Intra and Inter-Rater Reliability of the Golf Movement Screen (GMS)

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ABSTRACT

The aim of the study was to determine the intra- and inter-rater reliability of the golf movement screen (GMS). The GMS consists of 10 tests, which are assessed by rating a number of body segments specific to each movement. Intra-rater reliability was performed by an experienced rater assessing a sample of twenty golfers aged 12-18 years old who were part of a National High Performance Golf Program. For the inter-rater analysis, one experienced and three novice raters examined the videos of ten golfers of varying ability preforming the GMS, and were asked to rate their movement competency. The sum of all ten movements provides the total GMS score (0-93) which had good intra- and inter-rater reliability with ICC = 0.94 in both cases. The total score of each test included in the GMS achieved good intra-rater reliability (ICC = 0.76 – 0.94), with nine out of the ten achieving good inter-rater reliability (ICC > 0.75). Average kappa values for the intra-rater analysis for each body segment demonstrated moderate to very good reliability across the GMS (k = 0.4-0.84); however, the inter-rater reliability reported for most of the segments was only fair (k = 0.20-0.37). The GMS has good levels of total score and total exercise score reliability when examined by both experienced and novice raters. An experienced rater can reliably use total score, total exercise score and body segment scores; whereas, novice raters should use body segment scoring with caution.

INTRODUCTION

The aim of a movement screen is to identify functional movement deficits that may predict performance limitations or injury risk (Africa & Kidd, 2013; Barnett et al., 2015; Cook, Burton, & Hoogenboom, 2014; Frohm, Heijne, Kowalski, Svensson, & Myklebust, 2012; Kritz, 2012). Previously, the functional movement screen (FMS) has shown to be related to sprint, jump and agility performance (Lloyd et al., 2015), while the tuck jump test has been shown to be predictive of ACL injury risk (Myer, Ford and Hewett, 2008). While generic movement screens provide a valuable insight into an individual's fundamental movement quality (Cook, 2010; Kritz, 2012), the varying demands and movement profiles of different sports dictate that specific screens may also be required to increase sensitivity in the detection of aberrant mechanics that will limit sports performance. Additionally, there appears to be a lack of evidence that supports movement screens can predict performance or injury within specific sports. Golf is a sport that requires mobility and stability, high levels of postural awareness and the ability to rotate efficiently to allow effective transfer of force along the kinetic chain (Sprigings & Neal, 2000). Despite the bespoke movement patterns inherent to the sport, a reliable golf specific movement screen does not currently exist.

A range of movement screens with a variety of rating systems have been developed for specific purposes. These include: assessment of movements that are rated as a whole movement across a range of exercises (Barnett et al., 2015; Cook et al., 2014); a range of movements that rate individual body segments independently (Kritz, Cronin, & Hume, 2009a; Kritz, Cronin, & Hume, 2009b); single movements that are rated in-depth, such as tuck jumps and the back squat (Myer, et al., 2014; Myer, Ford, & Hewett, 2008); and screens for use in specific sports or with certain populations (Gulgin, Schulte, & Crawley, 2014; Kazman, Galecki, Lisman, Deuster, & O'Connor, 2014; Loudon, Parkerson-Mitchell, Hildebrand, & Teague, 2014). However, the screens that currently exist do not meet the demands of golf as the exercises selected are not appropriate or the rating system is too broad. Therefore, a golf specific movement screen that has golf relevant test and a thorough rating system is needed.

Within the available literature, the FMS has been most widely examined (e.g Cook et al., 2014; Gribble, Brigle, Pietrosimone, Pfile, & Webster, 2013; Kazman, Galecki, Lisman, Deuster, & O'Connor, 2014; Loudon et al., 2014), likely due to its ease of administration and time efficiency. The aim of the FMS is to examine multiple movements that place individuals in extreme positions where weaknesses and imbalances can be identified if mobility and stability is not optimal (Cook et al., 2014). The screen examines seven fundamental movements, scoring each on a scale of 0-3 based on the individual's performance against a specified set of criteria. The scores from each test are then added together to provide a composite score, where a total of 21 is the maximum attainable. While existing screens have shown to have good reliability, there appears to be a lack of evidence that supports golf-specific screens to be reliable.

To the authors knowledge there is currently only one golf specific movement screen in existence, which has been developed by the Titleist Performance Institute (TPI). The TPI screen includes a mix of general and golf-specific movements that are deemed to be relevant to golf, which can be interpreted by both technical and strength and conditioning coaches. Authors identified that three of the 13 exercises included in the screen are related to deficits identified during the golf swing (overhead squat, bridging, single leg balance) (Gulgin et al., 2014). While a number of movement tests within the TPI screen relates specifically to golf performance, the reliability of the screen has not been reported.

The Golf Movement Screen (GMS) has adopted a similar approach to the TPI screen because it has been developed to examine particularly relevant movements for golf. Chimera and Warren (2016) have suggested movement screens need to be developed by collaboration between clinicians, practitioners and researchers. The GMS was developed by the primary author (and experienced rater) in conjunction with clinical and academic experts and had been used and adapted through work with a professional golf union (novice raters had no experience using the screen and no association with the golf union). The screen consists of several tests that adopt movement planes and movement patterns that are specific to the golf. For example, seated thoracic rotation simulate the movement of the spine during a golf shot and rotation over fixed foot simulate movements of the hip during a golf shot. Also, tests included in other screens, which are also within the GMS, have previously been linked to golf performance. Parchmann et al., (2011) found that 1 RM on the squat test has been linked to swing speed. Gulgrin et al., (2014) identified that poor squat mechanics have been associated with technical deficiencies in the golf swing. Furthermore, many of the tests are fundamental to strength and conditioning, including an overhead squat (Kritz, Cronin, & Hume, 2009; Myer, et al., 2014) and lunge (Kritz, et al., 2009). In the GMS, the rating system includes an assessment of body segments that are important to each test that are rated as a pass or fail. This approach has been used in previous screens (Kritz, 2012; Lubans, Smith, Harries, Barnett, & Faigenbaum, 2014; Myer, et al., 2014). A score of 1 is given to the body segment if it meets the descriptive criteria and 0 score is given for segments that do not meet the criteria. Scores for each segment are summed to provide a total score for each movement, which in turn are summed to provide a total GMS score. This approach allows limitations for movement competency to be identified from a global perspective, for each movement, and for each contributing body segment, which can inform strength and conditioning coaches with the use of coaching ques or relevant exercise prescription. However, before the GMS can be tested for its validity the reliability must be established. Therefore, the aim of the present study was to assess both the intra- and inter-rater reliability of the GMS.

METHOD

Experimental Approach to the Problem

Intra-rater reliability was determined by the same experienced rater who is the developer of the screen; collected and examining the videos of twenty high level golfers on two separate occasions. Video analysis was conducted to eliminate the learning effect of participants and to focus only on the reliability of raters. The first and second trials were conducted seven days apart in order to ensure the rater had no preconceived memory of previous scores (Gribble et al., 2013). To assess inter-rater reliability, a total of four raters were used; the same experienced rater and three further novice raters who were strength and conditioning coaches who had previous experience with movement screening but no prior knowledge of the GMS. The experienced rater provided all training to novice raters. The novice raters received one individual practical training session that lasted one hour; this session involved reviewing examples of good and poor movements for each exercise. In total, raters assessed ten participants from the video resources collected during the intra-rater reliability analysis. Ten videos were chosen to reflect a full range of movement competency across the sample, testing the raters on both good and bad movements.

Subjects

Twelve male and eight female golfers in an Elite National Program participated in the study. The mean handicap was 4.25 and ranged between +1 and 17. The age of the participants ranged from 12-18 years old (15.1 ± 1.7). Ten participants from the intra-rater reliability sample were used for the inter-rater reliability study. Ethical approval was granted by the institutional ethics committee in accordance with the declaration of Helsinki.

Golf Movement Screen protocol

The GMS was designed to analyze movements that simulate some of the important motions that are involved during a golf swing (e.g. seated thoracic rotation and rotation over fixed foot), and movements believed to represent general physical qualities fundamental to strength and conditioning (e.g. squat, lunge and core control) that have the potential to influence golf performance (Parchmann et al., 2011; Gulgrin et al., 2014). A full copy of the screening document with description of the criteria for each individual component is included (**Supplementary File**). The GMS includes 10 tests, with a number of body segments to be independently rated in each exercise. Each segment is rated on a pass (1) /fail (0) basis. This approach has been used in other screens including the movement competency screen (Kritz, 2012); resistance training skills battery (RTSB) (Lubans et al., 2014); back squat assessment (Myer, et al., 2014); and the tuck jump assessment (Myer et al., 2008). Each exercise within the GMS has a different number of body segments rated dependent on the requirements of the movement (see supplemental digital content and table 1). Body segment scores are added together to give an overall score for each exercise and the scores for each exercise are then summed to provide a composite score for the GMS. The range in total exercise score is 4 to 18 depending on the number of body segments rated in each test. Administering the screen takes 20 minutes per participant. An electronic tablet was used to record scoring of the GMS (iPad mini, Apple, USA).

Prior to conducting the screen, participants were given a correct demonstration of each exercise along with a verbal explanation, but were not allowed to practice the movements. Two cameras (Sony video camera, Sony Cyber Shot) were placed in both sagittal and frontal positions, to the closest possible distance that allowed the full movement to be captured. Similar to the back squat assessment (Myer, et al., 2014), in order for each segment to be assessed, the individual was required to perform a total number of repetitions equivalent to the number of body segments to be rated. For example, the seated hamstring had two segments to be rated from the sagittal position, followed by four from the frontal position. Therefore, the individual was required to perform two repetitions on the left leg and two repetitions on the right leg, which is videoed from the frontal position. The individual rested for 30 seconds between sets. A second video was then recorded from the sagittal position; the participant will perform four reps on the left leg, then four on the right leg. Therefore, the participant will complete a total of 12 repetitions. The rater assessed each repetition independently on each individual component (e.g. the first repetition concentrated on foot position, while the second repetition focused on hip pressure). Pilot testing showed rotational tests were more difficult to rate as a single observation provided total score reliability of ICC=0.67 in the thoracic rotation and ICC= 0.68, which improved to ICC=0.88 in both tests with a repeated rating. Therefore, only the thoracic rotation and rotation over fixed foot were rated twice to obtain agreement and a single score.

Table 1. Position of rating and number of body segments to be rated in each test of the GMS

Test	Frontal	Frontal	Sagittal	Sagittal	Total

	Left	Right	Left	Right	
Trunk Inclination	N/A	N/A	*4	*4	4*
Seated Hamstring	2	2	4	4	12
Seated thoracic Rotation	3	3	4	4	14
Rotation over fixed foot	5	5	N/A	N/A	10
Mini Squat	N/A	N/A	*5	*5	5*
Lunge	5	5	4	4	18
Over head squat	*3	*3	*5	*5	8*
Basic Balance	4	4	N/A	N/A	8
Diamonds	(Above) 3	(Above) 3	1	1	8
Side planks	3	3	N/A	N/A	6
Total					**93**

Reliability procedures

Intra-rater reliability was determined from video recordings of 20 participants completing the GMS. Each video was rated twice, separated by one week. Inter-rater reliability was conducted following an initial training session for raters to become familiar with the screen. Raters then followed instructions detailing the pass/fail descriptors for each individual component. Each individual rater then assessed the same 10 participants selected from the video resource on one occasion, within one week of training. The samples were selected to reflect scores across a full range of GMS competency.

Statistical Analysis

To examine the reliability of the GMS a number of statistical measures were adopted. Intraclass correlation coefficients (ICC) were used to determine the reliability of the total GMS score and reliability of the total score of independent tests (Frohm et al., 2012; Gribble et al., 2013; Onate et al., 2012; Teyhen et al., 2012). Reliability of total exercise score and total GMS score were based on ICC thresholds of; >0.75 considered good reliability, 0.50-0.74 considered moderate reliability, and <0.50 indicated poor reliability (Teyhan et al., 2012). ICC analysis were calculated using SPSS (V.18 for Windows). Percent agreement and unweighted kappa analysis was used on the non-parametric binary data (pass/fail) to determine the reliability of body segment rating within the GMS, similar to previous studies (Loudon et al., 2014; Minick et al., 2010; Teyhen et al., 2012). The kappa statistic adjusts for the likelihood that agreement can occur purely by chance. Kappa values were interpreted as follows: <0.00 poor, 0.0-0.20 slight, 0.21-0.4 fair, 0.41-0.6 moderate, 0.61-0.8 substantial and >0.81-1.0 almost perfect (Landis and Koch, 1977). Average kappa values were calculated across all the segments that contribute to each exercise.

RESULTS

Both inter- and intra-rater reliability of the total GMS score was good with an ICC = 0.94. Intra-rater analysis showed all tests had good reliability (ICC range = 0.75-94), while the inter-rater analysis indicated good reliability in nine of the 10 tests (Figure 1). The side plank was the only screening test that showed poor inter-rater reliability (ICC=0.17).

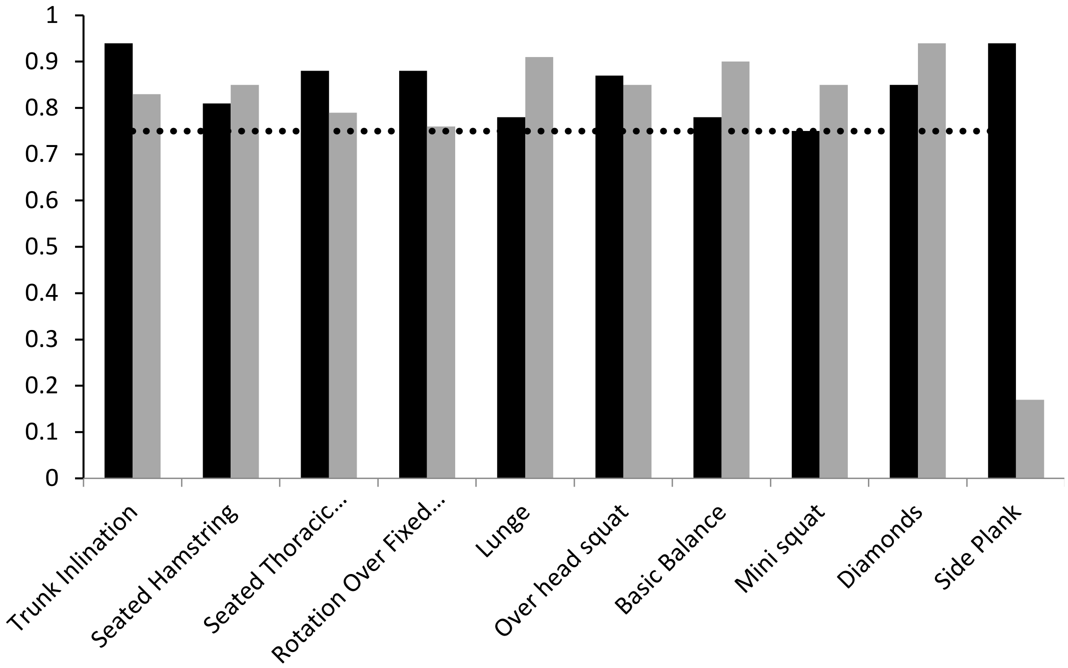

Figure 1. Intra (black) & inter-rater (grey) intra-class correlation coefficients of the reliability of total scores for each test of the golf movement screen. Dash line represents the threshold line for good reliability.

Table 2 displays the average kappa values, indicating that intra-rater reliability was almost perfect for one exercise (k = 0.84), substantial for four movements (k = 0.61-0.75), and moderate for five tests (k = 0.4-0.54). Average kappa values showed inter-rater reliability to be moderate in two tests (k = 0.46-0.48), fair in five (k = 0.2-0.37) and fair in three exercise (k = 0.07-0.2). Intra-rater kappa frequency counts across 93 body segments that were assessed in all movements revealed that just under half (43/93) of the components had substantial or almost perfect reliability. Only 11 of the components were rated poor (3) or slight (8), with all of the remaining items showing fair (15) to moderate reliability (24). The inter-rater kappa frequency count found 36 of the segment ratings to have poor to slight reliability with the remaining 57 displaying fair to almost perfect reliability.

Table 2. Intra- and inter-rater kappa reliability and percent agreement of individual items within each test.

Test	Percent agreement Average %		Percent agreement Range %		Kappa Average		Kappa Range	
	Intra	Inter	Intra	Inter	Intra	Inter	Intra	Inter
Trunk Inclination	91	73	85-95	30-100	0.84	0.48	0.69- 0.99	-0.3-1.00
Seated Hamstring	84	68	65-100	20-100	0.54	0.28	0.21-0.86	-0.32-1.00
Thoracic Rotation	72	69	65-90	0-100	0.40	0.20	-0.53- 0.89	-0.2-1.00
Rotation over fixed foot	90	63	70-100	10-100	0.48	0.24	-0.53-1	0.18-1.00
Mini squat	86	68	80-95	10-100	0.61	0.20	0.44-0.83	-0.30-1.00
Lunge	81	66	55-100	20-100	0.50	0.23	0.1-1	-0.36-1.00
Overhead squat	89	69	75-100	30-100	0.75	0.30	0.5-1	-0.30-1.00
Basic Balance	85	71	70-100	50-100	0.64	0.37	0.14-1	-0.18-1.00
Diamonds	91	72	80-100	0-100	0.66	0.46	0-0.79	0.00-1.00
Side plank	89	75	75-100	40-100	0.66	0.07	0.35-1	-0.15-0.78

DISCUSSION

The aim of the study was to examine intra- and inter-rater reliability of the golf movement screen (GMS). Total GMS score showed good intra- and inter-rater reliability. Intra-rater analysis indicated all ten tests to have good total score reliability, while nine of the 10 tests had good inter-rater reliability. Tests that are novel to the GMS and that have not been included in other screens, which include rotation over fixed foot, basic balance, mini squat and diamonds, were all found to have good intra- and inter-rater reliability for total score. Rating of individual components showed under 50% of segments showed substantial to almost perfect reliability when the same experienced rater was used. Kappa values indicated lower levels of reliability for the inter-rater reliability of novice raters. Overall the results indicate that total GMS and total exercise score have good intra- and inter-rater reliability. Experienced raters can reliably administer assessment of body segments; however, those who are inexperienced should interpret body segment scores with caution.

Total GMS score showed good intra-rater reliability, which compares favorably to other reliability studies utilizing different movement screens (Kritz, 2012; Lubans et al., 2014; Myer, et al., 2014; Teyhen et al., 2012). Intra-rater reliability of the FMS total score has been reported to range from 0.74-0.98 (Frohm et al., 2012; Onate et al., 2012; Shultz, Anderson, Matheson, Marcello, & Besier, 2013; Smith, Chimera, Wright, & Warren, 2013; Teyhen et al., 2012), highlighting moderate to good levels of reliability. Additionally, good total score (ICC=0.88) re-test reliability has been reported previously in the RTSB using a population of secondary school children (Lubans et al., 2014). These data indicate that the GMS displays similar total score intra-rater reliability to the FMS and RTSB. Good reliability of total GMS score was also observed in the inter-rater analysis, suggesting that both experienced and novice raters can use the screen to provide an accurate composite score for players of different levels. This is in accordance with existing research examining the inter-rater reliability of FMS total score (ICC=0.76-0.92) (Frohm et al., 2012; Leeder, Horsley, & Herrington, 2016; Onate et al., 2012; Smith et al., 2013; Teyhen et al., 2012). Comparisons to other screens that also include a composite score such as the movement competency screen (Kritz, 2012) and back squat assessment (Myer, et al., 2014) are problematic, as the reliability of those screens has not been reported. Based on the findings of the current study, GMS total score can be reliably screened in golf athletes by both experienced and novice raters.

It was important to investigate the reliability of independent movements within the GMS as they may be used to guide subsequent exercise interventions. Nearly all tests screened within the GMS display good intra- and inter-rater reliability for total score. Other movement screens including several tests such as the RTSB have shown that four of the seven tests can be assessed with good levels of reliability while three were fair to good (Lubans et al., 2014). An examination of a screening battery comprising nine tests and found that only one exercise could be rated with good total score reliability, with the remaining eight ranging from poor to good (ICC=0.30-0.74) (Frohm et al., 2012). It was suggested that the grading criteria within the screen was not clear enough for the more complex tests such as the single leg squat and the diagonal lift test (Frohm et al., 2012). Taking these findings into account, the results of the current study indicate that total GMS score and the majority of total exercise score are reliable for both experienced and non-experienced raters. Furthermore, as a number of these tests are novel and are designed to simulate movement characteristics relevant to the sound execution of a golf swing, practitioners may wish to consider their inclusion as part of a test battery to screen golfers for movement proficiency.

The only exercise that fell below the good threshold of ICC ≥ 0.75 was the side plank for the inter-rater analysis. It is not clear why inter-rater reliability of the plank was so poor, but this may be due to the rating of a static exercise making it difficult for raters to consistently identify deficits, which become more obvious with movement. The poor inter-rater reliability of the side plank in the GMS needs to be considered when comparing results across raters. Time to fatigue in a side plank hold which is a test of muscle endurance, has been shown to have good reliability (McGill, Childs, & Liebenson, 1999). However, when measuring movement of the side plank within the GMS the levels of reliability have shown to be poor. It may be suggested that clearer grading criteria are needed to allow novice raters to reliably screen the side plank.

When designing the movement competency screening, Kritz, (2012) stated the importance of including body segment measures in order to provide more insight to identify faults in gross movements and to further direct exercise prescription. Although a range of screens within the available literature include the rating of body segments to provide a total score (Kritz, 2012; Lubans et al., 2014; Myer, et al., 2014; Myer et al., 2008), the reliability of these individual components has often not been reported (Gribble et al., 2013; Onate et al., 2012; Teyhen et al., 2012). The current study examined the reliability of body segment analysis within each exercise, the majority of finding showed substantial to almost perfect levels of intra-rater reliability. Conversely, inter-rater reliability showed a number of items to only be poor to slight. It has been suggested that experience plays a role in the reliability of an individual to accurately rate movement competency (Gribble et al., 2013) and it has been reported that practitioners with a minimum of six months experience record the strongest levels of reliability in comparison to less experienced raters (Gribble et al., 2013). Therefore, it could be suggested that individuals using the GMS should first gain suitable experience and regularly use the screening process in order to enhance the reliability of measurement. Raters should also establish their own reliability when administering the screen. Given the present study has confirmed the reliability of the GMS future research should establish the validity and usefulness of the GMS by examining how it related to injury and performance in golf.

Lastly, the GMS screen provides a starting point to examine the movement competency of golfers as the screen proves to be reliable amongst experienced and novice raters. However, it would be advised that each rater establishes their own reliability prior to using the screen. Additionally, this should be an ongoing process for any individual using the screen. Although this research has determined the reliability of the GMS future work is needed to establish the validity of the screen. Furthermore, although the screen only takes 20 minutes to administrate, practitioners could choose to select movements they think are most relevant rather than performing the entire screen.

PRACTICAL APPLICATIONS

As a result of this research it can be put forward that developer and experienced raters can reliably use total GMS score, total exercise score and individual components when screening golfers. Novice raters should be cautious when using body segments rating to guide prescription. Although the intra-rater reliability demonstrated good levels of reliability it would be suggested that both experienced and novice raters should establish their own intra-rater reliability before using the screen, and then on an ongoing basis as more experience is accumulated. Practically, the screen should be used to guide Strength and Conditioning coaches by using total GMS score to give a general overview of the movement competency of golfers. Furthermore, total score for each exercise can be used to rate movement ability in golf specific tasks, and this information can inform strength and conditioning coaches and future exercise prescription. Lastly, body segment analysis can be used to identify specific limitations and compensation strategies during movements relevant to golf.

REFERENCES

Africa, E. K., & Kidd, M. (2013). Reliability of the-Teen Risk Screen: a Movement Skill Screening Checklist for Teachers. *South African Journal for Research in Sport Physical Education and Recreation*, *35*(1), 1–10.

Barnett, L., Reynolds, J., Faigenbaum, A. D., Smith, J. J., Harries, S., & Lubans, D. R. (2015). Rater agreement of a test battery designed to assess adolescents' resistance training skill competency. *Journal of Science and Medicine in Sport*, *18*(1), 72–76.

Cook, G., Burton, L., & Hoogenboom, B. J. (2014). Functional Movement Screening : The Use of Fundamental Movements as an Assssment of Function- Part 2. *International Journal of Sports Physical Therapy*, *9*(4), 549–563.

Chimer N. J. and Warren M. (2016) Use of clinical movement screening tests to predict injury in sport. *World Journal of Orthopedics*. 18; 7(4): 202–217.

Frohm, A., Heijne, A., Kowalski, J., Svensson, P., & Myklebust, G. (2012). A nine-test screening battery for athletes: A reliability study. *Scandinavian Journal of Medicine and Science in Sports*, *22*(3), 306–315.

Gribble, P. A., Brigle, J., Pietrosimone, B. G., Pfile, K. R., & Webster, K. A. (2013). Intrarater reliability of the functional movement screen. *Journal of Strength and Conditioning Research / National Strength & Conditioning Association*, *27*(4),

Gulgin, H. R., Schulte, B. C., & Crawley, A. A. (2014). Correlation of Titleist Performance Institute (TPI) level 1 movement screens and golf swing faults. *Journal of Strength and Conditioning Research*, *28*(2), 534–539.

Kazman, JB, Galecki, JM, Lisman, P, Deuster, PA, and O'Connor, F. (2014). Factor structure of the functional movement screen in Marine officer candidates, *28*(1999), 672–678.

Kritz, M. (2012). *Development, reliability and effectiveness of the Movement Competency Screen (MCS)* PhD Thesis. AUT University. Available at: http://aut.researchgateway.ac.nz/bitstream/handle/10292/4670/KritzM.pdf ?sequence=3 (accessed: January 2014).

Kritz, M., Cronin, J., & Hume, P. (2009a). The Bodyweight Squat: A Movement Screen for the Squat Pattern. *Strength and Conditioning Journal*, *31*(1), 76–85.

Kritz, M., Cronin, J., & Hume, P. (2009b). Using the body weight forward lunge to screen an athlete's lunge pattern. *Strength & Conditioning Journal*, *31*(6), 15–24.

Landis, J.R., Koch, G.G. (1977). "The measurement of observer agreement for categorical data". *Biometrics*. **33** (1): 159–174.

Leeder, J. E., Horsley, I. G., & Herrington, L. C. (2016). The Inter-rater Reliability of the Functional Movement Screen Within an Athletic Population Using Untrained Raters. *Journal of Strength and Conditioning Research / National Strength & Conditioning Association*, *30*(9), 2591–9.

Loudon, J. K., Parkerson-Mitchell, A. J., Hildebrand, L. D., & Teague, C. (2014). Functional movement screen scores in a group of running athletes. *Journal of Strength and Conditioning Research*, *28*(4), 909–13.

Lloyd, R.S, Oliver, J.L, Radnor, J.M., Rhodes, B.C., Faigenbaum, A.D. and Myer, G.D. (2015) Relationships between functional movement screen scores, maturation and physical performance in young soccer players. *Journal of Sports Sciences*, 33 (1); 11–19.

Lubans, D. R., Smith, J. J., Harries, S. K., Barnett, L. M., & Faigenbaum, A. D. (2014). Development, test-retest reliability, and construct validity of the resistance training skills battery. *Journal of Strength and Conditioning Research / National Strength & Conditioning Association*, *28*(5), 1373–80.

McGill, S. M., Childs, A., & Liebenson, C. (1999). Endurance times for low back stabilization exercises: Clinical targets for testing and training from a normal database. *Archives of Physical Medicine and Rehabilitation*, *80*(8), 941–944.

Minick, K. I., Kiesel, K. B., Burton, L., Taylor, A., Plisky, P., & Butler, R. J. (2010). Interrater reliability of the functional movement screen. *Journal of Strength and Conditioning Research*, *24*(2), 479–486.

Myer, G. D., Cscs, D., Kushner, A. M., Brent, J. L., Schoenfeld, B. J., & Hugentobler, J. (2014). The Back Squat : A Proposed Assessment of Functional Deficits and Technical Factors That Limit Performance, *36*(6), 4–27.

Myer, G. D., Ford, K. R., & Hewett, T. E. (2008). Tuck Jump Assessment for Reducing Anterior Cruciate Ligament Injury Risk. *Athletic Therapy Today : The Journal for Sports Health Care Professionals*, *13*(5), 39–44.

Myer, G. D., Kushner, A. M., Brent, J. L., Schoenfeld, B. J., Hugentobler, J., Lloyd, R. S., … Hugentobler, J. (2014). The Back Squat : A Proposed Assessment of Functional Deficits and Technical Factors That Limit Performance. *Strength & Conditioning Journal, 36*(6), 4–27.

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. *Journal of Strength and Conditioning Research*, *26*(2), 408–415.

Parchmann, C. J., & McBride, J. M. (2011). Relationship between functional movement screen and athletic performance. *Journal of Strength and Conditioning Research*, *25*(12), 3378–84.

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.

Smith, C. A., Chimera, N. J., Wright, N. J., & Warren, M. (2013). Interrater and intrarater reliability of the functional movement screen. *Journal of Strength and Conditioning Research / National Strength & Conditioning Association*, *27*(4), 982–987.

Sprigings, E. J., & Neal, R. J. (2000). An insight into the importance of wrist torque in driving the golfball: A simulation study. *Journal of Applied Biomechanics*, *16*(4), 356–366.

Teyhen, D. S., Shaffer, S. W., Lorenson, C. L., Halfpap, J. P., Donofry, D. F., Walker, M. J., … Childs, J. D. (2012). The Functional Movement Screen: a reliability study. *The Journal of Orthopaedic and Sports Physical Therapy*, *42*(6), 530–40.