

The first purpose of this study was to assess the feasibility of an anterior cruciate ligament (ACL) injury prevention program with external focus (EF) and internal focus (IF) instructions. Adherence rates to the program and integration of the ACL injury prevention program in the warm-up were examined. The second purpose was to determine the effect of adopting an EF versus IF in an ACL injury prevention program on biomechanical ACL injury risk factors during a drop vertical jump (DVJ) in female soccer players. Nineteen female soccer players performed drop vertical jumps (DVJ) pre- and postintervention; kinematics and kinetics were calculated. The subjects performed neuromuscular warm-up programs twice a week for 12 weeks. One team received IF instructions (IF); another team received EF instructions (EF).
Results showed that the adherence was higher in the EF group (84%) compared to the IF group (67%) ($P = 0.03$). In both groups some players showed improvement in landing technique, whereas other players did not. Three players in the IF group (38%) decreased absolute peak knee valgus moment during landing. In the EF group, six players decreased absolute knee valgus moment slightly (55%).
In conclusion, this study showed a higher adherence for the EF prevention program compared to the IF program. Both teams implemented the training program and showed positive and negative individual results on modifying potential ACL injury risk factors. Future research should concentrate on optimizing the warm-up program developed in this study.

INTRODUCTION

Non-contact anterior cruciate ligament (ACL) injuries occur frequently in female soccer players,[1] with a higher incidence compared to male soccer players.[2] ACL injuries often occur during single or double legged landings after a jump.[3,4] In a review, several prospective studies have reported potential risk factors for ACL injuries.[5] For example, a greater knee valgus moment during landing has been shown to be a risk factor for ACL injuries.[6] Prevention programs that aim to decrease these risk factors and ACL incidence have been developed.[7] These prevention programs include neuromuscular, balance, plyometric and agility exercises and showed a short-term decrease in number of ACL injuries in female soccer players.[8-10] With regards to risk factors, a neuromuscular training program reduced knee valgus moment during stop jumps and increased maximal knee flexion during drop jumps in female soccer players.[11] In contrast, a 6-week injury prevention program did not change knee joint angles during drop jumps.[12] Unfortunately, despite all efforts and reported successes of these programs, the overall ACL injury incidence has not decreased over the last twenty years.[1,13,14]

An explanation for this discrepancy between positive study results and findings in overall injury rates may be explained by the translation from lab to the field. In other words, inefficient translation of consciously learned landing technique in training sessions to a game where unexpected and automatic movements are required. One characteristic of the ACL injury prevention programs examined so far is that they use an internal focus of attention (IF) to instruct soccer players.[8-10] When an IF is used, the player is instructed to focus on the movements of the body.[15] For instance, "bend your knees" to increase knee flexion angle upon landing. Using an IF however has been known to interfere with automatic learning processes due to high levels of conscious awareness that degrades motor learning.[16]

As a result the transfer of correct landing patterns to the sport may be restricted as the athletes have to focus and react on opponents and the ball as well.[16] This could explain why the long-term effectiveness of prevention programs was limited.[16] In contrast, an external focus of attention (EF) directs the attention of an individual towards the movement effect.[15] For instance, "land softly" to increase knee flexion angle. Instructions that induce an EF may have the potential to improve current ACL injury prevention strategies, since it has clear advantages in comparison with learning with an IF.[17] An EF results in motor learning processes that are more resistant to physical or psychological stress and fast movements, which can be advantageous in a game.[17] Furthermore, the learning process occurs faster and effects tend to hold

longer.[16,17] A recent review showed positive effects of an EF on landing technique and performance compared to IF including less time needed for maintenance, more efficient skill acquisition and an improved transfer to sport.[18] These benefits of EF instructions may increase adherence to a prevention program.[18] However, most research on EF instructions has been performed in lab sessions,[19,20] therefore it is yet unknown how an EF can be applied to a practice situation (i.e. integrated in warm-up sessions). In addition, there is little knowledge about how an EF affects the execution of commonly used warm-up exercises in ACL injury prevention. Moreover, adherence in current ACL injury prevention programs is limited[21] and the adherence to an EF ACL injury prevention program has not been investigated. To the best knowledge of the authors, this is the first study that incorporates an EF in a warm-up for soccer players, therefore the focus needs to be on practical aspects as well; does it fit in a warm-up program and can it easily be applied? Therefore, the purpose of this study was (1) to assess the feasibility of an ACL injury prevention program with EF and IF instructions based on adherence rates and practical aspects of integration of the ACL injury prevention program in the warm-up and (2) to determine the effect of adopting an EF versus IF in an ACL injury prevention program on biomechanical ACL injury risk factors during a drop vertical jump (DVJ) in female soccer players. We expected that an EF prevention program would be more effective in modifying landing biomechanics.

METHODS

A pretest-posttest design was used. Thirty-five female soccer players, selected from two teams playing at the highest recreational level by the first author in September 2012, were selected for this study. These two teams were selected for their training location and level, both teams trained two times per week. Exclusion criteria included a history of major lower extremity and any known current lower extremity injury. Figure 5.1 shows a flow chart describing the process of excluding players. Nineteen players were included in the analysis. All athletes signed an informed consent form and approval was granted in accordance with ethical standards, conforming to the Helsinki Declaration. This study was approved by the local IRB. For players younger than 18 years old, parents or legal guardians filled out an informed consent form as well.

Drop vertical jump

All measurements took place in the SportsFieldLab Groningen, the Netherlands. First, mass and height of subjects were collected. Sixteen reflective markers were placed on the lower extremities according to the Plug-In-Gait model (PiG—Vicon Motion Systems, Oxford, UK), with additional markers on clavicle, sternum, right scapula, C7 and T10. All players executed a warm-up (5 minutes on a bicycle ergometer (70-100 Watt) (Excalibur Sport, Lode B.V., 123 Groningen, The Netherlands), 3 lunges per leg, 3 squats and 3 jumps). The DVJ consisted of a double-leg jump forward from a 30 cm platform, a distance of half their body height, landing with both feet on two force plates and immediately jumping vertically as high as possible.[22] After practicing, three successful trials were recorded. The requirements of a successful jump were described previously.[22] For all variables, the average value of three jump trials was used as the outcome measure.

The Vicon Motion Analysis system (Vicon Motion Systems, Inc., Centennial, CO), two forceplates (Bertec Corporation, Columbus, Ohio) in combination with Vicon Nexus Software (Version 1.6, Vicon Motion Systems, Inc., Centennial, CO) were used to collect and analyze three-dimensional data. This method was reported previously.[19] Force plates were used to collect vertical ground-reaction force (vGRF) data during two jump tasks at 1000 Hz. A fourth order Butterworth filter at a cut off frequency of 10 Hz was used to filter kinetic data.

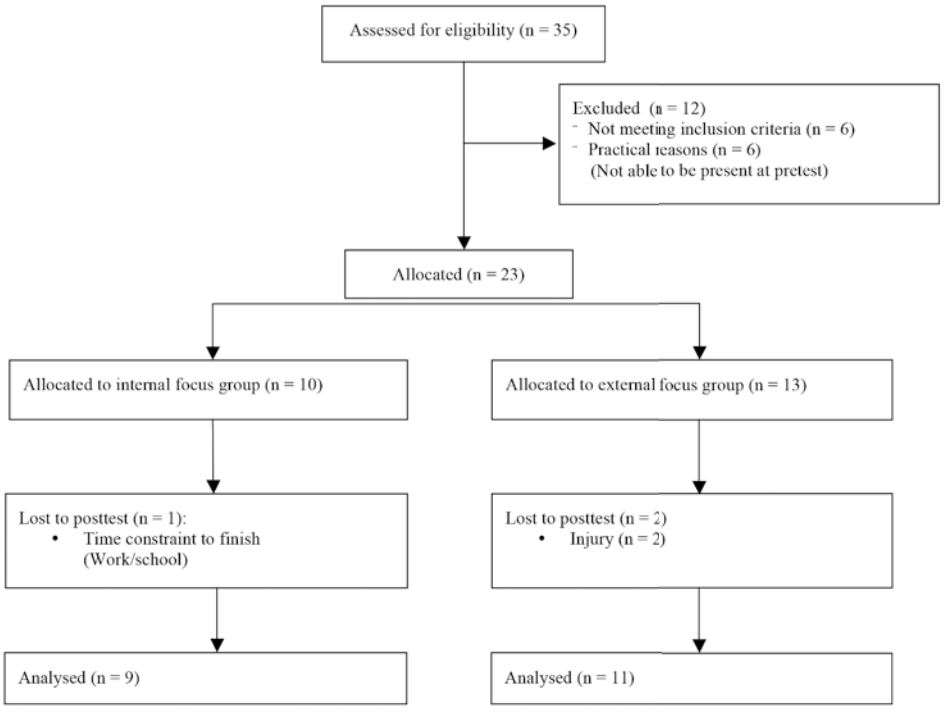

Figure 5.1. Enrollment, randomization and dropout of players allocated to the internally focused, and externally focused group

Intervention program

The first author randomly allocated the two teams to one of the following groups by flipping a coin: a group receiving EF instructions (EF) and a group receiving IF instructions (IF). Both groups executed a warm-up program twice a week for twelve weeks. This program was an adapted version of the PEP program.[8] The stretching exercises were replaced by balance and trunk control exercises as described in the FIFA 11 plus program.[9] Also, some additional strength[23,24] and agility exercises were added.[25] The complete warm-up program is described in Appendix 1. An instructor was selected for each intervention group. Eligibility criteria for these instructors were: experience with training soccer players and availability two times a week. The instructors participated in two training sessions of one hour supervised by the first author. These instructors provided the warm-up program including the instructions. Additionally, the instructors were asked to track how many players attended each training session in order to calculate adherence rates. The players in the IF and EF groups performed the same exercises, however the instructions they received were different (see Appendix 1 and 2). The instructions were provided by the instructors

prior to each exercise; one instruction per set of exercises was mentioned. For each exercise two or three instructions were available, which were alternated.

Data reduction and analysis

A custom made Matlab (release 12, The MathWorks, Natick, MA) program was used to calculate hip, knee and ankle joint kinetics and kinematics. The absolute peak knee valgus or varus moment during landing was selected for the dominant leg, a method which was reported in a previous study.[19] The primary outcome variables were frontal and sagittal knee moments and sagittal ankle moments. All moments were expressed as external moments. Additionally, sagittal hip, knee and ankle joint angles and range of motion (RoM) as well as vGRF were outcome variables of interest. These were calculated at the time of peak knee valgus or varus moment. The RoM of the hip, knee and ankle flexion angle were defined as the angle at the time of peak knee valgus or varus minus the angle at the time of initial contact. For the data analysis, joint moments and vGRF were normalized to the players body mass.[20,26]

Statistical analysis

Differences in adherence were calculated by means of an independent t-test. Individual scores were calculated for all included variables at baseline and after twelve weeks warm-up program. The alpha was set at 0.05. Considering the small sample size, large variation in some variables and the fact that this was a pilot study, no statistical analysis was performed for the changes from pre to post test in both groups. Instead, we presented these individual data in graphs to show the changes for each soccer player.

RESULTS

Player characteristics and adherence

Table 5.1 and 5.2 show the individual player characteristics for the IF and EF group. The adherence rate was significantly higher for the EF group (84±13%) compared to the IF group (67±18%) ($P = 0.03$). Both groups performed the ACL injury prevention program as a warm-up program prior to each training. In addition, extra running exercises were added for both groups, because the players needed more time to warm-up considering the cold temperature. Therefore, the duration of the warm-up was approximately 20-25 minutes.

Kinematics and kinetics

The individual changes in all kinematics and kinetics at the peak knee abduction or adduction moment during landing are presented in Figure 5.2 and 5.3. In both groups some players showed improvement in landing technique, whereas other players did not. Three players in the IF group (38%) decreased absolute peak knee valgus moment during landing. In the EF group, six players decreased absolute knee valgus moment slightly (55%).

For three players in the IF group knee flexion moment during landing decreased, while for five players knee flexion moment increased. In the EF group, six players decreased and five players increased knee flexion moment. Additionally, VGRF decreased for two players in the IF group and increased for six players. In the EF group, vGRF decreased for seven players and increased for four players. The ankle flexion angle decreased in three players in the IF group and increased in five players. Also, one player changed from dorsiflexion to plantarflexion angle. In addition, seven players in the EF group decreased ankle flexion angle during landing, two players increased this angle, one changed from plantar to dorsiflexion angle and one changed from dorsiflexion angle to plantar flexion angle. Ankle flexion RoM decreased for six players and increased for two players in the IF group. In the EF group, four players decreased ankle flexion RoM, while for seven players this RoM increased. At last, hip flexion angle during landing decreased in four players in the IF group and increased in four other players. In the EF group, eight players decreased and three players increased hip flexion angle.

Table 5.1. Player characteristics for the internal focus group

	INT								
	1	2	3	4	5	6	7	8	Mean ± *SD*
Age (y)	27	18	25	32	27	22	20	24	24.11 ± 4.23
Height (cm)	171	166	169	189	169	175	171	172	173.39 ± 6.79
Mass (kg)	58	54	70	72	59	73	63	66	65.72 ± 7.76

Table 5.2. Player characteristics for the external focus group

	EXT											
	1	2	3	4	5	6	7	8	9	10	11	Mean ± *SD*
Age (y)	20	26	28	29	30	23	16	26	23	23	17	23.73 ± 4.65
Height (cm)	80	60	90	95	90	90	90	100	60	75	90	167.45 ± 8.55
Mass (kg)	174	167	174	165	169	161	160	176	164	151	181	64.18 ± 10.46

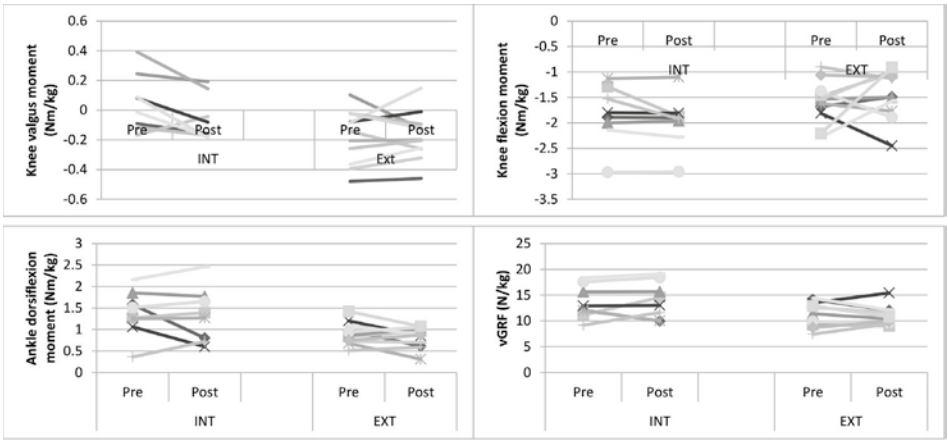

Figure 5.2. Individual changes in peak knee valgus moment, knee flexion moment, ankle dorsiflexion moment and vertical ground reaction force.

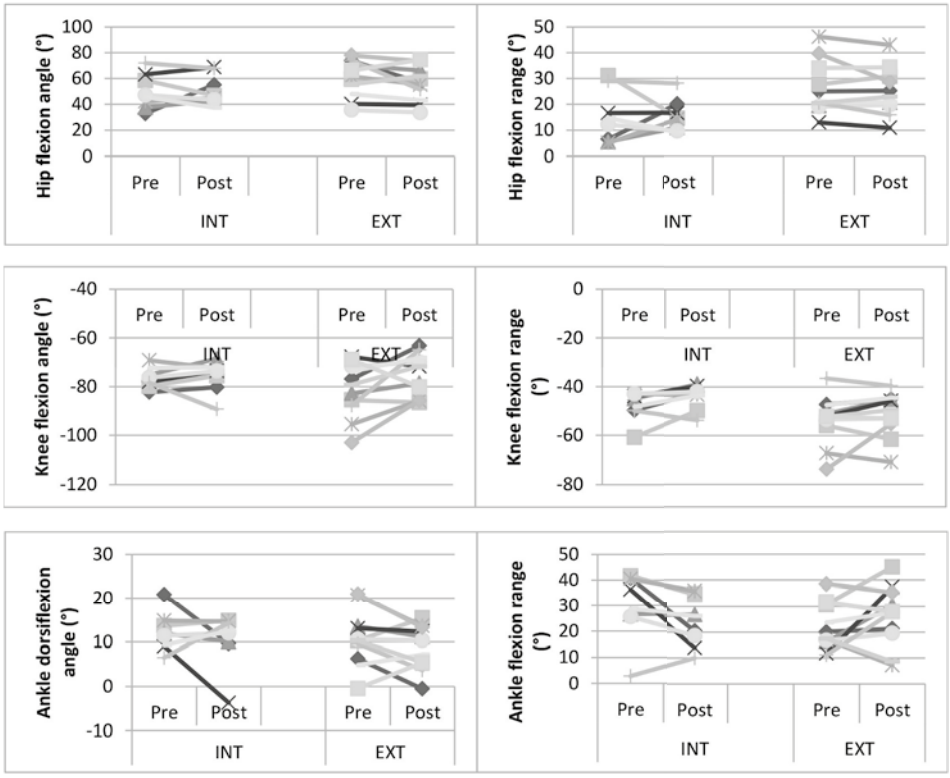

Figure 5.3. Individual changes in sagittal hip, knee and ankle flexion angles and range of motion.

DISCUSSION

Feasibility

This study showed that adherence to the program was significantly higher for the EF group compared to the IF group (84% vs 67%). In line with these results, a previous study showed that although coaches or clubs were motivated to implement ACL injury prevention programs, still a low adherence to the program was reported.[27] Recently, another study showed that coaches did not implement an injury prevention program because they thought it would not add any value.[28] Another reason for not implementing a prevention program was that it did not match with the needs of the coaches and was difficult to implement in practice.[28] Previous studies reported larger effects of a neuromuscular prevention program (i.e. lower ACL injury rate) if the adherence rates were larger.[21,29] Therefore, the effect of the warm-up program might have been different if adherence rates were the same for all groups. The results of this study emphasize that it is crucial to be aware of and report adherence and compliance issues as they do have a great influence on the effect of prevention programs.[30,31]

There were some practical issues with incorporating the warm-up program. The warm-up program started in winter, therefore the weather conditions were not optimal and for both groups three training sessions had to be cancelled.

Although we put a lot of effort in training instructors and trying to contrast the instructions, the difference between instructions may not have been large enough. For example, some EF instructions still mention body parts, such as "move your knee towards", which may have directed attention internally to some extent. Players could have had problems applying the instructions during practice as well. For example, the instructions "Bring your center of gravity close to the ground" or "Pretend like there is a plank in your back" may be difficult to apply.

In addition, players in the IF and EF group received the instructions prior to each exercise, which could have resulted in an overkill of information in the IF group, resulting in less optimal results and a lower motivation to apply the instructions to the exercises.[32] On the other hand, Wulf and colleagues have shown that in a case of adopting EF instructions a higher frequency is more optimal.[32] Implementing a self-controlled feedback strategy might be a solution, since it may increase motivation of players and supports motor learning.[33] Moreover, for all exercises an instruction was provided. Some EF instructions were difficult to understand (i.e. warm-up exercises and trunk), adapting the EF instructions may improve the suitability for practice.

Training program

After the 12 week warm-up program a large variation in individual kinetics and kinematics was found. Based on our descriptive results it seems that in both groups (IF and EF group) players improved and deteriorated their landing strategy after the warm-up program. The most notable differences between the IF and EF groups were found for the knee valgus moment, knee flexion moment, vGRF, hip flexion angle, ankle dorsiflexion angle and RoM during landing. We have to keep in mind that no statistical analysis was performed, therefore no conclusions can be made about which program improved landing technique more. Also, some of the exercises were comparable to exercises that the players already performed during warm-up before the intervention started, which may explain why we did not find large effects.

In the EF group more players decreased knee valgus moment compared to the IF group. This is an interesting finding considering that knee valgus moment is found to be a risk factor for ACL injuries.[6] In the EF group more players decreased the absolute knee flexion moment compared to the IF group, which may indicate a stiffer landing for the EF group. Furthermore, in the EF group more players decreased vGRF compared to the IF group. A decrease in vGRF may be beneficial for reducing ACL risk.[6] In the EF group, more players decreased hip flexion angle compared to the IF group, indicating a stiffer landing.[34] More players in the IF group increased ankle dorsiflexion angle than the players in the EF group, whereas more players in the EF group increased the ankle flexion range than players in the IF group. A larger ankle dorsiflexion RoM may indicate a softer landing, and therefore indirectly might decrease biomechanical ACL injury risk factors.[35]

LIMITATIONS

Besides the practical issues with the preventive program, some methodological issues need to be addressed as well. At first, the final sample size was slightly lower than the sample size calculated a priori due to a larger drop-out than expected and inability to be present at pre- and posttests. A second limitation of this study was that only individual results were presented and no statistical analyses were performed. In order to be able to determine differences in effect of an IF and EF ACL injury prevention program, a larger sample size is required as well as a control group. At last, skin-based markers were used for the estimation of knee joint angles and moments, therefore the accuracy may be restricted.[36,37]

This study is innovative and informative for coaches and medical staff and forms a basis for further research. What this study adds for future prevention programs is that feedback in prevention programs is suggested to be self-controlled as this increases motivation of players, supports motor learning and enhances adherence.[33] Adherence of athletes may also be enhanced by variance in exercises, supervision by a coach, performance enhancement and decrease of time needed.[7,21,25] The last two may encourage coach adherence as well.[18,38] Also, having fun and setting goals may help.[39,40]

CONCLUSION

This study showed that the adherence was higher for the EF prevention program compared to the IF program. Both teams implemented the training program and showed some positive and negative individual results on modifying potential ACL injury risk factors. Future research should concentrate on pilot sessions to optimize the warm-up program developed in this study and on reducing the influence of practical issues, such as optimize the frequency of instructions and increase adherence. After that, a randomized clinical trial should be designed to determine the differences in the effects of the IF and EF prevention program on ACL injury risk factors.

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Appendix 1.

Internally and externally focused instructions for each exercise that was included in the ACL injury prevention program.

Type of exercise	Exercise	Internal focus	External focus
Warm-up	Jogging Shuttle run Backwards running	Keep your hip, knees and ankles in a straight line. Bend your knees and hips.	Move your knees towards the fence. Run softly on the ground.
Strength	Walking lunges	Keep your upper body straight up. Hold your knee above your ankle.	Pretend like there is a plank in your back. Move your knees towards the fence.
	Squats	Move your buttocks backwards and your trunk forwards. Hold your knees above your ankles . Bend your hips and knees 90 degrees.	Pretend that you are going to sit on a chair. Pretend like you have to hold a ball between your knees.
	Split lunge	Keep your knee above your foot. Keep your upper body straight up. Bend your hip and knees while landing.	Move your knee towards the fence. Pretend like there is a plank in your back. Land softly on the ground.
	Squats with toe raise	Move your buttocks backwards and your trunk forwards. Hold your knees above your ankles . Bend your hips and knees 90 degrees.	Pretend that you are going to sit on a chair. Pretend like you have to hold a ball between your knees.
	Split lunge 45°	Keep your knee above your foot. Keep your upper body straight up. Bend your hip and knees while landing.	Move your knee towards the fence. Pretend like there is a plank in your back. Land softy on the ground.
	Single legged squats	Hold your knee above your ankle. Bend your hip and knee 90 degrees.	Move your knee towards the fence. Pretend that you are going to sit on a chair.
Agility	Serpentine run	Push with your forefoot while performing a slalom. Bend your knees and hips.	Push off softly on the ground during the slalom. Touch the cones every time.
	Modified shuttle run	Bend your knees and hips Take small, fast steps. Keep hip, knee and ankle in a straight line.	Bring your center of gravity close to the ground. Touch the ground as short as possible. Move your knee towards fence.
	Square drill	Push with your forefoot at turning points. Bend your knees and hips. Keep your knee in a straight line with your foot.	Push off softly on the ground at turning points. Touch the cones. Move your knee towards the fence.
	Nebraska drill	Bend your knees and hips. Push with your forefoot at turning points. Take small, fast steps.	Touch the cones. Push off softly on the ground at turning points. Touch the ground as short as possible.
	Illinois drill	Bend your knees and hips. Push with your forefoot at turning points. Take small, fast steps.	Touch the cones. Push off softly on the ground at turning points. Touch the ground as short as possible.
	T-drill 5-10-5	Bend your knees and hips. Push with your forefoot at turning points. Keep your knee in a straight line with your foot.	Touch the cones. Push off softly on the ground at turning points. Move your knee towards the fence.
Balance	Hold ball	Hold your knee above your ankle. Keep your weight on the ball of your foot.	Focus on the goal or fence. Focus on balancing the ball.

Appendix 1. Continued.

Type of exercise	Exercise	Internal focus	External focus
	Throw ball	Hold your knee above your ankle. Keep your weight on the ball of your foot.	Focus on catching the ball. Focus on the goal or fence.
	Test your partner	Hold your knee above your ankle. Keep your weight on the ball of your foot.	Don't let your partner push you off balance. Focus on the goal or fence.
Plyometrics	Lateral jumps	Bend your hips and knees while landing. Keep your knee above your foot while landing.	Land softly on the ground. Pretend like you have to hold a ball between your knees while landing.
	Forwards-backwards jumps	Bend your hips and knees while landing. Keep your knee above your foot while landing.	Land softly on the ground. Pretend like you have to hold a ball between your knees while landing.
	Vertical jumps	Extend your knees as fast as possible. Keep your knees above your foot while landing.	Push of against the ground as forcefully as possible. Pretend like you have to hold a ball between your knees.
	Bounding in place	Bend your knee and hip while landing. Hold your knee above your ankle during landing.	Land softly on the ground. Move your knee towards the fence.
	SLJ lateral	Bend your knee and hip while landing. Hold your knee above your ankle during landing.	Land softly on the ground. Move your knee towards the fence.
	SLJ forwards-backwards	Bend your knee and hip while landing. Hold your knee above your ankle during landing.	Land softly on the ground. Move your knee towards the fence.
	180°'s	Extend your knees as fast as possible. Bend your knee and hip while landing. Bend your knees and hips while landing.	Push of against the ground as forcefully as possible. Land softly on the ground. Pretend like you have to hold a ball between your knees.
	Tuck jumps	Extend your knees as fast as possible. Move your knees towards your chest. Bend your knees and hips while landing.	Push of against the ground as forcefully as possible. Reach your knees as high as you can. Land softly on the ground.
	45° lateral leaps	Bend your knee and hip while landing. Hold your knee above your ankle.	Land softly on the ground. Point with your knee towards the fence.
	Single leg forward jump	Bend your knee and hip while landing. Hold your knee above your ankle.	Land softly on the ground. Point with your knee towards the fence.
	Crossover hop	Bend your knee and hip while landing. Hold your knee above your ankle.	Land softly on the ground. Point with your knee towards the fence.
Trunk control	Bench	Keep your body in a straight line. Pull your stomach in.	Keep your body in a straight line. Pull your stomach in.
	Sideways bench	Keep your body in a straight line. Pull your stomach in.	Keep your body in a straight line. Pull your stomach in.
	Bridge	Keep your body in a straight line.	Keep your body in a straight line.
	Sit-ups	-	-
	V-sits	-	-
	Bicycle crunch	-	-
Speed-agility	Forward run + 3 step deceleration	Keep hip, knee and ankle in a straight line. Bend your knee and hip while landing. Take small, fast steps.	Move your knee towards the fence. Run softly on the ground. Touch the ground as short as possible.

Type of exercise	Exercise	Internal focus	External focus
	Bounding run	Keep hip, knee and ankle in a straight line. Extend your knee as fast as possible during offtake. Bend your knee and hip while landing.	Move your knee towards the fence. Push of against the ground as forcefully as possible. Run softly on the ground.

SLJ=single leg jump

Appendix 2.

Exercises performed per session (week 1-6): duration or number of repetitions

	Week		1		2		3		4		5		6
	Session	1	2	3	4	5	6	7	8	9	10	11	12
Warm-up	Jogging	30s	30s	30s	30s	30s	30s	30s	30s	30s	30s	30s	30s
	Shuttle run	30s	30s	30s	30s	30s	30s	30s	30s	30s	30s	30s	30s
	Backwards running	30s	30s	30s	30s	30s	30s	30s	30s	30s	30s	30s	30s
Agility	Serpentine run	2	2	3	3								
	Modified shuttle run					2	2	2	2				
	Square drill									2	2	3	3
	Nebraska drill												
	Illinois drill												
	T-drill												
Strength	Walking lunges	2x10		2x10		2x13		2x13					
	Split lunge									10s		2x10s	
	Split lunge 45°												
	Squats		2x8		2x8		2x10		2x10				
	Squats with toe raise										2x10		2x10
	Single legged squats												
Balance	Hold ball	2x20s	2x20s	2x30s	2x30s	2x30s	2x30s	2x30s	2x30s				
	Throw ball									2x30s	2x30s	2x30s	2x30s
	Test your partner												
Plyometrics	Lateral jumps	2x5		2x5	1x5		1x8	1x8	1x8				
	Forwards-backwards jumps		2x5		1x5	2x5	1x8	1x8	1x8				
	SLJ lateral									2x5		2x5	
	SLJ forwards-backwards										2x5		2x5
	Vertical jumps	2x5		3x5		3x5		3x5					
	Bounding in place		20s		20s		25s		25s				
	180°'s									2x5		2x5	
	Tuck jumps										10s		2x10s
	45° lateral leaps												
	Single leg forward jump												

Appendix 2. Continued.

	Week		1		2		3		4		5		6
	Session	1	2	3	4	5	6	7	8	9	10	11	12
	Crossover hop												
Trunk control	Bench	3x20s		3x20s	3x20s		3x20s	3x20s		3x25s	3x25s		3x25s
	Sideways bench		4x20s	4x20s		4x20s	4x20s		4x20s	4x25s		4x25s	4x25s
	Bridge	30	30		30	30		30	30		30	30	
	Sit-ups	20 St 15 Si			20 St 15 Si			20 St 15 Si			30 St 25 Si		
	Bicycle crunches		30s			30s			30s			30s	
	Jackknife sit-up			10			10			15			15
Speed agility	Forward run + 3 step deceleration	60s	60s	60s	60s	60s	60s	60s	60s	60s	60s	60s	60s
	Bounding run	2	2	2	2	2	2	2	2	2	2	2	2

St=straight sit-ups; si=sideways sit-ups

Exercises performed per session (week 7-12): duration or number of repetitions

	Week		7		8		9		10		11		12
	Session	13	14	15	16	17	18	19	20	21	22	23	24
Warm-up	Jogging	30s	30s	30s	30s	30s	30s	30s	30s	30s	30s	30s	30s
	Shuttle run	30s	30s	30s	30s	30s	30s	30s	30s	30s	30s	30s	30s
	Backwards running	30s	30s	30s	30s	30s	30s	30s	30s	30s	30s	30s	30s
Agility	Serpentine run												
	Modified shuttle run												
	Square drill												
	Nebraska drill	2	2	3	3								
	Illinois drill					3	3	4	4				
	T-drill									3	4	4	4
Strength	Walking lunges												
	Split lunge	2x10s		2x10s									
	Split lunge 45°					2x10s		2x10s		2x10s		2x10s	
	Squats												
	Squats with toe raise		2x12		2x12								

Appendix 2. Continued.

	Week		7		8		9		10		11		12
	Session	13	14	15	16	17	18	19	20	21	22	23	24
	Single legged squats						8x		8x		8x		8x
Balance	Hold ball												
	Throw ball	2x30s	2x30s	2x30s	2x30s								
	Test your partner					2x30s	2x30s	2x30s	2x30s	2x30s	2x30s	2x30s	2x30s
Plyometrics	Lateral jumps						2x5		2x5				
	Forwards-backwards jumps					2x5		2x5					
	SLJ lateral	5	5	7	7								
	SLJ forwards-backwards	5	5	7	7								
	Vertical jumps												
	Bounding in place												
	180°'s	2x5		3x5		3x5		3x5		4x5		4x5	
	Tuck jumps		2x10s		2x10s		20s		20s		20s		20s
	45° lateral leaps					2x5	2x5	2x5	2x5	3x5	3x5	3x5	3x5
	Single leg forward jump										5x3		5x3
	Crossover hop									6x3		6x3	
Trunk control	Bench	3x25s		3x25s	3x25s		3x30s	3x30s		3x30s	3x30s		3x30s
	Sideways bench		4x25s	4x25s		4x30s	4x30s		4x30s	4x30s		4x30s	4x30s
	Bridge	30	30		30	30		30	30		30	30	
		30 st			30 st			30 st			30 st		
	Sit-ups	30 si			30 si			30 si			30 si		
	Bicycle crunches		40s			40s			40s			40s	
	Jackknife sit-up			20			20			25			25
Speed agility	Forward run + 3 step deceleration	60s	60s	60s	60s	60s	60s	60s	60s	60s	60s	60s	60s
	Bounding run	2	2	2	2	2	2	2	2	2	2	2	2

St=straight sit-ups; si=sideways sit-ups