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Exercise program for prevention of groin pain in football players: a cluster-randomized trial

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Groin injuries cause major problems in sports and particularly in football. Exercise is effective in treating adductor-related groin pain, but no trials have been published regarding the specific prevention of groin pain or prevention specifically targeting overuse injuries in sport using exercise programs. We performed a cluster-randomized trial including 55 football clubs representing 1211 players. The clubs were randomized to an exercise program aimed at preventing groin injuries ($n = 27$) or to a control group training as usual ($n = 28$). The intervention program consisted of six exercises including strengthening (concentric and eccentric), coordination, and core stability exercises for the muscles related to the pelvis. Physiotherapists assigned to each club registered all groin injuries. Twenty-two clubs in each group completed the study, represented by 977 players. There was no significant effect of the intervention (HR = 0.69, 95% CI 0.40–1.19). The risk of a groin injury was reduced by 31%, but this reduction was not significant. A univariate analysis showed that having had a previous groin injury almost doubles the risk of developing a new groin injury and playing at a higher level almost triples the risk of developing a groin injury.

Groin pain in athletes is a major problem in sports medicine, and among football players it is a serious and very common injury, which may end the sports career. In a study of long-standing adductor-related groin pain, 72% of the athletes had ceased to participate in sport because of the groin pain (Hölmich et al., 1999).

The annual frequency of groin injuries is 8–18% in football (Hölmich, 1998; Ekstrand & Hilding, 1999) and 20% in ice hockey (Emery et al., 1999). Treatment of these injuries may take months and is costly both for the player and for the health service system. Prevention would be beneficial for the athletes as well as for the society.

Training as rehabilitation has been widely used for many years. In the past 10 years, using training with specific exercises as a treatment has been a rising issue in sports medicine as well as in the general treatment of musculo-skeletal overuse pain (Alfredson et al., 1998; Young et al., 2005; Slade et al., 2006). In a randomized trial, we have shown that a training program including strength training of the adductor, abdominal and low-back muscles, combined with coordination and balance exercises, was significantly better in treating long-standing adductor-related groin injuries in athletes than traditional "passive" physiotherapy (Hölmich et al., 1999). The training program resulted in return of 80% of the players to the previous level of sport without any groin pain (Hölmich et al., 1999). Based on our experiences with this training program, we have developed a new training program with the aim of preventing groin injuries in connection with football. The program comprises strength and coordination exercises focusing on the muscles related to the pelvis. It also includes core stability as well as eccentric exercises. The purpose of this cluster-randomized clinical trial was to investigate the effect of a specific training program aimed at preventing groin injuries in male football players. The effect of the program was evaluated by comparing an intervention group with a control group (CG) that received warmup and training as usual.

Material and methods

Study population

In cooperation with the Danish Football Federation (DBU), 120 football clubs from the Denmark, Copenhagen, and Zealand series and series 1–3 were invited to participate. The

clubs represented both urban as well as non-urban clubs. The football players were amateurs training and playing at a competitive level. The number of training sessions each week varied between 2 and 4; generally the higher the level, the more the training sessions. The coaches and managers of the eligible clubs were invited to a number of meetings, where detailed information was given regarding the trial. The Ethics Committee of Copenhagen and Frederiksberg Municipalities and The Danish Data Protection Agency approved the study (KF 01-171-97 and 1997-1200-271). All players and trainers gave written informed consent before entering the study. The trial is registered at ClinicalTrials.gov as NCT00226603.

Design

Randomization at the individual level could not be carried out, as we feared spillover to the controls. We therefore chose a cluster randomization design, where the football club was the unit of randomization. A physiotherapist was allocated to each club before randomization. The physiotherapist was in cooperation with the coach, responsible for collecting data and to report to the data manager. The randomization was carried out as cluster randomization, with each club being a cluster. Before randomization, the clubs were stratified according to level: (i) Denmark, Copenhagen, and Zealand series or (ii) series 1–3 and according to geography: (i) urban or (ii) non-urban. Because of the nature of the intervention, blinding of the participants and observers (physiotherapist and coach) was not possible.

Before the start of the 1997/1998 season, 78 clubs had accepted to participate in the trial, and they were randomized to the prevention group (PG) or the CG by block randomization (block size two). The randomization was computer generated. The individual physiotherapists and coaches were informed about the allocation of their club by a letter in a sealed and opaque envelope mailed by a secretary not involved in the analysis of the data. The data manager, the statistician, and the authors were all blinded to the result of the randomization.

The clubs and the players were invited to participate in the trial before the allocation, and both the players as well as the coaches gave written informed consent. Before initiating the trial, the physiotherapists were trained in the use of the questionnaire and in how to perform the intervention program correctly. The physiotherapists collected a self-administered questionnaire form from each included player providing information about the demographic data, type of work, football experience, playing position, participation in other sports, and previous groin injuries. The coaches and the players of the clubs allocated to the PG were instructed on how to perform the exercises by the physiotherapist. The questionnaires were given to the players before information of allocation. At the next visit, the physiotherapist collected the questionnaires and the instructions regarding the allocation were given. The season (from September 13, 1997 to July 5, 1998) included the 33 weeks of active playing and 9 weeks around Christmas with no training or matches. A number of circumstances, not related to the study, resulted in an unfortunate delay in reporting of the trial.

Intervention

The intervention program consisted of six exercises; four of those were also part of the previously described treatment program (Hölmich et al., 1999). Exercise no. 5 was specifically developed as an in-field partner exercise that should strengthen the adductor and abductor muscles of the femur both eccentrically and concentrically. The stretching exercise for the iliopsoas (no. 6) was included, as pain and tightness of this muscle in our clinical experience (Hölmich, 2007) is often a significant problem. For such a program to be implemented, it is our belief that it must be easy to perform without the need for additional equipment, fast to carry out, and adoptable within the regular football warmup.

The exercises were

1. Isometric adduction against a football placed between the feet when lying supine, the first toe pointed straight forward and pressure against the ball as hard as possible; each adduction 10 s, five repetitions (stimulating the adductor muscle group and the torso-to-pelvis stability).
2. Isometric adduction against a football placed between the knees when lying supine with flexed hips and knees and feet flat on the surface, the first toe pointed straight forward and pressure against the ball as hard as possible; each adduction 10 s, five repetitions (stimulating the adductor muscle group and the torso-to-pelvis stability).
3. Combined abdominal sit-up and hip flexion, starting from the supine position and with a football placed between the knees (“folding knife exercise”); two series of 20 repetitions performed rhythmically in a slow pace (stimulating the coordination of both eccentric as well as concentric work of the torso muscles and the hip- and pelvis-related muscles).
4. One-leg coordination exercise flexing and extending the knee and swinging the arms in the same rhythm (“cross-country skiing on one leg”); 1 min two times for each leg (stimulating the neuromuscular coordination utilizing the principles of core stability including the muscles of the torso as well as of the lower extremities).
5. Hip adduction against a partner’s hip abduction. In the sitting position, supported by the hands placed on the ground behind the trunk, one player places his straight leg with the feet and lower shin on the outside of his partner’s feet and lower shin. He adducts as the partner abducts eccentrically and slowly gets his feet pressed together. He then abducts concentrically as the partner adducts eccentrically and is slowly brought into abduction. They work like this for 1 min and then shift positions; two series of 1 min in both positions (stimulating concentric and eccentric strength of both the adductor and the abductor muscles).
6. Stretching of the iliopsoas muscle with a standardized technique; 20 s stretch for each leg repeated twice (securing the length of the iliopsoas muscle, given the common secondary involvement of the muscle).

The duration of the exercise program was approximately 13 min and the exercises were used as an integrated part of the warmup exercises before every regular football practice.

The experimental and CGs were warming up and training in the traditional way according to the standards of the coach education program of the DBU (http://www.dbu.dk). The coaches in all clubs registered the number of hours and sessions of training (including any intervention) and the number of matches. The registration was carried out at the team level. The physiotherapist also checked at random whether the intervention program was performed correctly. All injuries were reported to the physiotherapist, who attended the club at least every second week and at shorter intervals if needed because of injuries. The injury was assessed by the physiotherapist to determine whether it was a groin injury, and if so, it was recorded. When a player was recorded with a

groin injury, he was censored, i.e., no player could be recorded with more than one injury.

Injury definition

An injury was defined as any physical complaint that is the result of participating in football training or a football match incapacitating the player when playing football and/or demanding special medical attention for the player to be able to participate or preventing him from participating in training or a match. We later found this definition to be in concordance with the consensus statement by the Injury Consensus Group under the auspices of Federation Internationale de Football Association published in 2006 (Fuller et al., 2006).

Sample size

With an intracluster coefficient estimated to be 0.08 (Cornfield, 1978; Donner et al., 1981) and a cluster size of 20 players and a power of 80% and a significance level of 5%, we calculated that 80 clubs were needed to detect a reduction of 50% from 10% to 5% in the occurrence of a groin injury.

Outcome measure and statistical analysis

Double data entry was performed and the data management were unaware of the allocation.

The primary outcome measure was the time until the first groin injury. This is a rather complex response variable to analyze in the presence of clustering, because it is not normally distributed, and it may be censored. Therefore, the approach adopted here was to first investigate whether clustering of groin injuries at the club level was at all present, and then subsequently choose a proper analysis for the primary response variable, depending on whether the groin injuries cluster. An investigation of clustering was carried out at the aggregated club level in a Poisson model with the number of groin injuries within the club as the response variable, and the total number of weeks under risk, summed over players within club, as the offset variable. Thus, the expected number of groin injuries is assumed to be proportional to the total time under risk. The hypothesis of ''no within club correlation'' was then tested using the chi-square distributed deviance (McCullagh & Nelder, 1989).

If there was no within-club correlation at the club level, then the clustering may be disregarded in the analysis of the primary endpoint: time until first groin injury. Tests for marginal associations between each of the covariates and the time until groin injury were carried out using log-rank tests. Cox's proportional hazards model (Cox, 1972) was used for multiple regression analysis of time until groin injury, and likelihood ratio tests were used for hypothesis testing, including tests for interaction between covariates. The assumption of proportional hazards was investigated using the chi-square distributed test suggested by Grambsch and Therneau (1994). The significance level was 5% in all hypothesis testing. All analyses were carried out in the statistical package R (R Development Core Team, 2006).

Results

Of the 120 eligible football clubs, 78 clubs accepted to participate, but when the inclusion of players and the implementation of exercises had to begin, 23 clubs could not cope with the task and withdrew immediately without including any players: 12 clubs from the experimental and 11 clubs from the CG. During the trial, another 11 clubs withdrew: five from the experimental and six from the CG (Fig. 1). The reasons were too much work registering the injuries, bad results in the tournament, the coach did not want anything ''irrelevant'' to disturb the players, or change of coach during the trial period and the new coach did not want to participate. Forty-four clubs, 22 clubs in each group, completed the trial, represented by 977 players, of whom 907 presented with complete data. The baseline characteristics are shown in Table 1.

The analysis of the number of groin injuries at the club level reveals no within-club correlation ($\chi^2 = 35.46$, $df = 44 - 4 = 40$, $P = 0.67$, conditional on the three cluster-level covariates, and $\chi^2 = 45.83$, $df = 44 - 1 = 43$, and $P = 0.36$ for the unconditional analysis), i.e., the intraclass correlation equals zero. Therefore, the cluster sampling may be disregarded in the analysis of the primary response variable: time until first groin injury.

Results from the univariate analysis of each of the covariates on the 907 complete cases are shown in Table 2. There was no significant effect of the intervention (HR = 0.69, $P = 0.18$), although the estimate suggests a 31% smaller hazard in the intervention group compared with the CG. Kaplan–Meier estimates are shown for the two groups in Fig. 2.

Having had a previous groin injury almost doubles the hazard of developing a new groin injury (HR = 1.97, $P = 0.015$), and playing at a higher level almost triples the hazard of developing a groin injury (HR = 2.58, $P < 0.001$). There was no effect of the type of work ($P = 0.91$), age ($P = 0.50$), or the position played on the field ($P = 0.65$) of the player on the time until groin injury, and it did not matter whether the club was urban or non-urban ($P = 0.09$). The results from the same analysis carried out on the 977 available cases did show any relevant differences.

The results from the multiple regression analysis on the covariates including the 907 players with no missing information are shown in Table 3. Exactly the same variables were significant as in the univariate analyses: having had an injury previously and playing at a high level increase the hazard (HR = 1.95, $P = 0.017$ and HR = 2.56, $P < 0.001$), while neither the intervention nor the other covariates had a significant effect on the time until groin injury.

To investigate the fit of the model, tests for interaction between variables with a significant main effect on the outcome, time until groin injury, were carried out, and the assumption of proportional hazards was investigated using the test suggested by

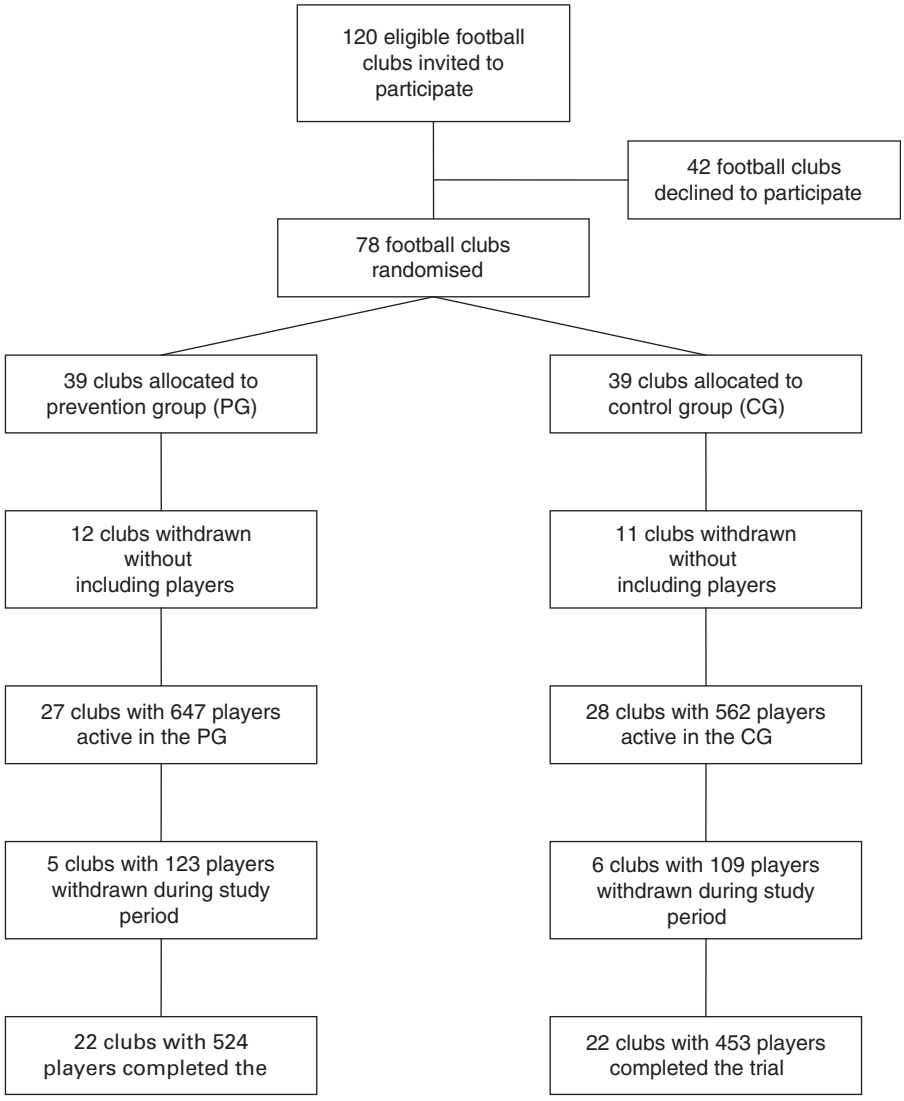

Fig. 1. Trial profile.

Grambsch and Therneau (1994) for the variables that showed a significant main effect on the outcome. None of the tests were significant.

Discussion

Prevention specifically targeting overuse injuries in sport using exercise programs has, to our knowledge, not yet been the subject of any published randomized clinical trial to date, nor have we been able to identify any randomized clinical trial aimed specifically at the prevention of groin injuries.

A number of studies have been published evaluating prevention programs for acute injuries as anterior cruciate ligament ruptures (Caraffa et al., 1996; Myklebust et al., 2003; Olsen et al., 2005) and ankle sprains (Wedderkopp et al., 2003; Verhagen et al., 2004; Olsen et al., 2005).

The 31% reduction in risk found in this study is not significant ($P = 0.18$). We based our sample size estimation on a relative risk reduction of 50% based on our experience with the treatment effect of a similar training program used for treating groin injuries (Hölmich et al., 1999). This may have been too optimistic. Second, we had anticipated that 10% of the football players in the CG would develop a groin injury. In fact, only 8% did so. Third, we experienced even larger difficulties with getting clubs to participate and remain in the trial than anticipated. These factors all increase our risk of type II errors, i.e., risk of overlooking a real intervention effect. The compliance of the players to perform the exercises with both the intended frequency and the intended intensity could also be a problem. We chose the best possible solution and had the coaches super-

Table 1. Baseline characteristics of 907 players presenting with a complete dataset

	Prevention group ($N = 477$)	Control group ($N = 430$)
Median age (years)	24.49	24.62
Previous groin injury		
Yes	183	203
No	294	207
Level of play		
High	108	130
Low	369	300
Location of club		
Urban	431	357
Non-urban	46	73
Physical work		
Not working	117	75
Not physically demanding	129	118
Slightly demanding	83	61
Demanding	99	100
Very demanding	49	76
Position on field		
Mixed	90	86
Goalkeeper	42	32
Defence	120	102
Midfield	157	152
Striker	68	58

Table 2. Log rank tests and maximum likelihood estimates from the univariate Cox regression analysis of the 907 complete cases

Variable	HR	95% confidence interval	*P* value
Intervention			0.18
No	1		
Yes	0.69	[0.40–1.19]	
Age			0.50
Per additional year	0.98	[0.92–1.04]	
Previous groin injury			0.015
No	1		
Yes	1.97	[1.13–3.42]	
Level of play			<0.001
Low	1		
High	2.58	[1.49–4.46]	
Location of club			0.09
Urban	1		
Non-urban	1.80	[0.90–3.60]	
Physical work			0.91
Not working	1		
Not physically demanding	0.89	[0.38–2.05]	
Slightly demanding	1.28	[0.53–3.07]	
Demanding	1.21	[0.53–2.78]	
Very demanding	1.07	[0.41–2.80]	
Position on field			0.65
Mixed	1		
Goalkeeper	0.68	[0.22–2.07]	
Defence	0.85	[0.41–1.79]	
Midfield	0.63	[0.30–1.33]	
Striker	0.52	[0.19–1.47]	

vise and register the participation in the prevention program. A trial including a much lager sample size, as we originally intended, is needed to definitely test the beneficial and harmful effects of our preventive training program. With the number of players who completed this study, no significant effect of the prevention program could be shown. The 31% reduction of the risk of developing a groin injury would, however, if significant, be a considerable advantage that would make it worthwhile for the football players to complete the program.

The strength of this study is that the randomization was computer generated and that the allocation was unknown to the data manager, the statistician, and the authors, thus preventing allocation bias. The registration and examination techniques used were systematic and uniform in order to prevent registration bias. This is the first study to evaluate prevention strategies aimed at groin injuries in athletes. The limitations of this study were that a large number of eligible clubs did not participate and that a number of clubs that were randomized exited the study but without including players. However, no sign of allocation bias was found when comparing the baseline characteristics. A risk of assessment bias because the registration of the injuries was not blinded due to the nature of the intervention and the practical circumstances. Missing data in some cases could lead to attrition bias but no sign of this was found when comparing the full data with the complete data. A drawback of this trial is the extraordinarily long-reporting time, which was due to a high number of competing tasks.

Twenty-three clubs withdrew before including players. This was a matter of clubs agreeing to participate, but when faced with the start of the tournament they could not cope with the task. Because this group was evenly distributed between the two allocations, we do not find this alarming from a trial quality point of view but very unfortunate from a sample size point of view. The dropout after entering the study with players was 11/55 clubs (20%) and 232/1209 players (19%) without difference between the two groups.

The risk of sustaining a groin injury is almost doubled if the player had a previous groin injury. This is in concordance with the results of previous studies on other injuries in sports (Arnason et al., 2004; Petersen & Holmich, 2005; Hagglund et al., 2006).

Playing football at the highest level (Denmark, Zealand, and Copenhagen series) compared with the other levels included in this study almost tripled the risk of a groin injury. This is the first time it is shown that the risk of sustaining a groin injury increases with the competition level. This is probably not the result of more training hours but may be the result of a higher intensity in the training and match play. In studies examining hamstring injuries, the risk of sustaining an injury increases with the age of the athlete (Petersen & Holmich, 2005). This is not the

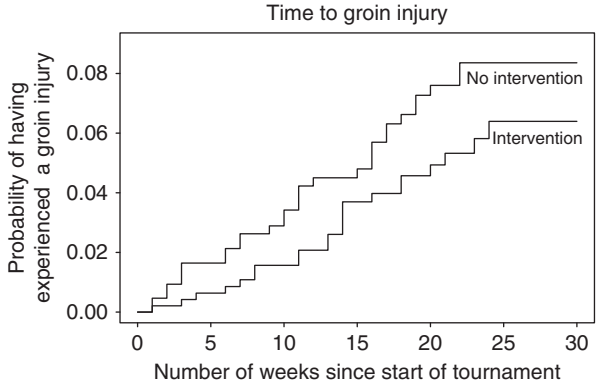

Fig. 2. Time to groin injury.

Table 3. Likelihood ratio tests and maximum likelihood estimates from the multiple Cox regression analysis on the 907 complete cases

Variable	HR	95% confidence interval	*P* value
Intervention			0.44
No	1		
Yes	0.80	[0.46–1.40]	
Age			0.59
Per additional year	0.98	[0.92–1.05]	
Previous groin injury			0.017
No	1		
Yes	1.95	[1.12–3.40]	
Level of play			<0.001
Low	1		
High	2.56	[1.48–4.42]	
Location of club			0.50
Urban	1		
Non-urban	0.75	[0.33–1.72]	
Physical work			0.85
Not working	1		
Not physically demanding	0.80	[0.35–1.85]	
Slightly demanding	1.16	[0.53–2.78]	
Demanding	1.24	[0.54–2.82]	
Very demanding	0.99	[0.38–2.61]	
Position on field			0.56
Mixed	1		
Goalkeeper	0.71	[0.23–2.19]	
Defence	0.90	[0.43–1.89]	
Midfield	0.60	[0.29–1.26]	
Striker	0.52	[0.19–1.46]	

The tests and parameter estimates for the statistically significant variables are provided in a model with those variables only. The test and parameter estimates for statistically insignificant variables are corrected for the effect of the significant variables.

case in the present study. There is no evident explanation to this, but it could be speculated that the injuries are of a different nature (hamstring injuries are primarily acute muscle strains whereas groin injuries are primarily overuse injuries) and as such caused by different etiologies not necessarily influenced by age.

The present study is the result of an analysis of risk factors and incidence. According to previously described guidelines for the prevention of injuries (van Mechelen et al., 1992), we have identified the incidence and risk factors of groin injuries from the available literature, we have aimed at developing a program that is likely to reduce the risk of groin injury, and we have evaluated this in a randomized clinical trial. Likewise, a study on acute knee and ankle injuries in youth team handball (Olsen et al., 2005) has shown a preventive effect of a general program including warm-up, technique, balance, and strengthening exercises. The program was the result of an analysis of the known risk factors focusing on control of the knees and ankles during pivoting and landing movements. A preventive program utilizing exercises would probably not have effect from the first day, as the idea is to strengthen certain physical abilities and thereby prevent injuries. This will take some time, but it is not known how much. We started data collection at the same time as the program was initialized and as can be seen in Fig. 2, it took a couple of weeks before a difference between the two curves became apparent.

The adductor-, iliopsoas-, and inguinal-related groin injuries are the most common causes of groin pain in athletes (Hölmich et al., 2003; Hölmich, 2007), and strengthening the related muscles could potentially be beneficial to avoid injury. Strength has been indicated as a possible risk factor for adductor-related injuries in a study of ice hockey players (Tyler et al., 2001). The present study utilizes the idea that the exercises of a treatment program (Hölmich et al., 1999) can potentially serve as the basis for preventing that same injury (Wedderkopp et al., 2003; Verhagen et al., 2004). The preventive program tested is derived from that treatment program and includes concentric as well as eccentric strengthening and coordination exercises for the muscles related to the pelvis, with special emphasis on the adductor and abductor muscles.

Groin pain may be the result of a number of causes, the majority of them being related to muscles and tendons, and often more than one cause can be identified. A large and important list of differential diagnosis should be kept in mind by anyone involved in the medical handling of these athletes. Groin pain primarily related to hip joint disorders such as femoro-acetabular impingement (FAI), arthritis, labral lesions, and others might not benefit directly from a program like the one tested in our study.

Another possible risk factor is the flexibility of the adductor muscles, but neither a study of football (Witvrouw et al., 2003) nor a study of ice hockey (Emery & Meeuwisse, 2001) could show any influence of adductor flexibility on the incidence of adductor-related groin injuries.

Eccentric exercises have been emphasized as being of major value in the treatment of tendon-related overuse injuries (Fyfe & Stanish, 1992; Alfredson

et al., 1998; Young et al., 2005). The exercises used in the present study include eccentric strengthening in exercises number 3, 4, and especially 5,and the eccentric exercises were also utilized in the original treatment protocol for adductor-related groin pain (Hölmich et al., 1999). The explanation for the beneficial effect of eccentric exercises on tendon-related problems is not clear (Fyfe & Stanish, 1992; Rees et al., 2006).

Core stability (core strengthening) is another modality that has developed in the last 10 years into an important element in the exercise treatment of musculo-skeletal problems. Core stability is defined as the ability to control the position and motion of the trunk over the pelvis to allow optimum production, transfer, and control of force and motion to the terminal segment in integrated athletic activities (Akuthota & Nadler, 2004; Kibler et al., 2006). The exercises utilized in the original treatment study as well as in the prevention program of the present study includes this principle, and especially exercises number 3 and 4 stimulate the core stability both regarding the lumbar spine and the pelvis, as the trunk position must be stabilized to perform the exercises correctly.

The present cluster-randomized clinical trial addressed a very common overuse injury using football players as the target group. A simple program based on experience and the available literature including strength (concentric and eccentric), balance, and core-stability exercises was used. The risk of sustaining a groin injury was decreased by 31%, but this reduction was not significant. The risk of sustaining a groin injury was significantly increased when the athlete had been groin injured previously. Playing at a higher level also increased the risk significantly.

Perspectives

Overuse injuries are a major problem in society at large and in sports specifically. The increasing awareness of physical activity used as both treatment and prevention of a large number of medical diseases such as hypertension, diabetes, overweight, and others (Andersen, 2007; Church et al., 2007) has substantially increased the problem of overuse injuries, as a large number of new ''athletes'' with little or no experience are taking up sport. This underlines the need for prevention studies in order to avoid an epidemic of athletic overuse injuries interfering with the aim to prevent and treat lifestyle diseases. Groin injuries continuously constitute a major overuse problem. Further studies into prevention of groin injuries are warranted. However, as this field is still developing and new diagnose are emerging (FAI as an example), the design of the ''next'' study should be adequately adapted to this. The size of the study is also an important and very demanding subject. Perhaps more specific subgroups of groin injuries should be targeted.

Key words: cluster-randomized trial, football, groin injury, overuse injury, prevention.

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