Distribution of intensities and quantification of training load in young U15 elite tennis players

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ABSTRACT

The objectives of this study were to quantify training intensity as a function of time spent in three metabolic intensity zones, to compare programmed intensity, measured intensity (heart rate) and estimated intensity (RPE: Rating Perceived Exertion), and then to determine the training loads in 8 high level male tennis players. No difference was found between the time programmed in zones 1 (69.9 ± 4.8 %) and 2 (22.8 ± 4.4 %) and the time spent at a heart rate below Ventilatory Threshold 1 (VT1) (78.9 ± 9.4 %) and between VT1 and Ventilatory Threshold 2 (VT2) (18.3 ± 9.5 %) (p > 0.05). Thus, they trained in accordance with the programmed and recommended intensity distribution by adopting a "pyramid" pattern of intensity distribution. Furthermore, significant differences were found between the percentages of scheduled time and the percentages of perceived time (RPE) for all zones (p < 0.05). The overestimation of the estimated intensity can be explained by their age and the intermittent nature of tennis. Finally, we can note that the programmed training load is like that observed for players of the same age and level.

INTRODUCTION

In addition to the mental, technical-tactical and perceptive-cognitive qualities that the athlete must possess, tennis performance requires a complex interaction between the energy pathways (aerobic and anaerobic) (Fernandez et al., 2006) and complete physical qualities (speed of movement, endurance, explosive strength, coordination, agility, flexibility) (Girard et al., 2018). The combined development of these different capacities requires methodological skills on the part of the coaches. Several studies have quantified the intensity of training in different types of endurance athletes (Esteve-Lanao et al., 2007; Seiler & Kjerland, 2006). To quantify training intensity, coaches usually rely on physiological and subjective indicators and divide the range of training intensities into 3 or 5 distinct zones. The 3-zone model and the 5-zone model have common intensity points around the lactic (2 and 4 mmol.L-1) and ventilatory thresholds (Seiler, 2010) (Figure 1).

The model most commonly used by athletes, particularly in tennis, is the so-called "polarised" model (Stöggl & Sperlich, 2014). In this model, 75-80% of the sessions are performed at low intensities, i.e. less than or equal to the first ventilatory threshold (Zone 1) and 15-20% at intensities, known as very high, greater than or equal to the second ventilatory threshold (Zone 3) (Laursen, 2010; Stöggl & Sperlich, 2014; Treff et al., 2019). In addition to the distribution of intensities, coaches also seek to achieve a sufficiently high training load while limiting the risk of injury (Halson, 2014). A variety of methods have been proposed to measure training load. The principle common to the various approaches to quantifying training load is to multiply a volume indicator by a difficulty or intensity indicator of the training (Foster et al., 2001; Impellizzeri et al., 2004). They are divided into two approaches: on the one hand, quantification methods based on physiological variables (heart rate (HR), lactatemia, maximum oxygen consumption (VO2max)); on the other hand, methods using psychometric variables (difficulty of perceived effort, called RPE) (Seiler, 2010). Heart rate is a parameter that can be measured quickly, non-invasively,
easily implemented in training and applicable to a large number of players at the same time (Buchheit, 2014). In addition, numerous methods for quantifying training load, based on heart rate, have emerged, notably the “Training Impulse” method (TRIMPS) (Banister, 1991; Edwards, 1993; Lucia et al., 2003). However, the measurement of heart rate as the only tool for analysing training load requires a certain amount of expertise when analysing and interpreting the data collected. Other physiological measures, such as lactate and VO2max measurements, are not practical in training situations and even less so in competition. In order to quantify the training load, RPE is the most frequently used method (Halson, 2014). The RPE, developed by Borg, allows the athlete to provide information about his or her perceived effort after training or competition on a Borg scale (Borg, 1998). Chen et al. (2002) have indicated that the RPE is a valid means of assessing exercise intensity. In addition, the assessment of perceived exertion is widely recognised as one of the most appropriate methods for monitoring tennis load (Costill et al., 2010; Gomes et al., 2011). The method proposed by Foster et al. (2001) called session-RPE (sRPE), consists of multiplying the overall perceived difficulty of the session (RPE taken on a modified Borg CR-10 scale) by the total duration of the session (in minutes) to obtain a score expressed in arbitrary units (AU) that quantifies the training load. However, no published study has described the distribution of training intensity and training loads in high-level U15 tennis players. The main objective of this study was therefore to quantify the distribution of daily training intensity and training loads in young tennis players. We also compared the distribution of training intensity using two independent measures: heart rate and perceived effort during training sessions. We hypothesised that players would train in a ‘pyramid’ training pattern, where relatively little training would be performed at intensities above the second ventilatory threshold.

MATERIALS AND METHODS

Players
Eight male tennis players (age: 13.8 ± 1.0 years; height: 166.1 ± 12.8 cm; body mass: 51.5 ± 11.0 kg) with an International Tennis Number (ITN) ranging from 2 to 3 (ITN 2 = 2 players; ITN 2 > 6 players) and belonging to the Pôle France (integrated into the CREPS of Poitiers), participated in this study. The recruited tennis players, who were volunteers, were in good health and free of any type of chronic injury. After receiving information about the procedures used in this study, the participants and their legal representatives signed an informed consent form.

Procedures
At the beginning of the season, all players completed the TEST procedure which determined ventilatory thresholds for tennis training (Brechbuhl et al., 2016a, 2016b). Then for 12 weeks (February to May) of the 2022 season, Heart Rate (HR) and Rating of Perceived Exertion (RPE) were collected during training sessions, simulated matches, and official matches. The training programme was planned by the tennis coaches for each player according to the tournaments, the fitness level, possible injuries, and the technical and physical goals of each player. The training sessions took place 70% of the time on outdoor clay, 25% of the time on indoor GreenSet® and 5% of the time on outdoor GreenSet®. Each tennis player performed 11.5 ± 2.2 technical/tactical training sessions per week ranging from 30 minutes to 3 hours in duration for each training period (morning or afternoon). Heart rate data were collected during each training session using a Polar H10 heart rate monitor® (Polar Electro, Kempele, Finland), except for weeks 9 and 10 (Figure 2B), when data could not be collected (International Tournament). In addition, every evening, each athlete recorded their RPE for the whole of each session (morning and/or afternoon) using the modified Borg CR-10 scale (Foster et al., 2001; Gomes et al., 2015; Haddad et al., 2017). Players were asked to choose a score between 0 (rest) and 10 (maximum effort).

DATA PROCESSING

The distribution of intensity
Training duration was determined using the coaches’ planned training schedule. Heart rate data was only considered when the player wore the heart rate monitor at least 75% of the time for each week. This data was recorded using Polar Team System software® (Polar Electro, Kempele, Finland) which calculates the percentage of time spent in each of the predefined HR zones. This data was then used to determine the intensity of each training week in three intensity zones (Zone 1 ≤ SV1; Zone 2 > SV1 and < SV2; Zone 3 ≥ SV2). The two ventilatory thresholds, for tennis training, were established on the basis of the results of the TEST procedure (Brechbuhl et al., 2016a, 2016b). Based on the results of a study of 14-15 year old triathletes with a comparable training volume (Birat et al., s.d.), SV1 was set at 70% HRmax and SV2 was set at 90% HRmax for all non-tennis training for all players. For the RPE data, the CR-10 scores were divided into three zones: Zone 1 ≤ 4; Zone 2 > 4 and < 7; Zone 3 ≥ 7, according to Seiler & Kjerland (2006). Subsequently, the time spent in each RPE zone per week was calculated by summing the duration of each session for each zone. The percentage of time spent in each heart rate-based and RPE-based training zone was compared to the coaches’ programmed intensity distribution.

The training load
The results of the Gomes et al. (2015) study confirm the validity and, therefore, the possibility of using the session-RPE (sRPE) method to quantify training load in tennis. The daily training load or SRPE is calculated as the product of intensity (half-day sRPE) and volume (the duration of the activity) (Foster et al., 2001). Then the weekly training load is obtained by summing the daily sRPEs for the week.

DATA ANALYSIS

All data were expressed as mean ± standard deviation and were analysed using RStudio (RStudio v1.3.1093, US). The normality of the data distribution was checked by the Shapiro-Wilk test. The distribution of training intensity was compared for each assessment method (programmed (trainer) vs. measured (HR) vs. estimated (RPE)) and for each intensity zone (Zone 1 vs. Zone 2 vs. Zone 3) using a two-factor ANOVA (assessment method and intensity zone). If a significant difference was found, a pairwise comparison (Bonferroni method) was used as a post-hoc test. The significance level was set at p <0.05 for all analyses.
RESULTS

On average, each week, the scheduled intensity is distributed as follows: more than 9 h of training in Zone 1, about 3 h in Zone 2 and 1 h in Zone 3 (Figure 2A). The heart rate data show that the players spent on average just under 12 h in Zone 1, just over 2 h in Zone 2 and 30 min in Zone 3 each week (Figure 2B). Regarding the distribution of intensities achieved according to the RPE, the players perceived their effort, on average per week, more than 4 h in Zone 1, about 5 h in Zone 2 and 3 h in Zone 3 (Figure 2C).

As the training programme was planned for each player according to tournaments (singles and doubles matches), fitness and injuries, we chose to represent the training load of two players, representative of the inter-individual variability. In total, 18 matches were played with an average win rate of 61.1 ± 15.1 % for player 1 (Figure 4A) and 9 matches were played with an average win rate of 22.2 ± 29.9 % (Figure 4B). The average weekly training load during the 12 weeks was 5445 ± 2016 AU (Arbitrary Units), ranging from 1935 AU to 9375 AU for player no. 1 (Figure 4C) and 4381 ± 1919 AU, ranging from 1950 AU to 7710 AU for player no. 2 (Figure 4D). The training load is well individualised, but it did not have the expected results in terms of winning for player no. 2. Furthermore, we found that there is no higher training load in the training weeks compared to the match weeks.

DISCUSSION

The aim of this study was to quantify the distribution of daily training intensity with different assessment methods, and to follow the evolution of training load in young elite tennis players from programmed intensity revealed that a pyramidal distribution, whereby 70-75% of the total training volume is performed at low intensities (Zone 1) and about 5-10% at very high intensities (Zone 3), is proposed. This distribution has been suggested as one of the optimal training intensity distributions and one of the most frequently used in adult elite endurance athletes (Bourgois et al., 2019; Brechbuhl et al., 2017). The results observed via the heart rate monitor are similar to the training sessions programmed in Zone 1 (78.9 ± 9.4 %) and Zone 2 (18.3 ± 9.5 %) (p > 0.05). No difference was found between the time scheduled in Zone 1 and the time spent at a heart rate between SV1 and SV2 (18.3 ± 9.5 %) (p > 0.05). Furthermore, significant differences were found between the percentage of time programmed in Zone 2 (22.8 ± 4.4 %) and the percentage of time perceived by the players in Zone 2 (Intensity between 4.5 and 6.5) (38.3 ± 8.1 %) (p < 0.01) No difference was found between the time programmed in Zone 3 (7.3 ± 2.0 %) and the percentage of time spent at a heart rate greater than or equal to SV2 (2.7 ± 2.0 %) (p > 0.05).
increase peripheral sensations of fatigue (Mutch & Banister, 1983) and therefore RPE (St Clair Gibson & Noakes, 2004). This overestimation could also be explained by an increase in central sensations linked to the intermittence of the heart rate during repeated efforts. Thus, the fatigability of tennis training sessions would be underestimated if only heart rate is considered as an indicator of internal load. Another explanatory factor could be the age of the players. Indeed, Grosclambert & Mahon (2006) found a poorer correlation between RPE and heart rate during incremental exercise in adolescents than in adults. Furthermore, peripheral factors (i.e., maximal lactate, maximal minute ventilation, and mechanical work output) appeared to explain only 36% of the variance in RPE measured with the CR-10 during intense exercise from childhood to adolescence (Bardin et al., s. d.). This suggests that other psychosocial factors may be important in estimating RPE during exercise. Thus, although RPE, which considers the involvement and intuition of each player, is a useful monitoring tool for the coach to simply assess the perceived effort of the session, it would be necessary to quantify the intensity of training with both physiological and psychometric variables in young categories.

Regarding training load, the average (respectively 5373 AU and 4381 AU for players #1 and #2) imposed over the 12 weeks is similar to that of young players in futsal (15.8 ± 0.8 years) (Moreira et al., 2013) and basketball (19 ± 1 years) (Moraes et al., 2017) where the training load does not exceed 6000 AU. In addition, the training loads of the technical/tactical sessions (51.2 ± 191 AU) are similar to those observed for Australian players aged 17 ± 1.3 years ranked 135 ± 22 in the International Tennis Federation junior and 1309 ± 370 in the Association of Tennis Professionals who had a load of 492 ± 304 AU (Murphy et al., 2015). However, some weeks (e.g., weeks 6 and 8 Figure 4) have training loads above 7000 AU. These high training loads are due to weeks with high volume sessions (more than 2 h training per session). Long training sessions are perceived as difficult because of their long duration, and the associated level of perceived exertion is multiplied by the duration of the effort (Foster et al., 2001). As a result, the duration of the effort is taken into account twice, which tends to overestimate the loads for high volume training situations (Martin, 2018). However, these weeks with high training loads are automatically followed by a week with a load of less than 4000 AU, which shows that the previous weeks are considered to plan the training in the most optimal way. We observe that the organisation of the training loads allowed half of the players to maintain good performance while minimising any risk of injury. In contrast, the other half of the players had a negative win percentage (n = 2) or did not play any official matches (n = 2) due to injuries. This suggests that the training load was not planned in the most judicious way. In order to reduce training-related injuries in the long term, Gabbett (2016). The importance of monitoring the training load is emphasised.

CONCLUSION

The present results show that young elite French tennis players train 70-75% of the time in a low intensity zone, about 20% in a moderate intensity zone and 3-5% in a high intensity zone. These data therefore demonstrate that a "pyramid" training model is used. In addition, the age of the players is a factor confirming the importance of aerobic work during training. However, the players overestimated the
intensity of their efforts (moderate to intense intensities) compared to the prescribed training intensity and the actual training intensity (heart rate). This overestimation can be explained by the intermittent nature of tennis and the age of the players in this study. Therefore, it seems essential to couple heart rate with RPE in future studies. Furthermore, the programmed training load was like that observed for players of the same age at a high level. We can conclude that for half of the players, this planning allowed them to maintain good performance while minimising the risk of injury. The results presented here can therefore be seen as a first step towards the recognition of the necessary distribution of the actual training intensity performed by young tennis players. Tennis coaches will now be able to compare the training loads of their players with the results presented here. In addition, tennis coaches can use the current training monitoring methods adopted in the present study to verify the internal training load of their players. The use of such an approach should allow coaches to adjust the training load to avoid the phenomenon of ‘overtraining’. As the current data are on young male players, further studies on female tennis players are needed. The use of heart rate variability monitoring can also complement the monitoring of individual physiological response over time (Schmitt et al., 2006).

CONFLICT OF INTEREST AND FUNDING

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REFERENCES


