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Paula Barreiros Debien

Training load management in rhythmic gymnastics

Juiz de Fora
2020

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Thesis presented to the Postgraduate Program of Physical Education, doctoral level, from the Federal University of Juiz de Fora as a partial requirement to obtaining the doctoral degree in Physical Education.
Area: Exercise and sport.
Research line: Studies of sport and its manifestations.

Supervisors: Dr. Maurício Gattás Bara Filho
Dr. Tim Gabbett

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I dedicate this work to my parents, Jurema and Marcos, who gave me the best education they could and are always there for me.

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RESUMO

Ginástica rítmica (GR) é um esporte complexo que exige perfeição técnica, capacidades físicas e artísticas bem desenvolvidas. Apesar da literatura escassa, pesquisas têm apontado para elevadas cargas de treinamento e ocorrência de adaptações negativas nessa modalidade. Ademais, ainda há uma lacuna entre a ciência e as práticas no ginásio. Logo, o objetivo desta tese consiste em avançar no conhecimento em relação ao controle da carga de treinamento na GR. Foram realizados dois estudos e uma completa revisão de literatura. O estudo um buscou descrever a carga interna de treinamento, recuperação e lesões em atletas de elite de conjunto de GR durante períodos competitivos. Seis ginastas da seleção brasileira de conjuntos de GR foram diariamente monitoradas por 126 dias, incluindo treinamento regular e quatro competições. A carga de treinamento foi medida pela percepção subjetiva do esforço da sessão. A carga diária, crônica, e a relação entre a carga aguda e crônica (ACWR) foram calculadas. A escala de Qualidade Total de Recuperação foi utilizada para monitorar a recuperação e a média móvel de três dias foi calculada. As lesões foram diagnosticadas e reportadas pela equipe médica e seus relatórios foram usados na análise. As ginastas apresentaram diferentes padrões de cargas diárias, ACWR, recuperação, e ocorrência de lesões durante os períodos competitivos investigados. Todas as ginastas apresentaram rápidos aumentos na carga (“spike”). Três ginastas apresentaram recuperação insuficiente por mais de 60% do tempo. Quatro atletas tiveram cinco lesões durante o estudo. Fatores individuais como idade e carga crônica podem moderar como cada ginasta responde ao treinamento e tolera os “spikes” na carga. Além disso, lesões durante o período competitivo parecem afetar as carreiras das ginastas no curto e longo prazo, e influenciam a organização do time no treinamento e competições. O objetivo do segundo estudo foi descrever e analisar as práticas e percepções de treinadores, equipe médica, e ginastas de GR quanto ao controle da carga de treinamento. Questionários online foram distribuídos entre profissionais e ginastas envolvidos no treinamento desse esporte ao redor do mundo. Cem participantes de 25 países responderam ao questionário. A percepção do treinador é frequentemente utilizada como método de monitoramento da carga, recuperação/fadiga e desempenho. Variáveis, métodos e medidas comumente reportados na literatura não são frequentes na GR. A maioria dos treinadores percebe que adaptações negativas são raras ou nunca ocorrem. A equipe médica é pouco envolvida no compartilhamento e discussão das informações sobre carga de treinamento e percebem que as práticas implementadas na GR não são boas quanto ao monitoramento da recuperação/fadiga das ginastas. As ginastas observam boa qualidade no monitoramento do seu desempenho e no recebimento de feedback. A maioria dos participantes acredita que um modelo específico de controle da carga de treinamento para a GR pode ser muito ou extremamente efetivo. Em conclusão, o controle da carga de treinamento na GR precisa deixar de ser centrado no treinador e focado em aspectos técnicos e passar a ser um processo multidisciplinar centrado nas ginastas e delineado, também, para minimizar efeitos negativos do treinamento.

Palavras-chave: ginástica rítmica, treinamento, ginasta, controle da carga, recuperação, lesão.

ABSTRACT

Rhythmic gymnastics is a complex aesthetic sport, which requires perfection of technical gestures, associated with well-developed physical and artistic capacities. Although there is scarce literature, research has shown high training loads and maladaptation occurrence among rhythmic gymnasts. Moreover, there is still a gap between scientific knowledge and practices implemented in the field. Therefore, the general purpose of this thesis was to advance the knowledge surrounding training load management in rhythmic gymnastics. A comprehensive literature review and two studies were developed in this research program. Study one aimed to describe individual training load, recovery and injuries in elite group rhythmic gymnasts during competitive periods. Six gymnasts from the Brazilian senior rhythmic gymnastics group were monitored daily over a 126-day period comprising regular training and four competitions. Training load was measured using the session rating of perceived exertion (session-RPE). Daily load, chronic load, and acute:chronic workload ratio (ACWR) were assessed. The Total Quality Recovery (TQR) scale was used to monitor recovery and a 3-day rolling average (3RA) TQR was also measured. Injuries were diagnosed and reported by the medical staff and their reports were used in the analysis. Descriptive statistics were used. The gymnasts presented distinct daily load, ACWR, and recovery patterns, as well as injuries across the competitive periods. All athletes had rapid increases (“spikes”) in load. Three athletes were underrecovered more than 60% of the time. Four athletes sustained five injuries during the time of the study (all lower limb overuse injuries, two severe, two mild, one slight). Individual factors such as age and chronic load could moderate how each gymnast responds to training and tolerates spikes in load. Moreover, injuries sustained during competitive periods appear to affect the short and long-term careers of gymnasts, as well as impair training and competition organization of the team. The purpose of the second study was to describe and analyse the practices and perceptions of rhythmic gymnastics coaches, medical staff, and athletes on training load management. Online surveys were distributed among professionals and gymnasts currently involved in rhythmic gymnastics training across the world. One hundred (N=50 coaches, N=12 medical staff, N=38 gymnasts) participants from 25 different countries completed the surveys. Coaches’ perception was frequently used as a method of monitoring load, recovery/fatigue, and performance. Variables, methods, and metrics commonly reported in the training load literature and other sports were not very frequently used in rhythmic gymnastics. The majority of coaches perceived that maladaptation rarely or never occurred. Medical staff involvement in sharing and discussing training load information was limited and they also perceived that the measurement of athletes' recovery/fatigue was not very good. Gymnasts noted good quality on measuring performance and receiving feedback. Most participants believed that a specific training load management model for rhythmic gymnastics could be very or extremely effective. In conclusion, training load management in rhythmic gymnastics needs to move from a coach-centred process focused on technical components to a multidisciplinary approach centred on the gymnasts in order to minimize negative outcomes.

Keywords: rhythmic gymnastics, training, gymnast, load management, recovery, injury.

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1 INTRODUCTION

The primary goal of training is performance improvement through positive adaptations (VIRU; VIRU, 2000), mainly to achieve good results in competitions. Monitoring training load and athletes' response is key to comprehending and optimizing this process (BORRESEN; LAMBERT, 2009). For decades researchers have been looking for variables, methods, and models in an attempt to understand the complex association between training load and performance (FOSTER et al., 1996; FOSTER; RODRIGUEZ-MARROYO; KONING, 2017). Similarly, more recently the body of literature regarding the training load-injury relationship has also increased (GABBETT, 2020b; WINDT; GABBETT, 2017). Despite the growing evidence addressing the importance of training load management in order to achieve peak performance and minimize negative effects of training (BOURDON et al., 2017; GABBETT, 2016; HALSON, 2014; SOLIGARD et al., 2016), it is essential that this process is underpinned by the comprehension of the specific characteristics and demands of the sport in question.

Rhythmic gymnastics is an aesthetic sport defined by the interaction among body movements, manual apparatus, and musical accompaniment (BARBOSA-RINALDI; MARTINELI; TEIXEIRA, 2009; SIERRA-PALMEIRO et al., 2019). Gymnasts' performance in competition is measured through judging evaluation that provides a final score based on difficulty level, as well as technical and artistic quality of routines (DEBIEN et al., 2014; LEANDRO et al., 2017). Therefore, along with well-developed physical capacities, rhythmic gymnastics demands high technical compliance of body and apparatus movements in accordance with music rhythm and character, making training an even more challenging process (CAVALLERIO; WADEY; WAGSTAFF, 2016; LAFFRANCHI, 2001, 2005; SILVA; PAIVA, 2015).

Studies in rhythmic gymnastics have shown high training loads across the season with an increase during competitive periods (DEBIEN et al., 2019, 2020a). Debien et al. (2020a) have observed that 67% of all "spikes" (i.e., rapid increase) in training load across the season occurred close to competitions in elite group rhythmic gymnasts, which could represent a higher risk of injury (GABBETT, 2020b) exactly when peak performance is required. Indeed, competitive periods seem to be critical moments in this sport, as there is also evidence pointing to gymnasts experiencing insufficient recovery (DEBIEN et al., 2019, 2020a), lower stress tolerance (ANTUALPA et al., 2015), performance decreases (FERNANDEZ-VILLARINO et al., 2015), poor sleep habits, nutritional deficiencies (SILVA; PAIVA, 2016), low energy availability (SILVA; PAIVA, 2015), and overuse injuries (EDOUARD et al., 2018). In addition, rhythmic gymnasts perceive inadequate training loads as one of the causes of their injuries (KOLAR et al., 2017). Despite this scenario, none of the previous investigations have collectively analysed individual training load, recovery, and injuries in elite rhythmic gymnasts during competitive periods.

Aiming to understand the complex dose-response relationship in training, sport science has invested a lot of effort in methods to monitor several variables such as external and internal training load, recovery, fatigue, and performance (BORRESEN; LAMBERT, 2009; BOURDON et al., 2017; HALSON, 2014; KELLMANN et al., 2018). Regardless of scientific and technological development on monitoring these variables both in training and competition during the last decades (FOSTER; RODRIGUEZ-MARROYO; KONING, 2017), little is known about the application of these advances in the practical context (BUCHHEIT, 2017; BURGESS, 2017; FULLAGAR et al., 2019). In this respect, coaches and/or practitioners in soccer (AKENHEAD; NASSIS, 2016; WESTON, 2018), rugby (STARLING; LAMBERT, 2018), endurance sports (ROOS et al., 2013), and high-level sports programs (TAYLOR et al., 2012) have been surveyed in order to understand their practices and perceptions on training load management. For instance, some methods commonly used in practice include Global Positioning System (GPS), athlete self-report measures (ASRM), performance tests (e.g., jump, submaximal), while biochemical markers are not very common (MCGUIGAN et al., 2020).

Although relevant, the research that has investigated practices and perceptions on training load monitoring in applied settings also has some limitations. Most of the studies described which methods and tools are implemented in practice, but specific details on frequency, procedures, or even what was being monitored was not well described (MCGUIGAN et al., 2020). To our knowledge, just a few have simultaneously analysed perceptions of coaches, medical staff, *and athletes* in this regard (BARBOZA et al., 2017; SAW et al., 2015). Moreover, the nuances of training load management in female aesthetic sports as rhythmic gymnastics is yet to be deeply investigated.

In general, the translation of scientific knowledge into coaches' practices remains scarce (BISHOP, 2008; FULLAGAR et al., 2019; STOSZKOWSKI; COLLINS, 2016) and slow (BUCHHEIT, 2017; EISENMANN, 2017). Furthermore, researchers are commonly criticized for not asking pertinent and practical questions, and disseminating results with limited practical application (BISHOP, 2008; BUCHHEIT, 2017, 2020; COUTTS, 2017). In this respect, authors have suggested adopting specific research strategies in order to bridge this gap between science and practice. First, is through *qualitative research methods*, such as questionnaires and interviews (HARPER; MCCUNN, 2017). Second, the importance of conducting *case studies* to better comprehend training information from elite level athletes (HALPERIN, 2018; RUDDOCK et al., 2019). Third, establishing *collaborative works* between researchers and practitioners (COUTTS, 2016; GABBETT, 2020a; MCGUIGAN et al., 2020).

The above-described strategies may help to obtain a deeper understanding of actions, opinions, and needs of professionals and athletes in the field on essential aspects of training load management. Moreover, it may help to develop models, new tools, as well as applied and specific research questions. Consequently, coaches and medical staff would be able to improve their practices and potentially lead athletes to better performances and fewer instances of maladaptation. Therefore, this thesis intends to address these three points by 1) conducting a case study in elite level rhythmic gymnasts, 2) deeply surveying practices and perceptions of professionals and gymnasts on training load management, and 3) proposing a conceptual model that may help both researchers and practitioners working collaboratively in rhythmic gymnasts environment.

1.1 AIMS

The collective aim of the studies that comprise this thesis was to investigate training load distribution and management in rhythmic gymnastics. The purpose of study *one* was to describe training load distribution, recovery and injury in elite rhythmic gymnasts in main competitive periods. The aim of study *two* was to describe and analyse practices and perceptions of coaches, medical staff, and gymnasts regarding training load management in rhythmic gymnastics.

2 LITERATURE REVIEW

The general purpose of this literature review is to provide an overview of scientific research performed in rhythmic gymnastics to date, mainly regarding training load management. To date, despite increasing research related to training load in various sports, evidence in rhythmic gymnastics remains scarce. Therefore, a second objective of this review is to highlight the gaps in the literature, provide directions for future research, and work as a conceptual guideline for the studies comprising this thesis.

2.1 RHYTHMIC GYMNASTICS CHARACTERISTICS AND DEMANDS

2.1.1 Concepts, evolution and organization

The three main pillars that define rhythmic gymnastics are body movements, manual apparatus, and musical accompaniment (BARBOSA-RINALDI; MARTINELI; TEIXEIRA, 2009; SIERRA-PALMEIRO et al., 2019). Gymnasts must be able to perform high-level body difficulty elements (e.g., jumps, balances, and rotations) and apparatus skills (e.g., throws and catches), as well as demonstrate good artistic capacities and few technical errors (SIERRA-PALMEIRO et al., 2019). The current apparatus are rope, hoop, ball, clubs, and ribbon. There are two types of exercises: individual (one gymnast) and group (five gymnasts at the same time). For individual exercises, the duration of routines ranges from 1’15’’ to 1’30’’. As for group exercises, the duration of routines ranges from 2’15’’ to 2’30’’ (FIG, 2018).

The sport as it is known today reflects an evolutionary process started in the 18th century, which was influenced by different European thinkers, schools, and movements. However, its systematization as a competitive sport only began in the mid-19th century, led by the Soviet Union. Since 1963, rhythmic gymnastics is one of the gymnastics disciplines recognized and organized by the International Gymnastics Federation (FIG). Initially called “modern gymnastics”, its first Code of Points, which determines the competition rules, was only published in 1970 (TOLEDO; ANTUALPA, 2016). Since then, these rules have been frequently reviewed and new Codes of Points are formulated each four years (SIERRA-PALMEIRO et al., 2019). In 1984, individual exercises were officially included in the Olympic Games, followed by group exercises, in 1996.

2.1.2 Judging

Different from other sports, rhythmic gymnastics does not have an objective or automatic system to measure competition results. The gymnasts' performance is evaluated by judges that give a score based on specific criteria from the Code of Points. In general, gymnasts and groups receive points for well-executed difficulty elements and are penalized for technical and artistic mistakes during the routine (FIG, 2018). The jury is organized into panels and subgroups in such a way that the final score calculation represents an attempt to minimize judging subjectivity and allow each judge to focus on evaluating fewer aspects of the routine. However, these nuances increase the importance and responsibility of the judges, making their performance also an important determinant to the gymnasts' success (DEBIEN et al., 2014; LEANDRO et al., 2017; VAN BOKHORST et al., 2016).

2.1.3 Competition demands

Thanks to technological advances in the last decades, a variety of team and individual sports are able to quantify competition loads in a very precise and detailed manner (BORRESEN; LAMBERT, 2009; BOURDON et al., 2017; HALSON, 2014). The ability to capture the demands in which athletes are exposed during competitions has changed the way training is planned, implemented, and managed in several sports.

Conversely, specific competition demands and loads in rhythmic gymnastics are not well stated in the literature. The routine contents can be extremely different among gymnasts or even between routines for the same gymnast (e.g., different apparatus routines). However, some studies have tried to identify different capacities that might be related to rhythmic gymnastics specific performance (DOUDA et al., 2008; HUME et al., 1993). Due to the aesthetical component, the gymnasts' anthropometric profile is commonly described as one of the determinants of good performance in rhythmic gymnastics (DOUDA et al., 2008; HUME et al., 1993; PURENOVIĆ-IVANOVIĆ; POPOVIĆ, 2014). Moreover, one study quantified physiological aspects (e.g., energy cost and sources) during rhythmic gymnastics individual routines (GUIDETTI et al., 2000) and several others described routine technical components in past Olympic cycles (ÁVILA-CARVALHO et al., 2012a; ÁVILA-CARVALHO; KLENTROU; LEBRE, 2012; ÁVILA-CARVALHO; PALOMERO; LEBRE, 2010; BATISTA; GARGANTA; ÁVILA-CARVALHO, 2017, 2019; LEANDRO, 2018; LEANDRO et al., 2016). However, considering that rhythmic gymnastics rules are frequently changed and updated (SIERRA-PALMEIRO et al., 2019) these findings are unlikely to represent current requirements.

In general, coaches choose routine content based on the gymnasts current abilities and the specific movements they would like for them to perform in the future. Therefore, a detailed understanding and quantification of routine and competition loads and demands might be very useful to the entire training process. Future studies could explore and quantify gymnastics competition loads through available (e.g., inertial measurement sensors) or even new technologies.

2.1.3.1 Competition format

For individual exercises each gymnast must perform four different routines, using pre-determined apparatus. As for group exercise, each group must perform two routines, which include simple (one type of apparatus) and mixed (two types of apparatus). The competition is divided into qualification and finals, and gymnasts and groups compete for team, all-around, and apparatus medals (FIG, 2018). In general, competitions last around two to four days. The gymnasts and groups that qualify for the finals present each routine twice during the entire competition. However, the number of routines per day and time between each routine may vary depending on the event organization.

2.1.3.2 Anthropometric profile

Athletes' anthropometric characteristics could influence performance, either due to biomechanics or factors relating to aesthetics. Rhythmic gymnastics rules have clear requirements for amplitude, elegance, and beauty in all movements executed by the gymnasts. Obviously, subjectivity is involved in the judgment of these aspects, but different studies have observed associations between anthropometric components and performance (DOUDA et al., 2008; HUME et al., 1993; PURENOVIĆ-IVANOVIĆ et al., 2019). An analysis of young European gymnasts involved in national and international competitions found that anthropometric components were significantly related and explained 45% of all-around scores (sum of scores obtained in each exercise presented during the qualification phase) (DOUDA et al., 2008). In general, a slim somatotype, with long and thin limbs, small circumferences, and low body fat is common among rhythmic gymnasts that achieve better results in competitions, irrespective of the technical level and age (ÁVILA-CARVALHO et al., 2012a; HUME et al., 1993). It is worth noting that anthropometric profile depends on genetic factors and also training morphological adaptations. Therefore, it is also important to be aware of rigorous aesthetical demands imposed on a gymnast's body as it could impact on their nutritional habits, energy availability, health, and performance (MICHOPOULOU et al., 2011; SILVA; PAIVA, 2016).

2.1.3.3 Physiological demands

Duration of routines in rhythmic gymnastics is fixed by the Code of Points. However, due to a higher number and difficulty level of elements in the routine, it appears that these demands have increased each Olympic cycle. Information regarding specific physiological demands during gymnastics competition is scarce. One previous study conducted in nine young elite gymnasts showed that the relative energy system contribution during individual ball routines were: 49% aerobic, 42% anaerobic alactic, and 9% anaerobic lactic (GUIDETTI et al., 2000). In this regard, Douda et al. (2008) showed that young elite gymnasts have higher VO_{2max} than non-elite gymnasts. Moreover, they found that aerobic capacity explained 7.4% of all-around performance and anaerobic metabolism 4.6%. When considering just the elite group of gymnasts in the study, they observed that 58.9% of the score variation was explained by VO_{2max} (DOUDA et al., 2008). Despite these studies have been conducted during previous Codes of Points, these findings indicate that training in rhythmic gymnastics should aim to develop aerobic power and increase the maximal oxygen consumption of the gymnasts in order to meet specific competitive demands.

2.1.3.4 Physical demands

Despite scarce evidence, some studies reported that general flexibility and lower limb power were determinant physical capacities to rhythmic gymnasts success in competition (DOUDA et al., 2008; HUME et al., 1993). A multiple regression analysis revealed that flexibility and lower limb explosive strength explained 12.1% and 9.2% respectively of total variance in performance among young elite gymnasts (DOUDA et al., 2008). Hume et al. (1993) explored the association of various physical components with performance indicators among 106 New Zealand gymnasts ranging seven to 27 years old. Similarly, they found positive correlations between performance and flexibility, and lower limb power. Another study in young gymnasts revealed that physical capacities were associated with technical score (DONTI et al., 2016). Although each of these studies have made an important contribution to our understanding of the role of physical qualities on performance, more studies are needed to properly understand the physiological and physical competition demands in current senior elite rhythmic gymnasts.

2.1.3.5 Technical, aesthetical and artistic demands

Current rhythmic gymnastics rules require that gymnasts perform jumps, balances, rotations, and dance steps as body difficulty elements, as well as dynamic elements with rotation (e.g., throw the apparatus, perform several body rotations during its flight, and catch) and apparatus difficulties (e.g., innovative and difficult apparatus masteries). However, the number and difficulty level of elements vary among gymnasts as each routine is exclusively elaborated. In addition, every movement must be logically connected, demonstrating fluency, elegance, and beauty in accordance with the music rhythmic and character (FIG, 2018). Therefore, the strategies and choices related to the elaboration of routines are also very important to achieve good results in competitions.

In an attempt to describe common technical components, a Portuguese research group have dedicated much effort analysing routines of international competitions during the last decade (ÁVILA-CARVALHO et al., 2012a, 2012b; ÁVILA-CARVALHO; KLENTROU; LEBRE, 2012; ÁVILA-CARVALHO; PALOMERO; LEBRE, 2010; BATISTA; GARGANTA; ÁVILA-CARVALHO, 2017, 2019; LEANDRO, 2018; LEANDRO et al., 2016). Batista, Garganta, & Ávila-Carvalho (2019) investigated 288 individual routines of gymnasts that competed at Lisbon World Cup in 2013 and 2014. The better-ranked gymnasts showed lower variation of body difficulties among their routines and performed more rotations (e.g., pivots) and a higher number of turns. A similar investigation analysed 126 group routines from 28 countries that participated in the 2007, 2008, 2009, and 2010 Portimao World Cups (ÁVILA-CARVALHO et al., 2012b). The authors highlighted the common focus on exchanges (throw your apparatus and catch others' apparatus), balances, and jumps, while, in contrast with individual routines, less rotations. In group exercises, the difficulty elements must be performed by all gymnasts, and only small differences and variations are permitted. Therefore, the routine elaboration and the training process should be based on developing a harmonic, synchronized, and similar performance among group gymnasts.

However, in addition to individual differences, technical and artistic requirements in rhythmic gymnastics also change quickly across each Olympic cycle, mainly due to changes in the rules (LEANDRO, 2018; SIERRA-PALMEIRO et al., 2019; TOLEDO; ANTUALPA, 2016). Therefore, the understanding of detailed technical and artistic demands is a challenging task for any professional or researcher involved in rhythmic gymnastics. This emphasizes the relevance of a frequent, individual, and multidimensional approach to manage how each athlete copes and responds to competition and training loads.

2.1.4 Training demands

Generally, the training session is divided into warm-up, ballet, technical training, routine repetition, and conditioning, depending on the context and training phase (LAW; CÔTÉ; ERICSSON, 2007). Warm-up is focused on preparing the body for the following activities and may include stretching and light and short running. Ballet consists of a specific routine of static and dynamic exercises originally from classical ballet environment, which aims to improve gymnasts' body technique (REIS-FURTADO et al., 2020). Technical training is the moment to learn, develop, repeat, and adjust body and apparatus movements in order to avoid technical errors in routines. It is common to divide the routine into smaller parts and isolated elements to perform specific-movements repetitions. Routine repetition is the execution of the entire routine (or parts) with music accompaniment, as during competition. Finally, conditioning involves the development of specific physical capacities, mainly flexibility and strength. During off-season and pre-season it is also common to include dancing classes to develop artistic capacities (LAFFRANCHI, 2001).

There is a consensus in the literature that rhythmic gymnasts are exposed to high training volume, ranging from 20 to 40 hours/week depending on age and technical level (ÁVILA-CARVALHO et al., 2013; DEBIEN et al., 2020a; KOLAR et al., 2017; LAW; CÔTÉ; ERICSSON, 2007; SILVA; PAIVA, 2016). In this respect, a detailed analysis of elite rhythmic gymnasts' development compared training volume distribution across Olympic and international-level (i.e., competed in international events with exception to the Olympic Games) gymnasts across their careers (LAW; CÔTÉ; ERICSSON, 2007). Table 1 describes the findings of this study according to the relative percentages of total training duration in each career stage for each part of training. The authors highlighted that since the gymnasts were 13 years old almost half of training session duration was dedicated to routine repetition, consequently decreasing warm-up for both groups and conditioning time in the Olympic group. Moreover, the authors found that Olympic-level gymnasts trained more hours than international-level gymnasts during all career phases. This investigation illustrates an usual thinking in rhythmic gymnastics training culture that *more* is always *better* (CAVALLERIO; WADEY; WAGSTAFF, 2016).

Table 1 – Relative distribution of training duration in elite rhythmic gymnasts across different career stages.

Part of the session	Athlete's level	Career stages (age)			
		6 to 8 years	9 to 12 years	13 to 15 years	>16 years
Warm-up	Olympic	16.0%	11.2%	5.0%	3.6%
	International	23.0%	19.9%	15.7%	11.5%
Ballet	Olympic	28.7%	29.5%	18.5%	17.5%
	International	17.8%	7.9%	9.6%	11.9%
Technical	Olympic	20.2%	20.9%	19.8%	20.3%
	International	20.8%	22.9%	18.7%	17.8%
Routine	Olympic	22.5%	26.5%	48.1%	50.3%
	International	31.1%	41.9%	49.7%	50.6%
Conditioning	Olympic	12.5%	11.8%	8.5%	8.4%
	International	7.4%	7.3%	6.4%	8.1%

Source: Adapted from Law, Côté, & Ericsson (2007).

2.1.5 Context of gymnasts' development

Rhythmic gymnastics is commonly reported as an early involvement and specialization sport (HUME et al., 1993; JAYANTHI et al., 2013; LAW; CÔTÉ; ERICSSON, 2007). Some authors stated that gymnasts begin their careers around six to eight years old, being exposed to high training volume since then (ÁVILA-CARVALHO et al., 2013; HUME et al., 1993; LAW; CÔTÉ; ERICSSON, 2007). Law, Côté, & Ericsson (2007) have found that Olympic-level gymnasts began competing at regional competitions at ~7.3 ± 0.8 years old, significantly earlier than international-level gymnasts (8.8 ± 1.7 years). In addition to that, by 12 years old they were already competing in international events. Moreover, by 11 years of age both groups were exclusively dedicated to rhythmic gymnastics practice (LAW; CÔTÉ; ERICSSON, 2007).

Gymnasts seem to reach their peak performance career at earlier ages when compared to other sports. For instance, Olympic-level gymnasts earned their first international titles by 15 years of age (LAW; CÔTÉ; ERICSSON, 2007). According to public reports on the FIG website, the average age among gymnasts that participated in World Championships and Olympic Games between 1998 and 2015 was 18 ± 0.9 years old. Interestingly, there is only one individual gymnast in the history of the sport that won two Olympic gold medals. In addition, just 15.5% of all gymnasts participating in the 2015 World Championship, and 47.8% of individual gymnasts in 2017 have also participated in the 2019 edition, which highlights the need to better understand how current training practices impact on career longevity.

2.2 TRAINING LOAD MANAGEMENT

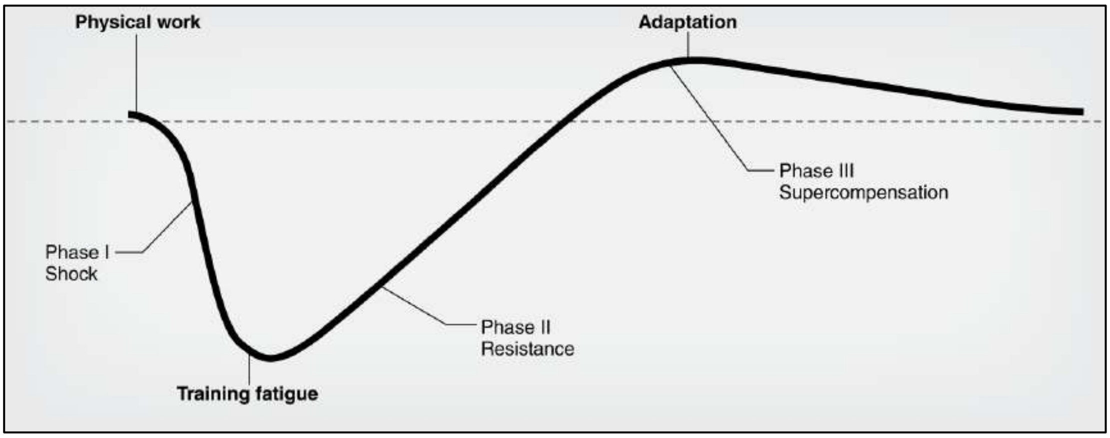
2.2.1 Training process

Training is a systematic and complex process which aims to improve athletic performance through positive adaptations (VIRU; VIRU, 2000). The complexity is related to the non-linear relationship between athletes' individuality and sports specific demands. The systematization relates to the fact that the goals, planning, and program are underpinned by fundamental training principles (e.g., progressive overload, specificity, variety, individualisation, adaptation, and reversibility).

The general adaptation syndrome, described by Selye (1936), is a paramount theoretical framework for the training process (CUNANAN et al., 2018). It consists of a general biological response to stress (e.g., exercise) expressed by three stages: (1) alarm reaction, where the physiological state is diminished; then, after appropriate recovery, (2) resistance, where regeneration occurs; and, if the challenge was greater than the organism's adaptive capabilities, it results in (3) exhaustion (SELYE, 1936).

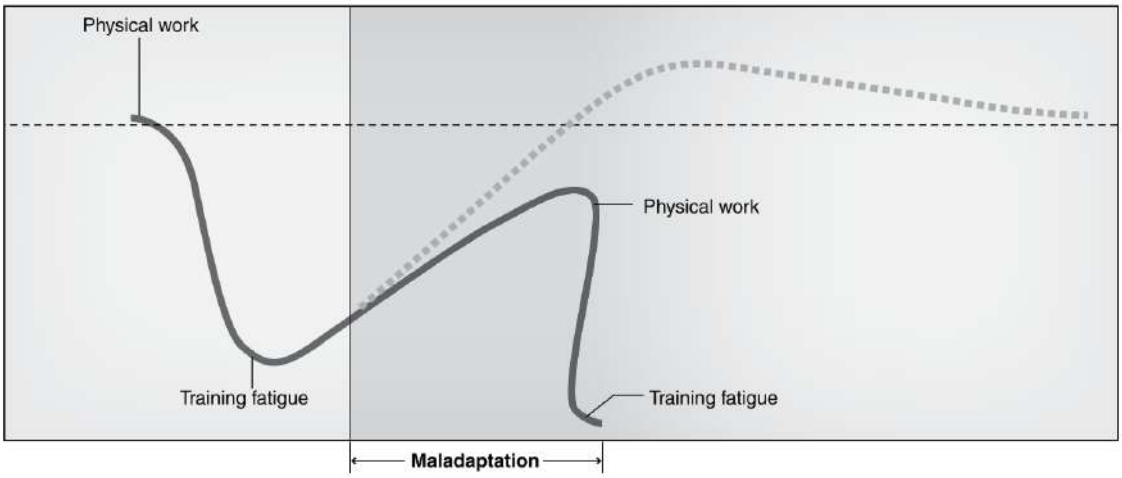
Based on this theory, training can be comprehended as a dose-response relationship, as graphically represented in Figure 1. A training dose works as a stressor stimulus that induces psychophysiological responses in the athletes (i.e. organism) (COUTTS; CORMACK, 2014). Consequently, how athletes respond and recover from training will dictate the adaptation process (IMPELLIZZERI et al., 2020a). The basis of a training program is to understand the effects that each dose (i.e., training load) produces in athletes' bodies. After being exposed to this stressor stimulus, the basal level of athletes' capacities is reduced and the organism works to re-establish the initial balanced state (i.e., homeostasis). It is expected that, during recovery, positive adaption occurs in order to improve an athletes' capacity to tolerate more load (i.e., supercompensation) (BOMPA; BUZZICHELLI, 2019; ISSURIN, 2010; VIRU; VIRU, 2000). However, a stimulus greater than what the individual is capable of tolerating, or inappropriate recovery between stimuli could lead to a reduced capacity or maladaptation (FIGURE 2).

Figure 1 – General adaptation syndrome explaining response to a stressor.



Source: Coutts & Cormack (2014).

Figure 2 – Maladaptive training due to insufficient recovery after a training dose.

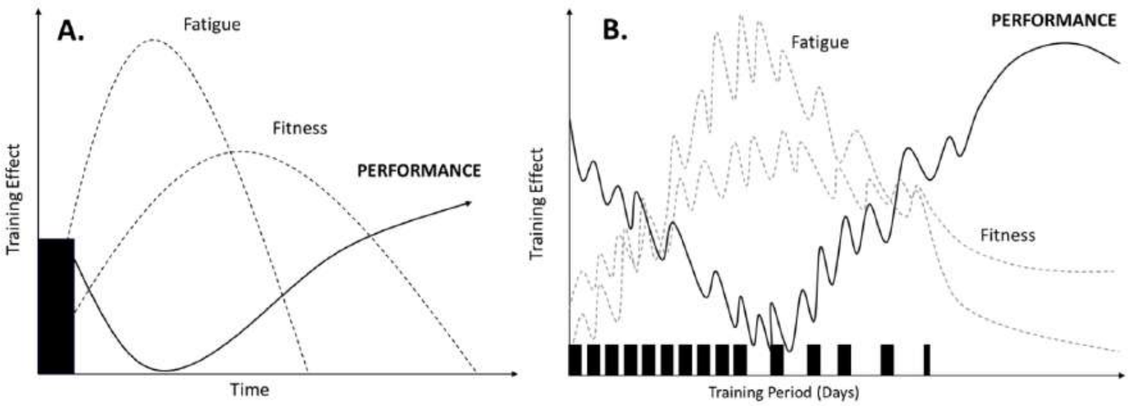


Source: Coutts & Cormack (2014).

As competitive sports and technology has evolved, reaching the best performance at the desired moments has become essential. Therefore, further models have proposed strategies for training planning, dose-response quantification, and performance modelling in an attempt to reach the optimal performance through appropriate training load distribution across time (FOSTER et al., 1996; FOSTER; RODRIGUEZ-MARROYO; KONING, 2017).

A remarkable model that has influenced most of the following research in training load is the fitness-fatigue model. In brief, this model presents an application of systems theory to predict performance from the interaction of fitness and fatigue (Performance = Fitness – Fatigue). The difference between these two components at any point in time is defined as “readiness to perform” (BANISTER, 1991). Based on this model, it is possible to understand the training load-recovery cycle to single or multiple doses of exercise (FIGURE 3). In this perspective, despite its limitations (HELLARD et al., 2006), the fitness-fatigue model is a key theoretical foundation to training load management (BOURDON et al., 2017; COUTTS; CROWCROFT; KEMPTON, 2017).

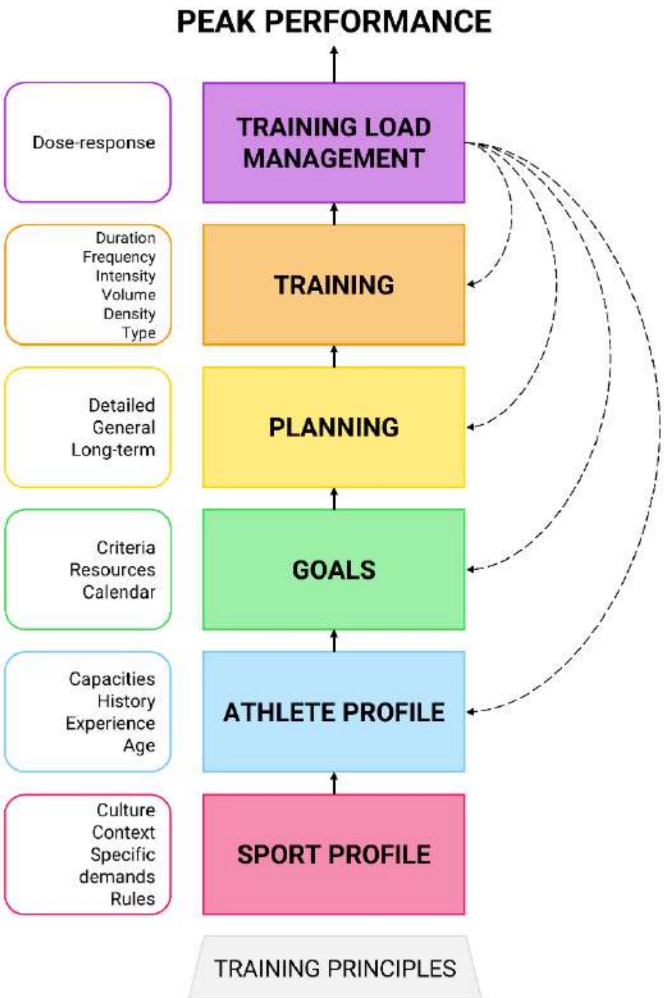
Figure 3 – The modelled fitness and fatigue responses to A) a single bout, and B) a sequence of training bouts.



Source: Coutts, Crowcroft, & Kempton (2017).

In light of these theoretical frameworks, it is possible to describe how the training process could be organized to reach peak performance (FIGURE 4). It starts with the understanding of sport specific demands and characteristics (ROSENBLATT, 2014). The second step should be a complete assessment of an athletes’ capacities, profile, and history. At this moment, several different professionals could be involved in the process (e.g., strength and conditioning coaches, medical staff). Then, it is feasible to set the training goals and start the planning. Important aspects such as the calendar, stage of athlete’s career, available financial resources, and staff composition may influence the selection of training goals. In brief, planning involves long-term and detailed organization (i.e., programming) of training variables based on the previous stages. After that, training is implemented and the dose-response relationship should be managed to follow how athletes are coping with the training process and make adjustments as needed (COUTTS; CROWCROFT; KEMPTON, 2017). Therefore, as illustrated in Figure 4, each “step” (colored rectangles) of the training process influences and underpins the next and training load management provides relevant information that could be used to “rethink” the entire training process itself.

Figure 4 – A schematic of the training process.



Source: elaborated by the author (2020).

As mentioned above, sport science has made a great effort in the past decades to develop methods to quantify and monitor training load and its responses (BORRESEN; LAMBERT, 2009; BOURDON et al., 2017; HALSON, 2014).

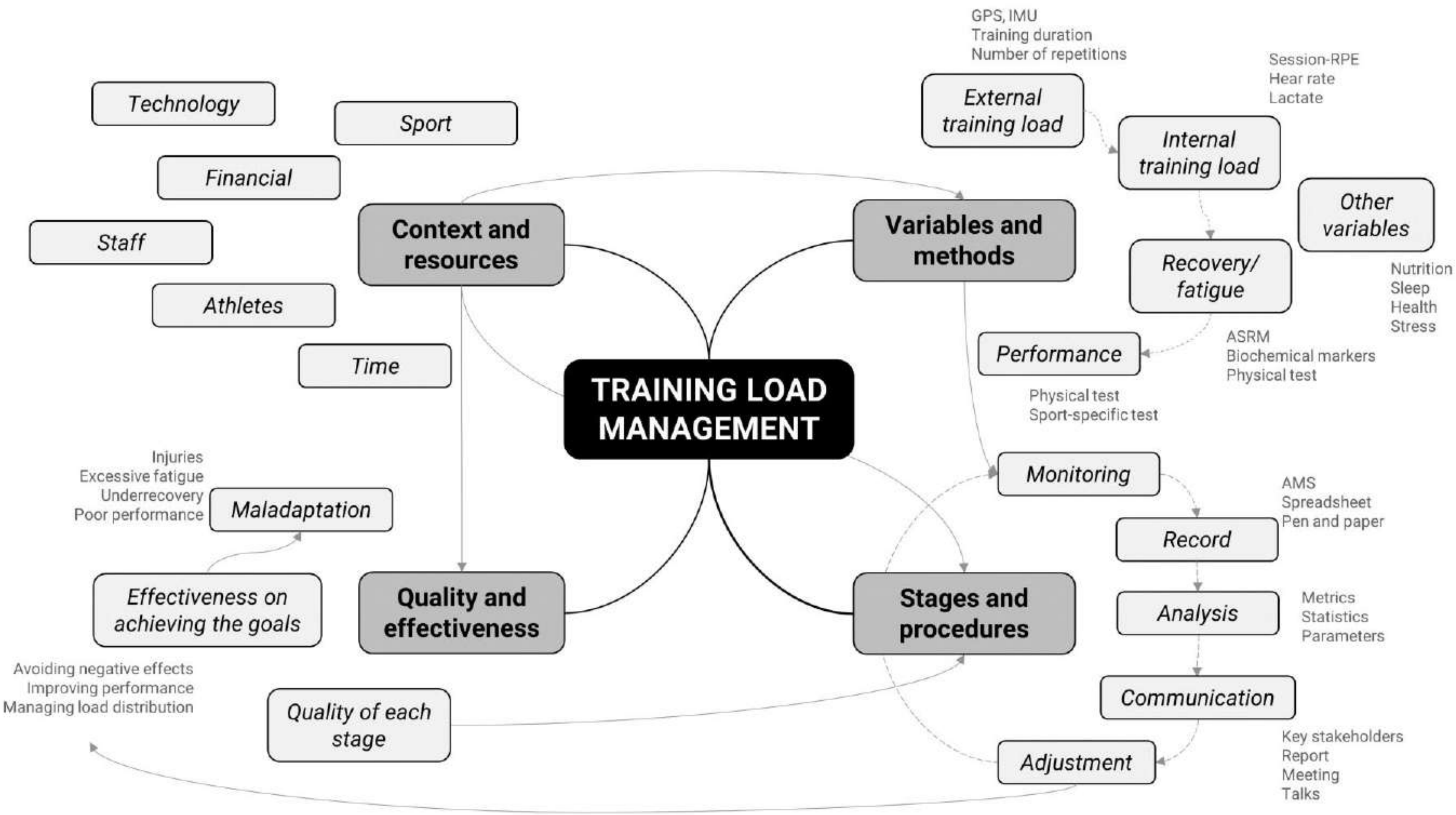
Consequently, different expressions have emerged. Some commonly seen are "training load monitoring", "workload monitoring", "athlete monitoring", "athlete management", "load control", and "load management". In this thesis, *training load management* is used as a broad expression which includes all different variables, procedures, stages, and systems that, collectively, aim to understand the training dose-response relationship (including during competition), as well as contribute to athletes' performance improvement and fewer negative outcomes.

Training load management concerns the process of understanding the individual training dose-response relationship in order to prescribe appropriate training load, improve performance, and avoid maladaptation (GABBETT et al., 2017; HALSON, 2014). Diverse variables, methods, stages, and stakeholders are involved in this process, as illustrated in Figure 5. In the next subsections of this review a broad approach has been used to elucidate some of these aspects.

2.2.2 Variables and methods

As already presented in this literature review, the conceptual basis of training load management is the interaction between fitness and fatigue levels across cycles of training load and recovery. From a deeper look into the dose-response relationship, in terms of how this could be measured and quantified, some concepts and variables appear (FIGURE 6). To date, there is no single measure that can be used to accurately manage the entire process (BORRESEN; LAMBERT, 2009; BOURDON et al., 2017; HALSON, 2014). In general, researchers and practitioners try to measure variables related to training dose (e.g., external and internal load), response (e.g., recovery, fatigue, wellbeing), and performance (e.g., fitness, readiness) (IMPELLIZZERI et al., 2020a). Some common undesired outcomes (e.g., excessive fatigue, overuse injuries) or symptoms (e.g., illness, psychological disturbs) could also be investigated as negative responses or maladaptation to training that should be minimized.

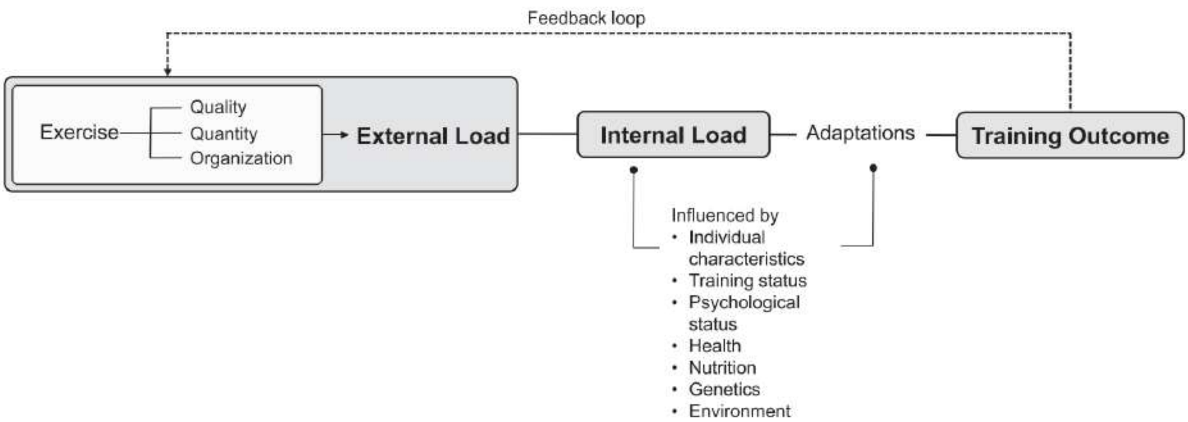
Figure 5 – A schematic of training load management.



Source: elaborated by the author (2020).
Dashed lines represent sequences and grey lines represent influence.

Moreover, different types, contents, and magnitudes of training doses will cause different effects on the athletes' organism. Depending on how each system (e.g., musculoskeletal, cardiovascular) is stimulated, the response and adaptation will vary (VIRU; VIRU, 2000). In addition, other "non-training" and health variables (e.g., sleep, nutrition, social aspects, school demands) also influence how this process occurs (KENTTÄ; HASSMÉN, 1998; VERHAGEN; GABBETT, 2019). Therefore, it is paramount to use a multidimensional approach in training load management (KELLMANN et al., 2018; MEEUSEN et al., 2013). The choice of each variable and method must be underpinned by all the previous stages of the training process (FIGURE 4), in order to develop and apply specific systems/models capable of contributing to better decision-making in day-to-day practice (GABBETT et al., 2017).

Figure 6 – Training process framework and measurable components for monitoring.



Source: Impellizzeri et al. (2020a).

2.2.3 Training load

Training load (also known as "workload" or "load") is defined as the sport burden (single or multiple physiological, psychological or mechanical stressors) as a stimulus that is applied to a human biological system (SOLIGARD et al., 2016). Training load can be described as external and internal. *External load* is the "work" performed by the athlete as prescribed in the training program. Consequently, *internal load* is the athlete's psychophysiological response which occurs during the execution of the exercise (i.e., external load) (IMPELLIZZERI; MARCORA; COUTTS, 2019). The individual characteristics of each athlete combined with the applied external and internal training loads determine the training effects. External and internal training load are quantified by distinct methods, although existing consensus is that both should be monitored to better understand how athletes cope with training (BOURDON et al., 2017; GABBETT et al., 2017; HALSON, 2014; IMPELLIZZERI; MARCORA; COUTTS, 2019).

2.2.3.1 Methods of measuring training load

Common measures for external training load include distance covered, speed, time, acceleration, power output, and movement repetition counts (BORRESEN; LAMBERT, 2009; BOURDON et al., 2017; HALSON, 2014). Other metrics using specific thresholds and/or combinations of measures are also used, such as high speed distance, PlayerLoad™, and Training Stress Score™. Nowadays, wearable devices with global position system (GPS) and microelectrical mechanical systems (MEMS) have contributed to quantify external load more easily, allowing practitioners to objectively collect a large amount of data on multiple athletes (MALONE et al., 2017). Moreover, specific algorithms to quantify sport-specific movements have been developed for various sports (CHAMBERS et al., 2015). Regardless of how useful it could be, it is recommended to understand how the data is generated, verify the validity and reliability of these tools, as well as be aware of how it should be appropriately used in the training load management process (CAMOMILLA et al., 2018; MALONE et al., 2017). Despite the increased amount of research related to novel methods of quantifying external training load, to date, no study have analysed the use of these technologies in rhythmic gymnastics (CAMOMILLA et al., 2018).

Measures such as heart rate (HR), blood lactate concentration, oxygen consumption, and ratings of perceived exertion (RPE) are some of the methods to assess internal training load (BOURDON et al., 2017; HALSON, 2014). Blood lactate concentration and oxygen consumption are infrequently used to manage training load in the field due to the limitations of applying these measures on a regular basis and providing useful information to inform training prescription (BORRESEN; LAMBERT, 2009). In general, HR and RPE metrics involving the interaction of training volume and intensity are more commonly used.

Banister proposed a unit to quantify the training impulse (TRIMP), where changes in HR represent a measure of intensity and training duration a measure of volume (BANISTER, 1991). In brief, the Banister's TRIMP is calculated using training duration, maximal HR, resting HR and average HR during the training session. There is a weighting factor that emphasizes high-intensity exercise and is applied to the calculation to avoid giving disproportionate relevance to exercises with long duration and low intensity when compared with intense, short-duration activities (BANISTER, 1991). Further derived models have used different zones and thresholds of HR in conjunction with other weighting factors to calculate the TRIMP (BORRESEN; LAMBERT, 2009; HALSON, 2014). Despite the relevant contribution of this method to internal training load quantification, HR-based methods may not be accurate for some contexts and sports, as HR could be influenced by the environment, athlete's hydration, and usage of medication, for example (HALSON, 2014).

Foster et al. (2001b) proposed the session rating of perceived exertion (session-RPE). At the end of each training session, usually 30 minutes, athletes respond to the question "How was your session?", indicating a value and correspondent descriptor on the scale. The scale is adapted from Borg's original version (BORG, 1982) and vary from 0 (rest) to 10 (maximal) (FOSTER et al., 2001b). The score (intensity) is multiplied by the training duration in minutes (volume) and a value in arbitrary units (AU) is obtained. Due to its ecological validity, reliability, easy application, and low cost, this method has been largely used across various sports and contexts (HADDAD et al., 2017), including rhythmic gymnastics (ANTUALPA; AOKI; MOREIRA, 2017, 2018; DEBIEN et al., 2019, 2020a). Like all methods, the session-RPE presents some limitations. It is a subjective method and the successful implementation depends on the athletes' compliance and honesty (SAW et al., 2015). However, at the same time that the subjectivity might be considered a limitation, it is also a positive aspect as the session-RPE is capable of capturing psychosocial aspects, which are also relevant in understanding internal training load.

2.2.3.2 Acute:chronic workload ratio

The acute:chronic workload ratio (ACWR) was developed based on Banister's fitness-fatigue model, where the acute load is analogous to "fatigue" and the chronic load is analogue to “fitness” (GABBETT, 2016; HULIN et al., 2014). Basically, this variable captures the training load performed in a short period of time (i.e., acute load) relative to the training load performed over a longer time period (i.e., chronic load). The ratio of these two measures provides an index, which, in conjunction with other information (e.g., fitness levels, age, season period, injury history) can provide insights regarding “athlete preparedness” to tolerate load (GABBETT, 2016). An ACWR higher than 1 indicates an acute training load higher than the chronic and vice versa. This measure can be obtained using external or internal training load and is a relevant tool to progress training loads safety, especially with regards to mitigating injury risk (ANDRADE et al., 2020; GABBETT, 2016; GRIFFIN et al., 2020). However, methodological aspects should be taken into consideration when interpreting this measure (GABBETT, 2020b; GRIFFIN et al., 2020). It can be obtained by coupled or uncoupled calculation, rolling averages (RA) or exponentially weighted moving averages (EWMA), and also using different time windows for acute and chronic workloads.

The original version was proposed using coupled RA ACWR. In this first study, the acute workload corresponded to training load of the current week and the chronic workload was calculated using a rolling average of the last four weeks, including the current week (i.e., acute workload) (HULIN et al., 2014). The model has been criticised, due to the possible spurious correlation caused by the mathematical coupling, albeit the criticism was based on simulated data (LOLLI et al., 2019a). Consequently, a further study presented other possible ways to calculate the ACWR, which excluded the acute workload from the chronic workload calculation (i.e., uncoupled) (WINDT; GABBETT, 2018). In this regard, recent studies using real data from high-performance sports have demonstrated that both coupled and uncoupled ACWR show very similar results, suggesting that this criticism may be unwarranted as long as practitioners and researchers are aware of the method used to calculate the ACWR (COYNE et al., 2019; GABBETT et al., 2019a).

Additionally, the use of simple RA was questioned for not representing daily training load variations and how training effects vary over time (MENASPÀ, 2017). As a result, an alternative exponentially weighted moving average (EWMA) was proposed by Williams et al. (2017a), which assigns a decreasing weighting for each older training load value in the calculation of ACWR (WILLIAMS et al., 2017a). A recent systematic review on this topic have shown that the coupled RA ACWR is the most common calculation in team sports studies and it is associated with injury incidence (GRIFFIN et al., 2020). However, EWMA seems to be a more sensitive approach in relation to injury risk associations (GRIFFIN et al., 2020; MURRAY et al., 2017). Regarding the time periods for acute and chronic workloads, the most commonly investigated was seven days for acute and 28 days for chronic workload, despite some variations (e.g., 7:14, 7:21) (GRIFFIN et al., 2020). In general, the most suitable calculation depends on the training and competition characteristics of each sport. There is still a gap in the literature concerning the different methods to calculate the ACWR, as well as its application in aesthetic sports and female athletes.

Despite any criticism regarding the use of the ACWR in practice (IMPELLIZZERI et al., 2020b; LOLLI et al., 2019b), the essential message of this model is that athletes must be well-prepared to perform the loads they are expected to encounter (GABBETT, 2016, 2020a, 2020b). This is a paramount concept in the training process, which reinforces the main goals of training load management and explains the wide use of ACWR in various sports (ANDRADE et al., 2020; GRIFFIN et al., 2020). Like any other measure used to manage training load, the ACWR was not proposed to be used in isolation. It should be considered in conjunction with other appropriate measures of training load and response to load (GABBETT, 2020b; HULIN; GABBETT, 2019; WINDT; GABBETT, 2018).

2.2.4 Recovery

Recovery is defined as a multifactorial (e.g., physiological, psychological, social) restorative *process* related to time, which aims to re-establish the organism's impaired resources and return to a balanced state (i.e., homeostasis) (KELLMANN et al., 2018). On the other hand, fatigue can be characterized as a psychobiological *state* associated with an inability to complete a task that was once achievable within a recent time frame, and is usually associated with altered perceptions of effort, feelings of tiredness, and/or exhaustion (COUTTS; CROWCROFT; KEMPTON, 2017; HALSON, 2014). Despite distinct concepts, both are multidimensional constructs that involve diverse mechanisms and are directly related to adaptation. Therefore, recovery and fatigue can be understood as a continuum, where excessive fatigue accumulation and poor recovery might result in maladaptation while an adequate recovery process contributes to minimizing fatigue levels (KELLMANN et al., 2018; KENTTÄ; HASSMÉN, 1998; MEEUSEN et al., 2013). In this respect, the assessment of recovery and fatigue as part of training load management is often an attempt to identify at which point across this continuum each athlete is at a specific point in time. The management of this continuum plays an essential role in optimizing readiness to perform, and also minimizing the risk of negative outcomes such as overtraining, injuries, and psychological disorders (HEIDARI et al., 2019).

2.2.4.1 Methods of measuring the recovery-fatigue continuum

Heidari et al. (2019) stated that a multidimensional approach to monitoring recovery and fatigue should include biological, psychological, and sociological indicators carefully chosen based on the context. In this respect, the literature describes a variety of methods used to assess the recovery-fatigue continuum, ranging from specific biological markers to broad psychometric scales and questionnaires (HEIDARI et al., 2019; MEEUSEN et al., 2013; THORPE et al., 2017). In the same perspective as for training load, the choices depend on the sport demands. The cost, time demanded to analyse and interpret may also influence the approach used to monitor these variables in the practical environment.

Various biological parameters might also be used to monitor the training process. These may include physiological (e.g., heart rate), biochemical (e.g., creatine kinase), immunological (e.g., immunoglobulin A), and/or hormonal markers (e.g., cortisol, testosterone) (HEIDARI et al., 2019; MEEUSEN et al., 2013). These biological indicators may provide relevant objective information to understand aspects related to muscle damage, illness, stress, and symptoms of maladaptation. Nevertheless, the timeframe regarding collection and analysis, financial resources, high inter- and intra-individual variations, and staff composition are some of the potential limitations to be considered before using these measures in the field.

In addition to the methods earlier mentioned, the use of performance tests to assess neuromuscular function or joint range of motion, for example, could be also seen as recovery-fatigue monitoring tools. Once the normal performance outcome is known, it is possible to analyse the athletes' current capacities after training or competition. Frequent tests applied in team sports environment include jump tests, sport-specific test protocols, strength tests, and submaximal tests (TAYLOR et al., 2012; THORPE et al., 2017).

Psychological and/or sociological aspects are usually measured by athlete self-reported measures (ASRM) through subjective scales and questionnaires (SAW et al., 2017). In general, these tools were originally developed in overtraining research, aiming to diagnose some related symptoms. Consequently, they also began to be used to capture how the athletes perceive some points concerning the recovery-fatigue continuum including dimensions as stress, mood, general wellbeing, and emotions. Some of these measures are underpinned by well-described theoretical frameworks and others are consequence of ecological validity and/or wide application in the field (SAW et al., 2017).

Among the questionnaires, two that are commonly mentioned in the literature are the Profile of Mood States (POMS) and the Recovery-Stress Questionnaire for Athletes (RESTQ-Sport) (HEIDARI et al., 2019; MEEUSEN et al., 2013; SAW; MAIN; GASTIN, 2016). The POMS comprises 65 items and six mood dimensions (i.e., tension, depression, anger, vigor, fatigue, and confusion) (MORGAN et al., 1987). The RESTQ-Sport intend to provide information regarding the recovery-stress state through 19 scales and 76 Likert-type questions. It is underpinned by a structured theoretical basis of the interrelation of stress-states and recovery demands, known as "scissors-model" (KELLMANN, 2010). In attempt to offer a more suitable instrument to the practical context, further shorter versions were also developed (KÖLLING et al., 2020). Both RESTQ-Sport and POMS are broad instruments that could provide insightful information to better understand the recovery-fatigue continuum. However, they consume considerable time to collect and analyse the data, which may limit application in day-to-day practice.

Inspired by Borg's RPE, the Total Quality Recovery (TQR) scale was proposed by Kenttä and Hassmén (1998) as a measure capable of assessing the recovery process. The TQR conceptual model is supported by the RESTQ-Sport theoretical framework, yet it is described as an attempt to view the complex overtraining and recovery processes in their full context (KENTTÄ; HASSMÉN, 1998). The original model proposed two subscales: 1) TQR perceived, that should be applied before bedtime aiming to provide a perception of recovery in the last 24 hours, and 2) TQR action, which athletes score their actions and accumulate recovery “points” over a 24-hour period from four main recovery categories (nutrition and hydration, sleep and rest, relaxation and emotional status, and stretching/cooldown). However, most research has used only the TQR perceived, usually before the training sessions begin. This scale varies from 6 (minimum score) to 20 (maximal score). The authors also suggested the score 13 (reasonable recovered) as a minimum acceptable level, even after intense training (KENTTÄ; HASSMÉN, 1998). It has been applied to monitor the perceived recovery in longitudinal studies in volleyball (DEBIEN et al., 2018; FREITAS et al., 2014; TIMOTEO et al., 2018), soccer (BRINK et al., 2010; FANCHINI et al., 2015), basketball (DOEVEN et al., 2017), as well as rhythmic gymnastics (DEBIEN et al., 2019, 2020a).

As an alternative to these empirical measures, different custom-made wellbeing/wellness scales including fatigue, muscle soreness, sleep quality, mood, and stress have also been widely adopted in team and individual sports environments (ANTUALPA; AOKI; MOREIRA, 2017; BUCHHEIT et al., 2015; GALLO et al., 2015; MALONE et al., 2018; MCLEAN et al., 2010; THORPE et al., 2017; TIMOTEO et al., 2017). Despite its ease of application, it is fundamental that researchers and practitioners are aware of the psychological proprieties (e.g., instrument development, theoretical basis, reliability, validity, reference values) of these self-reported measures before applying in scientific studies and practice (SAW et al., 2017). Despite scare scientific validation (DUIGNAN et al., 2020; JEFFRIES et al., 2020), they seem to provide sensible information concerning relevant aspects of the recovery-fatigue continuum and could be carefully implemented in a daily basis in the field.

A systematic review has shown that subjective measures, such as those presented above (recovery, stress, mood), have greater sensitivity and responsivity to external training load variations than other more objective tools (SAW; MAIN; GASTIN, 2016). In order to better align research and practice, Saw et al. (2017) recommend several steps to choose an appropriate ASRM for training load management. First, practitioners should consider the purpose, stakeholder engagement (e.g., athletes, coaches, and staff), and feasibility. Second, practitioners should look for a deep understanding of which dimensions and theoretical basis underpin the measure (SAW et al., 2017).

It is well-known that recovery is an extremely individualized and multifactorial process. Therefore, several authors recommend that recovery should be periodised in a detailed manner and the recovery-fatigue continuum frequently monitored to adjust the recovery strategies and training program in accordance with the individual and sport demands (HEIDARI et al., 2019; KELLMANN et al., 2018; SKORSKI et al., 2019). Reviewing the strategies and methods to optimize the recovery process is not an aim of this literature review, although, it is worth noting that there is no consensus in the literature regarding the application of these strategies, especially including the long-term effects (DUPUY et al., 2018).

2.2.5 Performance

Performance responses to training are nonlinear, influenced by a myriad of training and non-training related factors, and difficult to accurately predict or measure (BOURDON et al., 2017). A single and unique definition of performance that fits all sports and contexts does not exists. Nevertheless, a broad concept that is commonly accepted is the interaction between physical, technical, tactical and psychological capabilities in order to succeed in a specific sport (COUTTS; CROWCROFT; KEMPTON, 2017). As performance improvement is the main goal of training, the ability to assess this variable is key to understanding the training process and managing training loads appropriately.

2.2.5.1 Methods of measuring performance

Original models that have attempted to predict performance (CALVERT et al., 1976; FOSTER et al., 1996) failed to consider the complex and non-linear nature of the training dose-response. For instance, performance assessment might be simple in some individual sports (e.g., track and field, cycling, swimming), but quite complex in team sports, martial arts, and aesthetic sports. Consequently, it has become more feasible to measure related and specific components or indicators of performance.

Common reported measures include physical performance or fitness tests and sport-specific skills evaluation (AKENHEAD; NASSIS, 2016; TAYLOR et al., 2012).

Conversely, most of the methods used to measure fatigue levels may be used to assess performance as well. For example, jump tests using force platform, contact mat or even validated smartphone applications are able to provide insightful information regarding lower limb neuromuscular function, which are commonly used in team sport environments (DEBIEN et al., 2018; MILOSKI et al., 2016; THORPE et al., 2015). Other examples include the Yo-Yo intermittent recovery test in rugby league (HULIN et al., 2019), short sprint tests in futsal (MILOSKI et al., 2016), and submaximal running tests in basketball (AOKI et al., 2017). However, in the high-performance team sport environment, it is extremely difficult to measure performance using test and specific protocols given the intense schedule, where players need to be fit, recovered, and cope with travel on a weekly basis (HALSON, 2014). Therefore, sport-specific measures of performance might be an interesting strategy as it can be monitored during normal training activities.

2.2.6 Injury

At the same time that training load management aims to improve athletes' performance it also aims to avoid undesired consequences, such as injuries. Sport injuries result from an extremely complex interaction between several aspects such as training load, fitness level, age, biomechanical factors, and previous injuries (BITTENCOURT et al., 2016; GABBETT et al., 2019b). When an athlete sustains an injury there are diverse negative consequences, from individual psychological aspects to organization financial loss. Moreover, an injured athlete that cannot train and compete is deprived of performance, which may impair his/her chances of achieving success (DREW; RAYSMITH; CHARLTON, 2017) as well as his/her entire career.

The sport science literature presents diverse methodologies with regard to injury research. In general, aspects such as injury definition, incidence, site, type, cause, and severity could vary and should be clearly stated, as well as critically analysed when comparing results from different studies (BAHR et al., 2020). In team sports, despite some variations, injury definition is usually related to missing games or training sessions due to pain or incapacity to perform (GRIFFIN et al., 2020). In contrast, there is no consensus for injury definition in rhythmic gymnastics investigations (GRAM; CLARSEN; BØ, 2020). Given that gymnasts compete infrequently but commonly train and compete with injury symptoms (CAVALLERIO; WADEY; WAGSTAFF, 2016; EDOUARD et al., 2018; HARRINGE; LINDBLAD; WERNER, 2004), a context-specific definition should be adopted in future studies.

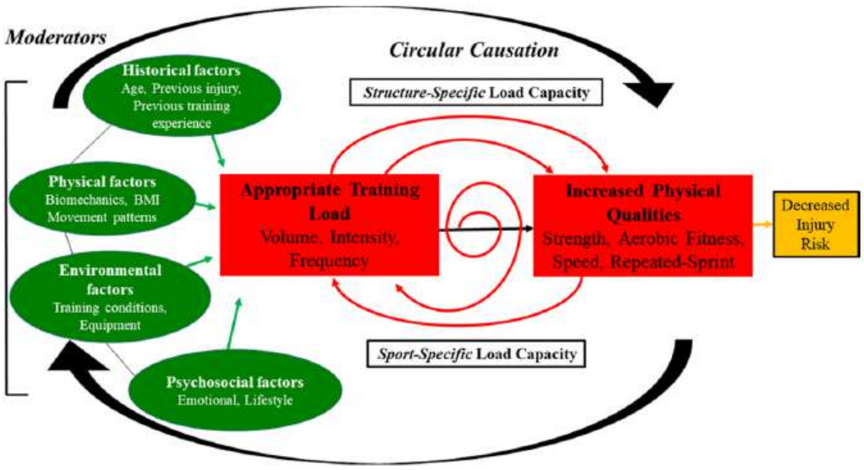
2.2.6.1 Relationship between injury, training load, and recovery

Sport injuries result from a complex interaction between several determinants which could work as risk or protective profiles (BITTENCOURT et al., 2016). Recognizing the emergent patterns resultant from the interaction among these determinants is essential to comprehend injury and elaborate strategies to mitigate the risk. There is a consensus in the literature that cycles of inappropriate training load and insufficient recovery could result in maladaptation, including injuries (SOLIGARD et al., 2016). However, several other individual and external factors influence the relationship between injuries, training load, and recovery.

Previous research described that high training loads were related to higher injury incidence (ANDERSON et al., 2003). However, more recent evidence has shown that high chronic training loads appropriately achieved could also “protect” athletes from sustaining certain types of injuries (GABBETT, 2016, 2020b; GABBETT et al., 2016a; HULIN et al., 2014, 2016). Given these findings, in conjunction with the complex nature of sport injuries, training load might be protective as well as predictive of injury, depending on how it is managed and applied. In this respect, Gabbett et al. (2019b) proposed a model to align two different sports injury frameworks, describing how moderators (green) and circular causations (red) interact in the training load-capacity relationship (FIGURE 7).

Recent systematic reviews have analysed the association of injury and training load variables (ANDRADE et al., 2020; ECKARD et al., 2018; GRIFFIN et al., 2020; JONES; GRIFFITHS; MELLALIEU, 2017). All reviews have stated strong evidence for the association of the ACWR model and injury incidence. Jones, Griffiths, & Mellaieu (2017) searched for longitudinal studies which included analysis of the relationship between training load and/or fatigue markers and injury and/or illness. The authors found mixed results concerning fatigue markers and injury. Moreover, they reported that periods of training load intensification, accumulation of training load, and acute changes in load may expose the athlete to higher injury/illness risks (JONES; GRIFFITHS; MELLALIEU, 2017). Regarding the methods for assessing training load, Eckard et al. (2018) found that session-RPE method was a more sensitive tool than other training load methods and metrics in relation to the interaction between training load and injury. The two other reviews have particularly investigated the association between the ACWR and injuries in team sports (ANDRADE et al., 2020; GRIFFIN et al., 2020). Despite the limitations and current criticism (IMPELLIZZERI et al., 2020b) on the use of the ACWR, both reviews have found several studies from different research groups, conducted among distinct sport contexts, pointing to an association between ACWR and injury risk (ANDRADE et al., 2020; GRIFFIN et al., 2020).

Figure 7 – Moderators and circular causation in training load-capacity relationship.



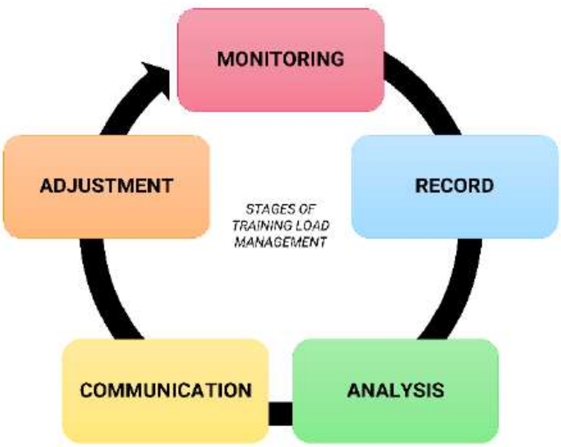
Source: Gabbett et al. (2019b).

A 37-week investigation in professional volleyball players showed that injured athletes reported lower perceived recovery and higher ACWR, measured by TQR and session-RPE methods, respectively (TIMOTEO et al., 2018). Another study assessed recovery and injury in 86 male and female team sports athletes over a ten month period, where each three weeks the athletes responded to the RESTQ-Sport (VAN DER DOES et al., 2017). Multinomial regression analysis showed a decreased perceived recovery was associated with increased injury risk (VAN DER DOES et al., 2017). Collectively, these findings reinforce the importance of longitudinal and multidimensional investigations in order to elucidate how training load, recovery, and injury could be associated in each context. To date no studies have investigated the relationship among training load, recovery, and injury incidence in rhythmic gymnastics.

2.2.7 Stages of training load management

Training load management is a systematic process which can be summarized and “simplified” in a few steps (IMPELLIZZERI et al., 2020a; THORNTON et al., 2019). An interpretation of current training load research allows us to summarize this process in five main cyclical stages: monitoring, recording, analysis, communication, and adjustment (FIGURE 8) (TIMOTEO; DEBIEN, 2019). Ideally, this 5-stage cycle come after *training* and should provide information to keep the entire training process “alive” (FIGURE 4). This is a broad approach to understand how the training process should occur and its quality and accuracy depends on several aspects, as already illustrated by the Figure 5. However, this cycle is capable of contributing to better decision-making and evidence-based practice, considering athletes’ individuality and aligning the practices of stakeholders involved in the process.

Figure 8 – Stages of training load management.



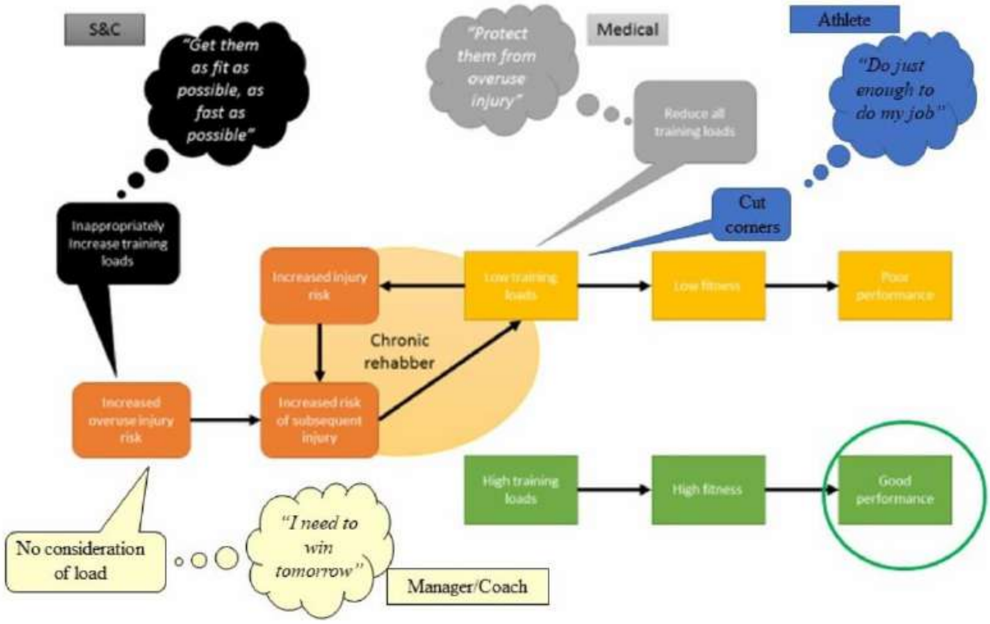
Source: Adapted from Timoteo & Debien (2019).

In summary, *monitoring* consists of the simple act of following or measuring a specific variable. *Recording* concerns storing the collected data, which could be through digital systems or simply using pen and paper. Then, this data should be appropriately *analysed* using complex statistical tools, artificial intelligence, or basic spreadsheets (ROBERTSON; BARTLETT; GASTIN, 2017). After the analysis it is necessary to interpret the results based on the broad context and professional experience, aiming to translate this into relevant information. This information is *communicated* among the interested stakeholders, and, finally, a *decision* is made, to either increase, decrease, or maintain training load, for instance.

2.2.8 Stakeholders involved in training load management

In addition to choosing appropriate variables and following the above-mentioned steps, the integration among stakeholders involved in training load management is also determinant to success (GABBETT; WHITELEY, 2017). Depending on the sports organization, the number and roles of stakeholders could be very different (BUCHHEIT; CAROLAN, 2019). It is expected that athletes, coaches, staff, and managers share the same goals: enhance performance and minimize negative outcomes. However, these goals might be quite difficult to be achieved if their practices and perceptions regarding training load management are divergent and lacking collaboration (GABBETT; WHITELEY, 2017). In this respect, Gabbett & Whiteley (2017) developed a schematic representation of how distinct understandings of the links between training loads, injury risk, and performance can lead to undesired outcomes such as poor performance and increased injury risk (FIGURE 9). In an attempt to explore these aspects in the practical environment, some studies have investigated what professionals (e.g., coaches, medical staff, practitioners) and athletes do and think in relation to training load management in the field (AKENHEAD; NASSIS, 2016; FULLAGAR et al., 2019; ROOS et al., 2013; SAW et al., 2015; STARLING; LAMBERT, 2018; TAYLOR et al., 2012; WESTON, 2018). Nevertheless, no studies have conducted this type of investigation in aesthetic sports.

Figure 9 – Divergent understanding among key stakeholders regarding the link between training load, injury risk, and performance.



Source: Adapted from Gabbett & Whiteley (2017).

Professional sports with large budgets could have a robust and specialized coaching and support staff performing very specific roles. Other sports may not have the same resources and structure, so coaches must perform several tasks. In general, coaches are focused on winning games and achieving desired results in competitions without giving great consideration to training load management. This is not a rule and depends on staff composition as well. Regarding the importance of coaches in the process, evidence has pointed *how* they could influence training load management. Practitioners involved in high-level soccer leagues in Europe and Australia responded to a survey about their practices and perceptions concerning training load monitoring (AKENHEAD; NASSIS, 2016). The results showed that low coach buy-in was a limiting factor to manage training load appropriately. A similar investigation in English soccer teams compared the practices and perceptions of coaches and practitioners (WESTON, 2018). Despite some level of agreement, there were difference in perceptions for who decides to monitor training load, who is responsible for the analysis and interpretation of training load data, and who the training load information is produced for. Other studies from rugby union have also found that coaches and support staff think that an adequate monitoring protocol should satisfy both scientific principles and the coach's demands (STARLING; LAMBERT, 2018). In a similar perspective, Ross et al. (2013) found that endurance sports coaches want a training load management system that reduces the total amount of information to the most relevant facts and able to learn from previous events. Collectively, these findings highlight the importance of a good integration among coaches and staff in order to provide appropriate training load management and achieve the desired goals.

Medical staff is a broad expression used to describe professionals as doctors and physical therapists, for instance. This group has a background completely different from coaches and their main concern is to avoid injuries/illness and rehabilitate injured athletes. Therefore, they are also an important part of the training load management "puzzle" (BYTOMSKI et al., 2019; GABBETT, 2020a). In this respect, Ekstrand et al. (2019) searched medical staff interpretations and descriptions of internal communication quality in elite soccer teams to determine whether communication was associated with injuries and/or player availability at training and matches. They have found that teams with high internal communication quality among medical staff and coaches had lower injury rates and higher player availability than teams with low communication quality (EKSTRAND et al., 2019). Several other authors have highlighted the relevance of efficient communication among these key characters (FULLAGAR et al., 2019; GABBETT et al., 2016b; SAW; MAIN; GASTIN, 2015).

Ideally, this entire training process should be centred on the athletes. As a determinant part of this puzzle, it is essential that they perceive how training load management could help them to achieve the goals. If their buy-in, adherence, attitudes, and beliefs are not aligned with the bigger purposes it could reflect in negative outcomes. A recent study interviewed elite sprinters to understand their perceptions regarding training monitoring systems and their primary reasons for non-completion (NEUPERT; COTTERILL; JOBSON, 2019). The results showed that perceptions of confusion and unfair decision-making on training programme modifications and insufficient feedback were the primary causes for poor athlete adherence to training load management. This finding highlights the importance of cooperative behaviours and aligned understandings by all stakeholders, including the athletes.

Despite the increasing research attempting to comprehend these nuances related to key stakeholders, to our knowledge, only two studies have simultaneously analysed perceptions of coaches, medical staff, and athletes about training load management (BARBOZA et al., 2017; SAW et al., 2015). However, they were focused on very specific tools, such as athlete self-reported measures (SAW et al., 2015) and online sports-health surveillance system (BARBOZA et al., 2017), which may not provide a broad overview of the whole process. Moreover, none has explored perceptions of coaches, medical staff, and gymnasts regarding training load management in rhythmic gymnastics. We believe that this kind of investigation can be very useful to develop context-specific systems to manage training load manage and contribute to evidence-based practices.

2.3 TRAINING LOAD MANAGEMENT IN RHYTHMIC GYMNASTICS

As the main focus of this thesis, the present topic aims to review specific literature regarding training load management in rhythmic gymnastics underpinned by the conceptual frameworks already presented in subchapters 2.1 and 2.2.

2.3.1 Training load in rhythmic gymnastics

Few studies have investigated training load in rhythmic gymnasts (ANTUALPA; AOKI; MOREIRA, 2017, 2018; DEBIEN et al., 2019, 2020a; FERNANDEZ-VILLARINO et al., 2015). Fernandez-Villarino et al. (2015) monitored seven Spanish elite individual gymnasts during 10 training sessions across a competitive period. In this study, mean rating of perceive exertion (RPE) (Borg's 10-point version) scores varied around 7 to 9 and no correlation was found between average heart rate measures and RPE (FERNANDEZ-VILLARINO et al., 2015).

Using the session-RPE method, an elite group was monitored daily across one entire 43-week pre-Olympic season (DEBIEN et al., 2020a). The results presented high weekly training loads, reaching a maximum weekly value of 21,012 ± 2,122 AU and mean 10,381 ± 4,894 AU. The mean weekly session-RPE score was 5.0 ± 1.6 and the highest was 8.1 ± 0.4. The mean ACWR across the season was 1.09 ± 0.52, reaching 2.69 ± 0.25 in the 34th week. Moreover, 80% of high weekly training loads (≥75% maximum), 74% of high-intensity training (session-RPE ≥ 7), and 67% of spikes in load (ACWR≥1.5) occurred in competitive periods (DEBIEN et al., 2020a). Additionally, Debien et al. (2019) compared the weekly profile of training load between preparatory and competitive periods, and the competition weeks. The competitive period as a whole showed higher mean daily training load and strain, and lower monotony than the others. However, during the competition weeks gymnasts presented highest monotony scores, despite lower daily training loads (DEBIEN et al., 2019).

Another two studies explored the effects of training intensification followed by tapering in different variables in young amateur gymnasts (ANTUALPA; AOKI; MOREIRA, 2017, 2018). In regards to the training load, the authors stated that the ACWR based on the session-RPE method could be a useful metric to safely progress training loads when adopting this strategy in this population (ANTUALPA; AOKI; MOREIRA, 2018). Moreover, they also suggest that a period of training load intensification followed by tapering, could be a useful approach to improve physical performance of youth rhythmic gymnasts, while maintaining the perception of wellbeing.

Among these studies, all have used RPE-based methods and none have precisely quantified external training load. Despite the validity and reliability of the session-RPE method, it is possible that other more specific and/or objective tools provide additional training load information and avoid possible over-estimations, especially due to the long duration and number of coaches' interventions during training sessions. As previously mentioned in this review, the application of microtechnologies such as GPS and inertial measurement units is yet to be investigated in rhythmic gymnastics and could provide novel useful information for the practical setting.

2.3.2 Recovery in rhythmic gymnastics

The evidence related to the recovery-fatigue continuum in rhythmic gymnastics is scarce. The 5-point wellbeing scale used by McLean et al. (2010) was also used in one study regarding taper following training intensification in youth gymnasts (ANTUALPA; AOKI; MOREIRA, 2017). Despite training load and performance modifications, the wellbeing of young gymnasts did not change across the study period. The authors also measured testosterone and cortisol, and no significant changes were observed during the study. In an additional analysis, they found increased immunoglobulin A after the 4-week intensification period (ANTUALPA; AOKI; MOREIRA, 2018).

Two other investigations have monitored the recovery state of elite gymnasts using the TQR scale on a daily basis (DEBIEN et al., 2019, 2020a). During competition weeks, the gymnasts presented lower recovery compared to training weeks, especially in the competition days (DEBIEN et al., 2019). When analysing individual weekly recovery scores, it was found that the gymnasts were poorly recovered across 50.9% of the season (DEBIEN et al., 2020a). Both studies showed moderate negative correlations between training load and recovery, and concluded that daily and weekly training load should be better distributed in attempt do provide adequate recovery to elite rhythmic gymnasts involved in international competitions (DEBIEN et al., 2019, 2020a).

2.3.3 Performance in rhythmic gymnastics

As an aesthetic sport, rhythmic gymnastics performance is measured by judges' evaluation and translated into a final score. The official competitions have at least ten judges evaluating different components of the routine to give a score (FIG, 2018). However, it is arduous to use this approach in day-to-day practice. As a consequence, despite scarce evidence in this regard, the coach's perception might be commonly used to assess the gymnasts' performance. It is important to establish additional strategies that could enhance performance assessment and monitoring in order to appropriately manage training load in rhythmic gymnastics.

In general, performance goals in rhythmic gymnastics are related to making fewer technical mistakes during routine repetitions. In this respect, one study conducted in national level young gymnasts analysed how physical performance was related to execution scores (i.e., technical performance) in routine presentations (DONTI et al., 2016). A multiple regression analysis revealed that sideways leg extension, body fat, and push ups accounted for 62.9% of the variance in the technical execution score for the gymnasts that did not qualify for the finals, while for the ones who did, only 37.3% of the variance in the technical execution score was accounted for by sideways leg extension and spine flexibility.

Despite some studies reporting the use of jump tests, flexibility tests and aerobic capacity tests, or even specific drills tests to measure performance in rhythmic gymnastics (ANTUALPA; AOKI; MOREIRA, 2017; FERNÁNDEZ-VILLARINO et al., 2018; GATEVA, 2015), future investigations are needed to explore other methods capable of providing accurate, specific, and applied performance measures in rhythmic gymnastics. Most of these studies neglected, for instance, the apparatus skills in the performance analysis and this could be a determinant component to understand specific performance outcomes in this sport.

Another proposal focused on technical performance is detailed by Laffranchi (2005). In brief, the author presented a model whereby technical training load is planned in accordance with the number of repetitions (isolated movements, parts of the routine, and entire routine) performed by the gymnasts across the season (LAFFRANCHI, 2005). Despite the model highlighting the relevance of an increased number of correct repetitions (i.e., hits) in competitive periods, gymnasts must be able to perform *better*, not necessarily perform *more*. The capacity to complete countless repetitions during training sessions is not a determinant of successful competition since gymnasts have only one chance to present the routine without mistakes. If the gymnast or group need to perform the element several times to achieve success, the possibility of making a mistake during competition could be higher. Thus, a better approach to measure specific performance in rhythmic gymnastics could be an “efficiency index” based on movement repetition counts.

2.3.4 Injuries in rhythmic gymnastics

In team sports, sometimes it is possible to substitute an athlete that has sustained an injury during training or even during matches. However, in rhythmic gymnastics, an injury could represent worse scenarios as substitutions are not possible during competitions. Even during training, changing one gymnast in a group exercise is quite difficult as each gymnast has a specific role in the routine. This situation could also lead to unexpected modification in training load since the group are required to adjust the entire routine performance within the new squad formation.

Although some methodological limitations, few studies have investigated injuries in rhythmic gymnastics (CODONHATO et al., 2018; CUPISTI et al., 2007; EDOUARD et al., 2018; GRAM; CLARSEN; BØ, 2020; KOLAR et al., 2017; PAXINOS et al., 2019; ZETARUK et al., 2006). It is worth mentioning that these studies presented different designs, injury definitions, and data analysis, which requires caution when comparing the findings. In this regard, two recent systematic reviews have collectively analysed different gymnastics disciplines, which may not present clear injury information, as each discipline has unique sport-specific requirements (CAMPBELL et al., 2019; THOMAS; THOMAS, 2019). Therefore, only the results related to rhythmic gymnasts were used in the current literature review.

Injury *incidence* in longitudinal investigations is commonly reported as number of injuries per 1000 hours of training or competition exposure (HOPKINS et al., 2007). In a study of 70 sub-elite Italian rhythmic gymnasts, aged 13 to 19 years, the reported injury incidence was 1.08 injuries/1000h of training (CUPISTI et al., 2007). In this study, 44.3% of the gymnasts remained free from injuries. However, in two separate studies involving higher level gymnasts from two different national teams (sample sizes: 20 and 8), all gymnasts sustained at least one injury during the 1-year investigation (CODONHATO et al., 2018; ZETARUK et al., 2006). During a 15-week preseason of 107 competitive Norwegian gymnasts, an incidence of 4.2 new overuse injuries and 1.0 new acute injuries per gymnast per year was reported (GRAM; CLARSEN; BØ, 2020). Edouard et al. (2018) investigated injury incidence in gymnastics disciplines during the last three summer Olympic Games (2008, 2012, and 2016). Considering only the rhythmic gymnasts, they found an incidence of 73.4 injuries/1000 gymnasts. In total, 21 injuries were reported, with 76.2% occurring during training and 14.3% during competition. It could be hypothesized that sample sizes, injury definition, gymnasts' level, as well as the study duration may have influenced these results. More epidemiological studies are needed in order to better understand injury incidence in elite rhythmic gymnastics.

Regarding the *site* of injury, Edouard et al. (2018) found the following percentages: 23.8% ankle, 19% foot, 19% hip/groin, and 19% trunk. Similarly, Cuspiti et al. (2007) showed that the most common locations were ankle and foot (37%).

Another study also showed high injury incidence to the lower extremities (44%) and trunk/back (41.2%) (ZETARUK et al., 2006). Based on a 10-year report of Greek national team members, Paxinos et al. (2019) found higher injury incidence for the hip (26.5%) and lumbar spine (20%). One last study analysed injury location, severity, and incidence (i.e., injury burden) and observed that the knee, low back, and hip/groin had the highest injury burdens among competitive rhythmic gymnasts (GRAM; CLARSEN; BØ, 2020). Despite the similarities, these studies have adopted different classifications for injury location which may have influenced the results. Future studies should rely on current literature recommendations when developing their injury definitions (BAHR et al., 2020).

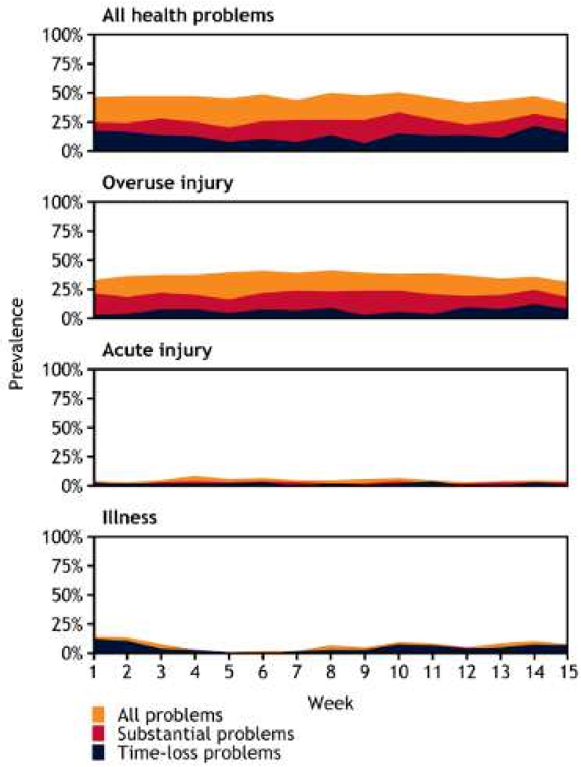
With respect to injury *severity*, not all studies have used time-loss as a criteria to classify the injuries. For instance, Codonhato et al. (2018) described that six gymnasts (75%) presented time-loss injuries and, on average, each gymnast lost 85 days of training and/or competitions due to injuries. In addition, they highlighted that three gymnasts (37.5%) were cut from the final Olympic team due to severe injuries. Zetaruk et al. (2006) reported injuries to 20 gymnasts within a national team across one year and found that 65% of gymnasts suffered from time-loss injuries. In the Olympics investigation, four (19%) injuries were classified as time-loss injury (EDOUARD et al., 2018). A more recent investigation that used the recommendation from the International Olympic Committee consensus (BAHR et al., 2020) reported only one severe injury (>28 days of time-loss) across 15 weeks of preseason in rhythmic gymnastics (GRAM; CLARSEN; BØ, 2020).

Regarding injury *type*, Edouard et al. (2018) reported 28.6% sprain, ligamentous rupture, dislocation; 23.8% tendinopathy, impingement, arthritis fasciitis; 9.5% stress fractures; and 9.5% strain/muscle cramps. Although some methodological differences existed, Cupisti et al. (2007) found 24.5% strain, 16.3% sprain and dislocation, and 16.3% contusions. On the other hand, Paxinos et al. (2019) reported a higher incidence of tendinopathies (42.6%). Most studies usually present injury mode of onset (i.e., acute or overuse) instead of pathology type.

In general, the literature shows that *overuse* injuries (i.e., gradual onset) are more frequent in rhythmic gymnastics (CAVALLERIO; WADEY; WAGSTAFF, 2016; EDOUARD et al., 2018; GRAM; CLARSEN; BØ, 2020; PAXINOS et al., 2019) (FIGURE 10). Among Olympic gymnasts, 42.8% of injuries were classified as overuse

(23.8% gradual and 19% sudden onset) and 28.6% recurrence (EDOUARD et al., 2018). A 10-year retrospective study of injury in Greek national team gymnasts showed that overuse injuries accounted for 94% of all injuries (PAXINOS et al., 2019). Similarly, the weekly mean overuse injury prevalence during preseason was 37% and mean acute injury prevalence was 5% (GRAM; CLARSEN; BØ, 2020). A deep qualitative investigation also showed that the culture and coach-athlete relationship may influence the occurrence of overuse injuries in rhythmic gymnastics (CAVALLERIO; WADEY; WAGSTAFF, 2016).

Figure 10 – Prevalence of all health problems, overuse injuries, acute injuries and illness in rhythmic gymnasts.



Source: Gram, Clarsen & Bø (2020).

The study conducted by the Norwegian group of researchers represents the best-quality evidence so far in respect to injuries among rhythmic gymnasts (GRAM; CLARSEN; BØ, 2020). In addition to the topics presented above, this investigation also analysed *risk factors*. Considering all types of injuries, *previous injuries* (OR=30.38; 95% CI=5.04 to 183.25) and *age* appeared as risk factors for new injuries (OR=0.61;

95% CI=0.39 to 0.97). When considering only substantial injuries (led to moderate or severe reductions in sports performance or participation), the main risk factors were *previous injuries* (OR=11.09; 95% CI=2.26 to 54.37) and *menarche* (OR=0.2; 95% CI=0.06 to 0.71).

Despite the studies design, collectively, they indicate that higher level gymnasts seem to have higher overuse injury incidence, even during main competitive events. Training programs should include strategies to avoid these injuries, mainly to the lower extremities (ankle, foot, and hip/groin) and lower back. Moreover, to our knowledge, no studies have investigated the association between injuries and training load or recovery variables in rhythmic gymnastics, which may provide valuable insights for better training organization in this sport.

2.4 SUMMARY AND DIRECTIONS OF THE THESIS

Rhythmic gymnastics is a complex sport with scarce specific scientific evidence related to training load management, and some indices of undesired outcomes as a consequence of training. It is known that appropriate training load management may contribute to better performance and less maladaptation. In brief, managing training load includes choosing adequate variables and methods; following the steps of properly monitoring, recording, analysing, communicating and, possibly adjusting training; and depends on an integrated and collaborative approach from all key stakeholders. However, it should be underpinned by the details of the training process, including the sport characteristics and specific demands. In this respect, no studies have deeply investigated training load is managed in aesthetic sports as rhythmic gymnastics. Therefore, this thesis will aim to advance knowledge on training load management in rhythmic gymnastics by conducting a case study in elite gymnasts and surveying coaches, medical professionals and gymnasts about their practices and perceptions in this regard.

3 STUDY 1 - TRAINING LOAD, RECOVERY AND INJURIES IN ELITE RHYTHMIC GYMNASTS DURING MAIN COMPETITIVE PERIODS: A CASE STUDY

This study has been accepted for publication following peer-review. Full reference details are:

DEBIEN, P. B. et al. Training load, recovery and injuries in elite rhythmic gymnasts during main competitive periods: a case study. **Science of Gymnastics Journal**, v. 12, n. 3, p. 277–285, 2020.

3.1 ABSTRACT

Competitive periods are critical periods where elite rhythmic gymnasts experience higher training loads and insufficient recovery. The aim of this short report is to describe individual training load, recovery and injuries in elite group rhythmic gymnasts during competitive periods. Six gymnasts from the Brazilian senior rhythmic gymnastics group were monitored daily over a 126-day period comprising regular training and four competitions. Training load was measured using the session rating of perceived exertion (session-RPE). Daily load, chronic load, and acute:chronic workload ratio (ACWR) were assessed. The Total Quality Recovery (TQR) scale was used to monitor recovery and a 3-day rolling average (3RA) TQR was also measured. Injuries were diagnosed and reported by the medical staff and their reports were used in the analysis. Descriptive statistics were used. The gymnasts presented distinct daily load, ACWR, and recovery patterns, as well as injuries across the competitive periods. All athletes had rapid increase ("spike") in load. Three athletes were underrecovered more than 60% of the time. Four athletes sustained five injuries during the time of the study (all lower limb overuse injuries, two severe, two mild and one slight). Individual factors such as age and chronic load could moderate how each gymnast responds to training and tolerates spikes in load. Moreover, injuries sustained during competitive periods appear to affect the short and long-term careers of gymnasts, as well as impair training and competition organization of the team.

Keywords: gymnastics, injury, ACWR, competition.

3.2 INTRODUCTION

Rhythmic gymnastics is an aesthetic sport that demands high technical compliance, and well-developed physical and artistic capacities (DEBIEN et al., 2020a; DOUDA et al., 2008). Group exercises are performed by five gymnasts at the same time mainly characterized by harmonic collective work (ÁVILA-CARVALHO; KLENTROU; LEBRE, 2012). The group competition format requires peak performance during one to four days. Each group presents two different routines in qualification phase and the first eight ranked groups perform these routines again at the finals. Elite groups involved in international competitions may have five or six events in one season including two or three main competitions (e.g., World Championship, Continental Games/Championship, Olympic Games).

Competitive periods in rhythmic gymnastics are associated with higher training loads, rapid increase (“spikes”) in load (DEBIEN et al., 2020a), and insufficient recovery (DEBIEN et al., 2019). Spikes in load and an imbalance between load and recovery might expose the gymnasts to maladaptation and higher injury risk (SOLIGARD et al., 2016). Moreover, injury sustained in competitive periods prevent athletes from training and performing, thereby impairing their chance of success (DREW; RAYSMITH; CHARLTON, 2017). In a rhythmic gymnastics group, any changes in the starter squad due to injuries during the competitive period may affect the training load of the entire team by causing routine adjustments and more repetitions as each gymnast performs very specific roles in the routines.

In order to achieve peak performance and minimize injury risk, it is essential to manage training load and individual responses to that load. An interesting way to better understand training information from elite level athletes is through case studies. This format is a powerful tool to bridge the gap between science and practice (HALPERIN, 2018; RUDDOCK et al., 2019). However, to date no study has analysed individual training load, recovery and injuries among elite level rhythmic gymnasts. Therefore, the aim of this short report is to describe individual training load, recovery and injuries in elite group rhythmic gymnasts during competitive periods.

3.3 METHODS

3.3.1 Subjects

Six gymnasts from the Brazilian senior rhythmic gymnastics group participated in the current study (TABLE 2). This group comprised the best-selected gymnasts across the country, which represented Brazil in senior international competitions, including the Pan-American Games and World Championship. The study was approved by the University's Ethics Committee (ATTACHMENT A).

Table 2 – Gymnasts' characteristics at the beginning of the season.

	Age (yrs)	Experience in RG (yrs)	Height (m)	Weight (kg)
Athlete 1	26	17	1.64	53
Athlete 2	18	13	1.70	61
Athlete 3	22	12	1.60	50
Athlete 4	20	13	1.67	52
Athlete 5	20	17	1.67	54
Athlete 6	20	17	1.58	48

Yrs: years; RG: rhythmic gymnastics.
Source: elaborated by the author (2020).

3.3.2 Data collection and analysis

Data were collected across 126 days comprising regular training and four competitions. Regular training sessions started with a light warm up, followed by ballet, strength and conditioning, and technical training. Training load was assessed daily using the session rating of perceived exertion (session-RPE) (ATTACHMENT D) method (FOSTER et al., 2001b). Daily load was obtained by the sum of loads of all training sessions during that day. Acute and chronic loads were calculated by exponentially weighted moving averages (EWMA) using 7 and 28 days for time decays, respectively (WILLIAMS et al., 2017a). The acute:chronic workload ratio (ACWR) (GABBETT, 2016) was also measured on a daily basis. This measure describes the size of the current training load (i.e., acute load) in relation to longer-term training load (i.e., chronic load) (GABBETT, 2020b). ACWR≥1.3 was considered a “spike” in load (MURRAY et al., 2017). The Total Quality Recovery (TQR) scale (ATTACHMENT F) (KENTTÄ; HASSMÉN, 1998) was used to monitor recovery before the first training session of each day. A 3-day rolling average (3RA) TQR was calculated. A score of ≥13 (reasonable recovery) indicates a minimally adequate recovery state (DEBIEN et al., 2020a; KENTTÄ; HASSMÉN, 1998). On days of no training, training load was considered zero and TQR was not collected. Injuries were diagnosed and recorded by the medical staff, which provided individual reports containing body region, injury type, time-loss, date of occurrence, and observations regarding the impact of injuries on competitions and dismissals. All musculoskeletal injuries that required medical attention (BAHR et al., 2020) during the study period were reported and included in our analysis. Injury severity was classified based on time-loss (number of days that the athlete was unavailable for training and competition) as following: slight (no absence), mild (1 to 7 days), moderate (8 to 28 days), and severe (>28 days) (BAHR et al., 2020). Descriptive statistics were used.

3.4 RESULTS

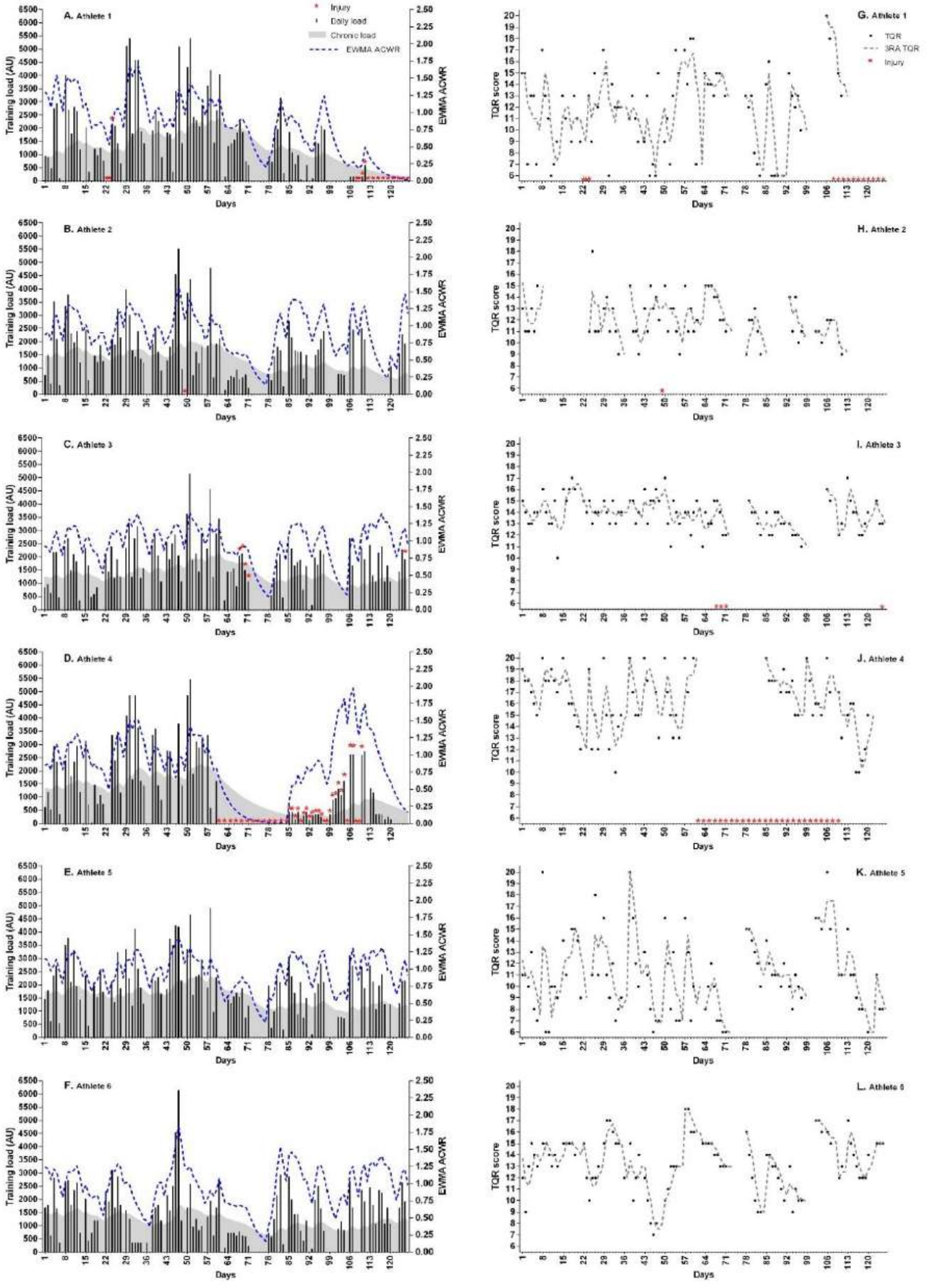
Individual training load, recovery, injuries details, and status in competitions are described in Table 3. Figure 11 shows daily load, chronic load, EWMA ACWR, recovery and injuries of each gymnast across 126 days comprising the competitive periods of the season. Figure 12 presents EWMA ACWR in relation to chronic load and 3RA TQR score for each gymnast. Four athletes had five injuries during the time of the study, all of which were lower limb overuse injuries.

Table 3 – Individual training load, recovery, injuries, and status during each competition of elite group rhythmic gymnasts across competitive periods.

	Training load and recovery				Injuries			Competitions				
	Daily load (AU)	Chronic load (AU)	EWMA ACWR (%)	3RA TQR (%)	Body region	Type	Severity	1	2*	3	4*	Olympic Games*
	Mean (SD) Max Min	Mean (SD) Max Min	≥1.3	<13				Days 20 and 21	Days 68 to 71	Days 96 and 97	Day 125	Following season
Athlete 1	1211 (1421) 5400 0	1296 (598) 2426 163	15%	64%	Hip Foot	Tendinopathy Bone stress fracture	Mild Severe	Starter	Starter	Starter	Injured	No
Athlete 2	1233 (1229) 5520 0	1312 (385) 2068 572	11%	65%	Hip	Bursitis	Mild	Starter	Starter	Starter	Starter	No
Athlete 3	1350 (1114) 5160 0	1366 (311) 2162 775	6%	18%	Foot	Tendinopathy	Slight	No	Starter	Starter	Starter	No
Athlete 4	1064 (1376) 5460 0	1166 (612) 2288 279	17%	6%	Lower leg	Bone stress injury	Severe	Starter	Injured	Injured	No	No
Athlete 5	1496 (1245) 4920 0	1559 (365) 2328 928	5%	74%	-	-	-	Reserve	Reserve	Reserve	Reserve	Starter
Athlete 6	1182 (1076) 6150 0	1208 (271) 1795 657	9%	37%	-	-	-	No	Reserve	Starter	Reserve	Starter

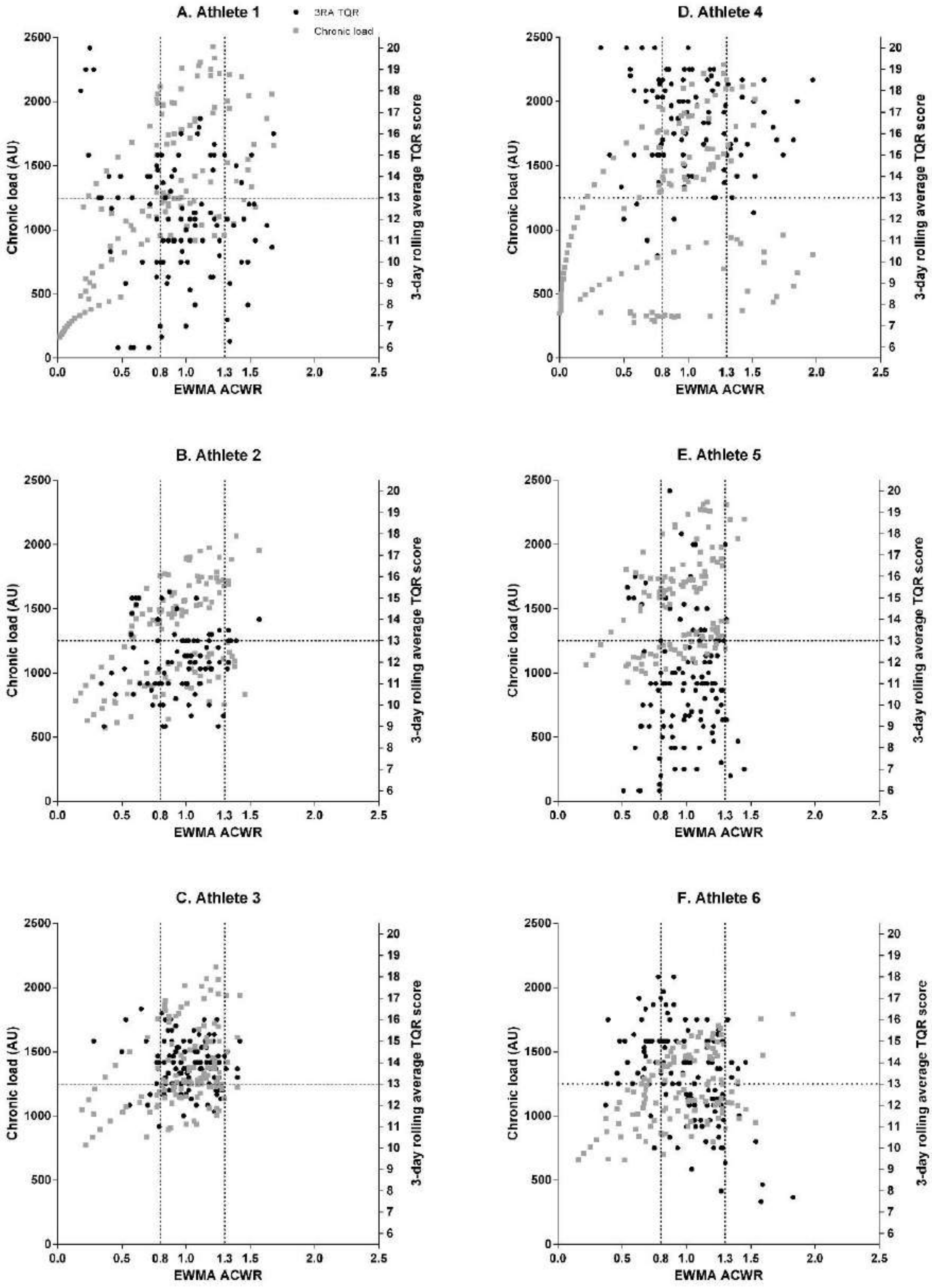
AU: arbitrary units; SD: standard deviation; EWMA: exponentially weighted moving averages; ACWR: acute:chronic workload ratio; 3RA TQR: 3-day rolling average Total Quality Recovery score; %: percentage of days in relation to the total measured; Starter: compete in both routines; Reserve: compete in one routine; No: not selected to compete: Injured: unavailable to compete due to injury.
Source: elaborated by the author (2020).

Figure 11 – Individual daily load, chronic load, acute:chronic workload ratio, recovery and injuries throughout competitive periods in elite group rhythmic gymnasts.



AU: arbitrary units; EWMA: exponentially weighted moving average; ACWR: acute:chronic workload ratio; TQR: Total Quality Recovery; 3RA: 3-day rolling average.
Source: elaborated by the author (2020).

Figure 12 – Individual daily acute:chronic workload ratio in relation to chronic load and recovery of elite group rhythmic gymnasts across competitive periods.



AU: arbitrary units; EWMA: exponentially weighted moving average; ACWR: acute:chronic workload ratio; TQR: Total Quality Recovery.
Source: elaborated by the author (2020).

3.5 DISCUSSION

The aim of this short report was to describe individual training load, recovery and injuries of elite group rhythmic gymnasts during competitive periods. Our results illustrate the importance of individual training load management in this sport in order to minimize the risks of undesired outcomes during competitive periods preceding an Olympic season.

Athletes 1 and 4 sustained severe overuse injuries that resulted in absence from training and competition for several weeks. Athlete 1 was the oldest (26 years) and the only athlete who sustained two different injuries. She presented a few spikes (ACWR≥1.3) in training load at the same time as underrecovery (3RA TQR<13) in the first half of competitive periods (FIGURE 11A and 11G). Athlete 4 also showed spikes in load before the first main competition, but mainly in conjunction with low chronic load and decreasing recovery during her return to training post-injury (FIGURE 11D). Despite being starters before their injuries, they were not able to regain this position in the group and were waived at the end of the season. Athletes 2 and 3 presented mild and slight overuse injuries, respectively, which did not affect their position in both main competitions. Athlete 2 lost one day of training (day 49) followed by spikes in load on days 46 to 48. Athlete 3 was injured during the two principal events, however it was a chronic injury that recurrently occurred. This injury required constant treatment despite her ability to maintain full training. In this regards, Figure 12C illustrates how athlete 3 was frequently in a “safe zone” concerning adequate chronic load, recovery, and ACWR. Athletes 5 and 6 had no injuries during the study period and, despite not initially being starters, went to the Olympic Games as starters the following year. It is worth noting that Athlete 5 was underrecovered 74% of the time and athlete 6 had a few spikes in load, possibly when she started to train as a reserve.

High chronic loads are associated with fewer injuries, however, these loads must be progressively increased relative to the athlete’s capacity to tolerate load (GABBETT, 2020b). Moreover, the training load-injury relationship is moderated by several factors such as age, previous injury, and lifestyle (GABBETT et al., 2019b). Previous investigations have found higher training loads, frequent spikes in load, and underrecovery during competitive periods in elite rhythmic gymnasts (DEBIEN et al., 2020a). All gymnasts in our study had at least one spike in load, yet each one may have tolerated this change in load differently based upon their age, chronic load, and recovery status. Some spikes occurred that did not result in injury, perhaps indicating that a combination of factors may need to occur for athletes to get injured (i.e., the "perfect storm"). Nevertheless, we highlight that the two athletes who sustained severe injuries also experienced more spikes in load. Both athletes presented spikes in load until competition 2, while athlete 4 also had spikes in load during her return to training, which might explain her inability to regain her position on the team (GABBETT, 2019). Despite the protective nature of high chronic loads, it is important to understand the chronic load of each athlete, the "ceiling" of safety, and the time available to safely reach the required loads for the sport (GABBETT, 2019). Our results reinforce how training load data should not be interpreted in isolation. The context and factors influencing load tolerance on an individual basis must always be taken into consideration in the decision-making process.

In order to achieve good technical performance, the main training content during competitive periods in rhythmic gymnasts are routine repetitions. Each group routine lasts 150 seconds and includes several jumps, rotations, balances, throws, and catches performed with high intensity effort (ÁVILA-CARVALHO; KLENTROU; LEBRE, 2012; DOUDA et al., 2008). Considering one heavy day with two sessions, four hours each (DEBIEN et al., 2020a), and a session-RPE score of 10 (maximal) for both sessions would result in a daily load of 4,800 AU. Nonetheless, all gymnasts reached more than this value at least once in our study. In addition, studies have shown that elite rhythmic gymnasts are regularly underrecovered during competitive periods (DEBIEN et al., 2019, 2020a). Recovery is essential to promote appropriate adaptation and achieve good performance (KENTTÄ; HASSMÉN, 1998; SOLIGARD et al., 2016) however it should be noted that in this study spikes in load, low (or excessively high) chronic load and drops in recovery were not necessarily temporally aligned, and the lag effect for each is likely to be different among athletes. Future studies should focus on understanding the positive and negative effects of such high load in rhythmic gymnastics.

Albeit the pioneer findings, our study presents some limitations. We highlight that is also important to measure and analyse external training load data. However, this is a complex measure in rhythmic gymnastics training and future investigations should focus on quantifying it through repetition counting and wearable technology, for instance. Moreover, studies are needed to establish an accurate threshold of EWMA ACWR in regards to injury risk in elite rhythmic gymnastics.

Spikes in load in conjunction with underrecovery and low chronic load in elite group rhythmic gymnastics may represent a large-cost and low-benefit decision for most athletes, especially during the main competitive periods of a pre-Olympic season. Moreover, considering all injuries were lower limb overuse injuries, rhythmic gymnasts may benefit from specific injury prevention programs designed to reduce the risk of these injuries.

In general, coaches want their best athletes fit, fresh, and prepared for the main competitions. However, not all gymnasts can tolerate training load as a starter during competitive periods. Considering that national senior groups practice on a full-time basis, having a larger group of 10 to 12 gymnasts training together would allow the distribution of training load amongst starters and reserves, thereby reducing exposure to spikes in load close to important events.

3.6 CONCLUSION

Elite group rhythmic gymnasts present different injuries, load, and recovery patterns across competitive periods. Factors such as age and chronic load could moderate how each gymnast responds to training and tolerates spikes in load. Moreover, injuries sustained during competitive periods appear to affect the short and long-term careers of gymnasts, and impair training and competition organization of the team.

3.7 ACKOWLEDGMENT

We thank the Brazilian Gymnastics Confederation, technical staff, and gymnasts for their contributions. This study was financed in part by the *Coordenação de Aperfeiçoamento de Pessoal de Nível Superior* - Brazil (CAPES) - Finance Code 001 and by the *Fundação de Amparo a Pesquisa do Estado de Minas Gerais* (FAPEMIG).

4 STUDY 2 – TRAINING LOAD MANAGEMENT IN RHYTHMIC GYMNASTICS: PRACTICES AND PERCEPTIONS OF COACHES, MEDICAL STAFF, AND GYMNASTS

This study has been prepared to be submitted for peer-review in the Journal of Sports Sciences.

4.1 ABSTRACT

This study aimed to describe and analyse practices and perceptions of rhythmic gymnastics coaches, medical staff, and athletes on training load management. Online surveys were distributed among professionals and gymnasts currently involved in rhythmic gymnastics training across the world. One hundred (N=50 coaches, N=12 medical staff, N=38 gymnasts) participants from 25 different countries completed the surveys. Coaches' perception was frequently used as a method of monitoring load, recovery/fatigue, and performance. Variables, methods, and metrics commonly reported in the training load literature and other sports were not very frequently used in rhythmic gymnastics. The majority of coaches (60.3 ± 17%) perceived that maladaptation rarely or never occurred. Medical staff involvement in sharing and discussing training load information was limited and they perceived that the measurement of athletes' recovery/fatigue was not very good. Gymnasts noted good quality related to the measurement of performance and receiving feedback. Most participants (>85%) believed that a specific training load management model for rhythmic gymnastics could be very or extremely effective. In conclusion, training load management in rhythmic gymnastics needs to move from a coach-centred process focused on technical components to a multidisciplinary approach centred on the gymnasts in order to minimize negative outcomes.

Keywords: rhythmic gymnastics, monitoring, gymnasts, recovery, load management.

4.2 INTRODUCTION

Training is a systematic and complex process that aims to improve athletic performance through positive adaptations (VIRU; VIRU, 2000). Accordingly, understanding the dose-response relationship is key to achieving success in this process (BORRESEN; LAMBERT, 2009). In the last decades, researchers have found associations between training load and performance (FOSTER; RODRIGUEZ-MARROYO; KONING, 2017), as well as training load and injury (GABBETT, 2016, 2020b; WINDT; GABBETT, 2017). Given these relationships, training load monitoring has become essential in sports as a strategy capable of maximizing positive effects (e.g., fitness, readiness, performance) and potentially minimizing negative outcomes of training (e.g., fatigue, injuries, illness) (BOURDON et al., 2017; GABBETT et al., 2017; HALSON, 2014).

Training load is defined as the stimulus applied to the organism (SOLIGARD et al., 2016), which can be described and measured as external or internal. External load is the physical work prescribed and completed by the athlete, while internal load is the psychophysiological response to that load (IMPELLIZZERI; MARCORA; COUTTS, 2019). However, monitoring training load *alone* is not enough to understand how athletes are responding, coping, and adapting to training. As an open and complex system, the training process is also influenced by external stressors and athletes' lifestyle and health (IMPELLIZZERI et al., 2020a). In this perspective, there is no single variable capable of giving all the answers to practitioners or researchers, highlighting the importance of implementing holistic approaches in training load management (GABBETT, 2020a; VERHAGEN; GABBETT, 2019; WEAVING et al., 2017).

Variables related to the dose-response process and commonly reported in the literature include external and internal load, recovery, fatigue, wellbeing, and performance, which can be measured using several methods depending on the goals, sport, and context (BORRESEN; LAMBERT, 2009; BOURDON et al., 2017; HALSON, 2014). It is also fundamental to emphasize that the "athlete monitoring cycle" is more than solely measuring training variables (GABBETT et al., 2017). Ideally, in addition to monitoring (i.e., measuring), it is also necessary to record, analyse, communicate, and possibly adjust the training process based on the collected information. Moreover, for this process to work, athletes and professionals in the team (e.g., coaches, medical staff, strength and conditioning staff, sport scientists, managers) must be aligned with the same goals (GABBETT; WHITELEY, 2017) and communicate well (EKSTRAND et al., 2019).

Although there has been considerable scientific and technological advancements in training load monitoring, there is still a gap between research and practice (BUCHHEIT, 2017; FULLAGAR et al., 2019), and information on how evidence is applied in the field is scarce (MCGUIGAN et al., 2020). In this respect, some studies have tried to identify and describe training monitoring practices and perceptions of professionals and/or athletes in various sports (AKENHEAD; NASSIS, 2016; MCGUIGAN et al., 2020; ROOS et al., 2013; SAW et al., 2015; STARLING; LAMBERT, 2018; TAYLOR et al., 2012; WESTON, 2018). However, to our knowledge, few have simultaneously analysed perceptions of coaches, medical staff, and athletes (SAW et al., 2015). Furthermore, no study has explored how training load is managed in practical settings of a female, aesthetic, and Olympic sport such as rhythmic gymnastics.

Training load in rhythmic gymnastics is extremely high and tends to increase rapidly during competitive periods (DEBIEN et al., 2020a, 2020b). In addition, studies in rhythmic gymnasts have shown insufficient recovery across the season (DEBIEN et al., 2020a) and during competitions (DEBIEN et al., 2019), as well as high incidence of overuse injuries (EDOUARD et al., 2018; GRAM; CLARSEN; BØ, 2020), low energy availability (SILVA; PAIVA, 2015), eating disorders symptoms (KOULOUTBANI; EFSTATHIOU; APOSTOLOS, 2012), poor sleep quality (SILVA; PAIVA, 2016), along with a rigid culture (CAVALLERIO; WADEY; WAGSTAFF, 2016) and incidences of coaching abuse. Taken together, this evidence points to a need for a deeper understanding of training practices implemented in the rhythmic gymnastics training environment. Comprehending what has been done in the field and how coaches and staff apply valid and common methods is the first step of improving current practices and bridging the gap between research and practice (MCGUIGAN et al., 2020). Based on this information, researchers and practitioners could collaborate (COUTTS, 2016; GABBETT, 2020a) on a specific training load management system, in order to attain better outcomes and less maladaptation in rhythmic gymnastics. Therefore, the aim of the current study is to describe and analyse practices and perceptions of coaches, medical staff and gymnasts regarding training load management in rhythmic gymnastics.

4.3 METHODS

4.3.1 Participants

Online surveys were distributed to coaches, medical staff and senior gymnasts (aged 16 years or older) currently involved in rhythmic gymnastics training around the world. Only participants who completed the survey were included (37% completion rate). The sample (N=100) came from 25 countries, including all five continents. All participants were informed of the risks and benefits involved in the study before providing informed consent expressing their voluntary participation. Written informed parental consent was obtained from gymnasts under 18 years old as a compulsory item in the first part of the survey (HARRIS; PORCELLATO, 2018). This study was approved by the Ethics Committee in Research with Humans at the Federal University of Juiz de Fora (CAAE 28609620.8.0000.5147) (ATTACHMENT B).

4.3.2 Instrument

Three surveys were specifically designed for each group of participants – 1) coaches, 2) medical staff, and 3) gymnasts – in two languages (Portuguese and English) for the purpose of the present study. They were initially drafted by the author, based on recommendations in the literature (DILLMAN; SMYTH; CHRISTIAN, 2014), previous similar studies (AKENHEAD; NASSIS, 2016; STARLING; LAMBERT, 2018; TAYLOR et al., 2012), and the specificities of the investigated sport. Secondly, the surveys were reviewed for content validity, clarity, format and grammar by several experts, including university professors with doctoral qualifications in sport-related fields, sports scientists, gymnastics coaches, and physiotherapists. A final revision was conducted by the author. Following the review process, all three surveys had a similar structure comprised of two sections: general information and training load management. The coaches' survey included 29 items, medical staff 25, and gymnasts

19 items. They were mostly closed-ended (e.g., yes/no and Likert scale) questions and took between 15 and 20 minutes to complete. Section one contained open and closed-ended questions designed to elicit demographic information including nationality, current location, age, education, experience, participation in national and international events, and staff composition. Section two comprised closed-ended questions regarding variables, methods, frequency, stages, quality, importance, and effectiveness of training load management in rhythmic gymnastics. A few questions had the option "other", where the respondent could specify his/her answer if the options did not apply. A copy of the final surveys are shown in the Appendix (B to G).

4.3.3 Procedure

The surveys were developed using an online survey platform (SurveyMonkey, Palo Alto, California, USA, www.surveymonkey.com) and the six links were placed on a website created specifically for this purpose (https://rhythmic-gymnastics-science.webnode.pt/). It was widely distributed through email and social media (Facebook, Instagram, LinkedIn, Twitter, and WhatsApp) over a five-month period. The email, posts on social media, website, as well as the first page of the survey contained an explanation of the study aim and procedures. Participants who started but not finished answering the survey were contacted through email and asked to complete the missing items, in an attempt to include their answers in the study. Moreover, participants were encouraged to circulate the surveys to their own personal networks and peers.

4.3.4 Data analysis

Descriptive frequency analysis was conducted for each question. Results were presented as absolute frequency counts or percentage of respondents. For appropriate questions, results were grouped and presented as a percentage of respondents in that specific group. Respondents were asked about the importance, quality, effectiveness, and frequency of training load management aspects using 5-point Likert scales (e.g., extremely, very, somewhat, slightly, and not at all). Answers were then grouped as three (e.g., extremely/very, somewhat, and slightly/not at all) in the analysis of each item.

4.4 RESULTS

4.4.1 General information

Overall, 50 coaches (age: 38.1 ± 10.8 y; experience in rhythmic gymnastics: 15.9 ± 9.9 y), 12 medical staff professionals (age: 32.0 ± 6.4 y; experience in rhythmic gymnastics: 4.8 ± 1.4 y), and 38 gymnasts (age: 18.5 ± 3.1 y; experience in rhythmic gymnastics: 10.1 ± 3.9 y) completed the online survey. They were involved in 78 different clubs/teams from 25 countries, including eight national rhythmic gymnastics teams. The group of *coaches* included national head coaches (n=1), coaches (n=44), assistant coaches (n=3), and strength and conditioning coaches (n=2), with 72% (n=36) being a rhythmic gymnast in the past. Of the 50 coaches, 90% (n=45) had a bachelor's degree in Sport Science (or equivalent). Regarding the three levels of the coaches education program from the International Gymnastics Federation (FIG), 16% (n=8) of coaches had the Level 1 brevet, 12% (n=6) Level 2, and 10% (n=5) Level 3. Moreover, each coach was responsible for coaching, on average, 14.4 ± 8.9 gymnasts, and 34% (n=17) coached at least one gymnast in all age groups from 9-16 years old. The *medical staff* group included one doctor and 11 physiotherapists; only one was a former gymnast. Considering all 100 respondents, 64% (n=64) had participated in international competitions in the current (2017-2020) and/or previous Olympic cycles, 31% (n=31) participated in FIG World Cups, 21% (n=21) in World Championships, and 8% (n=8) in the Olympic Games. Coaches and gymnasts answered the number of full and part-time professionals that comprised their coaching and medical staff. On average, the staff consisted of 8.1 ± 4.9 professionals. Table 4 presents the details regarding staff composition in rhythmic gymnastics based on the coaches and gymnasts responses. In addition to the options presented in the survey, three different coaches stated they had one of the following professionals in their staff: mental coach, massage therapist, or theatre teacher.

Table 4 – Staff composition in rhythmic gymnastics (N=88).

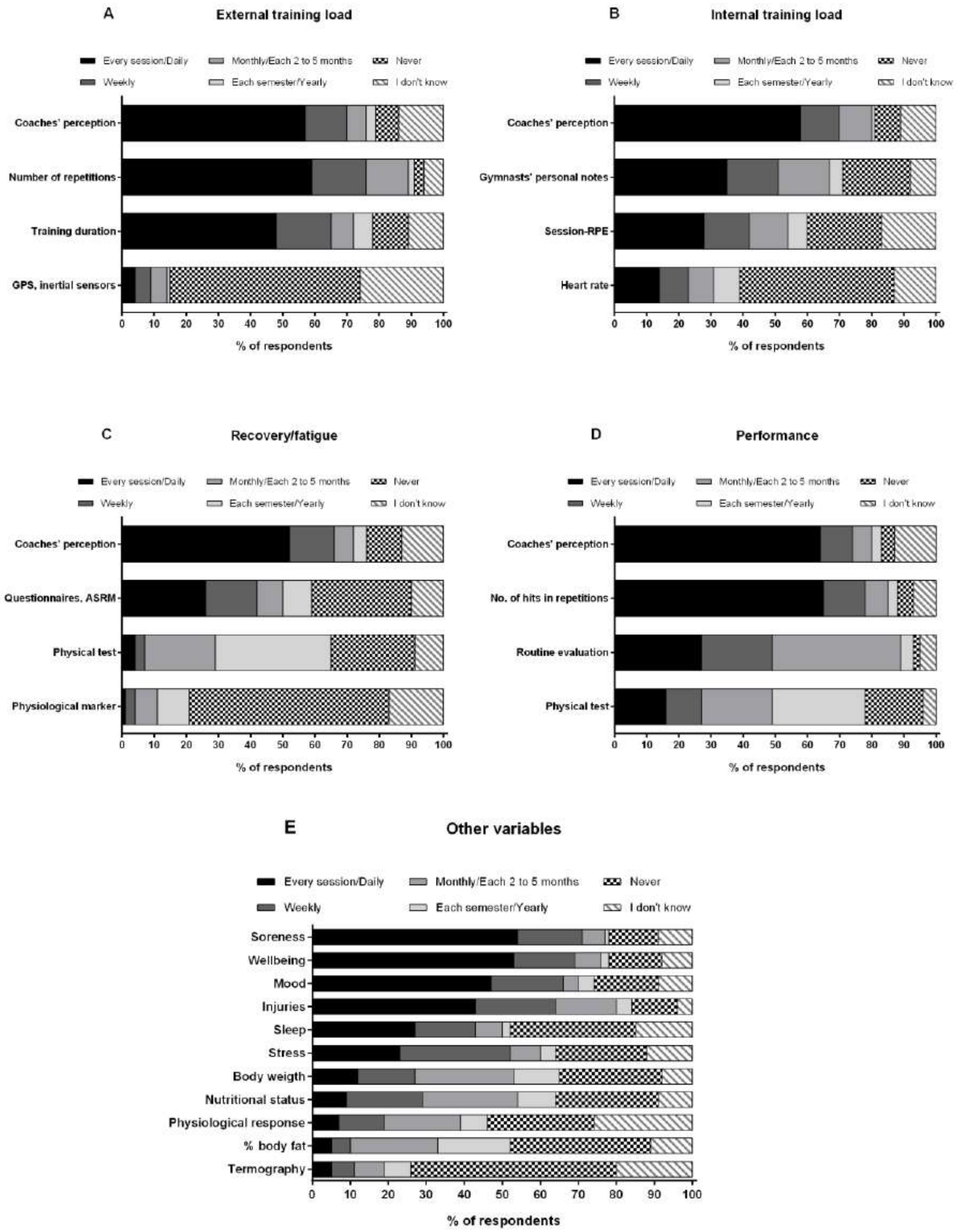
	Number of professionals				Full time	Part time	Total
	0 No. (%)	**1-2** No. (%)	**3-4** No. (%)	**5+** No. (%)	(Mean ± SD)	(Mean ± SD)	(Mean ± SD)
Coach	1 (1)	59 (67)	18 (20)	10 (11)	1.5 ± 1.3	0.8 ± 1.3	2.4 ± 1.8
Assistant coach	26 (30)	48 (55)	4 (5)	10 (11)	0.7 ± 1.0	0.9 ± 1.8	1.6 ± 1.9
Ballet teacher	25 (28)	61 (69)	0 (0)	2 (2)	0.4 ± 0.7	0.5 ± 0.8	1.0 ± 0.7
Choreographer	62 (70)	26 (30)	0 (0)	0 (0)	0.2 ± 0.5	0.1 ± 0.3	0.3 ± 1.0
S&C coach	54 (61)	32 (36)	2 (2)	0 (0)	0.3 ± 0.7	0.2 ± 0.5	0.5 ± 0.8
Physiotherapist	43 (49)	37 (42)	3 (3)	5 (6)	0.4 ± 1.0	0.6 ± 1.4	1.0 ± 1.0
Nutritionist/Dietitian	60 (68)	27 (30)	1 (1)	0 (0)	0.2 ± 0.4	0.2 ± 0.6	0.4 ± 1.0
Doctor	65 (74)	19 (22)	4 (5)	0 (0)	0.2 ± 0.6	0.2 ± 0.6	0.4 ± 1.0
Psychologist	54 (61)	34 (38)	0 (0)	0 (0)	0.2 ± 0.5	0.3 ± 0.5	0.5 ± 1.0
Physiologist	84 (95)	4 (5)	0 (0)	0 (0)	0.0 ± 0.2	0.0 ± 0.1	0.0 ± 0.2
Sport scientist	87 (99)	1 (1)	0 (0)	0 (0)	0.0 ± 0.1	0.0 ± 0.0	0.0 ± 1.0
Biomechanist	87 (99)	1 (1)	0 (0)	0 (0)	0.0 ± 0.1	0.0 ± 0.0	0.0 ± 1.0

S&C: strength and conditioning
Source: elaborated by the author (2020).

4.4.2 Variables and methods

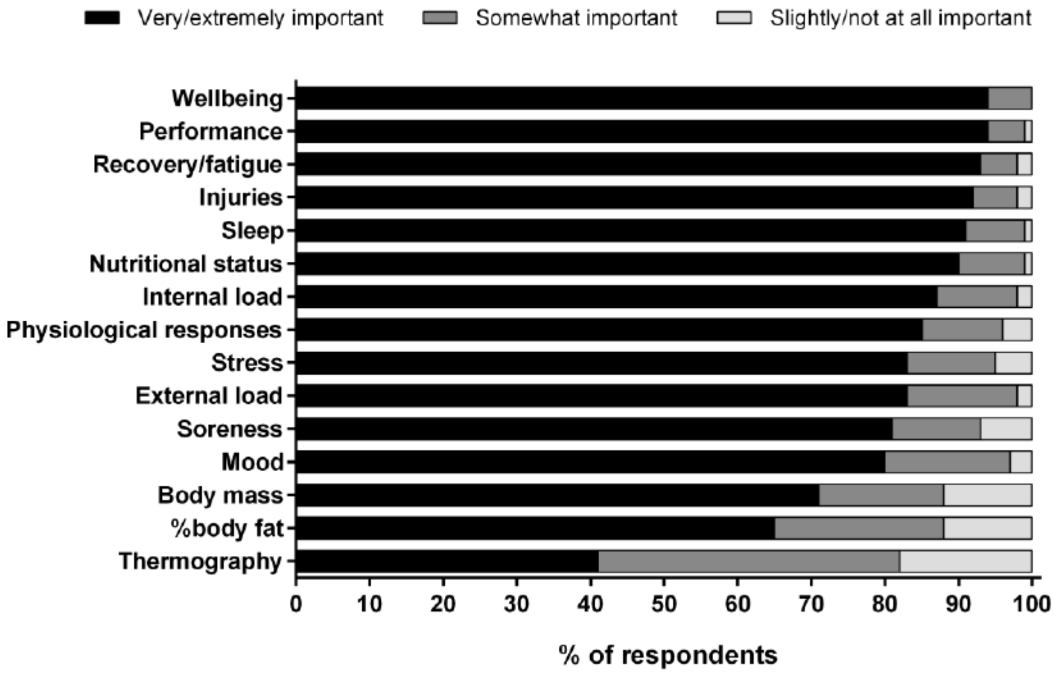
Figure 13 shows how often each method was used to monitor external training load, internal training load, recovery/fatigue, performance, as well as frequency of monitoring other variables. Figure 14 presents participants perception of the importance of each variable in training load management in rhythmic gymnastics.

Figure 13 – Frequency of administration of several methods of monitoring external training load (A), internal training load (B), recovery/fatigue (C), performance (D), and other variables (E) in rhythmic gymnastics (N=100).



Source: elaborated by the author (2020).

Figure 14 – Perceived importance of each variable in training load management in rhythmic gymnastics (N=100).



Source: elaborated by the author (2020).

4.4.3 Stages and procedures

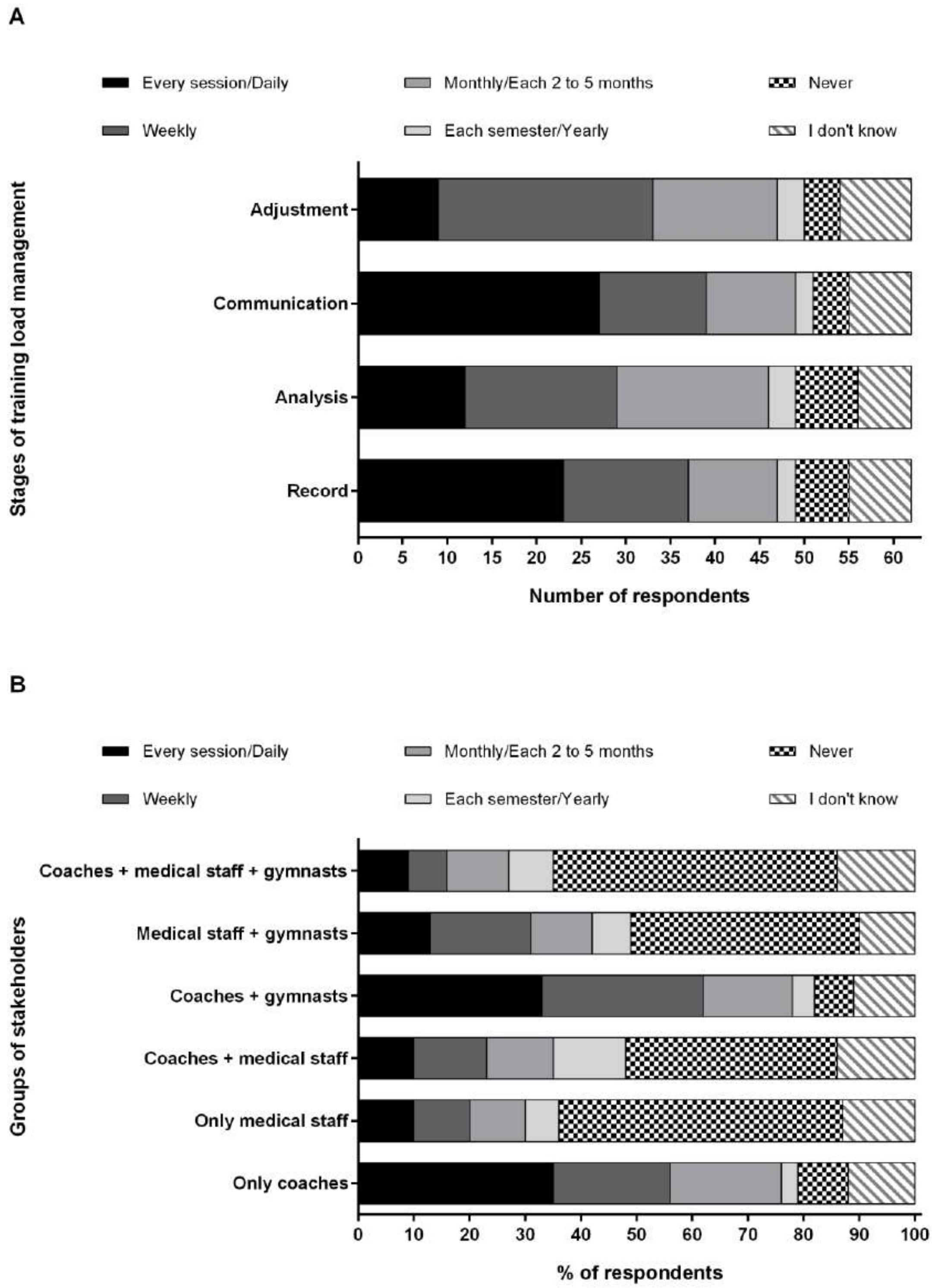
The methods and parameters used in recording, analysing, and communicating training load information according to coaches and medical staff is presented in Table 5. The frequency of each stage of training load management other than monitoring (i.e., recording, analysis, communication, and adjustment), and how often training load information is discussed and shared among different groups of stakeholders is presented in Figure 15A and B, respectively.

Table 5 – Methods and parameters used in recording, analysing, and communicating training load information in rhythmic gymnastics (N=62).

Stage	**Method or parameter used**	**Yes** No. (%)	**No** No. (%)	**I don't know** No. (%)
Recording	Specific software or platform	9 (15)	44 (71)	9 (15)
	Custom-made digital spreadsheet	29 (47)	28 (45)	5 (8)
	Pen and paper	52 (84)	9 (15)	1 (2)
Analysing	Automatic analysis made by commercially available software or platform	8 (13)	45 (73)	9 (15)
	Descriptive and inferential statistics	21 (34)	33 (53)	8 (13)
	Machine learning predictive analysis	5 (8)	45 (73)	12 (19)
	Traffic-light system flagging red, amber and green	8 (13)	42 (68)	12 (19)
	ACWR	11 (18)	36 (58)	15 (24)
	% week to week change in training load	35 (56)	18 (29)	9 (15)
	Acute load	13 (21)	36 (58)	13 (21)
	Quartile in relation to maximal training load	15 (24)	35 (56)	12 (19)
	Chronic load	11 (18)	37 (60)	14 (23)
	Individual values in relation to the group	33 (53)	18 (29)	11 (18)
	External and internal load relation	25 (40)	24 (39)	13 (21)
Communicating	Sending reports	16 (26)	44 (71)	2 (3)
	Formal meetings	34 (55)	27 (44)	1 (2)
	Informal talks	50 (81)	11 (18)	1 (2)
	Punctual information by email or message	30 (48)	30 (48)	2 (3)

Source: elaborated by the author (2020).

Figure 15 – Frequency of each stage of training load management (A) (N=62) and how often training load data is shared and discussed amongst stakeholders in rhythmic gymnastics (B) (N=100).

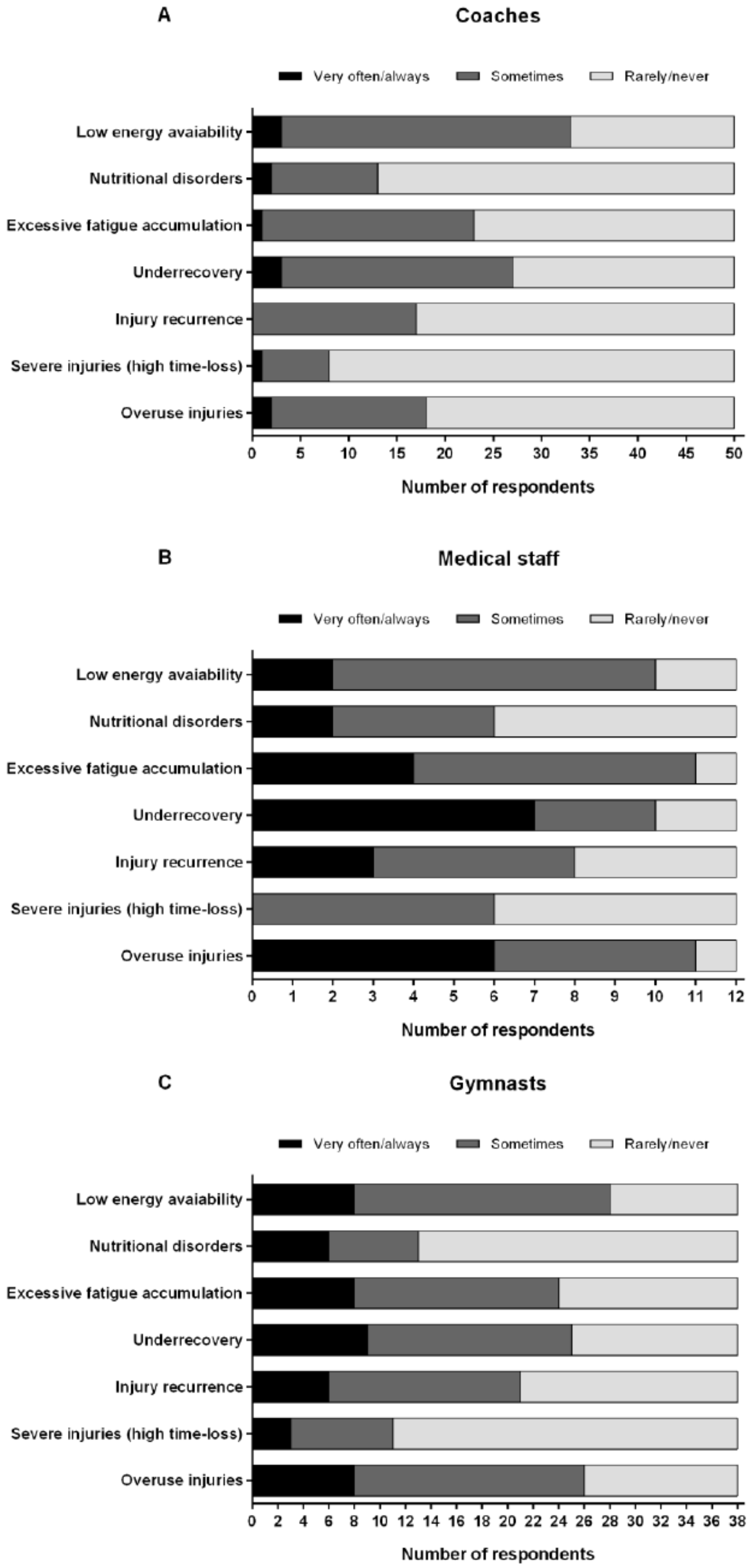


Source: elaborated by the author (2020).

4.4.4 Quality and effectiveness

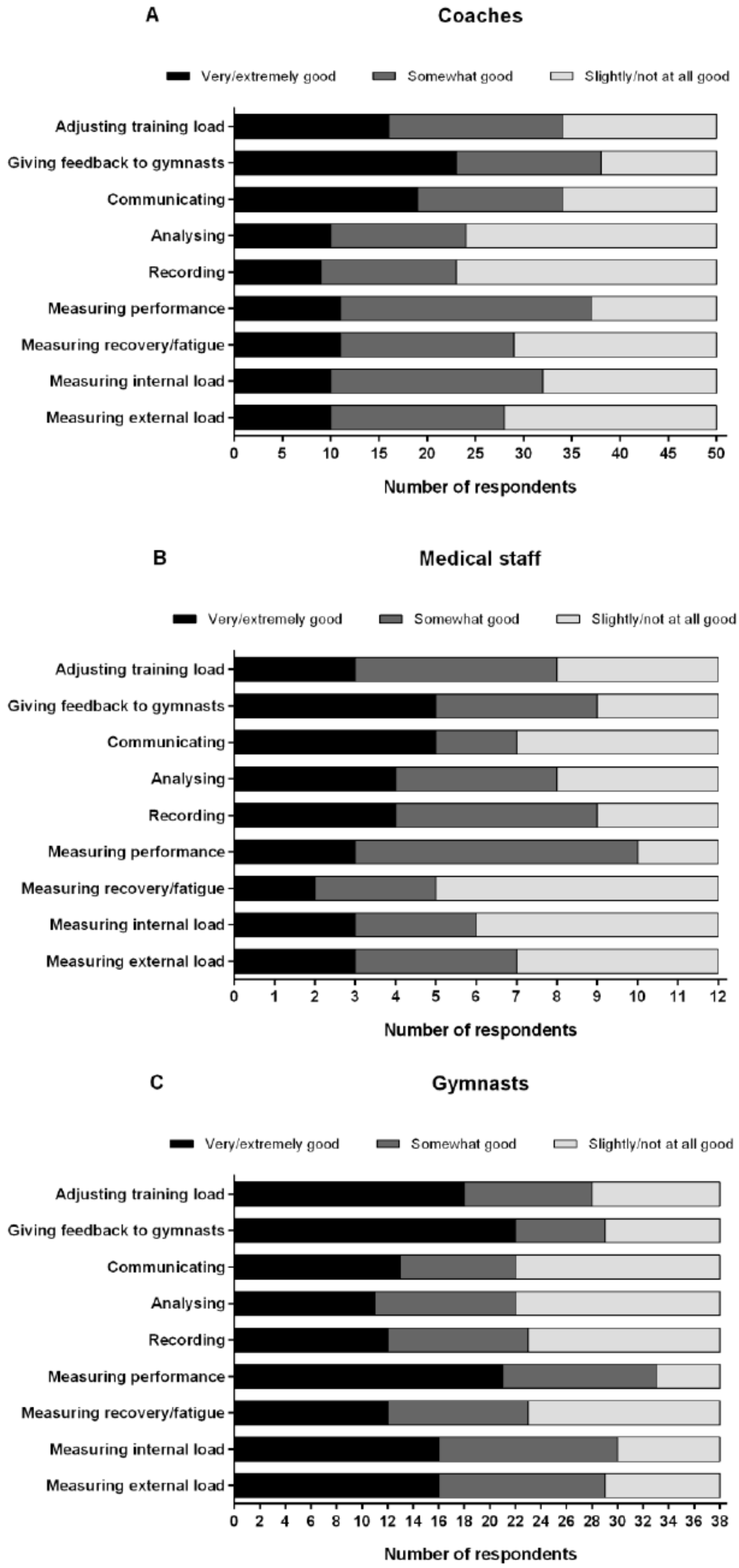
The perception of rhythmic gymnastics coaches, medical staff, and gymnasts on frequency of maladaptation, quality of training load management, and effectiveness of training load management on achieving specific goals are presented separately in Figures 16, 17 and 18. On average, the frequencies (%) of coaches perception regarding maladaptation occurrence were 3.4 ± 2.2 *very often/always*, 36.3 ± 15.7 *sometimes*, and 60.3 ± 17 *rarely/never*. For medical staff, the distribution was 28.6 ± 4.9% *very often/always*, 45.2 ± 3.4% *sometimes*, and 26.2 ± 4.4% *rarely/never*. Gymnasts perceived maladaptation occurrence as 18.0 ± 4.1% *very often/always*, 37.6 ± 9.8% *sometimes*, and 44.4 ± 13.2% *rarely/never*. Regarding the *quality* of training load management, coaches perceived, on average, 26.4 ± 10.6% as *very/extremely good*, 35.6 ± 8.5% as *somewhat good*, and 38.0 ± 12.1% as *slightly/not at all good*. Medical staff perceived 29.6 ± 2.2% as *very/extremely good*, 34.3 ± 3.2% as *somewhat good*, and 36.1 ± 3.3% as *slightly/not at all good*. In this same topic, 41.2 ± 9.3% of gymnasts indicated as *very/extremely good*, 28.7 ± 3.4% as *somewhat good*, and 30.1 ± 8.6% as *slightly/not at all good*. The *effectiveness* of training load management was perceived by 30.3 ± 13.0% of coaches, 27.8 ± 2.9% of medical staff, and 45.2 ± 16.2% of gymnasts as *very/extremely effective*. The average perception on *somewhat effective* was 47.3 ± 18.2%, 34.7 ± 4.1%, and 30.3 ± 12.1% of coaches, medical staff, and gymnasts, respectively. Last, 22.3 ± 10.3% of coaches, 37.5 ± 4.2% of medical staff, and 24.6 ± 8.2% of gymnasts perceive training load management as *slightly/not at all effective*. When asked how effective a specific model of training load management in rhythmic gymnastics could be, the participants responded as shown in Figure 19.

Figure 16 – Perceived frequency regarding maladaptation in rhythmic gymnastics.



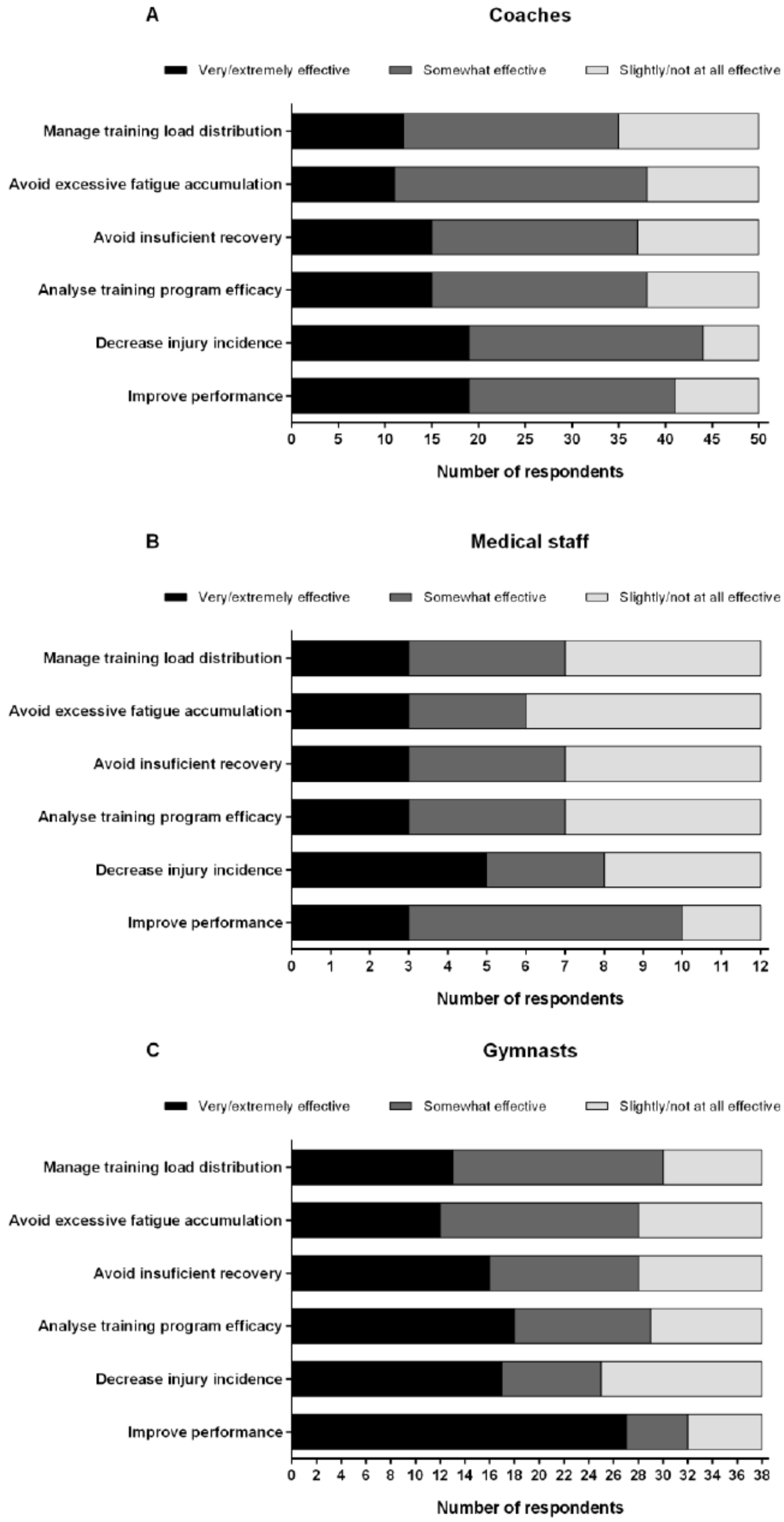
Source: elaborated by the author (2020).

Figure 17 – Perceived quality of training load management in rhythmic gymnastics.



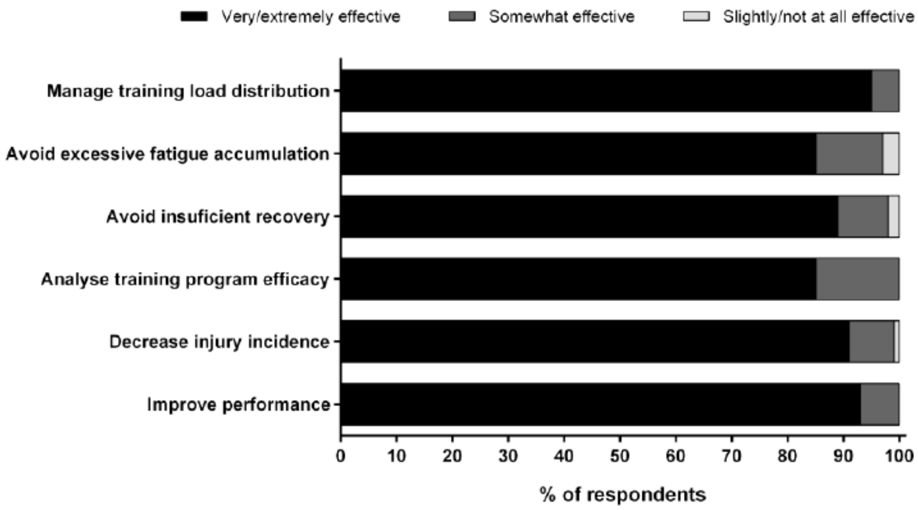
Source: elaborated by the author (2020).

Figure 18 – Perceived effectiveness of training load management objectives in rhythmic gymnastics.



Source: elaborated by the author (2020).

Figure 19 – How effective it could be using a specific model for training load management in rhythmic gymnastics (N=100).



Source: elaborated by the author (2020).

4.5 DISCUSSION

The purpose of this study was to describe and analyse practices and perceptions of rhythmic gymnastics professionals and athletes on training load management. Coaches' perception was frequently used as a method of monitoring load, recovery/fatigue, and performance. Variables, methods, and metrics commonly reported in training load literature and other sports practical settings were not commonly used in rhythmic gymnastics. In general, the majority of coaches perceived that maladaptation rarely or never occurred. Medical staff involvement in sharing and discussing training load information was limited and they perceived that the measurement of athletes' recovery/fatigue were not very good. Gymnasts noted good quality on measuring performance and giving them feedback. Most participants believed that a specific training load management model for rhythmic gymnastics could be very or extremely effective.

4.5.1 General information

Although there is no consensus on job titles and roles concerning support staff in elite sports (BUCHHEIT; CAROLAN, 2019), strength and conditioning coaches, sport scientists, and physiologists are some of the practitioners who normally engage in training load management in the applied environment (AKENHEAD; NASSIS, 2016; TAYLOR et al., 2012; WESTON, 2018). The entire staff (and the athletes themselves) share the responsibility of preparing the athletes and keeping them healthy to train and compete (GABBETT; WHITELEY, 2017; MOONEY et al., 2017). Our results point to a rhythmic gymnastics staff directed towards technical aspects, as 70% (n=62) of respondents reported a staff with one or more assistant coaches or ballet teachers, while between 61-99% did *not* have a strength and conditioning coach, physiologist, or a sport scientist in their staff. In contrast, a similar study with professional soccer teams showed that all 41 clubs employed at least one fitness coach or sport scientist and 17 employed a dedicated data analyst for the purposes of analysing monitoring data (AKENHEAD; NASSIS, 2016). This distinct reality observed in our study might be related to financial resources and better structure of high-level team sports (STARLING; LAMBERT, 2018), as well as the great importance of technical aspects in aesthetic sports in order to achieve good performance. Nevertheless, considering our sample includes members of eight national teams and several international level professionals and gymnasts, a higher representation of strength and conditioning coaches and sport scientists in the staff might be expected. Rhythmic gymnastics coaches usually share their attention among several gymnasts with different age groups and competitive demands, thus training load management could be more challenging and overwhelm coaches without a multidisciplinary staff. Additionally, coaches and practitioners may have different interests, sources of knowledge, and perceptions on how to apply evidence in the field (FULLAGAR et al., 2019). Therefore, having these professionals in the staff and/or collaborating with academics could be an interesting strategy to reduce the gap between research and practice (COUTTS, 2016, 2017; GABBETT, 2020a) in rhythmic gymnastics.

4.5.2 Variables and methods

One of the most common methods to monitor external training load in sports is via GPS and inertial measurement units (MALONE et al., 2017). These tools are common among field-based team sports (AKENHEAD; NASSIS, 2016; MCGUIGAN et al., 2020; TAYLOR et al., 2012; WEST et al., 2019; WESTON, 2018), and capable of measuring many metrics, including sport-specific movements (e.g., jumps, tackles). In rhythmic gymnastics, the adoption of this equipment to measure external load is rare, with 59% (n=59) of respondents stating they had never used this technology. It is relevant to highlight that there is still no evidence that this technology could be reliably implemented in rhythmic gymnastics. Moreover, these tools are expensive and might not be suitable for the current reality of the majority of rhythmic gymnastics teams around the world. On the other hand, our study shows that simpler methods such as number of repetitions, coaches' perception, and training duration were more frequently employed to monitor external load (FIGURE 13A). Although these methods can be limited as they only account for training volume, they are also used in other sports (MCGUIGAN et al., 2020), and represent easy and inexpensive strategies. Future studies should investigate the application of wearable technology in rhythmic gymnastics in order to advance the understanding on the sports demands and improve training prescription.

Coaches' perception was expressed as the most frequent method to monitor internal training load in the current study (FIGURE 13B). Corroborating this finding, coaches from elite soccer teams also often rely on their perception to monitor training load (WESTON, 2018). Nonetheless, research in futsal (RABELO et al., 2016), basketball (DOEVEN et al., 2017), volleyball (NOGUEIRA et al., 2014), swimming (WALLACE; SLATTERY; COUTTS, 2009), tennis (MURPHY et al., 2014), running (FOSTER et al., 2001a), judo (VIVEIROS et al., 2011), and soccer (BRINK et al., 2014; BRINK; KERSTEN; FRENCKEN, 2017) has shown significant differences between the coaches and athlete's perceptions of training load.

Internal training load, along with other factors (e.g., health, nutrition, psychological status), determines adaptations and training outcomes and might be different among athletes exposed to the same external load (IMPELLIZZERI; MARCORA; COUTTS, 2019). Thus, it is essential to comprehend individual psychophysiological responses during the exercise (i.e., internal load) through established methods such as heart rate or session-RPE. Although relevant in endurance sports (ROOS et al., 2013), heart rate may not be appropriate for short duration and intermittent activities (IMPELLIZZERI; MARCORA; COUTTS, 2019), and our results demonstrate that its usage is uncommon in rhythmic gymnastics (48% never use). However, session-RPE is a reliable and simple method widely used in research (HADDAD et al., 2017) and practice (MCGUIGAN et al., 2020) in various sports, including elite (DEBIEN et al., 2019, 2020a) and youth (ANTUALPA; AOKI; MOREIRA, 2018) rhythmic gymnasts. We have identified that 28% of respondents use session-RPE in a daily basis as an instrument to monitor internal training load, albeit 23% never use it. Previous studies using session-RPE in elite rhythmic gymnasts have found extremely high daily (DEBIEN et al., 2019) and weekly loads, increasing during competitive periods (DEBIEN et al., 2020a), which reinforce the importance of implementing reliable tools to constantly monitor the internal load in this sport.

Conceptually, recovery and fatigue are distinct constructs/phenomenon albeit both are present in the same continuum (KELLMANN et al., 2018). In general, methods applied to monitor training response (e.g., recovery, fatigue, wellbeing) attempt to track at which point the athletes are in this continuum and how they are coping with training. Therefore, recovery and fatigue are sometimes monitored as only *one* variable, as was this case in the present and previous research (STARLING; LAMBERT, 2018; TAYLOR et al., 2012). In this respect, studies in different high-level sports (AKENHEAD; NASSIS, 2016; SAW; MAIN; GASTIN, 2015; TAYLOR et al., 2012) have reported frequent use of athlete self-report measures (ASRM) to assess training responses. In contrast with these findings, we found that less than half (42%) of respondents used ASRM to monitor gymnasts' recovery/fatigue at least on a weekly basis. Our surveys did not examine which ASRM were used yet existing research in rhythmic gymnastics has adopted both Total Quality Recovery (DEBIEN et al., 2019, 2020a) and wellbeing scales (ANTUALPA; AOKI; MOREIRA, 2017). Regarding this choice, recent reviews (DUIGNAN et al., 2020; JEFFRIES et al., 2020) highlighted the lack of theoretical basis and validation of single-item (e.g., wellness items) and custom-made ASRM, which are commonly used in practice (TAYLOR et al., 2012) and research (MCLEAN et al., 2010). Even though subjective measures (e.g., mood, perceived recovery, and stress) can reflect acute and chronic training loads with superior consistency and sensitivity than objective measures (e.g., biochemical, physiological, performance) (SAW; MAIN; GASTIN, 2016), as well as contribute to better communication between athletes and staff (SAW; MAIN; GASTIN, 2015), they should be carefully selected and implemented (SAW et al., 2017).

The respondents stated that coaches' perception was the most common method to monitor recovery/fatigue in rhythmic gymnastics. Moreover, between 35 and 79% of participants stated that they did not know or never used some of the three other methods (ASRM, physical test, physiological marker) mentioned in the survey (FIGURE 13C). Similarly, direct observation was also the most frequent method used by coaches and support staff to monitor the recovery/fatigue status of rugby players (STARLING; LAMBERT, 2018). It is worth emphasising that due to the individual, complex, and multifactorial nature of training responses such as recovery and fatigue, relying exclusively on how coaches perceive this state might be a limited and inaccurate choice given research shows that coaches tend to overestimate athletes recovery in some situations (DOEVEN et al., 2017). Furthermore, evidence points to poor perceived recovery among elite rhythmic gymnasts during half of a pre-Olympic season (DEBIEN et al., 2020a) as well as in competition (DEBIEN et al., 2019). Together, these findings suggest the need for a better approach other than simply *coaches' perception* to properly monitor how rhythmic gymnasts are coping with training and competition.

Precisely monitoring performance in aesthetic sports is challenging as these modalities normally depend on subjective aspects in judging and evaluating. In order to achieve good competitive results, rhythmic gymnasts must be able to perform high-level body and apparatus difficulty elements, in accordance with the rhythm and character of the music, and make few technical and artistic mistakes (SIERRA-PALMEIRO et al., 2019). In this respect, it was observed a regular use of methods as counting hits in repetitions sets, routine evaluation (i.e., simulated judging), as well as coaches' perception (FIGURE 13D). Only 5% (or fewer) of respondents said they had never used some of these three methods. Although previous similar studies (AKENHEAD; NASSIS, 2016; STARLING; LAMBERT, 2018; TAYLOR et al., 2012) have not necessarily investigated *performance* as a specific variable – but as a broader construct (i.e., training response) – it is possible to regularly implement physical/performance tests (e.g., jumps, submaximal, strength/power) in several sports contexts (MCGUIGAN et al., 2020). In the present investigation, physical tests were reported with low frequency as a method to monitor performance.

The use of each of these methods might be related to the different phases of the season, as distinct frequencies of application were also observed by other authors (AKENHEAD; NASSIS, 2016; STARLING; LAMBERT, 2018; TAYLOR et al., 2012) in varied practical contexts. For instance, in rhythmic gymnastics, physical tests may be used across preparatory periods – when routines are not finalised – while evaluating entire routines is quite often performed during competitive periods as this is the most specific measurement of performance in the sport. As for number of hits and coaches' perception, these methods could be used for monitoring performance in isolated elements, parts of the routine, and the entire routine as well, which may occur anytime across the season and explains its high frequency of application among the respondents. In addition to that, there is still a gap in the literature regarding which physical tests are reliable for comprehending rhythmic gymnastics performance. Despite earlier research with youth rhythmic gymnasts (ANTUALPA; AOKI; MOREIRA, 2017) implementing tests found in the literature (GATEVA, 2011), some are yet to be deeply investigated and validated and should be used with caution. Moreover, despite existing evidence (DOUDA et al., 2008) regarding determinants of performance in rhythmic gymnastics, each Olympic cycle is unique in regards to rules and demands of this sport (SIERRA-PALMEIRO et al., 2019). Therefore, there is still a lack of understanding on which methods and metrics are indeed useful for monitoring the modern rhythmic gymnastics performance besides coaches' and judges' evaluation.

The training process is influenced by several other aspects and variables aside from training load and response (IMPELLIZZERI et al., 2020a). Thus, adopting a multivariate approach in training load management is essential (VERHAGEN; GABBETT, 2019; WEAVING et al., 2017). Given that, the respondents of the current study were also asked how often they monitor other variables (FIGURE 13E) than load, recovery/fatigue, and performance, and how they perceive the importance of monitoring each of these variables in rhythmic gymnastics (FIGURE 14). More than 60% of respondents monitor soreness, wellbeing, mood, or injuries on a minimum weekly basis. Conversely, 33% stated that they never monitor sleep, although 91% affirmed it was very/extremely important, with research showing poor sleep habits among elite rhythmic gymnasts prior to international competitions (SILVA; PAIVA, 2016).

Despite their current practices, more than 90% of respondents also perceived monitoring wellbeing, performance, recovery/fatigue, injuries, and nutritional status to be of high importance. These findings are consistent with those in rugby players (STARLING; LAMBERT, 2018). It is known that all of these variables can influence training load, recovery, and/or performance (BOURDON et al., 2017). Some could be easier to measure more often – as there are simple non-invasive and inexpensive methods – and others may require a specialized professional or equipment, demand more time, or require less frequent monitoring. Regardless, before choosing *what* to measure it is paramount that rhythmic gymnastics coaches and staff deeply comprehend the sport demands (context before content), as well as the reasons *why* they should implement a training load management system (GABBETT et al., 2017). Any training variable, method, or measurement has its limitations, yet, if correctly selected and applied, it could represent an important piece of the puzzle (GABBETT, 2020a). Therefore, we highlight the importance of adopting solid and evidence-based practices in rhythmic gymnastics – taking into consideration practical experience, athlete values and expectations, along with good quality research evidence (GABBETT, 2020a) – in order to contribute to better athlete management decisions.

4.5.3 Stages and procedures

Along with monitoring, training load management includes recording, analysing, and communicating information among staff members and athletes (THORNTON et al., 2019). Professionals involved in our study indicated that data analysis and training adjustments were not as frequent as recording and communicating training load information (FIGURE 15A). The procedures adopted in each of these stages might be influenced by the use of technology (WINDT et al., 2020), or financial and human resources. For instance, in rugby, Weston (2018) observed that training load data analysis/interpretation was mostly attributed to sports scientists and fitness coaches. Approximately 20% of coaches and medical staff in our study declared that they did not know or never performed some of the four stages specified in the survey (i.e., record, analyse, communicate, adjust).

In this regard, there are an abundance of methods, tools, parameters, and metrics that can help transform the numbers into informed decisions in the field (THORNTON et al., 2019). We found that 47% (n=29) of rhythmic gymnastics professionals use digital sheets (e.g., Google Sheets, Microsoft Excel) and only a few (15% or less) use specific software or platforms to record and/or analyse training load data. Conversely, 84% (n=52) stated using pen and paper as a method of recording this information. In their study of main soccer leagues across the world, Akenhead and Nassis (2016) observed that 90% of participants use Microsoft Excel spreadsheets and 56% use an additional software for this same purpose. These findings could be explained by the higher application of commercially available wearable devices (and its software) in field-sports (MCGUIGAN et al., 2020). Nevertheless, to properly manage the costs and benefits involved in decision-making in training (GABBETT; WINDT; GABBETT, 2016), it is recommended that these stages be carefully and systematically followed (THORNTON et al., 2019), even without sophisticated technology and resources.

Ultimately, the effectiveness of training load management is defined by the quality of the decisions made from the above-mentioned stages (AKENHEAD; NASSIS, 2016). Regarding analysis and interpretation of training load data, there is no consensus in the literature on which statistical approaches or metrics to apply, especially, due to the nuances of sports and contexts (ROBERTSON; BARTLETT; GASTIN, 2017; THORNTON et al., 2019). However, investigation in professional rugby showed that metrics of acute, cumulative, and changes in load are relevant to help managing injury risk (WILLIAMS et al., 2017b). One study conducted in elite soccer (AKENHEAD; NASSIS, 2016) reported the use of these metrics by practitioners, who also highlighted its relevance to prescribing and adjusting training. Among rhythmic gymnastics coaches and staff, 56% (n=35) calculated the percentage of weekly change in training load, 21% (n=13) analysed the acute load, and 18% (n=11) the chronic load. The literature indicates that high and adequate chronic loads, when safely achieved, along with good physical qualities could provide a protective effect against overuse injury and, therefore, could be a pertinent metric in practical settings (GABBETT, 2020b), albeit it is not commonly analysed in rhythmic gymnastics (TABLE 5). The acute:chronic workload ratio (ACWR) also stands out as an insightful metric regarding training load progression and has already been shown to be related to injury risk in several sports (ANDRADE et al., 2020; GABBETT, 2020b; GRIFFIN et al., 2020). Although research on the utility of the ACWR in rhythmic gymnastics exists (ANTUALPA; AOKI; MOREIRA, 2018; DEBIEN et al., 2020a), only 18% (n=11) of respondents in the current study used this metric in their analysis. In general, the relevant metrics and parameters of analysis concerning training load, performance, and injuries are yet to be investigated in rhythmic gymnastics.

Additionally, it is fundamental to understand how these metrics change over time for each athlete. There are multiple ways to comprehend if these changes are meaningful from both a practical and statistical viewpoint, including smallest worthwhile changes, coefficient of variation, magnitude-based inferences, standard deviation, as well as using “traffic lights” and “red flags” systems (COUTTS; CROWCROFT; KEMPTON, 2017; ROBERTSON; BARTLETT; GASTIN, 2017; THORNTON et al., 2019). The use of “red flags” to inform decisions has been reported in high-level sports programs (TAYLOR et al., 2012) and national institutes (SAW; MAIN; GASTIN, 2015), whereas our results showed that only 13% (n=8) use traffic-light systems or commercially available software during the analysis of training load data. The use of red, amber, or green indicators (i.e., “traffic-lights”) has been suggested in the literature (ROBERTSON; BARTLETT; GASTIN, 2017; THORNTON et al., 2019) and may facilitate data interpretation and visualization. To our knowledge, very little research (SAW; MAIN; GASTIN, 2015) has surveyed so deeply the practices and perceptions concerning each of these stages and procedures of training load management. Once again, these findings could be associated with resources, technology, staff composition, expertise, and the insights desired in order to inform further decisions. Regardless of how training load data is analysed and which criteria is used to make decisions, the entire process must be context- and individual-dependent, coherent with the established goals, as well as collaborative.

Ideally, prior to decision-making based on athlete monitoring data (i.e., adjustment), it is expected that this information is shared and discussed among key stakeholders. When describing a 4-step framework for developing an athlete monitoring system in team-sports, Thornton et al. (2019) highlighted that the success of this system is underpinned by the ability of the staff to communicate relevant information to coaches, eventually culminating in improvements in athletic performance. Corroborating this, research in soccer has found that the quality of internal communication within staff members (e.g., head coach, manager, and medical staff) was associated with injury rates (negative), training attendance (positive), and match availability (positive) (EKSTRAND et al., 2019). In our study, the communication among rhythmic gymnastics stakeholders is mostly through informal discussions (81%), with 71% (n=44) of respondents stating that they did not use reports to share training load information.

One of the items in our surveys was specifically designed to identify how often the three investigated groups share and discuss training load information (FIGURE 15B). The responses demonstrate that medical staff were not heavily involved in this process, as between 38 and 51% of respondents indicated that medical staff were *never* included in the groups of stakeholders. It could either be explained by the fact that several teams do not even have medical staff (TABLE 4), or these professionals are only included when the gymnasts sustain health problems and then medical attention is required. In this respect, the model presented by Gabbett and Whiteley (2017) outlines the negative effects athletes may confront (e.g., poor performance, chronic rehabilitation) when stakeholders involved in training load management do not collaborate and have different goals. The content and format of communication are vital and should be, simple, relevant, and informative. However, rhythmic gymnastics professionals should primarily focus on having an aligned and collaborative staff that can communicate effectively and support coaches on their decisions, based on the good quality of each of the prior stages of training load management.

4.5.4 Quality and effectiveness

The majority of coaches perceived maladaptation in rhythmic gymnastics as uncommon (FIGURE 16A). Contrary to existing evidence pointing to a high incidence of overuse injuries in rhythmic gymnasts during pre-season (GRAM; CLARSEN; BØ, 2020) and competition (EDOUARD et al., 2018), 64% (n=32) of coaches stated that it rarely or never occurred. In contrast to coaches, half of the medical staff perceived overuse injuries as very or extremely frequent and 68% (n=26) of gymnasts perceived it happens at least sometimes. These findings were not surprising given a 12-month ethnographic investigation (CAVALLERIO; WADEY; WAGSTAFF, 2016) has shown how rhythmic gymnastics cultural norms, values, and behaviours lead coaches to misinterpret the occurrence of overuse injuries. As for severe injuries (i.e., high time-loss), most of the participants indicated it was not common in rhythmic gymnastics. Indeed, only one severe injury (>28 days of time-loss) was reported during a 15-week preseason of 107 competitive Norwegian rhythmic gymnasts (GRAM; CLARSEN; BØ, 2020). Regardless of severity, this same study found that gymnasts with previous injury presented a higher risk of sustaining subsequent injuries (GRAM; CLARSEN; BØ, 2020). Even though injury occurrence is a complex phenomenon, it is worth noting that gymnasts believe that inadequate training load is one of the main causes of their injuries (KOLAR et al., 2017). Accordingly, 45% (n=12) of gymnasts in our study perceived that their training load management was slightly or not at all effective in decreasing injury incidence. Therefore, investigations of the relationship between training load and injuries in rhythmic gymnastics could help to improve training load management in this sport. Furthermore, given that the majority of coaches in the current study stated they frequently relied on their perception to monitor several training variables, this could be one more alert to involve medical staff in training load management, adopt more reliable methods to monitor injuries, as well as look for better understanding on how gymnasts are coping with training.

Medical staff perceived rhythmic gymnasts experiencing underrecovery or excessive fatigue accumulation (FIGURE 16B). Similarly, most of the gymnasts (>60%) believed these negative outcomes occurred sometimes or more frequently. These perceptions are corroborated by research (DEBIEN et al., 2020a). Moreover, the majority of medical staff stated that the quality of training load management on measuring gymnasts recovery/fatigue – which is commonly through coaches' perception – was not good (FIGURE 17B), complementing their perception of poor effectiveness on avoiding excessive fatigue (FIGURE 18B). Recovery is key to achieve peak performance and the current study should be interpreted as a "call to action" in this regard together with several scientific papers (DEBIEN et al., 2019, 2020a; SILVA; PAIVA, 2015, 2016) which have discussed maladaptation in rhythmic gymnasts. Adequate training load management could help to minimize these negative outcomes and provide longer and healthier careers.

All three groups (71% of all participants) perceived low energy availability as a negative outcome that occurred sometimes or even more often among rhythmic gymnasts. In addition, 68% (n=60) of professionals stated that they did not have a nutritionist or dietitian in their staff. Low energy availability is an alarming situation in sport which can impair athletes health and performance (LOGUE et al., 2018). Corroborating our findings, Silva and Paiva (2015) have found low energy availability and micronutrient deficiencies in rhythmic gymnasts just before an international competition. Due to the aesthetic demands of this sport, the pursuit of a lean body is common among high-level gymnasts (DOUDA et al., 2008) and can contribute to eating disorders. Despite most of the respondents in our study perceiving infrequent nutritional disorders, this is a relevant topic for aesthetic sports and must be included in a holistic approach to manage training load in rhythmic gymnastics in an attempt to ensure the gymnasts are physically and mentally healthy to train and compete.

Improving performance and avoiding undesired effects of training are two main goals of any practitioner; training load management is thought to help achieve this (AKENHEAD; NASSIS, 2016; TAYLOR et al., 2012). However, a previous study has indicated that practitioners believe the real effectiveness of training load management is lower than expected (AKENHEAD; NASSIS, 2016). In this regard, our results show that both gymnasts, medical staff, and coaches perceived good effectiveness of training load management in rhythmic gymnastics on improving gymnasts' performance. Additionally, most of the respondents in the three groups felt that in terms of the measurement of gymnasts' performance, the training load management was between somewhat and extremely good. Some of the barriers that could prevent the effectiveness of this process are coach buy-in, poor communication, lack of resources, data analysis, and validity and reliability of methods (AKENHEAD; NASSIS, 2016; SAW et al., 2015; STARLING; LAMBERT, 2018). In this respect, one study (NEUPERT; COTTERILL; JOBSON, 2019) interviewed nine elite sprinters about their training monitoring system. The sprinters reported their main reason for poor buy-in was a lack of feedback on their monitoring data from key staff. In contrast, the rhythmic gymnasts, as well as coaches and medical staff, in our study perceived good quality on their training load management with respect to giving feedback to the gymnasts. Irrespective of the perceived effectiveness on their current practices, more than 85% of the professionals and rhythmic gymnasts believe a specific model of training load management for this sport could be very or extremely efficient for improving gymnasts' performance, decreasing injury incidence, analysing the training program, avoiding insufficient recovery and fatigue accumulation, and managing load distribution over time. The literature present guidelines (COUTTS; CROWCROFT; KEMPTON, 2017; THORNTON et al., 2019) on how to develop athlete monitoring systems, which, in conjunction with our findings (i.e., practical context of the sport), could be used to build a model of training load management for rhythmic gymnastics to be applied in practice.

Although relevant for bridging the gap between research and practice, this study presents some limitations. The online surveys were developed in only two languages, which may have prevented a larger number of respondents. Despite the sample characteristics and heterogeneity, the results should be interpreted and generalised with caution as it does not represent the entire rhythmic gymnastics community. Moreover, we decided to adopt technical terminology in the surveys items, which may have been a barrier to a clear understanding for some respondents. However, this investigation overcame limitations of previous research on this topic (MCGUIGAN et al., 2020) by deeply surveying details on frequency, methodology, describing which variables are being monitored, as well as capturing the perception of different key stakeholders in respect to training load management in one specific sport. Our findings demonstrate the training load monitoring methodologies valued by coaches, staff, and athletes. Therefore, this information can be used to improve the training monitoring process and disseminate this information to those working in the field.

The scarce applied literature and the current practices in rhythmic gymnastics training point to an empirical approach mostly based on coaches' perceptions on monitoring load, training response, and performance in rhythmic gymnastics. Given the sport culture and mismatches between athlete and coaches perception on load and recovery, this might represent a vulnerable scenario which may lead to maladaptation among the gymnasts. Although this study might be a sign that some changes are needed in rhythmic gymnastics training practices, we recognize that financial and structural aspects are difficult to change in the short term. Moreover, based on these findings, an applied and specific conceptual model of training load management might help the sport to minimize the negative effects of training and hopefully achieve better outcomes.

4.6 CONCLUSION

Training load management in rhythmic gymnastics is mostly centred around the coach and focused on technical components. Coaches' perception is frequently used to monitor training load, recovery/fatigue, and performance. Some variables, technologies, methods, parameters of analysis, and metrics commonly reported in the literature and other sports are unusual in rhythmic gymnastics. Coaches generally perceive maladaptation as infrequent in rhythmic gymnastics, however the majority of medical staff and gymnasts indicate that low energy availability, underrecovery, excessive fatigue, and overuse injuries, at least sometimes, occur. Although the measurement of performance and giving feedback to gymnasts was perceived to be good quality, better recording and analysis approaches, as well as measurement of training tolerance is required in order to achieve training goals and minimize negative outcomes in rhythmic gymnastics. Moreover, most participants believed that a specific training load management model for rhythmic gymnastics could be very or extremely effective for improving gymnasts' performance, decreasing injury incidence, analysing the training program, avoiding insufficient recovery and fatigue accumulation, and managing load distribution.

In conclusion, rhythmic gymnastics coaches' perception could be a limited method to guarantee an effective training load management in this sport. A multifactorial approach, relying on different variables, methods, as well as a more effective involvement of supporting staff in order to avoid the frequent negative effects of training is recommended. Training load management in rhythmic gymnastics should move from a *coach*-centred process focused on technical components to an aligned and multidisciplinary approach centred on the *gymnast*. Training should be designed to prepare gymnasts for the specific demands of the sport while minimizing negative outcomes.

4.7 ACKNOWLEDGEMENTS

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5 SUMMARY AND CONCLUSIONS

This section presents the summary of main findings of the studies in this thesis as well as its strengths and limitations. Additionally, a model comprising the key conclusions of the current research program has been schematically organized, along with some directions for future research and practical applications.

5.1 SUMMARY

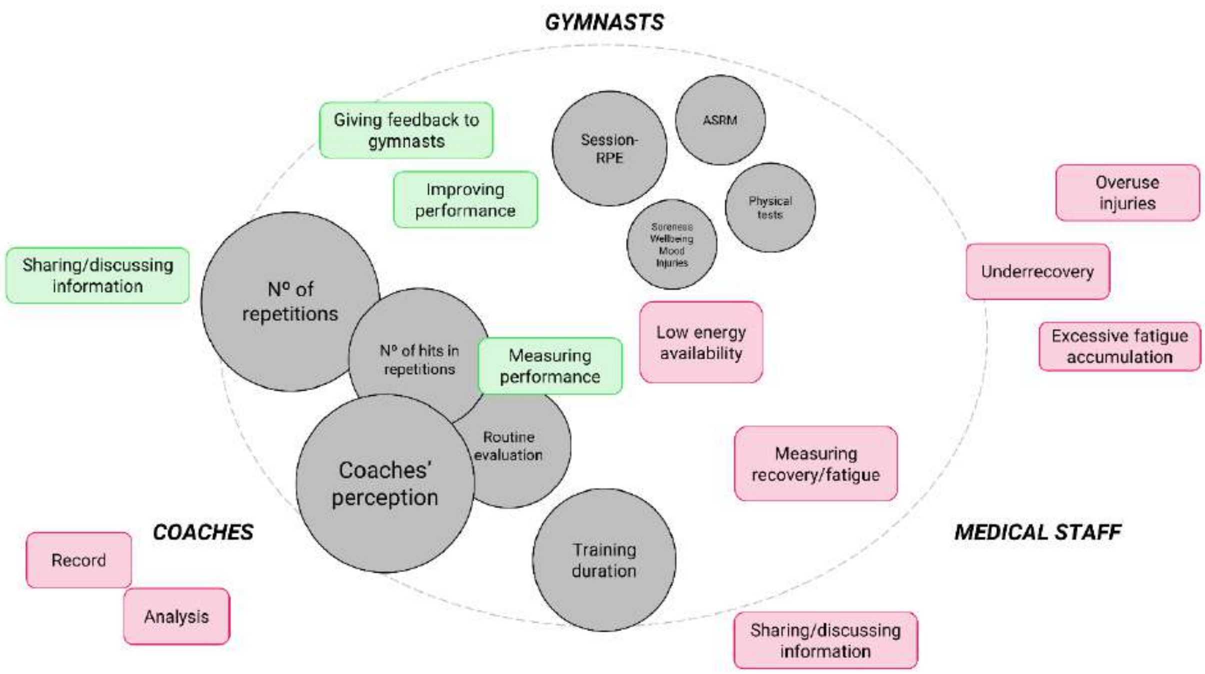
The collective aims of the studies that encompass this thesis were to: 1) describe individual training load, recovery and injuries in elite group rhythmic gymnasts during competitive periods; and 2) describe and analyse practices and perceptions of coaches, medical staff, and gymnasts regarding training load management in rhythmic gymnastics.

Study *one* investigated internal training load, perceived recovery, and injuries in six elite rhythmic gymnastics during 126 days of regular training and four competitions. Based on a deep individual analysis, different patterns of load and recovery were observed among the gymnasts, which were part of the same group and competing internationally. Four athletes sustained five lower limb overuse injuries that appeared to affect their short and long-term careers, as well as impaired training and competition organization of the team.

The gap between research and practice is a paramount topic in sports science, since scientific evidence "does not always apply" in the field. In this respect, study *two* surveyed practices and perceptions of coaches, medical staff, and gymnasts currently involved in rhythmic gymnastics training. The 100 respondent came from 25 countries, covering all five continents, and included members from eight national teams. They responded to online surveys regarding details of training load management, the variables and methods used, and quality and effectiveness of the process. Coaches' perception is a frequently used method of monitoring load, recovery/fatigue, and performance. Moreover, variables and methods commonly reported in the training load literature and other sports practical settings were not very frequently employed in rhythmic gymnastics. The majority of participants believed a specific model of training load management in this sport could be very effective.

Expanding this summary, Figure 20 displays a schematic of the main findings of the current research program with respect to training load management in rhythmic gymnastics. In this figure, the *light grey dashed circle* represents the area of high *congruence* among perceptions of coaches, rhythmic gymnasts, and medical staff. The *grey circles* represent common methods used to monitor external and internal load, recovery/fatigue, performance, and other variables. In this case, the *larger* the grey circle, the more usual and relevant is the response. The *light green rectangles* show the aspects perceived as *good quality* or *effective in achieving the goals*. Conversely, the *light pink rectangles* illustrate maladaptation occurrence and aspects rated as *not* good or effective. The items outside the dashed circle indicate the perception of one or two groups only, depending on its location in the figure. For example, overuse injuries (maladaptation) was perceived by both medical staff and gymnasts as a frequent occurrence, but not by the coaches. Therefore, it is represented outside the dashed circle and in between medical staff and gymnasts.

Figure 20 – A schematic of current training load management practices and perceptions in rhythmic gymnastics.



Source: elaborated by the author (2020).

5.2 LIMITATIONS

Although this thesis provides relevant, pioneering, and practically applicable information, it also presents some limitations. A better interpretation of internal load, recovery, and injuries could be provided with external training load information, which is missing in study one. Moreover, the thresholds established to analyse chronic load, recovery, and exponentially weighted moving average (EWMA) of the acute:chronic workload ratio (ACWR) are, at present, not strongly supported by the literature. While the small sample of elite athlete case studies is interesting with respect, it also prevents more robust statistical analysis.

Additionally, the online surveys were developed in only two languages, which might have prevented a higher number of respondents in study two, especially, considering that the best-ranked countries in rhythmic gymnastics are not native speakers of either English or Portuguese (e.g., Russia, Bulgaria, Italy, Belarus, Ukraine). Despite the sample characteristics and heterogeneity, the results should be interpreted and generalised with caution. Moreover, the use of technical expressions in the survey items may have been a barrier to a clear understanding for some respondents. Finally, although we had 100 respondents in study two, the small number of medical staff professionals is also a limitation of this thesis, and prevents the use of inferential statistics.

5.3 STRENGTHS

The strengths of this research program are summarised as:

- Advancing the current understanding of training load management in rhythmic gymnastics;
- Proposing a practical systematization of *training load management* as a broad concept, based on a solid review of the current literature;
- Conducting a case study among elite level rhythmic gymnasts in preparation for international events, and providing a deep look into relevant data in regard to training load, recovery, and injuries;

- Providing pioneer information on practices and perceptions of professionals and gymnasts from different countries and levels on training load management;
- Overcoming limitations of the current literature by describing simultaneously details regarding the variables, stages, procedures, and key stakeholders on training load management in practical settings;
- Presenting a schematic model of training load management in rhythmic gymnastics, which enables a visual and specific interpretation of *how it currently is* and *how it should be*;
- Bridging the gap between research and practice in rhythmic gymnastics.

5.4 FUTURE DIRECTIONS

Given the above-presented limitations, the advances in knowledge provided by this thesis, as well as the remaining gaps in the literature, we present some recommendations for future studies in rhythmic gymnastics.

Previous studies and the current thesis have shown high internal training loads in elite rhythmic gymnasts, but no information regarding the external training load. Future studies should investigate external training load quantification in rhythmic gymnastics, especially through the application of wearable technology. More precise information on the completed “work” during training and competition in rhythmic gymnastics could provide useful data to practitioners.

Despite recent research providing high-quality evidence (GRAM; CLARSEN; BØ, 2020), there is still a lack of epidemiological studies investigating injuries in elite rhythmic gymnastics during longer periods. Moreover, the case study presented here is the first to analyse training load, recovery, and injuries in rhythmic gymnasts.

Considering that rhythmic gymnastics is, until this date, one of the only female-exclusive Olympic sports, would also be interesting investigating the nuances of hormonal responses and menstrual disorders in such sport and its relation with training load.

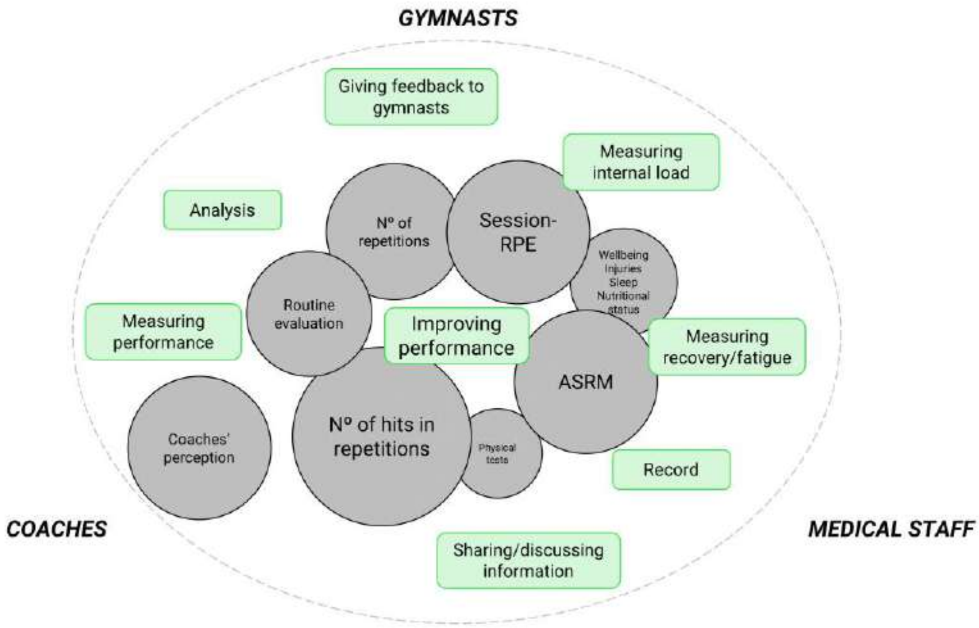
Finally, further investigations are needed to explore other methods capable of providing accurate, specific, and applied performance measures in rhythmic gymnastics. Although it has been presented as a “positive” practice in this thesis, it is mostly based on coaches and/or judges evaluation. It would also be interesting to have objective and relevant parameters or tests of readiness and fitness in order to provide better information on specific performance in rhythmic gymnastics.

5.5 PRACTICAL APPLICATIONS

Similar to Figure 20, Figure 21 is a representation of a conceptual model that, in comparison to the current practices and perceptions, could be used to improve specific aspects of training load management in rhythmic gymnastics. In this case, the size of the *grey circles* represents the “importance” that should be given to each variable and/or method. This model relies on shifting from a *coach*-centred process to a *gymnast*-centred process. In addition to the aspects that are already considered good and effective (e.g., green rectangles in Figure 20) by practitioners, coaches, and gymnasts, it is suggested that focusing on 1) more reliable methods to monitor how rhythmic gymnasts are responding and coping to training, 2) better strategies to record and analyse training load information, 3) sharing and discussing this information with support and medical staff, 4) improving gymnasts’ performance as the main goal. While requiring empirical studies to evaluate its effectiveness, it is anticipated that the adoption of this model could result in fewer occurrences of undesired outcomes and maladaptation in rhythmic gymnastics.

In addition, it is paramount that the understanding that changes are needed in training load management in rhythmic gymnastics invovles managers, coaches, medical staff, and gymnasts. All the characters in this sport must embrace their roles and responsabilities in this process of evolving and improving their practices for a better rhythmic gymnastics.

Figure 21 – A schematic of a conceptual model to improve training load management in rhythmic gymnastics.



Source: elaborated by the author (2020).

5.6 CONCLUSIONS

The purpose of this thesis was to increase the knowledge and understanding of training load management in rhythmic gymnastics. Previous studies have highlighted high internal training loads, rapid increases in load, poor recovery, and overuse injuries among rhythmic gymnasts. However, until now, none have concurrently investigated all of these variables in this sport. A case study was conducted among elite level rhythmic gymnasts during competitive periods and the results showed that elite group rhythmic gymnasts presented different injuries, load, and recovery patterns. Factors such as age and chronic load could moderate how each gymnast responds to training and tolerates rapid increases in load. Moreover, injuries sustained during competitive periods appear to affect the short and long-term careers of gymnasts and impair training and competition organization of the team.

This thesis also described practices and perceptions of coaches, medical staff, and rhythmic gymnasts from 25 different countries regarding training load management. It was noted that rhythmic gymnastics coaches' perception – which is commonly used in this sport to monitor several training variables – could be a limited method to ensure effective management of training load. In this respect, it is recommended to adopt a multifactorial approach, relying on different variables and methods, as well as a more effective involvement of support staff in order to avoid the frequent negative effects of training. In conclusion, training load management in rhythmic gymnastics should move from a *coach*-centred process focused on technical components to an aligned and multidisciplinary approach centred on the *gymnast.* Training should be designed to prepare athletes for the specific demands of the sport and minimize negative outcomes.

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FIG. **Code of Points of Rhythmic Gymnastics**FIG, , 2018.

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APPENDIX A – Evidence of publication

Study 1: DEBIEN, P. B. et al. Training load, recovery and injuries in elite rhythmic gymnasts during main competitive periods: a case study. **Science of Gymnastics Journal**, v. 12, n. 3, p. 277–285, 2020.

TRAINING LOAD, RECOVERY AND INJURIES IN ELITE RHYTHMIC GYMNASTS DURING MAIN COMPETITIVE PERIODS: A CASE STUDY

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Case study

Abstract

Competitive periods are critical periods where elite rhythmic gymnasts experience higher training loads and insufficient recovery. The aim of this short report is to describe individual training load, recovery and injuries in elite group rhythmic gymnasts during competitive periods. Six gymnasts from the Brazilian senior rhythmic gymnastics group were monitored daily over a 126-day period comprising regular training and four competitions. Training load was measured using the session rating of perceived exertion (session-RPE). Daily load, chronic load, and acute:chronic workload ratio (ACWR) were assessed. The Total Quality Recovery (TQR) scale was used to monitor recovery and a 3-day rolling average (3RA) TQR was also measured. Injuries were diagnosed and reported by the medical staff and their reports were used in the analysis. Descriptive statistics were used. The gymnasts presented distinct daily load, ACWR, and recovery patterns, as well as injuries across the competitive periods. All athletes had rapid increase ("spike") in load. Three athletes were underrecovered more than 60% of the time. Four athletes sustained five injuries during the time of the study (all lower limb overuse injuries, two severe, two mild and one slight). Individual factors such as age and chronic load could moderate how each gymnast responds to training and tolerates spikes in load. Moreover, injuries sustained during competitive periods appear to affect the short and long-term careers of gymnasts, as well as impair training and competition organization of the team.

Keywords: gymnastics, injury, ACWR, competition.

INTRODUCTION

Rhythmic gymnastics is an aesthetic sport that demands high technical compliance, and well-developed physical and artistic capacities (Debien et al., 2020; Douda, Toubekis, Avloniti, & Tokmakidis, 2008). Group exercises are performed by five gymnasts at the same time mainly characterized by harmonic collective work (Ávila-Carvalho, Klentrou, & Lebre, 2012). The group competition format requires peak performance during one to four days. Each group presents two different routines in qualification phase and the first eight ranked groups perform these routines again

APPENDIX B – Survey: Coaches (English)

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TRAINING LOAD MANAGEMENT IN RHYTHMIC GYMNASTICS (Coaches)

SURVEY PRESENTATION

Welcome to the survey from the doctoral research entitled "TRAINING LOAD MANAGEMENT IN RHYTHMIC GYMNASTICS".

The questionnaire has 29 questions divided into 2 parts:

1. **General information**
2. **Training load management**

You should take around 20 minutes to finish it.

We thank you in advance, your contribution is extremely important!

geccart | ufjf

TRAINING LOAD MANAGEMENT IN RHYTHMIC GYMNASTICS (Coaches)

CONSENT

We would like to invite you to participate as a volunteer in the doctoral research project entitled "TRAINING LOAD MANAGEMENT IN RHYTHMIC GYMNASTICS". We believe that is necessary to understand what rhythmic gymnastics coaches, medical staff, and gymnasts do and think about training load and try to bridge the gap between science and practice. This study aims to identify and analyze practices and perceptions of rhythmic gymnasts and professionals about training load management, as well as propose a model applied to rhythmic gymnastics.

If you agree to participate, you will answer a questionnaire with 29 questions about your practices and perceptions about rhythmic gymnastics training. This research presents a few small risks related to the application of surveys including tiredness and discomfort. However, we ensure the anonymity of your personal data. Furthermore, we would encourage you to complete the survey in a quiet place where you are most comfortable.

We hope to contribute to the scientific evidence in rhythmic gymnastics, contribute to evidence-based practices and also try to develop a model of training load management that could help to avoid negative effects to training, the achievement of better performances, and contribute to longer and healthier careers.

You will not have costs or receive money to participate. You will receive all the information you want about this research. Feel free to participate or not. Even if you decide to participate now, you can decline participation at any time. Your involvement is voluntary and if you refuse to participate,

you will not be penalized in any way. The researcher will not share your name. The results will be available when the research is done. Your name or any other information that indicates your participation will not be shared without your approval. You will not be identified in any further publication.

Collected data will be stored with the main researcher for 5 (five) years. After that, the researcher will destroy the data based on current laws. Researchers will treat your identity with professionalism and privacy, as demanded by Brazilian laws (Resolution n° 466/12 CNS), using information just for scientific and academic needs.

Completing the questionnaire, you affirm agreement of participation in this research and state that we gave you the opportunity to read the above information and ask any questions relating to the research.

Main researcher: Paula Barreiros Debien

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Phone: BRA +55 31 99213-6457/AUS +61 0410 062 540

Email: paulinhadebien@hotmail.com

In case of questions related to ethics, you may get in touch with:

CEP – Ethical Committee of Research with Humans (UFJF)

Phone: +55 32 2102- 3788 / Email: cep.propesq@ufjf.edu.br

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TRAINING LOAD MANAGEMENT IN RHYTHMIC GYMNASTICS (Coaches)

PART 1: GENERAL INFORMATION

Please, answer the following questions based on your current rhythmic gymnastics training environment.

1. What is your email?

____

2. What is your date of birth?
(DD/MM/YYYY)

____

3. In what country were you born?

____

4. In what country do you currently work?

[ ]

5. What is the name of your team/club?

(Example: Australian National Team, Flamengo, etc.)

[ ]

6. Which is your current job title in your team/club?

- ○ Coach
- ○ Assistant coach
- ○ Strength and conditioning coach
- ○ Other (specify)

[ ]

7. Do you have a bachelor's degree in Sports Science or any other equivalent degree?

- ○ Yes
- ○ I am an undergraduate student
- ○ No

8. Were you a rhythmic gymnast before becoming a coach?

- ○ Yes
- ○ No

9. Which year did you start your career as a rhythmic gymnastics coach?

(YYYY)

[ ]

10. As a rhythmic gymnastics coach, do you have any of the following FIG Academy courses/brevet?

Choose one answer for each line.

	Yes	No
L1	○	○
L2	○	○
L3	○	○
LBR	○	○
LHB	○	○

11. As a rhythmic gymnastics coach, have you ever participated in any of the following competitions?

The National Championships refer to the highest level championships in your country.

Choose at least one answer for each line.

	Current Olympic cycle (2017-2020)	Previous Olympic cycles	No
National Championship - Junior	☐	☐	☐
National Championship - Senior	☐	☐	☐
Continental Championship - Junior	☐	☐	☐
Continental Championship - Senior	☐	☐	☐
Continental Games	☐	☐	☐
Youth Olympic Games	☐	☐	☐
Olympic Games	☐	☐	☐
World Championship - Junior	☐	☐	☐
World Championship	☐	☐	☐
FIG World Cup	☐	☐	☐
Other International Championships or Tournaments (Junior or Senior)	☐	☐	☐
National Championship - Age Group	☐	☐	☐
International Championship - Age Group	☐	☐	☐
Regional and/or National Tournaments (any age)	☐	☐	☐

12. Considering just the gymnasts who participate in national and/or international competitions AND who train at least 15 hours per week, how many gymnasts of at least 9 years of age old do you coach?

Insert the number of gymnasts for each age group. In case you do not coach that age group, insert 0 (zero).

9 to 10 years	
11 to 12 years	
13 to 15 years	
16 years or more	

13. How many of the following professionals are in the coaching/medical staff of your team?

Choose the number of full-time and part-time professionals for each type. In case your team/club does not have, select 0 (zero).

	Full-time	Part-time
Coach		
Assistant coach		
Ballet teacher		
Choreographer		
Strength and conditioning coach		
Physiotherapist		
Nutritionist/dietitian		
Doctor		
Psychologist		
Physiologist		
Sport scientist		
Biomechanist		

Other (specify)

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TRAINING LOAD MANAGEMENT IN RHYTHMIC GYMNASTICS (Coaches)

PART 2 - TRAINING LOAD MANAGEMENT

In this survey, "training load management" consists of procedures adopted to quantify and understand the training doses and consequent athletes' responses in order to optimize the training process.

14. How often does the coaching/medical staff use each of the following methods to monitor external training load ("work" performed by the gymnast) of your gymnasts?

Choose one answer to each line.

	Every session	Daily	Weekly	Monthly	Each 2 to 5 months	Each semester	Yearly	Never	I don't know
Training duration	○	○	○	○	○	○	○	○	○
Number of repetitions (elements, routines)	○	○	○	○	○	○	○	○	○
GPS, inertial sensors	○	○	○	○	○	○	○	○	○
Coaches' perception	○	○	○	○	○	○	○	○	○

Other (specify)

15. How often does the coaching/medical staff use each of the following methods to monitor internal training load (gymnast "response" to performing external load) of your gymnasts?

Choose one answer to each line.

	Every session	Daily	Weekly	Monthly	Each 2 to 5 months	Each semester	Yearly	Never	I don't know
Session rating of perceived exertion (session-RPE)	○	○	○	○	○	○	○	○	○
Heart rate	○	○	○	○	○	○	○	○	○
Gymnasts' personal notes (diary)	○	○	○	○	○	○	○	○	○
Coaches' perception	○	○	○	○	○	○	○	○	○

Other (specify)

16. How often does the coaching/medical staff use each of the following methods to monitor your gymnasts' recovery/fatigue?

Choose one answer to each line.

	Every session	Daily	Weekly	Monthly	Each 2 to 5 months	Each semester	Yearly	Never	I don't know
Questionnaires or self-report measures	○	○	○	○	○	○	○	○	○
Physiological marker (e.g., CK, cortisol, etc.)	○	○	○	○	○	○	○	○	○
Physical test	○	○	○	○	○	○	○	○	○
Coaches' perception	○	○	○	○	○	○	○	○	○

Other (specify)

17. How often does the coaching/medical staff use each of the following methods to monitor your gymnasts' performance?

Choose one answer to each line.

	Every session	Daily	Weekly	Monthly	Each 2 to 5 months	Each semester	Yearly	Never	I don't know
Physical test	○	○	○	○	○	○	○	○	○
Number of hits in repetitions	○	○	○	○	○	○	○	○	○
Routine evaluation (simulate judging)	○	○	○	○	○	○	○	○	○
Coaches' perception	○	○	○	○	○	○	○	○	○

Other (specify)

18. How often are the following variables monitored in your gymnasts?

Choose one answer to each line.

	Every session	Daily	Weekly	Monthly	Each 2 to 5 months	Each semester	Yearly	Never	I don't know
Nutritional status	○	○	○	○	○	○	○	○	○
Body weight	○	○	○	○	○	○	○	○	○
% body fat	○	○	○	○	○	○	○	○	○
Soreness	○	○	○	○	○	○	○	○	○
Sleep	○	○	○	○	○	○	○	○	○
Mood	○	○	○	○	○	○	○	○	○
Stress	○	○	○	○	○	○	○	○	○
Well-being	○	○	○	○	○	○	○	○	○
Thermography	○	○	○	○	○	○	○	○	○
Injuries	○	○	○	○	○	○	○	○	○
Physiological responses	○	○	○	○	○	○	○	○	○

Other (specify)

19. Considering the training load management of your gymnasts, how are the monitored variables recorded?

Choose one answer to each line.

	Yes	No	I don't know
Specific software or platform (athlete monitoring system, app, cloud, etc.)	○	○	○
Custom-made digital spreadsheet (Excel, Google, etc.)	○	○	○
Pen and paper	○	○	○

Other (specify)

20. Considering the training load management of your gymnasts, how are the monitored variables analyzed?

Choose one answer to each line.

	Yes	No	I don't know
Automatic analysis made by commercially available software or platform (athlete monitoring system, app, cloud, etc.)	○	○	○
Descriptive and inferential statistics	○	○	○
Machine learning predictive analysis	○	○	○
Traffic-light system flagging red, amber or green	○	○	○

Other (specify)

21. Are any of the following parameters analyzed during the training load management process of your gymnasts?

Choose one answer to each line.

	Yes	No	I don't know
Acute:chronic workload ratio (ACWR)	○	○	○
% of training load change per week compared to previous week	○	○	○
Absolute training load magnitude (acute load)	○	○	○
Quartile in relation to maximal training load	○	○	○
Chronic load	○	○	○
Individual values in relation to the group values	○	○	○
External and internal load relation	○	○	○

Other (specify)

22. How is the training load information of your gymnasts communicated to the staff?

Choose one answer to each line.

	Yes	No	I don't know
Sending reports	○	○	○
Formal meetings	○	○	○
Informal talks	○	○	○
Punctual information by email or instantaneous message app	○	○	○

Other (specify)

23. How often does the training load data of your gymnasts get <u>shared and discussed</u> amongst the following groups of stakeholders?

Choose one answer to each line.

	Every session	Daily	Weekly	Monthly	Each 2 to 5 months	Each semester	Yearly	Never	I don't know
Only amongst coaches	◯	◯	◯	◯	◯	◯	◯	◯	◯
Only amongst medical staff	◯	◯	◯	◯	◯	◯	◯	◯	◯
Coaches and medical staff	◯	◯	◯	◯	◯	◯	◯	◯	◯
Coaches and gymnasts	◯	◯	◯	◯	◯	◯	◯	◯	◯
Medical staff and gymnasts	◯	◯	◯	◯	◯	◯	◯	◯	◯
Coaches, medical staff, and gymnasts	◯	◯	◯	◯	◯	◯	◯	◯	◯

Other (specify)

____

24. How often are each of the following stages of training load management of your gymnasts done?

Choose one answer to each line.

	Every session	Daily	Weekly	Monthly	Each 2 to 5 months	Each semester	Yearly	Never	I don't know
Record	◯	◯	◯	◯	◯	◯	◯	◯	◯
Analysis	◯	◯	◯	◯	◯	◯	◯	◯	◯
Communication	◯	◯	◯	◯	◯	◯	◯	◯	◯
Adjustment	◯	◯	◯	◯	◯	◯	◯	◯	◯

25. How do you rate the quality of the following aspects of the training load management of your gymnasts?

Choose one answer to each line.

	Not at all good	Slightly good	Somewhat good	Very good	Extremely good
Measuring external load	◯	◯	◯	◯	◯
Measuring internal load	◯	◯	◯	◯	◯
Measuring recovery/fatigue	◯	◯	◯	◯	◯
Measuring performance	◯	◯	◯	◯	◯
Recording the data monitored	◯	◯	◯	◯	◯
Analyzing the data	◯	◯	◯	◯	◯
Communicating among the staff	◯	◯	◯	◯	◯
Giving feedback to the gymnasts	◯	◯	◯	◯	◯
Adjusting future training loads	◯	◯	◯	◯	◯

26. How effective do you think the current training load management of your gymnasts <u>is</u> at achieving the following objectives?

Choose one answer to each line.

	Not at all effective	Slightly effective	Somewhat effective	Very effective	Extremely effective
Improve gymnasts' performance	◯	◯	◯	◯	◯
Decrease injury incidence	◯	◯	◯	◯	◯
Analyze training program efficacy	◯	◯	◯	◯	◯
Avoid insufficient recovery	◯	◯	◯	◯	◯
Avoid high accumulated fatigue	◯	◯	◯	◯	◯
Manage training load distribution	◯	◯	◯	◯	◯

Other (specify)

____

27. In general, how often do you think the following situations occur with your gymnasts?

Choose one answer to each line.

	Never	Rarely	Sometimes	Very often	Always
Overuse injuries	◯	◯	◯	◯	◯
Severe injuries (high time-loss)	◯	◯	◯	◯	◯
Injury reccurence	◯	◯	◯	◯	◯
Underrecovery	◯	◯	◯	◯	◯
Excessive fatigue accumulation	◯	◯	◯	◯	◯
Nutritional disorders	◯	◯	◯	◯	◯
Low energy availability	◯	◯	◯	◯	◯

28. How important are each of the following variables for training load management in rhythmic gymnastics?

Choose one answer to each line.

	Not at all important	Slightly important	Somewhat important	Very important	Extremely important
External load	◯	◯	◯	◯	◯
Internal load	◯	◯	◯	◯	◯
Recovery/fatigue	◯	◯	◯	◯	◯
Performance	◯	◯	◯	◯	◯
Nutritional status	◯	◯	◯	◯	◯
Body mass	◯	◯	◯	◯	◯
% of body fat	◯	◯	◯	◯	◯
Soreness	◯	◯	◯	◯	◯
Sleep	◯	◯	◯	◯	◯
Mood	◯	◯	◯	◯	◯
Stress	◯	◯	◯	◯	◯
Well-being	◯	◯	◯	◯	◯
Thermography	◯	◯	◯	◯	◯
Injuries	◯	◯	◯	◯	◯
Physiological responses	◯	◯	◯	◯	◯

Other (specify)

29. How effective do you think a specific model of training load management for rhythmic gymnastics could be at achieving the following objectives?

Choose one answer to each line.

	Not at all effective	Slightly effective	Somewhat effective	Very effective	Extremely effective
Improve gymnasts' performance	○	○	○	○	○
Decrease injury incidence	○	○	○	○	○
Analyze training program efficacy	○	○	○	○	○
Avoid insufficient recovery	○	○	○	○	○
Avoid high accumulated fatigue	○	○	○	○	○
Manage training load distribution	○	○	○	○	○

Other (specify)

APPENDIX C – Survey: Coaches (Portuguese)

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CONTROLE DA CARGA DE TREINAMENTO NA GINÁSTICA RÍTMICA (Treinadores)

APRESENTAÇÃO DO QUESTIONÁRIO

Bem-vindo (a) ao questionário da pesquisa "CONTROLE DA CARGA DE TREINAMENTO NA GINÁSTICA RÍTMICA".

O questionário possui 29 questões divididas em 2 partes:

1. **Informações gerais**
2. **Controle da carga de treinamento**

O tempo total de preenchimento é aproximadamente 20 minutos

Desde já, agradecemos pela sua contribuição, ela é extremamente importante!

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CONTROLE DA CARGA DE TREINAMENTO NA GINÁSTICA RÍTMICA (Treinadores)

TERMO DE CONSENTIMENTO LIVRE E ESCLARECIDO

Gostaríamos de convidar você a participar como voluntário (a) da pesquisa "CONTROLE DA CARGA DE TREINAMENTO NA GINÁSTICA RÍTMICA". O motivo que nos leva a realizar esta pesquisa é a necessidade de entender o que os treinadores, equipe médica e ginastas de ginástica rítmica (GR) fazem e pensam em relação ao controle da carga de treinamento e buscar uma aproximação do conhecimento científico e a prática. Nesta pesquisa pretendemos identificar e analisar as práticas e percepções de profissionais e atletas de GR quanto ao controle da carga de treinamento, bem como propor um modelo específico que seja aplicável à GR.

Caso você concorde em participar, você responderá a um questionário contendo 29 perguntas sobre suas práticas e percepções em relação ao treinamento na GR. Esta pesquisa tem alguns riscos mínimos relacionados a aplicação de questionários, como cansaço, desconforto ou constrangimento durante o preenchimento. No entanto, para diminuir a chance desses riscos acontecerem, todos os cuidados serão tomados para assegurar um preenchimento tranquilo e máximo esforço será empregado para garantir o anonimato dos dados individuais. Sugerimos que responda ao questionário em um lugar tranquilo e confortável. Esta pesquisa pode ajudar no aumento de evidências científicas na GR, contribuir para práticas profissionais baseadas em evidências, bem como auxiliar no desenvolvimento de modelos de controle da carga de treinamento na GR que podem colaborar para minimizar efeitos negativos ao treinamento e proporcionar às ginastas carreiras mais saudáveis, duradouras e com melhores resultados.

Para participar deste estudo você não terá nenhum custo, nem receberá qualquer vantagem

financeira. Você terá todas as informações que quiser sobre esta pesquisa e estará livre para participar ou recusar-se a participar. Mesmo que você queira participar agora, você pode voltar atrás ou interromper sua participação a qualquer momento. A sua participação é voluntária e o fato de não querer participar não vai trazer qualquer penalidade ou mudança na forma em que você é atendido (a). Os pesquisadores não vão divulgar seu nome. Os resultados da pesquisa estarão à sua disposição quando finalizada. Seu nome ou o material que indique sua participação não será liberado sem a sua permissão. Você não será identificado (a) em nenhuma publicação que possa resultar.

Os dados coletados na pesquisa ficarão arquivados com a pesquisadora responsável por um período de 5 (cinco) anos. Decorrido este tempo, a pesquisadora avaliará os documentos para a sua destinação final, de acordo com a legislação vigente. Os pesquisadores tratarão a sua identidade com padrões profissionais de sigilo, atendendo a legislação brasileira (Resolução Nº 466/12 do Conselho Nacional de Saúde), utilizando as informações somente para os fins acadêmicos e científicos.

Declaro que concordo em participar da pesquisa e que me foi dada a oportunidade de ler e esclarecer as minhas dúvidas.

Pesquisadora principal: Paula Barreiros Debien

Universidade Federal de Juiz de Fora (UFJF)

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E-mail: paulinhadebien@hotmail.com

Em caso de dúvidas, com respeito aos aspectos éticos desta pesquisa, você poderá consultar:

CEP - Comitê de Ética em Pesquisa com Seres Humanos - UFJF

Campus Universitário da UFJF

Pró-Reitoria de Pós-Graduação e Pesquisa

CEP: 36036-900

Fone: (32) 2102- 3788 / E-mail: cep.propesq@ufjf.edu.br

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CONTROLE DA CARGA DE TREINAMENTO NA GINÁSTICA RÍTMICA (Treinadores)

PARTE 1: INFORMAÇÕES GERAIS

Por favor, responda às questões abaixo de acordo com a atual realidade do treinamento da equipe na qual você atua.

1. Qual o seu e-mail?

[ ]

2. Qual sua data de nascimento?

(DD/MM/AAAA)

[ ]

3. Em qual país você nasceu?

4. Em qual país você trabalha atualmente?

5. Qual o nome do clube/equipe que você atua?

(Exemplo: Seleção Brasileira, Minas Tênis Clube, etc)

6. Qual o seu cargo no clube/equipe que trabalha atualmente?

- ◯ Treinador
- ◯ Auxiliar técnico
- ◯ Preparador físico
- ◯ Outro (especifique)

7. Você é graduado em Educação Física, Ciência do Esporte ou equivalente?

- ◯ Sim
- ◯ Sou estudante de graduação
- ◯ Não

8. Você foi atleta de ginástica rítmica antes de se tornar treinador?

- ◯ Sim
- ◯ Não

9. Em qual ano você iniciou sua carreira de treinador de ginástica rítmica?

(AAAA)

10. Enquanto treinador de ginástica rítmica, você possui algum dos seguintes cursos/brevês da Academia FIG?

Selecione uma resposta para cada linha.

	Sim	Não
L1	◯	◯
L2	◯	◯
L3	◯	◯
LBR	◯	◯
LHB	◯	◯

11. Enquanto treinador de ginástica rítmica, você participou de alguma das seguintes competições?

Os Campeonatos Nacionais se referem aos eventos de maior nível técnico no país.

Selecione pelo menos uma resposta para cada linha/competição.

	Ciclo Olímpico atual (2017-2020)	Ciclos Olímpicos anteriores	Não
Campeonato Nacional Juvenil	☐	☐	☐
Campeonato Nacional Adulto	☐	☐	☐
Campeonato Continental Juvenil	☐	☐	☐
Campeonato Continental Adulto	☐	☐	☐
Jogos Continentais (multiesportivos)	☐	☐	☐
Jogos Olímpicos da Juventude (YOG)	☐	☐	☐
Jogos Olímpicos	☐	☐	☐
Campeonato Mundial Juvenil	☐	☐	☐
Campeonato Mundial	☐	☐	☐
Copa do Mundo FIG	☐	☐	☐
Outros Campeonatos ou Torneios Internacionais (Juvenil e/ou Adulto)	☐	☐	☐
Campeonato Nacional Pré-Infantil e/ou Infantil	☐	☐	☐
Campeonatos Internacionais Age Group	☐	☐	☐
Torneio Regional e/ou Nacional (qualquer categoria)	☐	☐	☐

12. Considerando apenas as ginastas que participam de competições nacionais e/ou internacionais E que treinam pelo menos 15 horas por semana, quantas ginastas com pelo menos 9 anos de idade participam de treinamento sob sua responsabilidade direta atualmente?

Preencha o número de ginastas para cada categoria etária. Caso não treine ginastas de alguma dessas categorias, insira 0 (zero).

9 a 10 anos	
11 a 12 anos	
13 a 15 anos	
16 anos ou mais	

13. Quantos profissionais integram a comissão técnica/médica de sua equipe?

Selecione o número de cada tipo de profissional que trabalha em tempo integral ou parcial junto a sua equipe. Caso não tenha algum tipo de profissional, insira 0 (zero) nas duas colunas.

	Tempo integral	Parcialmente
Treinador		
Auxiliar técnico		
Professor de ballet		
Coreógrafo		
Preparador físico		
Fisioterapeuta		
Nutricionista		
Médico		
Psicólogo		
Fisiologista		
Cientista do esporte		
Biomecânico		

Outro (especifique)

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CONTROLE DA CARGA DE TREINAMENTO NA GINÁSTICA RÍTMICA (Treinadores)

PARTE 2 - CONTROLE DA CARGA DE TREINAMENTO

Nesta pesquisa, a expressão "controle da carga de treinamento" consiste no conjunto de procedimentos adotados para quantificar e compreender as doses de treinamento e consequentes respostas dos atletas, na tentativa de otimizar o processo de treinamento.

14. Com qual frequência a comissão técnica/médica usa cada um dos métodos abaixo para monitorar a carga externa de treinamento (treinamento prescrito e realizado pelas ginastas) das suas ginastas?

Selecione uma resposta para cada linha.

	Todas as sessões	Diariamente	Semanalmente	Mensalmente	De 2 a 5 meses	Semestralmente	Anualmente	Nunca	Não sei
Duração do treino	○	○	○	○	○	○	○	○	○
Número de repetições (elementos, séries)	○	○	○	○	○	○	○	○	○
Tecnologia de posicionamento/movimento (GPS, acelerômetro, etc.)	○	○	○	○	○	○	○	○	○
Percepção do treinador	○	○	○	○	○	○	○	○	○

Outro (especifique)

15. Com qual frequência a comissão técnica/médica usa cada um dos métodos abaixo para monitorar a carga interna de treinamento ("resposta" do organismo da ginasta ao treinamento realizado) das suas ginastas?

Selecione uma resposta para cada linha.

	Todas as sessões	Diariamente	Semanalmente	Mensalmente	De 2 a 5 meses	Semestralmente	Anualmente	Nunca	Não sei
Percepção subjetiva do esforço (PSE) da sessão	○	○	○	○	○	○	○	○	○
Frequência cardíaca	○	○	○	○	○	○	○	○	○
Anotações pessoais das ginastas (diário)	○	○	○	○	○	○	○	○	○
Percepção do treinador	○	○	○	○	○	○	○	○	○

Outro (especifique)

16. Com qual frequência a comissão técnica/médica usa cada um dos métodos abaixo para monitorar a recuperação/fadiga das suas ginastas?

Selecione uma resposta para cada linha.

	Todas as sessões	Diariamente	Semanalmente	Mensalmente	De 2 a 5 meses	Semestralmente	Anualmente	Nunca	Não sei
Questionários e/ou escalas de auto relato	◯	◯	◯	◯	◯	◯	◯	◯	◯
Marcador fisiológico (creatina kinase, cortisol, etc.)	◯	◯	◯	◯	◯	◯	◯	◯	◯
Testes de capacidades físicas	◯	◯	◯	◯	◯	◯	◯	◯	◯
Percepção do treinador	◯	◯	◯	◯	◯	◯	◯	◯	◯

Outro (especifique)

17. Com qual frequência a comissão técnica/médica usa cada um dos métodos abaixo para monitorar o desempenho das suas ginastas?

Selecione uma resposta para cada linha.

	Todas as sessões	Diariamente	Semanalmente	Mensalmente	De 2 a 5 meses	Semestralmente	Anualmente	Nunca	Não sei
Testes de capacidades físicas	◯	◯	◯	◯	◯	◯	◯	◯	◯
Quantidade de acertos nas repetições	◯	◯	◯	◯	◯	◯	◯	◯	◯
Avaliação da série inteira (simulação de arbitragem)	◯	◯	◯	◯	◯	◯	◯	◯	◯
Percepção do treinador	◯	◯	◯	◯	◯	◯	◯	◯	◯

Outro (especifique)

18. Com qual frequência as variáveis abaixo são monitoradas nas suas ginastas?

Selecione uma resposta para cada linha.

	Todas as sessões	Diariamente	Semanalmente	Mensalmente	De 2 a 5 meses	Semestralmente	Anualmente	Nunca	Não sei
Estado nutricional	◯	◯	◯	◯	◯	◯	◯	◯	◯
Massa corporal	◯	◯	◯	◯	◯	◯	◯	◯	◯
% de gordura corporal	◯	◯	◯	◯	◯	◯	◯	◯	◯
Dor	◯	◯	◯	◯	◯	◯	◯	◯	◯
Sono	◯	◯	◯	◯	◯	◯	◯	◯	◯
Humor	◯	◯	◯	◯	◯	◯	◯	◯	◯
Estresse	◯	◯	◯	◯	◯	◯	◯	◯	◯
Bem-estar	◯	◯	◯	◯	◯	◯	◯	◯	◯
Termografia	◯	◯	◯	◯	◯	◯	◯	◯	◯
Lesões	◯	◯	◯	◯	◯	◯	◯	◯	◯
Respostas fisiológicas	◯	◯	◯	◯	◯	◯	◯	◯	◯

Outro (especifique)

____

19. Como os dados das variáveis monitoradas no treinamento das suas ginastas são registrados?

Selecione uma resposta para cada linha.

	Sim	Não	Não sei
Software ou plataforma especializada (aplicativo, nuvem, programa, etc.)	◯	◯	◯
Planilha digital customizada (Excel, Google, etc.)	◯	◯	◯
Caneta e papel	◯	◯	◯

Outro (especifique)

____

20. Como os dados das variáveis monitoradas no treinamento das suas ginastas são analisados?

Selecione uma resposta para cada linha.

	Sim	Não	Não sei
Análise automática feita por software/plataforma disponível no mercado (app, nuvem, programa, etc.)	○	○	○
Análise estatística descritiva e inferencial	○	○	○
Análise preditiva por meio de aprendizado de máquina (inteligência artificial)	○	○	○
Sistema de "luzes de trânsito", sinalizando vermelho, amarelo ou verde	○	○	○

Outro (especifique)

21. Algum dos parâmetros abaixo são analisados durante o processo de controle da carga de treinamento das suas ginastas?

Selecione uma resposta para cada linha.

	Sim	Não	Não sei
Relação da carga aguda e crônica (ACWR)	○	○	○
% de alteração da carga em relação à semana anterior	○	○	○
Magnitude absoluta da carga	○	○	○
Magnitude da carga em relação ao máximo	○	○	○
Carga crônica	○	○	○
Relação dos valores individuais em relação ao grupo	○	○	○
Relação da carga interna e externa	○	○	○

Outro (especifique)

22. Como as informações do contole da carga de treinamento das suas ginastas são comunicadas à comissão técnica/médica?

Selecione uma resposta para cada linha.

	Sim	Não	Não sei
Envio de relatório	○	○	○
Reuniões formais	○	○	○
Conversas informais	○	○	○
Informações pontuais por e-mail ou aplicativo de mensagem instantânea	○	○	○

Outro (especifique)

23. Com qual frequência os dados de carga de treinamento das suas ginastas são compartilhados e discutidos entre os seguintes grupos de pessoas?

Selecione uma resposta para cada linha.

	Todas as sessões	Diariamente	Semanalmente	Mensalmente	De 2 a 5 meses	Semestralmente	Anualmente	Nunca	Não sei
Apenas entre os treinadores	○	○	○	○	○	○	○	○	○
Apenas entre a equipe médica	○	○	○	○	○	○	○	○	○
Treinadores e equipe médica	○	○	○	○	○	○	○	○	○
Treinadores e ginastas	○	○	○	○	○	○	○	○	○
Equipe médica e ginastas	○	○	○	○	○	○	○	○	○
Treinadores, equipe médica e ginastas	○	○	○	○	○	○	○	○	○

Outro (especifique)

24. Qual a frequência de realização de cada uma das etapas do controle da carga de treinamento das suas ginastas?

Selecione uma resposta para cada linha.

	Todas as sessões	Diariamente	Semanalmente	Mensalmente	De 2 a 5 meses	Semestralmente	Anualmente	Nunca	Não sei
Registro	◯	◯	◯	◯	◯	◯	◯	◯	◯
Análise	◯	◯	◯	◯	◯	◯	◯	◯	◯
Comunicação	◯	◯	◯	◯	◯	◯	◯	◯	◯
Ajuste	◯	◯	◯	◯	◯	◯	◯	◯	◯

25. Como você avalia a qualidade dos seguintes aspectos do controle da carga de treinamento das suas ginastas?

Selecione uma resposta para cada linha.

	Não é bom	Pouco bom	Moderadamente bom	Muito bom	Extremamente bom
Quantificação da carga externa de treinamento	◯	◯	◯	◯	◯
Quantificação da carga interna de treinamento	◯	◯	◯	◯	◯
Quantificação da recuperação/fadiga	◯	◯	◯	◯	◯
Quantificação do desempenho	◯	◯	◯	◯	◯
Registro dos dados monitorados	◯	◯	◯	◯	◯
Análise dos dados	◯	◯	◯	◯	◯
Comunicação entre os membros da comissão técnica/médica	◯	◯	◯	◯	◯
Fornecer feedback às ginastas	◯	◯	◯	◯	◯
Ajuste das futuras cargas de treinamento	◯	◯	◯	◯	◯

26. Como você avalia a eficácia do controle da carga de treinamento das suas ginastas em relação a atingir os seguintes objetivos?

Selecione uma resposta para cada linha.

	Não é eficaz	Pouco eficaz	Moderadamente eficaz	Muito eficaz	Extremamente eficaz
Melhorar o desempenho das ginastas	◯	◯	◯	◯	◯
Diminuir incidência de lesões	◯	◯	◯	◯	◯
Analisar a eficácia do programa de treinamento	◯	◯	◯	◯	◯
Evitar recuperação insuficiente	◯	◯	◯	◯	◯
Evitar acúmulo excessivo de fadiga	◯	◯	◯	◯	◯
Controlar a distribuição das cargas de treinamento	◯	◯	◯	◯	◯

27. Em geral, com qual frequência você acha que as seguintes situações ocorrem com suas ginastas?

Selecione uma resposta para cada linha.

	Nunca	Raramente	Algumas vezes	Muito frequente	Sempre
Lesões por sobrecarga (overuse)	◯	◯	◯	◯	◯
Lesões graves (elevado tempo de afastamento)	◯	◯	◯	◯	◯
Recorrência de lesões prévias	◯	◯	◯	◯	◯
Recuperação insuficiente	◯	◯	◯	◯	◯
Acúmulo excessivo de fadiga	◯	◯	◯	◯	◯
Distúrbios alimentares	◯	◯	◯	◯	◯
Baixa disponibilidade de energia	◯	◯	◯	◯	◯

28. Qual o nível de importância de cada uma das variáveis abaixo para o controle da carga de treinamento na ginástica rítmica?

Selecione uma resposta para cada linha.

	Não é importante	Pouco importante	Moderadamente importante	Muito importante	Extremamente importante
Carga externa	○	○	○	○	○
Carga interna	○	○	○	○	○
Recuperação/fadiga	○	○	○	○	○
Desempenho	○	○	○	○	○
Estado nutricional	○	○	○	○	○
Massa corporal	○	○	○	○	○
% de gordura corporal	○	○	○	○	○
Dor	○	○	○	○	○
Sono	○	○	○	○	○
Humor	○	○	○	○	○
Estresse	○	○	○	○	○
Bem-estar	○	○	○	○	○
Termografia	○	○	○	○	○
Lesões	○	○	○	○	○
Respostas fisiológicas	○	○	○	○	○

Outro (especifique)

29. O quão eficaz você acha que um modelo específico de controle da carga de treinamento para a ginástica rítmica poderia ser na conquista dos seguintes objetivos?

Selecione uma resposta para cada linha.

	Não seria eficaz	Pouco eficaz	Moderadamente eficaz	Muito eficaz	Extremamente eficaz
Melhorar o desempenho das ginastas	○	○	○	○	○
Diminuir incidência de lesões	○	○	○	○	○
Analisar a eficácia do programa de treinamento	○	○	○	○	○
Evitar recuperação insuficiente	○	○	○	○	○
Evitar acúmulo excessivo de fadiga	○	○	○	○	○
Controlar a distribuição das cargas de treinamento	○	○	○	○	○

APPENDIX D – Survey: Medical staff (English)

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TRAINING LOAD MANAGEMENT IN RHYTHMIC GYMNASTICS (Medical staff)

SURVEY PRESENTATION

Welcome to the survey from the doctoral research entitled "TRAINING LOAD MANAGEMENT IN RHYTHMIC GYMNASTICS".

The survey has 25 questions divided into 2 parts:

1. **General information**
2. **Training load management**

You should take around 20 minutes to finish it.

We thank you in advance, your contribution is extremely important!

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TRAINING LOAD MANAGEMENT IN RHYTHMIC GYMNASTICS (Medical staff)

CONSENT

We would like to invite you to participate as a volunteer in the doctoral research project entitled "TRAINING LOAD MANAGEMENT IN RHYTHMIC GYMNASTICS". We believe that is necessary to understand what rhythmic gymnastics coaches, medical staff, and gymnasts do and think about training load and try to bridge the gap between science and practice. This study aims to identify and analyze practices and perceptions of rhythmic gymnasts and professionals about training load management, as well as propose a model applied to rhythmic gymnastics.

If you agree to participate, you will answer a questionnaire with 25 questions about your practices and perceptions about rhythmic gymnastics training. This research presents a few small risks related to the application of surveys including tiredness and discomfort. However, we ensure the anonymity of your personal data. Furthermore, we would encourage you to complete the survey in a quiet place where you are most comfortable.

We hope to contribute to the scientific evidence in rhythmic gymnastics, contribute to evidence-based practices and also try to develop a model of training load management that could help to avoid negative effects to training, the achievement of better performances, and contribute to longer and healthier careers.

You will not have costs or receive money to participate. You will receive all the information you want about this research. Feel free to participate or not. Even if you decide to participate now, you can decline participation at any time. Your involvement is voluntary and if you refuse to participate,

you will not be penalized in any way. The researcher will not share your name. The results will be available when the research is done. Your name or any other information that indicates your participation will not be shared without your approval. You will not be identified in any further publication.

Collected data will be stored with the main researcher for 5 (five) years. After that, the researcher will destroy the data based on current laws. Researchers will treat your identity with professionalism and privacy, as demanded by Brazilian laws (Resolution n° 466/12 CNS), using information just for scientific and academic needs.

Completing the questionnaire, you affirm agreement of participation in this research and state that we gave you the opportunity to read the above information and ask any questions relating to the research.

Main researcher: Paula Barreiros Debien

Federal University of Juiz de Fora (UFJF)

Phone: BRA +55 31 99213-6457/AUS +61 0410 062 540

Email: paulinhadebien@hotmail.com

In case of questions related to ethics, you may get in touch with:

CEP – Ethical Committee of Research with Humans (UFJF)

Phone: +55 32 2102- 3788 / Email: cep.propesq@ufjf.edu.br

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TRAINING LOAD MANAGEMENT IN RHYTHMIC GYMNASTICS (Medical staff)

PART 1: GENERAL INFORMATION

Please, answer the following questions based on your current rhythmic gymnastics training environment.

1. What is your email?

____

2. What is your date of birth?

(DD/MM/YYYY)

____

3. In what country were you born?

____

4. In what country do you currently work?

____

5. What is the name of the rhythmic gymnastics team/club you currently work (or is related to)?

(Example: Australian National Team, Flamengo, etc.)

6. Which is your current job title in your team/club?

- Doctor
- Physiotherapist
- Nutritionist/dietician
- Other (specify)

7. Were you a rhythmic gymnast before becoming a medical staff?

- Yes
- No

8. Which year did you start your career as a rhythmic gymnastics medical staff?

(YYYY)

9. As a rhythmic gymnastics medical staff, have you ever participated in any of the following competitions?

The National Championships refer to the highest level championships in your country.

Choose at least one answer for each line.

	Current Olympic cycle (2017-2020)	Previous Olympic cycles	No
National Championship - Junior	☐	☐	☐
National Championship - Senior	☐	☐	☐
Continental Championship - Junior	☐	☐	☐
Continental Championship - Senior	☐	☐	☐
Continental Games	☐	☐	☐
Youth Olympic Games	☐	☐	☐
Olympic Games	☐	☐	☐
World Championship - Junior	☐	☐	☐
World Championship	☐	☐	☐
FIG World Cup	☐	☐	☐
Other International Championships or Tournaments (Junior or Senior)	☐	☐	☐
National Championship – Age Group	☐	☐	☐
International Championship – Age Group	☐	☐	☐
Regional and/or National Tournaments (any age)	☐	☐	☐

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TRAINING LOAD MANAGEMENT IN RHYTHMIC GYMNASTICS (Medical staff)

PART 2 - TRAINING LOAD MANAGEMENT

In this survey, "training load management" consists of procedures adopted to quantify and understand the training doses and consequent athletes' responses in order to optimize the training process.

10. How often does the coaching/medical staff use each of the following methods to monitor external training load ("work" performed by the gymnast) of your gymnasts?

Choose one answer to each line.

	Every session	Daily	Weekly	Monthly	Each 2 to 5 months	Each semester	Yearly	Never	I don't know
Training duration	○	○	○	○	○	○	○	○	○
Number of repetitions (elements, routines)	○	○	○	○	○	○	○	○	○
GPS, inertial sensors	○	○	○	○	○	○	○	○	○
Coaches' perception	○	○	○	○	○	○	○	○	○

Other (specify)

11. How often does the coaching/medical staff use each of the following methods to monitor internal training load (gymnast "response" to performing external load) of your gymnasts?

Choose one answer to each line.

	Every session	Daily	Weekly	Monthly	Each 2 to 5 months	Each semester	Yearly	Never	I don't know
Session rating of perceived exertion (session-RPE)	○	○	○	○	○	○	○	○	○
Heart rate	○	○	○	○	○	○	○	○	○
Gymnasts' personal notes (diary)	○	○	○	○	○	○	○	○	○
Coaches' perception	○	○	○	○	○	○	○	○	○

Other (specify)

12. How often does the coaching/medical staff use each of the following methods to monitor your gymnasts' recovery/fatigue?

Choose one answer to each line.

	Every session	Daily	Weekly	Monthly	Each 2 to 5 months	Each semester	Yearly	Never	I don't know
Questionnaires or self-report measures	○	○	○	○	○	○	○	○	○
Physiological marker (e.g., CK, cortisol, etc.)	○	○	○	○	○	○	○	○	○
Physical test	○	○	○	○	○	○	○	○	○
Coaches' perception	○	○	○	○	○	○	○	○	○

Other (specify)

13. How often does the coaching/medical staff use each of the following methods to monitor your gymnasts' performance?

Choose one answer to each line.

	Every session	Daily	Weekly	Monthly	Each 2 to 5 months	Each semester	Yearly	Never	I don't know
Physical test	○	○	○	○	○	○	○	○	○
Number of hits in repetitions	○	○	○	○	○	○	○	○	○
Routine evaluation (simulate judging)	○	○	○	○	○	○	○	○	○
Coaches' perception	○	○	○	○	○	○	○	○	○

Other (specify)

14. How often are the following variables monitored in your gymnasts?

Choose one answer to each line.

	Every session	Daily	Weekly	Monthly	Each 2 to 5 months	Each semester	Yearly	Never	I don't know
Nutritional status	○	○	○	○	○	○	○	○	○
Body weight	○	○	○	○	○	○	○	○	○
% body fat	○	○	○	○	○	○	○	○	○
Soreness	○	○	○	○	○	○	○	○	○
Sleep	○	○	○	○	○	○	○	○	○
Mood	○	○	○	○	○	○	○	○	○
Stress	○	○	○	○	○	○	○	○	○
Well-being	○	○	○	○	○	○	○	○	○
Thermography	○	○	○	○	○	○	○	○	○
Injuries	○	○	○	○	○	○	○	○	○
Physiological responses	○	○	○	○	○	○	○	○	○

Other (specify)

15. Considering the training load management of your gymnasts, how are the monitored variables recorded?

Choose one answer to each line.

	Yes	No	I don't know
Specific software or platform (athlete monitoring system, app, cloud, etc.)	◯	◯	◯
Custom-made digital spreadsheet (Excel, Google, etc.)	◯	◯	◯
Pen and paper	◯	◯	◯

Other (specify)

16. Considering the training load management of your gymnasts, how are the monitored variables analyzed?

Choose one answer to each line.

	Yes	No	I don't know
Automatic analysis made by commercially available software or platform (athlete monitoring system, app, cloud, etc.)	◯	◯	◯
Descriptive and inferential statistics	◯	◯	◯
Machine learning predictive analysis	◯	◯	◯
Traffic-light system flagging red, amber or green	◯	◯	◯

Other (specify)

17. Are any of the following parameters analyzed during the training load management process of your gymnasts?

Choose one answer to each line.

	Yes	No	I don't know
Acute:chronic workload ratio (ACWR)	◯	◯	◯
% of training load change per week compared to previous week	◯	◯	◯
Absolute training load magnitude (acute load)	◯	◯	◯
Quartile in relation to maximal training load	◯	◯	◯
Chronic load	◯	◯	◯
Individual values in relation to the group values	◯	◯	◯
External and internal load relation	◯	◯	◯

Other (specify)

18. How is the training load information of your gymnasts communicated to the staff?

Choose one answer to each line.

	Yes	No	I don't know
Sending reports	◯	◯	◯
Formal meetings	◯	◯	◯
Informal talks	◯	◯	◯
Punctual information by email or instantaneous message app	◯	◯	◯

Other (specify)

19. How often does the training load data of your gymnasts get shared and discussed amongst the following groups of stakeholders?

Choose one answer to each line.

	Every session	Daily	Weekly	Monthly	Each 2 to 5 months	Each semester	Yearly	Never	I don't know
Only amongst coaches	○	○	○	○	○	○	○	○	○
Only amongst medical staff	○	○	○	○	○	○	○	○	○
Coaches and medical staff	○	○	○	○	○	○	○	○	○
Coaches and gymnasts	○	○	○	○	○	○	○	○	○
Medical staff and gymnasts	○	○	○	○	○	○	○	○	○
Coaches, medical staff, and gymnasts	○	○	○	○	○	○	○	○	○

Other (specify)

20. How often are each of the following stages of training load management of your gymnasts done?

Choose one answer to each line.

	Every session	Daily	Weekly	Monthly	Each 2 to 5 months	Each semester	Yearly	Never	I don't know
Record	○	○	○	○	○	○	○	○	○
Analysis	○	○	○	○	○	○	○	○	○
Communication	○	○	○	○	○	○	○	○	○
Adjustment	○	○	○	○	○	○	○	○	○

21. How do you rate the quality of the following aspects of the training load management of your gymnasts?

Choose one answer to each line.

	Not at all good	Slightly good	Somewhat good	Very good	Extremely good
Measuring external load	◯	◯	◯	◯	◯
Measuring internal load	◯	◯	◯	◯	◯
Measuring recovery/fatigue	◯	◯	◯	◯	◯
Measuring performance	◯	◯	◯	◯	◯
Recording the data monitored	◯	◯	◯	◯	◯
Analyzing the data	◯	◯	◯	◯	◯
Communicating among the staff	◯	◯	◯	◯	◯
Giving feedback to the gymnasts	◯	◯	◯	◯	◯
Adjusting future training loads	◯	◯	◯	◯	◯

22. How effective do you think the current training load management of your gymnasts is at achieving the following objectives?

Choose one answer to each line.

	Not at all effective	Slightly effective	Somewhat effective	Very effective	Extremely effective
Improve gymnasts' performance	◯	◯	◯	◯	◯
Decrease injury incidence	◯	◯	◯	◯	◯
Analyze training program efficacy	◯	◯	◯	◯	◯
Avoid insufficient recovery	◯	◯	◯	◯	◯
Avoid high accumulated fatigue	◯	◯	◯	◯	◯
Manage training load distribution	◯	◯	◯	◯	◯

Other (specify)

23. In general, how often do you think the following situations occur with your gymnasts?

Choose one answer to each line.

	Never	Rarely	Sometimes	Very often	Always
Overuse injuries	◯	◯	◯	◯	◯
Severe injuries (high time-loss)	◯	◯	◯	◯	◯
Injury recurrence	◯	◯	◯	◯	◯
Underrecovery	◯	◯	◯	◯	◯
Excessive fatigue accumulation	◯	◯	◯	◯	◯
Nutritional disorders	◯	◯	◯	◯	◯
Low energy availability	◯	◯	◯	◯	◯

24. How important are each of the following variables for training load management in rhythmic gymnastics?

Choose one answer to each line.

	Not at all important	Slightly important	Somewhat important	Very important	Extremely important
External load	◯	◯	◯	◯	◯
Internal load	◯	◯	◯	◯	◯
Recovery/fatigue	◯	◯	◯	◯	◯
Performance	◯	◯	◯	◯	◯
Nutritional status	◯	◯	◯	◯	◯
Body weight	◯	◯	◯	◯	◯
% of body fat	◯	◯	◯	◯	◯
Soreness	◯	◯	◯	◯	◯
Sleep	◯	◯	◯	◯	◯
Mood	◯	◯	◯	◯	◯
Stress	◯	◯	◯	◯	◯
Well-being	◯	◯	◯	◯	◯
Thermography	◯	◯	◯	◯	◯
Injuries	◯	◯	◯	◯	◯
Physiological responses	◯	◯	◯	◯	◯

Other (specify)

25. How effective do you think a specific model of training load management for rhythmic gymnastics could be at achieving the following objectives?

Choose one answer to each line.

	Not at all effective	Slightly effective	Somewhat effective	Very effective	Extremely effective
Improve gymnasts' performance	○	○	○	○	○
Decrease injury incidence	○	○	○	○	○
Analyze training program efficacy	○	○	○	○	○
Avoid insufficient recovery	○	○	○	○	○
Avoid high accumulated fatigue	○	○	○	○	○
Manage training load distribution	○	○	○	○	○

Other (specify)

APPENDIX E – Survey: Medical staff (Portuguese)

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CONTROLE DA CARGA DE TREINAMENTO NA GINÁSTICA RÍTMICA (Equipe médica)

APRESENTAÇÃO DO QUESTIONÁRIO

Bem-vindo (a) ao questionário da pesquisa "CONTROLE DA CARGA DE TREINAMENTO NA GINÁSTICA RÍTMICA".

O questionário possui 25 questões divididas em 2 partes:

1. **Informações gerais**
2. **Controle da carga de treinamento**

O tempo total de preenchimento é aproximadamente 20 minutos

Desde já, agradecemos pela sua contribuição, ela é extremamente importante!

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CONTROLE DA CARGA DE TREINAMENTO NA GINÁSTICA RÍTMICA (Equipe médica)

TERMO DE CONSENTIMENTO LIVRE E ESCLARECIDO

Gostaríamos de convidar você a participar como voluntário (a) da pesquisa "CONTROLE DA CARGA DE TREINAMENTO NA GINÁSTICA RÍTMICA". O motivo que nos leva a realizar esta pesquisa é a necessidade de entender o que os treinadores, equipe médica e ginastas de ginástica rítmica (GR) fazem e pensam em relação ao controle da carga de treinamento e buscar uma aproximação do conhecimento científico e a prática. Nesta pesquisa pretendemos identificar e analisar as práticas e percepções de profissionais e atletas de GR quanto ao controle da carga de treinamento, bem como propor um modelo específico que seja aplicável à GR.

Caso você concorde em participar, você responderá a um questionário contendo 25 perguntas sobre suas práticas e percepções em relação ao treinamento na GR. Esta pesquisa tem alguns riscos mínimos relacionados a aplicação de questionários, como cansaço, desconforto ou constrangimento durante o preenchimento. No entanto, para diminuir a chance desses riscos acontecerem, todos os cuidados serão tomados para assegurar um preenchimento tranquilo e máximo esforço será empregado para garantir o anonimato dos dados individuais. Sugerimos que responda ao questionário em um lugar tranquilo e confortável. Esta pesquisa pode ajudar no aumento de evidências científicas na GR, contribuir para práticas profissionais baseadas em evidências, bem como auxiliar no desenvolvimento de modelos de controle da carga de treinamento na GR que podem colaborar para minimizar efeitos negativos ao treinamento e proporcionar às ginastas carreiras mais saudáveis, duradouras e com melhores resultados.

Para participar deste estudo você não terá nenhum custo, nem receberá qualquer vantagem

financeira. Você terá todas as informações que quiser sobre esta pesquisa e estará livre para participar ou recusar-se a participar. Mesmo que você queira participar agora, você pode voltar atrás ou interromper sua participação a qualquer momento. A sua participação é voluntária e o fato de não querer participar não vai trazer qualquer penalidade ou mudança na forma em que você é atendido (a). Os pesquisadores não vão divulgar seu nome. Os resultados da pesquisa estarão à sua disposição quando finalizada. Seu nome ou o material que indique sua participação não será liberado sem a sua permissão. Você não será identificado (a) em nenhuma publicação que possa resultar.

Os dados coletados na pesquisa ficarão arquivados com a pesquisadora responsável por um período de 5 (cinco) anos. Decorrido este tempo, a pesquisadora avaliará os documentos para a sua destinação final, de acordo com a legislação vigente. Os pesquisadores tratarão a sua identidade com padrões profissionais de sigilo, atendendo a legislação brasileira (Resolução Nº 466/12 do Conselho Nacional de Saúde), utilizando as informações somente para os fins acadêmicos e científicos.

Declaro que concordo em participar da pesquisa e que me foi dada a oportunidade de ler e esclarecer as minhas dúvidas.

Pesquisadora principal: Paula Barreiros Debien

Universidade Federal de Juiz de Fora (UFJF)

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E-mail: paulinhadebien@hotmail.com

Em caso de dúvidas, com respeito aos aspectos éticos desta pesquisa, você poderá consultar:

CEP - Comitê de Ética em Pesquisa com Seres Humanos - UFJF

Campus Universitário da UFJF

Pró-Reitoria de Pós-Graduação e Pesquisa

CEP: 36036-900

Fone: (32) 2102- 3788 / E-mail: cep.propesq@ufjf.edu.br

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CONTROLE DA CARGA DE TREINAMENTO NA GINÁSTICA RÍTMICA (Equipe médica)

PARTE 1: INFORMAÇÕES GERAIS

Por favor, responda às questões abaixo de acordo com a atual realidade do treinamento da equipe na qual você atua.

1. Qual o seu e-mail?

____

2. Qual sua data de nascimento?

(DD/MM/AAAA)

____

3. Em qual país você nasceu?

4. Em qual país você trabalha atualmente?

5. Qual o nome do clube/equipe que você atua (ou está relacionado)?

(Exemplo: Seleção Brasileira, Minas Tênis Clube, etc)

6. Qual o seu cargo no clube/equipe que trabalha atualmente?

- Médico
- Fisioterapeuta
- Nutricionista
- Outro (especifique)

7. Você foi atleta de ginástica rítmica antes de se tornar membro de equipe médica?

- Sim
- Não

8. Em qual ano você iniciou sua carreira como membro de equipe médica de atletas de ginástica rítmica?

(AAAA)

9. Enquanto membro da equipe médica, você participou de alguma das seguintes competições de ginástica rítmica?

Os Campeonatos Nacionais se referem aos eventos de maior nível técnico no país.

Escolha pelo menos uma resposta para cada linha/competição.

	Ciclo Olímpico atual (2017-2020)	Ciclos Olímpicos anteriores	Não
Campeonato Nacional Juvenil	☐	☐	☐
Campeonato Nacional Adulto	☐	☐	☐
Campeonato Continental Juvenil	☐	☐	☐
Campeonato Continental Adulto	☐	☐	☐
Jogos Continentais (multiesporitivos)	☐	☐	☐
Jogos Olímpicos da Juventude (YOG)	☐	☐	☐
Jogos Olímpicos	☐	☐	☐
Campeonato Mundial Juvenil	☐	☐	☐
Campeonato Mundial	☐	☐	☐
Copa do Mundo FIG	☐	☐	☐
Outros Campeonatos ou Torneios Internacionais (Juvenil e/ou Adulto)	☐	☐	☐
Campeonato Nacional Pré-Infantil e/ou Infantil	☐	☐	☐
Campeonatos Internacionais Age Group	☐	☐	☐
Torneio Regional e/ou Nacional (qualquer categoria)	☐	☐	☐

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CONTROLE DA CARGA DE TREINAMENTO NA GINÁSTICA RÍTMICA (Equipe médica)

PARTE 2 - CONTROLE DA CARGA DE TREINAMENTO

Nesta pesquisa, a expressão “controle da carga de treinamento” consiste no conjunto de procedimentos adotados para quantificar e compreender as doses de treinamento e consequentes respostas dos atletas, na tentativa de otimizar o processo de treinamento.

10. Com qual frequência a comissão técnica/médica usa cada um dos métodos abaixo para monitorar a carga externa de treinamento (treinamento prescrito e realizado pelas ginastas) das suas ginastas?

Selecione uma resposta para cada linha.

	Todas as sessões	Diariamente	Semanalmente	Mensalmente	De 2 a 5 meses	Semestralmente	Anualmente	Nunca	Não sei
Duração do treino	○	○	○	○	○	○	○	○	○
Número de repetições (elementos, séries)	○	○	○	○	○	○	○	○	○
Tecnologia de posicionamento/movimento (GPS, acelerômetro, etc.)	○	○	○	○	○	○	○	○	○
Percepção do treinador	○	○	○	○	○	○	○	○	○

Outro (especifique)

11. Com qual frequência a comissão técnica/médica usa cada um dos métodos abaixo para monitorar a carga interna de treinamento ("resposta" do organismo da ginasta ao treinamento realizado) das suas ginastas?

Selecione uma resposta para cada linha.

	Todas as sessões	Diariamente	Semanalmente	Mensalmente	De 2 a 5 meses	Semestralmente	Anualmente	Nunca	Não sei
Percepção subjetiva do esforço (PSE) da sessão	○	○	○	○	○	○	○	○	○
Frequência cardíaca	○	○	○	○	○	○	○	○	○
Anotações pessoais das ginastas (diário)	○	○	○	○	○	○	○	○	○
Percepção do treinador	○	○	○	○	○	○	○	○	○

Outro (especifique)

12. Com qual frequência a comissão técnica/médica usa cada um dos métodos abaixo para monitorar a recuperação/fadiga das suas ginastas?

Selecione uma resposta para cada linha.

	Todas as sessões	Diariamente	Semanalmente	Mensalmente	De 2 a 5 meses	Semestralmente	Anualmente	Nunca	Não sei
Questionários e/ou escalas de auto relato	○	○	○	○	○	○	○	○	○
Marcador fisiológico (creatina kinase, cortisol, etc.)	○	○	○	○	○	○	○	○	○
Testes de capacidades físicas	○	○	○	○	○	○	○	○	○
Percepção do treinador	○	○	○	○	○	○	○	○	○

Outro (especifique)

13. Com qual frequência a comissão técnica/médica usa cada um dos métodos abaixo para monitorar o desempenho das suas ginastas?

Selecione uma resposta para cada linha.

	Todas as sessões	Diariamente	Semanalmente	Mensalmente	De 2 a 5 meses	Semestralmente	Anualmente	Nunca	Não sei
Testes de capacidades físicas	○	○	○	○	○	○	○	○	○
Quantidade de acertos nas repetições	○	○	○	○	○	○	○	○	○
Avaliação da série inteira (simulação de arbitragem)	○	○	○	○	○	○	○	○	○
Percepção do treinador	○	○	○	○	○	○	○	○	○

Outro (especifique)

14. Com qual frequência as variáveis abaixo são monitoradas nas suas ginastas?

Selecione uma resposta para cada linha.

	Todas as sessões	Diariamente	Semanalmente	Mensalmente	De 2 a 5 meses	Semestralmente	Anualmente	Nunca	Não sei
Estado nutricional	○	○	○	○	○	○	○	○	○
Massa corporal	○	○	○	○	○	○	○	○	○
% de gordura corporal	○	○	○	○	○	○	○	○	○
Dor	○	○	○	○	○	○	○	○	○
Sono	○	○	○	○	○	○	○	○	○
Humor	○	○	○	○	○	○	○	○	○
Estresse	○	○	○	○	○	○	○	○	○
Bem-estar	○	○	○	○	○	○	○	○	○
Termografia	○	○	○	○	○	○	○	○	○
Lesões	○	○	○	○	○	○	○	○	○
Respostas fisiológicas	○	○	○	○	○	○	○	○	○

Outro (especifique)

15. Como os dados das variáveis monitoradas no treinamento das suas ginastas são registrados?

Selecione uma resposta para cada linha.

	Sim	Não	Não sei
Software ou plataforma especializada (aplicativo, nuvem, programa, etc.)	○	○	○
Planilha digital customizada (Excel, Google, etc.)	○	○	○
Caneta e papel	○	○	○

Outro (especifique)

16. Como os dados das variáveis monitoradas no treinamento das suas ginastas são analisados?

Selecione uma resposta para cada linha.

	Sim	Não	Não sei
Análise automática feita por software/plataforma disponível no mercado (app, nuvem, programa, etc.)	○	○	○
Análise estatística descritiva e inferencial	○	○	○
Análise preditiva por meio de aprendizado de máquina (inteligência artificial)	○	○	○
Sistema de "luzes de trânsito", sinalizando vermelho, amarelo ou verde	○	○	○

Outro (especifique)

17. Algum dos parâmetros abaixo são analisados durante o processo de controle da carga do treinamento das suas ginastas?

Selecione uma resposta para cada linha.

	Sim	Não	Não sei
Relação da carga aguda e crônica (ACWR)	○	○	○
% de alteração da carga em relação à semana anterior	○	○	○
Magnitude absoluta da carga	○	○	○
Magnitude da carga em relação ao máximo	○	○	○
Carga crônica	○	○	○
Relação dos valores individuais em relação ao grupo	○	○	○
Relação da carga interna e externa	○	○	○

Outro (especifique)

18. Como as informações da carga de treinamento das suas ginastas são comunicadas à comissão técnica/médica?

Selecione uma resposta para cada linha.

	Sim	Não	Não sei
Envio de relatório	◯	◯	◯
Reuniões formais	◯	◯	◯
Conversas informais	◯	◯	◯
Informações pontuais por e-mail ou aplicativo de mensagem instantânea	◯	◯	◯

Outro (especifique)

19. Com qual frequência os dados de carga de treinamento das suas ginastas são compartilhados e discutidos entre os seguintes grupos de pessoas?

Selecione uma resposta para cada linha.

	Todas as sessões	Diariamente	Semanalmente	Mensalmente	De 2 a 5 meses	Semestralmente	Anualmente	Nunca	Não sei
Apenas entre os treinadores	◯	◯	◯	◯	◯	◯	◯	◯	◯
Apenas entre a equipe médica	◯	◯	◯	◯	◯	◯	◯	◯	◯
Treinadores e equipe médica	◯	◯	◯	◯	◯	◯	◯	◯	◯
Treinadores e ginastas	◯	◯	◯	◯	◯	◯	◯	◯	◯
Equipe médica e ginastas	◯	◯	◯	◯	◯	◯	◯	◯	◯
Treinadores, equipe médica e ginastas	◯	◯	◯	◯	◯	◯	◯	◯	◯

Outro (especifique)

20. Qual a frequência de realização de cada uma das etapas do controle da carga de treinamento das suas ginastas?

Selecione uma resposta para cada linha.

	Todas as sessões	Diariamente	Semanalmente	Mensalmente	De 2 a 5 meses	Semestralmente	Anualmente	Nunca	Não sei
Registro	◯	◯	◯	◯	◯	◯	◯	◯	◯
Análise	◯	◯	◯	◯	◯	◯	◯	◯	◯
Comunicação	◯	◯	◯	◯	◯	◯	◯	◯	◯
Ajuste	◯	◯	◯	◯	◯	◯	◯	◯	◯

21. Como você avalia a qualidade dos seguintes aspectos do controle da carga de treinamento das suas ginastas?

Selecione uma resposta para cada linha.

	Não é bom	Pouco bom	Moderadamente bom	Muito bom	Extremamente bom
Quantificação da carga externa de treinamento	◯	◯	◯	◯	◯
Quantificação da carga interna de treinamento	◯	◯	◯	◯	◯
Quantificação da recuperação/fadiga	◯	◯	◯	◯	◯
Quantificação do desempenho	◯	◯	◯	◯	◯
Registro dos dados monitorados	◯	◯	◯	◯	◯
Análise dos dados	◯	◯	◯	◯	◯
Comunicação entre os membros da comissão técnica/médica	◯	◯	◯	◯	◯
Fornecer feedback às ginastas	◯	◯	◯	◯	◯
Ajuste das futuras cargas de treinamento	◯	◯	◯	◯	◯

22. Como você avalia a eficácia do controle da carga de treinamento das suas ginastas em relação a atingir os seguintes objetivos?

Selecione uma resposta para cada linha.

	Não é eficaz	Pouco eficaz	Moderadamente eficaz	Muito eficaz	Extremamente eficaz
Melhorar o desempenho das ginastas	◯	◯	◯	◯	◯
Diminuir incidência de lesões	◯	◯	◯	◯	◯
Analisar a eficácia do programa de treinamento	◯	◯	◯	◯	◯
Evitar recuperação insuficiente	◯	◯	◯	◯	◯
Evitar acúmulo excessivo de fadiga	◯	◯	◯	◯	◯
Controlar a distribuição das cargas de treinamento	◯	◯	◯	◯	◯

23. Em geral, com qual frequência você acha que as seguintes situações ocorrem com suas ginastas?

Selecione uma resposta para cada linha.

	Nunca	Raramente	Algumas vezes	Muito frequente	Sempre
Lesões por sobrecarga (overuse)	◯	◯	◯	◯	◯
Lesões graves (elevado tempo de afastamento)	◯	◯	◯	◯	◯
Recorrência de lesões prévias	◯	◯	◯	◯	◯
Recuperação insuficiente	◯	◯	◯	◯	◯
Acúmulo excessivo de fadiga	◯	◯	◯	◯	◯
Distúrbios alimentares	◯	◯	◯	◯	◯
Baixa disponibilidade de energia	◯	◯	◯	◯	◯

24. Qual o nível de importância de cada uma das variáveis abaixo para o controle da carga de treinamento na ginástica rítmica?

Selecione uma resposta para cada linha.

	Não é importante	Pouco importante	Moderadamente importante	Muito importante	Extremamente importante
Carga externa	◯	◯	◯	◯	◯
Carga interna	◯	◯	◯	◯	◯
Recuperação/fadiga	◯	◯	◯	◯	◯
Desempenho	◯	◯	◯	◯	◯
Estado nutricional	◯	◯	◯	◯	◯
Massa corporal	◯	◯	◯	◯	◯
% de gordura corporal	◯	◯	◯	◯	◯
Dor	◯	◯	◯	◯	◯
Sono	◯	◯	◯	◯	◯
Humor	◯	◯	◯	◯	◯
Estresse	◯	◯	◯	◯	◯
Bem-estar	◯	◯	◯	◯	◯
Termografia	◯	◯	◯	◯	◯
Lesões	◯	◯	◯	◯	◯
Respostas fisiológicas	◯	◯	◯	◯	◯

Outro (especifique)

____

25. O quão eficaz você acha que um modelo específico de controle da carga de treinamento para a ginástica rítmica poderia ser na conquista dos seguintes objetivos?

Selecione uma resposta para cada linha.

	Não seria eficaz	Pouco eficaz	Moderadamente eficaz	Muito eficaz	Extremamente eficaz
Melhorar o desempenho das ginastas	◯	◯	◯	◯	◯
Diminuir incidência de lesões	◯	◯	◯	◯	◯
Analisar a eficácia do programa de treinamento	◯	◯	◯	◯	◯
Evitar recuperação insuficiente	◯	◯	◯	◯	◯
Evitar acúmulo excessivo de fadiga	◯	◯	◯	◯	◯
Controlar a distribuição das cargas de treinamento	◯	◯	◯	◯	◯

APPENDIX F – Survey: Gymnasts (English)

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TRAINING LOAD MANAGEMENT IN RHYTHMIC GYMNASTICS (Gymnasts)

SURVEY PRESENTATION

Welcome to the survey from the doctoral research entitled "TRAINING LOAD MANAGEMENT IN RHYTHMIC GYMNASTICS".

The questionnaire has 19 questions divided into 2 parts:

1. **General information**
2. **Training load management**

You should take around 15 to 20 minutes to finish it.

We thank you in advance, your contribution is extremely important!

1. Please, select your age group:

- ◯ 18 years old or more
- ◯ Under 18 yearls old

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TRAINING LOAD MANAGEMENT IN RHYTHMIC GYMNASTICS (Gymnasts)

CONSENT (18+ years older)

We would like to invite you to participate as a volunteer in the doctoral research project entitled "TRAINING LOAD MANAGEMENT IN RHYTHMIC GYMNASTICS". We believe that is necessary to understand what rhythmic gymnastics coaches, medical staff, and gymnasts do and think about training load and try to bridge the gap between science and practice. This study aims to identify and analyze practices and perceptions of rhythmic gymnasts and professionals about training load management, as well as propose a model applied to rhythmic gymnastics.

If you agree to participate, you will answer a survey with 19 questions about your practices and perceptions about rhythmic gymnastics training. This research presents a few small risks related to the application of surveys including tiredness and discomfort. However, we ensure the anonymity of your personal data. Furthermore, we would encourage you to complete the survey in a quiet place where you are most comfortable.

We hope to contribute to the scientific evidence in rhythmic gymnastics, contribute to evidence-based practices and also try to develop a model of training load management that could help to avoid negative effects to training, the achievement of better performances, and contribute to longer

and healthier careers.

You will not have costs or receive money to participate. You will receive all the information you want about this research. Feel free to participate or not. Even if you decide to participate now, you can decline participation at any time. Your involvement is voluntary and if you refuse to participate, you will not be penalized in any way. The researcher will not share your name. The results will be available when the research is done. Your name or any other information that indicates your participation will not be shared without your approval. You will not be identified in any further publication.

Collected data will be stored with the main researcher for 5 (five) years. After that, the researcher will destroy the data based on current laws. Researchers will treat your identity with professionalism and privacy, as demanded by Brazilian laws (Resolution n° 466/12 CNS), using information just for scientific and academic needs.

Completing the questionnaire, you affirm agreement of participation in this research and state that we gave you the opportunity to read the above information and ask any questions relating to the research.

Main researcher: Paula Barreiros Debien

Federal University of Juiz de Fora (UFJF)

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In case of questions related to ethics, you may get in touch with:

CEP – Ethical Committee of Research with Humans (UFJF)

Phone: +55 32 2102- 3788 / Email: cep.propesq@ufjf.edu.br

2. Agreement:

☐ I am 18 years old or above and agree to participate.

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TRAINING LOAD MANAGEMENT IN RHYTHMIC GYMNASTICS (Gymnasts)

ASSENT (less than 18 years old)

We would like to invite you to participate as a volunteer at doctoral research entitled "TRAINING LOAD MANAGEMENT IN RHYTHMIC GYMNASTICS". We believe that is necessary to understand what rhythmic gymnastics coaches, medical staff, and gymnasts do and think about training load and try to bridge the gap between science and practice. This study aims to identify and analyze practices and perceptions of rhythmic gymnasts and professionals about training load management, as well as propose a model applied to rhythmic gymnastics.

If you agree to participate, you will answer a survey with 19 questions about your practices and perceptions about rhythmic gymnastics training. This research presents a few small risks related to the application of surveys including tiredness and discomfort. However, we ensure the anonymity of your personal data. Furthermore, we would encourage you to complete the survey in a quiet place where you are most comfortable.

We hope to contribute to the scientific evidence in rhythmic gymnastics, contribute to evidence-based practices and also try to develop a model of training load management that could help to avoid negative effects to training, the achievement of better performances, as and contribute to longer and healthier careers.

To participate in this study your parent/guardian must provide consent. You will not have costs or receive money to participate. You will receive all the information you want about this research. Feel free to participate or not. Even if you decide to participate now, you can decline participation at any time, and your parent/guardian can remove the consent. Your involvement is voluntary and if you refuse to participate, you will not be penalized in any way. The researcher will not share your name. The results will be available when the research is done. Your name or any other information that indicates your participation will not be shared without your approval. You will not be identified in any further publication.

Collected data will be stored with the main researcher for 5 (five) years. After that, the researcher will destroy the data based on current laws. Researchers will treat your identity with professionalism and privacy, as demanded by Brazilian laws (Resolution nº 466/12 CNS), using information just for scientific and academic needs.

Having the consent of my parent/guardian, I declare that I agree to participate in the research and that I have been given the opportunity to read and clarify any questions.

Main researcher: Paula Barreiros Debien

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TRAINING LOAD MANAGEMENT IN RHYTHMIC GYMNASTICS (Gymnasts)

CONSENT (parents/guardians)

We would like to invite the minor under your responsibility to participate as a volunteer in the doctoral research entitled "TRAINING LOAD MANAGEMENT IN RHYTHMIC GYMNASTICS". We believe that it is necessary to understand what rhythmic gymnastics coaches do and think about training load and try to bridge the gap between science and practice. This study aims to identify and analyze practices and perceptions of rhythmic gymnastics coaches about training load management, as well as propose a model applied to rhythmic gymnastics.

If you agree, she will answer a survey with 19 questions about her practices and perceptions about rhythmic gymnastics training. This research presents a few small risks related to the application of surveys including tiredness and discomfort. However, we ensure the anonymity of her personal data.

We hope to contribute to the scientific evidence in rhythmic gymnastics, contribute to evidence-based practices and also try to develop a model of training load management that could help to avoid negative effects to training, the achievement of better performances, and contribute to longer and healthier careers.

You will not have costs or receive money to participate. You will receive all the information you want about this research. Feel free to participate or not. Even if you decide to consent her participation now, you and/or her can decline participation at any time. Her involvement is voluntary and if you/her refuse to participate, she will not be penalized in any way. The researcher will not share her name. The results will be available when the research is done. Her name or any other information that indicates her participation will not be shared without your approval. She will not be identified in any further publication.

Collected data will be stored with the main researcher for 5 (five) years. After that, the researcher will destroy the data based on current laws. Researchers will treat your identity with professionalism and privacy, as demanded by Brazilian laws (Resolution n° 466/12 CNS), using information just for scientific and academicals needs.

Ticking the following box, you consent her participation in this research and state that we gave you the opportunity to read the above information and ask any questions related to the research.

Main researcher: Paula Barreiros Debien

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Phone: +55 32 2102- 3788 / Email: cep.propesq@ufjf.edu.br

3. Consent:

☐ My parents/guardians have read the previous information and consented my participation.

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TRAINING LOAD MANAGEMENT IN RHYTHMIC GYMNASTICS (Gymnasts)

PART 1: GENERAL INFORMATION

Please, answer the following questions based on your current rhythmic gymnastics training environment.

4. What is your email?

5. What is your date of birth?

(DD/AA/YYYY)

6. In what country were you born?

7. In what country do you currently train?

8. What is the name of your team/club?

(Example: Australian National Team, Flamengo, etc.)

9. Which year did you start your career as a rhythmic gymnast?

(YYYY)

10. Have you ever participated in any of the following competitions?

The National Championships refer to the highest level championships in your country.

Choose at least one answer for each line.

	Current Olympic cycle (2017-2020)	Previous Olympic cycles	No
National Championship - Junior	☐	☐	☐
National Championship - Senior	☐	☐	☐
Continental Championship - Junior	☐	☐	☐
Continental Championship - Senior	☐	☐	☐
Continental Games	☐	☐	☐
Youth Olympic Games	☐	☐	☐
Olympic Games	☐	☐	☐
World Championship - Junior	☐	☐	☐
World Championship	☐	☐	☐
FIG World Cup	☐	☐	☐
Other International Championships or Tournaments (Junior or Senior)	☐	☐	☐
National Championship – Age Group	☐	☐	☐
International Championship – Age Group	☐	☐	☐
Regional and/or National Tournaments (any age)	☐	☐	☐

11. How many of the following professionals are in your coaching/medical staff?

Choose the number of full-time and part-time professionals for each type. In case your team/club does not have, select 0 (zero).

	Full-time	Part-time
Coach		
Assistant coach		
Ballet teacher		
Choreographer		
Strength and conditioning coach		
Physiotherapist		
Nutritionist/dietitian		
Doctor		
Psychologist		
Physiologist		
Sport scientist		
Biomechanist		

Other (specify)

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TRAINING LOAD MANAGEMENT IN RHYTHMIC GYMNASTICS (Gymnasts)

PART 2 - TRAINING LOAD MANAGEMENT

In this survey, "training load management" consists of procedures adopted to quantify and understand the training doses and consequent athletes' responses in order to optimize the training process.

12. How often does your coaching/medical staff use each of the following methods to monitor your external training load ("work" performed by the gymnast)?

Choose one answer to each line.

	Every session	Daily	Weekly	Monthly	Each 2 to 5 months	Each semester	Yearly	Never	I don't know
Training duration	○	○	○	○	○	○	○	○	○
Number of repetitions (elements, routines)	○	○	○	○	○	○	○	○	○
GPS, inertial sensors	○	○	○	○	○	○	○	○	○
Coaches' perception	○	○	○	○	○	○	○	○	○

Other (specify)

13. How often does your coaching/medical staff use each of the following methods to monitor your internal training load (gymnast "response" to performing external load)?

Choose one answer to each line.

	Every session	Daily	Weekly	Monthly	Each 2 to 5 months	Each semester	Yearly	Never	I don't know
Session rating of perceived exertion (session-RPE)	○	○	○	○	○	○	○	○	○
Heart rate	○	○	○	○	○	○	○	○	○
Gymnasts' personal notes (diary)	○	○	○	○	○	○	○	○	○
Coaches' perception	○	○	○	○	○	○	○	○	○

Other (specify)

14. How often does your coaching/medical staff use each of the following methods to monitor your recovery/fatigue?

Choose one answer to each line.

	Every session	Daily	Weekly	Monthly	Each 2 to 5 months	Each semester	Yearly	Never	I don't know
Questionnaires or self-report measures	○	○	○	○	○	○	○	○	○
Physiological marker (e.g., CK, cortisol, etc.)	○	○	○	○	○	○	○	○	○
Physical test	○	○	○	○	○	○	○	○	○
Coaches' perception	○	○	○	○	○	○	○	○	○

Other (specify)

15. How often does your coaching/medical staff use each of the following methods to monitor your performance?

Choose one answer to each line.

	Every session	Daily	Weekly	Monthly	Each 2 to 5 months	Each semester	Yearly	Never	I don't know
Physical test	○	○	○	○	○	○	○	○	○
Number of hits in repetitions	○	○	○	○	○	○	○	○	○
Routine evaluation (simulate judging)	○	○	○	○	○	○	○	○	○
Coaches' perception	○	○	○	○	○	○	○	○	○

Other (specify)

16. How often are the following variables monitored in you?

Choose one answer to each line.

	Every session	Daily	Weekly	Monthly	Each 2 to 5 months	Each semester	Yearly	Never	I don't know
Nutritional status	○	○	○	○	○	○	○	○	○
Body weight	○	○	○	○	○	○	○	○	○
% body fat	○	○	○	○	○	○	○	○	○
Soreness	○	○	○	○	○	○	○	○	○
Sleep	○	○	○	○	○	○	○	○	○
Mood	○	○	○	○	○	○	○	○	○
Stress	○	○	○	○	○	○	○	○	○
Well-being	○	○	○	○	○	○	○	○	○
Thermography	○	○	○	○	○	○	○	○	○
Injuries	○	○	○	○	○	○	○	○	○
Physiological responses	○	○	○	○	○	○	○	○	○

Other (specify)

17. How often does your training load data get shared and discussed amongst the following groups of stakeholders?

Choose one answer to each line.

	Every session	Daily	Weekly	Monthly	Each 2 to 5 months	Each semester	Yearly	Never	I don't know
Only amongst coaches	◯	◯	◯	◯	◯	◯	◯	◯	◯
Only amongst medical staff	◯	◯	◯	◯	◯	◯	◯	◯	◯
Coaches and medical staff	◯	◯	◯	◯	◯	◯	◯	◯	◯
Coaches and gymnasts	◯	◯	◯	◯	◯	◯	◯	◯	◯
Medical staff and gymnasts	◯	◯	◯	◯	◯	◯	◯	◯	◯
Coaches, medical staff, and gymnasts	◯	◯	◯	◯	◯	◯	◯	◯	◯

Other (specify)

18. How do you rate the quality of the following aspects of your training load management?

Choose one answer to each line.

	Not at all good	Slightly good	Somewhat good	Very good	Extremely good
Measuring external load	◯	◯	◯	◯	◯
Measuring internal load	◯	◯	◯	◯	◯
Measuring recovery/fatigue	◯	◯	◯	◯	◯
Measuring performance	◯	◯	◯	◯	◯
Recording the data monitored	◯	◯	◯	◯	◯
Analyzing the data	◯	◯	◯	◯	◯
Communicating among the staff	◯	◯	◯	◯	◯
Giving feedback to the gymnasts	◯	◯	◯	◯	◯
Adjusting future training loads	◯	◯	◯	◯	◯

19. How effective do you think your training load management is at achieving the following objectives?

Choose one answer to each line.

	Not at all effective	Slightly effective	Somewhat effective	Very effective	Extremely effective
Improve your performance	○	○	○	○	○
Decrease injury incidence	○	○	○	○	○
Analyze training program efficacy	○	○	○	○	○
Avoid insufficient recovery	○	○	○	○	○
Avoid high accumulated fatigue	○	○	○	○	○
Manage training load distribution	○	○	○	○	○

Other (specify)

20. In general, how often do you think the following situations occur with you?

Choose one answer to each line.

	Never	Rarely	Sometimes	Very often	Always
Overuse injuries	○	○	○	○	○
Severe injuries (high time-loss)	○	○	○	○	○
Injury reccurence	○	○	○	○	○
Underrecovery	○	○	○	○	○
Excessive fatigue accumulation	○	○	○	○	○
Nutritional disorders	○	○	○	○	○
Low energy availability	○	○	○	○	○

21. How important are each of the following variables for training load management in rhythmic gymnastics?

Choose one answer to each line.

	Not at all important	Slightly important	Somewhat important	Very important	Extremely important
External load	◯	◯	◯	◯	◯
Internal load	◯	◯	◯	◯	◯
Recovery/fatigue	◯	◯	◯	◯	◯
Performance	◯	◯	◯	◯	◯
Nutritional status	◯	◯	◯	◯	◯
Body weight	◯	◯	◯	◯	◯
% of body fat	◯	◯	◯	◯	◯
Soreness	◯	◯	◯	◯	◯
Sleep	◯	◯	◯	◯	◯
Mood	◯	◯	◯	◯	◯
Stress	◯	◯	◯	◯	◯
Well-being	◯	◯	◯	◯	◯
Thermography	◯	◯	◯	◯	◯
Injuries	◯	◯	◯	◯	◯
Physiological responses	◯	◯	◯	◯	◯

Other (specify)

____

22. How effective do you think a specific model of training load management for rhythmic gymnastics could be at achieving the following objectives?

Choose one answer to each line.

	Not at all effective	Slightly effective	Somewhat effective	Very effective	Extremely effective
Improve gymnasts' performance	◯	◯	◯	◯	◯
Decrease injury incidence	◯	◯	◯	◯	◯
Analyze training program efficacy	◯	◯	◯	◯	◯
Avoid insufficient recovery	◯	◯	◯	◯	◯
Avoid high accumulated fatigue	◯	◯	◯	◯	◯
Manage training load distribution	◯	◯	◯	◯	◯

Other (specify)

____

APPENDIX G – Survey: Gymnasts (Portuguese)

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CONTROLE DA CARGA DE TREINAMENTO NA GINÁSTICA RÍTMICA (Ginastas)

APRESENTAÇÃO DO QUESTIONÁRIO

Bem-vindo (a) ao questionário da pesquisa "CONTROLE DA CARGA DE TREINAMENTO NA GINÁSTICA RÍTMICA".

O questionário possui 19 questões divididas em 2 partes:

1. **Informações gerais**
2. **Controle da carga de treinamento**

O tempo total de preenchimento é aproximadamente 15 a 20 minutos

Desde já, agradecemos pela sua contribuição, ela é extremamente importante!

1. Por favor, selecione sua faixa etária:

- ◯ 18 anos ou mais
- ◯ Menos de 18 anos

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CONTROLE DA CARGA DE TREINAMENTO NA GINÁSTICA RÍTMICA (Ginastas)

TERMO DE CONSENTIMENTO LIVRE E ESCLARECIDO (maiores de 18 anos)

Gostaríamos de convidar você a participar como voluntário (a) da pesquisa "CONTROLE DA CARGA DE TREINAMENTO NA GINÁSTICA RÍTMICA". O motivo que nos leva a realizar esta pesquisa é a necessidade de entender o que os treinadores, equipe médica e ginastas de ginástica rítmica (GR) fazem e pensam em relação ao controle da carga de treinamento e buscar uma aproximação do conhecimento científico e a prática. Nesta pesquisa pretendemos identificar e analisar as práticas e percepções de profissionais e atletas de GR quanto ao controle da carga de treinamento, bem como propor um modelo específico que seja aplicável à GR.

Caso você concorde em participar, você responderá a um questionário contendo 19 perguntas sobre suas práticas e percepções em relação ao treinamento na GR. Esta pesquisa tem alguns riscos mínimos relacionados a aplicação de questionários, como cansaço, desconforto ou constrangimento durante o preenchimento. No entanto, para diminuir a chance desses riscos acontecerem, todos os cuidados serão tomados para assegurar um preenchimento tranquilo e máximo esforço será empregado para garantir o anonimato dos dados individuais. Sugerimos que responda ao questionário em um lugar tranquilo e confortável. Esta pesquisa pode ajudar no aumento de evidências científicas na GR, contribuir para práticas profissionais baseadas em

evidências, bem como auxiliar no desenvolvimento de modelos de controle da carga de treinamento na GR que podem colaborar para minimizar efeitos negativos ao treinamento e proporcionar às ginastas carreiras mais saudáveis, duradouras e com melhores resultados.

Para participar deste estudo você não terá nenhum custo, nem receberá qualquer vantagem financeira. Você terá todas as informações que quiser sobre esta pesquisa e estará livre para participar ou recusar-se a participar. Mesmo que você queira participar agora, você pode voltar atrás ou interromper sua participação a qualquer momento. A sua participação é voluntária e o fato de não querer participar não vai trazer qualquer penalidade ou mudança na forma em que você é atendido (a). Os pesquisadores não vão divulgar seu nome. Os resultados da pesquisa estarão à sua disposição quando finalizada. Seu nome ou o material que indique sua participação não será liberado sem a sua permissão. Você não será identificado (a) em nenhuma publicação que possa resultar.

Os dados coletados na pesquisa ficarão arquivados com a pesquisadora responsável por um período de 5 (cinco) anos. Decorrido este tempo, a pesquisadora avaliará os documentos para a sua destinação final, de acordo com a legislação vigente. Os pesquisadores tratarão a sua identidade com padrões profissionais de sigilo, atendendo a legislação brasileira (Resolução Nº 466/12 do Conselho Nacional de Saúde), utilizando as informações somente para os fins acadêmicos e científicos.

Pesquisadora principal: Paula Barreiros Debien

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E-mail: paulinhadebien@hotmail.com

Em caso de dúvidas, com respeito aos aspectos éticos desta pesquisa, você poderá consultar:

CEP - Comitê de Ética em Pesquisa com Seres Humanos - UFJF

Campus Universitário da UFJF

Pró-Reitoria de Pós-Graduação e Pesquisa

CEP: 36036-900

Fone: (32) 2102- 3788 / E-mail: cep.propesq@ufjf.edu.br

2. Consentimento

☐ Declaro que possuo 18 anos ou mais, concordo em participar da pesquisa e foi me dada a oportunidade de ler e esclarecer as minhas dúvidas.

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CONTROLE DA CARGA DE TREINAMENTO NA GINÁSTICA RÍTMICA (Ginastas)

TERMO DE ASSENTIMENTO LIVRE E ESCLARECIDO

Gostaríamos de convidar você a participar como voluntário (a) da pesquisa "CONTROLE DA CARGA DE TREINAMENTO NA GINÁSTICA RÍTMICA". O motivo que nos leva a realizar esta pesquisa é a necessidade de entender o que os treinadores, equipe médica e ginastas de ginástica rítmica (GR) fazem e pensam em relação ao controle da carga de treinamento e buscar uma aproximação do conhecimento científico e a prática. Nesta pesquisa pretendemos identificar e analisar as práticas e percepções de profissionais e atletas de GR quanto ao controle da carga de treinamento, bem como propor um modelo específico que seja aplicável à GR.

Caso você concorde em participar, você responderá a um questionário contendo 19 perguntas sobre suas práticas e percepções em relação ao treinamento na GR. Esta pesquisa tem alguns riscos mínimos relacionados a aplicação de questionários, como cansaço, desconforto ou constrangimento durante o preenchimento. No entanto, para diminuir a chance desses riscos acontecerem, todos os cuidados serão tomados para assegurar um preenchimento tranquilo e máximo esforço será empregado para garantir o anonimato dos dados individuais. Sugerimos que responda ao questionário em um lugar tranquilo e confortável. Esta pesquisa pode ajudar no aumento de evidências científicas na GR, contribuir para práticas profissionais baseadas em evidências, bem como auxiliar no desenvolvimento de modelos de controle da carga de treinamento na GR que podem colaborar para minimizar efeitos negativos ao treinamento e proporcionar às ginastas carreiras mais saudáveis, duradouras e com melhores resultados.

Para participar deste estudo seu responsável devem consentir. Você não terá nenhum custo, nem receberá qualquer vantagem financeira. Você terá todas as informações que quiser sobre esta pesquisa e estará livre para participar ou recusar-se a participar. Mesmo que você queira participar agora, você pode voltar atrás ou interromper sua participação ou seu responsável retirar o consentimento a qualquer momento. A sua participação é voluntária e o fato de não querer participar não vai trazer qualquer penalidade ou mudança na forma em que você é atendido (a). Os pesquisadores não vão divulgar seu nome. Os resultados da pesquisa estarão à sua disposição quando finalizada. Seu nome ou o material que indique sua participação não será liberado sem a sua permissão. Você não será identificado (a) em nenhuma publicação que possa resultar.

Os dados coletados na pesquisa ficarão arquivados com a pesquisadora responsável por um período de 5 (cinco) anos. Decorrido este tempo, a pesquisadora avaliará os documentos para a sua destinação final, de acordo com a legislação vigente. Os pesquisadores tratarão a sua identidade com padrões profissionais de sigilo, atendendo a legislação brasileira (Resolução Nº 466/12 do Conselho Nacional de Saúde), utilizando as informações somente para os fins acadêmicos e científicos.

Tendo o consentimento do meu responsável, declaro que concordo em participar da pesquisa e que me foi dada a oportunidade de ler e esclarecer as minhas dúvidas.

Pesquisadora principal: Paula Barreiros Debien

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CONTROLE DA CARGA DE TREINAMENTO NA GINÁSTICA RÍTMICA (Ginastas)

TERMO DE CONSENTIMENTO LIVRE E ESCLARECIDO (responsáveis)

O menor sob sura responsabilidade está sendo convidado (a) a participar como voluntário (a) da pesquisa "CONTROLE DA CARGA DE TREINAMENTO NA GINÁSTICA RÍTMICA". O motivo que nos leva a realizar esta pesquisa é a necessidade de entender o que os treinadores, equipe médica e ginastas de ginástica rítmica (GR) fazem e pensam em relação ao controle da carga de treinamento e buscar uma aproximação do conhecimento científico e a prática. Nesta pesquisa pretendemos identificar e analisar as práticas e percepções de profissionais e atletas de GR quanto ao controle da carga de treinamento, bem como propor um modelo específico que seja aplicável à GR.

Caso você concorde na participação do (a) menor, ele (a) responderá a um questionário contendo 19 perguntas sobre suas práticas e percepções em relação ao treinamento na GR. Esta pesquisa tem alguns riscos mínimos relacionados a aplicação de questionários, como cansaço, desconforto ou constrangimento durante o preenchimento. No entanto, para diminuir a chance desses riscos acontecerem, todos os cuidados serão tomados para assegurar um preenchimento tranquilo e máximo esforço será empregado para garantir o anonimato dos dados individuais. Sugerimos que responda ao questionário em um lugar tranquilo e confortável. Esta pesquisa pode ajudar no aumento de evidências científicas na GR, contribuir para práticas profissionais baseadas em evidências, bem como auxiliar no desenvolvimento de modelos de controle da carga de treinamento na GR que podem colaborar para minimizar efeitos negativos ao treinamento e proporcionar às ginastas carreiras mais saudáveis, duradouras e com melhores resultados.

Para participar deste estudo, o (a) menor sob sua responsabilidade e você não terão nenhum custo, nem receberão qualquer vantagem financeira. Ele (a) terá todas as informações que quiser sobre esta pesquisa e estará livre para participar ou recusar-se a participar. Mesmo que você queira deixa-lo (a) participar agora, você pode voltar atrás e interromper a participação a qualquer momento. A participação dele (a) é voluntária e o fato de não deixá-lo (a) participar não vai trazer qualquer penalidade ou mudança na forma em que ele (a) é atendido (a). Os resultados da pesquisa estarão à sua disposição quando finalizada. O nome ou o material que indique a participação do (a) menor não será liberado sem a sua permissão. O (a) menor não será identificado (a) em nenhuma publicação que possa resultar.

Os dados coletados na pesquisa ficarão arquivados com a pesquisadora responsável por um período de 5 (cinco) anos. Decorrido este tempo, a pesquisadora avaliará os documentos para a sua destinação final, de acordo com a legislação vigente. Os pesquisadores tratarão a sua identidade com padrões profissionais de sigilo, atendendo a legislação brasileira (Resolução Nº 466/12 do Conselho Nacional de Saúde), utilizando as informações somente para os fins acadêmicos e científicos.

Declaro que concordo em deixá-lo (a) participar da pesquisa e que me foi dada a oportunidade de ler e esclarecer as minhas dúvidas.

Pesquisadora principal: Paula Barreiros Debien

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E-mail: paulinhadebien@hotmail.com

Em caso de dúvidas, com respeito aos aspectos éticos desta pesquisa, você poderá consultar:

CEP - Comitê de Ética em Pesquisa com Seres Humanos - UFJF

Campus Universitário da UFJF

Pró-Reitoria de Pós-Graduação e Pesquisa

CEP: 36036-900

Fone: (32) 2102- 3788 / E-mail: cep.propesq@ufjf.edu.br

3. Consentimento

☐ Meu responsável leu as informações anteriores e consente minha participação.

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CONTROLE DA CARGA DE TREINAMENTO NA GINÁSTICA RÍTMICA (Ginastas)

PARTE 1: INFORMAÇÕES GERAIS

Por favor, responda às questões abaixo de acordo com a atual realidade do treinamento da equipe na qual você atua.

4. Qual o seu e-mail?

5. Qual sua data de nascimento?

(DD/MM/AAAA)

6. Em qual país você nasceu?

7. Em qual país você treina atualmente?

8. Qual o nome do clube/equipe que você treina atualmente?

(Exemplo: Seleção Brasileira, Minas Tênis Clube, etc)

9. Em qual ano você iniciou sua carreira de ginasta?

(AAAA)

10. Você participou de alguma das seguintes competições de ginástica rítmica?

Os Campeonatos Nacionais se referem aos eventos de maior nível técnico no país.

Escolha pelo menos uma resposta para cada linha/competição.

	Ciclo Olímpico atual (2017-2020)	Ciclos Olímpicos anteriores	Não
Campeonato Nacional Juvenil	☐	☐	☐
Campeonato Nacional Adulto	☐	☐	☐
Campeonato Continental Juvenil	☐	☐	☐
Campeonato Continental Adulto	☐	☐	☐
Jogos Continentais (multiesportivos)	☐	☐	☐
Jogos Olímpicos da Juventude (YOG)	☐	☐	☐
Jogos Olímpicos	☐	☐	☐
Campeonato Mundial Juvenil	☐	☐	☐
Campeonato Mundial	☐	☐	☐
Copa do Mundo FIG	☐	☐	☐
Outros Campeonatos ou Torneios Internacionais (Juvenil e/ou Adulto)	☐	☐	☐
Campeonato Nacional Pré-Infantil e/ou Infantil	☐	☐	☐
Campeonatos Internacionais Age Group	☐	☐	☐
Torneio Regional e/ou Nacional (qualquer categoria)	☐	☐	☐

11. Quantos profissionais integram a sua comissão técnica/médica?

Selecione o número de cada tipo de profissional que trabalha em tempo integral ou parcial. Caso não tenha algum tipo de profissional, insira 0 (zero) nas duas colunas.

	Tempo integral	Parcialmente
Treinador		
Auxiliar técnico		
Professor de ballet		
Coreógrafo		
Preparador físico		
Fisioterapeuta		
Nutricionista		
Médico		
Psicólogo		
Fisiologista		
Cientista do esporte		
Biomecânico		

Outro (especifique)

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CONTROLE DA CARGA DE TREINAMENTO NA GINÁSTICA RÍTMICA (Ginastas)

PARTE 2 - CONTROLE DA CARGA DE TREINAMENTO

Nesta pesquisa, a expressão "controle da carga de treinamento" consiste no conjunto de procedimentos adotados para quantificar e compreender as doses de treinamento e consequentes respostas dos atletas, na tentativa de otimizar o processo de treinamento.

12. Com qual frequência sua comissão técnica/médica usa cada um dos métodos abaixo para monitorar a sua carga externa de treinamento (treinamento prescrito e realizado pela ginasta)?

Selecione uma resposta para cada linha.

	Todas as sessões	Diariamente	Semanalmente	Mensalmente	De 2 a 5 meses	Semestralmente	Anualmente	Nunca	Não sei
Duração do treino									
Número de repetições (elementos, séries)									
Tecnologia de posicionamento/movimento (GPS, acelerômetro, etc.)									
Percepção do treinador									

Outro (especifique)

13. Com qual frequência sua comissão técnica/médica usa cada um dos métodos abaixo para monitorar a sua carga interna de treinamento ("resposta" do organismo da ginasta ao treinamento realizado)?

Selecione uma resposta para cada linha.

	Todas as sessões	Diariamente	Semanalmente	Mensalmente	De 2 a 5 meses	Semestralmente	Anualmente	Nunca	Não sei
Percepção subjetiva do esforço (PSE) da sessão									
Frequência cardíaca									
Anotações pessoais das ginastas (diário)									
Percepção do treinador									

Outro (especifique)

14. Com qual frequência sua comissão técnica/médica usa cada um dos métodos abaixo para monitorar a sua recuperação/fadiga?

Selecione uma resposta para cada linha.

	Todas as sessões	Diariamente	Semanalmente	Mensalmente	De 2 a 5 meses	Semestralmente	Anualmente	Nunca	Não sei
Questionários e/ou escalas de auto relato	◯	◯	◯	◯	◯	◯	◯	◯	◯
Marcador fisiológico (creatina kinase, cortisol, etc.)	◯	◯	◯	◯	◯	◯	◯	◯	◯
Testes de capacidades físicas	◯	◯	◯	◯	◯	◯	◯	◯	◯
Percepção do treinador	◯	◯	◯	◯	◯	◯	◯	◯	◯

Outro (especifique)

15. Com qual frequência sua comissão técnica/médica usa cada um dos métodos abaixo para monitorar o seu desempenho?

Selecione uma resposta para cada linha.

	Todas as sessões	Diariamente	Semanalmente	Mensalmente	De 2 a 5 meses	Semestralmente	Anualmente	Nunca	Não sei
Testes de capacidades físicas	◯	◯	◯	◯	◯	◯	◯	◯	◯
Quantidade de acertos nas repetições	◯	◯	◯	◯	◯	◯	◯	◯	◯
Avaliação da série inteira (simulação de arbitragem)	◯	◯	◯	◯	◯	◯	◯	◯	◯
Percepção do treinador	◯	◯	◯	◯	◯	◯	◯	◯	◯

Outro (especifique)

16. Com que frequência as variáveis abaixo são monitoradas em você?

Selecione uma resposta para cada linha.

	Todas as sessões	Diariamente	Semanalmente	Mensalmente	De 2 a 5 meses	Semestralmente	Anualmente	Nunca	Não sei
Estado nutricional	○	○	○	○	○	○	○	○	○
Massa corporal	○	○	○	○	○	○	○	○	○
% de gordura corporal	○	○	○	○	○	○	○	○	○
Dor	○	○	○	○	○	○	○	○	○
Sono	○	○	○	○	○	○	○	○	○
Humor	○	○	○	○	○	○	○	○	○
Estresse	○	○	○	○	○	○	○	○	○
Bem-estar	○	○	○	○	○	○	○	○	○
Termografia	○	○	○	○	○	○	○	○	○
Lesões	○	○	○	○	○	○	○	○	○
Respostas fisiológicas	○	○	○	○	○	○	○	○	○

Outro (especifique)

17. Com qual frequência os seus dados de carga de treinamento são compartilhados e discutidos entre os seguintes grupos de pessoas?

Selecione uma resposta para cada linha.

	Todas as sessões	Diariamente	Semanalmente	Mensalmente	De 2 a 5 meses	Semestralmente	Anualmente	Nunca	Não sei
Apenas entre os treinadores	○	○	○	○	○	○	○	○	○
Apenas entre a equipe médica	○	○	○	○	○	○	○	○	○
Treinadores e equipe médica	○	○	○	○	○	○	○	○	○
Treinadores e ginastas	○	○	○	○	○	○	○	○	○
Equipe médica e ginastas	○	○	○	○	○	○	○	○	○
Treinadores, equipe médica e ginastas	○	○	○	○	○	○	○	○	○

Outro (especifique)

18. Como você avalia a qualidade dos seguintes aspectos do controle da sua carga de treinamento?

Selecione uma resposta para cada linha.

	Não é bom	Pouco bom	Moderadamente bom	Muito bom	Extremamente bom
Quantificação da carga externa de treinamento	◯	◯	◯	◯	◯
Quantificação da carga interna de treinamento	◯	◯	◯	◯	◯
Quantificação da recuperação/fadiga	◯	◯	◯	◯	◯
Quantificação do desempenho	◯	◯	◯	◯	◯
Registro dos dados monitorados	◯	◯	◯	◯	◯
Análise dos dados	◯	◯	◯	◯	◯
Comunicação entre os membros da comissão técnica/médica	◯	◯	◯	◯	◯
Fornecer feedback às ginastas	◯	◯	◯	◯	◯
Ajuste das futuras cargas de treinamento	◯	◯	◯	◯	◯

19. Como você avalia a eficácia do controle da sua carga de treinamento em relação a atingir os seguintes objetivos?

Selecione uma resposta para cada linha.

	Não é eficaz	Pouco eficaz	Moderadamente eficaz	Muito eficaz	Extremamente eficaz
Melhorar o seu desempenho	◯	◯	◯	◯	◯
Diminuir incidência de lesões	◯	◯	◯	◯	◯
Analisar a eficácia do programa de treinamento	◯	◯	◯	◯	◯
Evitar recuperação insuficiente	◯	◯	◯	◯	◯
Evitar acúmulo excessivo de fadiga	◯	◯	◯	◯	◯
Controlar a distribuição das cargas de treinamento	◯	◯	◯	◯	◯

20. Em geral, com qual frequência você acha que as seguintes situações ocorrem com você?

Selecione uma resposta para cada linha.

	Nunca	Raramente	Algumas vezes	Muito frequente	Sempre
Lesões por sobrecarga (overuse)	◯	◯	◯	◯	◯
Lesões graves (elevado tempo de afastamento)	◯	◯	◯	◯	◯
Recorrência de lesões prévias	◯	◯	◯	◯	◯
Recuperação insuficiente	◯	◯	◯	◯	◯
Acúmulo excessivo de fadiga	◯	◯	◯	◯	◯
Distúrbios alimentares	◯	◯	◯	◯	◯
Baixa disponibilidade de energia	◯	◯	◯	◯	◯

21. Qual o nível de importância de cada uma das variáveis abaixo para o controle da carga de treinamento na ginástica rítmica?

Selecione uma resposta para cada linha.

	Não é importante	Pouco importante	Moderadamente importante	Muito importante	Extremamente importante
Carga externa	◯	◯	◯	◯	◯
Carga interna	◯	◯	◯	◯	◯
Recuperação/fadiga	◯	◯	◯	◯	◯
Desempenho	◯	◯	◯	◯	◯
Estado nutricional	◯	◯	◯	◯	◯
Massa corporal	◯	◯	◯	◯	◯
% de gordura corporal	◯	◯	◯	◯	◯
Dor	◯	◯	◯	◯	◯
Sono	◯	◯	◯	◯	◯
Humor	◯	◯	◯	◯	◯
Estresse	◯	◯	◯	◯	◯
Bem-estar	◯	◯	◯	◯	◯
Termografia	◯	◯	◯	◯	◯
Lesões	◯	◯	◯	◯	◯
Respostas fisiológicas	◯	◯	◯	◯	◯

Outro (especifique)

22. O quão eficaz você acha que um modelo específico de controle da carga de treinamento para a ginástica rítmica poderia ser na conquista dos seguintes objetivos?

Selecione uma resposta para cada linha.

	Não seria eficaz	Pouco eficaz	Moderadamente eficaz	Muito eficaz	Extremamente eficaz
Melhorar o desempenho das ginastas	◯	◯	◯	◯	◯
Diminuir incidência de lesões	◯	◯	◯	◯	◯
Analisar a eficácia do programa de treinamento	◯	◯	◯	◯	◯
Evitar recuperação insuficiente	◯	◯	◯	◯	◯
Evitar acúmulo excessivo de fadiga	◯	◯	◯	◯	◯
Controlar a distribuição das cargas de treinamento	◯	◯	◯	◯	◯

APPENDIX H – Additional work completed during the candidature

DEBIEN, P. B. et al. Monitoring training load, recovery, and performance of Brazilian professional volleyball players during a season. **International Journal of Sports Physiology and Performance**, v. 13, n. 9, p. 1182–1189, 19 out. 2018.

International Journal of Sports Physiology and Performance, 2018, 13, 1182-1189
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Human Kinetics
ORIGINAL INVESTIGATION

Monitoring Training Load, Recovery, and Performance of Brazilian Professional Volleyball Players During a Season

Paula B. Debien, Marcelly Mancini, Danilo R. Coimbra, Daniel G.S. de Freitas, Renato Miranda, and Maurício G. Bara Filho

Purpose: To describe and analyze the distribution of internal training load (ITL), recovery, and physical performance of professional volleyball players throughout 1 season. ***Methods:*** Fifteen male professional Brazilian volleyball players participated in this study. The session rating of perceived exertion (s-RPE) and Total Quality Recovery (TQR) score were collected daily for 36 wk. s-RPE was collected after each training session, and TQR, before the first session of the day. The sum of the ITL of each session during the week, training monotony, strain, acute:chronic workload ratio, match difficulty score, and average of the TQR scores were recorded for the analysis. In addition, the athletes performed countermovement-jump (CMJ) tests with and without the use of the arms 4 times over the season. ***Results:*** The season mean weekly ITL was 3733 (1228) AU and the TQR was 15.02 (0.71). The ITL and recovery demonstrated undulating dynamics over the 36 wk, with higher weekly ITL in the preparatory periods ($F = 50.32$; $P < .001$) and worse recovery during the main competition ($F = 6.47$; $P = .004$). Negative correlations were found between TQR and ITL variables ($P < .05$). There was improvement and maintenance in CMJ tests without ($F = 11.88$; $P < .001$) and with ($F = 16.02$; $P < .001$) the use of the arms after the preparatory periods. ***Conclusions:*** The ITL variables, recovery, and physical performance changed significantly throughout a professional volleyball season. Despite the decrease in ITL during the main competitive period, the correct distribution of weekly ITL seems to be very important to guarantee the best recovery of athletes.

Keywords: session-RPE, TQR, CMJ, competition, Superliga

Volleyball is characterized by intermittent efforts of short duration and high intensity, interspersed with brief rest periods. The main physical attributes and skills required in this sport include lower-limb explosive power and agility in displacement to cover short distances.[1,2] In relation to technical movement actions, the vertical jump is considered a very important element during volleyball training sessions and matches, as it is used in the basic actions for setting, serving, blocking, and attacking.[3] In this way, good training periodization is essential to ensure that, during competitive periods, athletes present great performance in these and other volleyball-specific skills.[4–6]

The particularities of the competitive calendar make the process of planning and organizing team sports training even more complex, especially due to the short preparation time and the need to maintain the athletes' high level of performance throughout many months of competition.[7–9] The success of training, in turn, depends on the balance between the magnitude and distribution of the training load and the recovery applied during the season.[10–12] In order to avoid negative adaptations to training, it is necessary that these variables be precisely monitored during the entire season, along with monitoring of athletes' performance levels.[13–15]

In recent decades, the session rating of perceived exertion (session-RPE)[16] has proved to be an accurate, valid, simple, and inexpensive tool, which is useful in the quantification and monitoring of internal training load (ITL) for team sports,[17–20] including volleyball.[6,21] Malone et al,[22] Miloski et al,[23] and Moreira et al[24,25] used the session-RPE for monitoring ITL of teams during a full season of soccer (England), futsal (Brazil), Australian Football (Australia), and rugby (Australia), respectively. However, there is a lack of studies that have conducted monitoring such as this across an entire season of professional volleyball. Analysis of the seasonal distribution of the ITL of professional volleyball players could be useful for better understanding the specificities of the training process and for youth player training organization, especially in the categories that precede the professional level.[3,6]

Regarding recovery, researchers have sought to understand the behavior of this variable in different training situations, as it is considered an important factor in the prevention and minimization of injuries[26] and situations that can impair athlete's performance.[11,13,15,27] From this perspective, Kellmann[11] presented a longitudinal monitoring study of professional rowers and highlighted the changes in the recovery state of the athletes as a function of the characteristics of training and competitions, as well as the importance of performing this control periodically in order to prevent nonfunctional adaptations and a loss of sports performance.

In view of limitations and difficulties in the application of the main instruments used for monitoring recovery, Kenttä and Hassmén[12] proposed a practical and noninvasive method that allows for faster and more frequent assessment of athlete recovery in the sporting environment: the Total Quality Recovery (TQR) scale. The TQR has been successfully used in scientific investigations on soccer,[28] basketball,[29] and volleyball.[5,21]

Although volleyball is widely played in Brazil and in the world, there is a need to advance the specific knowledge about the distribution of training loads in professional volleyball.

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Furthermore, the joint seasonal monitoring of ITL, recovery, and performance of professional volleyball players could provide essential information about the planning and organization of training, and contribute directly to the work of coaches, strength and conditioning staff, physiologists, physical therapists, and researchers. Therefore, the aim of this study is to describe and analyze the distribution of ITL, recovery, and physical performance of professional volleyball players throughout one season.

Methods

Subjects

Fifteen male athletes who were members of a professional volleyball team in the State of Minas Gerais, which plays in the Superliga—the main Brazilian volleyball competition—participated in this study. At the beginning of the season, athletes presented mean (SD) of age, weight, height, and body fat of 24.0 (3.6) years, 96.7 (11.3) kg, 194.3 (6.7) cm, and 13.8% (5.4%),[30] respectively. Minimum participation of 75% in the monitored training sessions was specified as the inclusion criterion. The athletes were familiarized with all adopted procedures and tests, which were commonly used during their training program. The study was approved by the Ethics Committee in Research with Humans at the Federal University of Juiz de Fora (Protocol No. 278/2010). All participants were informed of the risks and benefits involved in the study before providing informed consent expressing their voluntary participation.

Design

Data were collected from a professional male adult volleyball team over 36 weeks of training and competition for a regular season. The season was divided into 4 periods, each with distinct characteristics and objectives: preparatory 1 (P1: 1st–7th wk), competitive 1 (C1: 8th–13th wk), preparatory 2 (P2: 14th–20th wk), and competitive 2 (C2: 21st–36th wk). C1 corresponded to the State Championship and C2 to the Superliga. The typical organization of the training week for each period is described in Table 1. Training was planned and implemented by the team's technical staff and was not influenced by the actions of the researchers.

Internal Training Load

The ITL was quantified by the session-RPE method as proposed by Foster et al[16] and used with a similar sample of volleyball players.[5,21] Thirty minutes after the end of each daily training session and matches, the athletes were presented with the 10-point RPE scale and answered the question, "How was your workout?" The session ITL was calculated by multiplying the reported session-RPE score and the total time of the session in minutes resulting in a value in arbitrary units (AU). The ITL was described using the total weekly ITL (wITL), consisting of the sum of the ITLs of all training sessions during that week. On the sessions and days off, the ITL was considered 0 and was included in the wITL analysis. The wITL was classified in accordance with the range between minimal and maximal values observed throughout the 36 weeks, as suggested by Miloski et al.[23] Training monotony and strain were calculated based on the method of Foster.[31] Monotony was determined as the ratio between wITL and its SD. Strain was determined as the product of wITL and monotony.[31] From the values of wITL, the acute:chronic workload ratio (ACWR) was measured. This ratio describes the acute workload (1-wITL) in relation to the chronic workload (the 4-wITL rolling average).[32,33]

Match Difficulty Score

The match difficulty system of Kelly and Coutts[34] was used to determine the difficulty of each match during the competitive periods. As the authors recommend, the scores were adjusted. The level of opposition score was determined based on the ranking of the teams at the end of each championship (1–12). The score for the days between matches varied between 0 (more than 7 d) and 14 (1 d) and the match location score between 1 (home) and 5 (travel to another state). The match difficulty score for each week was determined by the sum of the match scores during that week.

Recovery

The TQR scale[12] was used to monitor recovery. Before the start of the first training session of the day, the athletes answered the question "How do you feel about your recovery?" using the TQR scale, in which answers are rated from 6 to 20. The weekly average TQR score for each athlete was calculated as the average of the daily values from a given week. The TQR was not assessed on days off.

Physical Performance

The athletes performed vertical jump tests at 4 different times over the season: 2nd, 5th, 16th, and 31st weeks. The tests were performed before the training session in a randomized order. All players were largely familiarized with the test procedures, which were commonly performed during their training program. The vertical jump height was measured through countermovement jumps, with (CMJa) and without (CMJ) the use of the arms, and was carried out on an Ergojump contact mat (Cefise®, Nova Odessa, Brazil).[3,5,6] During each test session, all athletes performed the jump from 2 different stances, once with the use of their arms (CMJa) and once with the hands on the hips (CMJ), with at least 5 minutes of rest between stances. In each of these 2 positions, athletes performed 3 jumps in a row—with 10-second intervals between them. The mean value of the 3 attempts of CMJ and the 3 attempts of CMJa were used for analysis.

Statistical Analysis

Data are expressed as mean (SD). The assumption of normality was verified by the Shapiro–Wilk test, and sphericity was assessed with the Mauchly's test. Weekly descriptive analysis of ITL variables and recovery were reported throughout the season. The comparison between the means of wITL, monotony, strain, ACWR, and TQR of each training period, as well as the different testing sessions of the vertical jump tests were carried out using analysis of variance with repeated measures and the Bonferroni post hoc. Spearman's correlation coefficient and corresponding 90% confidence intervals (CIs) were used to analyze the correlations between ITL variables and TQR over the season and between all variables and match difficulty scores during the competitive periods. The magnitude of correlations was determined using the modified scale of Hopkins[35]: r values <.1 (trivial), .1 to .3 (small), .3 to .5 (moderate), .5 to .7 (large), .7 to .9 (very large), >.9 (nearly perfect), and 1 (perfect). If the 90% CI overlapped positive and negative values, the magnitude was deemed unclear; otherwise, it was deemed the observed

Table 1 Training Content of a Typical Week of Each Training Period During the Season

Period	Day-shift	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday	Sunday
P1	1	Resistance (strength) TT	Resistance (strength) TT (sand)	Resistance (strength) TT	Resistance (strength) TT (sand)	Resistance (strength) TT	Functional Resistance (strength)	Off
	2	TT	Off	Functional TT	Off	TT	Off	Off
C1	1	Resistance (strength) TT	TT video	Off	Resistance (strength) TT	TT video	Off	Off
	2	TT	Match (State championship)	TT	TT	Match (State championship)	Off	Off
P2	1	Resistance (strength) TT	Resistance (strength) TT	Off	Resistance (strength)	Friendly match	Off	Off
	2	Functional TT	Anaerobic circuit TT	Resistance (strength) TT	Friendly match	Resistance (strength) TT	Off	Off
C2	1	Off	Resistance (strength) TT	Off (travel)	TT video exposure	Off (travel)	TT video exposure	Off
	2	Resistance (strength) TT	TT	Resistance (strength) TT	Match (Superliga)	TT	Match (Superliga)	Off

Abbreviations: C1, competitive 1; C2, competitive 2; P1, preparatory 1; P2, preparatory 2; TT, technical–tactical.

magnitude. Data were analyzed using SPSS software (version 20.0; SPSS Inc, Chicago, IL). Statistical significance was set as $P < .05$.

Results

Figure 1 outlines wITL (A), TQR (B), strain (C), monotony (D), and ACWR (F) over the season, as well as the match difficulty scores of the weeks of C1 and C2 (E). The wITL mean was 3733 (1228) AU and the higher value was 5027 (1006) AU (17th wk). Across the season, 63.9% of the wITL magnitudes were classified as high (≥3770 AU), 27.8% as moderate-high (≥2514 to <3770 AU), 5.6% as moderate-low (≥1257 to <2514 AU), and only the 2 weeks off as low (<1257 AU). The TQR mean was 15.02 (0.71), and varied between 13.76 (1.38) (24th wk) and 16.83 (1.33) (first week). The mean values of strain, monotony, ACWR, and match difficulty score were 5364 (1828) AU, 1.25 (0.26), 1.06 (0.23), and 34.18 (9.95), respectively.

The mean wITL, monotony, strain, ACWR, and TQR of each period are displayed in Table 2. When the mean wITLs of each training period were compared, the results demonstrated significant variations over time ($F = 50.32$; $P < .001$). A higher mean wITL during P2 and a lower mean during C1, compared with the other periods, were observed. The mean wITL of P1 was significantly higher than both competitive periods. The monotony changed significantly across the periods ($F = 9.66$; $P < .001$), as well as the strain ($F = 16.65$; $P < .001$) and ACWR ($F = 83.13$; $P < .001$). A lower mean monotony was observed during C1 compared with P1 and P2. The mean strain during C1 was significantly lower than the other periods, and the value in P2 was significantly higher than P1 and C2. The mean ACWR of P2 was higher than the other periods, and the value in C1 was the lowest mean. The recovery also changed significantly over the season periods ($F = 6.47$; $P = .004$). The mean TQR score of C2 was significantly lower than that of P1.

Significant correlations were observed between TQR and wITL ($r = -.37$; 90% CI, −0.44 to −0.30; $P < .001$; N = 509), strain ($r = -.36$; 90% CI, −0.42 to −0.30; $P < .001$; N = 502), and monotony ($r = -.23$; 90% CI, −0.30 to −0.16; $P < .001$; N = 504). No significant correlation was verified between TQR and ACWR ($r = -.08$; 90% CI, −0.16 to 0.00; $P = .108$; N = 419) and trivial (almost unclear) correlation was observed between the TQR of the week before and ACWR ($r = -.103$; 90% CI, −0.18 to −0.03; $P = .03$; N = 450). No correlation was found between match difficulty score and the other variables during the competitive weeks.

Table 3 presents the results of the physical performance tests conducted on 4 separate occasions. A significant variation in CMJ ($F = 11.88$; $P < .001$) and CMJa ($F = 16.02$; $P < .001$) was detected across the season. The CMJa of the 16th and 31st weeks and the CMJ of the 5th, 16th, and 31st weeks were higher than the 2nd week. The CMJa of the 31st week was also higher than the 5th week.

Discussion

The purpose of this study was to describe and analyze the distribution of ITL, recovery, and physical performance of professional volleyball players during an entire 36-week season. The wITL, monotony, strain, ACWR, TQR scores, and vertical jump height of the athletes changed significantly over the season. Moderate correlations were found between TQR and wITL and strain, besides small correlation between TQR and monotony over the weeks. This is the first study to investigate weekly training load variables and recovery throughout the regular season of an elite Brazilian volleyball team.

The dynamic of ITL, over the 36 weeks monitored, presented an undulating characteristic, being influenced by specific aspects of the competitive Brazilian high-level volleyball calendar. This training load behavior is consistent with one of the basic principles of sports training periodization,[7] and corroborates the findings of Miloski et al,[23] who conducted a similar study with futsal athletes. However, it is important to emphasize that 88.9% of the wITLs during the season were classified as high or moderate-high in the present study, contrasting with the 40.9% observed in futsal.[23] The correct distribution of wITL magnitudes across each season period is essential to obtain the best performance in the competition periods and avoid maladaptation.[14] Corroborating this, in recent years, some investigations have outlined a relation of the training load pattern and injury risk in team sports.[8,27,32] The isolated high magnitude of training loads is not the problem, rather the cause might be the quick and excessive increase in load, in relation to what the athlete is used to and/or prepared for (ACWR > 1.5),[8,32,33] as well as long periods of load intensification (eg, preparatory periods).[27] Both wITL patterns were found in this study, especially in the second half of the season. In long competitive periods, like in the Brazilian professional volleyball, a better balance among high and low wITLs should be carried out. The optimal load proportion in team sports could be better understood in further studies, though the distribution of 40% (moderate-high and high) and 60% (moderate-low and low) seems to be adequate in futsal.[23]

Similarly, the TQR scores showed an undulating dynamic over the season, reinforcing the negative moderate correlation between wITL and TQR, and also the model exposed by Kellmann.[11] Likewise, the recovery was inversely correlated with strain (moderate) and monotony (small). These relationships were particularly obvious at moments of 2 weeks in a row with a decrease in TQR (15th–16th, 20th–21st, 23rd–24th, and 29th–30th wk). At these moments, it is possible to observe a combination of at least 3 of the 4 critical aspects: high wITL, strain above 6000 AU, and monotony and ACWR around 1.5. It is relevant to point out that the risk of illness and/or injury in athletes has been associated with high training loads,[9] as well as high training strain (>6000 AU), monotony (~2),[31] and ACWR (>1.5).[8,33] Corroborating this, a recent study with team sports players found that a decrease in perceived recovery can indicate an increased injury risk.[26] Furthermore, in volleyball players, studies have shown worse performance at the end of one preseason with an insufficient recovery period,[36] as well as significantly decreased recovery during training load intensification[5] and match congestion periods.[21] This emphasizes the need to monitor recovery individually and frequently during different stages[11] of team sports seasons, not only during a few specific training or competition situations.[5,21,28,29]

It was observed that both preparatory periods (P1 and P2) showed, on average, weeks with higher wITL than their respective and subsequent competitive periods (C1 and C2). However, the training load variables of C2 were higher than C1, with the exception of monotony. Higher training loads in preseasons and preparatory periods followed by further reductions during competitive periods are common in other team sports.[23,24] During periods without competitions, it is possible to intensify the training loads aiming to improve and/or maintain athlete performance.[18] In contrast, during competitive periods, training loads are not as high, since it is necessary that athletes are able to properly recover between matches, in order to avoid a drop in performance on match days.[17,19,34] In a study with professional rugby athletes, Moreira

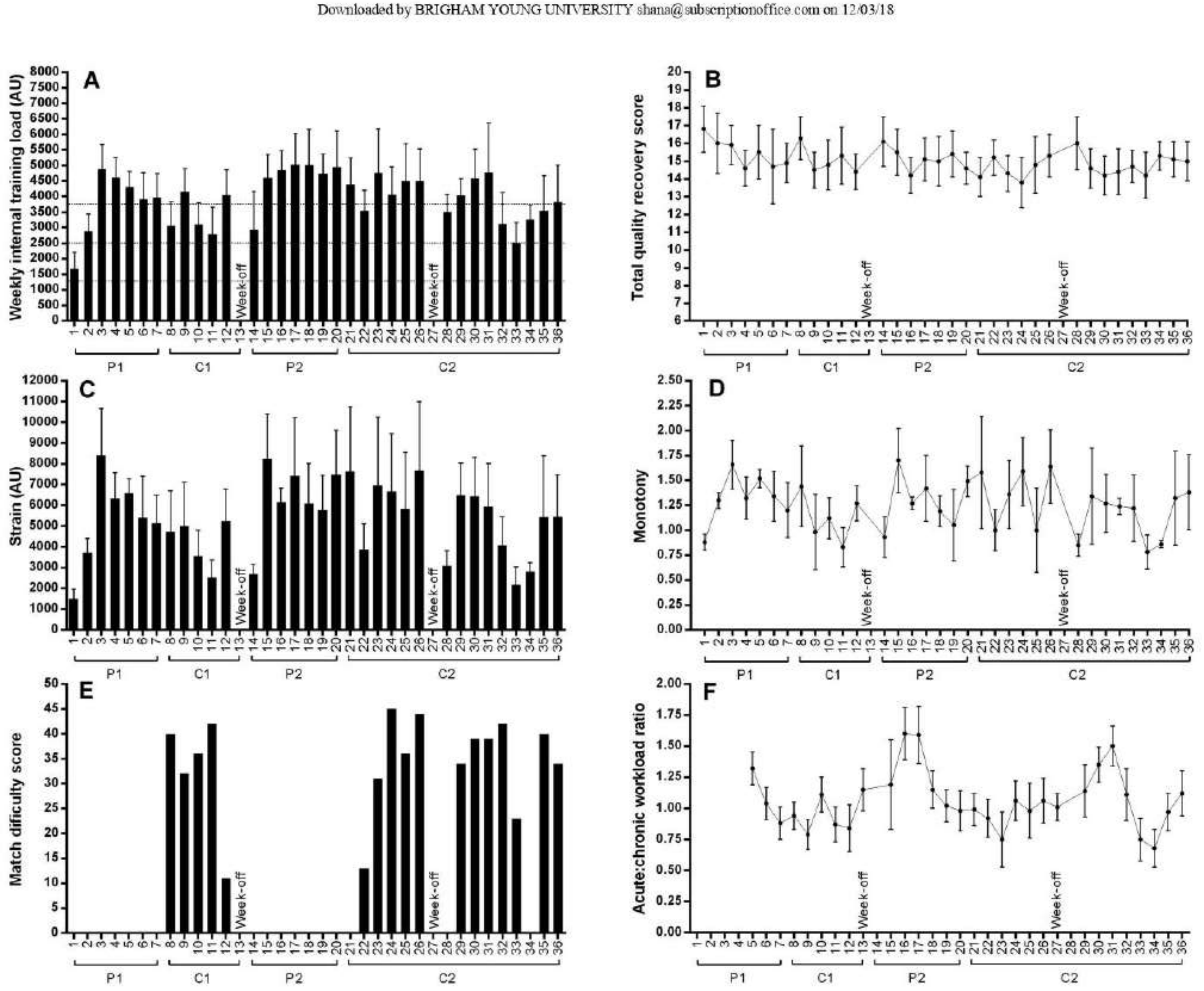

Figure 1 — Weekly internal training load (A), Total Quality Recovery score (B), strain (C), monotony (D), match difficulty score (E), and acute:chronic workload ratio (F) throughout a season in professional Brazilian volleyball. Values on the *x*-axis are weeks and periods. AU indicates arbitrary units; C1, competitive 1; C2, competitive 2; P1, preparatory 1; P2, preparatory 2.

Table 2 Weekly Internal Training Load (wITL), Monotony, Strain, ACWR, and Recovery of Each Period of the Season, Mean (SD)

	P1	C1	P2	C2
Number of weeks	7	6	7	16
Official matches	0	8	0	22
wITL, arbitrary units	3748 (472)[b,c]	2858 (472)[a,c,d]	4588 (558)[a,b,d]	3728 (650)[b,c]
Monotony	1.32 (0.09)[b]	1.13 (0.20)[a,c]	1.29 (0.15)[b]	1.22 (0.16)
Strain	5217 (893)[b,c]	4092 (1250)[a,c,d]	6214 (1197)[a,b]	5255 (1608)[b]
ACWR	1.08 (0.09)[b,c]	0.95 (0.04)[a,c,d]	1.25 (0.03)[a,b,d]	1.03 (0.03)[b,c]
TQR	15.63 (0.80)[d]	15.02 (1.03)	15.14 (0.96)	14.75 (0.79)[a]

Abbreviations: ACWR, acute:chronic workload ratio; C1, competitive 1; C2, competitive 2; P1, preparatory 1; P2, preparatory 2; TQR, Total Quality Recovery mean score.
[a] Different from P1. [b] Different from C1. [c] Different from P2. [d] Different from C2 ($P < .05$).

Table 3 Vertical Jump Height During the Season, Mean (SD)

	2nd wk	5th wk	16th wk	31st wk
Countermovement jump, cm	39.35 (5.25)	41.82 (4.93)[a]	43.29 (4.97)[a]	44.79 (5.32)[a]
Countermovement jump with arm swing, cm	46.93 (5.46)	48.21 (4.95)[c]	51.77 (6.39)[a]	53.45 (5.79)[a,b]

[a] Different from 2nd week. [b] Different from 5th week. [c] Different from 31st week ($P < .05$).

et al[25] noted that microcycles with fewer days between matches presented a lower training load than those with more days between one match and the next. In general, the literature indicates that such variations in load are influenced by different types and magnitudes of psychophysiological stimuli for every aspect of periodization, besides the fact that preparation periods allow for a greater training volume throughout the week when there are no official matches.[18,19,34] In this way, research has shown that it is also important to pay attention to the possible variations between individual ITLs in the different types of training (tactical, technical, conditioning) in both preparatory and competitive periods.[20,24] Therefore, to maintain the best physical performance during competition periods, we suggest a specific daily variation in training load magnitude and content rather than long moments of wITL intensification, as has been shown in literature.[19,25,34]

Athlete performance in competitions depends on development of physical, technical, tactical, and psychological capacities. To achieve the best performance at the desired moments it is not sufficient only to control the training loads, it is also necessary to guarantee good recovery.[11] In the present study, recovery during the main competition of the season (C2) was lower than during the preparatory period at the beginning of the season (P1). Possibly, the reduction in ITL during C2 (compared with P2) was not sufficient to ensure better recovery. In addition, there were moments of wITL intensification (23rd–26th and 29th–31st wk) and a spike in the acute load after the week off (27th wk). Another point that may have contributed to the worse recovery in C2 was the wITL distribution in P2, which presented 6 weeks in a row with high wITL and no tapering for supercompensation before the start of the Superliga.[5,12] The match difficulty score was not related with the distribution of the other variables during the competitive periods, which possibly means that this was not a criteria used for planning the wITL distribution during C2,[25,34] and might have influenced the decreased recovery. Moreover, the worse recovery in C2 may be related to the psychophysiological stress accumulation over the season,[27] as well as the traveling (Brazil is a big country and some cities do not have airports), and worse rest, sleep,[10] and nutrition conditions during this competition period.[9,15,21,31] A study with professional basketball players and coaches using the TQR scale showed that, during match congestion periods, coaches usually underestimate recovery scores.[29] Therefore, it is suggested that special attention be paid to load control and recovery time and strategies during competition periods of professional team sports to avoid decreased performance on match days.

One important point in this particular season was that matches were generally played twice a week with only one day off (with a travel) between them (Thursdays and Saturdays). Another point that was not deeply analyzed in this study is the influence of number of sets played on athletes' recovery. In this season, athletes performed at least 4 sets in 68% of Superliga's matches. Besides that, in the second round of Superliga (29th–36th wk), 91% of matches had 4 or 5 sets. This seems to influence directly in recovery not depending only to training load by itself.[21] Adequate recovery time and strategies, as well as bigger decrease in wITL could have led to a better recovery. It is suggested that, in volleyball, training load should be planned considering the number and duration of matches since it can vary considerably.

In volleyball, a positive relationship was confirmed between performance in basic actions that require good vertical jumps (serve, block, and attack) and success in matches;[1] thus, the CMJ has been considered as a good performance parameter for the analysis of athletes in this sport.[3] Monitoring the development of jumping capacity in this sport is essential to understand the training adaptation process.[2,6] In the present study, both CMJ and CMJa performances increased over the season. The CMJ height presented a significant increase from the 5th week and subsequent maintenance of performance during the season. During P2, the CMJa was higher than P1, and during the mean competition period (C2), athletes achieved their season best performance in the CMJa. It is important to point out that even with lower recovery scores in C2, the players achieved their best physical performance of the season. However, they did not feel well recovered, which may have compromised their performance during the matches. These results highlight the need for good training load distribution and organization during the preparatory period, not only in the preseason, but also during the season, to guarantee the increase and maintenance of physical performance over the competition periods. Other studies also found improvement in CMJ and CMJa performances of volleyball players of different technical levels, ages, and gender after appropriate periodized training during preparation periods.[3–6] Moreover, number of jumps may be part of training load control in volleyball, leading coaches to consider it in planning of training and matches, according to individuality of the players.[1]

Even though the data presented herein might be considered relevant, it is possible that load distribution may vary between different volleyball teams within the same context (eg, a different team playing in the Superliga). Furthermore, more frequent vertical jump tests and control could have been performed over the season and better explained the variation in physical performance, since this component is crucial to volleyball. In addition, although the jump tests were performed before the training sessions, it is possible that the training load of the day before could have influenced the jump performance.[37] This highlights the difficulties in assessing and intervening in the training routine of professional sports teams and explains the few longitudinal studies like this with Brazilian high-level volleyball players. Another limitation of this study was the absence of objective and/or physiological markers and injury risk, which could complement the analysis of these variables. Despite this, the tools used are consolidated in the context of sports science and are applicable for use in a longitudinal study like the present study. Future research could examine these parameters in other Brazilian volleyball teams and other sports, during an entire season. This would enable better comparisons to be made and lead to an overall better understanding of the specific features of sports training within each environment.

Practical Applications

Monitoring of the ITL, recovery, and performance of the athletes over the season is very important to help coaches and technical staff of team sports to decide the best training options and strategies. Simple tools such as the session-RPE and TQR provide frequent and simple data about the training process and how the athletes are dealing with it. This control may help coaches to obtain optimal performance from players during the main competition periods.

Conclusions

The Brazilian professional volleyball calendar reflects a wave distribution of ITL throughout the season, where periods of preparation involve higher loads than competitive periods. The ITL, recovery, and physical performance changed over the season. Despite the decrease in wITL during the main competition period, athletes did not achieve their best recovery scores at the desired moment, which outline that although they are related, wITL is not the only aspect that interferes on recovery. Preparation periods at the beginning and during the season are important to improve and maintain vertical jump height capacity during the competitive periods of professional volleyball players. The results reveal the need for multivariate, longitudinal, and frequent monitoring and control of training loads and responses.

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APPENDIX I – Additional work completed during the candidature

DEBIEN, P. B. et al. Weekly profile of training load and recovery in elite rhythmic gymnasts. **Science of Gymnastics Journal**, v. 11, n. 1, p. 23–35, 2019.

WEEKLY PROFILE OF TRAINING LOAD AND RECOVERY IN ELITE RHYTHMIC GYMNASTS

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Original article

Abstract

The aim of this study is to analyze the weekly profile of internal training load (ITL) and recovery of elite rhythmic gymnasts during a season. Eight professional rhythmic gymnasts of the Brazilian senior group participated. The session rating of perceived exertion (session-RPE) and Total Quality Recovery (TQR) score were collected daily across a 37-week season. The session-RPE was collected after each session and the TQR before the first session of the day. The sum of ITL of each session of the day (dITL) and week (wITL), as well as average TQR scores, were retained for the analysis. Training monotony and strain were also recorded. For the analysis, the season was divided into preparatory period, competitive period and a period comprising the competition weeks, within the competitive period. The ITL and recovery profile were different between the days of the periods and the competition weeks. The competitive period as a whole showed higher mean wITL, dITL, and strain, and lower monotony than the others. However, during the competition weeks gymnasts presented the worst recovery and highest monotony scores, despite the lowest mean wITL and dITL. Negative correlation was found between dITL and TQR of the following day ($r= -0.333$; $p<0.001$). The ITL and recovery profile changed between the season periods and competition weeks. The training load profile of the competitive period and competition weeks did not guarantee good recovery, especially on the weekend. More variability in load magnitude is suggested, possibly including a day off, during competitive periods and competition weeks.

Keywords: *session rating of perceived exertion, Total Quality Recovery, competition, gymnast.*

INTRODUCTION

The success of training depends on the control of the relation between load, recovery, and performance (Bourdon et al., 2017; Halson, 2014). This is a very complex relation, which can lead to positive adaptations to training as well as non-functional overreaching, injury, illness, drop in performance, underrecovery, and other undesired situations (Kellmann et al., 2018; Meeusen et al., 2013; Soligard et al., 2016).

The challenge of maintaining the balance in this relation increases the importance of frequent, longitudinal, and multivariate assessments of training load and responses in the bodies of athletes (Borresen & Lambert, 2009). This situation has contributed to the development of various monitoring tools in recent years (Borresen & Lambert, 2009; Bourdon et al., 2017). The nature of modern sport, with an intense calendar of competitions and demands for ever better performance, requires precise daily control of these variables in order to enable adjustments during the training process and not after it. In this perspective, simple, inexpensive and validated tools such as session rating of perceived exertion (session-RPE) (Foster et al., 2001; Haddad, Stylianides, Djaoui, Dellal, & Chamari, 2017) and the Total Quality Recovery (TQR) scale (Kenttä & Hassmén, 1998) stand out as methods of monitoring the internal training load (ITL) and recovery, respectively.

These and other tools has been used to understand training load distribution during entire seasons (Debien et al., 2018; Malone et al., 2018; Miloski, Freitas, Nakamura, Nogueira, & Bara-Filho, 2016; Moreira et al., 2015), specific periods (Thorpe et al., 2015), and weeks (Jeong, Reilly, Morton, Bae, & Drust, 2011; Manzi et al., 2010; Timoteo et al., 2017; Wrigley, Drust, Stratton, Scott, & Gregson, 2012) in different team sports. However, there is a lack of longitudinal investigations about training load in elite rhythmic gymnastics (RG).

The majority of team sports have long competitive periods over the season, with one or two matches of distinct simultaneous championships almost every week (Debien et al., 2018; Jeong et al., 2011; Thorpe et al., 2015). On the other hand, professional RG groups usually compete four or five times across one entire season. Each of these competition moments in RG last for a few minutes (routine presentation) and a small mistake during the presentation can ruin a whole season of hard training (Dumortier et al., 2017; Victorii, Valentin, Tara, Iryn, & Ulyan, 2016). Furthermore, studies have shown that gymnastics is a very complex sport due to the elevated requirement for technical perfection (Cavallerio, Wadey, & Wagstaff, 2016) and high training load from young ages (Antualpa, Aoki, & Moreira, 2017), together with the occurrence of nutritional disturbances (Silva & Paiva, 2016), and frequent overuse injuries (Cavallerio et al., 2016; Edouard et al., 2018; Kolar, Pavletič, Smrdu, & Atiković, 2017). Moreover, the literature has shown that gymnasts are exposed to training load increases, with a drop in performance (Fernandez-Villarino, Sierra-Palmeiro, Bobo-Arce, & Lago-Peñas, 2015), added to lower stress tolerance (Antualpa, Moraes, Schiavon, Arruda, & Moreira, 2015), and sleep problems (Dumortier et al., 2017; Silva & Paiva, 2016) during competition periods.

In this way, understanding the weekly distribution of training load and recovery in elite RG during different periods across the season, as well as in the specific competition weeks, may contribute to the planning and organization of training in order to guarantee the best performance at the competition moments and minimize maladaptation in this sport. In addition, a weekly profile of training and recovery of professional athletes could help the process of development of youth gymnasts. Therefore, the aim of this study is to analyze the weekly profile of ITL and recovery of elite rhythmic gymnasts during a season.

METHODS

Eight professional rhythmic gymnasts of the Brazilian senior group participated in the current study. At the beginning of the season, the athletes presented mean ± standard deviation (SD) of age, time of experience in RG, weight, and height of 20.5±2.5 years, 14.3±2.4 years, 53.38±3.93 kg, and 1.65±0.04 m, respectively. Prior to data collection, all participants were familiarized with the tools and signed a term of consent to their voluntary participation. The study was approved by the local Ethics

Committee in Research with Humans (CAAE 41423314.7.0000.5147).

During a 37-week season, ITL and recovery of the gymnasts were monitored daily. For the analysis, the season was divided into two periods: preparatory and competitive. In addition, the competition weeks were highlighted for comparison with both periods. Table 1 presents the usual content of training sessions during the different periods and competition weeks of the season. All training sessions started with a non-standardized and individual warm-up (10 min). Ballet consisted of a regimented routine of classical ballet exercises in the bar, center and floor. Conditioning were activities designed to improve physical capacities, mainly, strength, agility, and aerobic power. Flexibility were specific activities to development of this capacity, which is very important in RG. Technical training included apparatus work, body difficulty work, as well as repetitions of isolated elements (e.g., body difficulties, dance steps, risks, exchanges and collaborations), parts and the entire routine with and without the music. In general, the number (volume) and quality (intensity) of these repetitions in technical training were planned as described in Table 2. Training organization and execution were carried out, exclusively, by the technical staff of the group, without any interference from the researchers.

The ITL was determined by the session-RPE method (Foster et al., 2001). Daily, 30 minutes after each session, athletes answered the question "How was your workout?", pointing to a value on the scale between 0 (rest) and 10 (maximal). The session ITL was calculated by the product of duration of the training session (in minutes) and the reported session-RPE score, resulting in a value in arbitrary units (AU). The daily ITL (dITL) consisted of the sum of the ITLs of all training sessions during that day and the weekly ITL (wITL) was the sum of all the sessions during that week. The dITL was classified in accordance with the range between minimal and maximal mean values observed throughout the season periods: high (≥75%), moderate-high (≥50% a <75%), moderate-low (≥25% a <50%), and low (<25%) (Debien et al., 2018; Miloski et al., 2016). Training monotony and strain were calculated based on the method of Foster et al. (2001). Monotony was determined as the ratio between wITL and its SD. Strain was determined as the product of wITL and monotony. On sessions and days off the ITL was considered zero.

The TQR scale (Kenttä & Hassmén, 1998) was used to monitor recovery. Before the start of the first training session of the day, the athletes answered the question "How do you feel about your recovery?", pointing to a value on the scale from 6 to 20. The daily and weekly averages of TQR scores were retained for analysis. TQR was not assessed on days off.

Data are expressed as means ± SD. The assumption of normality was verified by the Shapiro-Wilk test, and sphericity was assessed with the Mauchly's test. Comparisons between mean wITL, dITL, monotony, strain, and TQR between the periods and competition weeks were carried out using ANOVA with repeated measures and the Bonferroni post hoc. The same tests were used to compare dITL and TQR of each day of the week between the periods and competition weeks. Exceptionally, for comparisons between the Sundays, we used the paired *t*-test. Spearman's correlation coefficient and corresponding 90% confidence intervals (CI) were used to analyze the correlations between individual dITL and TQR score of the following day over the season. The magnitude of correlation was assessed with the following thresholds: $r < 0.1$, trivial; 0.1–0.3, small; 0.3–0.5, moderate; 0.5–0.7, large; 0.7–0.9, very large; >0.9, nearly perfect; and 1 perfect (Hopkins, Marshall, Batterham, & Hanin, 2009). Data were analyzed using SPSS software (v. 20.0, SPSS Inc, Chicago, IL, USA). Statistical significance was set as $p<0.05$.

Table 1

Training content of a typical week of the gymnasts studied, for each training period during the season, including the competition weeks.

	Preparatory		Competitive		Competition weeks	
Weeks	1st to 11th		12th to 37th		15th, 22nd, 25th, 29th, 37th	
Session	Morning	Afternoon	Morning	Afternoon	Morning	Afternoon
Monday	Ballet (60 min) Condit. (30 min) Technical (130 min) Flexibility (20 min)	Condit. (60 min) Technical (120 min) Condit. (30 min)	Ballet (40 min) Technical (200 min)	Condit. (60 min) Technical (150 min)	Ballet (40 min) Technical (160 min)	Condit. (30 min) Technical (120 min)
Tuesday	Ballet (60 min) Condit. (30 min) Technical (120 min) Flexibility (20 min)	Condit. (60 min) Technical (120 min) Condit. (30 min)	Ballet (40 min) Flexibility (20 min) Technical (170 min)	Technical (200 min)	Travel (light warm-up at airports)	Travel
Wednesday	Ballet (60 min) Technical (160 min) Flexibility (20 min)	Off	Ballet (40 min) Technical (200 min)	Off	Ballet (30 min) Technical (120 min)	Off
Thursday	Ballet (60 min) Condit. (30 min) Technical (120 min) Flexibility (20 min)	Condit. (60 min) Technical (150 min)	Ballet (40 min) Condit. (20 min) Technical (160 min)	Condit. (60 min) Technical (140 min)	Technical (140 min)	Technical (140 min)
Friday	Ballet (60 min) Condit. (30 min) Technical (120 min) Flexibility (20 min)	Condit. (60 min) Technical (150 min)	Ballet (40 min) Technical (180 min)	Technical (200 min)	Ballet (30 min) Technical* (120 min)	Technical (140 min)
Saturday	Ballet (90 min) Technical (160 min)	Off	Ballet (40 min) Technical (150 min) Simulated presentations (30 min)	Off	Competition (qualification) (170 min)	Off
Sunday	Off	Off	Simulated presentations (90 min)	Off	Competition (finals) (120 min)	Off

*Podium training at the competition space; Condit.: conditioning

Table 2
Planned number and quality of repetitions of technical training components for each training period during the season, including the competition weeks.

	Preparatory	Competitive	Competition weeks
Body difficulties, dance steps, and risks	10	5	2
Exchange difficulties and collaborations	20	10	2
Parts of routine	6 (without music) + 4 (with music)	4 (with music)	1 (with music)
Entire routine	0	6	2
Demanded quality of repetitions	Low	Few mistakes	Without any mistakes

Table 3
Weekly and daily internal training load (AU), monotony, strain, and recovery of each period and competition weeks across the season (mean±SD).

	Preparatory	Competitive	Competition weeks
wITL	10507±1199 [b, c]	12496±524 [a, c]	8231±640 [a, b]
dITL	1501±171 [b, c]	1785±74 [a, c]	1212±78 [a, b]
Monotony	1.65±0.05 [b, c]	1.51±0.06 [a, c]	1.91±0.11 [a, b]
Strain	17098±2213 [b]	20482±953 [a, c]	17413±1768 [b]
TQR	13.66±1.31 [b, c]	12.45±1.11 [a, c]	11.46±1.20 [a, b]

Legend: wITL: Weekly internal training load; dITL: Daily internal training load; TQR: Total Quality Recovery mean score. [a] Different from preparatory period; [b] different from competitive period; [c] different from competition weeks ($p<0.05$).

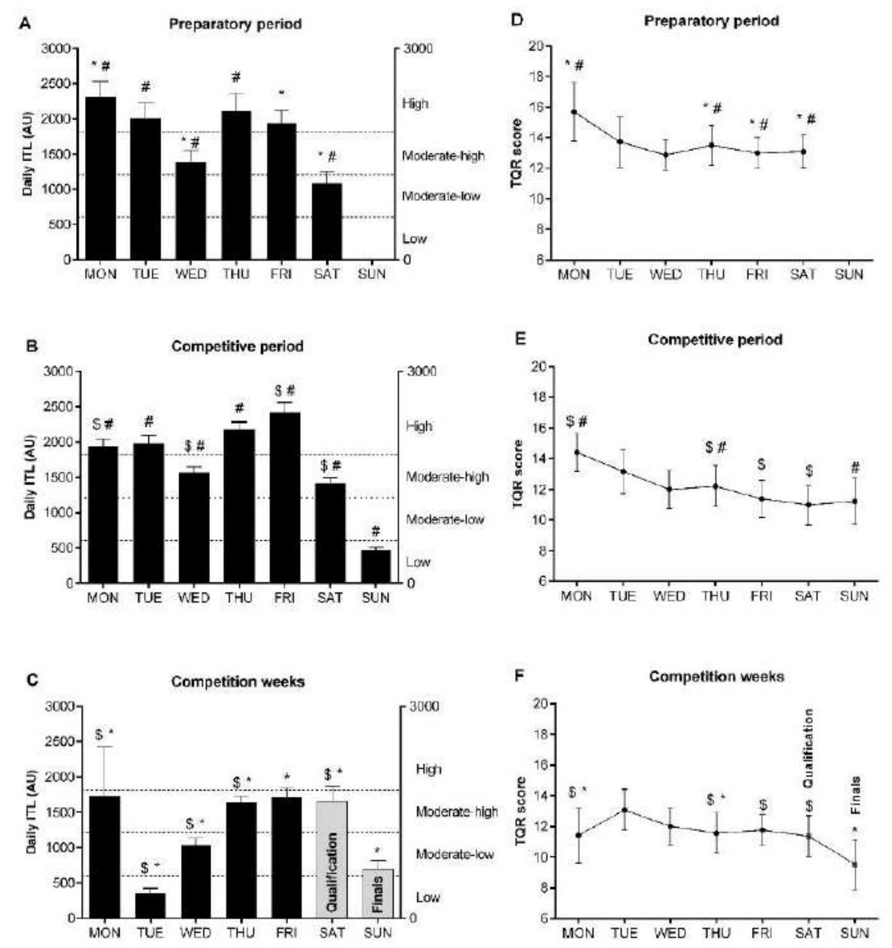

Figure 1. Weekly profile of internal training load (A, B, and C) and recovery (D, E, and F) of each period and competition weeks across the season of an elite rhythmic gymnastics group.

Legend: [$]Different from the same day of preparatory period ($p<0.05$); *Different from the same day of competitive period ($p<0.05$); [#]Different from the same day of competition weeks ($p<0.05$); ITL: internal training load; TQR: Total Quality Recovery; AU: arbitrary units; Mon: Monday; Tue: Tuesday; Wed: Wednesday; Thu: Thursday; Fri: Friday; Sat: Saturday; Sun: Sunday

RESULTS

Figure 1 displays a schematic representation of ITL and recovery weekly profiles during preparatory period (A and D), competitive period (B and E), and competition weeks (C and F), respectively. The comparison of dITL between each day of the periods and competition weeks demonstrated significant differences on Monday (F=69.26; p<0.001), Tuesday (F=439.32; p<0.001), Wednesday (F=63.6; p<0.001), Thursday (F=43.85; p<0.001), Friday (F=43.94; p<0.001), Saturday (F=41.33; p<0.001), and Sunday (p<0.001). The comparisons of TQR between each day of the periods and competition weeks were significantly different on Monday (F=22.83; p=0.001), Thursday (F=20.8; p=0.001), Friday (F=13.43; p=0.001), Saturday (F=39.71; p<0.001), and Sunday (p<0.001). The classification of dITL magnitude showed distinct distribution over the periods and competition weeks (Figure 1a, 1b, 1c). Moreover, a significant correlation was found between dITL and the TQR score of the following day (r= -0.333; 90% CI [-0.374; -0.295]; p<0.001; N=1678).

The mean wITL, dITL, monotony, strain, and TQR of each period and competition weeks are displayed in Table 3. When comparing wITL, there was a significant difference between periods (F=71.29; p<0.001). The post hoc analysis showed higher wITL during competitive period and lower during competition weeks, when compared to the other periods. The mean dITL was significantly different between periods and competition weeks (F=60.46; p<0.001). A higher mean dITL was observed during competitive period and the lowest during competitive weeks. The monotony also changed significantly across the periods (F=51.92; p<0.001). The highest and lowest monotony were observed during competition weeks and competitive periods, respectively, in comparison to the other periods. Strain varied during the season (F=12.45; p=0.001) and the competitive period was significantly higher than the other two periods. There was a reduction in TQR over the season (F=22.46; p<0.001). Higher TQR was observed during the preparatory period and lower across competition weeks, when compared to the other periods.

DISCUSSION

The current study explored the weekly profile of ITL and recovery across a full season of elite rhythmic gymnasts. The main findings were that both ITL and recovery weekly profiles were different between preparatory period, competitive period, and competition weeks. The competitive period showed higher wITL, dITL, and strain, besides lower monotony than the other periods. Furthermore, during competitive weeks, athletes were worse recovered than during preparatory and competitive periods. A negative moderate correlation was found between dITL and TQR of the following day. This is the first study to analyze the weekly profile of ITL and recovery in elite RG. This analysis is important to better understand the required training load and athletes' responses, and might be useful to optimize the long-term planning and control of training in RG.

The weekly profile of ITL across the preparatory period showed five days in a row, from Monday to Friday, with high or moderate-high dITL, even with just one training session on Wednesday. This wave shape of dITL magnitude is different from that observed in a pre-season of elite soccer (Jeong et al., 2011), while on the other hand, it is very similar to the weekly profile of elite women's artistic gymnasts (Dumortier et al., 2017). A different ITL and recovery profile during preparatory periods in a RG season is expected, as during this moment the focus of training is the development of flexibility, explosive strength, aerobic capacity, and less specific technical training than the competitive period (Laffranchi, 2001). This load distribution reflected positively on maintenance of appropriate recovery (at least "reasonable recovery", score 13) (Kenttä & Hassmén, 1998) all week, especially on Monday, after the load reduction on the weekend (Leme et al., 2015). Moreover, the association of weekend load decrease, without any training session on Sunday, with a moderate-high dITL on Wednesday seems to be a good strategy to achieve higher recovery from Thursday to Saturday than during the competitive period and competition weeks in RG.

The competitive period presented an increased dITL on Wednesday, Friday, and Saturday, together with a decrease on Monday, when compared to the preparatory period. This scenario resulted in six days in a row with at least moderate-high dITL. In addition, Sunday, which is usually a day off in the preparatory period, in this period has a training session with low dITL. The load reduction on Monday was sufficient to maintain the same recovery scores as the preparatory period on Tuesday and Wednesday. However, the general increase in mean dITL and wITL impaired the athletes' recovery, especially from Thursday to Monday. At this moment of the season, the main training goal is achievement of the best technical performance, with a large number of repetitions of routine and isolated elements (Laffranchi, 2001). A deep investigation about expert development in RG demonstrated that technical training and routine repetitions required more physical effort and concentration than other parts/types of training sessions (Law, Côté, & Ericsson, 2008). Possibly, this change in training content added to the RG culture of never ending routine repetitions during competitive periods (Cavallerio et al., 2016), explains the higher ITL and impaired recovery. Ideally, this period should present a similar weekly training profile to that expected during main competitive weeks (Laffranchi, 2001), which was not observed. In RG, competitions usually occur on the weekend, which highlights the importance of greater recovery on Saturday and Sunday. An investigation of 10 training sessions during a competitive period in RG demonstrated performance decreases across the study course and suggested that better training load distribution could have minimized this drop in specific RG performance (Fernandez-Villarino et al., 2015). Furthermore, a study with professional handball players found a positive role of a passive rest weekend (two days off) for psychological and physical recovery (Leme et al., 2015). Based on these results and the higher recovery in the preparatory period, we suggest the inclusion of a day off during the week in the competitive period in RG in order to achieve better balance between load and recovery and avoid negative adaptations to training.

RG group competitions are short, usually around two or three days. Commonly, the first day is scheduled training at the competition location, called "podium training" (Dumortier et al., 2017). On Saturday all the groups present two routines in an attempt to qualify for the finals, in which the best eight ranked groups compete, summing the score of both routines. The qualification often has a longer duration, because of the higher number of presentations and the finals usually take place on Sunday morning. Each group routine takes around two and a half minutes and the presentations are interspersed by other countries, so that no group presents two routines in sequence. In this scenario of competition, it is essential that the weekly profile of training load provides the best recovery and performance on the weekend, as already mentioned. Contrasting this expectation, the present study results revealed the worst season recovery during the competition weeks, mainly on the weekend. The weekly ITL profile showed a completely different wave of magnitude than typically reported by the gymnasts over the season. Furthermore, the lowest mean wITL and dITL of the season was not enough to recover the gymnasts, reaching the lowest mean TQR score during competition weeks.

Moreover, the low dITL on Tuesday, as a consequence of traveling to the competition, is followed by a progressive load increase until the podium training on Friday. Despite the distinct physiological demand on a competition day in RG (Douda, Toubekis, Avloniti, & Tokmakidis, 2008), normally, team sports present a profile of daily load reduction until the match day, including a day off during the 7-day microcycle that involves the match (Malone et al., 2018; Manzi et al., 2010; Thorpe et al., 2015; Wrigley et al., 2012). It is worth noting that Malone et al. (2018) also found a negative moderate relation between the dITL and athlete wellness perception the next day of a professional goalkeeper, added to which, this approach of load reduction prior to the match day reflected positively on wellness score on the match day. Similarly, even during a very congested competition week, professional volleyball players perceived an improvement in recovery and state of well-being after a day off on Wednesday (Timoteo et al., 2017). The loads in competition weeks should be managed carefully and individually in RG, and a weekly profile of dITL reduction until podium training, added to a day off could provide greater recovery and performance in qualifications and finals.

Recovery is a multifactorial process that depends on time and is also impaired by training load, travel, nutrition, sleep disturbances, impaired social environment, and psychological stress (Kellmann et al., 2018), which are common during competition weeks. In RG, studies have shown that during competitions, gymnasts present overuse injuries (Edouard et al., 2018), low energy availability (Silva & Paiva, 2015), as well as poor sleep habits and nutrient deficiencies (Silva & Paiva, 2016). These outcomes are extremely opposed to those desired in the principal weeks of the entire season. Moreover, in the case of Brazilian gymnasts, the long-distance air travels to compete in other continents exposes them to travel fatigue and jet lag, which could also impair their recovery and performance during competition weeks (Dumortier et al., 2017; Soligard et al., 2016). It highlights the need for expressive changes in the weekly profile of training load during RG competitions, along with reflection about the consequences of RG culture on athlete performance and health, especially across these weeks.

In addition to the lower wITL, dITL, and TQR score, competition weeks also showed the highest monotony. Elevated loads across competitive periods are uncommon in other sports (Debien et al., 2018; Miloski et al., 2016; Moreira et al., 2015), mainly because of the precaution about athlete recovery during this period. Instead, the RG competitive period showed the highest training loads of the season. The literature suggests that training monotony and increases in strain are related to incidences of illness and injuries (Foster, 1998), and this should be avoided to prevent the occurrence of these kinds of maladaptation (Meeusen et al., 2013). However, corroborating the results of the current study, Dumortier et al. (2017) found high training monotony and strain in female artistic gymnastics due to the long training sessions. At same time, seasonal training monitoring of professional volleyball players found small negative correlations between TQR and training monotony (Debien et al., 2018). The variability in dITL magnitude is essential to recover athletes across the week, as well as avoid negative adaptations to training. These results confirm and reinforce the need for better dITL distribution during competition weeks in RG, with more low loads or even a complete day off.

Regardless of the pioneering and novel results, the present study has some limitations. Other national RG groups could present different weekly profiles of training load and recovery. In addition, the absence of precise external training load and performance assessments, as well as physiological variables are also limitations. However, our findings could benefit RG coaches and practitioners with training planning and daily control. Moreover, the association of a daily load and recovery management with long-term planning might optimize adjustments during the process and minimize maladaptation in RG. Other investigations could describe different national groups or even junior groups, as well as test the effects of specific experimental training weekly profiles.

Finally, in view of national RG groups working in a permanent way, the harmony between the gymnasts (Victorii, Valentin, Tara, Iryn, & Ulyan, 2016) and their adaptation to the process (not only training) are very important for success. Hence, specific knowledge about the weekly profile of ITL and recovery might be helpful to gymnasts that aspire to achieve this dream. In this way, these results could bridge the gap of the training reality between the clubs and national RG groups. Furthermore, our findings may facilitate the adaptation of gymnasts not only to high training loads, but also to other impairments in social life.

CONCLUSIONS

The weekly profiles of ITL and recovery differed between the season periods and competition weeks in an elite RG group. The competition weeks need special attention from coaches during planning and execution, as athletes should be prepared to reach their best performance towards the end (e.g., Friday, Saturday, and Sunday). A simple load reduction during competition weeks was not enough to improve the recovery of the gymnasts, which emphasizes that the daily load magnitude distribution over the week, as well as the frequency of training sessions are also very important. In general, the gymnasts did not achieve full recovery, even after a day off and were not capable of recover properly during the weeks. Our findings highlighted that daily control of ITL and recovery are essential to optimize the training process. Moreover, session-RPE and TQR seem to be useful tools to monitor ITL and recovery in RG.

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APPENDIX J – Additional work completed during the candidature

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Original Research

Training Load and Recovery During a Pre-Olympic Season in Professional Rhythmic Gymnasts

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Context: Rhythmic gymnastics requires a high level of complexity and perfection of technical gestures, associated with well-developed physical and artistic capacities. The training-load and recovery profiles of rhythmic gymnasts across a season are unknown.

Objective: To analyze the training load and recovery of professional rhythmic gymnasts during 1 season.

Design: Cohort study.

Setting: Brazilian National Training Center of Rhythmic Gymnastics and competition facilities.

Patients or Other Participants: Eight gymnasts from the Brazilian national senior rhythmic gymnastics group.

Main Outcome Measure(s): Session rating of perceived exertion (session-RPE) and total quality recovery (TQR) scores were collected daily for 43 weeks. We obtained the session-RPE after each session and TQR score before the first session of the day. Performances during 5 competitions were also recorded. The season was divided into 8 periods. Total weekly internal training load (wITL), training intensity, frequency, duration, recovery, and acute : chronic workload ratio were calculated for analysis.

Results: The season mean wITL was 10 381 ± 4894 arbitrary units, mean session-RPE score was 5.0 ± 1.6, and mean TQR score was 12.8 ± 1.3. The gymnasts trained an average of 8.7 ± 2.9 sessions per week, with a mean duration of 219 ± 36 minutes. Each competitive period showed increased wITL compared with the previous period. Training-load variables (wITL and session-RPE) and recovery were inversely correlated. Gymnasts were poorly recovered (TQR < 13) during 50.9% of the season (n = 167 times), especially during competitive weeks. Spikes in load (acute : chronic workload ratio ≥ 1.5) occurred across 18.1% of the season (n = 55 times).

Conclusions: The training-load variables and recovery changed throughout a professional rhythmic gymnastics group season, mainly during competitive periods. The correct distribution of training load is critical to ensure that gymnasts are entering competitions in a recovered state.

Key Words: monitoring, session rating of perceived exertion, total quality recovery, acute : chronic workload ratio

Key Points

- Most high weekly training loads, high-intensity training, and spikes in load occurred during competitive periods.
- Training-load variables increased during competitive periods.
- During half of the season, the gymnasts were not adequately recovered, especially during competition weeks.
- The periods of underrecovery were more frequent when associated with high-intensity training and an acute : chronic workload ratio ≥1.5, reinforcing the negative association between total quality recovery and internal training-load variables.
- Despite the negative relationship, high training loads alone did not cause underrecovery.

The challenge of sport training is to promote appropriate stimuli for each athlete to achieve specific adaptations and the best performance at the right moments.[1] Therefore, a balance between the stressor stimuli (load) and recovery is necessary to promote positive psychophysiological changes in athletes.[1–3] However, the relationship among load, recovery, and performance is complex, with a fine line between the achievement of training goals and the occurrence of maladaptation.[3–5] A better understanding of the relationship between the training load and consequent athlete response is possible via an individual, accurate, and longitudinal monitoring process during different periods of the season.[2]

To improve this understanding, several methods of quantifying internal and external training loads have been described.[2] Among these, the session rating of perceived exertion (session-RPE)[6] stands out as a method of monitoring internal training load (ITL) because it involves a simple, noninvasive, and low-cost application tool.

Portions of the Methods section were adapted with permission from Debien PB, Mancini M, Coimbra DR, de Freitas DGS, Miranda R, Bara Filho MG. Monitoring training load, recovery, and performance of Brazilian professional volleyball players during a season. *Int J Sports Physiol Perform.* 2018;13(9):1182–1189. Copyright 2020 Human Kinetics, Inc.

Moreover, it has been a reliable and ecologically valid method of monitoring ITL in athletes from multiple sports.[7]

Holistic monitoring of training requires an integrated analysis of several variables (eg, physiological, psychological, sociological, and mechanical) measured with different tools (eg, objective and subjective) to transform data into real-time action on the field.[2,3] Several instruments have been used to measure and monitor athletes' perceptions of recovery and wellbeing.[3,5,8] Subjective tools have greater sensitivity and responsivity to variations in external training load than do other, more objective tools.[3,8] Given its simplicity and practicality, the total quality recovery (TQR) scale[9] offers a viable method of monitoring athlete recovery.[10–13]

Rhythmic gymnastics requires a high level of complexity and perfection of technical gestures (with the body and manual apparatus), associated with well-developed physical and artistic capacities.[14] Gymnasts are subjected to high training loads from a very young age,[14–16] which can result in overuse injuries and maladaptation as a consequence of such training.[17–19] Elite gymnasts perceived that these high or inadequate training loads were the main causes of their injuries[20] and impaired sleep and performance.[21] Furthermore, researchers have recently identified relationships between injury risk and training-load distribution[4,22,23] and perceived recovery,[24] which reaffirm the importance of understanding the behavior and relationships of these variables in high-level sports, such as rhythmic gymnastics. Despite the many training-load studies that have been conducted, few investigators[16,25] have discussed the distribution of training load and responses to it in rhythmic gymnasts.

Research involving longitudinal monitoring of training in rhythmic gymnasts is lacking, reinforcing the need to better understand the training dose-response relationship in these athletes. The training-load and recovery profiles of rhythmic gymnasts across an entire season are unknown. Therefore, the purpose of our study was to analyze the training load and recovery of professional rhythmic gymnasts during 1 season.

METHODS

Participants

Eight gymnasts (age = 20.5 ± 2.5 years, height = 165 ± 4 cm, mass = 53.38 ± 3.93 kg, experience in rhythmic gymnastics = 14.3 ± 2.4 years) from the Brazilian senior rhythmic gymnastics group participated. In the last 2 decades, Brazil has developed a tradition of accomplishment in rhythmic gymnastics group exercises (5-time Pan American champions and 2-time Olympic finalists between 1999 and 2015) such that the best Brazilian gymnasts are invited to join the national group each season. The present sample of gymnasts were the Pan American champions and ranked 16th in the 2015 World Championship. They were in good health at the beginning of the study, although some had minor lower limb overuse injuries (eg, tendinopathy, fasciitis). They were familiarized with the monitoring tools. All participants provided written informed consent, and the study was approved by the Ethics Committee in Research with Humans of the Federal University of Juiz de Fora (CAAE 41423314.7.0000.5147).

Design

The group was monitored across 363 training sessions and 16 competition sessions during a 43-week period between February and December 2015. The training program was planned exclusively by the technical staff (C.F.) without interference from the researchers. Training sessions started with a light warm-up, followed by classical ballet, conditioning (strength and flexibility), and technical training (repetitions of isolated movements, parts, and the whole routine). The technical staff divided the season into 8 periods based on the model proposed by Laffranchi[26]: basic preparatory, specific preparatory, precompetitive, competitive 1, varied, competitive 2, competitive 3, and transitional (Table 1). During the monitored season, the group participated in 5 international competitions: Grand Prix Berlin Masters, Pan American Games (first main competition), World Cup, World Championship (second main competition), and Meeting Brazil.

Training Load

Duration and frequency of the training and competition sessions were captured. The ITL was determined by the session-RPE method.[6] The session ITL was calculated as the product of the duration of the training session (in minutes) and session-RPE score and reported in arbitrary units (AUs). The ITL was described using the total weekly ITL (wITL), which was the sum of all session ITLs during that week. The wITL was classified according to the range of mean values observed throughout the 43 weeks: *high* (≥75%), *moderate-high* (≥50% to <75%), *moderate-low* (≥25% to <50%), or *low* (<25%).[12,27] The session-RPE score of each session (training intensity) was classified as *high* (≥7), *moderate* (>4 to <7), or *low* (≤4).[28,29] From the wITL values, we computed the *acute : chronic workload ratio* (ACWR). This ratio describes the acute (1-week) workload in relation to the chronic (4-week rolling average) workload.[22,23] The ACWR was calculated using coupled acute and chronic workload data.[30] A *spike*, or rapid increase, in training load was defined as an ACWR ≥1.5. On days off, the training load was considered zero, and this value was included in the general analysis.

Recovery

The TQR scale[9] was used to monitor recovery. Before the first session of each day, athletes answered the question, "How do you feel about your recovery?" by pointing to a value on the scale from 6 to 20. Daily TQR values from a given week were used to calculate the weekly average TQR score for each athlete. The TQR score was not assessed on days off. A score of ≥13 (*reasonable recovery*) indicated a minimally adequate recovery state.[9]

Performance

Performance was assessed via competition scores[25] and rankings[21] obtained over the season. The gymnasts presented 2 routines in each competition (mix: 6 clubs and 2 hoops; simple: 5 ribbons). The judges evaluated each routine independently, and the maximal possible score was 20 points.

Table 1. Description of Season Periods of Professional Rhythmic Gymnasts

Period	Weeks	Characteristics
Basic preparatory	1–4	General conditioning, mainly flexibility, aerobic capacity, and strength; promotion of new morphologic adaptations in the athlete's body after vacation and the composition of new routines
Specific preparatory	5–9	Development of main physical capacities in a specific way (flexibility and explosive strength); decrease in duration of general conditioning and greater duration and intensity of specific conditioning; increase in technical training duration and intensity
Precompetitive	10–18	Improvement of the competitive performance, increasing the specificity in all components of the training session; shorter training sessions with high intensity and quality, focusing on technical training; decrease in conditioning duration
Competitive 1	19–22	Peak performance during the first main competition of the season; focus on technique and routine, with high intensity and decrease in errors during the repetitions with and without music; increase in presentations and simulations of competition, with audience; adjustment of training plan in accordance with the competition (eg, time zone, frequency, duration)
Varied	23–27	Recovery and maintenance of peak performance reached in the previous period; new period of preparation and conditioning, with lower duration and high specificity; intense technical-tactical training to correct mistakes observed during competitions; small changes in routine if necessary
Competitive 2	28–30	Peak performance during the second main competition of the season; adjustment of training loads, focusing on technical training and routine repetition
Competitive 3	31–40	Recovery and maintenance of peak performance reached in the previous period; adjustment of training loads, focusing on technical training and routine repetition
Transitional	41–43	Active recovery; great change in the usual training schedule; decrease in training load, with low intensity; focus on ballet and technique of apparatus, without great physical demand; possible creation of new routines for the next season

Statistical Analysis

The weekly descriptive analysis of training-load variables and recovery was reported throughout the season. To test differences among the wITL, session-RPE, training duration, recovery, and ACWR of the season periods, we used generalized estimating equations with a γ distribution. When differences were present, we compared the means of each period (except for the last) with the mean of the subsequent periods using the post hoc Bonferroni test. Effect sizes were calculated using Cohen *d*, adopting the following classification for data interpretation: *trivial* (<0.2), *small* (0.2–0.6), *moderate* (0.6–1.2), *large* (1.2–2.0), or *very large* (2.0–4.0).[31] Pearson product moment correlation coefficients and corresponding 90% confidence intervals (CIs) were used to analyze the relationships between the ITL variables and TQR score over the season. The magnitude of correlations was determined using the modified scale of Hopkins[31]: *trivial* ($r < 0.1$), *small* ($r =$ 0.1–0.3), *moderate* ($r =$ 0.3–0.5), *large* ($r =$ 0.5–0.7), *very large* ($r =$ 0.7–0.9), *nearly perfect* ($r > 0.9$), or *perfect* ($r = 1$). We also described the proportions of classifications of weekly wITL, training intensity, recovery state, and spikes in load completed by each gymnast during the season. Data were analyzed using SPSS (version 24; IBM Corp, Armonk, NY). The α level was set at .05.

RESULTS

The distributions of wITL, frequency and intensity (session-RPE) of sessions, recovery, and ACWR over the season are shown in Figure 1. The wITL mean was 10 381 ± 4894 AU, and the highest value was 21 012 ± 2122 AU (week 38). The mean weekly session-RPE score was 5.0 ± 1.6, and the highest was 8.1 ± 0.4 (week 38). The average number of sessions per week was 8.7 ± 2.9. Mean session duration was 219 ± 36 minutes, and mean total weekly duration was 1878 ± 671 minutes. The mean TQR score was 12.8 ± 1.3, the lowest was 9.9 ± 2.9 (week 40), and the highest was 15.3 ± 2.8 (week 41). The mean ACWR across the season was 1.09 ± 0.52, reaching 2.69 ± 0.25 in week 34.

Training load and recovery variables during each period of the season are presented in Table 2. Sequential comparison showed mainly variations of training-load variables across the second half of the season, especially in competitive 2. For recovery scores, we observed a small reduction in the precompetitive period and a moderate increase in the transitional period. The ACWR displayed very large increases in competitive 2 and 3 and a moderate reduction in the transitional period. Performance during the 5 competitions by the judges' scores (total score of each routine in qualification and final), all-around (sum of scores of qualification) ranking position, and number of national group participants is provided in Table 3.

We noted correlations, albeit they were small to moderate, between TQR score and wITL (N = 328; $r =$ −0.17; 90% CI = −0.26, −0.08; $P = .002$) and session-RPE (N = 328; $r = −0.32$; 90% CI = −0.40, −0.23; $P < .001$). No correlation existed between TQR score and duration (N = 328; $r = 0.01$; 90% CI = −0.08, 0.10; $P = .90$) and ACWR (N = 304; $r = 0.02$; 90% CI = −0.08, 0.11; $P = .80$).

Across the season, 12.8% (n = 44) of individual wITL magnitudes were classified as high, 30.2% (n = 104) as moderate-high, 43% (n = 148) as moderate-low, and 14% (n = 48) as low. Of the session-RPE classifications, 9.0% (n = 31) were high, 64.8% (n = 223) were moderate, and 26.2% (n = 90) were low intensity. The TQR score was <13 (underrecovery) in 50.9% (n = 167) of individual weekly occurrences. Across the 5 competitions (weeks 15, 22, 26, 30, and 40), the proportions of underrecovered gymnasts were 75% (n = 6), 50% (n = 4), 100% (n = 8), 75% (n = 6), and 87.5% (n = 7), respectively. Considering only the training intensity and recovery state, across 70.3% (n = 52/74) of low-intensity weeks, the gymnasts were recovered. In contrast, across 74.2% (n = 23/31) of high-intensity weeks, the athletes were in an underrecovered state. Individual spikes in load were observed 55 times (18.1%). Moreover, 80% of high wITL, 74% of high-

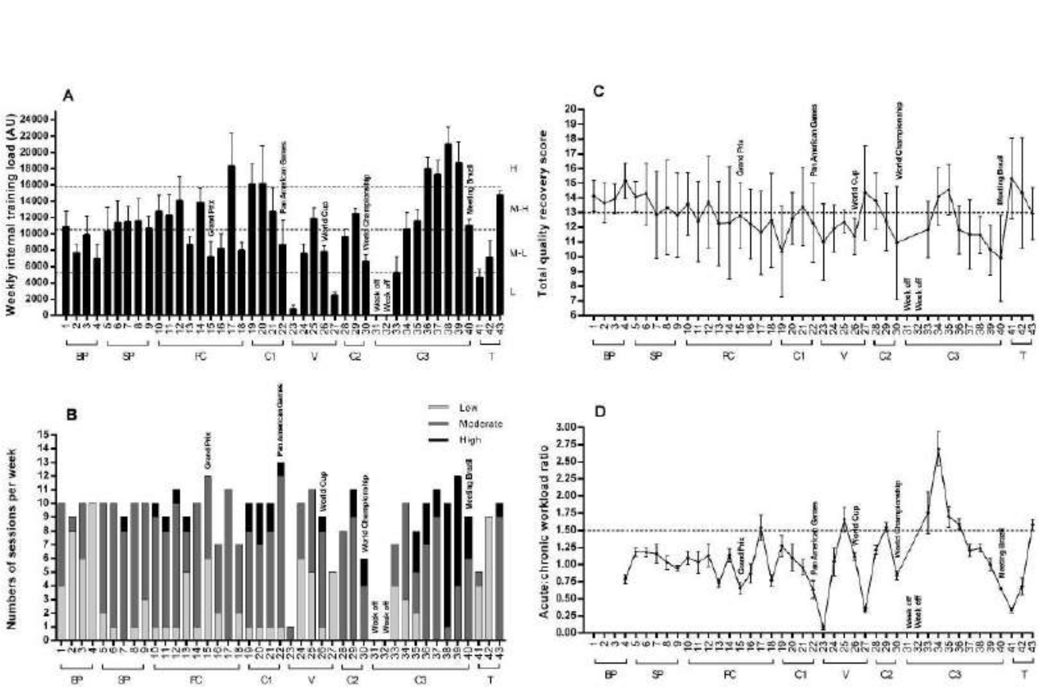

Figure 1. Distribution of A, weekly internal training load; B, number and intensity of sessions per week; C, total quality recovery score; and D, acute : chronic workload ratio throughout a season in a professional rhythmic gymnastics group.

intensity training, 41% of low-intensity training, and 67% of spikes occurred during competitive periods. The distribution and proportions of 304 individual measures of training load, spikes in load, and recovery state are illustrated in Figure 2. The proportion of gymnasts who had either a moderate-high or high training load, under-recovery state, or spikes in load during each week of the season is given in Figure 3.

DISCUSSION

We analyzed the training load and recovery of professional rhythmic gymnasts during 1 season. Training load and recovery changed across the season, particularly during competitive periods. The gymnasts were poorly recovered during half of the season, with negative correlations between recovery and training load. To ensure optimal recovery of rhythmic gymnasts preparing for international competitions, distribution of the training load may require modification.

Compared with values previously described in professional athletes,[10,12,27] the wITLs we observed in the rhythmic gymnasts were considerably higher. This was a consequence of the long duration and high frequency of training sessions per week.[15,19,20] Despite the higher absolute magnitude of wITL, the high-load weeks were less frequent across the season. Authors of similar studies of professional volleyball[12] and futsal[27] players have shown

Table 2. Weekly Internal Training Load, Session Rating of Perceived Exertion, Total Weekly Training Duration, Recovery Score, and Acute : chronic Workload Ratio of Each Period of the Season

	Weekly Internal Training Load		Session Rating of Perceived Exertion		Total Weekly Training Duration		Total Quality Recovery Score		Acute : chronic Workload Ratio	
Season Period	Mean ± SD, Arbitrary Units	Effect Size	Mean ± SD	Effect Size	Mean ± SD, min	Effect Size	Mean ± SD	Effect Size	Mean ± SD	Effect Size
Basic preparatory	8799 ± 2040	1.12	3.9 ± 0.8	1.13	2255 ± 39	0.22	14.2 ± 1.3	0.57	ND	ND
Specific preparatory	11 082 ± 3194[a]	0.12	4.8 ± 1.5[a]	0.21	2263 ± 207	1.01	13.5 ± 3.7	0.23	1.09 ± 0.08	1.25
Precompetitive	11 461 ± 2556	0.75	5.1 ± 0.9	0.58	2054 ± 257[b]	0.44	12.6 ± 6.3[b]	0.07	0.99 ± 0.08	0.00
Competitive 1	13 391 ± 3392[a]	2.16	5.7 ± 1.6	0.49	2168 ± 198	4.96	12.1 ± 2.8	0.01	0.99 ± 0.15	0.57
Varied	6073 ± 554[b]	6.31	4.8 ± 1.6[b]	0.74	1183 ± 152[b]	2.62	12.2 ± 1.3	0.13	0.87 ± 0.28	2.00
Competitive 2	9571 ± 370[a]	4.80	6.0 ± 0.2[a]	3.80	1583 ± 68[a]	1.99	12.4 ± 1.9	0.21	1.19 ± 0.04[a]	6.20
Competitive 3	11 348 ± 1931[a]	1.31	5.2 ± 0.8[b]	0.67	1718 ± 164[a]	0.51	12.0 ± 3.0	0.73	1.50 ± 0.06[a]	1.40
Transitional	8825 ± 696[b]	ND	4.6 ± 0.4[b]	ND	1801 ± 136[a]	ND	14.2 ± 2.4[a]	ND	0.87 ± 0.05[b]	ND

Abbreviation: ND, no data.

[a] Increase from the previous period ($P < .05$).

[b] Decrease from the previous period ($P < .05$).

Table 3. Scores and All-Around Rankings From the 5 Competitions During the Season

			Scores				
			Qualification		Final		
Competition	Location (City, Country)	Week	Mixed Routine[a]	Simple Routine[b]	Mixed Routine[a]	Simple Routine[b]	All-Around Ranking/ No. of Participants
Grand Prix Berlin Masters	Berlin, Germany	15	15.250	14.400	12.400	13.650	7/7
Pan American Games	Toronto, Canada	22	15.433	14.800	14.962	15.000	1/5
World Cup	Sofia, Bulgaria	26	16.200	15.000	ND	ND	13/19
World Championship	Stuttgart, Germany	30	15.900	16.041	ND	ND	16/24
Meeting Brazil	Vitoria, Brazil	40	16.550	16.100	17.250	16.100	2/3

Abbreviation: ND, no data.

[a] Six clubs and 2 hoops.

[b] Five ribbons.

frequencies of 64% and 27% high wITL during the season, respectively, contrasted with 12.8% in our study. The literature[22,23] has demonstrated that reaching high (and appropriate) chronic loads over the season is important, but the type, content, and progression of these loads are also relevant to minimize the risk of injury and optimize performance. Team sports usually present long competitive periods (months), with 1 or 2 matches per week,[4,12] which makes gradual increases in wITL across the in-season period difficult. Conversely, given the frequency and duration of competitions (2–4 days), the rhythmic gymnastics calendar may benefit from a safer wITL progression over the season. Along with what (type and content) and how (progression) high loads are achieved, it is also important to manage when they occur across the season for each athlete. In our study, 80% of high wITL, 74.2% of high-intensity training, and 67% of spikes occurred during competitive periods. This loading profile may impair gymnasts' recovery and performance during competitions, as well as expose them to maladaptation.

Corroborating our results, researchers[19,20,21] have also reported long training durations for rhythmic gymnasts. This finding may be related to the number of interventions and the feedback given by coaches during training sessions due to the highly technical demands of the sport. However, the concept of training load is not exclusively related to physical load.[4] In this respect, these moments are an inherent part of training in aesthetic sports and represent the cognitive load that would still contribute to the ITL. Despite the validity and reliability of the session-RPE method, it is possible that a more specific tool capable of measuring these nuances could provide more accurate training-load information and avoid overestimations.

In rhythmic gymnastics, greater focus on technical training and routine repetition is expected as a competition draws closer.[17,26] Law et al[19] found that technical training and routine repetition were the most demanding parts of training for elite rhythmic gymnasts. Furthermore, Fernandez-Villarino et al[25] observed session-RPE scores between 7 and 9 (high intensity) during 10 sessions in the competitive period. Our results showed an increase in session-RPE during the competitive 2 period and reduced frequency of low-intensity training in competitive periods

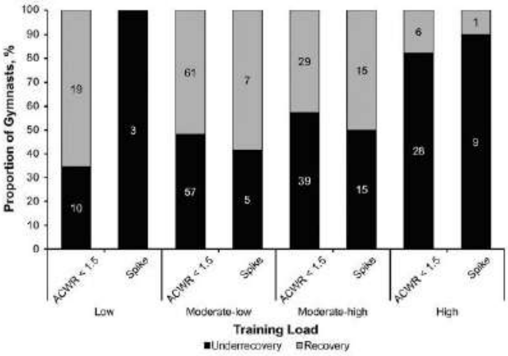

Figure 2. Number and proportion of gymnasts in >1 category of training load, underrecovery (total quality recovery score < 13) or recovery (total quality recovery score ≥ 13) state, or spikes (acute : chronic workload ratio [ACWR] ≥ 1.5) in load during each week of the season (N = 304). Low training load indicates a weekly internal training load <25%; moderate-low, 25% ≤ weekly internal training load <50%; moderate-high, 50% ≤ weekly internal training load <75%; and high, weekly internal training load ≥75%.

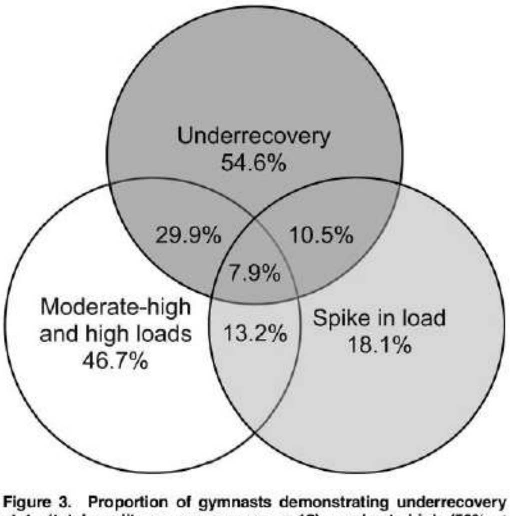

Figure 3. Proportion of gymnasts demonstrating underrecovery state (total quality recovery score < 13), moderate-high (50% ≤ weekly internal training load <75%) or high (weekly internal training load ≥75%) training load or spikes (acute : chronic workload ratio ≥1.5) in load during each week of the season (N = 304).

(41%). Considering this scenario and the negative association between session-RPE and TQR score, we suggest a better distribution of training intensity across the professional rhythmic gymnastics season to allow more recovery during competitive periods.

Kenttä and Hassmén[9] suggested a TQR score of 13 as the minimal level of recovery that athletes must attain, even after days of light training. Based on this approach, our gymnasts were poorly recovered during 50.9% of the season, and at least half of the group was underrecovered during all 5 competition weeks. In contrast to this result, Debien et al[12] reported that the lowest TQR score of professional volleyball players over a season was 13.8 ± 1.4, which occurred during the week with the highest difficulty match score. Despite the use of strategies for optimizing recovery, the process depends on time to adequately repair tissue and reestablish performance.[3] Therefore, the long duration (approximately 3.7 hours per session) and high frequency (8.7 ± 2.9 sessions per week) of training sessions in rhythmic gymnastics[21] disturb this restorative process, making it difficult for athletes to recover appropriately across the season.

In addition to high training load and intensity, other factors that may have impaired recovery in the rhythmic gymnasts were the concentrated high wITLs,[13] spikes in loads,[23] or even a mismatch between coaches' and athletes' perceptions of recovery.[11,17] Moreover, our results showed that the athletes were not appropriately recovered during 74.2% of the high-intensity weeks and the TQR score was >13 during 70.3% of the low-intensity weeks. Certainly, the multifactorial and individual nature of recovery reflects more than simple training loads; other aspects, such as sleep, social life, and nutrition, also affect the athletes' perceived recovery,[3,5] although we did not analyze them. The complexity of the relationship among training, recovery, and performance increases the importance of frequent, individual, and multivariate management of training and its responses. Furthermore, recovery should also be carefully planned, with the best individual strategies chosen to ensure better performance and less maladaptation during critical periods.[3]

The ACWR model has been used to safely progress training loads and manage injury risk in several team sports. This variable captures the training load performed in a short time period (ie, acute load) relative to the training load over a longer time (ie, chronic load).[22,23] Small fluctuations in training load (within an ACWR range of approximately 0.8 to 1.3) have been associated with a low injury risk, whereas higher ACWRs (≥1.5) have been associated with an increased injury risk.[22] We observed no correlations between ACWR and recovery, yet our results revealed 55 individual occurrences of spikes in load (ACWR ≥ 1.5) and increases in ACWR during competitive periods 2 and 3. Several authors[32–34] have encouraged practitioners to use the ACWR in combination with other variables when interpreting athlete-monitoring data. How the ACWR could be used in conjunction with other monitoring tools as a multidimensional athlete management system to contribute to decision making in the practical environment is highlighted in Figures 2 and 3.

In addition to ACWR, other training-load–derived metrics, such as monotony and strain, could provide relevant information related to training outcomes. *Monotony* represents the variability in the training stimulus, whereas *strain* is the product of monotony and training load.[6] In a study of female collegiate basketball athletes, Anderson et al[35] found a higher injury incidence when rapid increases in load occurred (ie, spikes) at the beginning of the season and after a week off. However, no conclusive results were demonstrated for monotony and strain.[35] The only study[16] in which researchers investigated ACWR among rhythmic gymnastics was conducted in young amateur athletes. Even though they recognized the need for further research, the authors[16] suggested that an ACWR between 1.2 and 1.4 might be a safe strategy to control training intensification (4-week period) in this population without impairment of mucosal immunity. Given the paucity of research in rhythmic gymnastics, further investigation is needed to better understand the interactions of training-load metrics, such as ACWR, monotony, and strain, as well as recovery, injury, and performance.

Our study had possible limitations. Our findings may be considered novel, but other national senior rhythmic gymnastics groups may present different training-load and recovery profiles over the season. Researchers should examine different training-load methods and other national rhythmic gymnastics groups and individuals, thoroughly analyze rhythmic gymnasts' daily training and competition demands, and assess the specific requirements of rhythmic gymnastics coaches and practitioners to improve their outcomes in the field.

CONCLUSIONS

The season of a professional senior rhythmic gymnastics group presents a particular and varied training-load distribution. Despite the high absolute magnitude of wITL, most wITL and session-RPE intensities across the season were moderate. Training-load variables increased during competitive periods. During half of the season, gymnasts were not adequately recovered, especially in competition weeks. The periods of underrecovery were more frequent when associated with high-intensity training and ACWRs ≥1.5, reinforcing the negative association between ITL variables and TQR score. Despite this negative relationship, high training loads alone did not cause underrecovery; it is also essential to manage the what (type and content), how (progression), and when (period) of these workloads applied across a professional rhythmic gymnastics season.

ACKNOWLEDGMENTS

We thank the Brazilian Gymnastics Confederation, technical staff, and gymnasts for their contributions. This study was financed in part by the Coordenação de Aperfeiçoamento de Pessoal de Nível Superior - Brazil (CAPES) - Finance Code 001 and by the Fundação de Amparo a Pesquisa do Estado de Minas Gerais (FAPEMIG).

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ATTACHMENT A – Ethics approval: Study 1

UNIVERSIDADE FEDERAL DE JUIZ DE FORA/MG

Plataforma Brasil

PARECER CONSUBSTANCIADO DO CEP

DADOS DO PROJETO DE PESQUISA

Título da Pesquisa: Monitoramento das cargas de treinamento e recuperação em atletas de ginástica rítmica

Pesquisador: Paula Barreiros Debien

Área Temática:

Versão: 3

CAAE: 41423314.7.0000.5147

Instituição Proponente: Faculdade de Educação Física

Patrocinador Principal: Financiamento Próprio

DADOS DO PARECER

Número do Parecer: 1.052.187

Data da Relatoria: 21/05/2015

Apresentação do Projeto:

O estudo proposto é pertinente e tem valor científico.

Objetivo da Pesquisa:

Apresenta clareza e compatibilidade com a proposta.

Avaliação dos Riscos e Benefícios:

Riscos e benefícios caracterizados.

Comentários e Considerações sobre a Pesquisa:

Projeto formulado de forma clara e objetiva.

Considerações sobre os Termos de apresentação obrigatória:

Todos são apresentados, conforme o exigido.

Recomendações:

Sugere-se revisão ortográfica no projeto, incluindo o resumo.

Conclusões ou Pendências e Lista de Inadequações:

Diante do exposto, o projeto está aprovado, pois está de acordo com os princípios éticos norteadores da ética em pesquisa estabelecido na Res. 466/12 CNS e com a Norma Operacional Nº 001/2013 CNS. Data prevista para o término da pesquisa:Junho de 2016.

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UNIVERSIDADE FEDERAL DE
JUIZ DE FORA/MG

Plataforma Brasil

Continuação do Parecer: 1.052.187

Situação do Parecer:

Aprovado

Necessita Apreciação da CONEP:

Não

Considerações Finais a critério do CEP:

Diante do exposto, o Comitê de Ética em Pesquisa CEP/UFJF, de acordo com as atribuições definidas na Res. CNS 466/12 e com a Norma Operacional Nº001/2013 CNS, manifesta-se pela APROVAÇÃO do protocolo de pesquisa proposto. Vale lembrar ao pesquisador responsável pelo projeto, o compromisso de envio ao CEP de relatórios parciais e/ou total de sua pesquisa informando o andamento da mesma, comunicando também eventos adversos e eventuais modificações no protocolo.

JUIZ DE FORA, 06 de Maio de 2015

Assinado por:
Francis Ricardo dos Reis Justi
(Coordenador)

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ATTACHMENT B – Ethics approval: Study 2

COMITÊ DE ÉTICA EM PESQUISA COM SERES HUMANOS | ufjf

UFJF - UNIVERSIDADE FEDERAL DE JUIZ DE FORA - MG

Plataforma Brasil

PARECER CONSUBSTANCIADO DO CEP

DADOS DO PROJETO DE PESQUISA

Título da Pesquisa: Controle da carga de treinamento na ginástica rítmica

Pesquisador: Paula Barreiros Debien

Área Temática:

Versão: 2

CAAE: 28609620.8.0000.5147

Instituição Proponente: Faculdade de Educação Física

Patrocinador Principal: Financiamento Próprio

DADOS DO PARECER

Número do Parecer: 3.950.855

Apresentação do Projeto:

As informações elencadas nos campos "Apresentação do Projeto", "Objetivo da Pesquisa" e "Avaliação dos Riscos e Benefícios" foram retiradas do arquivo Informações Básicas da Pesquisa.

"A ginástica rítmica é uma modalidade esportiva com alto grau de complexidade no seu treinamento e passível de adaptações negativas decorrentes desse processo. Apesar do avanço científico e tecnológico do monitoramento do treinamento, pouco se sabe a respeito da apropriação dos conhecimentos científicos e métodos de controle no contexto prático, especialmente em modalidades estéticas como a ginástica rítmica. Diante disso, presente estudo tem como objetivo identificar e analisar as práticas e percepções dos treinadores, equipe médica e ginastas de ginástica rítmica em relação ao controle da carga de treinamento nessa modalidade. A amostra será composta por profissionais e atletas de ginástica rítmica de diferentes nacionalidades que estejam envolvidos em competições nacionais e/ou internacionais no atual ciclo olímpico (2017-2020). Será aplicado um questionário online em cada grupo de participantes (treinadores, equipe médica e ginastas) contendo perguntas sobre suas práticas e

percepções no que tange os diferentes aspectos do controle da carga de treinamento. Os questionários contêm perguntas objetivas simples, múltipla escolha e de escala de avaliação (tipo Likert de 5 pontos). A análise dos dados terá abordagem tanto quantitativa quanto qualitativa, por meio de descrição da frequência de respostas e comparação entre os grupos."

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Objetivo da Pesquisa:

"Objetivo Primário: Objetivo identificar e analisar as práticas e percepções dos treinadores, equipe médica e ginastas de ginástica rítmica em relação ao controle da
carga de treinamento nessa modalidade.".

Avaliação dos Riscos e Benefícios:

"Esta pesquisa tem alguns riscos mínimos relacionados a aplicação de questionários, como cansaço, desconforto ou constrangimento durante o preenchimento. No entanto, para diminuir a chance desses riscos acontecerem, todos os cuidados serão tomados para assegurar um preenchimento tranquilo e máximo esforço será empregado para garantir o anonimato dos dados individuais. Esta pesquisa pode ajudar no aumento de evidências científicas na modalidade em questão, contribuir para práticas profissionais baseadas em evidências, bem como auxiliar no desenvolvimento de modelos de controle da carga de treinamento específicos que podem colaborar para minimizar
efeitos negativos ao treinamento e proporcionar às ginastas carreiras mais saudáveis, duradouras e com melhores resultados. Dito isso, acredita-se que este estudo é de suma importância para a Ciência do Esporte, em especial para a ginástica rítmica, o que implica em benefício indireto para e para os participantes envolvidos."

Comentários e Considerações sobre a Pesquisa:

O projeto está bem estruturado, delineado e fundamentado, sustenta os objetivos do estudo em sua metodologia de forma clara e objetiva, e se apresenta em consonância com os princípios éticos norteadores da ética na pesquisa científica envolvendo seres humanos elencados na resolução 466/12 do CNS e com a Norma Operacional Nº 001/2013 CNS.

Considerações sobre os Termos de apresentação obrigatória:

O protocolo de pesquisa está em configuração adequada, apresenta FOLHA DE ROSTO devidamente preenchida,com o título em português, identifica o patrocinador pela pesquisa, estando de acordo com as atribuições definidas na Norma Operacional CNS 001 de 2013 item 3.3 letra a; e 3.4.1 item 16. Apresenta o TERMO DE CONSENTIMENTO LIVRE ESCLARECIDO em linguagem clara para compreensão dos participantes, apresenta justificativa e objetivo, campo para identificação do participante, descreve de forma suficiente os procedimentos, informa que uma das vias do TCLE será entregue aos participantes,assegura a liberdade do participante recusar ou retirar o consentimento sem penalidades,garante sigilo e anonimato, explicita riscos e desconfortos esperados,indenização diante de eventuais danos decorrentes da pesquisa,contato do pesquisador e do CEP e informa que os dados da pesquisa ficarão arquivados com o pesquisador pelo período de cinco anos, de acordo com as atribuições definidas na Resolução CNS 466 de 2012, itens:IV letra b; IV.3 letras a,b,d,e,f,g e h; IV. 5 letra d e XI.2 letra f. Apresenta o INSTRUMENTO DE COLETA DE DADOS de forma pertinente aos objetivos delineados e preserva os participantes da pesquisa. O Pesquisador apresenta titulação e experiência compatível com o projeto de pesquisa, estando de acordo com as atribuições definidas no Manual Operacional para CPEs. Apresenta DECLARAÇÃO de infraestrutura e de concordância com a realização da pesquisa de acordo com as atribuições definidas na Norma Operacional CNS 001 de 2013 item 3.3 letra h.

Conclusões ou Pendências e Lista de Inadequações:

Diante do exposto, o projeto está aprovado, pois está de acordo com os princípios éticos norteadores da ética em pesquisa estabelecido na Res. 466/12 CNS e com a Norma Operacional Nº 001/2013 CNS. Data prevista para o término da pesquisa: dezembro de 2020.

Considerações Finais a critério do CEP:

Diante do exposto, o Comitê de Ética em Pesquisa CEP/UFJF, de acordo com as atribuições definidas na Res. CNS 466/12 e com a Norma Operacional Nº001/2013 CNS, manifesta-se pela APROVAÇÃO do protocolo de pesquisa proposto. Vale lembrar ao pesquisador responsável pelo projeto, o compromisso de envio ao CEP de relatórios parciais e/ou total de sua pesquisa informando o andamento da mesma, comunicando também eventos adversos e eventuais modificações no protocolo.

Este parecer foi elaborado baseado nos documentos abaixo relacionados:

Tipo Documento	Arquivo	Postagem	Autor	Situação
Informações Básicas do Projeto	PB_INFORMAÇÕES_BÁSICAS_DO_PROJETO_1381013.pdf	02/04/2020 13:18:23		Aceito
TCLE / Termos de Assentimento / Justificativa de Ausência	TCLE_treinador2.pdf	02/04/2020 13:15:16	Paula Barreiros Debien	Aceito
TCLE / Termos de Assentimento /	TCLE_treinador_ingles2.pdf	02/04/2020 13:15:04	Paula Barreiros Debien	Aceito

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Justificativa de Ausência	TCLE_treinador_ingles2.pdf	02/04/2020 13:15:04	Paula Barreiros Debien	Aceito
TCLE / Termos de Assentimento / Justificativa de Ausência	TCLE_responsaveis2.pdf	02/04/2020 13:14:49	Paula Barreiros Debien	Aceito
TCLE / Termos de Assentimento / Justificativa de Ausência	TCLE_responsaveis_ingles2.pdf	02/04/2020 13:14:33	Paula Barreiros Debien	Aceito
TCLE / Termos de Assentimento / Justificativa de Ausência	TCLE_ginastas2.pdf	02/04/2020 13:14:11	Paula Barreiros Debien	Aceito
TCLE / Termos de Assentimento / Justificativa de Ausência	TCLE_ginastas_ingles2.pdf	02/04/2020 13:13:41	Paula Barreiros Debien	Aceito
TCLE / Termos de Assentimento / Justificativa de Ausência	TCLE_eqmedica2.pdf	02/04/2020 13:13:20	Paula Barreiros Debien	Aceito
TCLE / Termos de Assentimento / Justificativa de Ausência	TCLE_eqmedica_ingles2.pdf	02/04/2020 13:13:04	Paula Barreiros Debien	Aceito
TCLE / Termos de Assentimento / Justificativa de Ausência	Assentimento_ginastas2.pdf	02/04/2020 13:12:47	Paula Barreiros Debien	Aceito
TCLE / Termos de Assentimento / Justificativa de Ausência	Assentimento_ginastas_ingles2.pdf	02/04/2020 13:12:26	Paula Barreiros Debien	Aceito
Projeto Detalhado / Brochura Investigador	Projeto_detalhado_CEP.pdf	20/01/2020 05:08:11	Paula Barreiros Debien	Aceito
Folha de Rosto	Folha_de_rosto_assinada.pdf	20/01/2020 05:07:08	Paula Barreiros Debien	Aceito
Outros	Questionario_eqmedica_ingles.pdf	03/01/2020 08:39:34	Paula Barreiros Debien	Aceito
Outros	Questionario_treinador_ingles.pdf	03/01/2020 08:38:48	Paula Barreiros Debien	Aceito
Outros	Questionario_ginasta_ingles.pdf	03/01/2020 08:34:38	Paula Barreiros Debien	Aceito
Outros	Questionario_eqmedica_portugues.pdf	03/01/2020 08:31:21	Paula Barreiros Debien	Aceito

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Continuação do Parecer: 3.950.855

Outros	Questionario_treinador_portugues.pdf	03/01/2020 08:30:44	Paula Barreiros Debien	Aceito
Outros	Questionario_ginastas_portugues.pdf	03/01/2020 08:29:59	Paula Barreiros Debien	Aceito

Situação do Parecer:
Aprovado

Necessita Apreciação da CONEP:
Não

JUIZ DE FORA, 02 de Abril de 2020

Assinado por:
Jubel Barreto
(Coordenador(a))

Endereço: JOSE LOURENCO KELMER S/N
Bairro: SAO PEDRO **CEP:** 36.036-900
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ATTACHMENT C – Participant consent form: Study 1

UNIVERSIDADE FEDERAL DE JUIZ DE FORA

PRÓ-REITORIA DE PESQUISA

COMITÊ DE ÉTICA EM PESQUISA EM SERES HUMANOS - CEP/UFJF

36036-900 JUIZ DE FORA - MG – BRASIL

TERMO DE CONSENTIMENTO LIVRE E ESCLARECIDO - ATLETAS

O (A) Sr. (a) está sendo convidado (a) como voluntário (a) a participar da pesquisa "**Monitoramento das cargas de treinamento e recuperação em atletas de ginástica rítmica"**. Nesta pesquisa pretendemos descrever e analisar o comportamento da carga interna e dos níveis de recuperação de atletas de ginástica rítmica ao longo de uma temporada e verificar, também, variáveis de desempenho e marcadores fisiológicos. O motivo que nos leva a estudar é a necessidade de controlar as cargas internas de treinamento e a recuperação na ginástica através de métodos não invasivos e de fácil aplicação, pois o controle feito somente pela carga externa (ex. volume do treinamento) pode não refletir o estresse que a sessão realmente provoca no organismo do atleta, o que pode prejudicar a periodização, interferindo diretamente no rendimento.

Para esta pesquisa adotaremos os seguintes procedimentos: 1) diariamente, antes da sessão de treinamento, o (a) Sr. (a) responderá à Escala de Qualidade Total de Recuperação; 2) ao final de cada sessão, responderá à Escala de Percepção Subjetiva de Esforço da sessão; 3) em momentos pontuais, responderá ao Questionário de Estresse e Recuperação para Atletas (RESTQ-Sport), realizará testes de salto vertical e coleta de saliva.

Os riscos envolvidos na pesquisa são mínimos, relacionados à aplicação de escalas e testes rotineiros e atividades cotidianas do treinamento esportivo de uma equipe de ginástica rítmica de alto rendimento. A pesquisa contribuirá para benefícios indiretos, ou seja, fornecer novos conhecimentos e fomentar novas discussões na área do Treinamento Esportivo e contribuir para o desenvolvimento da ginástica rítmica brasileira.

Para participar deste estudo o (a) Sr. (a) não terá nenhum custo, nem receberá qualquer vantagem financeira. Apesar disso, caso sejam identificados e comprovados danos provenientes desta pesquisa, o (a) Sr.(a) tem assegurado o direito a indenização. O (A) Sr. (a) terá o esclarecimento sobre o estudo em qualquer aspecto que desejar e estará livre para participar ou recusar-se a participar. Poderá retirar seu consentimento ou interromper a participação a qualquer momento. A sua participação é voluntária e a recusa em participar não acarretará qualquer penalidade ou modificação na forma em que o (a) Sr. (a) é atendido (a) pelo pesquisador, que tratará a sua identidade com padrões profissionais de sigilo. Os resultados da pesquisa estarão à sua disposição quando finalizada. Seu nome ou o material que indique sua participação não será liberado sem a sua permissão. O (A) Sr (a) não será identificado (a) em nenhuma publicação que possa resultar.

Este termo de consentimento encontra-se impresso em duas vias originais, sendo que uma será arquivada pelo pesquisador responsável, na Universidade Federal de Juiz de Fora e a outra será fornecida ao (à) Sr. (a). Os dados e instrumentos utilizados na pesquisa ficarão arquivados com o pesquisador responsável por um período de 5 (cinco) anos, e após esse tempo serão destruídos. Os pesquisadores tratarão a sua identidade com padrões profissionais de sigilo, atendendo à legislação brasileira (Resolução Nº 466/12 do Conselho Nacional de Saúde), utilizando as informações somente para os fins acadêmicos e científicos.

Eu, ____, portador do documento de Identidade _____________________ fui informado (a) dos objetivos da pesquisa "**Monitoramento das cargas de treinamento e recuperação em atletas de ginástica rítmica"**, de maneira clara e detalhada e esclareci minhas dúvidas. Sei que a qualquer momento poderei solicitar novas informações e modificar minha decisão de participar se assim o desejar.
Declaro que concordo em participar. Recebi uma via original deste termo de consentimento livre e esclarecido e me foi dada à oportunidade de ler e esclarecer as minhas dúvidas.

Juiz de Fora, _________ de ___________________________ de 20 .

Nome	Assinatura participante	Data
Nome	Assinatura pesquisador	Data
Nome	Assinatura testemunha	Data

Em caso de dúvidas, com respeito aos aspectos éticos desta pesquisa, você poderá consultar:

CEP - Comitê de Ética em Pesquisa em Seres Humano-UFJF
Campus Universitário da UFJF
Pró-Reitoria de Pesquisa
CEP: 36036-900
Fone: (32) 2102- 3788 / E-mail: cep.propesq@ufjf.edu.br

Nome do Pesquisador Responsável: Paula Barreiros Debien
Endereço: Rua Rubens Timponi, 5 - Granville
CEP: 36036-249 / Juiz de Fora – MG
Fone: (31) 9213-6457
E-mail: paulinhadebien@hotmail.com

ATTACHMENT D – Session rating of perceived exertion

geccart | ufjf

ESCALA DE PERCEPÇÃO SUBJETIVA DO ESFORÇO DA SESSÃO

COMO FOI A SUA SESSÃO DE TREINO?

0	Repouso
1	Muito, muito leve
2	Leve
3	Moderado
4	Um pouco pesado
5	Pesado
6	
7	Muito pesado
8	
9	
10	Máximo

ATTACHMENT E – Total Quality Recovery Scale

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ESCALA DE QUALIDADE TOTAL DE RECUPERAÇÃO

TQR

COMO VOCÊ SE SENTE COM RELAÇÃO À SUA RECUPERAÇÃO?

6	
7	Extremamente mal recuperado
8	
9	Muito mal recuperado
10	
11	Mal recuperado
12	
13	Razoavelmente recuperado
14	
15	Bem recuperado
16	
17	Muito bem recuperado
18	
19	Extremamente bem recuperado
20	