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Research Paper

Comparing FMS and nordbord scores in professional football athletes with prior hamstring injuries

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Abstract

The primary purpose of our study is to evaluate, compare and contrast the results of the FMS (Functional Movement Screen) and Norbord (the tool to gauge the eccentric strength of hamstring muscle group) methods, commonly used for athlete assessments.

Within the scope of this study, 20 athletes between the ages 18-37, who had not experienced hamstring injuries during the previous six months and 20 athletes, who had experienced hamstring injuries in the previous six months were tested with FMS test battery and Norbord device. The study was carried out between November 2017 and April 2018.

Athletes were assigned a score within the range 1-3 in the FMS test, according to the quality of their movements during 7 different functional evaluation tests. Both limbs were assessed and the lower score is used at the final score. The athletes who scored a total of 14 points or fewer are considered to be within the 'at risk' group, while those, who scored 15 or above are considered 'normal'.

An examination of the outcomes of the study reveals that the results, acquired from both methods, show parallelism with each other. Consequently, both methods can be used to detect prior injuries in hamstring muscle groups. However, further comprehensive studies, including an increase in the number of study participants, are essential to improve our understanding and knowledge.

Keywords: muscle injury, functional movement screen, nordbord, hamstring muscle group

Abbreviations: FMS: Functional Movement Screen; NMES: Nordbord Maximum Eccentric Strength; NI: Nordbord Imbalance; NEPT: Nordbord Eccentric Peak Torque; ALR: Active Leg Raise; MCL: Medial Collateral Ligament

INTRODUCTION

Hamstring muscle group injuries are the most frequent and recurring type of muscle injuries in football. The ability of a football club's medical team to detect potential hamstring injuries as early as possible and utilize a protective rehabilitation program would minimize the club from financial loss as a result of injured athletes. While the manner of occurrence of an injury depends on various risk factors, simple tests can be conducted which would help to identify some of these risk groups in economic and practical ways, allowing occupational advantages to be ensured, as football clubs are simultaneously spared millions of dollars of financial costs, caused by workforce losses [1-3].

Sports injuries differ, according to injury mechanisms, and this informs the management of the injury. An exact definition of a sports injury may prove to be problematic and definitions are, in this sense, not consistent.

There are multiple ways to classify sports injuries, according to how external loads injure the tissue, which type of tissue is affected, how severe the injury is and when the individual is injured. One method of classification to divide injuries into two classes: acute and overuse [4-6].

NAIRS CLASSIFICATION

All health problems related to the sport are described as 'sports injuries'. Sports injuries prevent participation in sporting activities the day after they occur. The National Athletic Injury/Illness Reporting System classifies sports injuries in three groups from this perspective:

1. Minor injuries: Minor injuries that persist for 1-7 days
2. Moderate injuries: Injuries that persist for 8-21 days
3. Major sports injuries: Injuries that prevent participation in sports activities for more than 21 days or cause permanent damage

As both a contact and effort sport, football witnesses many injuries, which are deemed inevitable. Jan Ekstrand et al. determined 2009 the injury statistics of the 50 best football teams in Europe (between 2001 and 2008); a total of 4483 injuries were recorded with 2546 of them (53%) occurring during games and 1937 occurring during training (47%). This study suggests that an athlete experiences 2 injuries on average per season. This translates to 50 injuries per season for a team of 25 athletes, 86% of the injuries are recorded on lower extremities. The most common injuries are muscle strains, ligament sprains and contusions, while the most common injury areas are reported to be femurs, knees, ankles and hips/groins. The most frequently observed injury is the femur strain accounting for 17% of all injuries (n=743), followed by hamstring (n=525, 12%) and quadriceps (n=218, 5%). Accordingly, a team of 25 athletes could expect approximately 10 femur strains per season; 7 of them would affect hamstrings and 3 of them, the muscle Quadriceps Femoris. Other subtypes of common injuries are adductor pain (n=399, 9%), ankle sprains (n=318, 7%) and Medial Collateral Ligament (MCL) injuries (n=220, 5%). Occurring as a result of traumas, injuries have a ratio of 81% during games and 59 and of them arise during training. Overuse injuries correspond to 28% of all injuries. Accuracy in numbers allows the sports club, coaches and medical personnel to be well informed about potential injuries in a season, yielding the opportunity for them to compare their levels to that of good clubs. A secondary outcome of this study was that hamstring muscle groups were identified as more prone to injuries than any other muscle groups [7].

Jan Ekstrand et al. identified, [7] that one third of almost all professional football injuries are muscle injuries and the majority (92%) affects the 4 main muscle groups in the lower extremities: 37% in hamstrings; 23% in adductors; 19% in quadriceps and 13% in calf muscles. It is well known that football injuries mainly affect lower extremities and this appears to be even more visible when muscle injuries are considered. Another important finding of this study, in addition to its substantial clinical significance for the practitioners in the field, is that recurring injuries cause athletes to be absent from football for considerably longer periods of time, compared to minor injuries. Highly reliable and standardized isokinetic tests and isokinetic tools are used to avoid recurrences; however, many clubs cannot afford the tool due to its high cost [8].

Observed in sports such as football or athletics, sprints are strongly related to the injuries on the long end of the biceps femoris muscle. Stretch injuries occur during the tensile stress, applied on extreme extension positions (hip flexion and knee extension). These are usually complex; yet, they are mainly seen in the areas of semi membranous muscle and its proximal tendon that are in close proximity of ischial tuberosity. In addition to the injury mechanism, the damage site within each muscle also changes in different prognoses [9].

DATA AND METHODOLOGY

Based on the Nordic Hamstring Concentric isotonic exercise, Norbord enables the numerical quantification of this exercise, which has not been possible to achieve. Norbord can perceive, collect and evaluate an athlete's hamstring strength via highly technologically developed compact sensors, wirelessly and in real-time, as the athlete does a Hamstring concentric isotonic exercise concentric isotonic.

It has been shown that the Nordic Hamstring Concentric isotonic is an efficient and reliable way of training eccentric hamstring strength and many of the prominent sports teams across the world currently use this application. An athlete can be tested with Norbord in approximately 30 seconds, whereas an isokinetic dynamometer takes 15 minutes. Manually held dynamometers can compete with Norbord in terms of speed, while Nordbord is more effective than all other systems with respect to accuracy and reliability [10].

FMS is a simple and convenient system using cheap and portable equipment which can assess the basic movement patterns of individuals. FMS is simple to apply and an easily portable screening system that is designed in a manner that ensures the evaluation and observation of the basic movement patterns that test both the right and left sides of the body requiring balance between mobilization and stabilization (including neuromuscular and motor control) [11].

As a testing system, FMS can be easily and quickly administered. Its aim is not to diagnose, but to scan the muscular-skeletal system. When tests are interpreted based on compensation and asymmetry during functional movements and not just focuses on scores, FMS can reveal important, they reveal important information, regarding the individual's functional movement patterns. Scores are formed on 1-2-3 point's basis. The final score in bilateral tests is assigned from the lowest score. The maximum score is 21. Despite its widespread clinical usage, validity and reliability studies are not yet found in the literature.

FMS scores were processed in a database, which was set with SPSS 20.00 (IBM SPSS, Turkey) for statistical analyses, after the Nordbord scores, body weight and other data were collected. Parametric analyses (Independent group t-test, (Analysis of variance) ANOVA, Pearson correlation test) were used for data that displays normal distribution. Non-parametric analyses (Chi-square and Spearman tests) were used for the data that is not in accordance with a normal distribution. Moreover, descriptive statistical analyses such as frequency distributions, minimum-maximum values, standard deviation and average of data were conducted on the data. Consequently, the significance is found to be $p<0.05$.

FINDINGS

Norbord and FMS values for participants, who had hamstring muscle group injuries during the previous six months, are shown in Table 1. The height and body weight values are important for the Nordbord device in order to calculate the torque and push values.

Nordbord and FMS values for participants, who did not experience hamstring muscle group injuries during the previous six months, are shown in Table 2. The height and body weight are important for the Nordbord device in order to calculate the torque and eccentric strength values.

As can be observed in Table 3, a positive (r=0.730) and significant (p=0.001<0.01) relation was found between the total Functional Movement Screen scores of the athlete group with prior injuries and the athlete group without prior injuries.

As is shown in Table 4, the difference between the total Functional Movement Screen (FMS) scores of the athlete group with prior injuries and the athlete group without prior injuries is significant (p=0.001 <0.05).

As demonstrated in Table 5, there is a positive and significant (p=0.001<0.01) relationship between the total Functional Movement Screen (FMS) scores and Active Leg Raise (ALR) scores of all the athletes, who participated in the study (n: 40), according to Independent Samples Test.

Table 5 also shows that there is a positive (r=0.586) and significant (p=0.007<0.01) relation between the total Functional Movement Screen (FMS) scores and Active Leg Raise (ALR) scores of the athlete group with prior injuries (n:20).

It can also be seen in Table 5 that there is a strong, positive (r=0.774) and significant (p=0.007<0.01) relation between the total Functional Movement Screen (FMS) scores and Active Leg Raise (ALR) scores of

Table 1. Individualized data of athletes with prior injuries

Age	Height	Weight	LMP	RMP	Imbalance	LMT	RMT	FMS	ALRR	ALRL
20	178	71	326	394	17.26	119	144	14	3	3
19	173	67	222	246	9.76	81	89	16	3	3
20	176	79	238	255	6.67	89	95	12	1	1
19	179	73	342	453	24.5	143	190	12	2	2
25	180	68	309	296	4.21	115	111	14	2	3
28	171	75	350	304	11.51	141	120	14	3	3
30	170	67	346	290	16.18	135	114	14	2	2
32	191	90	454	419	7.71	206	190	13	2	2
28	180	74	399	439	9.16	113	113	13	2	1
27	177	70	293	303	3.31	83	83	14	2	1
37	191	99	340	383	11.26	156	178	15	3	2
29	191	83	284	304	6.59	114	122	16	2	3
29	187	71	318	388	12.2	119	144	14	3	2
19	182	70	358	433	17.32	150	181	12	2	1
20	184	79	363	454	20.04	152	190	13	2	1
19	192	82	224	204	8.93	96	87	13	2	2
22	176	63	352	322	8.52	128	117	14	2	1
32	172	67	380	334	12.11	155	137	14	2	2
20	170	60	262	269	2.6	102	105	15	3	3
23	188	74	386	356	7.77	154	143	12	1	2

Height: cm; Weight: Body weight (kg); LMP: Left leg maximum push strength; RMP: Right hamstring maximum push strength; LMT: Left leg maximum peak torque; RMT: Right leg maximum peak torque; FMS: Functional Movement Analysis Score; ALRR: Right active leg raise test score; ALRL: Left active leg raise test score

Table 2. Individualized data of athletes without prior injuries

s	Height	Weight	LMP	RMP	Imbalance	LMT	RMT	FMS	ALRR	ALRL
30	178	80	410	483	15.11	186	220	16	2	2
20	178	72	392	378	3.57	150	145	16	2	3
22	170	70	388	439	11.62	170	192	15	2	2
18	188	80	509	455	10.61	199	178	16	3	3
26	189	80	441	424	3.85	181	174	17	3	3
24	190	83	406	392	3.45	163	157	18	3	3
18	182	82	462	420	9.09	173	157	17	3	3
22	180	70	413	345	16.46	158	132	17	3	3
24	175	65	408	345	15.44	152	129	16	2	3
20	185	76	429	415	3.26	168	162	18	3	3
21	188	80	458	420	8.3	192	176	16	3	3
30	181	78	419	397	5.25	175	166	16	3	3
25	180	75	444	401	9.68	186	168	16	3	3
20	190	77	414	406	1.93	185	181	14	1	1
20	179	71	409	404	1.22	160	158	14	2	1
27	198	82	554	532	3.97	252	242	16	2	2
33	190	82	445	437	1.8	198	195	18	3	3
21	190	79	426	388	8.92	163	149	16	3	3
21	180	75	422	432	2.31	161	165	16	3	3
23	192	89	461	481	4.16	185	193	15	2	2

Height: cm; Weight: Body weight (kg); LMP: Left leg maximum push strength; RMP: Right hamstring maximum push strength; LMT: Left leg maximum peak torque; RMT: Right leg maximum peak torque; FMS: Functional Movement Analysis Score; ALRR: Right active leg raise test score; ALRL: Left active leg raise test score the athlete group without prior injuries (n: 20), according to Pearson correlation test.

There is a negative (r=-0.350) and significant (p=.027<0.05) relationship between Nordbord Imbalance (NI) percentage values (n:20) and prior injury status, which can be observed in Table 6.

As shown in Table 6, the difference (n:20) between Nordbord Imbalance (NI) percentage value averages of the athlete group with prior injuries and the athlete group without prior injuries is significant (p=0.0.27<0.05) (in favor of the athlete group with prior injuries).

According to ANOVA test, there is a positive (r=0.721) and significant (p=0.001<0.01) relationship between Nordbord Maximum Eccentric Strength (NMES) values (n:40) of the athlete group with prior injuries and the athlete group without prior injuries, which can be observed in Table 7.

As Table 7 also demonstrates, there is a positive (r=0.405) and significant (p=0.010<0.01) relationship between the body weights (kg) of all the subjects, who participated in the study, and Nordbord Maximum Eccentric Strength (NMES) values (n:40).

Table 8 shows that there is a positive (r=0.502) and significant (p=0.001<0.01) relationship between the body weights (kg) of all the subjects, who participated in the study, and Nordbord Eccentric Peak Torque (NEPT) values (n:40).

As shown in Table 8, there is a very strong, positive (r=0.924) and significant (p=0.001<0.01) relationship between Nordbord Eccentric Peak Torque (NEPT) values of all the subjects, who participated in the study, and Nordbord Maximum Eccentric Strength (NMES) values (n:40).

There is a positive (r=0.416) and significant (p=0.008<0.01) relationship between the total Functional Movement Screen (FMS) scores of all the subjects, who participated in this study, and Nordbord Maximum Eccentric Strength (NMES) values (n:40), as can be seen in Table 9.

Table 9 also shows that there is a negative (r=-0.371) and significant (p=0.018<0.05) relationship between the total Functional Movement Screen (FMS) scores of all the participants, and the Nordbord Imbalance (NI) values (n: 40).

Moreover, there is a positive (r=0.382) and significant (p=0.015 <0.05) relationship between the Nordbord Eccentric Peak Torque (NEPT) values of all the participants, and total Functional Movement Screen (FMS) scores (n:40), as can be observed in Table 9.

Table 3. Athlete group FMS averages

	Groups	n	Average value	Standard deviation	Significance
Total FMS score	With prior injury	20	13.7000	1.21828	0.000
	Without prior injury	20	16.1500	1.13671	
n: total number of individuals or observations in the sample					

Table 4. Athlete group FMS correlation

	t	df	Sig	Mean difference	Standard error difference
Total FMS score	-6.576	37.819	0.000	-2.45000	0.37258
t: Continuous probability distributions; Df: Degree of Freedom; Sig: Significance					

Table 5. ALR, FMS values and injury history relation

Relation between FMS Score and ALR	n	Significance
With prior injury	20	0.007
Without prior injury	20	0.000
All participants	40	0.000

Table 6. Average imbalance values according to injury history

	Groups	n	Average	Standard deviation	Significance
Imbalance	Group with prior injury	20	10.8805	5.72741	0.027
	Group without prior injury	20	7.0000	4.89111	

Table 7. NMES and injury history relation

		n	Sig
NMES	Injury relation between groups	40	0.000
	Body weight relation	40	0.010
NMES: Nordbord Maximum Eccentric Strength; Sig: Significance			

Table 8. NEPT, NMES and body weight relation

		n	Sig
NEPT	Body weight relation	40	0.001
	NMES	40	0.000
NMES: Nordbord Maximum Eccentric Strength; NEPT: Nordbord Eccentric Peak Torque; Sig: Significance			

Table 9. Total FMS and NMES and imbalance values relation

		n	Sig
Total FMS score	NMES	40	0.008
	Imbalance	40	0.018
	NEPT	40	0.015
NMES: Nordbord Maximum Eccentric Strength; NEPT: Nordbord Eccentric Peak Torque; Sig: Significance			

DISCUSSION

Functional Movement Screen (FMS) is one of the new generation screening assessments that evaluate selective basic movement models to identify those at risk of potential injury [12].

Nordbord, is an assessment method that uses the Nordic Hamstring Concentric isotonic exercise as its basis, enabling the numerical quantification of the eccentric strength of the hamstring muscle group [13].

Examining the Functional Movement Screen (FMS) scores and Nordbord Scores of athletes with prior hamstring muscle group injuries, this study; Found a significant relationship between the total Functional Movement Screen (FMS) scores and prior hamstring muscle group injuries (p=0.001<0.01).

The mean value of the total FMS score of athletes with prior hamstring muscle group injuries was found to be 13.7 in our study. Kiesel et al. state in their study that in the event of the total FMS score being 14 or lower, the risk of injury to the athlete is 11 more likely than the risk of injury to an athlete with a score of 15 or above [14]. Michael Garrison et al., ascertain that in the event of the total FMS score being 14 or lower, the risk of injury of athletes increases to 15 times [15]. Moreover, Amir Letafatkar et al. suggest that if the total FMS score is 14 or lower, these athletes are 11.6 times more likely to face an injury' [16]. These results that can be found in the literature show a strong similarity with the findings of our study.

When we examine the Active Leg Raise (ALR) parameter within the Functional Movement Screen (FMS) test protocol undertaken within the scope of our study, due to this parameter's link with the hamstring muscle group assessment in the eccentric contraction pattern, a positive (r=0.586) and significant (p=0.007<0.01) relationship is observed between the total Functional Movement Screen (FMS) scores and Active Leg Raise (ALR) scores of the athlete group with prior injuries.

There is a strong, positive (r=0.774) and significant (p=0.007<0.01) relationship between the total Functional Movement Screen (FMS) scores and Active Leg Raise (ALR) scores of the athlete group without prior injuries.

The average Active Leg Raise (ALR) score for the athlete group with prior injuries, in our study, is found to be 1.85, while the average Active Leg Raise (ALR) score for the athlete group without prior injuries is 2.5.

In the research study conducted by Şahin M et al. undertaken with 92 youth team football athletes within the age range 14-16 and without taking into consideration their injury histories, they found an average Active Leg Raise (ALR) score of 1.95 [17].

Emre S et al. also conducted a research study with 37 female and 14 male handball athletes with an average age of 21 ± 4.50 without taking into consideration their injury histories, where they reported an Active Leg Raise (ALR) score average of 2.2 [18]. These results from the literature are similar to the findings of our study.

When the relation between Nordbord Scores and previous hamstring muscle group injuries is examined in our study;

A significant relation is detected ($p=0.001<0.01$) between the Nordbord Maximum Eccentric Strength (NMES) values (<350 N) and previous injuries in hamstring muscle groups.

There are a limited number of studies, for the Nordbord device has only been in use since 2012. The conducted literature review yielded the study of David A Opar et al., which was carried out with 200 Australian football athletes, where it was detected that athletes with Nordbord Maximum Eccentric Strength (NMES) values of 337 N or lower are exposed to 4 times more risk of injuries in the hamstring muscle groups [10]. Furthermore, the same study suggests that the existence or lack thereof of specific previous injuries of athletes with Nordbord Maximum Eccentric Strength (NMES) values of 500 N and above cannot be identified. None of the athletes in our study with prior hamstring muscle group injuries displayed a Nordbord Maximum Eccentric Strength (NMES) value exceeding 500 N, which shows parallelism with the findings of Opar et al. [10].

Within the scope of our study, the average Maximum Eccentric Strength (NMES) value for athletes with prior hamstring muscle group injuries is found to be 313.5 N, while the average Maximum Eccentric Strength (NMES) value for athletes without prior hamstring muscle group injuries is 412 N. A close alignment was also found between the average Maximum Eccentric Strength (NMES) values observed in this study and the average Maximum Eccentric Strength (NMES) observed in 2016-2017 England's Premier League (EPL: 641 athletes) and England Championship League (ECL: 204 athletes). These results (405 N in England Premier League- 423 N in England Championship League) are reported by Nordbord device's manufacturer, the Vald Performance company, and do not take into consideration the history of injuries.

A negative and significant relationship is found within the scope of our study, between Nordbord Imbalance (NI) values and prior hamstring muscle group injuries ($p=0.027<0.05$).

Whilst the mean value of Nordbord Imbalance (NI) for the athlete group with prior hamstring muscle group injuries is found to be 10.9%, the mean value of Nordbord Imbalance (NI) for the athlete group without prior hamstring muscle group injuries is 7%.

CONCLUSION

The aim of the study was to compare the Functional Movement Screen (FMS) scores and Nordbord scores of professional football athletes with prior hamstring injuries. Within the scope of our study, the following were observed:

There is a positive ($r=0.416$) and significant ($p=0.008<0.01$) relationship between the total Functional Movement Screen (FMS) scores and Nordbord Maximum Eccentric Strength (NMES) values of all the subjects, who participated in the study.

There is a negative ($r=-0.371$) and significant ($p=0.018<0.05$) relationship between the total Functional Movement Screen (FMS) scores and Nordbord Imbalance (NI) values of all the subjects, who participated in the study.

There is a positive ($r=0.382$) and significant ($p=0.015<0.05$) relationship between the Nordbord Eccentric Peak Torque (NEPT) values and total Functional Movement Screen (FMS) scores of all the subjects, who participated in the study.

As a result; much like the relation between the Functional Movement Screen (FMS) scores and prior hamstring muscle group injuries and the relation between Nordbord scores and prior hamstring muscle group injuries, a similar relation between Functional Movement Screen (FMS) scores and Nordbord scores is in question.

Having the highest rate of incidence among muscle injuries in football with 37%, the hamstring muscle groups also have a 27% recurrence rate. From this perspective, prevention and prediction of the injuries in this muscle group carry great importance.

Additionally, in football, two different types of hamstring muscle group injuries are often observed (running and kicking). Consequently, the need for further research is required in order to consider this difference.

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