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The Relationship among Flexibility, Aerobic Fitness, Leg Extension Power and Agility with Lower Extremity Injuries in Footballers

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Abstract. Eagerness to soccer has been increased considerably during the last decade. The increasing popularity of this sport has increased the probability of injuries. The risk of being injured in professional football is very high. The purpose of this study was to consider the relation among flexibility, muscle power, agility and aerobic fitness with lower extremity injury rates, and to quantify and determine the nature, and sites of injuries in soccer players. 60 male players who participated in the Iranian professional league were studied prospectively in a non-randomized controlled trial over football semi-seasons. Data were recorded by each team's athletic trainer on forms provided by the investigators. Physical fitness was assessed by sit-and-reach test, Sargent vertical jump test, and Astrand step test in the beginning of the survey. The data were statistically analyzed using a chi-square analysis to determine whether any of the factors had a relation to the incidence of injury. Statistical significance was noted by a P level of less than 0.05. Totally, 101 injuries were recorded. Bruising (30.7%) and sprains (20.8%) were the major injury types, the leg and ankle only being the site of 43.2% of the injuries reported. The results of this study showed a significant relationship between flexibility and agility with muscle cramp. Furthermore, this relation between flexibility and sprains was significant. Nevertheless, there was no significant relation between other physical fitness components and other injuries. More injuries occurred to the dominant leg. Professional football players are exposed to a high risk of injury and there is a need to investigate ways of reducing this risk. In this study, the number of lower extremity cramp and strain injuries was significantly fewer in player with increased flexibility. Flexibility and agility should be improved in football players by regular preseason programs.

Keywords: flexibility, aerobic fitness, leg extension power, agility, sprain, cramp, strain, contusion

1. Introduction

Eagerness to football is increased during last decades. Football is one of the most favorable and common sports in the world and almost 240 million people from two genders, and various age groups play football. 200 thousand people hold matches professionally (Olsen et al, 2004). Football is also a growing sport and only in recent years. Footballers have increased from 11.4 percent to 21.8 percent out of all athletes (American Academy of Pediatrics, 2000).

Football requires physical contact throughout tackling or contesting possession of the ball with competitors and this unavoidably leads to injury. A majority of injuries is inadvertent, resulting from an error on the part of the player concerned or by another player. The error may lead to an accident and some of these accidents lead to injury (Reilly, 2003). Unfortunately, the rate of injuries is increased by the increase of popularity of football. Although it seems that the rate of injuries in football is due to the high number of players, but recent researches show that the rate of increased injuries in football is more than increasing rate of football players (Larson et al, 1996). Many researchers have considered injuries in football but the results are not comparable because of incompatible descriptions of injuries, research method, data collection, work period, and research subjects. Nevertheless, the result of researches shows that football is one of the four sports with the highest incidence of injury (Junge et al, 2004).

Numerous researches are done to consider risk factors in football. The result of researches showed that two groups of factors affect hard injuries besides the behavior of players: 1) Internal factors such as the age of players, previous injury, insufficient rehabilitation after injury, joint instability, bad posture, deformity, be

skill less, the mental state of the player, the level of fitness and the existence of predisposing factors such as muscle weakness. 2) External factors such as the intense exercise during matches, overtraining, quality of exercises, state of the pitch, the weather conditions, inappropriate choice of footwear, inattention to warm up, the condition of playing field, equipments and violation of playing laws (Chomiak et al, 2000).

Most of the injuries in football are because of trauma, but the shin guard is the only mandatory support shield in football (Arnason et al, 1996). The majority of injuries to soccer players are soft tissue (tendon and muscle) and joint trauma. These occur predominantly in the lower limbs; the joints most frequently affected are the knee and ankle (Reilly, 2003). The rate of overuse injuries is about 9 to 34 percent of all injuries. Most of the injuries in football occur in lower limb (Chomiak et al, 2000 and Junge et al, 2004). Each game provides a reference in that it can be considered as exposing 22 players to injury over 90 minutes (Reilly, 2003).

In order to avoid such these injuries, warm up by stretching exercises, strength training, nutrition, protective equipment, appropriate conditions of playground, and following existing rules by the players has been discussed(Maghami et al, 2006). However, these finding are contrariety somehow. Another three disadvantages of these researches is that most of them are done according to laboratory tests or try to recognize revocable risk factors (Gabbe et al, 2005 and Witvrouw et al, 2003) and other risk factors such as warming up methods and nervous movement are either not studied completely or are considered by weak plans (Gabbe et al, 2005).

One of the factors to avoid football injuries is physical readiness of players. Some of the researchers believe that lack of physical readiness is a predisposing factor to occur injuries. Some researchers reported that insufficient physical fitness is the reason of one fifth of injuries in sports. They concluded that besides serious injuries, lack of appropriate physical readiness is one of the main reasons to occur chronic injuries. Commonly, all believe that a strong and flexible body can avoid injuries to a great extent. Some research on non-athletes showed that cardio-respiratory fitness and antagonist muscle strength are risk factors for injury (Hootman et al, 2001). On the other hand, physical readiness has several components which it seems that the contribution of each one to reduce the risk of injuries is different. Furthermore, the post of a player can be very important on the occurrence of injury.

The cost of recovering injured people is high. It is also possible professional players leave sport fields forever because of injuries. This problem certifies the necessity to create solutions to minimize these injuries. This research intends to consider the relation of some physical readiness component such as flexibility, aerobic fitness, leg extension power and agility with various injuries (sprain, cramp, strain and contusion) in lower limbs of professional footballers and also to describe the rate of each injury based on several posts of players.

2. Method

2.1. Subject

The subjects of this research include 60 footballers with four years playing history that was nonrandom selected among footballers of Champions League. Nine of them were goalie. 18 were defenders. 21 were halfbacks and 12 were forwards. Six of them were left-footed. 47 were right-footed and 7 could play with both feet. Before performing the research, a questionnaire including health information of players was completed and their consent forms were signed. They understood the targets of research and method of test in an explanation meeting. The subjects were studied during a half-season.

2.2. Assessment of physical readiness

Some of the physical readiness component which was related to injuries was assessed by some field tests. These indicators include flexibility, aerobic fitness, leg extension power and agility. To assess these indicators, a form including registered results of physical fitness tests and personal information of subjects were prepared. All tests were done by a single tester and in similar situations for all subjects. Sit-and-reach test while sitting was the test to measure flexibility. The test assessed flexibility of hamstring and back muscles. The subject sat against a wall with straight knees and pulled his hands forward and toward a box that was located with 30 cm height against his legs. He stayed in this situation for 3 second after getting the most amount of stretching. The distance between source point and tip of the fingers was registered as the record of each subject. Astrand step test was done to assess cardio-breathing readiness. The test has the maximum currency of 0.75 and value of 0.92. After warming up, the subject went up and down from a bench

with 40 cm height and with 22.5 rpm harmony that was controlled by a metronome. The heart rate of the athletes was counted immediately after the test, and his cardio-breathing readiness was measured based on the Astrand standard table. 4×9 running test was done to assess agility. For this purpose, first the desired distance was measured by tape, then using AAPHERD method (AAPHERD, 1997) tests performed. Finally, lower body muscular power using the Sargent vertical jump test was evaluated. The test instructions AAPHERD and graded by the board on the wall for all subjects were equal (AAPHERD, 1997). Total degrees of physical fitness and grades of all tests were considered and categorized in three groups of strong, medium and weak according to the range of scores.

2.3. Measuring injuries

All injuries, including dislocation, sprain, cramp, strain and contusion, fracture and muscle soreness was reported and registered during a half-season. In this order, one of the researchers participated directly in exercises and matches and categorized all injuries beside medical practitioners. The report included injured limb, type of injury, reason of injury, etc.

2.4. Statistical Analysis

Injury, exposure, post of players, protective equipment, type of injury, injured limb and physical readiness component and other baseline assessment data were coded and double entered on a personal computer. Chi-square test and Yates correction (2×2 tables, df=1) was used for analyzing of the hypothesis. Statistical significance was set at the $P<0.05$ level. These statistical analyses were performed with SPSS software (SPSS 11.5, SPSS).

3. Results

Descriptive data of results show that 45 percent of subjects used ankle bandage, 100 percent used shin guard and 40 percent used muscle shorts. Only 2 injuries of meniscus were reported which included 12.5 percent of all injuries of knee. 4 injuries were occurred in genital organs that were not protected by equipments. 6.7 percent of people have hard injuries including one fracture of sole bone, two hard knee injuries and one severe sprain of ankle. The most injuries were on thigh (31.3%) including strain and cramp. Leg had 22.5% of all injuries of lower limbs injuries including contusion (31.9%) and cramp (31.9%). Ankle with 20.7% of injuries including sprain (45%) and contusion (35%) was on third degree. 11.3 percent of injuries occurred on knees with most common contusion (72.7%). 6% of injuries occurred in hamstring. The least injuries with 1 % were toes fracture. Totally 80.6 percent of injuries occurred on right side of body and 19.4 percent occurred on left side.

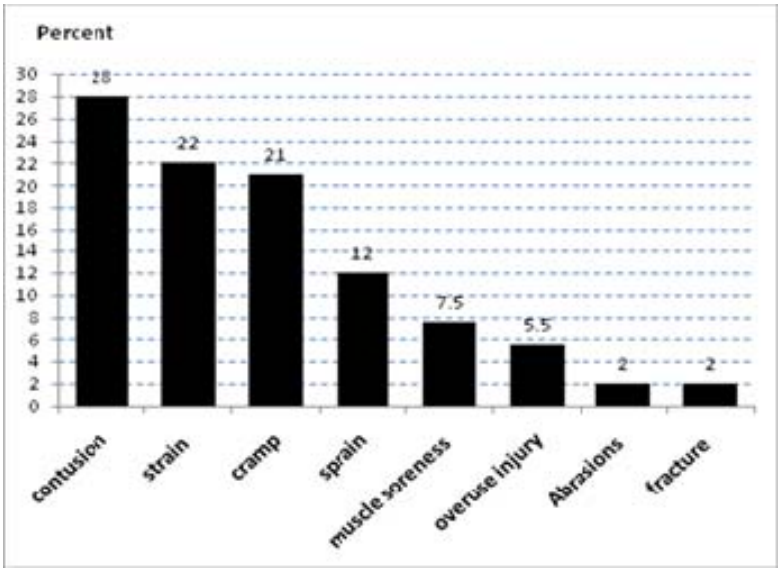

Fig 1. Exposure the kind of injures on lower extremity

As the chart 1, the most common injuries on lower limbs include contusion. This injury is more common among defenders and halfbacks. Thereafter strain, cramp and sprain were more common. Cramp among forwards and sprain and sprain among goalkeepers were more usual. Abrasions and fracture include 2

percent of injuries.

Distribution of injuries based on post of players show that halfbacks had 35.7% of injuries, defenders had 26.7% of injuries, forwards had 21.8% of injuries and goalkeepers had 15.8% of injuries.

Table 1: The situation of physical fitness of subjects in each indicator

component / group	flexibility		agility		leg extension power		Aerobic fitness	
	Frequency	Percent	Frequency	Percent	Frequency	Percent	Frequency	percent
Strong	23	38	20	33.33	18	30	4	6
Medium	19	32	20	33.33	22	37	28	47
Weak	18	30	20	33.33	20	33	28	47

Table 1 shows the component of physical readiness that categorized base on ranking. As it is shown the number of people in all components are approximately equal instead of aerobic fitness.

Table 2: The percentage of injuries for each physical fitness component category

Fitness component / Injuries	flexibility			agility			leg extension power			Aerobic fitness		
	Strong	Medium	Weak	Strong	Medium	Weak	Strong	Medium	Weak	Strong	Medium	Weak
strain	19	23.8	57.2	38.1	28.6	33.3	28.6	42.8	28.6	19	28.6	52.4
cramp	10	60	30	10	30	60	20	40	40	15	35	50
contusion	14.2	42.9	42.9	28.6	14.2	57.2	28.6	14.2	57.2	14.2	42.9	42.9
sprain	36.3	36.3	27.4	27.5	54.5	18	36.5	54.5	9	18	36.5	45.5

The results of table 2 showed that the exposure of strain, cramp and contusion is more in people with less flexibility but sprain is vice versa. More nimble players had less muscles cramp and contusion but sprain and strain were vice versa. Cramp and contusion were more in players with less power but sprain was vice versa. Strain was equal between players with strong and weak power. Increasing aerobic fitness decreases all injuries. Weak players in aerobic fitness had more injuries, although the number of players in strong group had a high percent of injured too.

As it seems in table 3, there is a significant relation among flexibility and injuries of strain and cramp but this relation is not significant with sprain and contusion. The relation between agility and cramp was significant too, but the relation among agility and contusion, sprain and strain was significant. At last there was no significant relation among aerobic fitness and leg extension power with any injuries.

Table 3: The relation between muscular injuries and physical fitness indicators

component / Injury	Indicator	Flexibility	Agility	Leg extension power	Aerobic fitness
Strain	Chi-square	11.699	0.440	0.579	0.144
	P value	0.003*	0.803	0.748	0.704
	df	2	2	2	1
Cramp	Chi-square	13.888	11.4	1.491	0.008
	P value	0.001*	0.003*	0.475	0.927
	df	2	2	2	1
Contusion	Chi-square	0.123	0.991	0.991	0.000
	P value	0.726	0.320	0.320	1.00
	df	1	1	1	1
sprain	Chi-square	0.141	2.894	3.731	0.000
	P value	0.932	0.235	0.155	1.00
	df	2	2	2	1

* Significant at $P \leq 0.05$

4. Discussion

Although a few research reported the effect of preventing programs on exposure of injury in soccer, the existence scientific literature about these programs is a reason of their fruitfulness. Coach, medical team, and players can play a role to avoid injuries in football. However, some effective factors on injuries do not change by themselves such as age and climate. The physical readiness factors can be paid attention directly

by regular programs to reduce the risk of injuries. Recognition of the best program to improve power, flexibility and aerobic fitness and agility is a guarantee to reduce the risk of injury.

The findings of this research showed that there is a significant relation among flexibility with strain and cramp, but this relation was not significant for sprain and contusion. In case of agility this relation was significant with cramp, but there was no significant relation between the agility and other kind of injuries. At last there was no significant relation among aerobic fitness and muscular power with all kinds of injury.

The results of table 2 showed that the exposure of strain, contusion and cramp is more in fewer flexible players. Agile players had fewer cramps. This means that the more physical fitness less risk of injuries. These achievements are important, especially about strain because of long term treatment and recovery. Improving flexibility reduces cost and time of treatment and the risk to lose key players.

The result of many researches indicates a reversed relation between injuries and physical fitness in players. Although only some of these researches are done for footballers, but it seems that this relation in all sports has the similar mechanism.

One of the mechanisms to reduce the risk of injury by improvement of physical fitness is to reduce fatigue. Some researchers believe that fatigue is the most common reason of sport injuries. In fact, fatigue decreases strength and power and increases injuries. Fatigue in football, that is a long time sport activity, depends on many factors such as carbohydrates and physical fitness, especially endurance of athletes. Giza and colleagues showed that physical readiness and body situation of a player before the beginning of the league can reduce injuries generally. They indicate that the reason of fewer injuries in professional players is due to the high level of physical fitness to participate in competitions, which give them more power and flexibility before the season. In fact, improvement of power and aerobic fitness reduces fatigue in player and reduces also the risk of injury (Giza et al, 2005). On the other hand, most of the researches explain that cold-down is an important factor to avoid injuries, especially muscle soreness, but many players avoid doing it. Maghami et al reported that fatigue is the main reason to avoid player to make cold-down after competitions (Maghami et al, 2006). So it can be concluded that high level of physical fitness can reduce fatigue of exercise and reduce the risk of injuries indirectly. Researchers show that contusions on soft tissue of the body are the most common non-dangerous injury in football. In this research, there is no significant relation between aerobic function and sport injuries. Among four players in the strong group, three players had crampe, and all of them had the strain of muscles. This finding rejects the results of previous researches, which believed in a relation between high aerobic fitness and fewer injuries. Similarly, Hootman et al reported a significant relation between high level of aerobic fitness as a risk factor and injuries in recreational athletes (Hootman et al, 2001). This finding may be explained that the amount of physical activities during exercise is uncontrolled in this study and other reports too. So the players with higher level of aerobic fitness are more at risk of injury because of more activities and conflictions. On the other hand, participation of an injured player (as a main or reserved player), participation time in competitions, psychological factors and the volume of exercises are not controlled. Colbert and colleagues concluded that in a classic response pattern to increasing the volume of exercises, the risk of injuries increased to attach the time of running daily in runners (Colbert et al, 2000). Probably, the results of researches, which consider aerobic fitness as a risk factor, have not controlled the amount of player activity in exercise and game. Hootman and colleagues suggest that other factors such as the anatomical and biomechanical problems and mood state may effect in this regard (Hootman et al, 2001). The relation between fatigue and injuries cannot be rejected.

Similar reasons can be revealed for the relation of power and injuries with aerobic fitness. The results of much research show that intense resistance training increases the strength of tendons and decreases the risk of injury during intensive contraction (Junge et al, 2004). Some researchers reported that polymeric and resistance training can be avoiding anterior cruciate ligament (ACL) injury (Impellizzeri et al, 2008). Maghami and colleagues reported in their research that almost all players of the Iranian champion league have strength training at least one time per week and about 95 percent of them believed that strong muscles are important to avoid injuries (Maghami et al, 2006). Olsen and colleagues reported that the strength training affected the reduced injuries on ACL in male footballers (Olsen et al, 2004). However, some research reveals reversed findings, which can be due to excessive strength training. Bovens and colleagues showed that among people who had intensive exercise, there is a significant relation between the amount of exercises and injuries of lower limbs (Bovens et al, 1989). Professional players try to empower themselves by polymeric and strength training before and during the league. This training is also able to injure players, so it is required to have an appropriate and accurate program for each player. Wolfson and colleagues indicate that a powerful neuromuscular system can set the body with acute pressures and stand against

injuries better. They suggested that using moderate exercise (Wolfson et al, 1995).

On the other hand, half of injuries occurs in those parts of the body which have been injured before. This means that players do not recover completely after injuries. Another probability says that the parts of the body which are injured to their power and stability. So retaining the power and joint stability can avoid injuries of muscles and connective tissue. Although Lehnhard and colleagues in long time research concluded that regarding other factors, it cannot be stated that exercises can avoid injuries, they reported a seven percent reduction in injuries after long term regular resistance training (Lehnhard et al, 1996). It should be mentioned that increase of general strength of the body is not assistant, but the strength of muscles must be increased in skills, which are involved in soccer. Even some researchers believe that strengthening antagonist muscles is a risk factor for injury (Yamamoto et al, 1993; Bennell et al, 1998). By the way, we need more study to find the relation between power and injury prevention in footballers. Another scope should be to find the best training program (Olsen et al, 2004).

This research reports that there is a significant relation between flexibility and injuries of lower limbs. This relation was not significant about sprain and contusion because these two injuries occur by trauma and twisting forces resulting in movement on the abnormal range of motion. Strain directly related to intensive contraction and fatigue and flexibility, which are due to elastic property of muscles. However, contusion and sprain are more affected by physiological characteristics of muscles and stability of joints and are less affected by flexibility. In addition, the effects of excessive range of motion on a sprain via instability of joint are important. These two injuries are done by trauma, which is an external risk factor.

Maghami and colleagues reported that about one third of footballers believe that players with less flexibility are being injured more than players with high flexibility. They believe that flexibility is an important factor to reduce strain, sprain and other injuries (Maghami et al, 2006). Moreover, the antagonist muscle's flexibility is a new approach for research. For example, a mechanism under which increase flexibility of quadriceps muscle avoids to hamstringing muscle injuries is unclear but maybe explains by changes of running or walking mechanisms (Gabbe et al, 2005). So it can be concluded that flexibility decrease the Probability of some kind of soccer injury.

There is a significant relation between agility and cramp. However, agility is not considered as an independent predictive factor until now. Several factors are affected agility such as power, speed, reaction time, neuromuscular coordination, and balance. 4×9 running test is used to assess agility in this research. Reduction in cramp in more agile players can be explained by more physical fitness of them.

In this study contusion, strain, cramp and sprain are the most common injuries, and fracture had the least exposure. This means that most of the injuries occur by trauma. Football is a contact sport, and trauma is unavoidable. According to researches, physical fitness has the light role in injuries, which are occurred by trauma. So this research did not consider the relation between contusion and physical fitness.

The results of tests on players in different posts show that halfbacks are more injured by 35.7%. Then defenders (26.7%), forwards (21.8%) and goalkeepers (15.8%) are on next positions. This research upholds the results of Hunt and Fulford about halfbacks and defenders (Hunt and Fulford, 1990). Ball is possessed more by halfbacks, and they have more conflict and running. After contusion, cramp and strain are more injuries in halfbacks. So it is necessary that halfbacks improve their flexibility and agility.

The results of this research confirm the relation between some kind of injury and physical fitness component but also several factors are important in this regard. This research has not controlled many factors such as history of injury, psychological factors, age, the condition of the playing field, skill level of players, climate and, etc. Controlling these factors may change these relations, so future researches should pay more attention to these factors.

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