Y–Balance Test in Female Gymnasts

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Abstract: The aim of this study was to examine the differences in dynamic balance between the legs and potential asymmetry in rhythmic gymnasts. The sample consisted of six rhythmic gymnasts competing at the senior level A category and members of the Croatian National Team. Dynamic balance was assessed using the "Y Balance" test. Each gymnast performed the test in the anterior, posteromedial, and posterolateral directions, following a practice attempt. Data analysis was conducted using Statistica 14. Differences in Y Balance test performance between the dominant and non-dominant leg were evaluated using the T-test for dependent samples, as well as the Wilcoxon Matched Pairs Test for variables that did not follow a normal distribution. The results revealed a statistically significant difference in the posteromedial reach distance between the dominant and non-dominant legs, indicated by variables RRDPMD and RRDPMND (p=0.021). This disparity was evident in both absolute and relative terms, with the dominant leg demonstrating a greater reach distance. These findings suggest that the gymnasts exhibit a preference for one leg over the other, potentially affecting performance and increasing the risk of injury. Monitoring these asymmetries is crucial for developing targeted training interventions to enhance balance and functional performance.

1 INTRODUCTION

Rhythmic gymnastics is a difficult and complex sport which requires increased space-time coordination between body movements and apparatus handling (Purenović – Ivanović et al., 2016). Execution of rhytmic gymnastic elements demands a high level of physical ability, thus, strong performance relies on muscular strength and endurance, motor coordination, and postural balance (Shigaki et al., 2013). The balance provided by the feet refers to the capacity to maintain the center of gravity within the base of support (Duarte & Freitas, 2010).

Balance ability is influenced by genetics, but postural control continues to evolve throughout a person's life (Calavalle et al., 2008). Postural control (or balance) can be defined statically as the ability to maintain a base of support with minimal movement, and dynamically as the ability to perform a task while maintaining a stable position (Ricotti, 2011; Winter et al., 1990). It relies on various factors, including vestibular, retinal, kinesthetic, and tactile systems, which complicates investigation and analysis (Gateva, 2016). There is a sensitive period for balance stability between the ages of 11 and 14 for girls, and one year later for boys. (Gateva, 2016). By the ages of 11 to 13, children can implement strategies similar to those used by adults to maintain balance in both stationary and moving conditions (Hatzitaki et al. 2002; Muller et al. 1992; Shumway-Cook and Wollacott 1985). Two of the three main groups of body exercises heavily rely on this ability. The Y Balance Test is a dynamic stability assessment that is recognized for its efficiency and clinical applicability in accurately evaluating lower limb neuromuscular control (Fratti Neves et al., 2017). Most exercises in rhythmic gymnastics require an above-average ability to maintain balance while standing on a very small support surface; what causes additional difficulty is that the gymnast is required to keep the free leg in different demanding positions and move the apparatus (FIG, 2022; Sobera & Rutkowska – Kucharska, 2019). In balance exercises, it is common to hold a position with a minimal support surface,

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while during rotations, the same balance positions are executed with a 360°, 720°, or even greater degree of rotation.(Gateva, 2016). Many studies compared the balance ability of athletes from different sports, underlying that gymnasts tended to have the best balance ability (Bressel, Yonker, Kras & Heath, 2007; Hrysomallis, 2011; Scursatone, Caire, Cerrina, & Pizzigalli, 2015). Authors Purenović-Ivanović et al. (2023) investigated balance ability and performance scores in rhythmic gymnastics on a sample of 126 various level rhytmic gymnasts. Study of Root et al., (2019), examines the participation characteristics and the impact of specialization level on fitness and functional performance in 131 youth gymnasts (84 females, 47 males; avg. age 10.9 years). Authors Kyselovičova and Zemkova (2024) analyzed performance adaptations over two years of training in a 22-year-old elite aerobic gymnast, using tests for postural coordination, balance, jumping, leg strength, and the Wingate test. Study of Overmoyer and Reiser (2015), aimed to explore the relationship between flexibility, flexibility asymmetries, and Y Balance Test performance in 20 healthy active young adults (9 men, 11 women; avg. age 21.9 years), who completed 9 lower extremity active range of motion (AROM) tests and the Y Balance Test in one session. Furthermore, research of Gateva (2016), establishes a database for static balance in rhythmic gymnastics by testing 60 competitors across five age groups using four balance tasks, with amplitude deviation measured on a force platform during 10-second trials. Santos et al. (2015), aimed to assess lower limb flexibility and potential asymmetry indexes in 30 Junior 1st Division gymnasts in Portugal, with a mean age of 13.73 years. In study of Simas Frutuoso et al. (2016), the aim was to evaluate how lateral preference in the lower extremities affects anthropometric measurements, range of motion, and isokinetic torque in rhythmic gymnastics athletes. The objective of study of Santos et al. (2023), was to evaluate upper and lower limb balance and lower limb static strength in 12 female rhythmic gymnasts (ages 7-17) during the pre-season, using the Upper Body Test, Lower Body Test, and manual dynamometry. Aydin et al. (2023), analyzed hand-foot/leg preferences in 75 final routines of 28 elite rhythmic gymnasts from the 2021 World Cup and European Championships, focusing on body and apparatus difficulties and preferred side usage. Two groups of female rhythmic gymnasts (N=40) from the Greek national team, aged 11-12 and 13-15, were tested to (a) identify perceptual and motor abilities linked to performance across age groups, and (b) assess the predictive power of these abilities between the groups (Kioumourtzoglou et al., 1998). The aim of this the investigation was to find out the difference in dynamic balance between legs and potentional assimetry in rhytmic gymnasts.

2 MATERIAL AND METHODS

2.1 Sample of Subjects

The sample of subjects consists of 6 rhythmic gymnasts who compete at level A of the senior category and are also a part od Croatian National Team. he limited number of participants in this study reflects the high level of expertise required in gymnastics, which restricts the pool of athletes eligible for inclusion. The condition for participation in the research was the absence of injuries or painful conditions of the lower extremities, which could negatively affect the performance of the test or further worsen the current condition. Before conducting the research, the protocol and possible risks of the tests were explained to all gymnasts and declarations of voluntary participation were signed.

2.2 Measurement Protocol and Test

The research was conducted in the "Stoja" sports hall in Pula, where gymnasts spent two weeks at a summer camp. Since the testing was carried out during the preparatory period of the pre-competition season, all of the gymnasts were on the same fitness level. Before carrying out the tests, the gymnasts warmed-up for an hour, so that the conditions were as close as possible to daily training. After warming up, one by one the gymnast came to the measurer, followed by a demonstration and description of the performance of the "Y balance" test. Before the performance of the test, each gymnast had a trial attempt of the performance.

2.3 Y Balance Test

Since the test platform was not available, tapes glued to the ground were used, according to the prescribed rules of installation and execution and with values in centimeters marked on each tape. The test is performed in the anterior (Figure 1), posteromedial (Figure 2) and posterolateral (Figure 3) directions, whereby the angle between the posterior arms must be 90°, and the angle between the anterior and posterior arm must be 135°. Before performing the test, the length of the lower limbs of the gymnasts was measured, which will later be necessary for the calculation of the absolute and relative reach distance, calculated according to the formula: absolute reach length = (reach 1 + reach 2 + reach 3)/3 (cm) and relative reach length = absolute reach length/limb length*100 (Walker, 2016). Each gymnast had 3 attempts to perform the test, with the order of performing each test as follows: dominant leg anteriorly, non-dominant leg anteriorly, dominant leg posteromedially, non-dominant leg posteromedially, dominant leg posterolaterally and non-dominant leg posterolaterally (Linek et al., 2017). All 3 performance attempts are first performed on one limb, and only then on the other.

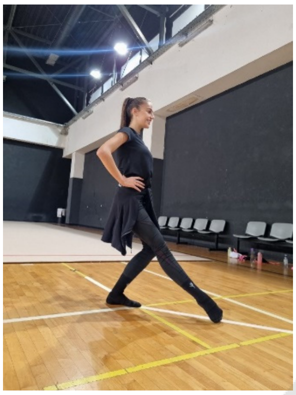

Figure 1: Y – balance test anteriorly.

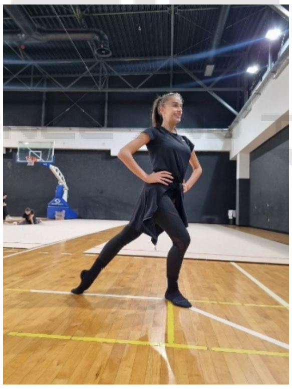

Figure 2: Y – balance test posteromedially.

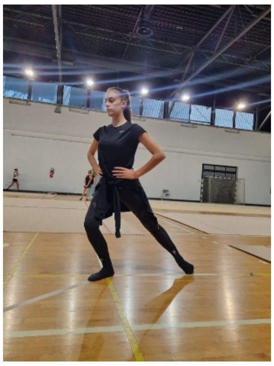

Figure 3: Y – balance test posterolaterally

2.4 Data Analysis

For easier use and data processing, all measurement data were entered into a Microsoft Excel table. Statistica 14 was used for further data analysis. Mean, minimum, maximum and standard deviation were calculated as indicators of descriptive statistics, while Kolmogorov-Smirnov test was used to check the normality of the distribution. The results showed that the distribution of the data is normal, except for variables ARDAND cm , ARDANND cm, RRDAND % , RRDANND %, ARDPMD cm, ARDPMND cm, which are not normally distributed. For the differences in the performance of the Y balance test between the dominant and non-dominant leg the T-test for dependent samples was used, as well as Wilcoxon Matched Pairs Test for variables that are not normally distributed.

3 RESULTS

Table 1 presents basic descriptive parameters for various reach distances in different directions (anterior, posteromedial, posterolateral) for both dominant and non-dominant legs.

Table 1: Descriptive Statistics.

Variable	Valid N	Mean	Minimum	Maximum	Std.Dev.
Height cm	6	169.167	163.000	178.000	6.039
length R leg cm	6	88.167	84.000	93.000	3.724
Length L leg cm	6	88.000	84.000	93.000	3.536
ARDAND cm	6	61.483	56.700	69.500	5.012
ARDANND cm	6	60.667	55.000	70.000	5.508
RRDAND %	6	70.200	64.800	74.700	3.248
RRDANND %	6	68.900	62.900	75.300	4.590
ARDPMD cm	6	94.217	69.500	112.000	16.295
ARDPMND cm	6	89.883	69.000	103.000	15.052
RRDPMD %	6	106.967	82.700	127.300	19.137
RRDPMND %	6	102.233	79.700	119.300	17.485
ARDPLD cm	6	90.817	70.300	106.300	13.465
ARDPLND cm	6	91.167	68.300	120.300	18.708
RRDPLD %	6	103.150	83.700	120.700	16.188
RRDPLND %	6	103.783	81.300	137.500	22.149

In Table 2 are the results of T-test for dependent samples. There is only statistically sgnificiant difference in variables RRDPMD and RRDPMND p=0.021.

Table 2: T-test for Dependent Samples.

Variable	Mean	Std.Dv.	N	df	p	Confi-dence -95,000%	Confi-dence +95,000%
RRDPMD %	106.967	19.137					
RRDPMND %	102.233	17.485	6	5	0.021*	1.052	8.414
ARDPLD cm	90.817	13.465					
ARDPLND cm	91.167	18.708	6	5	0.906	-7.618	6.918
RRDPLD %	103.150	16.188					
RRDPLND %	103.783	22.149	6	5	0.855	-9.090	7.823

Note. *Marked differences are significant at p < .05000

In Table 3 are the results of Wilcoxon Matched Pairs Test for variables which are not normally distributed. There is statistically significant difference between variables ARDPMD cm & ARDPMND cm.

Table 3: Wilcoxon Matched Pairs Test.

Pair of variables	No. of Non-ties	Percent v < V	Z	p-value
ARDAND cm & ARDANND cm	6	33.333	0.408	0.683
RRDAND % & RRDANND %	6	33.333	0.408	0.683
ARDPMD cm & ARDPMND cm	6	0.000*	2.041	0.041

4 DISCUSSION

Dynamic balance and stability, which are essential for gymnasts during a variety of routines and performances, are evaluated by the Y-Balance Test. It assesses an athlete's ability to stay balanced while reaching in different directions, modeling the demands of gymnastics. Postural stability is essential in rhythmic gymnastics during balance positions, as well as in pirouettes and jumps (Calavalle et al., 2008). Present the absolute and relative reach distances reached in the anterior, posteromedial, and posterolateral directions. Results shows that gymnasts' dominant and non-dominant legs had significantly different posteromedial reach distances, both in absolute and relative terms. Bilateral asymmetry in lower limb girth among both juvenile and adult gymnasts, attributing this to the dominance of exercises performed on the preferred side during training (Douda et al., 2002). The findings showed that in the posteromedial direction, the dominant leg's absolute reach distance was larger than the non-dominant leg. This suggests that when extending backward and inward, the gymnasts had greater stability and balancing abilities on their dominant side. The reason for this is that throughout training and performance routines, the dominant leg is used constantly, perhaps resulting in improved strength and proprioception. The main results revealed that 86.7% of the gymnasts exhibited significant flexibility asymmetry between their dominant and non-dominant limbs (Batista Santos et al., 2015). Similarly, the relative reach distance results indicated a noticeable difference between the dominant and non-dominant legs in the same posteromedial direction. This implies that even while the dominant leg works effectively, the non-dominant leg might not be able to attain a same degree of stability and balance. The preferred limb exhibited greater thigh girth and anatomical cross-sectional area, increased ankle dorsiflexor range of motion, and higher hip flexor torque at $60^{\circ}\cdot s^{-1}$, as well as greater plantarflexor torque at $180^{\circ}\cdot s^{-1}$ compared to the non-preferred limb (Simas Frutuoso et al., 2016). Reach distance ratios may indicate a dependence on the dominant leg, which may lead to an unequal development of balance and strength. Balance ability is a significant predictor of performance scores in rhythmic gymnastics, accounting for 35% of the variance in advanced-level gymnasts and 24% in the entire sample (Purenović-Ivanović et al., 2023). For gymnasts, these variations in reach distances are crucial since balance and stability are key components of an efficient rhythmic gymnastics performance. Asymmetry in reach lengths, particularly in the posteromedial direction, might impact skills like landings, jumps, and twists requiring for stability and lateral movement. Gymnasts tended to use the left foot for jumps and balances, while favoring the right foot for rotations (Aydin et al., 2023). Including specific training programs that target the non-dominant leg is crucial to correcting these asymmetries. For the lower limbs, a significant difference was found only between the right and left posterolateral patterns (G1=80.33 ± 5.06, G2=76.19 ± 8.14; $t(11) = -3.631$; $p = 0.004$; $d = 0.63$) (Santos et al., 2023). Exercises that improve posteromedial strength, stability, and flexibility need to be provided priority. Exercises for lateral balance, single-leg stability drills, and proprioceptive training may fall under this category. In the youngest elite athletes, eye-hand coordination, whole-body reaction time, and depth perception accounted for 40% of overall skill, while in the oldest group, dynamic balance, kinesthesis, and depth perception explained 56% (Kioumourtzoglou et al., 1998). Unipedal balance is a challenging skill specific to gymnasts, whereas bipedal stance is easier and less specific (Hrysomallis, 2011). There may be a higher chance of injury due to the observed imbalance in absolute and relative reach distances between the dominant and non-dominant legs. In a study by Plisky et al. (2009), the mean composite YBT scores for healthy high school and collegiate athletes were as follows: anterior reach 92.4% of leg length, posteromedial reach 92.9% of leg length, posterolateral reach 94.0% of leg length and composite score 93.1% of leg length. Asymmetry between limbs equal to or greater than 4 centimeters for the anterior direction and/or composite score less than 94% is related to neuromuscular control deficits and a higher probability of lower limb injuries (Fratti Neves et al., 2017; Plisky et al., 2009). Overuse injuries, especially to the ankle and knee, can result from an over-reliance on the dominant leg. Results indicate that the Y Balance Test can identify lower extremity flexibility deficits and asymmetries in the ankle and hip regions among recreationally active adults; however, it should be supplemented with additional tests for a comprehensive assessment of functional movement and injury risk (Overmoyer & Reiser 2015). The small sample size, while a limitation, is representative of the reality in elite gymnastics, where the number of athletes capable of competing at the highest level is inherently limited. This emphasizes the need for future research to consider the challenges of accessing a larger sample in such a specialized field.

5 CONCLUSIONS

The differences in relative reach distance between both legs can indicate balance and stability asymmetries in athletes. In the context of gymnasts, significant disparities in reach distance may suggest a preference for one limb over the other, potentially impacting performance and increasing the risk of injury. Monitoring these differences can help in developing targeted training interventions to improve overall balance and functional performance. A significant difference in reach distance in the posteromedial direction may indicate an imbalance in stability and control during movements that require weight shifting and lateral support. This is particularly relevant for gymnasts who frequently perform turns and transitions.

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