TRAINING INTENSITY OF GROUP IN RHYTHMIC GYMNASTICS

BATISTA Amanda[1,2], GOMES Thayse Natacha[1], GARGANTA Rui[1], ÁVILA-CARVALHO Lurdes[1]

Abstract

Aim. The aim of this study was to analyze the training intensity and training activities in rhythmic gymnasts.

Methods. Nine gymnast, from Brazilian National Group Team (20.8±1.9 years old), were studied. Accelerometers (ActiGraph, model GT3X+) were used to estimate the gymnasts energy expenditure during training session, in two periods – morning and afternoon. Training activities (types of exercises performed) in the evaluated session were recorded.

Results. The gymnasts were in the basic preparatory period of periodization and it was observed that 35% of training session was composed by moderate to very vigorous intensity exercises. The most part of the training presented light intensity training activities (65%). We observed the following training activities in the training session: flexibility training, ballet, warm-up, apparatus and body technique, routines (parts and isolate elements) and conditioning.

Conclusions. The higher intensity level in the training (moderate to very vigorous intensity exercises) corresponding especially to the training of routines parts. Several exercises characterized by a hard work of strength and endurance (ballet and warm-up) were classified as light intensity probably due to lack of changes in the body axis and/or displacement. On the other hand, the RG training is composed also by light intensity exercises (specific exercises such as flexibility training, apparatus handling techniques, etc.) and moments (stops for explanations and corrections) that are essential for the improvement of technique, tactics, physical, intellectual and psychological development in gymnasts' performance.

Keywords: rhythmic gymnastics, training intensity, training activities, accelerometers.

Introduction

Rhythmic Gymnastics (RG) is a complex sport that combines elements of ballet, gymnastics, dance and apparatus manipulation (rope, ball, hoop, clubs and ribbon) (Gateva, 2011). There are two competitions in the RG program: individual and group competitions. The program for senior individual gymnasts usually consist of 4 routines, and for senior groups consists of 2 routines, with one type of apparatus and two types of apparatus. The duration of the routines ranges from 1'15" to 1'30" for individual, and from 2'15" to 2'30" for groups (FIG, 2016). The performance in competition is evaluated by 2 panels of judges: difficulty and execution, but there are specific evaluation criteria for individual and group programs. In the difficulty component, the panel evaluates the routines content, which, according to the Code of Points (FIG, 2016) for individual program, is composed by four parts: body difficulty elements, dance steps combinations, dynamic elements with rotation, and apparatus difficulty; and for group program there are five parts: body difficulty elements, exchange difficulty, dance steps combinations, dynamic elements with rotation, and collaborations. For the execution component, the panel evaluates the performance quality during the routines and also applies technical and artistic faults.

The group competition is the most complex type of RG program due to its complexity, higher duration time of competition' routine and dynamic composition that need to be simultaneously performed by five gymnasts using one or two types of apparatus, executing a variety of athletes' movement interactions with synchronous and asynchronous movements (Victorii et al., 2014). Thus, the group competition is a singular spectacle in the RG, especially by harmony, synchrony and expression of the gymnasts (Bueno, 2010). But an incessant workout routine, with a detailed planning and organization of the training is needed to achieve success (Laffranchi, 2005).

The group workout involves several factors for a high performance: the physical, technical, tactical, intellectual and psychological preparation. Therefore, the RG training should be planned, systematic and guided by scientific principles and by coach practice gained with successful experiences (Laffranchi, 2005).

The training volume in RG has increased over the recent years (Berlutti et al., 2010). During the 70's and 80's the requirement was 15h and 20h per week, respectively (Georgopoulos et al., 2012). Elite gymnasts train 25-30h per week and, in some cases, 40h per week to achieve the essential preparation for a good performance, due to the high physical and

17

technical requirements in RG (Ávila-Carvalho et al., 2013; Zetaruk et al., 2006). Thus, most studies use the weekly training volume (hours of training per week) but this tells us very little about training intensity (Malina et al., 2013).

Volume is the training quantity (number of training hours, number of exercises, number of repetitions per exercise, distance travelled, etc.) and intensity is the training quality (speed, space, rest time – passive or active rest, amplitude of movements, etc.) (Dantas, 2003). More specifically in the RG, Laffranchi (2005) points out the procedures that can be used for the progression of the training load or increasing its intensity: execution of isolated elements and/or whole exercises without mistakes; execution of body elements used in the routine without mistakes; increasing the number of repetitions of whole exercises; increasing the speed of execution of elements from the general and specific physical preparation; reducing of rest intervals among whole exercises.

Therefore, an important question is to know how the high amount of training hours in RG has been used. Thus, the aim of this study was to analyze the training intensity and training activities in RG group gymnasts.

Methods

Subjects: Nine Brazilian rhythmic elite senior gymnasts from Brazil National Group Team (BNT) participated in this study (20.8 ± 1.9 years old), with a mean of 14.0 ± 2.4 years of RG practice, and about 36.0 ± 0.0h/week of training volume.

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

Training intensity: Accelerometers (ActiGraph, model GT3X+) were used to estimate the energy expenditure of gymnasts through the time spent in the training activities during a training session (7 hours), split in two periods – morning and afternoon. The data were analyzed in the ActiLife software. This information allowed us to estimate the distribution of training intensity. The cut points (Sasaki et al., 2011) were used to determine the intensity levels: light ($\leq$2690 counts per minute); moderate (2691-6166 counts per minute) vigorous (6167-9642 counts per minute) and very vigorous (>9642 counts per minute). The software presents the length of time in each intensity level in minutes.

Training activities: to understand the results derived from the accelerometers, the types of exercises performed by gymnasts during the training session evaluated were registered.

Statistical Procedures: Descriptive statistics were performed using the mean values and frequencies.

Results

Table 1 presents the time spent in the training activities in training session evaluated (two periods – morning and afternoon). It important to note that two gymnasts presented some body limitations duo an injuries, meaning that they had to perform adapted exercises. The gymnasts in our study were in the basic preparatory period of periodization.

**Table 1:** Training activities in Brazil National Team training separated by day periods

Morning Training (7h-11h)		Afternoon Training (15h-18h)	
7h to 7h10 (10')	Free stretching;	15h to 15h40 (40')	Warm-up in the floor (flexibility, strength, balance and endurance – use of many abdominal exercises and battements);
7h10 to 7h25 (15')	Passive flexibility (use of bench);	15h41 to 16h04 (23')	Exercises with displacement in lines (balances and several battements – use of body difficulties of routine);
7h25 to 7h55 (30')	Ballet Bar;	16h04 to 16h15 (11')	Hoop technique without displacement;
7h55 to 7h59 (4')	Fouetté Pivots (Center);	16h15 to 16h22 (7')	Break;
8h to 8h25 (25')	Diagonal ballet exercises;	16h22 to 16h26 (4')	Explanation of the next exercises;

8h25 to 8h29 (4')	Fouetté Pivots (Center);	16h26 to 17h03 (37')	- Circuit with jumps and rotations (all gymnasts) – Stops for heart rate evaluation; - Circuit with speed exercises using clubs and hoop (exercises with all gymnasts at the same time and others with one gymnast at a time). For each fault the gymnast should of the 5 push-ups;
8h30 to 8h43 (13')	Break;		
8h43 to 9h46 (1h3')	Ribbon technique with and without displacement – subsequent inclusion of pre-acrobatics and body difficulties;	17h03 to 17h10 (7')	Break;
9h46 to 9h52 (6')	Break;	17h10 to 17h46 (36')	Training of parts of routine with music and some changes in the routine composition (2 hoops and 6 clubs);
9h52 to 10h48 (56')	Training of collaborations and exchanges; and parts of routine (5 ribbons).	17h46 to 18h (14')	Break and free stretching.

Concerning to the intensity of training session, information from the accelerometer suggest that only 35% of the training session had activities and exercises of moderate to very vigorous intensities (18.3% of moderate intensity, and 16.7% of vigorous and very vigorous intensities) (Figure 1).

Figure 1. Intensity of a training session of Brazil National Team
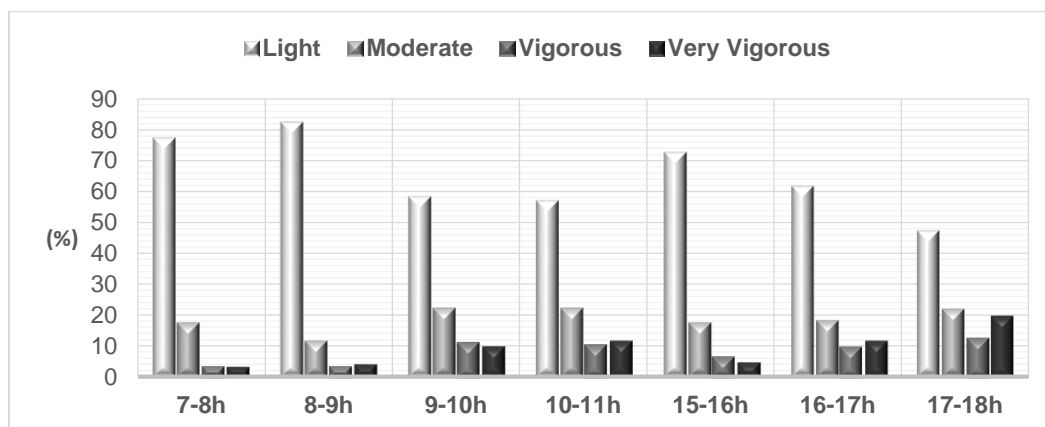
On the other hand, about 65% of the training session was composed by activities and exercises classified as light intensity by accelerometers.

A gradual increase in time used to perform very vigorous intensity exercises, during both morning (7h-11h) and afternoon (15-18h) training session (Figure 1). Furthermore, we observed higher training intensity (very vigorous intensity) in both evaluated period when the gymnasts were training the routines parts.

Table 2 shows the percentage of training intensity according to training activities performed by gymnasts separated by training hours.

Table 2: Training intensity according to the training activities by Brazil National Team gymnasts

Training hours	% of training intensity according to the training activities
7h-8h	Light (76.9%): Flexibility training; several explanations and corrections of exercises; Ballet Bar exercises not captured by accelerometers. Moderate to very vigorous (23.1%): Ballet Bar and Fouetté pivots.
8h-9h	Light (82.0%): Break; waiting time between exercises in Diagonal Ballet; Ribbon technique without displacement; several explanations and corrections of exercises. Moderate to very vigorous (18.0%): Diagonal Ballet and Fouetté pivots.

9h-10h	Light (57.9%): Break; explanations and corrections of exercises. Moderate to very vigorous (42.1%): Ribbon technique with displacement and body movements.
10h-11h	Light (56.7%): Explanations and corrections of exercises; end of training 12 minutes before established time. Moderate to very vigorous (43.3%): Training of collaborations and exchanges; and parts of routine.
15h-16h	Light (72.3%): Warm-up performed in the floor – several exercises not captured by accelerometers; explanations and corrections of exercises. Moderate to very vigorous (27.7%): Exercises with displacement in lines.
16h-17h	Light (61.4%): Hoop technique without displacement; Break; explanations and corrections of exercises. Moderate to very vigorous (38.6%): Circuit training.
17h-18h	Light (46.9%): Explanations and corrections of exercises; Break; free stretching. Moderate to very vigorous (53.1%): Training of parts of routine with music.

The light intensity in the training was composed mainly by important training activities in RG (such as flexibility training, warm-up and apparatus handling) and several stops to explanations and corrections of exercises.

We cannot characterize specifically the training activities as moderate, vigorous and very vigorous intensities, once that each training activity was formed by a set of exercises with different intensities.

Discussion

According to Bobo-Arce & Méndez-Rial (2013), the training process in RG has high demands in volume and intensity, and technical elements with a high difficulty level. The increase of training volume in RG has been pointed out by some authors (Ávila-Carvalho et al., 2013; Berlutti et al., 2010; Georgopoulos et al., 2012; Zetaruk et al., 2006) as the main characteristic of the training process in elite gymnasts in nowadays due to the high physical and technical requirements in RG. Ávila-Carvalho et al. (2013) analysed the training volume in elite gymnasts in some previous RG studies and concluded that there was an increase in training hours that starts at the second half of first decade of this century. However, according to Malina et al. (2013), hours per week provide limited information about demands placed in the training in gymnastics. Training hours include a considerable "down time" or reduced activity (explanations, corrections, waiting between repetitions, recovery, nutrition breaks, etc.). For the authors, the training in gymnastics is more complex than hours per week. Thus, the analysis of training intensity, in contrast to time, is more relevant to the questions of our study. But the training intensity measured by the gymnasts' energy expenditure applying field tests in RG training has not been studied. Despite of this, is no consensus regarding to the best method that should

be used to assess the training intensity in RG, we chose to use accelerometers, given their structural characteristics (small and light device), being easily placed in the hip region and secured by an elastic band. The device does not cause discomfort to the gymnasts and, therefore, it does not interfere in the gymnasts actions during the training session. Thus, there is not any interference of the instrument in the response. Accelerometers are electronic devices that measure the acceleration deceleration of body movements on three axes: vertical, mid-lateral and anteroposterior (Lagerros & Lagiou, 2007) and allow an objective quantification of the frequency, duration and intensity of physical activity (Romanzini et al., 2012). Accelerometers has been widely used in the assessment of energy expenditure (Crouter et al., 2006).

The main disadvantage of this device use in our study was the difficulty of register some types of body movements, such as exercises without body movements and/or displacement that are usually performed in RG training. According to Lagerros & Lagiou (2007) this device does not capture isometric activities, muscle work against an external strength (as to lift or carry weights), treadmill walking, rowing or skating, and it can may underestimate the physical activity. In addition, the accelerometers present less accurate records of movements of body segments to which they are not positioned (Cliff et al., 2009). Therefore, several exercises performed in RG training were considered of light intensity due to the lack of body axis changes, although there was a high work of strength and endurance, such as the following exercises: passive flexibility method exercises, apparatus handling techniques (ribbon, clubs and hoop) and some body technique training. Furthermore, as expected, the stops for corrections and explanations of exercises also were considered of light intensity. However, these breaks are very important for improve the technique, tactics,

intellectual, and psychological preparation in RG. A mistake of a single or several gymnasts in the group routine can cause an imbalance in the whole composition, which turn leads to a teamwork failure (Victorii et al., 2014). Thus, the constant effort for perfection in the execution of group technical elements constitutes an objective and fundamental direction in the preparation of gymnasts (Avilés et al., 2014).

Moraru (2012) explains that preventing and correcting mistakes is crucial in the RG training and it directly influences the performance. For the author, the use of feedback (any piece of sensorial information regarding the move) is one of the most important processes used in sportive training both for correcting mistakes and learning. According to Schmidt & Wrisberg (2008), the extrinsic feedback can be of two types: "knowledge of result" – usually achieved verbally. It is essential in improving performance and learning, as the athletes cannot notice and correct all their imperfections and mistakes. "Knowledge of performance" – it offers additional information about the cinematic characteristics of the move performed by the athlete. Unlike this, the "knowledge of result" provides information about the success of the movement in relation to the main set goal. In the evaluated training session we observed several moments of both types of extrinsic feedback.

The RG training sessions were generally long, homogeneous, and repetitive (Botti & Nascimento, 2011). The training activities are composed of static, dynamic exercises, with changes in posture, different velocities and strength implications, which probably cause different effects on the body's response (Ávila-Carvalho & Lebre, 2011). For elite gymnasts, the training include neuromuscular activation, stretching, ballet, technique training, apparatus manipulation and routines (Miletić et al., 2004) with variations according to the phase of the periodization and/or context of the training (Law et al., 2007).

Law et al. (2007) compared the early activity involvement, hours spent in training activities, rating of training resources and health in Olympic versus international gymnasts. From the results, all gymnasts showed to perform the same practice activities in the training session: warm-up, ballet, technique training, routines and conditioning. The warm-up was done to prepare the body for the other exercises in the training session. This activity included jogging and stretching. Ballet consisted of a regimented routine of exercises designed to improve and refine movements. Technique training consisted in learning, correction and repetition of new skills that would be used in the routines. Furthermore, during technique training, the routines were segmented and gymnasts worked on specific parts of the routine individually. Routine training

referred to practicing routines that had been choreographed for competition. Conditioning activities were described as activities designed to improve motor capacities such as strength, flexibility and cardiovascular fitness (Law et al., 2007). The same phases were observed in the BNT training session: stretching, warm-up, ballet, technique training (body and apparatus technique), routines (routines parts and isolated elements) and conditioning.

The BNT gymnasts started the training session with a ballet lesson (1 hour and 30 minutes). The aim of the ballet lesson varies according to gymnasts needs. In evaluated training session, the ballet was carried out mainly on the bar and the aims were to improve the placement of the hip, intense footwork and half point, battements and rotations. These exercises are extremely important for gymnasts' performance, but they were not considered as high intensity by accelerometer. The work of the ballet on the bar is one of the most important contributors to the development of gymnasts at an early stage and to the training of the specific physical preparation at elite gymnasts (Lebre & Araujo, 2006).

The initial warm-up in afternoon training, with duration of 40 minutes, was performed on the ground. The gymnasts executed several exercises for flexibility, strength and endurance, with movements focused on work of foot, legs, arms and posture, although without any displacement and small body axis changes, and therefore, they were classified as light intensity.

The training sessions are not always equal, due to the daily aims of the coach, the necessity to offer different stimuli to the gymnasts, oscillation of training loads (volume x intensity) and according to the periodization period that the training session is inserted. Thus, the intensity and structure of the training depends on several factors. According to Laffranchi (2005), the oscillation of the training loads implies a variation in the number of elements repetitions, training of parts and whole routine in a week. The author refer that differences in training loads are related to differences in volume and intensity with the purpose to achieve an improvement in performance.

In the training session evaluated, gymnasts were in the basic preparatory period of the periodization. The main aim of this period is to achieve a good physical and technical base thought an extensive and generalized work with high volume to sustain the training in the whole season (Laffranchi, 2005). Dantas (2003) explains that during the basic preparatory period, the volume training has a high preponderance over the intensity. In the specific period, the intensity acquires preponderance over the volume. This preponderance is accentuated during the competition period and reversed in the

transitional period. Accordingly, we verified that the training of whole routines was not the main focus. The routine training consisted especially of routines parts repetitions with and without music. The routine parts is a series of 7-15 elements of a composition connected and executed without interruption. The whole routine is the complete composition, forming a compact block, which all movements should be connected, always in connection with the music (Laffranchi, 2005).

We observed that the training of routine parts, exchanges elements and collaborations elements showed the higher values of vigorous to very vigorous intensity in the evaluated training session. The gymnasts repeat several times their routines (isolated elements, parts and/or whole routines) in the training with reduced recovery time, and usually it is expected a combination between technical effectiveness, safety and high-intensity effort (Jemni et al., 2003). Thus, the effort of gymnasts seems to develop under aerobic and anaerobic conditions (Ávila-Carvalho & Lebre, 2011).

Mihaela et al. (2012) assessed the oxygen consumption and other physiological indicators, under lab, training and simulated competitive conditions in 10 rhythmic gymnasts aged 15 to 17 years old (6 gymnasts of national group and 4 individual gymnasts from Romanian national team). In the training conditions of group gymnasts, the highest heart rate (HR) mean values were observed in the routine training: 140 bpm in routine parts; 152 bpm in half-whole routines; and 180 bpm in whole routines. Ávila-Carvalho & Lebre (2011) evaluated the HR of five groups during the execution of the competition routine and the authors verified that the mean HR values ranged from 166.5±14.6 bpm to 177.1±14.0 bpm and the maximum HR values ranged from 180.4±8.3 bpm to 188.4±8.4 bpm. Some other studies applied laboratory and field tests to assess the physiological indicators (oxygen consumption, HR and other) in individual rhythmic gymnasts to determine the level of fitness – cardiovascular and specific endurance (Gateva, 2014, 2015; Portier et al., 2006).

Gateva (2014) performed the HR monitoring and concentration of the blood lactate during and after the execution of a RG routine in 13 high-level gymnasts (average 15.4 years old). The maximal HR values during the execution of the routines were reached at the end of the routine (maximal HR at 200 bpm, and the minimum at 187 bpm). The maximal values of blood lactate were achieved after performing a routine (12.8 mmol/l), and the lowest measured values were above the anaerobic threshold (4.8 mmol/l). Therefore, RG routine had an anaerobic regime of work with HR values 180-195 bpm; lactate above 10 mmol/l. The author concluded

that the loading varies from sub-maximal to maximal during the competitive routine in RG.

Gateva (2015) performed the same analysis (HR monitoring and blood lactate) in twelve high-level rhythmic gymnasts (15.7±2.1 years old) during the following tests: VO$_2$max; 2 min submaximal treadmill test - authors' test; 2 min shuttle test; 2 min specific modified gymnastics routine - authors' tests; competitive routine. As main results, the authors verified that the lowest values of HR were achieved on the submaximal laboratory test – 186.2 bpm and the highest after RG routine – 194.1±4.2 bpm. The laboratory and shuttle tests provoked higher values of concentration of the blood lactate compared to gymnastics routines. The routine showed higher demands on the gymnasts' body systems' than the other three applied tests.

In Portier et al. (2006) study maximal oxygen uptake and lactate concentration were collected in laboratory after four routines (rope, clubs, hoop and ball) an after a training session (4 hours) in twelve elite gymnasts. The training included a warm-up, technical work, and four competition routines. The average training intensity was 55% of the VO$_2$max, which was low to allow a real improvement in aerobic capacities, but which represents a real expenditure of energy for these gymnasts. The intensity of the hoop, clubs and rope routines was around VO$_2$max while the intensity of ball routine was close to 70% of VO$_2$max. The lactate concentrations were higher in hoop, clubs and rope routines than in laboratory. There was no correlation between oxygen uptake and blood lactate concentrations and the performance level of each gymnast. RG was characterized as an anaerobic sport. However, at the same time, the study showed a high demand for aerobic and anaerobic metabolism during RG training.

These studies (Gateva, 2014, 2015; Portier et al., 2006) point the high intensity level in the training of the competitive routines in RG. These data are in agreement with our results, in which the higher intensity levels (vigorous and very vigorous intensities) were verified in the training of routines parts when compared to the other training activities.

The RG routines have a short duration and the exercise intensity is maximum in some moments. It is not continuously submaximal or maximal, as in cyclic sports (Ávila-Carvalho & Lebre, 2011). In fact, the performance in gymnastics is characterized by intermittent effort (Jemni et al., 2003), in which there are phases of rest or low intensity and phases of high intensity of variable duration, generally not allowing a complete recovery (Ávila-Carvalho & Lebre, 2011).

Conclusion

The assessment of intensity in a training session (7 hours) of BNT gymnasts, showed that only 35% of the training (2h27min) consisted of training activities of moderate to very vigorous intensities, corresponding especially to the routines parts training. The most part of the training session evaluated presented light intensity training activities (65%).

We observed the following training activities in the training session: flexibility training, ballet, warm-up, apparatus and body technique, routines (parts and isolate elements) and conditioning.

The records of training activities performed by gymnasts are one stand to be possible to identify the reasons of the high values of light training intensity. Several exercises performed with a high work of strength and endurance were considered of light intensity probably due to lack of movement and/or displacement, as the accelerometers measure the actions intensity through the body axis changes. However, it is important to consider that the daily training in RG has several aims. The RG training is composed also by light intensity exercises (specific exercises such as flexibility training, apparatus handling techniques, etc.) and moments (stops for explanations and corrections) that are essential for the improvement of technique, tactics, physical, intellectual and psychological preparation.

This analysis refers to the evaluation of a training session and therefore it is not possible to generalize the observed data, or reach conclusions about the training intensity in RG. This is a point of support for research in this direction, in order to know and understand how it is structured the training intensity in RG.

Acknowledgments

References

Ávila-Carvalho L, Klentroub P, Palomero ML, Lebre E, 2013, Anthropometric profiles and age at menarche in elite group rhythmic gymnasts according to their chronological age. Science & Sports, 28(4), 172-180.

Ávila-Carvalho L, Lebre E, 2011, Estudo do comportamento da frequência cardíaca: análise dos elementos técnicos em exercícios de conjuntos de GR Comunicação apresentada em Da Prática à Ciência. Artigos do 2º e 3º Congresso de FGP.

Avilés MI, Díaz YG, Borrás NO, 2014, Reflections on planning and control of sport training in Rhythmic Gymnastics. In L. M. Schiavon, T. Heinen, M. Bortoleto, M. Nunomura & E. Toledo (Eds.), High performance Gymnastics. Germany: Arete Verlag.

Berlutti G, Briganti C, Pamich T, Torrisi L, Franco A, Morino G, Caldarone G, 2010, Body composition, biological maturation, alimentary habit, anthropometric characteristics in rhythmic gymnastics athletes. From the Florence 1986 European Championships to the Turin 2008 Europian Championships, Twenty years of evolution.: Federazione Gimnastica D'Italia.

Bobo-Arce M, Méndez-Rial B, 2013, Determinants of competitive performance in rhythmic gymnastics. A review. Journal of Human Sport & Exercise 8(3), 711 717p.

Botti M, Nascimento JV, 2011, The teaching-learning-training process in Rhythmic Gymnastics supported by the ecological theory. Science of Gymnastics Journal, 3(1), 35-48.

Bueno TF, 2010, Ginástica Rítmica. Exercício de conjunto: cinco ginastas, um só corpo. In E. Paoliello & E. Toledo (Eds.), Possibilidades da Ginástica Rítmica. São Paulo: Phorte Editora.

Cliff DP, Reilly JJ, Okely AD, 2009, Methodological considerations in using accelerometers to assess habitual physical activity in children aged 0-5 years. Journal of Science and Medicine in Sport, 12(5), 557-567.

Crouter S, Churilla J, Bassett D, 2006, Estimating energy expenditure using accelerometers. European Journal of applied Physiology, 98(6), 601-612.

Dantas E, 2003, A prática da preparação física (Vol. 5). Rio de Janeiro: Shape.

FIG, 2016, Code of Points for Rhythmic Gymnastics: 2016-2020 [Versão eletrónica], disponível.

Gateva M, 2011, Investigations in Rhythmic Gymnastics. In The science of Gymnastics (pp. 45-54). USA and Canada: Routledge.

Gateva M, 2014, Investigation of the effect of the training load on the athletes in rhythmic and aesthetic group gymnastics during the preparation period. Research in Kinesiology, 4(1), 40-44.

Gateva M, 2015, Tests to determinate the fitness level in rhythmic gymnastics. Sport Mont(43-45), 63-70.

Georgopoulos N, Theodoropoulou A, Roupas N, Rottstein L, Tsekouras A, Mylonas P, Vagenakis G, Koukkou E, Armeni A, Sakellaropoulos G, Leglise M, Vagenakis K, Markou K, 2012, Growth velocity and final height in elite female rhythmic and artistic gymnasts. Hormones, 11(1), 61-69.

Jemni M, Friemel F, Sands W, Delamarche P, 2003, Effect of active and passive recovery on blood lactate and performance during simulated

competition in high level gymnasts. Can.J.Appl.Physiol., 28(2), 240-256.

Laffranchi B, 2005, Planejamento, Aplicação e Controle da Preparação Técnica da Ginástica Rítmica: Análise do Rendimento Técnico alcançado nas Temporadas de Competição. Porto: University of Porto. Relatorio de Estagio apresentado a

Lagerros YT, Lagiou P, 2007, Assessment of physical activity and energy expenditure in epidemiological research of chronic diseases. European Journal Epidemiology, 22(6), 353-362.

Law MP, Côté J, Ericsson KA, 2007, Characteristics of expert development in rhythmic gymnastics: A retrospective study. Journal International Journal of Sport and Exercise Psychology 5(1).

Lebre E, Araujo C, 2006, Manual de Ginástica Rítmica. Porto: Porto Editora.

Malina R, Baxter-Jones A, Armstrong N, Beunen G, Caine D, Daly R, Lewis R, Rogol A, Russell K, 2013, Role of Intensive Training in the Growth and Maturation of Artistic Gymnasts. Sports Med, 43, 783-802.

Mihaela M, Vasilica G, Lavinia P, 2012, Study about the energy expenditure assessment in rhythmic gymnastics. Science, Movement and Health, 12(2).

Miletić D, Katić R, Maleš B, 2004, Some anthropologic factors of performance in rhythmic gymnastics novices. Collegium Antropologicum, 28(2), 727-737.

Moraru C, 2012, Feedback in rhythmic gymnastics as a process of correcting technical mistakes Sport si Societate. Revista de Educatie Fizica, Sport si Stiinte Conexe, 12(2).

Portier H, Arlettaz A, Lepanse B, Lecocq AM, Labsy Z, Collomp K, 2006, Estimation de la dépense énergétique en gymnastique rythmique. Science & Sports, 21(5), 300-302.

Romanzini M, Petroski EL, Reichert FF, 2012, Limiares de acelerômetros para a estimativa da intensidade da atividade física em crianças e adolescentes: uma revisão sistemática. Revista Brasileira de Cineantropometria e Desempenho Humano, 14(1), 102-113.

Sasaki JE, John D, Freedson PS, 2011, Validation and comparison of ActiGraph activity monitors. Journal of Science and Medicine in Sport, 14(5), 411-416.

Schmidt RA, Wrisberg CA, 2008, Motor Learning and Performance - A Situation-Based Learning Approach (Vol. 4). USA: Human Kinetics.

Victorii L, Valentin S, Tara O, Iryn R, Ulyan P, 2014, Special physical training program in rhythmic gymnastics group exercises. Journal of Physical Education and Sport, 14(1), 1340 - 1347.

Zetaruk M, Fors MV, Zurakowski D, Mitchell Jr, W, Micheli L, 2006, Recomendaciones para el entrenamiento y prevención de lesiones en gimnastas de rítmica de elite Apunts Med Esport, 41(151), 100-106.