

FUNCTIONAL MOVEMENT SCREEN™ NORMATIVE VALUES IN A YOUNG, ACTIVE POPULATION

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ABSTRACT

Background: The Functional Movement Screen™ (FMS™) is a screening instrument which evaluates selective fundamental movement patterns to determine potential injury risk. However, despite its global use, there are currently no normative values available for the FMS™.

Objectives: To establish normative values for the FMS™ in a population of active, healthy individuals. Secondary aims were to investigate whether performance differed between males and females, between those with and without a previous history of injury, and to establish real-time inter-rater reliability of the FMS™.

Methods: Two hundred and nine (108 females and 101 males) physically active individuals, aged between 18 and 40 years, with no recent (<6 weeks) history of musculoskeletal injury were recruited. All participants performed the FMS™ and were scored using the previously established standardized FMS™ criteria. A representative sub-group participant sample (28%) determined inter rater reliability.

Results: The mean composite FMS™ score was 15.7 with a 95% confidence interval between 15.4 and 15.9 out of a possible total of 21. There was no statistically significant difference in scores between females and males ($t_{207} = .979$, $p = .329$), or those who reported a previous injury and those who did not ($t_{207} = .688$, $p = .492$). Inter-rater reliability (ICC_{3,1}) for the composite FMS™ score was .971, demonstrating excellent reliability. Inter-rater reliability (Kappa) for individual test components of the FMS™ demonstrated substantial to excellent agreement (0.70 – 1.0).

Discussion and Conclusion: This cross-sectional study provides FMS™ reference values for young, active individuals, which will assist in the interpretation of individual scores when screening athletes for musculoskeletal injury and performance factors.

Key words: Pre-participation screening, Functional Movement Screen™, injury risk, athletic performance.

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INTRODUCTION

Pre-participation and pre-season athletic screening procedures are well established components of international sport programs, and are utilized to identify potential risk factors that might lead to injury and illness such as cardiac disease, head injury, and specific musculoskeletal problems.¹⁻⁷ Screening procedures can also be used in injury prevention in order to counsel individuals with sport specific functional deficits, create individual pre-habilitation or rehabilitation programs and to enhance sporting performance.^{3,4,8} Originally, screening procedures were sport specific^{3,9,10} and often focused on identifying factors that would exclude a person from participating in certain activities,^{3,9} or were used to identify specific athletic talent.¹¹ However, the common misconception that screens by themselves can prevent injury has been challenged because they only provide individual information that is often based on standardized exercise recommendations, and may or may not suit an athlete's specific needs.^{4,9}

More recently, athletic screening has shifted towards a more functional approach based on the assumption that identifiable biomechanical deficits in fundamental movement patterns have the potential to limit performance and render the athlete susceptible to injury.^{4,9,12,13} Assessing basic fundamental movement provides an opportunity to create a more individualized training program that focuses on changing or modifying movement patterns, instead of focusing on the rehabilitation of specific joints and muscles.^{9,13}

One of the new generation of screening assessments which evaluates functional movement patterns is the Functional Movement Screen™ (FMS™). The FMS™ was developed as a comprehensive pre-participation and pre-season screen, and consists of seven tests/movements which challenge an individual's ability to perform basic movement patterns that reflect combinations of muscle strength, flexibility, range of motion, coordination, balance and proprioception.^{9,14} The primary goal of the FMS™ is to evaluate the body's kinetic chain system, where the body is evaluated as a linked system of interdependent segments, which often work in a proximal to distal direction to initiate movement.^{9,15} The FMS™ provides information that indicates if an

athlete has problems with stabilization and/or mobility. This provides the foundations for an informed prescriptive training program developed with a focus on creating sound movement patterns.⁹ Five of the seven FMS™ tests are scored separately for the left and right sides,¹⁶ and can therefore be used to locate asymmetries which have been identified as an injury risk factor. An FMS™ specified cut-off value of 14 or below is suggested to indicate an elevated risk of injury. This value was derived from a study of professional football players by utilizing information from a Receiver Operator Characteristic (ROC) curve which maximized the sensitivity and specificity of the test.¹² It is important to note that this study had a relatively small sample size (N = 46) and, along with the fact that only one sport was evaluated, the ability to generalize this cut-off value to other sport and recreation participants may be limited. The FMS™ has been utilized to evaluate and reduce injury risk in specific occupational groups (e.g. firefighters),^{17,18} and used in sports teams to screen pre-season for injury risk and to develop specific intervention programs to prevent injuries.^{12,16}

To date, there are no published normative values for score on the FMS™ to help sports physical therapists, coaches, and athletic trainers interpret the raw data collected during testing. The availability of reference values would enhance the use of the FMS™ by allowing comparison of an athlete's score with normative reference values. It is also considered important to gain a better understanding of the instrument and the performance of the individual tests in order to assist in the development of robust psychometric properties associated with the instrument. Only a minimal amount of information on the psychometric properties of the FMS™ has been published to date.^{12,13} The inter-rater reliability of the FMS™, established via analysis of video data, is high.¹³

The purpose of this study was to establish normative values for the FMS™ in a population of healthy active individuals. Secondary aims were to investigate whether performance differed between males and females, between those with and without a previous history of injury, and to establish real-time inter-rater reliability of the FMS™.

METHODS

Subjects

The study employed a prospective cross-sectional design with an included reliability component. A convenience sample of approximately 200 healthy females and males aged between 18 and 40 years was targeted and recruited from a tertiary student population (University & Polytechnic), sports clubs and the general public within the greater southern region of New Zealand. Subjects were included in the study if they participated in regular physical activity at a competitive or recreational level. Exclusion criteria included; the use of a mobility aid or a prophylactic device (e.g. knee brace), or if they had reported a recent (<6 weeks) musculoskeletal or head injury which was likely to affect their motor performance on the FMS™. The study was approved by the University of Otago Human Ethics Committee, and written informed consent was obtained from all subjects prior to data collection.

Data Collection Procedures

Subjects were recruited via advertising on community notice boards, announcements in university classes, direct contact, and word of mouth. Data collection took place between September and October 2010 in a university human movement testing laboratory or in a Physical Therapy clinic located at the university recreation center. The participants were asked to wear their usual athletic clothing and footwear for the study. The data were collected by two members of the research team (ÅD, EH) who worked with members of the extended research team to establish a data collection protocol. This included in-house training sessions in the administration and scoring of the FMS™, review of relevant literature, studying a training video and related documentation, and working with several members of the research team, which resulted in standardized data collection procedures. A pilot study was conducted with 10 participants in order to achieve a reliable level of agreement between the two test raters which resulted in Kappa values > .70 for all tests.

After providing written informed consent, and prior to testing, each subject completed a short questionnaire regarding their injury history, usual physical activity levels, and demographic information. Each

participant's weight was measured in kilograms and height in centimeters.

Limb dominance was measured to generate descriptive information about the subjects and to describe any asymmetry during testing. Four short tests which have been shown to provide a valid measure of footedness were conducted. The leg used to perform the tests was considered to be the dominant leg.¹⁹ Data from these tests were used to compute a lower limb Laterality Quotient (LQ), defined as: the number of tasks performed with the left leg subtracted from the tasks performed with the right leg, divided by the number of tasks. The LQ has potential scores ranging from -1 (left foot dominant) to +1 (right foot dominant).^{20,21} Upper limb preference was determined by observing which hand the subject used to write on the questionnaire.

The Functional Movement Screen™, developed by Cook and Burton, was used in the study.^{9,14} The test administration procedures, instructions and scoring process associated with the standardized version of the test^{9,14} were followed in order to ensure the scoring accuracy. Each participant was given three trials on each of the seven tests (deep squat, hurdle step, in-line lunge, shoulder mobility, active straight leg raise, trunk stability push-up and rotary stability). Each trial was scored on a scale from 0 to 3. A score of 0 indicated that pain was reported during the movement; 1 indicated failure to complete the movement or loss of balance during the movement; 2 completion of the movement with compensation; and 3 performance of the movement without any compensation. For each item, the highest score from the three trials was recorded and used to generate an overall composite FMS™ score with a maximum value of 21. For the tests that were assessed bilaterally, the lowest score was used. Three of the tests (shoulder mobility, trunk stability push-up and rotary stability) also have associated clearing exams that are scored as either positive or negative with a positive response indicating that pain was reproduced during the examination movement.^{9,14}

In order to establish that both raters who collected the study data scored the subjects in a similar manner, an inter-rater reliability component was included in the study design. Both raters were equal in terms

of clinical experience and their previous use of the FMS™. A sample of convenience was used to select subjects considered to be representative of the main study sample, and these were scored simultaneously and independently (without consultation) by the two raters. The same rater instructed all the subjects during the collection of the reliability data.

Data Analysis

In order to provide a comprehensive description of the participants and the FMS™ data; means, standard deviations, 95% confidence intervals (CI), and frequencies were computed for males and females separately, and for all participants combined. Where appropriate, independent t-tests were used to examine for potential differences between males and females, and between those who had and had not sustained an injury in the previous 6 months, with the exact probability values presented. The number of participants who scored at or below the cut-off value of 14 was tabulated. Chi-square tests were used to evaluate if there were any significant differences between males and females in the distribution of scores for the different tests. The Intra-class Correlation Coefficient (ICC model 3,1) was the reliability statistic used to establish the inter-rater reliability

for the FMS™ composite score, and the unweighted Kappa statistic was used to establish the inter-rater reliability measurement for each item. The inter-rater reliability data were interpreted according to the categories defined by Landis and Koch.²² A Kappa value over 80% represents excellent agreement; above 60% substantial level of agreement, 40-60% moderate level of agreement, and below 40% poor to fair agreement. All calculations were performed using SPSS (version 16.0) and the a priori level of significance was set at $p \leq 0.05$.

RESULTS

Two hundred and nine subjects participated in the study, 108 females (mean age 21.2, height 166.5 cm, weight 66.4 kg and BMI 23.9), and 101 males (mean age 22.7, height 178.5 cm, weight 79.7 kg and BMI 25.0). The descriptive data are presented in Table 1. All subjects were free from injury at the time of testing, however, 50 subjects reported having sustained an injury in the previous 6 months from which they had recovered, and were participating in a range of physical activities. Sixty-five percent of the subjects met the American College of Sport Medicine (ACSM) and American Heart Association (AHA) basic recommendations for age related exercise; meaning

Table 1. Subject characteristics for the combined group (N = 209), females (N = 108) and males (N = 101).

Variable	Mean ± SD			95% CI			Range*			t ₂₀₇ †	p
	Mean ± SD	95% CI	Range*	Mean ± SD	95% CI	Range	Mean ± SD	95% CI	Range		
	Combined			Females			Males				
Age (yr)	21.9 ± 3.7	21.4 - 22.4	18 - 40	21.2 ± 3.0	20.6 - 21.7	18 - 40	22.7 ± 4.2	21.9 - 23.5	19 - 37	3.087	.002
Mass (kg)	72.8 ± 12.3	71.1 - 74.5	40 - 118	66.4 ± 9.9	64.5 - 68.3	40 - 110	79.7 ± 10.8	77.6 - 81.8	55 - 118	9.278	.001
Height (cm)	172.3 ± 9.0	171.1 - 173.5	150 - 192	166.5 ± 6.7	165.2 - 167.7	150 - 181	178.5 ± 6.7	177.2 - 179.9	155 - 192	13.013	.001
BMI	24.4 ± 3.1	24.0 - 24.9	17 - 35	23.9 ± 3.2	23.3 - 24.5	17 - 35	25.0 ± 2.9	24.4 - 25.6	20 - 35	2.481	.014
LQ‡	0.8 ± 0.5	0.7 - 0.9	(-1) - 1.0	0.9 ± 0.4	0.8 - 0.9	(-1) - 1.0	0.8 ± 0.6	0.6 - 0.9	(-1) - 1.0	-1.544	.124
Numbers											
Arm dom§	19 left 190 right			7 left 101 right			12 left 89 right				
* min - max, † difference between females and males, ‡ Footedness laterality quotient, § dominance											

Table 2. Inter-rater reliability for individual FMSTM tests.

Variable	Agreement %	Kappa	Level of agreement‡
Deep squat	100	1.00	Excellent
Hurdle step R*	86	0.70	Substantial
Hurdle step L†	91	0.77	Substantial
Hurdle step final	93	0.80	Substantial
In-line lunge R	88	0.73	Substantial
In-line lunge L	90	0.79	Substantial
In-line lunge final	93	0.86	Excellent
Shoulder mobility R	97	0.91	Excellent
Shoulder mobility L	93	0.87	Excellent
Shoulder mobility final	97	0.94	Excellent
Active straight leg raise R	90	0.84	Excellent
Active straight leg raise L	90	0.84	Excellent
Active straight leg raise final	97	0.94	Excellent
Trunk stability push-up	100	1.00	Excellent
Rotary stability R	100	1.00	Excellent
Rotary stability L	100	1.00	Excellent
Rotary stability final	100	1.00	Excellent

* Right, † Left, ‡ Landis & Koch, 1977

that they performed moderate-intensity aerobic (endurance) physical activity for a minimum of 30 min on five days each week or vigorous-intensity aerobic physical activity for a minimum of 20 min on three days each week.²³

The inter-rater reliability (ICC) of the composite score for both testers was .971 which indicates excellent reliability. The inter-rater reliability (Kappa) for each score of the individuals' right and left side performance and for the final score for each test is presented in Table 2. Six of the seven final scores demonstrated excellent agreement and six of the ten right and left side scores also showed excellent agreement. The remaining scores demonstrated substantial agreement between the two raters.

All of the subjects completed the entire FMSTM. One individual reported pain on the in-line lunge, two on the shoulder mobility test, and three on the trunk stability push-up, which resulted in a score of zero for these tests items. The descriptive data for the FMSTM and its composite items are presented in Table 3. The combined composite mean score on the FMSTM was 15.7 with a standard deviation on 1.9 and a median of 16. The 95% confidence interval was 15.4 to 15.9 and the range was from 11 to 20. The mean for the composite score for the females was 15.6 and for the males 15.8, although this difference was not statistically significant ($p > .05$). Sixty five individuals (29 males and 36 females), representing 31% of the participants, had a composite score of 14

Table 3. The composite FMSTM Scores for the combined group (N = 209), females (N = 108), and males (N = 101).

Variable		Mean ± SD	95% CI	Range*	t ₂₀₇ †	p
Score	Combined	15.7 ± 1.9	15.4 - 15.9	11 - 20		
	Females	15.6 ± 2.0	15.2 - 15.9	11 - 20		
	Males	15.8 ± 1.8	15.5 - 16.2	12 - 20	.979	.329

* min - max, † difference between females and males

or below which indicates a heightened risk of injury according to Kiesel et al.¹²

Figure 1 describes the distribution of scores for the different FMSTM tests. A number of scoring patterns are of note. The active straight leg raise ($\chi^2 = 42.097$, $p = .000$), the trunk stability push-up ($\chi^2 = 64.475$, $p = .000$) and shoulder mobility test ($\chi^2 = 17.238$, $p = .001$) had a significant different pattern of scoring for females and males. Females were more flexible on the active straight leg raise with 46.3% (50/108) scoring a `3`, and 43.5% (47/108) scoring a `2`. The majority of males (48.5%, 49/101) scored a `2` on this test, with 40.6% (41/101) scoring a `1`. The shoulder mobility scores also indicated that females were more flexible than males; and while both males and females had the largest percentage of participants on score `3`, the males' scores were more widely distributed across the scoring spectrum. For the trunk stability push-up movement, the majority of males (76.2%, 77/101) recorded a score of `3`, while for the females the majority (58.3%, 63/108) scored a `1`. These results demonstrate the strength demand of this test, including stability and neuromuscular control, which males were better able to perform than females. For the rotary stability test 88.0% (184/209) of all the participants were scored as a `2`, 11.0% (23/209) a `1` and 1.0% (2/209) `3`. The rotary stability test also demonstrated a significantly different scoring pattern between males and females ($\chi^2 = 7.230$, $p = .027$), which indicates that males have a better core stability than females. No other Chi-squared tests reached statistical significance. An independent sample t-test demonstrated no significant differences on the composite score between individuals who had an injury during the 6 last months and for those who had not ($t_{207} = .688$, $p = 0.492$).

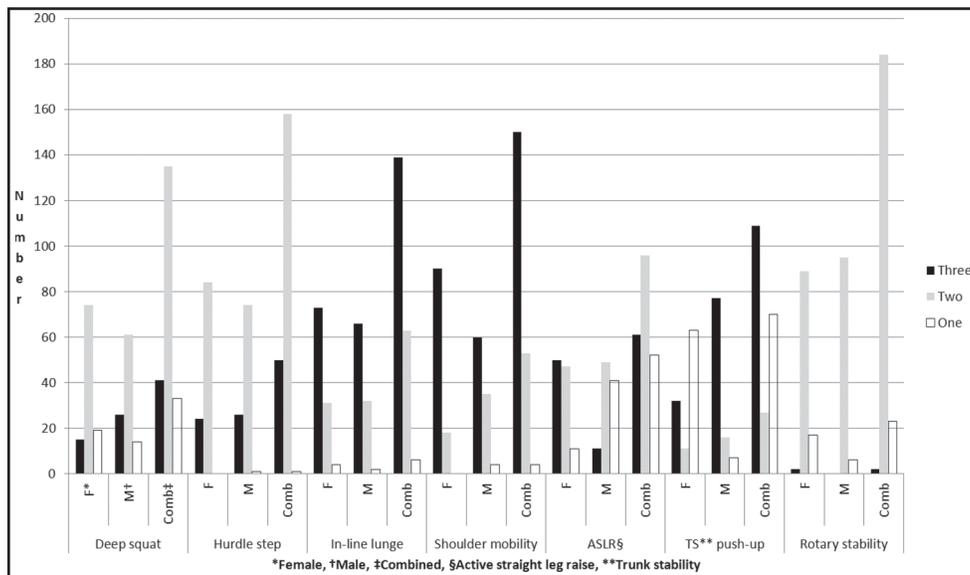


Figure 1. Score distributions for individual FMS™ test

DISCUSSION

The FMS™ is a screening instrument which evaluates selective athletic movement patterns to determine potential injury risk. To date, there have been no reference data available to assist sports physical therapists, coaches, and athletic trainers to interpret and compare individual data generated from the FMS™. This study provides data on a sizeable group of recreationally and competitively active males and females and shows the FMS™ evaluation process to have substantial to excellent inter-rater reliability.²²

There was no significant difference for composite scores between females and males, indicating that the FMS™ can be used to compare individuals in mixed populations. This is an important finding because the majority of published research on the FMS™ has been conducted either exclusively^{12,16} or predominantly^{17,18} on males.

The mean composite score reported in this study is slightly lower than that reported for a group of professional male football players (16.9).¹² It might be expected that professional football players score better than the average athlete due to their intensive training regimens, however, in a subsequent study on a similar cohort the mean pre-intervention composite score was 11.8 for “lineman” and non-lineman.¹⁶ The difference may relate to the cohort studied, the specific training regimens undertaken by each team or familiarity with the FMS™ testing

procedures. Cowen¹⁷ studied male and female firefighters whose mean baseline FMS™ score was also lower than our current study at 13.25. In the latter two studies the composite FMS™ score significantly increased following an exercise-based intervention.

It is important to note that while there was no difference in this current study for mean composite scores for males and females, significant differences were apparent between females and males on four individual FMS™ tests. Males were on average better on the trunk stability push-up and the rotary stability tests than females, and females performed better on the active straight leg raise and the shoulder mobility items. The trunk stability push-up is associated with upper body strength and stability (including core stability in the sagittal plane), the rotary stability test with transverse plane (rotational) core stability, the active straight leg raise with flexibility in the hamstring muscles, and the shoulder mobility test with range of motion in the shoulder complex and thoracic spine.¹⁴ The sex differential finding is supported by Kibler et al. who demonstrated that males were significantly stronger than females, and that females were significantly more flexible than males³ in a study that investigated 2107 athletes from a variety of sports inclusive of junior high to college levels.

The rotary stability test was distinctive from the other FMS™ tests in that very few subjects were able

to obtain the maximum score of `3´, with the majority scoring a `2´. This test demands trunk stability in the sagittal and transverse planes during asymmetric movement of the upper and lower extremities.¹⁴ The FMS™ training manual comments that it is difficult to obtain a score of `3´ (only 2 subjects did so in the present study) but it is included to capture elite performance. It is questionable if this test serves a practical role in a screen for the general athletic population and future versions of the FMS™ may need to consider its continuing inclusion. The rotary stability test does however provide the potential to measure change following a specific exercise training program targeted at asymmetric or multiplanar trunk stability.

In this study 31% of the participants had a score of 14 or less which might indicate a potentially higher risk of injury.¹² This is in comparison to the 22% of the professional football players in the Kiesel et al. study (2007)¹² and 89% in the subsequent study by Kiesel et al. (2009).¹⁶ The cutoff score of 14 was determined in a study on 46 professional football players but, because of the small sample size and the fact that the target group didn't represent a general athletic population, the authors of the current study suggest that this cutoff value should be used with caution. Further studies need to be conducted on other athletic and occupational groups before determining a substantiated cutoff value.¹²

The current study included a real-time, observational, inter-rater reliability component and the data demonstrated excellent or substantial agreement on all parts of the FMS™.²² This is useful as it allows for different individuals to be involved in the data collection when the screen is being administered to large groups. Despite some subtle differences in methodology, this result is similar to that reported in the only other published study on FMS™ inter-rater reliability.¹³ In reliability studies that use video analysis, the focus is mainly on the scoring of data which have been previously collected. In the present study both raters were required to score the subjects in real-time, with no opportunities for a replay of the performance; this is more likely to happen in a real-life setting. In this study the raters had received comparative training in the administration and scoring of the FMS™ movements and had also developed an appreciation of the

movement scoring by working together during data collection for the majority of the cohort. These factors might have influenced the results. The intra-rater reliability and test-retest stability of the FMS™ also needs to be established if it is to be used to monitor exercise interventions with confidence.

A major strength of this study was the large number and comprehensive descriptive profile of the participants, which allowed both meaningful comparisons between females and males and the potential to make useful future comparisons with similar studies. The provision of a normative dataset with narrow confidence intervals provides sports physical therapists, coaches, and athletic trainers with a reference standard to compare their individual data within a young healthy population. A limitation of this study was that there was no stratification based on the individuals' sport and exercise participation which reduces its ability to be generalized to specific sporting environments, however, this can conversely be seen as a strength of the study when general mass screening of individual athletes of different abilities is required. Another limitation related to the sample studied is that it only focuses on physically active college age athletes. Strength, flexibility and balance/stability all decrease with increasing age, particularly after the 4th decade, and for this reason it is important that this data is not used to make comparisons with, or draw conclusions regarding older athletes. Future research should target specific age groups as well as explicit sporting groups, such as gymnasts and dancers, who may have altered movement patterns as a result of their training and may challenge the test scoring system via a ceiling effect. Further studies could also generate reference data for a younger population of elementary to high school age that are entering their competitive sport career pathway and may have limited injury exposure. This may be useful in working to reduce injury rates in the emerging athletes.

CONCLUSION

This research is the first to provide reference data for the FMS™ on a large general cohort of competitive and recreational exercise participants. These normative data can act as a reference standard for sports physical therapists, coaches and athletic trainers in order to allow meaningful comparisons between

individual sport and exercise participants. Future research is recommended to further refine and validate the FMS™ as a screening tool that can be used in multiple sporting, recreational, and occupational settings.

INSTITUTIONAL REVIEW BOARD

The study was approved by the University of Otago Human Ethics Committee (Ref: 10/118).

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