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Relationship Between Functional Movement Screen, Lower Quarter Y-Balance Test and Physical Performance Tests in Athletes

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Abstract

Context: The Functional Movement Screen (FMS) and lower quarter Y-Balance Test (LQ-YBT) are examples of functional screening tools used to identify physical dysfunction or functional asymmetries. Limitations in flexibility, agility and power may also have negative consequences on performance in fundamental movements in sport. Due to the time constraints of physical therapists and athletic trainers providing care towards athletes during rehabilitation and treatment hours, it is not possible to perform multiple screening tests/tools prior to an athletic season to determine if athletes have poor mobility and fundamental movements that may alter sport performance. Understanding associations between movement performance and global screening tools (FMS and LQ-YBT) could provide a foundation for prevention programs and performance enhancement for athletes. Therefore, this study was performed to identify how FMS composite score and LQ-YBT relate to the measures of physical performance (flexibility, agility, and jump) in athletes. **Settings and Design:** A Cross-sectional study conducted on university athletes. **Methods and Material:** Demographic and Anthropometric data of 50 athletes (32 males,18 females) in the age group of 18 – 30 years were collected at the beginning of the test after obtaining informed consent. The seven FMS tasks, LQ-YBT, Sit and Reach Test, ProAgility Test and Standing Long Jump were performed sequentially in the order. A total of 3 trials were performed in each test and the average of three trials were recorded for statistical analysis. **Statistical analysis used:** Pearson correlation was used to assess the association between FMS C.S, LQ-YBT and other physical performance measures and $p < 0.05$ was utilized for statistical significance. **Results:** FMS CS and LQ-YBT showed significant positive correlation with standing long jump performance ($p<0.05$) but not with agility. LQ-YBT correlated significantly with sit and reach test ($p<0.05$). **Conclusions:** In athletes, the observed significant correlation between the FMS composite score (FMS CS) and the Lower Quarter Y Balance Test (LQ-YBT) with standing long jump performance suggests their potential utility in predicting jump capabilities. However, their lack of correlation with agility indicates limited applicability in that domain. Notably, the LQ-YBT's significant correlation with the sit and reach test underscores its potential as an indicator of flexibility. **Key message:** Utilizing the FMS or LQ-YBT autonomously or in pair might help sports medicine and strength and conditioning experts in their capacity to recognize people with an expanded gamble of injury during sports participation through distinguishing proof of physical or functional movement deficiencies.

Keywords: Agility; Flexibility; Functional Asymmetries; Power; Quality of Movement

1 Introduction

Sport and physical activity necessitate musculoskeletal health with great strength and power as well as adequate motor coordination and control to provide undeniable degrees of power during movement. Deficient functional strength or movement limitations can have a negative impact on sport performance or increase the risk of injury.[1–3] Athletes' ability to perform at any level is hampered by athletic injuries. According to Sheu et al.,[4] 8.6 million sports and recreation-related injuries occur in the United States each year, resulting in 34.1 injuries per 1000 individuals. Preventative exercise programmes, if planned and implemented properly, could lessen the severity and frequency of athletic injuries.[5]

Functional movement and sports execution tests are utilized to evaluate a competitor's circumstances and forestall sport related injuries.[6] These tests could likewise be utilized as clinical tests to anticipate the risk of sports injury, since poor fitness, ill-advised movement pattern, and lacking sensorimotor control are imperative elements in sports injuries.[7]

Clinical screening tests such as the Functional Movement Screen (FMS), Lower Quarter Y-balance Test (LQ-YBT), agility, and muscle power tests are commonly used to assess sports performance and injury prevention.[8] The FMS is designed to detect movement deficiencies and body imbalances, as well as to assess general musculoskeletal problems in order to predict injury risk.[9] This assessment has a high level of explicitness in identifying injury and moderate interrater reliability.[10]

While sports medicine experts use these instruments to assess movement, they may also have implications for an individual's performance in sports and active work, as decreased balance, a lack of neuromuscular control, and movement dysfunction have been proposed as indicators of poor athletic performance.[2,11,12] Competitors with contralateral imbalance are more prone to injury during sports, which contributes to compensatory movement patterns and muscle inhibition, perhaps resulting in poorer execution levels.[7]

The Star Excursion Balance Test (SEBT) and Lower Quarter Y-Balance Test (LQ-YBT) have both been extensively studied and utilised for determining physical readiness and injury risk, as well as return to sport testing and pre-post intervention monitoring.[13] The SEBT was found to be reliable, valid, and responsive to specific dynamic neuromuscular control training for injured and healthy athletic populations in a systematic review.[14]

LQ-YBT was developed from SEBT to improve SEBT reliability and field suitability.[13] LQ-YBT has been simplified to use only the three most reliable reach directions (compared to the eight reach directions in SEBT).[15] The LQ-YBT assesses dynamic balance and physical performance.[16] It identifies the risk of sport-related injuries of the lower extremities and exhibits high interrater reliability.[17] The SEBT and LQ-YBT have the advantage of testing neuromuscular control at the limits of stability, which can help us identify and emphasize subtle impairments and asymmetry.[13]

The agility and muscle power tests are used to evaluate athletic performance. Caswell et al.,[11] examined the relationship between sports injury and actual execution in American Youth Football crews. They inferred that an intricate relationship exists between the agility and muscle power of a competitor in terms of their movements and rates of injury occurrence. These four clinical screening tests could assist with distinguishing the risk of injury and add to the plan of an effective sports injury prevention technique.

Impaired balance and decreased functional movement are associated with increased injury risk. Ample studies done on the athletic population give evidence that impaired dynamic balance and decreased functional movements are a major cause of increased injury in them.[8,10,13,18–23]

Until this point in time, there is restricted examination with respect to the association between the FMS CS, LQ-YBT, and physical performance tests in athletes. Utilizing the FMS or LQ-YBT autonomously or in pair might help sports medicine and strength and conditioning experts in their capacity to recognize people with an expanded gamble of injury during sports participation through distinguishing proof of physical or functional movement deficiencies. Accordingly, the reason for this study was to explore the association between the FMS CS, LQ-YBT and tests of physical performance (Standing Long Jump, Sit and Reach Test, Pro Agility Test).

2 Subjects and Methods

The study was approved by Institutional Ethics Committee. Fifty athletes (32 males and 18 females) in the age group of 18-30 years were included in this study after obtaining the informed consent. The subjects were interviewed about their health status and were excluded if they reported any history of musculoskeletal injury in past 6 months which could affect the performance of the tests, and with any history of cardiovascular disease like angina, hypertension, neurological/cognitive impairment disorders, etc.

2.1 Procedure

- **Warm Up Exercises:** Before initiating the tests, the subjects underwent warm-up exercises. This regimen comprised jogging on the spot followed by stretching exercises.
- **Functional Movement Screening:** The Functional Movement Screening (FMS) was systematically administered using standard equipment (Functional Movement Systems, Lynchburg, VA, USA), procedures, and verbal instructions. The subjects sequentially performed seven FMS tasks: deep squat, hurdle step, in-line lunge, shoulder mobility, active straight leg raise, trunk stability push-up, and rotary stability test. Each movement was attempted a maximum of three times, with the lowest of the three scores being recorded as the composite score (FMS CS). A movement executed as instructed, with full range of motion and postural control, was awarded a score of three. A score of two was assigned if the movement was completed in a compensatory position or if it lacked full range of motion or postural control. Inability to complete the movement resulted in a score of one, while any indication of pain during the movement led to a score of zero. For bilateral movements, such as the hurdle step, in-line lunge, shoulder mobility, active straight leg raises, and rotary stability, the lower of the two scores was incorporated into the composite score (FMS CS).[3]
- **Lower Quarter Y-Balance Test:** For the Lower Quarter Y-Balance Test (LQ-YBT), subjects performed movements in three distinct directions: anterior, posteromedial, and posterolateral, all in accordance with standard procedures and instructions. Participants stood on one leg at the grid's center, positioning the most distal aspect of the great toe. Maintaining this single-leg stance, they reached with their free limb in the aforementioned directions relative to the stance foot. The furthest reach distance was marked on a tape measure using erasable ink, indicating where the foot's most distal part landed. This procedure was repeated three times in each direction for both legs, and the average of these three maximal reach distances was recorded. To determine leg length difference, the distance between the anterior superior iliac spine (ASIS) and the medial malleolus was measured. Both absolute and relative reach distances for the right and left legs in all three directions were then calculated for analysis.[3]
- **Sit and Reach Test:** In the Sit and Reach Test, subjects positioned themselves on the floor, removed their shoes, and extended their legs so that their feet lay flat against a table. They were then guided to reach forward, pushing their fingers along the table's surface to the furthest point possible. This distance, from the fingertips to the table's edge, was then measured. After three attempts, the average of these distances was taken for data analysis.[3]
- **Pro Agility Test:** For agility assessment, three markers were strategically placed five yards apart on the floor. Participants began at the central marker, sprinting five yards to their right, then ten yards to their left, and concluding with a five-yard sprint to their right, passing through the center marker. The entire sequence's duration was recorded using a stopwatch. After three trials, the average time was used for data analysis.[3]
- **Standing Long Jump:** In the Standing Long Jump test, participants were directed to position the toes of both feet behind a designated starting line. They were

then asked to jump as far as possible, ensuring a two-footed landing. The resultant distance, from the starting line to where the backmost part of the foot landed, was measured. This was repeated three times, with the average distance being used for subsequent analysis.[3]

2.2 Analysis

The data was statistically analysed using SPSS statistics version 28 (IBM, Chicago, IL, USA). Shapiro-Wilk Test was used to evaluate the normal distribution of the data. As the data was normally distributed, independent T-Test was used to determine gender differences between all the measures. Karl Pearson correlation was used to assess the association between FMS C.S, LQ-YBT and other physical performance measures and $p < 0.05$ was utilized for statistical significance.

3 Results

Descriptive statistics (mean ± standard deviation [SD]) for the demographic data and FMS CS are presented in Table 1 **A**. The FMS CS which indicates the quality of movement is 19.92 ± 1.104 in the subjects (N=50).

Descriptive statistics (mean ± standard deviation [SD]) of LQ-YBT, Sit and Reach Test, Pro Agility Test and Standing Long Jump in male and female athletes are presented in Table 1 **B**.

The comparison of demographic data, FMS CS and other physical performance measures between males and females are presented in Table 2. LQ-YBT is significantly different for males and females, with males having better reach than the females (p<0.05). Pro Agility Test is significantly different for males and females, with females outperforming males (p<0.05). There also exists a significant difference for Standing Long Jump between males and females, where males outperformed females (p<0.05).

On correlating the FMS CS with other physical performance measures using Pearson correlation, a significant positive correlation was found between FMS CS and Standing Long Jump (p<0.05) suggesting the good quality movement score indicates better performance in standing long jump test. However, no statistically significant correlation exists between FMS C.S, LQ-YBT, Sit and Reach Test and Pro Agility Test as shown in Table 3.

A significant positive correlation was found between all directions of LQ-YBT, Sit and Reach Test and Standing Long Jump (p<0.05) as shown in Table 4. This suggests a good reach in LQ-YBT is indicative of better performance in sit and reach as well as standing long jump tests.

Table 1. Demographic data

A. Descriptive Statistics of Demographic Data and Fmscs (N=50)

Parameter	**Mean ± SD**
AGE (year)	20.98 ± 2.74
HEIGHT (cm)	170.74± 10.24
WEIGHT (kg)	65.56 ± 10.88
BMI (kg/m2)	22.35 ± 1.89
FMS CS	19.92 ± 1.1

cm-centimetres, kg-kilogram, BMI- Body Mass Index, m-metres, FMS CS- Functional Movement Screening Composite Score

B. Descriptive Statistics of Physical Performance Measures (N=50)

Parameter	**Mean±SD**
ANT.ABS.R	79.18±15.43
ANT.REL.R	92.69±15.02
ANT.ABS.L	78.29±17.11
ANT.REL.L	91.51±16.49
PL.ABS.R	98.09±21.23
PL.REL.R	114.77±21.42
PL.ABS.L	105.33±20.40
PL.REL.L	123.28±19.65
PM.ABS.R	104.58±19.87
PM.REL.R	122.44±19.08
PM.ABS.L	93.82±18.26
PM.REL.L	109.72±17.14
SIT AND REACH	34.58±6.61
PRO AGILITY	6.83±0.54
SLJ	197.74±22.15

ANT-Anterior, PL-Posterolateral, PM-Posteromedial, ABS-Absolute, REL-Relative, R-Right, L-Left, SLJ- Standing Long Jump.

4 Discussion

The objective of this study was to investigate the association between FMS C.S, LQ-YBT and physical performance tests in male and female athletes. A significant relationship was found between FMS CS and Standing Long Jump but not with other measures (LQ-YBT, Pro Agility and Sit and Reach Test). The LQ-YBT was significantly correlated with the Standing Long Jump and Sit and Reach Test.

The significant relationship between FMS C.S and SLJ could be due to the fact that both depend on the flexibility of the muscles in the lower extremities. However, this is inconsistent with the result of Kramer et al.,[3] who found that exercise patterns associated with maximum results in performance tests (such as SLJ) required a significantly narrower range of motion compared to FMS for maximum results. For example, the FMS Deep Squat Test requires a ”femur below horizontal” position to achieve maximum score. In contrast, SLJ test results do not depend on the use of full range of motion. Instead, SLJ uses rapid stretching of agonist muscles with a wide shocking movement, followed by

Table 2. Comparison of Demographic Data, FMS CS and Physical Performance Measures Between Males And Females

	Males (N=32)	Females (N=18)			
Parameter	**Mean± SD**	**Mean± SD**	**t- value**	**p-value**	**Cohen's d**
AGE (year)	21± 3.1	20.98 ± 2.04	0.07	0.47	0.02
HEIGHT (cm)	**177.56 ±5.09**	**158.61 ±3.38**	**14.11**	**0**	**4.16**
WEIGHT (kg)	**71.63 ±8.78**	**54.78 ±2.92**	**7.87**	**0**	**2.32**
BMI (kg/m^2)	22.66±2.15	21.78±1.14	1.6	0.06	0.47
LEG LENGTH (cm)	**88.44 ±4.31**	**77.61 ±2.68**	**10.52**	**0**	**3.1**
FMS CS	19.84±1.14	20.06±1.06	0.65	0.26	-0.19
ANT.ABS.R	**85.72 ±12.62**	**67.56 ±13.14**	**4.81**	**0**	**1.42**
ANT.REL.R	**96.05 ±14.63**	**86.71 ±14.16**	**2.19**	**0.02**	**0.65**
ANT.ABS.L	**85.42 ±14.03**	**65.61 ±14.8**	**4.7**	**0**	**1.38**
ANT.REL.L	**95.64 ±15.4**	**84.16 ±16.17**	**2.49**	**0.01**	**0.73**
PL.ABS.R	**104.42 ±17.26**	**86.83 ±23.37**	**3.04**	**0.002**	**0.89**
PL.REL.R	116.79±18.69	111.18±25.77	0.89	0.19	0.26
PL.ABS.L	**113.17 ±17.16**	**91.39 ±18.47**	**4.19**	**0**	**1.23**
PL.REL.L	126.64±18.85	111.31±20.15	1.64	0.05	0.48
PM.ABS.R	**111.75 ±19.14**	**91.83 ±14.21**	**3.85**	**0**	**1.13**
PM.REL.R	124.93±20.68	118.01±14.94	1.24	0.11	0.36
PM.ABS.L	**101.16 ±16.29**	**80.78 ±14**	**4.46**	**0**	**1.31**
PM.REL.L	**113.99 ±17.63**	**103.74 ±14.87**	**1.9**	**0.03**	**0.56**
SIT AND REACH	35.16±6.52	33.56±6.82	0.82	0.21	0.24
PRO AGILITY	**6.96 ±0.55**	**6.6 ±0.45**	**2.33**	**0.01**	**0.69**
SLJ	**205.63 ±22.75**	**183.72 ±12.04**	**3.78**	**0**	**1.11**

cm-centimetres, kg-kilogram, BMI- Body Mass Index, m- metres, FMS CS- Functional Movement Screening Composite Score, ANT-Anterior, PL-Posterolateral, PM-Posteromedial, ABS-Absolute, REL-Relative, R-Right, L-Left, SLJ- Standing Long Jump

Table 3. Correlation o f FMS CS With Other Physical Performance Measures

Parameter	**r**	**p value**
ANT.ABS.R	0.084	0.564
ANT.REL.R	0.74	0.226
ANT.ABS.L	0.098	0.499
ANT.REL.L	0.183	0.203
PL.ABS.R	0.053	0.715
PL.REL.R	0.115	0.425
PL.ABS.L	0.15	0.297
PL.REL.L	0.252	0.078
PM.ABS.R	0.122	0.398
PM.REL.R	0.222	0.122
PM.ABS.L	-0.008	0.957
PM.REL.L	0.066	0.65
SIT AND REACH	0.158	0.274
PRO AGILITY	-0.248	0.083
SLJ	**0.397**	**0.004**

ANT-Anterior, PL-Posterolateral, PM-Posteromedial, ABS-Absolute, REL-Relative, R-Right, L-Left, SLJ-Standing Long Jump

Table 4. Correlation of LQ-YBT With Other Physical Performance Tests

Parameters	Sit and Reach		Pro Agility		Standing Long Jump	
	r	p value	r	p value	r	p value
ANT.ABS.R	0.343	**0.015**	0.125	0.388	0.595	**0**
ANT.REL.R	0.314	**0.027**	0.015	0.92	0.52	**0**
ANT.ABS.L	0.386	**0.006**	0.19	0.185	0.567	**0**
ANT.REL.L	0.380	**0.006**	0.111	0.444	0.508	**0**
PL.ABS.R	0.553	**0**	0.26	0.068	0.549	**0**
PL.REL.R	0.549	**0**	0.19	0.186	0.464	**0.01**
PL.ABS.L	0.499	**0**	0.179	0.213	0.605	**0**
PL.REL.L	0.488	**0**	0.078	0.592	0.533	**0**
PM.ABS.R	0.36	**0.01**	0.072	0.617	0.596	**0**
PM.REL.R	0.312	**0.027**	-0.062	0.668	0.508	**0**
PM.ABS.L	0.283	**0.046**	0.139	0.336	0.503	**0**
PM.REL.L	0.232	0.106	0.027	0.854	0.419	**0.02**

ANT-Anterior, PL-Posterolateral, PM-Posteromedial, ABS-Absolute, REL-Relative, R-Right, L-Left

maximizing muscle activation.[24]

Balance is a fundamental motor skill for sport and athletic performance as well as for everyday activities. In this study, we found dynamic balance (LQ-YBT) to be strongly associated with Standing Long Jump. The positive associations above indicate that the greater the dynamic balance, the higher the strength/power of the lower limbs. In addition, some studies have shown improvement in strength/power after balance training and, conversely, strength training interventions improve balance. The results of this study were consistent with the findings of Hammami et al.,[25] where a significant medium-large sized correlation between balance (static and dynamic) and power (SLJ, CMJ and 3-Hop Jump Tests) was observed. The positive correlation demonstrates that two variables vary in the same direction, the significant correlations not only predict that improved balance may contribute to the tested power measure, but it would also be predicted that the better SLJ performances would contribute to higher balance scores. In another study, Booysen et al.,[26] established a relationship between power and dynamic balance using the Y-Balance and CMJ tests.[27] The relationship between lower limb strength and balance may be due to the same neuropsychological structure responsible for controlling lower limb posture and strength. The same communication pathway (from Ia fibers) acts on motor neurons responsible for generating muscle strength and maintaining balance. Furthermore, voluntary muscle activity and long-latency reflex control during balance tasks are regulated by cortical excitability.[28,29] In addition, mechanoreceptors located in muscles (muscle axis) and tendons (Golgi tendon organ) provide reflex functions that aid in positioning (e.g., axis) of the lower extremities during motor tasks motion.[30] The significant relationship between dynamic balance and lower limb power in this study indicates that they are interdependent. These results can be used in future studies that focus on both the implementation of preventive training and the reinforcement of individual characteristics of athletic performance.

Flexibility as measured by Sit and Reach Test has also correlated significantly with Dynamic Balance which could be due to the fact that the athlete with better lower limb flexibility might have a greater excursion on LQ-YBT. This finding is in consistent with that of Kartal,[31] who found a significant relationship between balance and flexibility using SEBT and Sit and Reach Tests respectively. It signifies that athletes with good flexibility may perform better in dynamic balance with good postural control.

5 Limitations

This study had some limitations. First, since the sample size was limited due to the COVID-19 restrictions at the time of data collection process, further investigation is necessary to see if the strength of these associations remains true with larger groups of male and female athletes. Second, the selected tests, including the FMS, LQ-YBT, and other performance tests, provide specific insights but may not capture all aspects of an athlete's physical capabilities or injury vulnerabilities. Additionally, the scoring, particularly for the FMS, introduces a level of subjectivity, potentially affecting the consistency of the results. These factors should be considered when interpreting the study's outcomes and planning future research.

6 Conclusion

This study revealed that specific functional movement assessments, namely the FMS composite score and the Lower Quarter Y Balance Test, correlate significantly with standing long jump performance in athletes, but not with agility. This underscores their potential as indicators for certain athletic capabilities. However, the lack of correlation with agility and the inherent subjectivity in scoring highlight areas for further exploration. Future research should delve deeper into refining these assessment tools and broadening the scope to capture a more holistic view of athletic performance, especially within the Indian athlete demographic.

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