ACTIVE AND PASSIVE LOWER LIMB FLEXIBILITY IN HIGH LEVEL RHYTHMIC GYMNASTICS

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Abstract

Flexibility is one of the main physical abilities required in Rhythmic Gymnastics practice. It's expected that high level gymnasts as National Teams members show high levels of this motor ability. The aim of this study was to evaluate the level of active and passive flexibility of the lower limbs (preferred and non-preferred) of 5 high level junior gymnasts (13.60 ± 0.25 years old) during a sport season. The limb which effectively performs the task is considered the preferred and the one which functions as support is considered the non-preferred. For the flexibility assessment gymnasts were evaluated performing 7 specific Rhythmic Gymnastics movements in three different moments of the sports season. These movements were filmed and the videos were analyzed. A five point scale (from 0 to 4) was used to classify the performance of the gymnasts in each movement. For statistical analysis nonparametric tests (Mann-Whitney, Friedman and Wilcoxon test) were used. The results revealed that the gymnasts showed a high level of active and passive flexibility for the preferred lower limb (average of 3,98 points in the 7 tests) but lower levels with non-preferred lower limb (average of 3,10 points in the 7 tests). However, the gymnasts registered a significant improvement of the flexibility levels on the non-preferred lower limb at the different measurements moments over the season.

Keywords*: Preferred Lower Limb, Non-preferred Lower Limb, Flexibility, Rhythmic Gymnastics, High Level gymnasts.*

INTRODUCTION

Rhythmic gymnastics (RG) is a sport that combines elements of gymnastics, dance, and apparatus manipulation: rope, ball, hoop, clubs and ribbon (Despina et al., 2014) that involves beauty, elegance and excellence in body movement. A high level of development in motor skills, flexibility, strength, endurance, coordination, agility, rhythm and balance (Laffranchi, 2005) is required. However, flexibility and strength play a key role in RG. This sport requires gymnasts with high flexibility and a good compromise between strength and flexibility is advisable for high quality performance (Donti, Tsolakis, & Bogdanis, 2014; Douda, Tokmakidis, & Tsigilis, 2002). The work of

these motor skills is closely linked and considered indispensable for achieving a high level with top performances. For Laffranchi (2005), these performances are reached through a detailed planning and organization of training, in addition to the application of multilateral work for the harmonious development of the gymnast´s body, as well as necessary adjustments according to the sport requirements.

Lebre (1993) pointed out the importance of coaches devoting great attention to the training of motor skills. During training, knowing each gymnast individually is crucial to drawing up and planning a training program focused on their needs and physical and technical shortcomings, whilst also respecting their limits.

Gurak (2002) mentions that is essential to carry out assessments of gymnasts to promote RG development by enabling the progress monitoring, as well as the acquisition in the process of sports orientation and selection.

According to Monteiro (2000), the high importance of periodic evaluation of the training process is supported by various authors (Bobo & Sierra, 1998; Lisitskaya, 1995; Llobet, 2000). The evaluation of training process development allows monitoring the work objectives and the success levels during all process.

The aim of this study is to evaluate the level of passive and active lower limb (LL) flexibility and compare the level of flexibility of both lower limbs (lower limb preferred and non-preferred) in high level junior gymnasts at three distinct moments during the season 2010-2011. This longitudinal evaluation was important because the gymnasts were selected in begin to be part of the national team competing in international competitions and we would like to evaluate their evolution since the moment that the gymnasts were selected until the main competition in this sport season (European Championship).

The hypothesis of the study is that the elite gymnasts have high level of passive and active flexibility for the preferred and non-preferred lower limb (maximum levels, according to the battery of tests applied).

METHODS

Sample

This study concerns the analysis of 5 high level RG junior gymnasts with an average age of 13.6 ± 0.25 and with 7.2 years of gymnastics practice, i.e. since 6 or 7 years of age. They trained 7 times per week with an average of 3.75 hours per session.

In Table 1 we present the somatic measurements and some training characteristics of our sample.

Table 1
Descriptive statistics of somatic measurements and training characteristics.

Somatic Measurements(x ± sd)	
Age (years)	13.60 ± 0.245
Height (cm)	1.58 ± 0.007
Weight (kg)	41.60 ± 0.828
Years of practice (years)	7.20 ± 0.490
No. of training sessions / week	7 ± 0,000
No. of hours of training / day	3.57 ± 0.000

The first evaluation was carried out after a selection trial in November 2010, when the gymnasts were chosen to represent their country in European Championships. The second evaluation took place in March, 2011 and the third in June, 2011, following the European Championships.

The gymnasts were free of injury and testing was performed during the season 2010-2011. The parents of the gymnasts gave their written consent for the study before data collection. The study was approved by the University of Porto and all procedures were in accordance with the Helsinki declaration. Portugal Gymnastics Federation has also been informed and authorized the study.

Flexibility measurement

The battery of LL flexibility tests of Federation International Gymnastics (FIG, 2010) carried out in this study consists of the evaluation of 7 specific RG movements, executed with both LL: preferred lower limb (PLL) and non-preferred (NPLL). The limb which effectively performs the task is considered the PLL and the one which functions as support is considered the NPLL.

It should be pointed out that the gymnasts should have warmed up prior to the testing. The gymnasts performed the usual training warm up with ballet bar exercises, floor exercises and flexibility exercises – splits on one or two benches (about 1,5 hour). The tests were carried out in competition ambient in 1st evaluation (in the afternoon), and training ambient in 2nd and 3rd evaluation (in the afternoon). Each evaluation was carried in 30-45 minutes.

The tests evaluate maximum passive and active flexibility through the dimensionless method which compares the gymnast's joint range of motion against an assessment chart. There are 5 classification values attributed to each movement, referring to the maximum possible range of motion and on an ascending scale from 0 to 4 points, in which 0 = very poor, 1 = poor, 2 = average, 3 = good and 4 = excellent. Only whole numbers are attributed to results. For movements with a range of movement between two points of the assessment chart, the next lower value is registered. To register the images to a posterior analysis a Nikon Photographic Camera and a Samsung Video Camera were used. The flexibility tests were analyzed by an international judge with 10 years of experience. After 10 days, the judge repeated the evaluation two times. The data was processed using the SPSS statistics. Cronbach's reliability coefficient alpha and calculation of concordance between respective evaluator's grades and the common test object were used for evaluation of reliability. The reliability of assessment was high, which indicates an appropriate selection of test criteria and descriptions.

The tests and their 5 classification points are presented below in figures 1 to 7. To evaluate passive flexibility, supported hold exercises were performed of LL to the front (test 1), LL to the side (test 2), LL to the rear (test 5) and the splits on two benches (test 7). To evaluate flexibility, unsupported hold exercises were performed of LL to the front (test 3), LL to the side (test 4) and LL to the rear in Penché position (test 6).

The gymnasts were familiar with the stretching protocols, since they performed these exercises in every day training and competition.

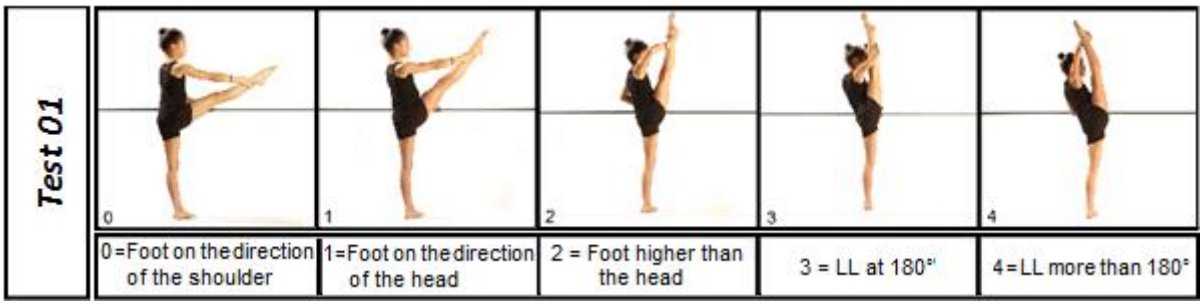

Figure 1. Reference points (0 – 4) of test 1: "supported LL hold to the front".

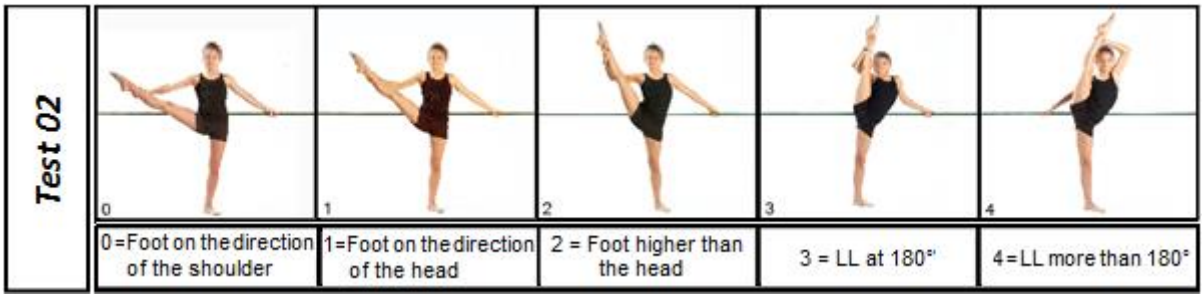

Figure 2. Reference points (0 – 4) of test 2: "supported LL hold to the side".

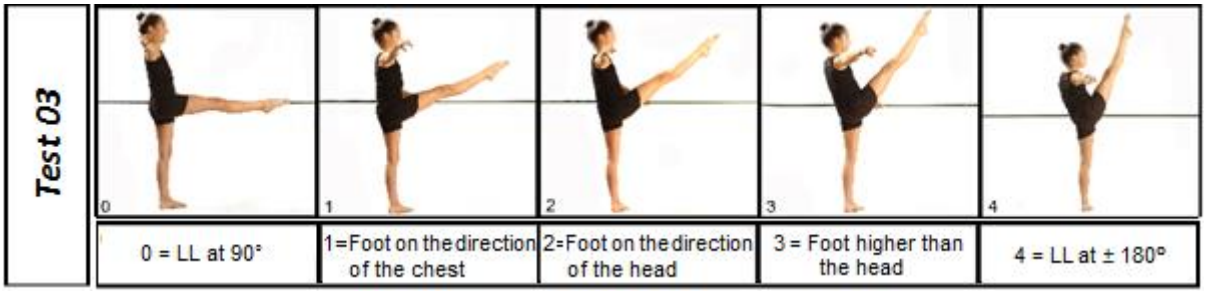

Figure 3. Reference points (0 – 4) of test 3: "unsupported LL hold to the front

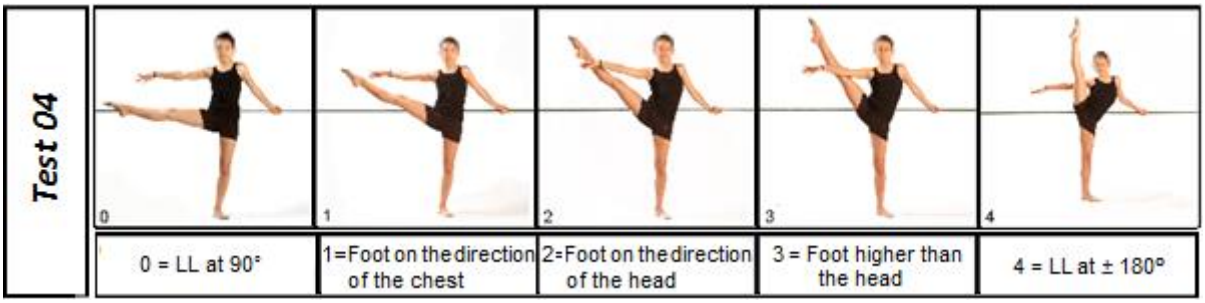

Figure 4. Reference points (0 – 4) of test 4: "unsupported LL hold to the side".

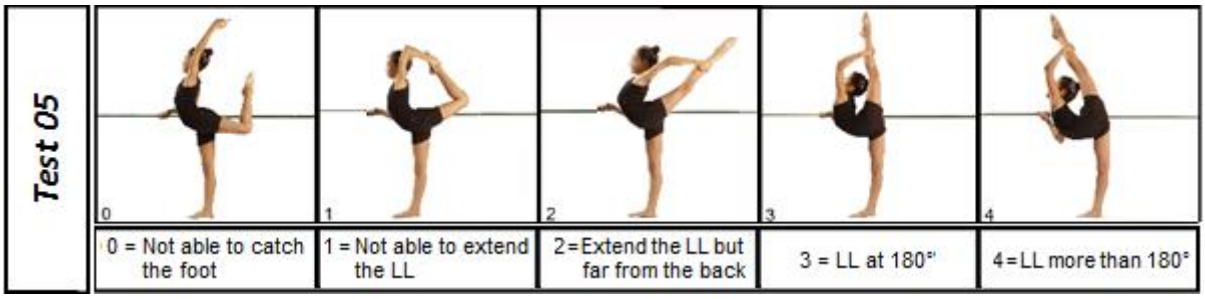

Figure 5. Reference points (0 – 4) of test 5: "supported LL hold to the rear"

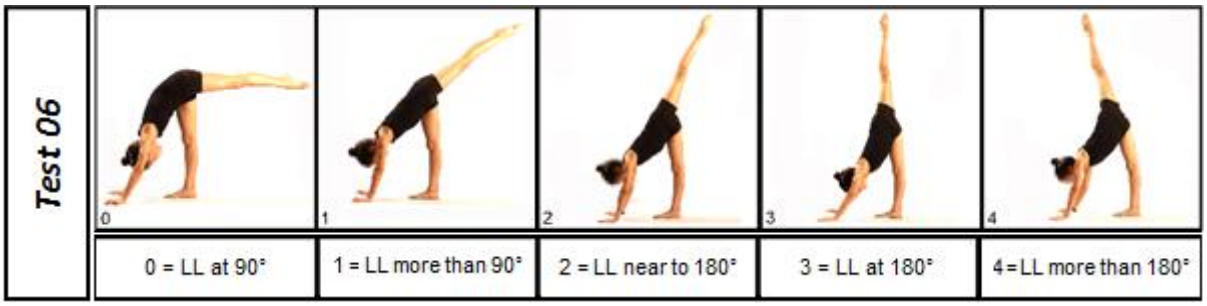

Figure 6. Reference points (0 – 4) of test 6: "unsupported LL hold to the rear – *Penché*".

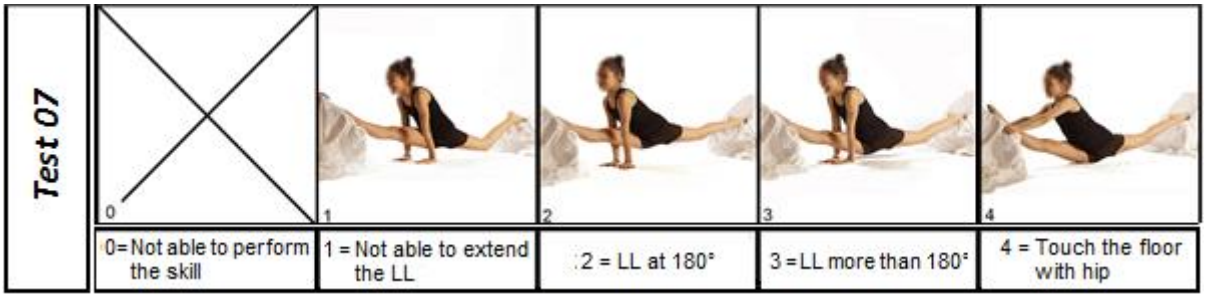

Figure 7. Reference points (0 – 4) of test 7: "Splits on two benches".

Statistical Procedures

The program *Statistical Package for the Social Sciences* – Version 18.0 (SPSS *Statistics* 18.0) was used for statistical treatment of the data, The significance level for the rejection of the null hypothesis was set at α=0.05 (confidence interval of 95%).

Initially perform the Shapiro-Wilk normality test (Table 2) and although some variables had normal distribution, as the flexibility tests are represented by ordinal variables, using of a scale of 0 to 4 points and our sample was reduced, the statistical treatment of these variables was carried out using non-parametric tests –Mann-Whitney test, Friedman test and Wilcoxon test, because they are free scale tests. The descriptive statistics were carried out using the median as measure of central tendency and the minimum and maximum values as measures of relative position.

Table 2
The Sapiro-Wilk normality test to Flexibility tests.

Shapiro-Wilk normality test		
	PLL	*NPLL*
Test 01	– **	0.046
Test 02	– **	0.161*
Test 03	– **	0.161*
Test 04	– **	0.001
Test 05	– **	0.200*
Test 06	– **	0.200*
Test 07	– **	0.026

RESULTS

Individual improvement on the tests with PLL and NPLL

The improvement was focused in the NPLL. It can be seen crossing the different evaluations, even when the differences were not highlighted in statistical terms. It is therefore necessary to point out the improvements made at the three evaluations for each test.

As can be observed in Figure 8 of Test 1 with NPLL, the gymnasts showed an

improvement from the 1st to the 3rd evaluations in the level reached. Gymnast C made significant progress, from 0 on the 1st evaluation to 3 on the 3rd. Gymnast D maintained the same results at the three points, showing any improvement.

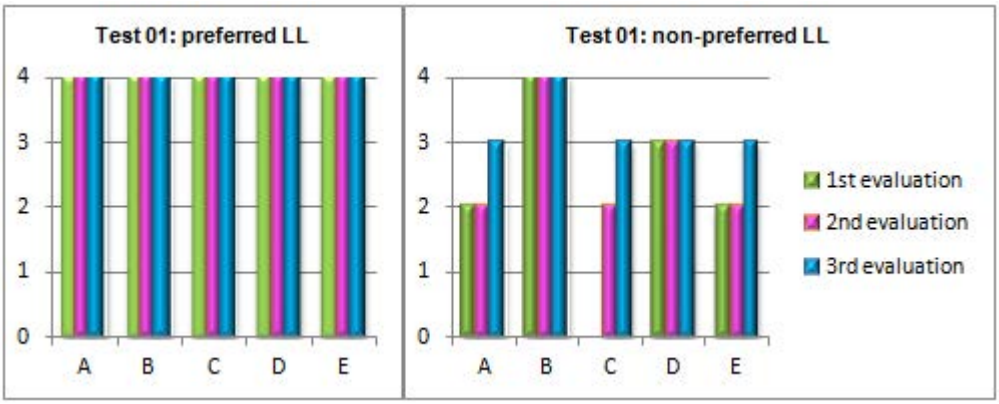

Figure 8. Level reached by each gymnast at three evaluations for Test 1 – "LL hold to the front".

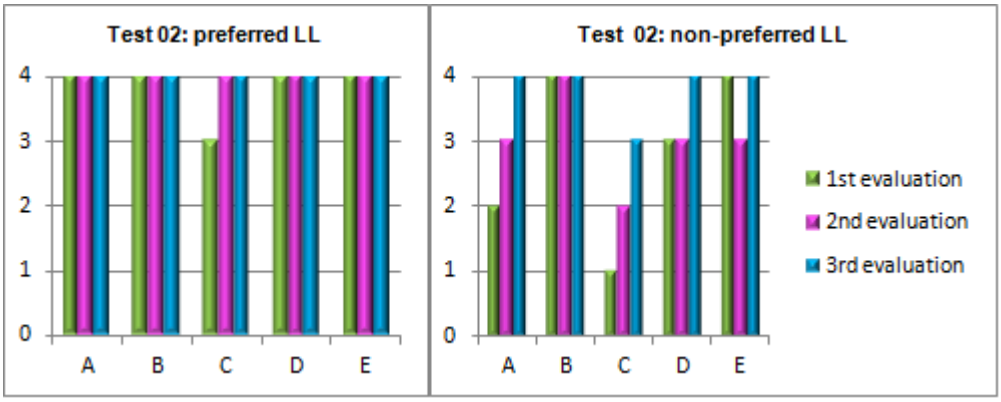

Figure 9. Level reached by each gymnast at three evaluations for Test 2 – "supported LL hold to the side".

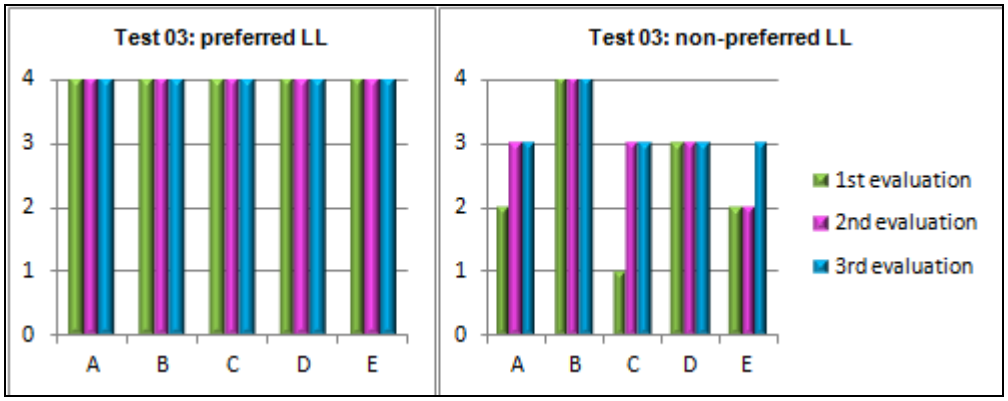

Figure 10. Level reached by each gymnast at three evaluations of Test 3 – "unsupported LL hold to the front".

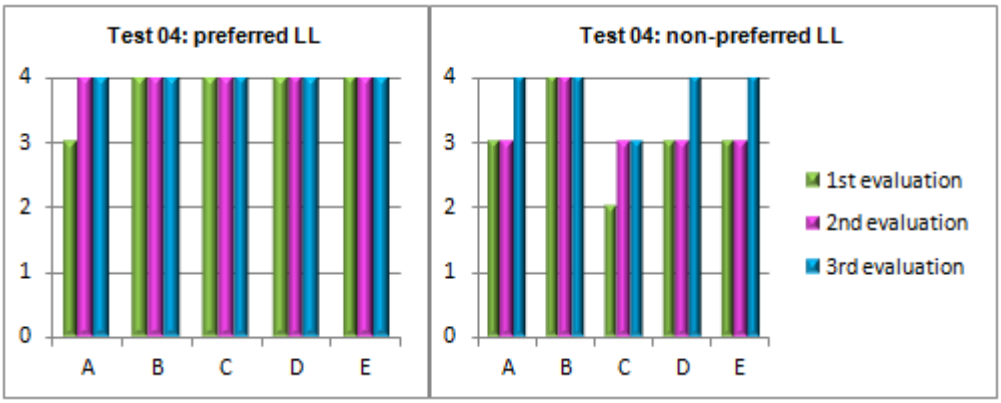

Figure 11. Level reached by each gymnast at three evaluations of Test 04 – "unsupported LL hold to the side".

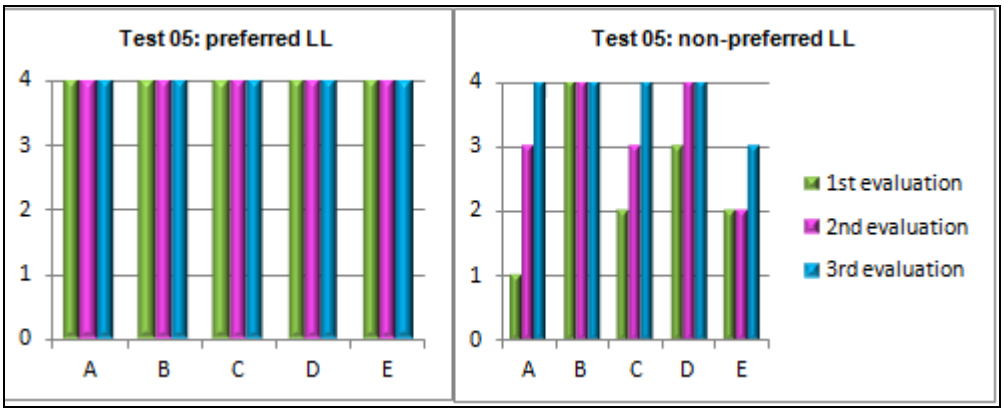

Figure 12. Level reached by each gymnast at three evaluations of Test 5 – "supported LL hold to the rear".

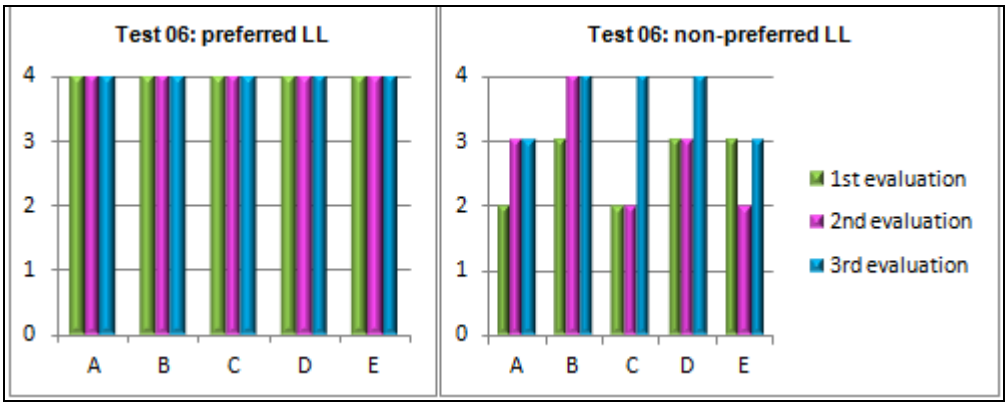

Figure 13. Level reached by each gymnast at three evaluations of Test 6 – unsupported LL hold to the rear – *Penché.*

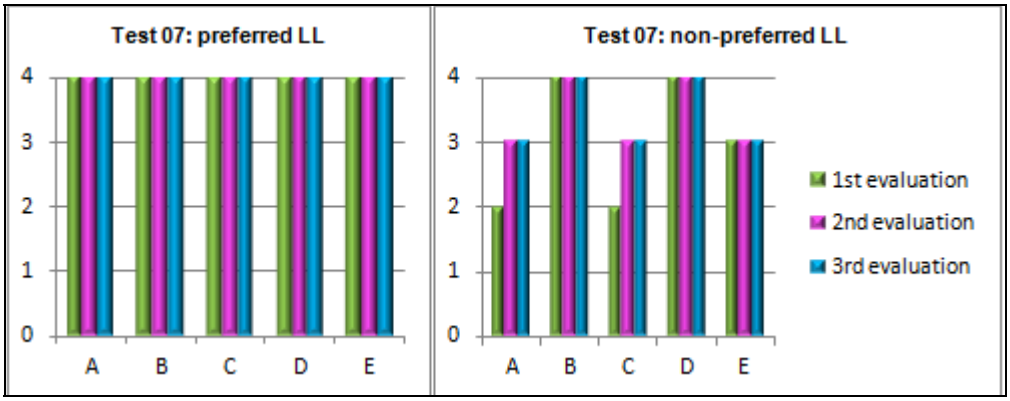

Figure 14. Level reached by each gymnast at three evaluations of Test 6 – "Splits on two benches".

Observing the results for Test 2 (figure 9), it can be found that the gymnasts showed an improvement in the level reached with NPLL from the 1st to the 3rd point, with the exception of gymnast E. All the gymnasts reached level 4 at the 3rd point, with the exception of gymnast C, who reached level 3. This gymnast showed great progress during the evaluation process, as in Test 1, from level 1 to level 3.

In the values for the Test 3 carried out with NPLL (figure 10) the gymnasts showed an improvement from the 1st to the 3rd evaluations, with the exception of gymnast D, who maintained the same results at the three points without any improvement, and gymnast B, who attained level 4 from the 1st evaluation. At the 3rd evaluation all the gymnasts attained level 3 with NPLL as their maximum at all points, except gymnast B who attained level 4. Once again, attention must be drawn to gymnast C who progressed from level 1 to level 3 during the three evaluations.

In test 4 (figure 11) all the gymnasts attained level 4 at the 3rd evaluation with NPLL, with the exception of gymnast C.

In Figure 12, it can be seen that in Test 5 with NPLL all the gymnasts reached level 4 at the final evaluation, with the exception of gymnast E. The results of gymnast A must be highlighted, she achieved level 1 at the 1st evaluation, level 3 at the 2nd evaluation and finally level 4 at the 3rd evaluation.

Observing the results for the Test 6, we can point out that the gymnasts improved on their level with NPLL from the 1st evaluation to the 3rd, with the exception of gymnast E, who registered a drop from the 1st to the 2nd evaluation and then returned to the same level attained at the 1st evaluation. At the 3rd evaluation, gymnasts B, C and D reached level 4 and gymnasts A and E reached level 3. Gymnast C registered the more visible evaluation (level 2 at the 1st and 2nd evaluation and level 4 at the 3rd evaluation).

As shown in Figure 14 of Test 7, it was registered a slight progress in level attained from the 1st to the 3rd evaluations with NPLL.

PLL evaluation at three moments:

According to Table 3, in all the flexibility tests carried out with PLL there were no significant differences between the results obtained at the three moments for the majority of the tests. The gymnasts had the highest level (level 4) at all evaluation moments on the tests 1, 3, 5, 6, and 7. For the tests 2 and 4, one gymnast obtained level 3 only in 1st evaluation.

At table 4 is visible the evolution on the data for NPLL. In Test 1, at least one gymnast exhibited level 0, defined as "very weak", at the 1st evaluation moment. Furthermore, in all the tests the highest level (level 4) was reached by at least one gymnast at each of the three evaluation moment.

Table 3
Median, minimum and maximum values and significance levels of Friedman tests in results obtained on PLL evaluation at three moments.

	PREFERRED LOWER LIMB (PLL)									
	1ST EVALUATION			2ND Evaluation			3RD Evaluation			*p*
	Min.	Max.	Median	Min.	Max.	Median	Min.	Max.	Median	
Test 01	4	4	4.0	4	4	4.0	4	4	4.0	– **
Test 02	3	4	4.0	4	4	4.0	4	4	4.0	*0.368*
Test 03	4	4	4.0	4	4	4.0	4	4	4.0	– **
Test 04	3	4	4.0	4	4	4.0	4	4	4.0	*0.368*
Test 05	4	4	4.0	4	4	4.0	4	4	4.0	– **
Test 06	4	4	4.0	4	4	4.0	4	4	4.0	– **
Test 07	4	4	4.0	4	4	4.0	4	4	4.0	– **

*p<0.05: there are significant differences
** there is no change in the results at the three moments

NPLL evaluation at three moments:

Table 4:
Median, minimum and maximum values and significance levels of Friedman tests referring to results obtained in the comparison of NPLL evaluation at three moments.

	NON-PREFERRED LOWER LIMB (NPLL)									
	1ST evaluation			2ND evaluation			3RD evaluation			*p*
	Min.	Max.	Median	Min.	Max.	Median	Min.	Max.	Median	
Test 01	0	4	2,0	2	4	2,0	3	4	3,0	*0.061*
Test 02	1	4	3,0	2	4	3,0	3	4	4,0	*0.071*
Test 03	1	4	2,0	2	4	3,0	3	4	3,0	*0.097*
Test 04	2	4	3,0	3	4	3,0	3	4	4,0	*0.039**
Test 05	1	4	2,0	2	4	3,0	3	4	4,0	*0.030**
Test 06	2	3	3,0	2	4	3,0	3	4	4,0	*0.074*
Test 07	2	4	3,0	3	4	3,0	3	4	3,0	*0.135*

*p<0.05: there are significant differences

From the data in Table 4 we can observe that were significant differences between at least two evaluation moments only in the Tests 4 and 5.

In order to determine between which points these differences exist in statistical terms in Tests 4 and 5, the analysis *Post-hoc* was used, performed with the Wilcoxon Signed-Rank Test, according to the following tables.

In Test 4 (unsupported LL hold to the side – NPLL), according to the significance

level shown in the comparisons of each evaluations, it can be seen in Table 5 that significant differences were only found in the results attained from the 1st to the 3rd evaluations.

Table 5
Comparison of three evaluations of Test 4 to determine statistical differences between evaluations.

Test 04	1st evaluation	2nd evaluation
1st evaluation		
2nd evaluation	*0.317*	
3rd evaluation	*0.046**	*0.083*

*p<0.05: there are significant differences

In Test 5 (LL hold to the rear – NPLL) (Table 6), there were significant differences from the 1st to the 2nd evaluations and from the 1st to the 3rd evaluations

Table 6
Comparison of three evaluation of Test 5 to determine statistical differences between evaluations.

Test 05	1st evaluation	2nd evaluation
1st evaluation		
2nd evaluation	*0.047**	
3rd evaluation	*0.036**	*0.063*

*p<0.05: there are significant differences

From the results of data in Test 5, it is possible to see that there was improvement from the 2nd to the 3rd evaluations, however, significant differences were not found.

DISCUSSION

According to Jastrjembskaia and Titov (1999) and Laffranchi (2005), the flexibility is the main motor skill of RG. Gymnasts of this sport are mainly characterized by their flexible joints and compliant muscles (Donti et al., 2014). Róbeva and Rankélova (1991), Petry (2008) and Stadnik, Ulbricht, Perin, and Ripka (2010) consider that gymnasts should exhibit flexible joints, in particular the joints of the hips. (coxo-femoral), the shoulders (scapula-humerus) and the vertebral column. These tests aim to assess flexibility levels of the coxo-femoral joint through exercises regularly used by the gymnasts in training. The ballet bar exercises aim to develop motor skills, as does the conscious assimiliation of the basic positions of RG for correct posture, facilitating, other than the bar, the execution of movements. These exercises are performed in many, if not all, training sessions (Laffranchi, 2001). Therefore, this statement appears to explain the good results in the fact that the gymnasts mainly obtained levels 3 and 4 in the PLL flexibility tests. However, the results obtained with NPLL at the 1st evaluation must be stressed; the gymnasts, despite their high technical level did not attain very significant levels.

Initially (in 1st evaluation), the results don't meet the hypothesis made in this study, because the gymnasts didn't submitted high levels of passive and active flexibility with NPLL.

However, it was possible to observe the gymnast's evolution during the concerned season, through the improvement registered in the flexibility level in lower limbs from the 1st to 3rd evaluation. The fact that these gymnasts were chosen to represent their country in the European Championships played a considerable motivation role in their daily training objectives.

The group level was crucial in the planning and definition of the aim of each training session, given that for Laffranchi (2005), the homogeneity of the team is essential for the gymnasts' growth and progress. For this reason, based on the results obtained at the last evaluation point, excellent advances were seen in NPLL flexibility. We don't know the type of

training led to improvements in flexibility, but through the results, it is possible recognize that the focus on symmetrical work caused the considerable fall in asymmetry ratings of the gymnasts.

Sometimes, the flexibility asymmetries appear as a result of the training type. Emphasis is given to the preferred limb through executing a higher number of repetitions with it or because of the greater intensity and desire of the gymnast to perform the exercise with the limb which is easiest. According to Cobalchini and Silva (2008), the NPLL can achieve a similar performance to the PLL when properly stimulated.

From the results of this study, gymnast B must be singled out for maintaining the highest level (level 4) in all the tests at all three evaluations, with the exception of test 06 (unsupported LL hold to the rear – *Penché*) in which only level 3 was obtained at the 1st point. This gymnast could be considered "excellent" according to our battery of flexibility tests. Gymnast C must also be singled out for obtaining an improvement of 130.1% with the NPLL from the 1st to the 3rd evaluation.

This type of study, accompanying the progress of the gymnasts over a season, is considered extremely valid to report performance, to orientate results, strengthen goals, as well as motivate and install the confidence in the work being done (Llobet, 2000). The work developed with the gymnasts observed on this study had a lot of positive points, proved by the results set out in this study.

Lisitskaya (1995) advises that in some training sessions, a larger proportion of movements with the NPLL should be used, given that according to (Giolo, 2008), both preferred and non-preferred sides are essential in the practice of RG. Thereby it is the responsibility of coaches to create the appropriate balance to avoid overloading one limb, as well as to direct the work in the training sessions in accordance with the needs and weaknesses of each gymnast.

CONCLUSIONS

These elite RG gymnasts from the 1st to 3rd evaluations showed excellent improvements in NPLL flexibility, and based on the results obtained at the last evaluation point, it can be concluded that, the focus on symmetrical work caused the considerable fall in asymmetry ratings of the gymnasts. They showed high level of flexibility in their preferred lower limb since 1st evaluation.

According the hypothesis of the study, it was expected that the elite gymnasts had high level of passive and active flexibility for the preferred and non-preferred lower limb, however, in 1st evaluation, the results don't meet the hypothesis, because the gymnasts showed high level of passive and active flexibility with PLL only. In 3rd evaluation, despite the improvement in the passive and active flexibility level with NPLL, this lower limb didn't showed the level maximum.

Thereby, the best suggestion for the flexibility training in RG is the implementation of symmetrical work, independent the selection of exercises, for to promote the correct and balanced development the gymnasts. The coaches are the key for success in this sport.

This study had limitations as the reduced sample, because the Portuguese junior gymnasts were the unique elite gymnasts in the country in the data collection moment. Furthermore, the tests applied had as limitation the type of evaluation with comparison of images and an assessment chart, but they are the FIG suggested tests, and they are close to Rhythmic Gymnastics reality.

REFERENCES

Bobo, M., & Sierra, E. (1998). *Ximnasia Rítmica Deportiva - Adestramento e competición*. Santiago de Compostela: Editora Lea.

Cobalchini, R., & Silva, E. R. d. (2008). Treinabilidade do membro inferior

não-dominante em atletas infantis de futebol. *Educación Física y Deportes, Revista Digital, 13*. Retrieved from http://www.efdeportes.com/efd125/treinabilidade-do-membro-inferior-nao-dominante-em-atletas-infantis-de-futebol.htm

Despina, T., George, D., George, T., Sotiris, P., Alessandra, D. C., George, K., . . . Stavros, K. (2014). Short-term effect of whole-body vibration training on balance, flexibility and lower limb explosive strength in elite rhythmic gymnasts *Human Movement Science, 33*, 149-158.

Donti, O., Tsolakis, C., & Bogdanis, G. C. (2014). Effects of Baseline Levels of Flexibility and Vertical Jump Ability on Performance Following Different Volumes of Static Stretching and Potentiating Exercises in Elite Gymnasts. *Journal of Sports Science and Medicine, 13*, 105-113.

Douda, H., Tokmakidis, S., & Tsigilis, N. (2002). Effects of specific training o muscle strength and flexibility of sports and artistic female gymnasts. *Coach Sport Sci. J., 4*, 23-27.

FIG. (2010). *Age group development program for rhythmic gymnastics sample physical testing program*. Lausanne: Federation International de Gymnastique.

Giolo, C. (2008). *Noção de Lateralidade: Um estudo diagnóstico com ginastas iniciantes.* Campinas - São Paulo.

Gurak, G. S. (2002). *Características antropométricas das atletas de Ginástica Rítmica Desportiva participantes dos Jogos Abertos de Santa Catarina*. Paper presented at the 17º Congresso Internacional da FIEP, Foz do Iguaçu.

Jastrjembskaia, N., & Titov, Y. (1999). *Rhythmic Gymnastics - Hoop, Ball, Clubs, Ribbon, Rope*. EUA: Human Kinectics Champaign.

Laffranchi, B. (2001). *Treinamento Desportivo Aplicado à Ginástica Rítmica*. Londrina: Unopar Editora.

Laffranchi, B. (2005). *Planejamento, Aplicação e Controle da Preparação Técnica da Ginástica Rítmica: Análise do Rendimento Técnico alcançado nas Temporadas de Competição.* Porto.

Lebre, E. M. X. G. (1993). *Estudo comparativo das exigências técnicas e morfofuncionais em Ginástica Rítmica Desportiva.* Porto.

Lisitskaya, T. (1995). *Gimnasia Rítmica. Deporte & Entrenamiento*. Barcelona: Editorial Paidotribo.

Llobet, A. C. (2000). *Gimnasia Rítmica Deportiva: Teoria y práctica* (3 ed.). Barcelona: Editorial Paidotribo.

Monteiro, S. G. P. (2000). *Quantificação e classificação das cargas de treino em Ginástica Rítmica: Estudo de caso - Preparação para o Campeonato do Mundo de Osaka 1999 da Selecção Nacional de Conjuntos Sénior.* Porto.

Petry, R. (2008). *Análise do deslocamento vertical de quatro saltos realizados por praticantes de Ginástica Rítmica em diferentes fases do treinamento.* Florianópolis.

Róbeva, N., & Rankélova, M. (1991). *Escola de Campeãs: Ginástica Rítmica Desportiva*. São Paulo: Ícone Editora.

Stadnik, A. M. W., Ulbricht, L., Perin, A., & Ripka, W. L. (2010). Avaliação da performance relacionada aos componentes equilíbrio, força e flexibilidade de meninas praticantes de Ginástica Rítmica. *Educación Física y Deportes, Revista Digital, 15*(145). Retrieved from http://www.efdeportes.com/efd145/avaliacao-de-meninas-praticantes-de-ginastica-ritmica.htm

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