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ORIGINAL RESEARCH

FUNCTIONAL MOVEMENT AND DYNAMIC BALANCE IN ENTRY LEVEL UNIVERSITY DANCERS

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ABSTRACT

Background: Dance requires integration and synergy between movement, postural stability, and body alignment to effectively execute the technical and aesthetic requirements of the performance. Evaluation of movement competency and dynamic balance provides opportunity to identify dysfunctional movement which may negatively impact both artistic and technical aspects of dance performance. Investigation of the relationships between movement competency and postural control may aid in technical development, performance improvement, and ultimately injury reduction. Although the Functional Movement Screen™ (FMS™) and Y-Balance Test (YBT) have assessed movement competency in athletes, they have not been used extensively in the performing arts.

Purpose: The purposes of this investigation were to examine movement competency in university dancers using the FMS™ and YBT and to determine the relationship between functional movement and dynamic balance.

Study Design: Cross sectional

Methods: Fifteen, injury-free, female members (19.1 ± 1.18 years old) of an introductory university ballet class volunteered to participate. Pearson product correlations were used to determine relationships between variables.

Results: The mean composite FMS™ score was 15.32 ± 2.30. Shoulder mobility (SM) ($r = 0.63$, $p = 0.01$), In-line lunge (ILL) ($r = 0.64$, $p = 0.01$), and Deep Squat (DS) ($r = 0.62$, $p = 0.01$) were correlated with composite FMS™ score. Overall composite YBT score was 86.62% ± 8.17%. Reach asymmetry was 3.25 cm ± 3.53 cm (anterior), 4.06 cm ± 3.59cm (posteromedial (PM)), and 3.28cm ± 2.61cm (posterolateral (PL)). Composite FMS™ score was not correlated with composite YBT composite score ($r = 0.44$, $p = 0.10$). A moderate to good correlation was found between the ILL and YBT composite score ($r = 0.64$, $p = 0.01$).

***Conclusion*:** Collectively the results indicate the FMS™ and YBT do not measure the same constructs. However, the associations between individual components of the FMS™ and YBT indicate a relationship between certain movements and dynamic balance, supporting their combined use in a dancer injury risk management program.

Level of Evidence: 2b

Keywords: ballet, dynamic balance, functional movement

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INTRODUCTION

The aesthetic beauty and technical execution required for dance requires coordination and integration of movement, proper body alignment, cardiovascular endurance, muscular strength and endurance, flexibility, and dynamic balance.[1,2] Functional movement, the ability to accurately and efficiently produce and maintain stability and mobility of body segments while performing, is essential for athletic activities including ballet.[3,4] The overall movement competency of the dancer is related to the interaction of postural control, mobility, and stability as the dancer performs technical elements as isolated exercises in choreographed routines. High levels of movement competency require synergy between mobility and stability and the ability to adjust in a dynamic environment. The adoption and implementation of screening to identify deficits, limitations, and/or asymmetries contributing to reduced movement competency is necessary to maintain and improve dancer health.

Despite calls for comprehensive dancer health and wellness screening[5-8] there remains a lack of consensus regarding the specific components of a dance movement screening. Given the requisite physical attributes required for dance are similar to that of other athletic events, the application of screening tools used with other athletic populations may be appropriate. The Functional Movement Screen™ (FMS™), a seven exercise assessment (in-line lunge (ILL), deep squat (DS), rotary stability (RS), trunk stability push up (TSPU), active straight leg raise (ASLR), shoulder mobility (SM), and the hurdle step (HS)) is used to identify functional deficits resulting from aberrations in mobility, stability, motor control, and/or combinations, providing a qualitative level of movement competency.[9-11] The FMS™ has been used to screen for movement competency in college student-athletes,[11-14] professional athletes,[15,16] and tactical populations.[17-20] Several authors have used components of the FMS™ with dancers, but failed to use all seven movement patterns, limiting the utility of their findings.[21-23] The Y-Balance Test (YBT) assesses dynamic balance through a series of unilateral lower extremity reaches while maintaining single limb stance.[24] YBT has been used to investigate postural control in college student athletes[12,24,25] and high school athletes,[26] with limited use in dance populations.[27] The FMS™ and YBT are often used for similar purposes, but there has been limited focus on the relationships between the two clinical screenings. The relationship between movement competency and dynamic balance has been investigated in college student athletes[28-30] and military personnel[19] but has not been explored in the dancers. Therefore, the purposes of this investigation were to evaluate movement competency and dynamic postural control, as measured by the FMS™ and the YBT, and to identify the relationship between them in entry-level university ballet dancers.

METHODS

Sixteen female students (n = 16) from a single introductory undergraduate ballet course volunteered to participate in this study. To be eligible for participation, the participants had to be enrolled in the introductory ballet class and free from injury at the time of data collection and the participants had to remain active in the course. All participants completed a written informed consent form in accordance with procedures approved by the University's Institutional Review Board.

Procedures

Each participant completed a health history questionnaire to assess general health and wellness variables (e.g., previous history of musculoskeletal injury [MSI], amount of training per week, number of rehearsals per week, number of performances per week/year, pain, sleep and rest, footwear, dance surfaces, warm-up practices, etc.). Training sessions per week, rehearsals per week, performances in a typical week, and hours per week of dance activity were categorized by a range of 5 hours (i.e., 0, 1-5 hours, 6-10 hours, etc.). Each participant completed the baseline data collection session, consisting of all components of the FMS™ and the YBT. An iPad Pro (Apple, Inc.) was used to video record the FMS™ for training and review purposes. FMS™ assessment was completed by a certified athletic trainer with 10 years of experience using the battery in clinical and performance-based research, and three undergraduate students who completed two training sessions conducted by the certified athletic trainer using standardized instructions for the testing procedures. YBT assessment was conducted by a dance educator and researcher with over four years of experience

using the test in clinical and performance-based research.

Assessments

The FMS™, composed of seven movements that are scored (in-line lunge [ILL], deep squat [DS], rotary stability [RS], trunk stability push-up [TSPU], active straight leg raise [ASLR], shoulder mobility [SM], and hurdle step [HS]) and three clearing tests (not included in the composite score), was used to identify asymmetries and/or deficiencies in movement competency. Each individual movement was scored using a 0-3 scale and summed to determine a composite score ranging from 0 to 21 points.[9,10] Each of the movements was scored using standard criteria,[4,9,10] with a score of 3 indicating the highest level of movement competency and a score of 1 indicating the lowest level of movement competency. A score of 0 indicated the participant had pain during performance of the exercise. The FMS™ has been shown to have adequate reliability with both novice and trained raters.[20,31,32]

The YBT was performed adhering to standard procedure.[24] Limb length was measured from the anterior superior iliac spine (ASIS) to the distal edge of the medial malleolus (cm). Participants stood in the center of the Y-Balance Test Kit (Move2Perform, Evansville, IL, USA) on one limb and were instructed to keep their hands on their hips while reaching as far as possible, pushing the reach indicator with the non-stance foot. Trials were repeated if the participant: failed to return to the starting position, lifted the heel of the stance limb, touched down with the non-stance limb, placed too much weight on the slide indicator, or flicked the slide indicator forward.[24,25] Each participant completed four practice attempts prior to the three testing trials to reduce the effect of a novel movement. Reach distances and composite reach distance were calculated according to previously established protocols.[33]

Statistical Analysis

Descriptive statistics (mean ± standard deviation) were calculated for all measures. Pearson product correlations were used to examine the relationship between variables. All analyses were performed using Statistical Program for Social Sciences (SPSS) software (SPSS V. 24, IBM Corporation, Armonk, NY, USA). Alpha levels were set *a priori* at 0.05.

RESULTS

A total of fifteen (15) participants completed all components of the FMS™, the YBT, and remained active participants throughout the ballet class. The participants were all female, 19.1 ± 1.18 years old. Demographic data collected from the participants highlighting their overall activity level are reported in Table 1.

Composite FMS™ score ranged from 9 to 18 (mean: 15.32; standard deviation: 2.30). Mean scores recorded for each of the individual components are reported in Table 2. YBT performance, including mean reach distances and composite reach distance are also shown in Table 2. Composite YBT score was 86.62% ± 8.17%. Reach asymmetry (the absolute difference between right and left reach) was 3.25 cm ± 3.53 cm for anterior, 4.06 cm ± 3.59cm for posteromedial (PM) reach, and 3.28cm ± 2.61cm for posterolateral (PL) reach. Pearson product correlation calculation revealed performance on the

Table 1. *Participant Demographics (n = 16; all female).*

Age (years)	19.06 ± 1.18
Limb Length (cm)	38.47 ± 3.3

Data are displayed as mean ± standard deviation

Training Status/Level (n=16)

Frequency range	Dance classes (per week)	Rehearsals (per week)	Hours of Training (per week)
0	0	11 (57.9)	0
1-5	14 (73.7)	3 (15.8)	4 (21.1)
6-10	1 (5.3)	2 (10.5)	8 (42.1)
11-15	0	0	1 (5.3)
>15	1 (5.3)	0	3 (15.8)

Data are displayed as number of participants in each category (%)

Table 2. *Descriptive statistics for Functional Movement Screen™ and Y-Balance Test scores. YBT scores are displayed as sample mean ± standard deviation (cm) (n = 15).*

Variable	Mean (SD)
FMS™	
Composite (0-21)	15.32 ± 2.30
ASLR	2.69 ± 0.48
SM	2.63 ± 0.50
RS	1.88 ± 0.34
TSPU	2.19 ± 0.77
HS	2.13 ± 0.34
ILL	1.93 ± 0.26
DS	2.2 ± 0.75
YBT Asymmetry (cm)	
Anterior	3.25 ± 3.53
Posteromedial	4.06 ± 3.59
Posterolateral	3.28 ± 2.61
YBT Composite (%)	86.62 ± 8.17

FMS™ = functional movement screen™; ASLR = active straight leg raise; SM = shoulder mobility; RS = rotary stability; TSPU = trunk stability push-up; HS = hurdle step; ILL = in-line lunge; DS = deep squat; YBT = Y Balance test

Table 3. *Pearson correlation between Composite FMS™ score and individual components. Data are displayed as Pearson correlation (r); significance (p-value).*

	ASLR	SM	RS	TSPU	ILL	HS	DS
Composite FMS™	0.40; 0.13	0.63; 0.01**	0.48; 0.06	0.27; 0.31	0.64; 0.01*	-0.14; 0.61	0.62; 0.01*

FMS™ = functional movement screen™; ASLR = active straight leg raise; SM = shoulder mobility; RS = rotary stability; TSPU = trunk stability push-up; HS = hurdle step; ILL = in-line lunge; DS = deep squat;
*= $p \leq 0.05$
** = $p \leq 0.01$

Table 4. *Pearson correlation results: Composite YBT (normalized) and FMS™ components. Data are displayed as Pearson correlation (r); significance (p-value).*

	Composite YBT
Composite FMS	0.44; 0.10
DS	0.48; 0.07
HS	0.12; 0.67
ILL	0.64; 0.01*
SM	0.15; 0.59
ASLR	-0.06; 0.85
TSPU	-0.14; 0.71
RS	0.46; 0.08

FMS™ = functional movement screen™; DS = deep squat; HS = hurdle step; ILL = in-line lunge; SM = shoulder mobility; ASLR = active straight leg raise; TSPU = trunk stability push-up; RS = rotary stability
*= $p \leq 0.05$

SM (r = 0.63, $p = 0.01$), ILL (r = 0.64, $p = 0.01$), and DS (r = 0.62, $p = 0.01$) were correlated with composite FMS™ score (Table 3). RS performance was related to composite FMS™ score, and trended toward, but did not reach significance (r = 0.48; p = 0.06).

Little to no correlation was found between composite FMS™ and composite YBT (r = 0.44, p = 0.10). Little to no correlations were found between RS and composite YBT (r = 0.46, p = 0.08) and DS and composite YBT (r = 0.48, p = 0.07) (Table 4). A moderate to good correlation was found between the ILL and composite YBT (r = 0.64, $p = 0.01$).

DISCUSSION

The purposes of this investigation were to describe movement competency and dynamic postural

control, as measured by FMS™ and YBT, and to examine their relationship in entry-level university dancers. The results show composite FMS™ higher and YBT scores similar to that of other college age populations.[33-35] Among FMS™ movement patterns, RS and ILL performance was the worst; ASLR and SM were the highest. PM reach asymmetry was greatest, followed by PL and ANT respectively. No relationship was found between composite FMS™ and composite YBT.

Movement competency, as indicated by composite FMS™, was higher in the current sample than other athletic and healthy populations. The composite FMS™ score obtained in the current study was higher than previously reported scores for general college students and female college-student athletes[33] and cheer and dance athletes (14 ± 1).[12] Reports of composite FMS™ score of women within the general population[34,35] are similar to those seen here. Other investigations have reported higher composite FMS™ scores in professional football players[16,36] and in military personnel.[37,38] Higher levels of activity have been linked to higher FMS™ score,[15,33,34] however, no association between hours of training per week and composite FMS™ score was found in the current study. The differences in FMS™ scores reported may be related to the specific activity type of the participants.[39] While there are notable differences between ballet, other genres of dance, and traditional athletic activities, it remains plausible that the technical elements, training goals, and overall movement pattern repetition elicit similar patterns of neuromuscular control. Future investigations should examine the impact of various genres of dance (e.g., ballet, jazz, modern/contemporary) or dance-related activities (i.e., cheerleading, figure skating) on composite FMS™ score.

Individually, performance on the RS and ILL were the lowest among the seven exercises of the FMS™. SM, ILL, and DS were significantly correlated with composite FMS™ score. The DS, ILL, and HS are considered the more complex movements within the FMS™, requiring the elevated coordination of mobility and stability in multiple body segments.[9,10,37,40] Stability of the lumbopelvic region is a necessary link in the overall kinetic chain.[41,42] Weakness and/or insufficiency (decreased mobility and/or altered motor control) in this region may result in compensation.[43] The association of upper extremity (SM) and the more complex lower extremity movement patterns (DS and ILL) to composite FMS™ score implicates the need for coordination and control of upper and lower body segments necessary for dance, and highlights the role of regional interdependence in overall movement competency in dancers.[44] Further study is needed to identify other factors that affect stability in the lumbopelvic region (i.e., muscular endurance, strength, range of motion) and the relative contribution to both the aesthetic (qualitative) and technical (quantitative) aspects dance performance.

Balance and postural control have been found to be greater in dancers than athletes and the general population.[45] Mean composite YBT score in the current study was similar to a previous investigation of dancers[45] but lower than those reported in college student athletes (men's and women's basketball, tennis, cross country, women's golf, cheer and dance, swimming and diving, volleyball, soccer; men's football),[12,33] general college students[33] and high school basketball players.[26] Collectively, this supports differences in dynamic balance demands based on sport/activity, highlighting the pertinence of existing normative data.[26,46,47] Reach asymmetries seen in the current sample follow similar patterns as college student athletes[12,25] as well as dancers,[27] but were less than established injury risk cut-offs.[47] Lower composite reach scores seen here may be partially due to the frequency of unanticipated movements in dance and the bilateral, symmetrical focus inherent to dance. Athletes more frequently respond to unanticipated movements due to the nature of the sport; dancers perform anticipated movements through isolated exercises in choreographed routines. The training for novice ballet dancers requires increased focus on small changes that affect balance, e.g., body position and alignment, while maintaining a position, where athletes attend to cues external to the body, i.e., objects and opponents. This internal, anticipated focus may explain why dancers have lower dynamic balance, but higher static balance, than athletes.[45,46] Ballet, considered by some dance professionals to provide the foundation for dance, involves the same fundamental components despite a variety of styles; this is not the case for other genres

(i.e., modern dance).[48,49] The heterogeneity of dance experience of the current sample and consistency with previous reports suggests, despite differences, there is sufficient overlap in the technical components of various genres of dance, resulting in similarities in control of balance. Future investigations should elaborate on the impact of experience level of the dancers and athletes and the genre of dance on differences in balance and postural control.

The lack of association between composite FMS™ score and composite YBT score obtained in the current study confirms previous work suggesting FMS™ and YBT measure different aspects of movement competency.[28-30,37] Harshbarger et al.,[28] examined the relationships between a modified Star Excursion Balance Test (SEBT) (reach in the same three directions as YBT), static balance, and FMS™, finding no association between composite scores of the FMS™ and the modified SEBT in college student-athletes. Lockie, et al.,[30] investigated the relationship between FMS™ and SEBT in recreational team athletes. While a modified version of each test was used (PM, medial and anteromedial reach directions of the SEBT and only DS, HS, ILL, ASLR), overall, no association between the selected components of the FMS™ and dynamic balance was found. Kelleher et al.,[29] however, found weak, but significant associations between composite FMS™ and PM, PL, and composite reach distances. These differences may be due in part to the fact that YBT assesses only lower extremity function, but FMS™ assesses full body function.[29] Dynamic balance is a component of only three of the FMS™ exercises (ILL, RS, and HS); the narrow base of support and unilateral stance of these movements does not fully mimic the extent of dynamic movement in the YBT.

Examining the individual movements of the FMS™, a moderate to good correlation between ILL performance and composite YBT was found. Both tasks require sufficient core stability to maintain adequate balance given the narrow base of support.[9] These results differ from Harshbarger et al.,[28] who found no association between ILL and composite YBT, but did report a significant correlation between RS and ANT and PM reach. Lockie., et al.[30] reported a significant relationship between left ILL score and L PM excursion, suggesting individual elements of the FMS™ may be related to dynamic balance. It was anticipated the connection between core stability and dynamic balance would be exposed between RS score and YBT composite or PM reach due to the rotary component of each movement. Little to no correlation between RS and YBT composite was found, inconsistent with Harshbarger et al.,[28] who found fair and significant correlations between RS and ANT and PM reach. The role of core stability in dynamic balance has been questioned,[27] exposing a need for further clarification of the relative role of core, lumbopelvic, and hip stability and mobility in dynamic balance.

Limitations and Future Directions

The interpretation of these results should be considered while taking the following methodological limitations into consideration. The sample (size, age, experience level, training status, and gender) was limited due to the number of students enrolled in the introductory ballet course and may not be representative of the population of university dancers. Additionally, the participants had a variety of dance backgrounds (genres and volumes), and were not strictly ballet dancers. Future studies should investigate these associations with as homogenous a sample (genre and experience) as possible.

Correlation does not imply causation between variables. There remain a number of factors, such as the type and amount of training/activity engaged in outside of the introductory course (i.e., other genres of dance, weight training, yoga, etc.), individual joint ranges of motion and strength, and/or core/trunk muscular strength and endurance which vary among university dancers, and influence functional movement and dynamic balance. Acknowledging that movement competency and dynamic balance can be altered with training[15,50] further research is warranted to identify the extent to which dance training can elicit changes.

Lastly, the YBT has been established as a reliable and valid measure of dynamic balance, but other assessments are available.[51] It is possible that the FMS™ may relate to others. The FMS™, has been established as a reliable measure of movement competency,[20,31,32] but there is debate over its construct validity.[37,52] In light of this debate, and considering

the clinical usefulness of the FMS™ in identifying deficiencies, limitations, and/or asymmetries, combining screenings is likely to provide a more robust picture of overall function and injury risk.

Dancer health and wellness is a complex process requiring collaboration between dancers, educators, dance scientists, and healthcare professionals to effectively address the technical, aesthetic, psychological, and physiological principles related to performance.[53] Assessment of single joint function and/or reliance on a sole screening tool, diminishes the integration necessary for optimal aesthetic and technical execution. The use of an established movement screen (e.g. FMS™ or Movement Competency Screen[54]) based on fundamental movement patterns, rather than a dance-specific screen, may provide greater utility in identifying injury risk when skill or technique is diminished.[43] The adoption of a screening process to identify abnormalities in movement patterns, asymmetry, and/or dynamic postural control is the first step in identifying areas of concern. The development, implementation, and evaluation of evidence-based interventions to improve dancer movement competency and dynamic balance may provide additional benefits of reducing injury and improving performance. Such programs are not only likely to improve resiliency and promote longevity of a dancer's career, but are necessary to advance dancer health and wellness.

CONCLUSION

The results of the current study reveal no association between composite FMS™ and composite YBT scores. Composite FMS™ score was consistent with other active populations and YBT reach distances were consistent with previous reports in dancers, but lower than athletes. Performance on the ILL was associated with YBT reach; further investigation is warranted to clarify the association. While the current results suggest a relationship between dynamic balance and certain fundamental movement patterns, the connection to dance performance remains unknown. It is hoped that these data will stimulate the discussion of the integration of movement competency screening into comprehensive dancer performance improvement and injury prevention programming.

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