WEEKLY PROFILE OF TRAINING LOAD AND RECOVERY IN ELITE RHYTHMIC GYMNASTS

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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 ($p<0.05$).

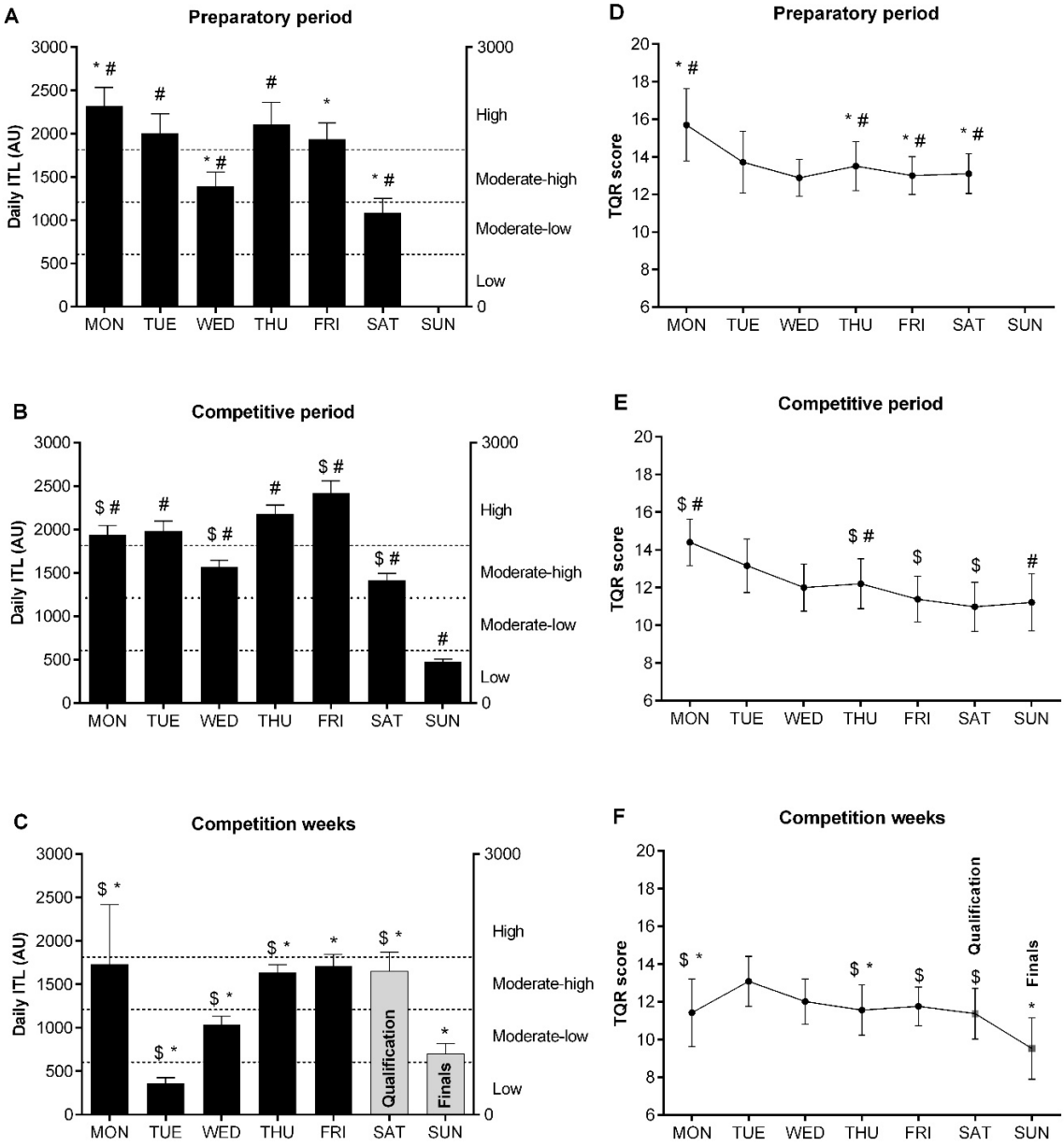

Figure 1. Weekly profile of internal training load (A, B, and C) and recovery (D, E, and F) of each period and competition weeks across the season of an elite rhythmic gymnastics group.

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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