The Functional Movement Screening Tool Does Not Predict Injury In Football

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ABSTRACT

Background: The Functional Movement Screen (FMS) is used to predict individuals at heightened risk of injury within sports such as American Football. However, the relationship between the FMS and injury within football (a.k.a. soccer) has yet to be quantified. The current literature does not allude to whether the FMS has a role in predicting injury within this sport specific group. **Objective:** To evaluate the association between the 7 FMS tasks and the incidence of non-contact injury amongst football players from a professional English football club over one season. **Methods:** 135 footballers between the ages of 8 and 21 years from one professional football club's academy were used. Players performed the FMS and then were observed throughout the study period to record and establish injury incidence in rates per 1000 training and match hours. **Results:** The deep squat (p=0.0128) and trunk stability push-up (p=0.0621) were significant predictors of non-contact injury. Players with a trunk stability push up score of 3 had a statistically significant lower risk of injury than those with a score of 1. There was a similar trend for players with a trunk stability push up score of 2, but this was not statistically significant. Total FMS score was not statistically significantly related to injury. **Conclusion:** There appears to be only statistically significant associations between 2 of the 7 FMS components and non-contact injury incidence within youth players from one professional football clubs' academy. Further investigations need to be conducted to see whether these results reflect the academy football population within the English academy programme.

INTRODUCTION

Football has a high incidence of injuries that require medical treatment and leads to time loss from training and competition [1, 2]. Injury has large financial implications for clubs in lost wages, increased insurance premiums and the associated medical costs [3]. These financial implications extend further if key players are unavailable to play, potentially reducing match attendance and prize money from cup competitions or poor league position [3]. More specifically at academy level, preventing injury is fundamental in ensuring the health and wellbeing of the players is maintained. Although there is a cost associated with injuries sustained within an academy setting, safeguarding the players to protect their welfare is paramount. In extreme cases, injury may affect a player's ability to pursue a career within the game. Therefore, the need to prevent time loss injuries at an academy level is an important role of the club's medical department.

Epidemiological research in English football has shown that professional footballers experience an average of 1.3 injuries per player per season [1]. Of all the injuries sustained, 38% were the result of contact mechanisms and 58% of non-contact mechanisms [1]. More recently, a 7 year European study found teams suffered an average of 2.0 injuries per player per season, which equates to an injury incidence of 8.0 injuries/1,000 training and match hours [4]. Injury incidence for English youth academy footballers was initially indicated to be lower, with data indicating teams to suffer 0.40 injuries per player per season [2]. However, much of the available data is over 14 years old and based upon an old academy model. Comprehensive data from a more recent 6 year study based within the English Premier League indicated

players to sustain 2.23 injuries per player per 1000 hours of total exposure [5].

Contact based injuries result from uncontrollable extrinsic factors, e.g. a tackle, and are thus unpredictable. Conversely, non-contact injuries, such as low back pain or injuries due to running, are theoretically predictable but their occurrence may be multi-factorial; for instance, such an injury may result from muscle imbalances, gender, baseline fitness levels, past history, activity and even ethnicity [6, 7]. More recently published literature support a growing consensus view that movement patterns and efficiency are a significant contributing factor [8]. The research implies that adopting less efficient and effective compensatory movement patterns predisposes an athlete to injury [9].

First developed by Gray Cook and Lee Burton, the FMS attempts to break down individual's movement patterns to highlight inefficiencies and deficiencies that may contribute to injury or poor performance [8, 10]. Using the FMS as an injury prediction tool therefore, provides health professionals with an opportunity to implement preventative measures aimed at reducing injury occurrence [10]. There are 7 tasks that constitute the FMS which are said to be basic movements that occur during many sporting activities [11]. Each task is scored from 0 to 3, with 3 constituting normal and efficient movement, creating a final score out of 21. To be completed successfully, the tasks demand a variety of attributes including strength, flexibility, range of movement (ROM), co-ordination, balance and proprioception [8]. Individuals with these attributes demonstrate a balance of stability, mobility and motor control, which is postulated to protect the body from injury [12].

There has been a large emphasis on movement screening following the Premier Leagues overhaul of the academy system within England. The recent implementation of the Elite Player Performance Plan (EPPP) includes a stipulation for clubs to conduct movement screening of players [13]. However, the evidence base that assesses the application of the FMS in determining injury risk within individuals specifically from football is limited.

Data from previously published literature based within American Football has demonstrated player's with a lower FMS score to have a greater risk of injury. Players with a score of 14 or less had an eleven-fold increase in the risk of injury when followed over a season within the National Football League (NFL) [8]. Other authors supported the use of the FMS within injury prediction but to a much lesser extent. Stating that individuals with a score less than 14 being associated with a one-fold [14], two-fold [15], four-fold [6] and eight-fold [16] increase in the risk of injury. Again, the populations used within these studies were not specific to football and varied from fire-fighters to female collegiate athletes.

There is limited evidence surrounding the FMS system in highlighting those individuals at heightened risk of injury within football. Evidence centres on American football or non-sports-persons without providing statistically significant results representative of the academy football community. This study is the first to be conducted upon a population of academy football players and helps to establish a more comprehensive analysis of the FMS system in football and its relationship with injury. Previous studies conducted have investigated the relationship between the FMS and performance in football [17]. Such evidence significantly correlates FMA to athletic performance. However, there is a body of evidence that contradicts these findings, albeit on a non-football population [18].

The aim of the study was to establish whether an association existed between the 7 FMS tasks and the incidence of non-contact injury amongst academy players from one professional English football club over one season. The null-hypothesis was that there would be no association between FMS scores and incidence of non-contact injury.

METHODS

A prospective cohort study of professional academy footballers during the 2012/2013 season (3rd September 2012 and 10th May 2013). All signed players (n=140) from one professional football academy (aged 8-21 years) were invited to participate. Players were excluded if they were injured at the start of the season, left the club during the season, or opted out of the study (n=20). Players were assessed performing the FMS at the beginning of the season by the lead strength and conditioning coach using the FMS' assessment criteria [12].

An injury was defined as "Any physical complaint sustained by a player that resulted from a football match or football training, irrespective of the need for medical attention or time loss from football activities. An injury that results in a player receiving medical attention is referred to as a 'medical attention' injury". This is in line with the consensus statement on injury definitions in studies of football injuries [19]. Contact injuries and illnesses were excluded because of their unpredictable nature when compared to non-contact mechanisms of injury.

Players were categorised in to the Foundation, Youth or Professional phase in relation to the EPPP academy programme. The Foundation phase consists of players from the under 9 – 12 age groups (8 to 12 year olds). The Youth Development phase consists of players from the under 13 to 16 age groups (12 to 16 year olds). Finally, the Professional Development phase consists of players from the under 18 to 21 age groups (16 to 21 year olds). Age groups were determined by the player's age as of the 31st August.

Individual player exposure (training and match hours) were collected through club records, recorded by the academy coaching staff and logged upon the Premier Leagues online

Player Management Application (PMA) [20]. Training exposure was defined as "team based and individual physical activities under the control or guidance of the team's coaching or fitness staff that are aimed at maintaining or improving players' football skills or physical condition" [19]. Match exposure was defined as "play between teams from different clubs" [19]. Time off play due to injury was also recorded. The injury incidence in rates per 1000 training and match hours were calculated.

Players had to be registered with the football club before the start of the study. Players joining the club after the beginning of the study were not included to avoid skewed results. Informed consent was obtained via an 'opt out' policy where player's data were automatically entered into the study, as it was purely observational. Also, players had to be fully fit prior to the start of the study so that the cohort shared similar baseline characteristics.

Statistical Analyses: The characteristics (age, height, weight, FMS score) of the cohort were reported, as was injury status (number and type of injuries, dichotomised into contact and non-contact injuries). Total exposure (match and training hours) were summarised. Incidence of injury per 1000 player hours was calculated. Injury in rates per 1000 training and match hours were calculated as the number of cases, multiplied by 1000, divided by the total exposure in hours. A logistic regression model was utilised (outcome: non-contact injury status yes/no) to investigate the relationship with individual FMS score and age. A paired comparison of means post hoc power calculation with standard assumptions of 80% power and $\alpha = 0.05$ was conducted to determine whether the study was sufficiently powered. All statistical analyses were undertaken in SAS® 9.3. The study was approved by the University of Nottingham Faculty of Medicine and Health ethics committee (Ref: E11042013 SCS)

RESULTS

One hundred and forty players were invited to participate in the study (n=140). Five were excluded due to injury at the start of the season; 15 were withdrawn from the study due to leaving the club (whether on loan or end of contract).

A paired comparison of means post hoc power calculation with standard assumptions of 80% power and $\alpha = 0.05$ determined that sufficient participants were included in this study to determine a difference of 0.6 in total FMS score. When the individual components of the FMS score are considered, shoulder mobility had the highest variance, but the study includes enough participants, has sufficient power to determine a difference of 0.2 points (range 0-3 points). This advocates that the study is sufficiently powered.

The mean age of the cohort was 13.6 years (range 8 to 20); the mean height was 178.4 cm (range 130.4 to 186.1) and weight was 55.3 kg (range 27.3 to 96.9) (see Table 2). The data were positively skewed, i.e. more younger, taller, heavier players.

The mean total FMS score was 12.1 (range 8 to 17, SD = 2.3). The 7 component scores of the FMS varied, with the active straight leg raise score having the highest mean and the Inline Lunge the lowest mean (see Table 1).

Table 1. Ummary of FMS scores (0-3)

FMS Task	Mean
Deep Squat	1.63
Hurdle Step	1.73
In-Line Lunge	1.53
Shoulder Mobility	1.71
Active Straight Leg Raise	2.03
Trunk Stability Push-up	1.83
Rotary Stability	1.64

There were 133 total injuries during the season, affecting 54 players. Players who were injured during the season were slightly older (p=0.678), shorter (p=0.435) and heavier (p=0.335) than the non-injured players (see Table 2). 72 injuries (54%) occurred during training activities, 46 (35%) during match play, and 15 (11%) were the result of other reasons, for example, developmental groin pathology. The most common injury was to muscle (41.4%) followed by contusions (20.3%) and ligament injuries (15%) (see Table 3).

The total time loss due to injury was 2923 days (mean 22 days per injury). There were 1870 days (64%) lost as a result of 86 non-contact injuries, whilst 1053 days (36%) were the result of 47 contact based injuries.

Table 2. Summary of cohort characteristics, stratified by injury status (any injury).

Injury Status	Age (years)	Height (cm)	Body mass (kg)
Non-contact Injury (*n*=54)	13.7 ± 2.85	167.2 ± 16.87	57.0 ± 16.32
Not Injured (*n*=66)	13.4 ± 3.63	187.6 ± 209.97	53.9 ± 18.71
Overall (*n*=120)	13.6 ± 3.29	178.4 ± 155.92	55.3 ± 17.67

Table 3. Summary of injury type.

Type of Injury	Total Number	Non-Contact
Fracture	4	0
Other bony injury	4	4
Haematoma/contusion/bruise	27	1
Muscle injury	55	55
Tendon injury	6	6
Dislocation/Subluxation	1	0
Sprain/Ligament Injury	20	18
Meniscus/Cartilage Lesion	1	0
Overuse	12	0

Total exposure was 25397.3 hours (mean exposure was 211.6 hours per player). There was an average of 237.3 training hours each, with wide variation (range 4 to 479.7 hours; SD = 144.17 hours). Similarly, there was an average of 19.7 match hours per player; range 2.9 to 50.2; SD = 9.4 hours). There was little difference in exposure between those players injured or not (mean total exposure was 211 hours for injured players and 213 hours for uninjured players, p=0.930).

Incidence of non-contact injury was 3.4 injuries per 1000 player hours [86 / 25397.3 x 1000]; and contact injury was 1.9 [47 / 25397.3 x 1000]; Incidence of all injury was 5.2 injuries per 1000 player hours [133 / 25397.3 x 1000].

Fifty four of one hundred and twenty players experienced a non-contact injury during the season. The logistic regression model comparing the individual components of the FMS score and age (youth, foundation or professional), showed that there is a significant difference between level 2 and level 1 in deep squat (p=0.0128) with its upper 95% confidence limit for odds ratio just touching one while the 95% confidence interval of odds ratio for trunk stability push up does not include unity when level 3 and 1 are compared in predicting outcome (i.e. non-contact injury, see Figure 1). Similarly, youth and professional players had a higher risk of injury (2.5x and 1.8x respectively) than foundation players (p>0.05). The ROC area under the curve was 0.7346, suggesting a good model fit. The logistic regression model comparing individuals total FMS score and outcome was not significant in the presence or absence of age. Therefore, total FMS score was not statistically significant in predicting outcome.

DISCUSSION

Statistically significant interactions were found between 2 of the 7 FMS tasks and noncontact injury incidence within youth academy footballers. There was a statistically significant interaction between the deep squat and non-contact injury incidence (p=0.0128). This may be because of its relationship with neuromuscular control and kinetic chain mechanics. Muscles do not work in isolation and are required to work together in order to produce movement

[21]. This multi muscle pattern of recruitment within the posterior chain requires high level neuromuscular control in order to be performed effectively. If there is an absence of co-ordinated firing patterns within the muscular chain then abnormal demands are placed on structures. If these abnormal loads or compensations exceed the normal biomechanical and structural role of the tissue, resulting in injury [22]. An example of this association between neuromuscular control and injury would be how altered neuromuscular firing within the posterior chain (e.g. reduced gluteal activation) would place higher demands on the hamstrings leading to a predisposition to injury [23]. This is because the hamstrings are required to work harder in order to achieve a required movement.
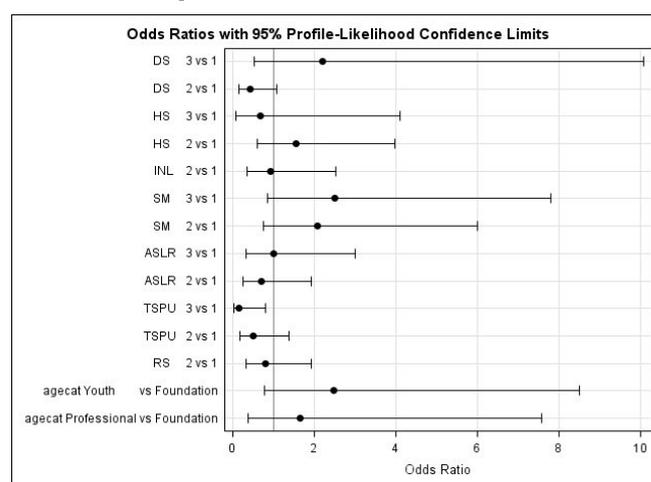
Figure 1. Odds ratios for individual FMS score and non-contact injury status

In addition, the squat also requires sufficient anterior core stability, which is documented to protect from injury [24]. The multi-joint movement also requires a combination of triple flexion and extension, which challenges individual's mobility [11]. Sufficient thoracic, hip and ankle mobility is all needed simultaneously in order to achieve a higher FMS score. The combination of stability achieved by synchronised neuromuscular firing patterns and multijoint mobility may be a reason as to why an association is present. It is important to note that the other FMS tasks consist of a strong neuromuscular element, especially the hurdle step and in-line lunge. However, it appears that the deep squat is superior to these in relation to injury.

Criticism of the deep squat may stem from it being a bilateral exercise [25]. Mechanisms of injury rarely result from player's having two feet on the ground (apart from some jumping/contact mechanisms), which questions the football specific nature of the deep squat. Alternatives, such as some single leg screening measures e.g. single leg squat may be more specific to the game of football and may show enhanced associations with injury. Further studies would need to be implemented to compare the two and establish whether the deep squat is inferior when compared to single leg alternatives.

A statistically significant interaction was also found between the trunk stability push-up and non-contact injury incidence as those individuals who scored a 3 had a statistically significant lower risk of injury than those with a score of 1 (p=0.0621). Scores on the remaining individual FMS tasks seem to be unrelated to injury.

The trunk stability push up assesses an individual's core stability and may be associated with injury because of the relationship between core stability and kinetic chain mechanics [8]. An individual's core is strongly documented to be associated with movement efficiency [26]. Therefore, altered core stability may elicit dysfunction within the kinetic chain. This dysfunction is thought to contribute toward compensatory movement patterns that exceed structures normal physical and structural capabilities, leading to such structures breaking down.

Screening procedures need to be efficient and succinct as time may be limited within the elite sporting environment. In this current study only 2 of the FMS tasks have a statistically significant role in predicting injury. Exclusion of the remaining 5 tests would allow for more useful tests to be added to a medical department's injury screen. It is important to note that these results are only applicable to injury prevention. Other authors have indicated the FMS to have a role in predicting performance, but that would be the subject of a separate study. There is existing research that illustrates a strong correlation between the FMS and performance within football [17]. However, there is conflicting evidence within alternative populations [18]. Therefore, as this pilot study shows, if the FMS has no relationship with injury or athletic performance, particularly within football, then there may be no justification for its implementation clinically due to its lack of external validity.

To date, there have been no comparable studies conducted that assesses the ability of the FMS to determine injury risk within academy footballers. In a smaller cohort of 46 National Football League (NFL) players, an FMS score of 14 or less prior to the start of a season had an eleven-fold increase in the risk of injury [8]. However, the injury definition used within the study did not enable comprehensive analysis, future studies should be based upon a definition that includes any injury leading to a time loss from training or competitive play.

Analysis within this study indicated that player's scoring 14 or less had a one-fold increase in the risk of injury, compared to those scoring over 14. Adjusted odds ratio (TFMS<=14 vs TFMS>14) = 1.125 (0.47, 3.43). A one-fold increase in the risk of injury is 10 times smaller than previous research [8], which suggests limited application to the academy football setting. Despite this, the data indicating a higher risk of getting injured for those scoring less than 14, it was not statistically significant. Therefore, the score of 14 not being significantly related to injury means that it may not be a relevant marker for highlighting those players's at heightened risk of injury within an academy football setting.

This study mirrors a large proportion of the published material in that it has only been able to highlight those players who were injured during one sporting season. It may be more appropriate to interpret player's FMS scores with more long term goals in mind. This lack of longitudinal follow-up over several competitive football seasons means that the diagnostic value of the FMS is based upon the assumption that players will become injured within that particular season. Although, the season long study may not have been long enough to draw appropriate conclusions, many injury screening and prevention programmes operate season to season, which makes long term follow-up very difficult within professional sport. One caveat of conducting long term studies within professional sport is the likelihood of a very small sample size at the completion of the study.

The findings may also differ from previously work because of the population and sport used. The physical demands of the sport may result in a variety of injuries and mechanisms underlying them [27]. For example among many differences, English football is predominantly continuous, whilst the NFL has large breaks in play and evidence indicates that intermittent involvement in play increases the risk of injury due to the altered ability of soft tissues to change and adapt [28]. The continuous nature of football may also predispose athletes to a higher proportion of pathology that result from repetitive load e.g. tendinopathy or fatigue related muscle injury.

Previous epidemiological research within youth football indicated an average of 2.23 injuries per 1000 player hours, with 51% and 36% of injuries occuring during competition and training respectively. The data from this study (5.2 injuries per 1000 player hours) indicates a large increase in the injury incidence compared to the epidemiological research conducted 10 years ago. These contrasting results may reflect the modern game of football, where previous research is dated and based upon an old academy model. The heightened injury incidence and occurrence during training activities could also be associated with the increased exposure associated with the EPPP.

The prospective injury surveillance incorporated within this study used a more robust definition of injury, ensuring that all injuries were captured, however minor. This allowed for more comprehensive reporting and therefore, a more comprehensive analysis of the association between FMS scores and non-contact injury incidence. This is compared to previous studies whose definitions only included injuries that resulted in a time loss of at least 3 weeks from normal training and competition and as a result, missed a substantial number of injuries [8]. In fact, time loss injuries are documented to be unrepresentative of a sample as non–time-loss injuries represent the largest proportion of injuries within athletes

[29].

The mean FMS score of 12.3 is lower than previously published literature. Previous studies have produced similar protocols and generated reference data and inter/intra

rater reliability based upon various smaller populations such as Fire-fighters and American Footballers, over much shorter study periods. This absence of research into the academy football setting means that the normative values documented within the literature are not representative of the players observed within this study.

It is undoubted that future research is required in order to expand on the current available research associated with the FMS and further establish its role within injury prevention. Future studies should be conducted in a prospective manner using a similar definition of injury that is robust enough to ensure that all injuries are captured, however minor. Following this pilot, it appears that the observed association between players FMS scores and injury incidence is representative to academy populations on a national level. Therefore, clinicians may not be able to justify the implementation of the FMS system within an academy football system to highlight those players at heightened risk of injury.

In summary, the FMS is not associated with non-contact injury incidence within youth footballers from one professional football academy over one season. The deep squat and trunk stability push up appear to be the only tasks from the FMS that appear to have a statistically significant association with non-contact injury incidence. Based on this, it would be appropriate to use these two tasks within medical screening. Further research that incorporates these two tasks with alternative screening measures e.g. single leg options may highlight better option for any injury prediction with in academy football settings. It appears that using the full FMS may not be appropriate in determining individual's injury risk within youth academy football.

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