European Journal of Human Movement, 2019: **42**, 138-154

FLEXIBILITY AND STRENGTH IN BRAZILIAN AND PORTUGUESE GYMNASTS

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ABSTRACT

Introduction: The purpose of this study was: 1) compare the flexibility and strength levels and 2) investigate possible functional asymmetries in flexibility in gymnasts from two National Teams of Rhythmic Gymnastics. Material and Methods: Participants included nine gymnasts from Brazilian National Team (BNT) (20.8±1.9 years) and four gymnasts from Portuguese National Team (PNT) (15.8±1.3 years). Ten specific flexibility tests and six specific strength tests were used. The Mann-Whitney and Wilcoxon tests were applied. Results and Conclusions: The Brazilian National Team was composed by older gymnasts with more years of practice than Portuguese National Team. The groups obtained similar training volume. Brazilian gymnasts showed an advantage in all strength tests, although significant differences were observed in 66.7% of tests. On the other hand, the Portuguese gymnasts reached higher results than Brazilian gymnasts in the spine and shoulders flexibility, although without statistical significance, as well as lower levels of functional asymmetries. In the lower limbs flexibility, the groups showed excellent results with preferred lower limb. However, functional asymmetries in the flexibility tests were found in 88.9% and 50% of Brazilian and Portuguese gymnasts, respectively. Therefore, we cannot observe an absolute superiority of one National Team in the motor performance.

Keywords: rhythmic gymnastics, brazilian gymnasts, portuguese gymnasts, flexibility, strength, motor capacities

FLEXIBILIDAD Y FUERZA EN GIMNASTAS BRASILEÑOS Y PORTUGUESES

RESUMEN

Introducción: El propósito de este estudio fue: 1) analizar y comparar la flexibilidad y los niveles de fuerza y 2) identificar posibles asimetrías funcionales en la flexibilidad de las extremidades inferiores en gimnastas de 2 equipos nacionales diferentes. Material y método: se estudiaron 13 gimnastas de rítmica: 9 del Equipo Nacional de Brasil (BNT) (20.8 ± 1.9 años) y 4 del Equipo Nacional de Portugal (PNT) (15.8 ± 1.3 años). La Federación Internacional de Gimnasia recomendó pruebas para evaluar la flexibilidad y la fuerza. Para el análisis estadístico, se aplicaron las pruebas de Mann-Whitney y Wilcoxon. Resultados y conclusiones: BNT fue compuesta por gimnastas mayores con más años de práctica de RG y mayor volumen de entrenamiento que las gimnastas de PNT. Las gimnastas mayores y experimentadas presentaron una clara ventaja en todas las pruebas de fuerza. En la evaluación de la flexibilidad en la columna vertebral y las articulaciones escapulohumeral, las gimnastas más jóvenes mostraron mejores resultados en las articulaciones de la cadera, ambos grupos mostraron resultados excelentes con la extremidad inferior dominante. Sin embargo, el 88.9% de las BNT y el 50% de las gimnastas de PNT tenían diferentes niveles de asimetría funcional en la flexibilidad de las extremidades inferiores. Por lo tanto, no observamos una superioridad absoluta de uno de los grupos analizados.

Palabras clave: gimnasia rítmica, gimnastas brasileñas gimnastas portugueses, flexibilidad, fuerza, capacidades motoras

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Submitted: 12/11/2018 *Accepted:* 09/03/2019

INTRODUCTION

Rhythmic gymnastics (RG) is a sport that requires many specific assumptions and, therefore, the training process has high demands from the volume and intensity, and technical elements with a high difficulty level (Bobo-Arce & Méndez-Rial, 2013). The sport performance is influenced by several technical, tactical, physical and psychological factors (Laffranchi, 2001). In RG the motor capacities may clearly affect the performance (Di Cagno et al., 2009; H. Douda, Toubekis, Avloniti, & Tokmakidis, 2008; Miletić, Katić, & Maleš, 2004). For competitive success and identification of potential talent in RG, the main motor capacities are flexibility, strength, coordination, rhythm, balance, agility and endurance (H. Douda et al., 2008; Laffranchi, 2001).

Most specialists in RG see flexibility as a fundamental motor capacity for this sport (Moraru, 2016). However, only the flexibility does not guarantee the execution of the elements with the necessary range and intensity, it is needed a "strength" that allows the gymnast to control her freedom of expression and perform the movements with the proper technique (Silva, 2001). Therefore, the correct technical performance is only possible if a high level of strength development is achieved (Bobo & Sierra, 1998).

Thus, flexibility and strength play a key role in the great technical demand and a good interaction between these motor capacities is recommended for high quality performance (Polat & Günay, 2016), once that appropriate levels of flexibility and explosive strength are a precondition for proper performance of all basic body elements (jumps, balance and rotation) (Miletić et al., 2004). The improvement of these motor capacities increase the possibility of executing different movements, thus, providing a higher gymnasts' technical level (Boligon, Deprá, & Rinaldi, 2016; Silva, Oliveira, Leme, Nascimento Júnior, & Anversa, 2016).

In RG, the high technical demand with the execution of increasingly complex elements requires an increasing volume of training (Vernetta, Montosab, & López-Bedoya, 2016). The high level gymnasts train on average 25-30 hours per week (Zetaruk, Fors, Zurakowski, Mitchell Jr, & Micheli, 2006) and, in some cases, 40 hours per week (Ávila-Carvalho, Klentroub, Palomero, & Lebre, 2013) in order to achieve the necessary preparation for a good performance.

The increase of training volume in RG has been pointed out by some authors (Ávila-Carvalho et al., 2013; Georgopoulos et al., 2012; Zetaruk et al., 2006) as the main characteristic of the training process in elite gymnasts of nowadays. According to H. T. Douda, Laparidis, and Tokmakidis (2002) the prolonged training volume of elite gymnasts can induce structural changes in their motion system, through of specific unilateral adaptations, due to partial use in the lower limbs. In RG, like most sports have a tendency to prioritize the

work with the preferred body side (Sousa, 1997). Bilateral asymmetry is accepted as being normal up to a 10% (Croisier, 2004) or 15% (Marchetti, 2009).

Therefore, the purpose of this study was to compare the flexibility and strength levels in Brazil (BNT) and Portugal National Teams (PNT) RG gymnasts, in addition to identify possible functional asymmetries in flexibility in the gymnasts of study.

METHOD

Participants

13 rhythmic elite senior gymnasts (n=13) participated in this study: nine gymnasts from BNT and four gymnasts from PNT.

Age and training characteristics

Chronological age, years of RG training and training volume were collected using questionnaires (Table 1).

TABLE 1
Age and training characteristics of Brazil and Portugal National Team.

VARIABLES	BNT	PNT	p value (BNT x PNT)
Age (years)	20.8*±1.9	15.8*±1.3	*0.003**
Training volume (hours/week)	36.0±0.0	34.5±3.0	*0.503*
RG practice (years)	14.0*±2.4	8.8*±2.2	*0.006**

Legend – BNT: Brazil National Team; PNT: Portugal National Team;
** p≤0.05: significant differences.*

Ethical Considerations

The study protocol was approved by the Ethics Committee of Faculty of Sport, University of Porto, Portugal. The requests were sent to the Scientific Committee of Brazil and Portugal Gymnastics Federation, which after being informed about the study, its scientific value and multiple benefits, approved the study, allowing the testing to be conducted during the BNT and PNT training sessions. All testing were performed in accordance with the ethical standards of the Helsinki Declaration.

Physical Tests

The International Gymnastics Federation (FIG) recommended tests were used (Aleksandrova, Lebre, Dias, & Fink, 2015; Klentrou et al., 2010) to assess the levels of flexibility, resistance and explosive strength using RG specific movements.

The tests were conducted in training environment following strictly the protocol proposed. A Nikon Photographic Camera and a Samsung Video Camera were used to register the images and videos. After, the tests were analyzed by two international judges with more than 10 years of experience. After 10 days, the judges repeated the evaluation. We observed high values of intra-examiner reliability (Kendall Coefficient of Concordance) and inter-examiner reliability (Intraclass Correlation Coefficient), which confirms a high quality of information.

Flexibility Measurements

The maximum passive and active flexibility was measured in ten specific RG movements using main joints: hip, scapulohumeral and spine. Eight of these tests – Leg up forward with help of the hand (LF1), sideways (LS1) or backward (LB1); Leg up forward without help of the hand (LF2), sideways (LS2) or backward (LB2); From lying on the floor (face down) lift the trunk to the vertical (TLV) and maximum trunk lift (MTL) measure – assess the flexibility comparing joint(s) range of motion against with an assessment chart (Table 2). There are 5 levels attributed to each movement, referring to the maximum possible range of motion using a scale from 0 to 4 points (0 = poor, 1 = satisfactory, 2 = good, 3 = very good and 4 = excellent). Only whole numbers were attributed to results. For movements with a range of movement between two points of the assessment chart, the next lower value was registered.

The second part includes two linear tests (Table 2): Forward Stand-and-Reach (FSR) and Rotation of the upper limbs (RUL).

TABLE 2
Flexibility tests (Aleksandrova et al., 2015; Klentrou et al., 2010).

TEST	Leg up with help of the hand (L1)	Leg up without help of the hand (L2)	Trunk Lift (TL)	Forward Stand-and-Reach (FSR)	Rotation of the upper limbs (RUL)*1
PURPOSE	To measure the passive range of motion of the hip joints	To measure the active range of motion of the hip joints	To measure the active range of motion in the upper back	To measure active range of motion in the lower back and hip	To measure the active range of motion of the scapulohumeral joint
EQUIPAMENT	Table 5 points (chart for rating)	Table 5 points (chart for rating)	Table 5 points (chart for rating)	Measuring tape	Ruler with scale (cm)
POSITION	Standing straight (wall, bar or backrest)	Standing straight (wall, bar or backrest)	Lying on the stomach	Standing on the bench with knees fully extended and toes at the edge of the bench	Standing with the ruler in front of the body with the minimum distance between hands
ACTION	Leg up forward (LF1), sideways (LS1) or backward (LB1) to maximum with help of the hand. Perform with both legs.	Leg up forward (LF2), sideways (LS2) or backward (LB2) to maximum without help of the hand. Perform with both legs.	Lift trunk upwards, without help until vertical (TLV) or the maximum extent (MTL)*2.	Leaning forward and reach toward the ground. Repeat 4 times; on the fourth trial, hold the position of maximum reach for one complete second.	Rotation of the extended upper limbs back without trunk inclination
MEASUREMENT	Maximum angle between legs	Maximum angle between legs	Maximum distance of the trunk from floor.	Maximum distance of fingers from the edge of the bench.	Minimum distance of hands during the rotation of upper limbs

**1: Test from Douda et al. (2008); *2: Test adapted from Klentrou et al. (2010).*

In the lower limb (LL) flexibility tests (L1 and L2), the gymnasts performed the exercises with preferred (PLL) and non-preferred lower limb (NPLL). The PLL is the leg that gymnast prefers to perform the task and the NPLL is the support leg. A limit of 15% bilateral difference was established as the maximum value for a normal difference (i.e. no asymmetry) between PLL and NPLL (Marchetti, 2009). The asymmetry index (AI) was calculated using the equation (Chavett, Lafortune, & Gray, 1997): AI (%) = [(PLL-NPLL)/PLL]*100, where AI represents the asymmetry index, PLL is the preferred lower limb test result (mean value achieved in the active and passive flexibility tests with PLL) and NPLL the non-preferred lower limb test result (mean value achieved in the active and passive flexibility tests with NPLL).

Resistance and explosive strength measurements

Six tests were performed. Part of these tests (Table 3) are exercises characterized by execution of energetic, fast and continuous movements, by performing the maximum number of repetitions in a given time (30 seconds): front power kicks (FPK), back power kicks (BPK), partial trunk elevations (PTE), partial curl-ups (PCU) and rope skipping (RPK). Therefore it required the gymnasts to have a good level of strength, due to the requirement of repetitions with maximum power, i.e., a maximum rhythm, keeping the optimal range of motion with short rest periods. We record in video the exercise execution and after the valid repetitions for each gymnast were counted.

TABLE 3
Strength tests (Klentrou et al., 2010).

TEST	Front power kick (FPK)	Back power kick (BPK)	Partial Trunk Elevations (PTE)	Partial Curl-Ups (PCU)	Rope skipping (SKR)	Vertical Jump test (VTJ)
PURPOSE	To measure explosive strength and muscular endurance (lower limbs).	To measure explosive strength and muscular endurance (lower limbs).	To measure explosive strength and muscular endurance (back).	To measure explosive strength and muscular endurance (abdomen).	To measure RG specific power, coordination and muscular endurance (lower limbs).	To measure explosive strength (lower limbs).
EQUIPAMENT	Stopwatch			Stopwatch and masking tape	Stopwatch	Ink and scale. (21x120cm, 1.6 – 2.0m from the ground).
POSITION	Lying on the back with legs straight.	Lying on the stomach with legs straight.	Lying on the stomach with legs straight.	Lying on the back, knees bent at 90º, feet flat on the floor, legs slightly apart, arms straight and parallel to the trunk with palms of hands resting on the floor. The head is in contact with the floor.	Standing with the rope stop behind the body or with movement in eight.	Standing with dominant shoulder half a foot away from the wall. The middle finger of the dominant hand is covered ink. After, touch in the scale fixed to the wall, and mark the first measure (M1), which is the highest point reached with feet flat on the ground.
ACTION	Lifting each leg to vertical position and altering as many time as possible. The hips in retroversion, upper limbs extended and apart, contracted abdomen, spine upright and fully supported on the ground.	Lifting each leg to vertical position and altering as many time as possible. The hips in retroversion, upper limbs in forward, next to the body or the elbows used as support, contracted abdomen and fully supported on the ground.	Lifting the trunk to the vertical with maximum speed. The hips in retroversion, contracted abdomen, lower limbs extended and hands on the head.	Initial phase involves "flattening out" of lower back region, followed by a slow "curling up" of the upper spine. Keeping heels in contact with the floor, the hands move forward, without to lift of the floor, towards the heels. Return the start position – repeat.	Double jumps with the rope.	Execution of vertical jump according to the vertical jumping technique with countermovement jump, to mark the second measure (M2), that it refers to the highest point reached during the jump, with the same body segment. 3 trials are allowed.
MEASUREMENT	Maximum repetitions in 30 seconds.					The highest distance (cm) from M1 to M2.

In addition, the gymnasts performed the vertical jump (VTJ) (Sargent, 1921), according to the vertical jumping technique with countermovement jump, which is the rapid flexion and hip extension, knee and ankle, in a body projection movement vertical (Komi & Bosco, 1978). The jumping technique was explained in detail verbally, repeated and demonstrated as needed. In the jump time, it was allowed to freely flex the LL and move the upper limbs, to provide the largest possible vertical impulse.

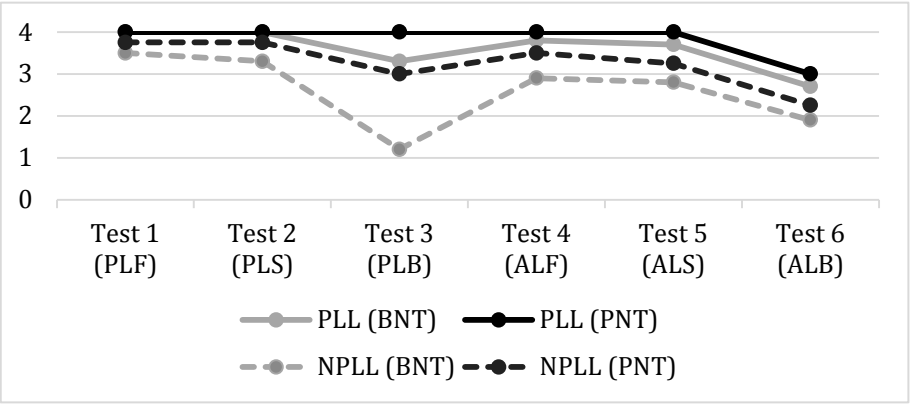
Statistical Procedures

Statistical analysis was performed using the Statistical Package for Social Sciences (SPSS 23.0). The significance level was set at 5%. Descriptive statistics were performed using the mean, standard deviation, median, minimum and maximum values. Mann-Whitney test was applied to compare flexibility and strength scores across National Teams. Further, Wilcoxon test was used to compare the preferred and non-preferred body sides in the flexibility tests.

RESULTS

Flexibility measurements

Figure 1 shows that BNT and PNT presented higher results in the flexibility test performed with PLL than NPLL.



*Legend –BNT: Brazil National Team; PNT: Portugal National Team; Passive flexibility tests – PLF: Leg up forward with help of the hand; PLS: Leg up sideways with help of the hand; PLB: Leg up backward with help of the hand; Active flexibility tests – ALF: Leg up forward without help of the hand; ALS: Leg up sideways without help of the hand; ALB: Leg up backward without help of the hand. * p≤ 0.05: significant differences.*

FIGURE 1: Lower limbs flexibility tests of Brazil and Portugal National Team.

When we compared the flexibility results achieved between National Teams (Figure 1), significant differences were observed only in one test with NPLL (p=0.034): Leg up backward with help of the hand (PLB test). Whereas the PNT obtained 3.0±1.4 points, BNT reached 1.33±0.70 points in referred test.

No differences were found in BNT and PNT in the flexibility tests with PLL: PLF (p=1.000); PLS (p=1.000); PLB (p=0.131); ALF (p=0.325); ALS (p=0.124); ALB (p=0.724); and with NPLL: PLF (p=0.181); PLS (p=0.083); ALF (p=0.110); ALS (p=0.214); ALB (p=0.669). However, although without statistical significance, PNT achieved higher flexibility levels than BNT in all tests, except in PLF and PLS tests with PLL, where both groups reached the maximum results.

In the functional asymmetry analysis, we verified significant differences in PLL and NPLL in all flexibility tests performed by BNT: PLF (p=0.014); PLS (p=0.011); PLB (p=0.017); ALF (p=0.005); ALS (p=0.035); ALB (p=0.014), and in only one test by PNT: ALS (p=0.049). Thus, it was important to verify the functional asymmetry levels by the asymmetry index. We can see, in Table 4, the functional asymmetry levels per gymnast of both groups. The values of PLL and NPLL in the Table 4 correspond to the mean values of passive and active flexibility tests with PLL and NPLL, respectively.

TABLE 4
Individual average values achieved in all flexibility tests performed with preferred and non-preferred lower limb, and respective classification order; asymmetry index in flexibility between lower limbs.

Gymnast	National Team	Mean (PLL)	Mean (NPLL)	Asymmetry Index
1	PNT	4.00 (1)	3.83 (1)	4.17%
2	BNT	3.83 (2)	3.67 (2)	4.18%
3	PNT	3.83 (2)	3.50 (3)	8.70%
4	BNT	2.83 (5)	2.33 (8)	**17.67%**
5	BNT	3.50 (4)	2.83 (5)	**19.14%**
6	PNT	3.83 (2)	3.00 (4)	**21.74%**
7	BNT	3.67 (3)	2.83 (5)	**22.89%**
8	PNT	3.67 (3)	2.67 (6)	**27.27%**
9	BNT	2.83 (5)	2.00 (9)	**29.33%**
10	BNT	3.83 (2)	2.50 (7)	**34.73%**
11	BNT	3.83 (2)	2.50 (7)	**34.73%**
12	BNT	3.83 (2)	2.50 (7)	**34.73%**
13	BNT	3.50 (4)	2.17 (9)	**38.00%**

Legend – BNT: Brazil National Team; PNT: Portugal National Team.

Table 4 shows that 76.9% gymnasts of this study presented functional asymmetry of different magnitudes (17.7 to 38.0%).

In UL and multi-joint flexibility tests (Table 5), no significant differences were found in the groups, however, despite not statistically significant, some

results were substantially relevant. PNT presented better results (11.5±18.1 cm) than BNT (27.6±25.5 cm) in the shoulder test (RUL). The high standard deviation values showed a high inter-individual variability in both groups. In FSR test, the groups presented similar results although the minimum and maximum values showed a high inter-individual variability especially in BNT. In TLV test, 100% of PNT and 88.9% of BNT achieved an excellent level (4). On the other hand, in MTL test, we observed lower results in BNT: 11.1% (level 4); 77.8% (level 3) and 11.1% (level 0). PNT showed better results: 75% (level 4) and 25% (level 3). Thus, significant differences were found in TLV versus MTL only in BNT (p=0.005).

TABLE 5
Upper limbs and multi-joint flexibility tests of Brazil and Portugal National Team.

Flexibility tests	General		BNT				PNT				p value
	x±sd	Med	Min	Max	x±sd	Med	Min	Max	x±sd	Med	
RUL (cm)	22.7±24.0	8	0	78.0	27.6±25.5	27.0	0	38.0	11.5±18.1	4.0	*0.260*
FSR (cm)	25.6±6.5	25.4	12.4	36.5	26.0±7.8	25.6	21.7	28.2	24.7±2.8	24.5	*0.825*
TLV (1)	3.8±0.8	4	1	4	3.7*±1.0	4	4	4	4.0±1.0	4	*0.825*
MTL (1)	3.1±1.0	3	0	4	2.8*±1.1	3	3	4	3.8±0.5	3	*0.076*

Legend – BNT: Brazil National Team; PNT: Portugal National Team; RUL: Rotation of the upper limbs; FSR: Forward Stand-and-Reach; TLV: Trunk Lift Vertical; MTL: Maximum Trunk Lift; (1): measure Table 5 points; Med: Median; p≤0.05: significant differences

Resistance and explosive strength measurements

BNT gymnasts presented better results than PNT gymnasts in all strength tests (Table 6), although these differences were significant only in FPK, BPK, PCU and VTJ tests. Thus, there is a pattern in the results of both groups in strength tests, in the following order: RSK, FPK, BPK, PTE, PCU.

TABLE 6
Strength tests of Brazil and Portugal National Team

Strength tests	General			BNT			PNT			p value
	Min	Max	x±sd	Min	Max	x±sd	Min	Max	x±sd	
FPK (rep)	26	39	32.9±4.0	31	39	34.8*±2.9	26	30	28.5*±1.7	*0.003**
BPK (rep)	26	34	30.2±2.5	28	34	31.1*±2.2	26	30	28.3*±2.1	*0.050**
PTE (rep)	16	27	22.8±2.7	22	27	23.8±1.8	16	24	20.5±3.4	*0.106*
PCU (rep)	15	22	17.9±2.4	16	22	18.9*±2.2	15	16	15.5*±0.6	*0.006**
RPK (rep)	39	49	45.6±3.1	44	49	47.0±2.0	39	47	43.8±3.4	*0.111*
VTJ (cm)	31.2	53.5	41.4±8.0	39.0	53.5	47.1*±5.6	31.2	36.8	34.3*±2.3	*0.016**

*Legend – BNT: Brazil National Team; PNT: Portugal National Team; FPK: Front power kicks; BPK: Back power kicks; PTE: Partial trunk elevations; PCU: Partial curl-ups; RPK: Skipping with the rope; VTJ: Vertical jump test; rep: repetitions. * p≤0.05: significant differences*

DISCUSSION

The sample of this study was composed by the best gymnasts from Brazil and Portugal Senior National Team. To be part of a Senior National Team demands a lot of work and effort over many years. A National Team has to be a special team, and composed by top athletes from their respective countries (Alves, 2003).

BNT gymnasts had more time to practice in RG (14.0±2.4 years) and they were older (20.8±1.9 years) than PNT gymnasts (age 16.5±1.2 years and practice of 8.8±2.2 years). This higher experience may be one of the justifications for the results found in our study. The training volume was also higher in BNT 36.0±0.0 hours/week against 34.5±3.0 hours per week in PNT, although, both groups present an hours/week training load according to international recommendations that suggest more than 30 hours per week. During the seventies and eighties the requirement was 15 hours and 20 hours per week, respectively (Georgopoulos et al., 2012). Other authors explain that to achieve the necessary preparation for a good performance, elite gymnasts train 25-30 hours per week and in some cases, 40 hours per week due to the high physical and technical requirements in RG (Ávila-Carvalho et al., 2013; Zetaruk et al., 2006).

Ávila-Carvalho et al. (2013) observed high training volume in elite gymnasts (39.5±7.0 hours per week for young gymnasts and 41.4±5.9 hours per week for adult gymnasts). The authors also analyzed the training volume in elite gymnasts in some RG studies done in previous years and concluded that there was an increase training in hours that starts at the second half of first decade of this century. Di Cagno, Baldari, Battaglia, Guidetti, and Piazza (2008) found similar training volume values (39.8±0.6 hours per week) in elite senior gymnasts (17.8±1.5 years). According to Berlutti et al. (2010), the gymnasts who participated in the European Championship of 1986 trained 21.7 hours per week and in 2008, 36 hours per week. These data demonstrate a tendency to increase the training volume over the recent years.

In RG, the high technical demand with the execution of increasingly complex elements requires an increasing volume of training (Vernetta et al., 2016), once that great performances in in this sport are the results of detailed, planned, organized and as well as a multilateral work towards the harmonious development of the gymnasts' body, and the adaptations of their body to the requirements of RG (Laffranchi, 2001).

In the physical tests performed, the gymnasts demonstrated familiarity with most exercises, since these are daily used in practice (Laffranchi, 2001; Lebre & Araujo, 2006).

In flexibility evaluation, we verified that the gymnasts showed high and similar flexibility levels in passive and active flexibility tests (forward and side), which require only flexibility of hip joint. On the other hand, in passive and active backward flexibility tests, we observed lower values, probably due to the necessary combination between flexibility in hip and spine joints to perform these skills successfully.

While the most BNT gymnasts reached maximum values in the TLV (88.9%), we verified in MTL results, different spine flexibility levels, where only 11.1% of gymnasts achieved the maximum level. All PNT gymnasts maintained a higher regularity, as all gymnasts obtained excellent results in TLV and 75% in MTL. This difficulty reflects the results presented in passive and active backward flexibility especially in BNT gymnasts.

On the other hand, Palmer (2003) points the importance of shoulder flexibility in RG. Douda et al. (2008) evaluated the flexibility of scapulohumeral joint in elite (16.0±11.5cm) and non-elite (17.3±12.7cm) gymnasts and the authors found lower values in BNT gymnasts (27.6±25.5cm) and higher values in PNT gymnasts (11.5±18.1cm). We verified a high inter individual variability when this test was performed.

In the FSR, BNT (26.0±7.8cm) and PNT (24.7±2.8cm) gymnasts presented similar results. We observed higher values than the results found in sit-and-reach test by Douda et al. (2008) in elite (22.2±3.5cm) and non-elite gymnasts (23.6±4.5cm).

Great performances in this sport are the results of detailed, planned, organized and as well as a multilateral work towards the harmonious development of the gymnasts' body, and the adaptations of their body to the demands of RG (Laffranchi, 2001).

When we compared the preferred and non-preferred LL in flexibility tests, the results were not expected due to the high level of gymnasts and high training volume in both groups. BNT gymnasts presented significant differences in the body sides in all flexibility tests, while PNT gymnasts only in one test (LKS). However, we observed that 50% of PNT and 88.9% of BNT gymnasts showed different functional asymmetries levels, according to the limit of 15% bilateral difference established as the maximum value for a normal difference between PLL and NPLL (Marchetti, 2009). In RG, as in most individual sports, there is a predominance in the development of one body side (Sousa, 1997), and laterality is the term used to describe the asymmetric behaviour in the use of right and left body side (Teixeira, 2006). When these differences exceed normal conditions, they can cause imbalance in the physical development of the gymnasts and induce, an elongation of the most used LL, pelvic torsion and/or lumbar scoliosis (Lisitskaya, 1995). Both body sides may be equally skilful if trained equivalently from the outset (Arango, 2003). Thus, although there is a

natural asymmetry of the human body, it is suggested that the asymmetry in this modality is mainly a training result (Lisitskaya, 1995). According to Batista-Santos et al. (2015), an emphasis is given to the preferred limb through executing a higher number of repetitions or because of the greater intensity and interest of the gymnast to perform the exercise with the "best" limb. Therefore, studies about this topic are very important to know the flexibility and asymmetry levels of the gymnasts, and to induce a reflection on the type of work that is being developed with gymnasts. Some of apparent asymmetries, according to Lisitskaya (1995), may reflect negatively on physical and technical preparation of gymnasts, which in the short term become performance conditioning factors and in long term, can produce pathologies. Batista-Santos, Bobo-Arce, Lebre, and Ávila-Carvalho (2015) analyzed the flexibility levels and functional asymmetry in Portuguese junior gymnasts (13.7 ± 0.2 years), and they verified that 86.7% of gymnasts presented high indexes of flexibility asymmetry between the preferred and non-preferred limbs of different magnitudes.

The strength tests used in this study measures the main and most important muscle groups in rhythmic gymnasts' body. According to Gateva (2013), LL explosive strength is a key ability in the body group exercises – jumps and leaps. Back and abdominal muscle control is the basis for a successful technical performance in the other body group exercises – rotations and balances.

In repetition tests, the gymnasts achieved best results in RPK (45.6±3.1 rep), on mean 1.52 repetitions per second. This movement is naturally faster than the remaining exercises evaluated. The technical ability has influenced this test. However, all gymnasts did not present execution errors, where it could change the results. The lower expressive results were presented in PCU (17.9±2.4 rep). Its probable that for smaller familiarity this was shown by gymnasts in this test. It was necessary 1.68" to perform each repetition of curl-ups.

We verified similar values in front and back power kicks (FPK and BPK), due to the similar execution, although different muscular groups are requested (FPK: hip flexors - iliopsoas, sartorius and rectus femoris; rectus abdominis. BPK: hip extensors - gluteal and hamstrings; lumbar square; iliopsoas; psoas minor). In these tests, the gymnasts used 0.91" and 0.99", respectively, to achieve each repetition. The values achieved in PTE are also among the lower results, although this exercise is usually used in the training gymnastics, as the *battements* exercises (FPK and BPK).

Therefore, we consider that FPK and BPK tests showed better results, probably because the trunk and UL weight are higher than LL weight that perform in the movement practice. Thus, the body remains more stable on the

ground and the gymnast can perform faster repetitions. On the other hand, in PTE and PCU, as the LL are lighter, because a body instability, when the trunk elevation is carried out until the vertical. Thus, the gymnast presents a greater difficulty and requires more strength to perform the execution of each repetition, and as result, the movement becomes slower. In these exercises, with the fixing of LL, insurance by some support or colleague, it would be possible to execute the movements with more speed and amplitude.

We also believe that these differences could also be justified if the gymnasts having higher strength levels in LL muscles as well as in the spine muscles.

In VTJ, BNT gymnasts (47.1±5.6cm) reached higher values than elite (37.5±3.5cm) and non-elite (35.9±3.5cm) gymnasts studied by Douda et al. (2008). However, PNT gymnasts (34.3±2.3cm) showed lower results.

When comparing BNT and PNT we observed that BNT gymnasts presented a clear advantage in all strength tests performed. This superiority can be justified by higher training volume, higher training intensity, older and experience in RG and/or possible genetic factors of BNT gymnasts.

CONCLUSIONS

BNT was composed by older gymnasts, with more years of RG practice and higher training volume than PNT gymnasts. These characteristics (age and experience) can probably explain the results found in our study. The older and experienced gymnasts presented a clear advantage in all strength tests. In flexibility assessment in spine joints and scapulohumeral joint, the younger gymnasts showed higher results and in the hip joints, both groups showed excellent results with PLL, due to the high requirement of this motor capacity in RG. However, 88.9% of BNT and 50% of PNT gymnasts had different functional asymmetries levels in flexibility of the LL, probably as a result of unilateral training in the years of practice. Therefore, we did not observe an absolute superiority of one of the groups analyzed.

ACKNOWLEDGMENTS

The authors would like to thank the Brazilian and Portuguese Federation of Gymnastics, the gymnasts and coaches that permitted the making of this study possible.

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