

Physical performance tests – a relationship of risk factors for muscle injuries in elite level male football players

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The purpose of the present study was to investigate whether there is a relationship between the outcome of preseason physical performance tests and the risk of sustaining lower extremity muscle injuries within the same season, in male football players at elite level. This is a cohort study of a male football team (63 players) from the first league in Sweden. The football players are prospectively followed, in terms of muscle injuries of the lower extremity during five seasons between 2010 and 2014. All muscle injuries were evaluated and diagnosed with ultrasonography. The following physical performance tests were included: squats, chin-ups, YoYo intermittent recovery level 2, counter movement jump, squat jump, standing long jump, sprint, one leg squat test, and a

functional movement screen. A total of 86 muscle injuries occurred during the study period. No significant correlation was found between the results of the physical performance tests and muscle injuries of the lower extremity. None of the evaluated tests predicted the risk of sustaining muscle injuries of the lower extremity. We conclude that muscle injury risk factors are more complex than solely related to the results of the preseason physical performance tests.


Keywords: Functional tests, Football-related exercises, Injury screening, Male athletes, Soccer

INTRODUCTION

Muscle injuries of the lower extremity are frequent in male football players at the elite level and a common focus in football-related sports medicine research (Hägglund et al., 2013). Muscle injuries, such as strains, ruptures, or contusions can include both the muscle and its tendon. More than 30% of the total number of football-related injuries consists of lower extremity muscle injuries (Ekstrand et al., 2011; Stubbe et al., 2015; Witvrouw et al., 2003). Most of these muscle injuries are not due to physical contact, but to running or kicking, which means that they could be prevented, at least to some extent (Ekstrand et al., 2011; Petersen et al., 2010). The number of muscle injuries in a football team at the national level has been reported to be 15 muscle injuries per season and team (Ekstrand et al., 2011). Ekstrand et al. (2011) also reported that 37 missed matches per season and team are due to muscle injuries of the lower extremity

and that 92% of the muscle injuries in football occur in the major muscle groups of the lower extremities: the hamstrings being involved in 37%, the adductors in 23%, the quadriceps in 19%, and the calf muscles in 13% of the cases. In addition, several other authors have reported hamstrings to be the most common injured muscle group of the lower extremity in male football players (Ekstrand et al., 2011; Noya Salces et al., 2014; Witvrouw et al., 2003).

The physical demands on a football player are complex, which may explain the high number of injuries in elite football (Noya Salces et al., 2014). Age, height, previous injuries, preferred kicking leg, impaired range of motion, muscle strength, and endurance as well as poor running performance, player position, years of playing, and foul play have been suggested to be injury risk factors (Bengtsson et al., 2013; Ekstrand et al., 2011; Hägglund et al., 2013; Haxhiu et al., 2015; McCall et al., 2014; Stubbe et al., 2015; Svensson et al., 2016; van Dyk et al., 2016). Match-related

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injuries increase throughout the season, while injuries related to training are more common during the preseason and decrease during the match-season (Noya Salces et al., 2014).

Football is an effective health promoting activity for all people, but it can also be a risk for a variety of injuries (Krustrup et al., 2009). In football, preseason physical performance tests are common in order to detect players at risk for injuries. Recently, the benefits of fitness tests for football players at a group level have been questioned (Bahr, 2016; Carling and Collins, 2014; Mendez-Villanueva and Buchheit, 2013). If it were possible to identify and screen for individual injury risk factors at preseason, it could be of significant value for implementing preventive strategies, which would lead to decreased injuries and avoid rehabilitation.

Therefore, the main purpose of the present study was to investigate whether there is a relationship between the outcome of the preseason physical performance tests and the risk of sustaining lower extremity muscle injuries within the same season in male football players at elite level.

MATERIALS AND METHODS

Definitions of injury

The study design followed the consensus according to the international guidelines for studies in football medicine (Fuller et al., 2006). These guidelines define an injury as a physical complaint leading to the player not being able to fully participate in football, during training and/or match. The present study used time-loss injury in order to define a muscle injury. The injuries are divided into different categories, based on their severity. Hence, football injuries are also divided into injury groups, resulting in slight (0 day), minimal (1 to 3 days), mild (4 to 7 days), moderate (8 to 28 days), severe (> 28 days), and career-ending injuries (Fuller et al., 2006).

Subjects

The present study is a clinical cohort study based on data prospectively collected from a Swedish elite male football team (first league) during five seasons (2010–2014). Based on the inclusion criteria, the study included 151 players. Out of these, 14 players did not carry out any physical performance tests and 137 players had at least been tested on one occasion immediately before the season. Of these 137 players, a total of 63 players between 16 and 36-year-old sustained one or more muscle injuries of the lower extremity during the study period (2010–2014).

All players have given their informed consent to participate in

the present investigation, and the study was conducted in accordance with the Declaration of Helsinki for Human studies. The present study was approved by the Regional Ethics Committee at Linköping University, Sweden (Dnr 2010/365-31).

Inclusion criteria

The inclusion criteria were participation in the team roster at the start of the match season for at least one of the years 2010–2014 and having sustained at least one muscle injury of the lower extremity. In addition, the muscle injuries had to be diagnosed by ultrasonography (Fig. 1). Each injury was counted separately, regardless of the number of muscle injuries that an individual player had sustained. At preseason, age, height, body constitution, playing position, and dominant/non-dominant leg were identified.

Preseason physical performance tests

Physical performance tests evaluating the muscle strength of the lower and upper extremity, leg muscle power, aerobic and anaerobic fitness, speed and acceleration, jumping ability, and different functional movements were used. These tests were chosen based on their importance for a football player (Bangsbo et al., 2008; Paul and Nassis, 2015; Wisløff et al., 2004).

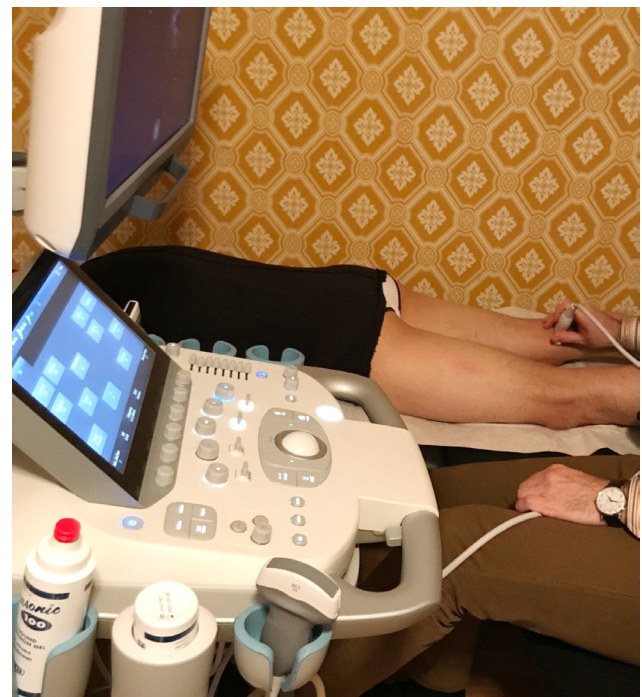


Fig. 1. Ultrasound examination with the ultrasound equipment (MyLab 70 Xvision, Esaote SpA, Florence, Italy).

Muscle strength

Muscle strength test of the lower extremity consisted of a squat test and measured as one repetition maximum. The test was performed using a loaded free barbell (Eleiko Sport AB, Halmstad, Sweden). The muscle test of the upper extremity consisted of chin-ups, by performing as many repetitions as possible without rest (Paul and Nassis, 2015; Wisløff et al., 2004).

Muscle power

Muscle power was tested by performing a one-leg squat. This test was performed in a Smith Machine (Smith Machine Atlantis E-154/E-155, Quebec, Canada) that was connected to power recorders (MuscleLab 4010/4020, Ergotest Innovation AS, Porsgrunn, Norway), measuring the power produced by each leg (Paul and Nassis, 2015; Wisløff et al., 2004).

Aerobic and anaerobic fitness

Aerobic and anaerobic fitness were evaluated with the YoYo intermittent recovery level 2 test (Bangsbo sport ApS, Slangerup, Denmark). X number of players performed the YoYo intermittent recovery level 2 test (YoYo IR2). The scores were recorded in meters at the level and number of shuttles immediately before the beep, upon which they were eliminated (Bangsbo et al., 2008; Krstrup et al., 2006).

Speed and acceleration

Speed and acceleration were evaluated with sprints over 30 m, with fractional times per 10, 20, and 30 m (between 2010 and 2013), and per 5, 10, and 20 m during 2014. The total time and fractional times were identified and measured with photo sensors (MuscleLab 4010/4020, Ergotest Innovation AS) (Paul and Nassis, 2015).

Jumping ability

Jumping ability was tested using three different jumps: two vertical and one horizontal. All jump tests were carried out three times, and the best trial was recorded. A digital jump meter with photo sensors (MuscleLab 4010/4020, Ergotest Innovation AS) was used for the vertical jumps, and a measuring tape was used for the horizontal jumps. The two vertical jumps consisted of a squat jump, carried out with the hands placed on the hips and performing an explosive jump. The counter movement jump is a vertical jump with a dynamic start and with free arm positioning (Paul and Nassis, 2015).

Functional movement screen

The functional movement screen (FMS) included six different functional movements per side: left and right. The FMS was rated 0–3, where 0 equals pain, 1 represented if the player was not able to perform the required movement pattern, 2 indicated that the player could perform the movement but with some kind of compensation, and 3 represented the player's ability to perform the movement as described (Minick et al., 2010).

Injury registration

Time of exposure to football (training and match) was continuously recorded by the medical team throughout the entire seasons by the "National Swedish Injury Register," according to guidelines recommended by the Union of European Football Association (UEFA) and Fédération Internationale de Football Association (Fuller et al., 2006; Häggglund et al., 2005). Throughout each season, the medical team also recorded football-related muscle injuries of the lower extremity. Whenever a player sustained an acute muscle injury during a training or a match, he was referred to a specific radiologist for ultrasound examination. The same radiologist performed all of the ultrasound examinations. This information was then incorporated in the medical records.

Statistical analysis

Data are presented using standard descriptive statistics, such as mean, standard deviation, and frequency. To receive sufficient statistical power, the injured players were combined over the five seasons and evaluated as one group (one unit). Pearson chi-square test was used to calculate the relationship between the categorical variables, e.g., the relationships between muscle injury and the player's position during football, training as well as match. One-way analysis of variance for possible differences between the multiple groups in a continuous variable, e.g., type of muscle injury and time loss from a regular match, i.e., continuous variable, was used. Tukey honest significant difference test for controlling the multiple testing was also used. Because of the skewed distributions, the results of the physical performance tests between the injured and the noninjured players were analyzed with nonparametric Mann–Whitney *U*-test. The results of the FMS test and the one-leg squat, which were approximately normally distributed, however, were analyzed with an ANOVA for repeated measurements (dominant vs. nondominant leg). The level of significance was set at $P < 0.05$, (two-tailed). All data and analysis were processed by using IBM SPSS Statistics ver. 22.0 (IBM Co., Armonk, NY, USA).

RESULTS

The injury incidence during the five seasons (2010–2014) was found to be, on average, 6.0 muscle injuries/1,000 hr of exposure (range, 5.4–6.8).

The results showed a total of 86 muscle injuries altogether in 37 players during the study period of five seasons. This equals an average of 17.2 muscle injuries per season, and an average of 0.6 muscle injuries per player and season. In the present study, the average injured player was 25 years of age, with an average time loss of 18.5 days per muscle injury (range, 2–89 days).

Totally, 96.5% of the lower extremity muscle injuries were found in the four major muscle groups: the hamstrings (36%), the adductors (31.4%), the quadriceps (19.8%), and the calf muscles (9.3%) (Table 1). The injury severity and distribution within each muscle group are shown in Table 2. Noncontact traumatic injuries were found in 84.9% of all muscle injuries of the lower extremity. The defenders were the most injured football players (Table 1). Forty injuries occurred in the left leg and 46 in the right leg (Table 1). No correlations were found, in terms of muscle injuries in the dominant and the nondominant leg.

The size of the team ranged between 28 and 33 players over the

Table 1. Location of muscle injuries in the lower extremities in an elite male football team (n=86)

Variable	Age (yr)			P-value
	16–18	19–25	> 25	
Muscle group				0.180
Calf muscles	0 (0)	6 (12)	2 (6)	
Hamstrings	0 (0)	19 (38)	12 (38)	
Quadriceps	3 (75)	10 (20)	4 (12)	
Adductors	1 (25)	14 (28)	12 (38)	
Other muscles	0 (0)	1 (2)	2 (6)	
Position of injured player				0.146
Goalkeeper	1 (25)	7 (14)	1 (3)	
Defender	1 (25)	18 (36)	20 (63)	
Midfielder	2 (50)	13 (26)	6 (19)	
Forward	0 (0)	12 (24)	5 (16)	
Side of injury				0.162
Left	2 (50)	24 (48)	14 (44)	
Right	2 (50)	26 (52)	18 (56)	
Type of injury				0.124
Overuse	0 (0)	20 (40)	15 (47)	
Noncontact traumatic injury	2 (50)	21 (42)	15 (47)	
Contact traumatic injury	2 (50)	9 (18)	2 (6)	
Total	4 (5)	50 (58)	32 (37)	

Values are presented as number of injuries (%).

studied period. The distribution of the muscle injuries to the lower extremity, when it comes to the playing position during the studied years are shown in Table 3.

No significant injury predictors could be found based on the preseason physical performance tests ($P = 0.448$). Physical performance tests carried out from 2010 to 2014 for the not injured and injured players are presented in Table 4.

DISCUSSION

The main finding of the present study was that there were no significant correlations between the results of the physical performance at preseason and the muscle injuries occurring during the studied seasons.

The mean time loss per muscle injury and the average number of injuries per player and season are similar to the earlier findings by Ekstrand et al. (2011). Furthermore, the distribution between the muscle groups is almost equal to earlier reports in larger studies (Häggglund et al., 2013; Noya Salces et al., 2014).

In line with earlier publications about football-related injuries, hamstring injuries were the most common muscle injury to the lower extremity (Bradley and Portas, 2007; Hawkins and Fuller, 1999; Noya Salces et al., 2014). In the present investigation, hamstring injuries represented more than one-third of all muscle injuries of the lower extremity. In the present study, more than

Table 2. Number of days away from active playing, dependent on injured muscle groups of the lower extremities in an elite male football team

Muscle group	Days				Total
	1–3	4–7	8–28	>28	
Calf muscles	2	1	2	3	8
Hamstrings	1	4	19	7	31
Quadriceps	4	3	7	3	17
Adductors	2	5	19	1	27
Other muscles	0	1	1	1	3
Total	9 (10)	14 (16)	48 (56)	15 (17)	86 (100)

Table 3. Number of lower extremity muscle injuries, based on player position from 2010 to 2014 in an elite male football team

Player position	2010	2011	2012	2013	2014	Total, n (%)
Goalkeeper	3	1	0	1	4	9 (10)
Defender	6	8	10	5	10	39 (45)
Midfielder	5	2	2	5	7	21 (24)
Striker	3	2	8	1	3	17 (20)
Total	17	13	20	12	24	86 (100)

Chi-square = 9.69, $df = 12$, $P = 0.643$.

Table 4. Physical performance tests carried out from 2010 to 2014 for not injured and injured players

Variable	Not injured		Injured		P-value
	No.	Mean±SD	No.	Mean±SD	
FMS, total-score, and dominant leg	34	13.9±2.92	30	14.8±1.51	0.210
YoYo, intermittent recovery test, and length in meter ^a	42	953.0±174.0	33	959.0±206.0	0.891
One-leg in Smith, dominant leg, and percent of total power	15	46.7±12.9	13	46.1±13.9	0.926
One-leg in Smith, nondominant leg, and percent of total power	15	46.6±12.9	13	46.1±13.9	0.712
Strength	32	10.2±5.9	27	9.07±4.46	0.411
Vitality and static	37	0.41±0.05	33	0.4±0.09	0.981
Vitality and dynamic start	37	0.47±0.10	33	0.48±0.11	0.532
Acceleration/speed 20 m (sec)	37	2.71±0.82	33	2.56±0.95	0.052
Standing jump (m)	24	2.50±0.54	22	2.65±0.13	0.152

SD, standard deviation; FMS, functional movement screen.

^aAnalyzed with Student *t*-test. All the rest are analyzed with the Mann–Whitney test.

80% of the muscle injuries were classified as noncontact injuries, which is in agreement with earlier publications (Ekstrand et al., 2011; Hawkins et al., 2001).

It has been suggested that FMS could be a good injury predictor if the total score is below 14 (out of 21) (Kiesel et al., 2007). In the present study, no correlation could be found between injury risk and the scoring of FMS. Moreover, it should be pointed out that the evidence level of the FMS tests has been questioned in recent research (McCall et al., 2014; McCall et al., 2015).

It has been reported that match injuries in football often occur at the end of each half. One of the theories is that a lower aerobic capacity might increase the injury risk due to fatigue (Ekstrand et al., 2011; Hawkins and Fuller, 1999). Therefore, the YoYo IR2 may be an adequate evaluation instrument, since a higher test score correlates with further running meters in match play (Bangsbo et al., 2008; Krstrup et al., 2003; Krstrup et al., 2006). However, if a player with a higher YoYo IR2 test score tends to run more than a player with a lower score, it might indicate that the YoYo IR2 test is not sensitive enough to predict injury risk. Furthermore, it has been questioned whether low aerobic capacity is an actual injury risk or if the player adapts to his actual aerobic capacity level and runs less in match play and training compared to a player in a better physical condition (McCall et al., 2015).

Some of the tests, such as FMS, have previously been found to correlate with injury risk (Kiesel et al., 2007), while some other tests are mainly used for their correlation to performance on the football field (Krstrup et al., 2006; Wisløff et al., 2004). Considering the high number of muscle injuries that are due to noncontact situations and the high incidence of reinjuries, a preseason screening of physical performance could be suggested in order to

try to prevent or at least reduce the occurrence of muscle injuries.

A limitation of the present study is that a muscle injury has been regarded as one case, regardless of the number of injuries sustained to one individual football player. If injured players were also regarded as one case, we might have identified factors that make the player more injury prone. Some individuals tend to sustain more muscle injuries during the season compared to others. Fuller et al. (2006) state that a study population normally should consist of more than one team. However, instead of a higher number of teams, we have prospectively followed one team very closely during a period of five seasons.

One of the strengths of the present study is that the team has had the same physiotherapist supervising and guiding the players when performing the preseason tests as well as treating the injured players throughout all five studied seasons. This guarantees that the players have gone through the same classification procedures when injured and followed an equal rehabilitation regime. All injuries have been examined and diagnosed with ultrasonography, which may explain the slightly higher muscle injury incidence per season compared to the study by Ekstrand et al. (2011), where ultrasonography was not used.

Based on the results and the limitation of the present study, future research in terms of preseason performance tests should be carried out. Are the tests merely for performance monitoring or should the tests also function as a screen for injury risks? Future studies including both physical and psychological parameters need to be performed with a broader and more complex spectrum of tests, focusing on identifying possible risk factors for muscle injuries.

In conclusion, the present study shows that muscle injury risk factors are more complex than solely related to the results of the

preseason physical performance tests. Further research focusing on physical performance tests tailored for elite male football players is needed to identify possible predictors, in order to prevent muscle injuries and further rehabilitation.

CONFLICT OF INTEREST

No potential conflict of interest relevant to this article was reported.

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