

Correlation of Dance Functional Status with Lower Limb Flexibility, Power and Dynamic Balance in Recreational Ballet Dancers – A Cross-Sectional Study

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ABSTRACT

Background: Paediatric ballet dancers are particularly prone to injuries due to the demanding nature of their art form, exacerbated by intensive training during crucial growth and maturation phases. The prevalence of injuries, especially those affecting lower limbs, hampers dancers' functional capacity. Unlike their professional counterparts, recreational ballet dancers lack specialized training, heightening their vulnerability. The accumulation of repetitive injuries often hampers their ability to attain the highest levels of achievement in their careers, underscoring the necessity to identify and comprehend contributing factors. The aim is to find a correlation between the Dance Functional Outcome Survey (DFOS) and critical factors like lower limb flexibility, power, and dynamic balance among recreational ballet dancers.

Methodology: 53 recreational ballet dancers aged 10–18 years with at least one year of dance experience were included. Lower limb flexibility was assessed using the sit and reach test, ankle flexibility, and straddle in supine tests, while power and dynamic balance were evaluated through vertical jump tests and Y balance tests. The DFOS questionnaire measured health status.

Result: Results revealed statistically significant weak positive correlations between DFOS and various factors: sit and reach test ($r=0.3060$), ankle flexibility ($r=0.3830$), straddle in supine ($r=0.3270$), vertical jump test ($r=0.3250$), and Y balance composite (Right: $r=0.3200$; Left: $r=0.3420$).

Conclusion: This study concludes that recreational ballet dancers with greater flexibility, power, and dynamic balance in the lower limb tend to exhibit a higher dance functional status.

Keywords: paediatric, ballet dancers, flexibility, power, dynamic balance, Dance Functional Outcome Survey

INTRODUCTION

Dance is a popular physical activity requiring strength, flexibility, and technical skill. While certain dancers view it as a recreational activity, numerous individuals commence rigorous training at a tender age with aspirations of pursuing a professional path in their career. As with other sports and athletic activities with high physical demand, there is a significant risk of injury (Yin et al., 2019). Within the field of professional dance companies,

annual injury rates have been documented as ranging from 67% to 95% among their dancers, whereas dance schools have reported injury rates of up to 77% for their adolescent dancers within a single academic year.

Ballet sees the highest prevalence of injuries among dancers aged 12 to 18 years (Garrick et al., 1999; Schafle et al., 1990). One systematic review by Hincapie et al. (2008) estimates the lifetime

prevalence of musculoskeletal injuries for university-level pre-professional and professional dancers as being 26–51% and 40–84%, respectively. Smith et al. (2016) conducted an additional study wherein a meta-analysis of 19 studies involving 2,617 pre-professional and professional ballet dancers revealed a period prevalence of 280%. When assessed about dance frequency, adult professional ballet, and modern dancers exhibit an injury rate ranging from 0.51 to 4.4 per 1000 dance hours (Shah et al., 2012; Nilsson et al., 2001; Bronner et al., 2003; Allen et al., 2012).

The greatest number of injuries occurred in the foot/ankle (53.4%), followed by the hip (21.6%), knee (16.1%), and back (9.4%) in ballet dancers by Gamboa et al. (2008). Increased prevalence in adolescent ballet dancers is because of early specialization and bias towards dance-specific skill acquisition. What is more alarming is that the risk to young pediatric ballet dancers is even higher than that of adult dancers, occurring at 0.77–4.71 per 1000 dance hours according to Ekegren et al. (2014).

However, it is worth noting that these studies primarily focused on amateur dancers and did not account for regulating daily practice hours. Not only does classical ballet serve as the foundational skill for other dance forms, but it also exhibits the highest injury rate within its technique, as mentioned by Costa et al. (2013).

Lehr et al. (2017) state that external risk factors, which are extrinsic to the individual, such as surface characteristics, footwear, and the nature of the athletic activity (practice versus competition), can exert an influence on the athlete's performance. Intrinsic risk factors are internal to the individual such as age, sex, body mechanics, and motor control which impact the athlete's ability to execute sport-related activities.

During the adolescent phase, dancers undergo a substantial surge in training intensity, a progression that aligns with their growth, development, and maturation process. Such injuries may, in part, be the result of repetitive movements performed with poor technique and growth-related factors. For example, peak growth and maturation are associated with a reduction in coordination, and decrements in flexibility, strength, and balance. This may impair dancers' ability to master technical skills and diminish confidence due to a perceived decrease in ability, as per Dowse et al. (2020).

Dance experts agree that pediatric ballet dancers are at risk of dance injuries due to the combination of increasingly physically and technically demanding training superimposed on a growing body

vulnerable to stressors because of rapid physiological and biomechanical changes from the maturation process (Micheli et al., 1983; Poggini et al., 1999).

Functional status is greatly affected by lower limb injury in ballet dancers. Unlike their professional counterparts, recreational pediatric ballet dancers lack specialized training, further amplifying their vulnerability. Injury leads to a decrease in strength, flexibility, and balance. If they continue dancing without adequate strength, and flexibility then they will be prone to future injury.

Bronner et al. (2019) found that the development of the DFOS, a self-report questionnaire focusing on functional outcomes, was specifically designed for ballet and modern dance communities. This tool addresses musculoskeletal injuries in areas such as the lower back and extremities, which are commonly susceptible to dance-related injuries.

Numerous researchers (Koutedakis Y et al., 2004; Daniel K et al., 2000) propose the existence of quantifiable inherent traits that play a role in dance-related injuries; these traits encompass factors like disparities in strength and flexibility, inadequate or excessive joint mobility, and suboptimal postural alignment. While these suppositions might appear logical, there is a notable scarcity of comprehensive studies that have examined the connections between the assessment of intrinsic attributes and the occurrence of dance injuries (Garrick et al., 2001; Howse et al., 1992; Leetun et al., 1997; Stephens et al., 1987).

By finding correlation we get information regarding modifiable risk factors for dance injury and can prevent future injuries and treat them according to their needs. Therefore, the purpose is to find a correlation of the dance function outcome survey with the lower limb flexibility, power, and dynamic balance in recreational ballet dancers.

MATERIALS AND METHODS

Study design: A Cross-sectional study

Participants:

Fifty-three (n=53) recreational ballet dancers in the age group 10–18 years (mean age 12.453 ± 2.493 years) who attended the class for at least 1 year with training sessions 1 hour daily, 3–5 times/week were included. The study setting was ballet dance classes from the city. Both male and female participants were included. The exclusion criteria were any recent surgery within 1 year, recent fracture, soft tissue injury, and subluxation within 1 year, congenital neuromusculoskeletal disorders, or any known vestibular problems.

Procedures:

Ethical clearance was obtained from the Institutional Ethics Committee (EC/NEW/INST/2019/377/109). Permission was taken from the dance institute. The entire procedure was explained to the participants. During screening the participants who met the inclusion criteria were included and written informed consent was taken for 18 years and above, oral assent for age groups 10–12 years, and written assent from the age group 13–17 years was taken, along with written parental consent.

Participants were provided with a dance functional outcome survey questionnaire to fill out. Dance Functional Outcome Survey (DFOS) is a dance-specific self-report functional outcome questionnaire for screening the health status of healthy ballet and modern dance populations. DFOS consists of 14 multiple-choice questions divided into 2 main sections, general activity (activities of daily living and pain) and dance technique (ability to perform dance-specific movements). The ADL has 40 points, and the dance technique has 50 points with a total of 90 points max. For 3–11 questions scoring is given as a 6-point Likert scale (0–5 points) and for questions 1–2 and 13–14 scoring is given as 0–10 points. A higher score reflects a higher function. Total points are normalized to a percentage, with 100% representing full function without limitations (Bronner et al., 2018).

Lower limb flexibility was assessed with a sit and reach test, straddle in supine, and ankle flexibility test:

In the **sit and reach test** participants would sit on the floor with legs extended and feet positioned against the box to assess hamstring muscle flexibility. They would place their hands on each other and extend their arms, ensuring alignment of head and back. Measurement began from the fingertips to the edge of the box using a yardstick as a reference point. Subsequently, participants were instructed to bend forward maximally, and the distance reached was then measured (Victor et al. 2011; Baltaci et al. 2003).

Normative values for sit and reach test are, for girls: >17.9 inches as excellent; 16.7–17.9 inches as good; 16.2–16.7 inches as average; 15.8–16.2 inches as fair; and <15.4 inches as poor. For boys, : >17.9 inches as excellent; 17–17.9 inch as good; 15.8–17 inch as average; 15–15.8 inch as fair; and <15 inches as poor.

In **straddle in supine**, the individual would lie on their back with legs and pelvis resting on a mat featuring a 0–90 scale drawn on both sides.

Ensuring alignment, the body would be centered along the dividing line of the mat, with legs extended and together. The subject would then straddle as wide as possible, maintaining the position for 3 seconds. The angle formed by the separation of the legs would then be measured, indicating the level of adductor muscle flexibility by Sporis et al. (2011).

In the **ankle flexibility test**, the individual stands facing a wall with their feet flat on the ground and their knees straight while extending their arms above their head and placing their chest against the wall. With a slow and deliberate movement, the participants would then proceed to move both feet away from the wall as far as possible. Throughout this movement, attention was paid to ensuring that the feet remained together, the heels stayed on the ground, the chest remained against the wall, and the arms remained outstretched above the head and in contact with the wall. The distance between the wall and the toes determines ankle (gastrocnemius & soleus muscle) flexibility (Norkin & White, 2016; Johnson & Nelson, 1986).

The normative values for the ankle flexibility test are, for girls: >81cm as excellent; 81–77 cm as good; 77–67 cm as average; 67–61 cm as fair; and <61cm as poor. For boys, values are: >88cm as excellent; 88–82 cm as good; 82–74cm as average; 74–67 cm as fair; and <67cm as poor.

Power was measured by a vertical jump test:

The participants would mark the end of their fingertips with chalk. Standing sideways to the wall, they planted both feet firmly on the ground. Using one hand, they reached upward as high as possible, marking the wall with the tips of their fingers (M1). From a static position, they then executed a maximal jump, marking the wall with the chalk on their fingertips at the peak of the jump (M2). The vertical distance between M1 and M2 was carefully measured. The distance between the two marks represents the height of the jump and the amount of power in the lower limb (Harman et al., 1991; Rodríguez-Rosell et al., 2017).

Normative values for the vertical jump test are, for girls: >58cm is excellent; 47–58 cm is above average; 36–46 cm is average; 26–35 is below average; and <26cm is poor. For boys, reference values are: >65cm is excellent; 50–65 cm is above average; 40–49 cm is average; 30–39 is below average; and <30 cm is poor.

Dynamic balance was measured by the Y balance test.

The Y balance assessment utilized three lines arranged in a Y configuration on the floor, with two

lines forming a 90° angle and the third positioned at a 135° angle in relation to the others.

Participants would balance on one foot, aligning the most distal part of the hallux with the center of the design, while the opposite leg extended as far as possible in three directions: anterior (ANT), posteromedial (PM), and posterolateral (PL).

Before formal measurement, participants were allowed three practice trials. The distance from the center of the design to the furthest point reached was recorded in each direction. The average distance from the three trials was calculated.

To determine leg length (LL), a separate measurement was taken with the participant lying supine on an examination table. A metric tape was employed to measure from the most distal portion of the anterior superior iliac spine to the ipsilateral medial malleolus.

The Composite Y balance score was then computed by dividing the sum of the largest distances reached in the ANT, PM, and PL directions by three times the LL, and multiplying the result by 100:

$\{[(ANT+PM+PL)/(LL \times 3)] \times 100\}$. (Martinez et al., 2014; Shaffer et al., 2013; Alhusaini et al., 2017)

Normative values for Composite value of Y balance test for boys Left leg= 98-102 cm, Right leg= 99-101 cm and for girls Left leg= 101-98 cm, Right leg= 100-96 cm by Schwiertz et al. (2020)

All the tests were repeated three times, and the average distance was used to assess the athletes' performance

Data Analysis:

Baseline data was analyzed to describe the patients' characteristics. SPSS version 25 and Minitab software version 19 are used for statistical analysis.

The Kolmogorov Smirnov test was applied to check the normality of data. Since the DFOS score was not normally distributed, the nonparametric test Spearman's Rho is used for all pairwise correlations (r). Spearman's Rho is used to find a correlation between dance functional status with lower limb flexibility, power, and dynamic balance in recreational ballet dancers. A scatter diagram with a trendline is used to observe a correlation between two variables. The correlation coefficient determines the strength and direction of the linear relationship between two variables. The p-value is used to find out the level of significance and $p < 0.05$ is considered significant.

RESULTS

53 participants (female=53, male=0) with the mean age of 12.453 ± 2.493 are included. The weight

of the subjects is distributed with a mean of 42.93 ± 8.70 kg. Mean for dance class experience since 4.413 ± 2.530 years. The mean for several training sessions/week is 3.4340 ± 0.7208 . The mean for total duration/week is 3.755 ± 0.897 hours.

Table 1: Descriptive statistics of variables

Variable	Mean	SD
Sit And Reach Test (Cm)	31.96	8.00
Ankle Flexibility Test (Cm)	28.378	5.403
Straddle In Supine (Degree)	113.69	13.18
Vertical Jump Test (Cm)	27.020	4.411
Y Composite Left (Cm)	87.840	6.755
Y Composite Right (Cm)	87.59	7.59
DFOS	85.547	4.652

Table 1 here shows the descriptive statistics of variables such as the sit and reach test, ankle flexibility, straddle in supine, vertical jump, and Y balance test.

Table 2: Correlation between DFOS and Flexibility, Power, and Dynamic balance

Variable	Correlation coefficient (r)	P value
DFOS and Sit And Reach Test (Cm)	0.3060	0.026*
DFOS and Ankle Flexibility Test (Cm)	0.3830	0.005*
DFOS and Straddle In Supine (Degree)	0.3270	0.017*
DFOS and Vertical Jump Test (Cm)	0.3250	0.018*
DFOS and Y Composite Left (Cm)	0.3420	0.012*
DFOS and Y Composite Right (Cm)	0.3200	0.019*

* = Significant
Survey

DFOS= Dance Functional Outcome

$p < 0.05$ * = Significant

Table 2 here shows it is inferred that the correlation between DFOS and Sit and Reach Test (Cm) $r=0.306$, which indicates a **weak positive correlation** as the p-value is 0.026 ($p < 0.05$) suggesting that this correlation is **significant**. Correlation between DFOS and Ankle Flexibility Test (Cm) $r=0.383$, indicating a **weak positive correlation** as the p-value is 0.005 ($p < 0.05$) suggests that this correlation is **significant**. The correlation between DFOS and Straddle in Supine (Degree) is $r=0.327$, indicating a **weak positive correlation** as the p-value is 0.017

($p < 0.05$) suggests that this correlation is **significant**. The correlation between DFOS and Vertical Jump Test (Cm) is $r = 0.325$, indicating a **weak positive correlation** as the p-value is 0.018 ($p < 0.05$) suggests that this correlation is **significant**. The correlation between DFOS and Y Composite Right is $r = 0.320$, indicating a **weak positive correlation** as the p-value is 0.019 ($p < 0.05$) suggesting that this correlation is **significant**. The correlation between DFOS and Y Composite Left is $r = 0.342$, indicating a **weak positive correlation** as the p-value is 0.012 ($p < 0.05$) suggesting that this correlation is **significant**.

DISCUSSION

In this study, the main findings were there was a weak positive correlation between DFOS and hamstring flexibility, gastrocnemius & soleus muscle flexibility, and adductor muscle flexibility. Secondly, there was a weak positive correlation between DFOS and lower limb power and dynamic balance.

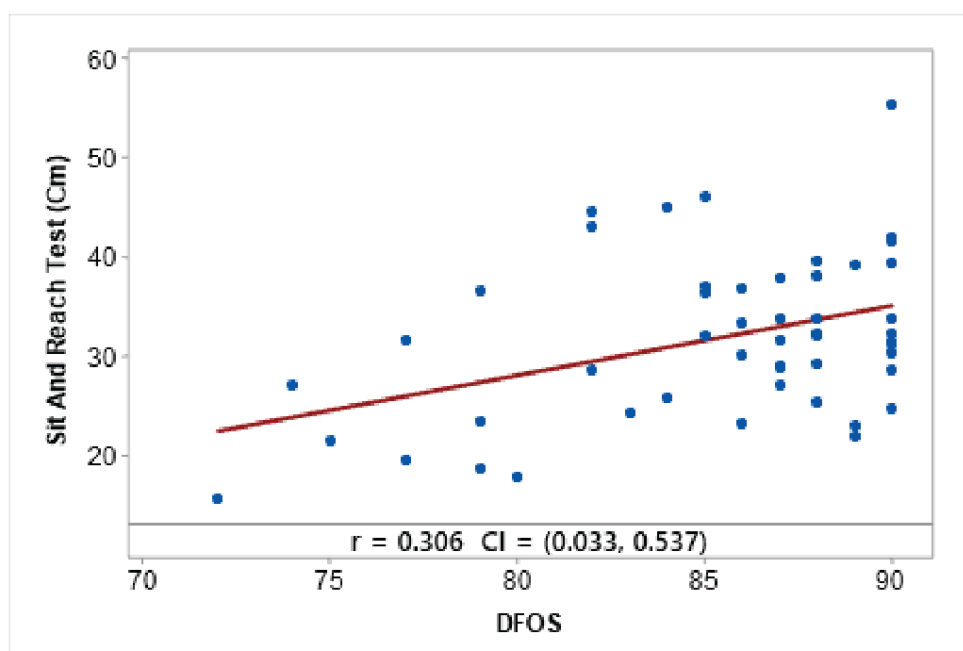
Correlation between DFOS and Sit and reach test:

In this study, it was found that there is a significant **weak positive correlation** ($r = 0.3060$) between the Sit and Reach Test and the Dance Functional Outcome Survey. This suggests that if hamstring flexibility increases then the functional status of the dancer also increases.

This observed positive correlation can be attributed to the pivotal role of hamstring flexibility in enhancing dance performance and refining dance techniques, particularly those involving extensions, leaps, and diverse body positions.

This is supported by research done by Reid et al. (1987) who stated that heightened flexibility in the hamstrings and lower back contributes to a dancer's capacity to execute movements with a broader range of motion and enhanced control, especially in ballet dancers. López-Miñarro et al. (2014), heightened flexibility also results in improved extensions and jumps, both of which are fundamental components of dance artistry.

Graph 1. Correlation of Sit and reach test and DFOS



Correlation between DFOS and Ankle flexibility test:

We found that there is a significant **weak positive correlation** ($r = 0.3830$) between ankle flexibility tests and the Dance Functional Outcome Survey.

This correlation can be explained by research done by (Smith et al., 2019; Johnson et al., 2013)

who demonstrated that ballet dancers with greater ankle flexibility exhibited improved balance and stability during intricate dance routines and the enhanced ankle ROM positively influences ballet dance movements requiring intricate footwork, such as quick direction changes and graceful turns.

These studies collectively underscore the

potential benefits of improved ankle flexibility in various aspects of dance performance. These findings are consistent with our current results, as greater ankle flexibility aligns with improved functional outcomes captured by the Dance Functional Outcome Survey.

Correlation between DFOS and Adductor flexibility test:

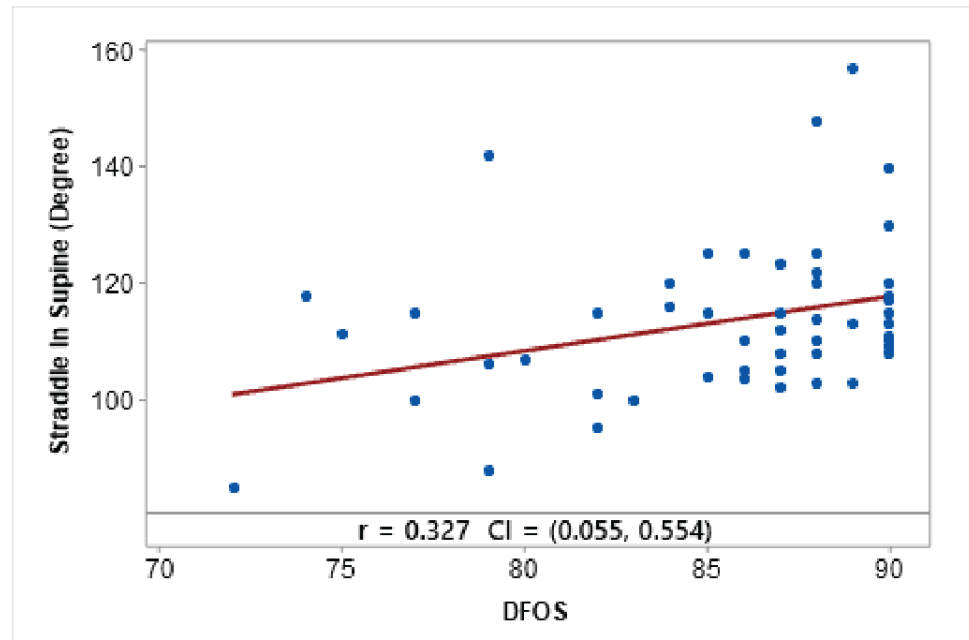
The finding of this study is a significant **weak positive correlation (r=0.3830)** between the straddle in the supine test for adductor flexibility and the Dance Functional Outcome Survey. This is supported by Kushner et al. (1990) who have demonstrated

that dancers with greater adductor flexibility are better equipped to achieve the wide leg positions and controlled movements that are characteristic of various dance styles.

Aiyegbusi et al.'s (2018) study findings reveal a noteworthy association between injury occurrence and the flexibility of the adductor group of muscles among ballet participants.

These insights align with our current findings, as enhanced adductor flexibility correlates positively with improved functional outcomes captured by the Dance Functional Outcome Survey.

Graph 2. Correlation of DFOS with Straddle in supine test



Correlation between DFOS and Vertical jump test:

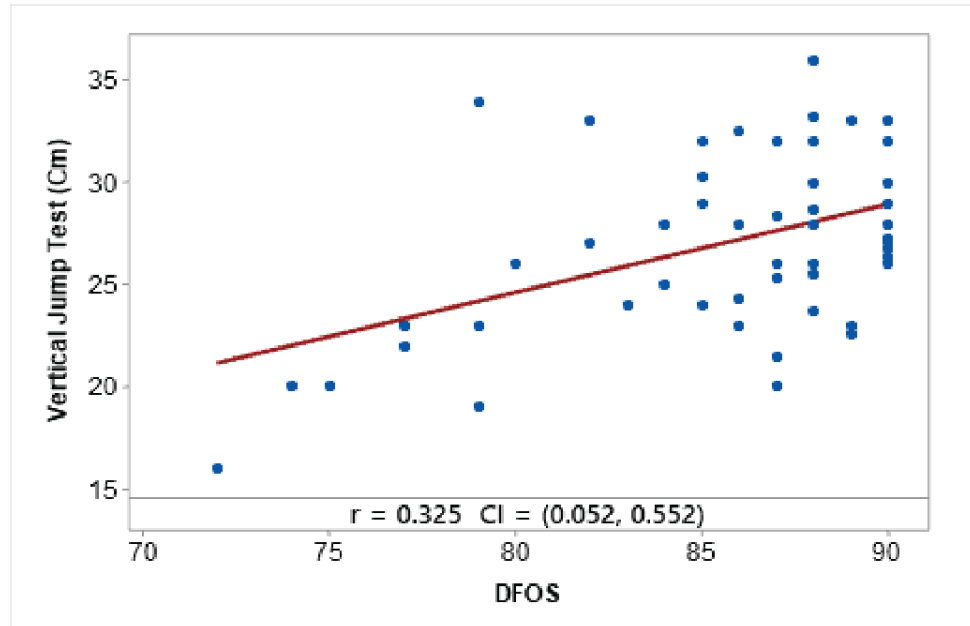
This study shows that there is a significant **weak positive correlation (r=0.3250)** between the dance functional outcome survey (DFOS) and the vertical jump test, which shows that enhancing lower body muscular strength and power can yield positive effects on dance performance.

Few studies have highlighted the significance

of lower body power in executing dynamic dance movements, particularly those involving leaping and lifting actions, and enhanced vertical jump ability contributes to increased height and gracefulness in jumps and lifts, key elements of ballet dance choreography according to Brown et al. (2007).

This correlation restates the importance of lower body power as a significant contributor to dance performance and functional outcomes.

Graph 3. Correlation of DFOS with Vertical jump test



Correlation between DFOS and Y balance test:

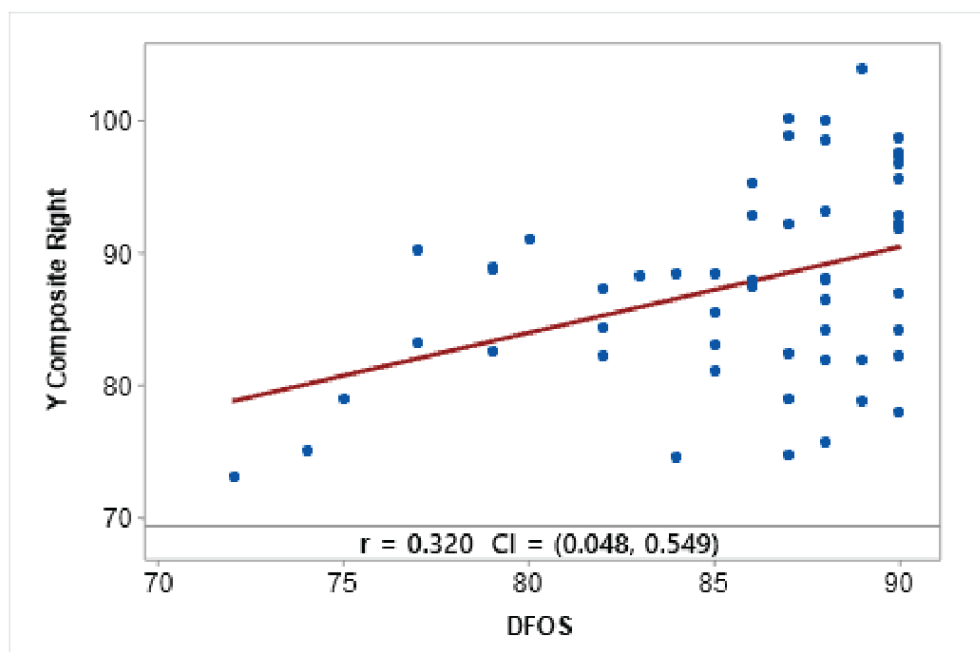
This study found that there is a significant **weak positive correlation ($r = 0.3200$)** and ($r = 0.3420$) between the scores from the Dance Functional Outcome Survey (DFOS) and the Y composite measures of balance on the right and left side.

As stated by (Bruyneel AV et al., 2010; Schmit JM et al., 2005), balance tends to improve in line with a dancer's skill level, with training playing a

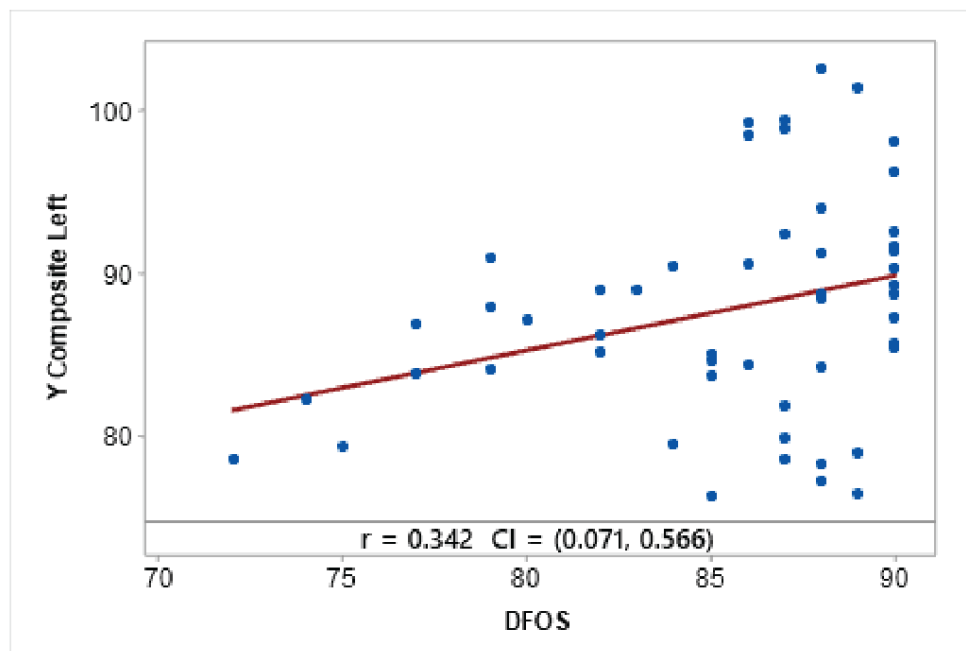
crucial role in enhancing motor control, directly impacting ballet performance and skill acquisition and more experienced and older dancers tend to exhibit superior balance compared to their younger counterparts.

Such insights help to explain that dancers with superior Y balance performance are assured to excel in executing complex routines demanding stability and spatial awareness, both crucial factors of dance choreography.

Graph 4. Correlation of DFOS with Right Y balance composite test



Graph 5. Correlation of DFOS with Left Y balance composite test



There are limitations to consider that including utilizing motion capture technology or advanced imaging techniques could provide more accurate assessments of lower limb attributes and their associations with dance functional status. The study included all female dancers, as no male dancers were available during the study, limiting the generalizability of finding a broader population that includes both males and females.

The clinical implications of this study encompass the development of tailored training programs, strategies for injury prevention and management, and the utilization of assessment tools for performance enhancement in ballet dancers.

Looking ahead, the future scope of research suggests the incorporation of biomechanical analysis for a more detailed understanding of the observed correlations. Additionally, a larger sample size could yield more powerful results, and including different age groups and professional levels in the study would contribute to more generalized findings.

CONCLUSION

This study concludes that recreational ballet dancers with greater flexibility, power, and dynamic balance in the lower limb tend to exhibit a higher dance functional status.

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