Supplementary Issue: Spring Conferences of Sports Science. 15th Convention and Workshop of the International Network of Sport and Health Science, 5-8 June 2019. University of Las Palmas de Gran Canaria, Las Palmas de Gran Canaria, Spain.

Novel way for FMS score calculation highlights field of sport- specific information among young competitive athletes

KIRSTI PEDAK ✉, KRISTJAN PORT, INDREK RANNAMA, BORISS BAZANOV

School of Natural Sciences and Health, Tallinn University, Estonia

ABSTRACT

Any complex movement encompasses information about a person's abilities and disabilities. FMS™ test includes such exercise tests that have shown to reflect risk for injury in the athletic population. There are few reports where FMS™ score reflects certain sports to be more prone to injury. The inconsistency of results may arise from the way subtest scores are combined. Instead of a summation we propose to apply more justified method of geometric mean of subtest scores to tally the final composite score. We used tests on 215 young competitive athletes, 133 young female (age 17.35 ± 1,65) and 82 males (age 17,78± 2.1) from 8 fields of sport (volleyball, basketball, handball, fencing, judo, biathlon, cycling, soccer). Original FMS 21 point (FMS21) were used and for every participant's arithmetic and geometric mean were calculated. The mean composite FMS™ score of young female athletes was 14.3±1.7 and for male's 13.8±1.6 out of possible 21 total point. The comparison of sport-specific geometric mean values among girls showed that basketball players had significantly lower results than athletes from biathlon and handball players. Contrarily among boys the handball players had lowest values, being significantly lower from in cyclists, fencers and soccer players. Cyclists had also higher geometric mean values than volleyball players and judo athletes. Detailed analysis of the structure of differences is needed to highlight the specific causes impacting FMS_GM for assessment for seriousness and for specific exercises to potentially compensate for the sport specific detrimental effect on the kinematic chain. **Keywords**: Functional Movement Screen; Sport-specific; Geometric means.

Cite this article as:
Pedak, K., Port, K., Rannama, I., & Bazanov, B. (2019). Novel way for FMS score calculation highlights field of sport- specific information among young competitive athletes. *Journal of Human Sport and Exercise, 14*(4proc), S732-S738. doi:https://doi.org/10.14198/jhse.2019.14.Proc4.34

✉ **Corresponding author.** *School of Natural Sciences and Health, Tallinn University.Räägu 49-207, 10620 Tallinn, Estonia.*
E-mail: kirsti.pedak@tlu.ee
Supplementary Issue: Spring Conferences of Sports Science. 15th Convention and Workshop of the International Network of Sport and Health Science, 5-8 June 2019. University of Las Palmas de Gran Canaria, Las Palmas de Gran Canaria, Spain.
JOURNAL OF HUMAN SPORT & EXERCISE ISSN 1988-5202

doi:10.14198/jhse.2019.14.Proc4.34

INTRODUCTION

Effective feedback methods for improving skilled performance are among the most valuable tools for achieving high athletic results. The methods for analysis of athletic performance vary and there is no agreement which method is the best for indicating the level of athletic sport specific performance and there are no universally accepted diagnostic measures of athletic performance (Smith, 2003). Testing the athlete's sport specific functional abilities has been traditionally based on the assessments of basic strength, endurance, balance abilities, speed and agility (Robertson, Burnett & Wilkie, 2013) and are predominantly concerned to the regular monitoring of physical fitness and sport-specific performance (Chaabene et al., 2018; Aquino et al., 2017). This emphasizes the importance of these components in elite sports to increase the likelihood of success in competition. Today’s athletic screening has shifted toward a more functional approach based on the assumption that identifiable biomechanical deficits in fundamental movement patterns have the potential to limit performance and increase the potential risk athlete susceptible of injuries (Kraus et al., 2014). One strategy to assess athletic performance is to analyse movement quality - the correct movement alignment, quality, and symmetry should reasonably correlate with enhanced movement and athletic performance (McGill, Andersen & Horne, 2012). A low-cost, user-friendly and relatively reliable tool, like the Functional Movement Screen (FMS™) has become a popular assessment instrument in the sport performance community (Parenteau et al., 2014; Onate et al., 2012; Smith et al., 2013). Number of professions from physiotherapist, coaches and trainers to research community have popularized usage of the FMS™ in prediction of injury risk and forecasting performance (Kraus et al., 2014). The FMS™ is used to assess mobility and stability within the kinetic chain, judgement of asymmetry, and identification of poor movement patterns (Cook, Burton & Hoogenboom, 2006a). However, available research infers that FMS™ test is controversial tool for functional movement interpretation. Multiple studies have showed substantial to excellent reliability (Parenteau et al., 2014; Onate et al., 2012; Smith et al., 2013). This seems to prevail despite the fact that many of the studies have had vast differences in their testing methods, training, test viewing methods, and even in the statistical analyses used to report the data (Kraus et al., 2014; Shultz et al., 2013). Few studies have examined the relationship of functional movements’ state and athletic performance (Chapman, Laymon & Arnold, 2014; Lockie et al., 2015). Nevertheless, the systematic review of tests outcome correlation with athletic performance suggest that the FMS is not a predictive indicator of athletic performance (Girard, Quigley & Helfst, 2016). At the same time, several critical and large systematic reviews and meta-analyses support the diagnostic accuracy of the FMS™ to predict injury (Dorrel et al., 2015). While at same time the different sports endure specific and repeated movement patterns and common overuse injuries, there is a lack of studies where athlete’s functional abilities and musculoskeletal adaptions from various sports are compared using FMS score.

In majority of research papers, classical statistics and arithmetic means are most popular data analysis approaches to interpret the FMS™ test results and explain movement deviations or describing weak links within movement of a kinematic chain. Contrary to popular belief, arithmetic means isn’t actually a thing. Having a group of data points the goal is to summarize them with fewer numbers, preferably a single number, then arithmetic mean is just one among many ways of arriving at an “average” value that is supposed to describe something in the vein of a typical case, a “summary statistics”, “measures of central tendency” or “measures of location”. There are many kinds of averages. Consequently, they should vary in utility. FMS™ test scores are essentially non-linear scaling factors of the measurements of actual physical movements in variable set of rules. Essentially – how much a subject deviated from a said ideal – greatly, moderately or minimally, i.e. 1-2-3 (Cook, Burton & Hoogenboom, 2006a, 2006b).

Scores on a scale from one (zero meaning pain on movement resulting in failure to complete movement) to three are essentially relational statements. Original FMS™ test scoring adds individual test results to a composite score (max: 21 = 7 exercise test times 3 points) as a predictor of a potential injury if the total score is below 14 (Cook, Burton & Hoogenboom, 2006a, 2006b). Conceptually this means that low test scores at the selected sites for testing of a kinematic chain reveal amounting weaknesses in the globally balanced system, and deterioration of the aggregate score informs of the risks of a harmful event.

Studies where either the total scores of FMS™ or the scores of distinct subtests are used for association analysis raises the question of selection of the proper population "average". For example if one is interested if there is a systematic effect from a particular field of sport on the FMS™ score, then the selection of a summary data point representing a typical case i.e. "the average" raises the question of a selection of justified reasoning behind an "average". That statistical model should also be appropriate for representing ratios as the scoring is essentially a relational statement as a deviation from a supposed ideal.

Based on the above we propose alternative approach to think about FMS™ testing to describe a multidimensional information space that includes potentially more information from sport related activities in addition to the injury risk. For the above concept state of the kinematic chain could be constructed as a multiplication product of FMS™ subtest scores. An average or typical case of which can be depicted using geometric mean.

Aim of current study was to represent data of FMS™ tests using traditional composite score and geometric means for the comparative investigation between several distinct fields of sport among competitive level young athletes.

MATERIAL AND METHODS

Participants

Participants of the current study were 212 young competitive athletes, 133 girls (age 17.35 ± 1,65, height 179,4 ± 1.65 cm, weight 72 ± 10 kg, BMI 22.3 ± 3) and 79 boys (age 17,78± 2.1, height 181 ±2.1, weight 74.2 ± 11, KMI 22.5 ± 2.7) from 8 fields of sport (volleyball, basketball, handball, fencing, judo, biathlon, cycling, soccer). Group sizes were between 9 (fencing) to 62 (basketball). All athletes had focused to performance sport and participated at least in national- level competitions. They had not any serious injuries in the past six months and were involved in regular training on average 6 times per week.

Procedure and measured parameters

The musculoskeletal status of athletes was evaluated with the FMS test package (Cook et al., 2014a, 2014b). Before FMS™ sub-tests participants performed 5 minutes warm up on riding ergometer and 5 minutes of light dynamic mobilization and activation exercises targeting the main muscle groups. All subjects were informed about the nature and study procedures and provided written informed consent. Ethical permission was provided for the study by the official ethics committee. Participants were screened using the standard protocol of the seven movement patterns: deep squat, hurdle step, in-line lunge, shoulder mobility, active straight leg raise, trunk stability push-up, and rotary stability (Cook et al., 2014a,2014b).

Participants performed three trials of each subtest. At least 3 attempts for all tests were captured by two computer-controlled HD cameras (frame rate 30 Hz) and saved for impending analysis. Recordings were analysed with video analysis software Kinovea 0.8.25 by an experienced (22 years of practice) physical therapist with 7 years of experience with the FMS™. Original FMS™ 21point scoring system (FMS21) was used for evaluation of athletes functional state (Cook et al., 2014a, 2014b).

Data analysis

Statistical analysis was conducted using composite FMS score and geometric mean of the test scores calculated per individual athlete. The descriptive statistic and coefficient of variation (STDEV/mean*100) were calculated for each group of athletes of different field of sports and gender. After testing for homogeneity of variance one - way analysis of variance was used for assessment if geometric mean of FMS™ sub tests scores from athletes of specific field of sport exhibit distinctive intergroup deviation. All statistical calculations were performed using SPSS version 25 (IBM, USA). The significance threshold was set at 95% ($p<0.05$).

RESULTS

The mean composite FMS™ score of young female athletes was 14.3±1.7 and for male's 13.8±1.6 out of possible 21 total point. Based of sport specificity the descriptive compositive items data for the FMS™ for girls are presented in table 1 and for boys in table 2.

Table 1. Young female athletes' descriptive data for the FMS™ composite score and geometric mean characteristics

Sport	N	FMS score		Geometric mean		
		Avr±SD	CoV (%)	Avr±SD		CoV (%)
Basketball	62	13.8 ± 1.8	12.9	1.92 ± 0.26	b.h	13.6
Biathlon	10	15.0 ± 1.6	10.9	2.09 ± 0.25	a	12.0
Fencing	9	14.6 ± 1.9	12.9	2.01 ± 0.29		14.6
Hand-ball	17	14.8 ± 1.6	10.6	2.05 ± 0.20	a	9.9
Judo	15	14.3 ± 1.8	12.3	1.95 ± 0.27		14.0
Volleyball	20	14.7 ± 1.2	8.3	2.02 ± 0.19		9.4
Total	133	14.3 ± 1.7	11.9	1.97 ± 0.25		12.7

Statistically significant (p<0.05) ANOVA differences between: a- basketball; b-biathlon; h-handball.

Table 2. Young male athletes' descriptive data for the FMS™ composite score and geometric mean characteristics

Sport	N	FMS score		Geometric mean		
		Avr±SD	CoV (%)	Avr±SD		CoV (%)
Biathlon	5	14.0 ± 0.0	0.0	1.90 ± 0.03		1.8
Cycling	19	14.5 ± 1.7	12.0	2.04 ± 0.26	h.j.v	12.8
Fencing	6	14.5 ± 1.5	10.5	2.04 ± 0.22	h	10.6
Hand-ball	11	12.7 ± 1.6	12.7	1.78 ± 0.21	c.f.s	11.7
Judo	8	13.3 ± 0.7	5.3	1.86 ± 0.19	c	10.3
Soccer	20	14.2 ± 1.5	10.8	1.96 ± 0.23	h	12.0
Volleyball	10	13.2 ± 1.5	11.2	1.87 ± 0.22	c	11.9
Total	79	13.8 ± 1.6	11.3	1.93 ± 0.23		12.1

Statistically significant (p<0.05) ANOVA difference between: c-cycling; f-fencing; h-handball; j-judo; s-Soccer; v-Volleyball.

The comparison of sport-specific geometric mean values among girls showed that basketball players had significantly lower results than athletes from biathlon and handball players. Contrarily among boys the handball players had lowest values, being significantly lower from in cyclists, fencers and soccer players.

Cyclists had also higher geometric mean values than volleyball players and judo athletes. Comparison of coefficients of variances between FMS composite scores and geometric mean based values demonstrated higher intra group variability using geometric means of the sub-scores.

DISCUSSION

The purpose of this study was to explore if specificity of a sport can be captured in FMS 21 scoring using for sub-score aggregation geometric means. According to the function of the original scoring study population was relatively homogenous, alas on the lower acceptable threshold of 14 points. A lower score than 14 points on the original FMS™ scoring using total sum of sub-scores has been shown to reflect predisposing circumstances for injury among young athletes comparable to current study population.

We found that original 21 point scoring did not differentiate between fields of sport. On the other hand the composite score calculated as geometric mean differentiated a few sports, as well as demonstrated higher variability. ANOVA analysis using geometric means highlighted differences (see Tables 1 and 2) that also were seemingly meaningful based on the subjective interpretation from people with personal experience of individual athletes. While this remains as a speculation at the current stage, the circumstances and logic of using geometric means encourages further study of the topic.

Performance of the kinematic chain that the FMS test examines is fundamentally closer to a multiplicative product instead of a sum of the distinct parts that the subtests assess. Accordingly, the FMS subtests reflect parts of kinematic chain that extend functionally in various modes and reach to each other. That is the essence of a “chain” used for the portrayal. The ratio of the scores of subtests to each other should depict this shared functionality. Without knowing the extent and variability of the supposed commonality between subtests one can hypothesize that the average of this measure might convey useful information. The question can be expressed as “what is the rate that all the rates would have to be if they were the same and produced the same expected outcome?” For example what is the rate between two FMS test subtest that differentiate basketball players from a representative judoka?

Potentially a different set of subtest exercises may have a higher informational value regarding specificity of a sport while retaining already accepted utility of warning of injury risks. It could be that for some sports the injury risk needs to be adjusted, suggesting that the same score bears a different degree of risk and also a type of potential injury.

CONCLUSIONS

The results of this study may influence the examination of the functional motion screen as a testing tool and the interpretation of the results. The study findings indicate to potentially meaningful differences in total FMS score depending on the sport. In the future detailed analysis of the structure of differences is needed to highlight the specific causes and hypothetical sport specific detrimental effect on the kinematic chain impacting FMS scoring using geometric means.

REFERENCES

Aquino, R., Puggina, E. F., Alves, I. S., & Garganta, J. (2017). Skill-related performance in soccer: A systematic review. Human Movement, 18(5), 3-24. https://doi.org/10.1515/humo-2017-0042

Chaabene, H., Negra, Y., Bouguezzi, R., Capranica, L., Franchini, E., Prieske, O., ... & Granacher, U. (2018). Tests for the assessment of sport-specific performance in Olympic combat sports: a systematic review with practical recommendations. Frontiers in physiology, 9, 386. https://doi.org/10.3389/fphys.2018.00386

Chapman, R. F., Laymon, A. S., & Arnold, T. (2014). Functional movement scores and longitudinal performance outcomes in elite track and field athletes. International journal of sports physiology and performance, 9(2), 203-211. https://doi.org/10.1123/ijspp.2012-0329

Cook, G., Burton, L., & Hoogenboom, B. (2006a). Pre-participation screening: the use of fundamental movements as an assessment of function–part 1. North American journal of sports physical therapy: NAJSPT, 1(2), 62.

Cook, G., Burton, L., & Hoogenboom, B. (2006b). Pre-participation screening: The use of fundamental movements as an assessment of function–Part 2. North American journal of sports physical therapy: NAJSPT, 1(3), 132.

Cook, G., Burton, L., Hoogenboom, B. J., & Voight, M. (2014a). Functional movement screening: the use of fundamental movements as an assessment of function-part 1. International journal of sports physical therapy, 9(3), 396.

Cook, G., Burton, L., Hoogenboom, B. J., & Voight, M. (2014b). Functional movement screening: the use of fundamental movements as an assessment of function-part 2. International journal of sports physical therapy, 9(4), 549.

Dorrel, B. S., Long, T., Shaffer, S., & Myer, G. D. (2015). Evaluation of the functional movement screen as an injury prediction tool among active adult populations: a systematic review and meta-analysis. Sports health, 7(6), 532-537. https://doi.org/10.1177/1941738115607445

Girard, J., Quigley, M., & Helfst, F. (2016). Does the functional movement screen correlate with athletic performance? A systematic review. Physical Therapy Reviews, 21(2), 83-90. https://doi.org/10.1080/10833196.2016.1227568

Hickey, J. N., Barrett, B. A., Butler, R. J., Kiesel, K. B., & Plisky, P. J. (2010). Reliability of the Functional Movement Screen Using a 100-point Grading Scale: 1765Board# 202 June 2 2: 00 PM-3: 30 PM. Medicine & Science in Sports & Exercise, 42(5), 392. https://doi.org/10.1249/01.mss.0000384722.43132.49

Kiesel, K., Plisky, P. J., & Voight, M. L. (2007). Can serious injury in professional football be predicted by a preseason functional movement screen?. North American journal of sports physical therapy: NAJSPT, 2(3), 147.

Kraus, K., Doyscher, R., & Schüt, E. (2015). Methodological Item Analysis of the Functional Movement Screen. German Journal of Sports Medicine/Deutsche Zeitschrift fur Sportmedizin, 66(10). https://doi.org/10.5960/dzsm.2015.199

Kraus, K., Schütz, E., Taylor, W. R., & Doyscher, R. (2014). Efficacy of the functional movement screen: a review. The Journal of Strength & Conditioning Research, 28(12), 3571-3584. https://doi.org/10.1519/jsc.0000000000000556

Lockie, R. G., Schultz, A. B., Callaghan, S. J., Jordan, C. A., Luczo, T. M., & Jeffriess, M. D. (2015). A preliminary investigation into the relationship between functional movement screen scores and athletic physical performance in female team sport athletes. Biology of sport, 32(1), 41. https://doi.org/10.5604/20831862.1127281

McGill, S. M., Andersen, J. T., & Horne, A. D. (2012). Predicting performance and injury resilience from movement quality and fitness scores in a basketball team over 2 years. The Journal of Strength & Conditioning Research, 26(7), 1731-1739. https://doi.org/10.1519/jsc.0b013e3182576a76

Onate, J. A., Dewey, T., Kollock, R. O., Thomas, K. S., Van Lunen, B. L., DeMaio, M., & Ringleb, S. I. (2012). Real-time intersession and interrater reliability of the functional movement screen. The

Journal of Strength & Conditioning Research, 26(2), 408-415. https://doi.org/10.1519/jsc.0b013e318220e6fa
Parenteau-G, E., Gaudreault, N., Chambers, S., Boisvert, C., Grenier, A., Gagné, G., & Balg, F. (2014). Functional movement screen test: A reliable screening test for young elite ice hockey players. Physical Therapy in Sport, 15(3), 169-175. https://doi.org/10.1016/j.ptsp.2013.10.001
Pelot, T. & Darmiento, A. (2013). The FMS Screen and its Relevance within Elite Sport Performance. Olympic Coach;Winter, Vol. 24 Issue 1, p27.
Robertson, S. J., Burnett, A. F., & Cochrane, J. (2014). Tests examining skill outcomes in sport: a systematic review of measurement properties and feasibility. Sports Medicine, 44(4), 501-518. https://doi.org/10.1007/s40279-013-0131-0
Shultz, R., Anderson, S. C., Matheson, G. O., Marcello, B., & Besier, T. (2013). Test-retest and interrater reliability of the functional movement screen. Journal of athletic training, 48(3), 331-336. https://doi.org/10.4085/1062-6050-48.2.11
Smith, C. A., Chimera, N. J., Wright, N. J., & Warren, M. (2013). Interrater and intrarater reliability of the functional movement screen. The Journal of Strength & Conditioning Research, 27(4), 982-987. https://doi.org/10.1519/jsc.0b013e3182606df2
Smith, D. J. (2003). A framework for understanding the training process leading to elite performance. Sports medicine, 33(15), 1103-1126. https://doi.org/10.2165/00007256-200333150-00003