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MONITORING TRAINING LOAD AND WELL-BEING DURING HIGH TRAINING VOLUME COMPETITIVE MICROCYCLE IN ELITE BASKETBALL PLAYERS

MASTER THESIS

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CONTENTS

LIST OF ABBREVIATIONS

RPE	Rate of Perceived exertion
sRPE	Session Rate of Perceived exertion
SHRZ	Summated-Heart-Rate Zones
AU	Arbitrary Units
GD	The day of competitive match

ABSTRACT

MONITORING TRAINING LOAD AND WELL-BEING DURING HIGH TRAINING VOLUME COMPETITIVE MICROCYCLE IN ELITE BASKETBALL PLAYERS

Aims: (1) Deeply investigate load and well-being of the professional basketball players during the competitive high-training-volume microcycle and (2) identify differences in load & well-being and its fluctuation during the microcycle; (3) conclude whether the microcycle(s) was planned optimally. **Methods:** 11 high-level male basketball athletes (mean±SD, age: 22.9±1.9 years, body mass: 89.2±10.9 kg, BMI: 22.6±1.6, height: 198.4±8.5cm) competing in national first division basketball league [Lietuvos Krepšinio lyga – „BetsafeLKL"] season of 2022/2023 participated in the study. Two of the most in-season repetitive microcycle structures *(Microcycle A & Microcycle B)* was taken for deeper analysis and different variables regarding players' wellness & load of high-load day(s) was compared to taper & maintenance and gamedays. **Findings:** results demonstrated that in analyzed microcycles' wellness score does not show clear visible fluctuations throughout the days. Differences were noticed of Muscle Soreness scores on estimated high-load day versus two days prior game (respectively 3.25 (±1.06) vs 2.68 (±0.45)) in *microcycle A*. Average *Sleep quality* score on high-load days were lower ($p<0.05$) compared to two days prior game (respectively 3.74±0.54 vs 3.83±0.29) in *microcycle B*. Day-wise comparison of sRPE and values of Summated heart rate zones (SHRZ) demonstrated load (AU) differences ($p<0.05$) between the estimated high-load day(s), taper & maintenance day(s) and gameday(s). **Conclusion:** Fluctuations of training-load and no fluctuations of wellness occurs across the days in elite professional basket players' high-volume microcycles. The intention of this study is to contribute to the growing pool of knowledge in sports science, provide valuable insights for coaches and practitioners, and help in enhancing the overall welfare and performance of elite basketball players.

Key words: basketball, wellness monitoring, training-load, sRPE, microcycle

SANTRAUKA

DIDELIO MESITRIŠKUMO KREPŠININKŲ TRENIRUOČIŲ KRŪVIO IR SAVIJAUTOS STEBĖJIMAS DIDELĖS TRENIRUOČIŲ APIMTIES MIKROCIKLUOSE

Tyrimo tikslai: (1) nuodugniai ištyrinėti didelio meistriškumo krepšininkų patiriamą krūvį ir jų savijautą didelės treniruočių apimties mikrocikluose, (2) nustatyti dviejų skirtingų mikrociklų formatų treniruočių krūvio ir savijautos rodiklių svyravimus; (3) įvertinti ir apibendrinti mikrociklų sudarymo strategijas. Tyrime dalyvavo 11 didelio meistriškumo sportinonkų (vidurkis ± SN: amžius 22.9±1.9 metai, kūno masė: 89.2±10.9 kg, KMI: 22.6±1.6, ūgis: 198.4±8.5cm) dalyvaujančių aukščiausioje šalies krepšinio lygoje [Lietuvos Krepšinio lyga – „BetsafeLKL“] 2022/2023 metų sezone. **Metodai:** Tyrimui buvo paimti du dažniausiai atsikartojantys mikrociklų formatai. Žaidėjų intensyviausių dienų krūvio ir savijautos rodikliai buvo palyginti su priešrungtyninių dienų, ir rungtynių dienos rodikliais. **Rezultatai:** Tyrimas parodė reikšmingus skirtumas ($p<0.05$) tarp raumenų skausmo (*Muscle soreness*) balų planuotose didelio krūvio dienose lyginant su dviejomis priešvaržybinėmis dienomis (atitinkamai 3.25 (±1.06) ir 2.68 (±0.45)) mikrocikle A. Miego kokybės (*Sleep quality*) balai didelio intensyvumo dienose buvo mažesni ($p<0.05$) lyginant su dviejomis priešvaržybinėmis dienomis (atitinkamai 3.74±0.54 ir 3.83±0.29) mikrocikle B. Pastebėti reikšmingi skirtumai ($p<0.05$) tarp patiriamo krūvio (*session-RPE*) ir sumuojamų širdies ritmo zonų (*Summated Heart Rate Zones*) rodiklių tarp planuotų didelio intensyvumo dienų, priešrungtyninių dienų ir rungtynių dienų. **Išvada:** Didelio meistriškumo krepšininkų treniruočių mikrocikluose pasireiškia treniruočių krūvio svyravimai ir savijautos rodiklių tolygumas. Šis tyrimas prisidės prie didėjančio sporto mokslo žinių bagažo suteikdamas daugiau žinių sportininkams ir sporto treneriams siekiantiems pagertinti žaidėjų savijautą, krūvio planavimą ir sporto rezultatus.

Raktažodžiai: krepšinis, savijautos stebėjimas, treniruočių krūvis, mikrociklas

INTRODUCTION

Relevance of the topic

Training load and wellness monitoring in basketball is gaining more attention and importance in modern sports science research, particularly in the context of maximizing elite basketball players' performance and preventing injuries. Since basketball is a sport that involves both high-intensity physical and cognitive demands, it is crucial to oversee and handle the athletes' overall well-being and training load to ensure their longevity and peak performance in their careers. According to Fox, Stanton, and Scanlan (2018), there is a growing demand for comprehensive player monitoring methodologies that include both internal and external load gauging to optimize the training and recovery processes. Svilar, Castellano, and Jukic (2019) further emphasize the significance of comprehending the connection between external and internal load indicators, as well as the necessity for individualized load supervision. Additionally, Brink, Visscher, Arends, Zwerver, Post, and Lemmink's (2010) study highlights the correlation between high training loads and increased chances of injuries, thereby emphasizing the importance of monitoring and adjusting the training load for injury prevention.

The practice of wellness & training load monitoring, which encompasses a variety of approaches, has gained increasing traction in the professional basketball realm in order to effectively manage player load, optimize performance, and mitigate injury risk. This context has prompted numerous studies that underscore the importance of such measures, however, there is still growing demand of up-to-date data and recommendations that take into consideration the actual situations and challenges that various athletes and coaching staff are facing form different levels and professional sport organizations all around the world.

Aims

Knowing that there is still huge demand of recent investigations of elite professional basketball that would help practitioners and coaches to settle more accurate training plans and improve performance - following aims of the study were formulated:

1) Deeply investigate load and well-being of the professional basketball players during the competitive high-training-volume microcycle.

2) Identify differences in training-load, well-being and its fluctuation during the microcycle.

3) Conclude whether the microcycle(s) was planned optimally.

By focusing on the subject of training load and wellness observation in basketball, this research of Master's degree will contribute to the growing pool of knowledge in sports science, provide valuable insights for coaches and practitioners, and help in enhancing the overall welfare and performance of elite basketball players.

1. LITERATURE REVIEW

1.2. Load monitoring in basketball

Load monitoring in basketball has evolved as an important component of sports science, helping players and coaches in optimizing performance while minimizing injury risk (Bourdon et al., 2017). Basketball is a high-intensity activity that requires a variety of physical characteristics such as strength, power, speed, and agility, necessitating an emphasis on load monitoring (Stojanović et al., 2018). Through the lens of statistical proof, this literature review will critically evaluate the extant scientific literature on load monitoring in basketball.

To successfully evaluate load tracking in basketball, both internal load (e.g., heart rate, rating of perceived exertion) and external load (e.g., accelerometers, GPS devices) metrics must be considered (Schelling & Torres-Ronda, 2016). A complete load monitoring system, according to Fox, Scanlan & Stanton (2017), should include both kinds of parameters to better comprehend the connection between the athlete's physiological stress and their performance. The selection of particular load tracking measures, however, is dependent on their validity, dependability, and practicality in the context of basketball (Stojanović et al., 2018).

Basketball's high physical demands put athletes at risk of injury, especially in the lower extremities (Drakos, Domb, Starkey, Callahan, & Allen, 2010). Load tracking can help spot crucial times when injury risk is high, such as during congested fixture schedules, enabling for the implementation of suitable interventions (Dennis, Finch, & Farhart, 2019). Furthermore, methodical tracking of individual competitors allows for the discovery of those who are more vulnerable to injury due to variables such as accumulated fatigue, allowing for customized prevention strategies (Caparrós, Casals, Solana, Peña, & Vázquez, 2018).

Coaching staff can spot times of under- or over-training and make changes appropriately to optimize athlete readiness for competition by continuously tracking training loads (Hulin, Gabbett, Caputi, Lawson, & Sampson, 2015). Furthermore, load monitoring can help guide training periodization, ensuring that competitors peak at the appropriate periods during the season (Issurin, 2010). Scanlan, Dascombe, Reaburn & Osborne (2014) discovered that monitoring training loads aided improve performance in a study of the impacts of load monitoring on the physical performance of semi-professional basketball players

Despite the advantages of load tracking in basketball, researchers and practitioners must address a number of issues. Accurate quantification of sport-specific motions such as jumping, sprinting, and changing direction is one such problem that may necessitate the creation of innovative monitoring technologies (Schelling & Torres-Ronda, 2016). Load tracking is an important instrument in basketball for injury avoidance and performance improvement. The current scientific literature supports the use of load tracking factors to reduce injury risk and improve performance. Several obstacles, however, persist, such as the exact quantification of sport-specific movements and the integration of load monitoring data with other pertinent variables.

1.3. Wellness monitoring in basketball

Wellness tracking has evolved into an important part of sports science, playing a critical role in assuring basketball players' well-being and optimum performance (Gallo, Cormack, Gabbett, & Lorenzen, 2015). It entails assessing a variety of physical, psychological, and mental variables in order for coaches and sports experts to make educated choices about training, recovery, and prevention of injuries (Brink et al., 2010). Basketball wellness tracking includes assessing bodily parameters such as sleep quality, muscular soreness, and fatigue, as well as psychological and emotional elements such as mood, stress and motivation (Saw, Main, & Gastin, 2016). To evaluate these parameters, a variety of instruments have been created, spanning from self-report surveys to objective physiological and performance evaluations (Gallo et al., 2015). Basketball wellness tracking can be used for a variety of reasons, including injury prevention, optimizing training load, and improving recovery. Coaching staff can spot early indications of overtraining or inadequate recovery and make suitable changes to training load by monitoring players' wellness state, lowering the risk of injury (Saw et al., 2016).

Wellness tracking can help athletes achieve optimal performance during crucial competition periods by informing training periodization (Issurin, 2010). Schelling, Calleja-González, Torres-Ronda, & Terrados, (2013), for example, examined the impacts of a 6-week training program that included wellbeing tracking on the physical performance of 18 top basketball players. The findings showed substantial improvements in a variety of performance parameters, such as sprint pace, vertical leap height and agility, emphasizing the possible advantages of wellness monitoring in basketball. Several studies have given statistical proof that wellness monitoring in basketball is successful. Gallo et al. (2015), for example, investigated the link between self-reported wellness parameters and performance results in 12 top male basketball players over a 12-week training span. Changes in fatigue, muscular soreness and sleep quality were found to have substantial unfavorable associations with changes in countermovement jump ability. These results imply that monitoring players' wellness can provide useful insights into their performance readiness and help guide training choices.

Furthermore, studies have shown that integrating wellness monitoring into basketball can help reduce injury risk. Fullagar et al. (2016) conducted research in which they examined the link between perceived sleep quality and injury risk in 12 professional basketball players during a competitive season. The findings showed that athletes who reported bad sleep quality had a substantially greater frequency of injury than those who reported improved sleep quality, highlighting the significance of tracking wellbeing metrics for injury prevention.

Furthermore, studies have shown that wellness tracking can be useful in improving exercise load and periodization. Staunton, Gordon, Custovic, Stanger, & Kingsley, (2017) conducted a 14-week research in which they investigated the link between self-reported health metrics and training intensity in ten professional basketball players. The findings showed that athletes with higher wellbeing ratings had better training burden control and were more likely to enhance their performance.

Despite the encouraging evidence backing the use of wellbeing tracking in basketball, researchers and practitioners face several obstacles. Integrating wellness tracking data with other pertinent information, such as load monitoring and accident history, is one such challenge (Gabbett, 2016). Another challenge is the creation of more complex tools for evaluating psychological and emotional variables, which may necessitate the use of cutting-edge technologies like machine learning algorithms and wearable devices (Lupo & Tessitore, 2020).

Wellness tracking is an important part of basketball, as it helps with pain avoidance, training optimization, and performance enhancement. The current scientific literature offers solid statistical proof supporting the efficacy of different wellness monitoring techniques in reaching these objectives, such as the Profile of Mood States questionnaire and heart rate variability monitoring. Several obstacles persist, however, including integrating wellness tracking data with other pertinent variables and developing more sophisticated assessment tools. Future study should concentrate on addressing these issues and capitalizing on the potential of emerging technologies to progress the field of basketball health tracking.

1.4. Heart Rate Monitoring in Basketball

Heart rate monitoring has become an essential instrument in sports science, especially in basketball, where it is used to evaluate players' physiological responses to training and competition (Cunniffe, Proctor, Baker, & Davies, 2011). It can help with training load control, performance improvement, and preventing injuries (Buchheit, Laursen, & Ahmaidi, 2009). Heart rate monitoring in basketball can be employed for various purposes, including assessing training intensity, optimizing training load, and evaluating recovery status. By monitoring athletes' heart rate responses to training and competition, coaching staff can make informed decisions regarding training load adjustments, periodization and tapering strategies, ultimately enhancing athletes' performance and reducing the risk of injury (Coutts, Wallace, & Slattery, 2007).

A variety of techniques can be used to measure heart rate, including constant monitoring during training and competition, as well as pre- and post-exercise evaluations (Coutts et al., 2007). Wearable technology advancements, such as heart rate trackers and GPS-enabled devices, have allowed the gathering of real-time heart rate data, allowing for the study of training burden, intensity, and recuperation state (Borresen & Lambert, 2009). The calculation of training impulse (TRIMP), which measures the physiological stress encountered by players during training practices and contests, is a popular technique for analyzing heart rate statistics in basketball (Banister, 1991). TRIMP incorporates both heart rate and session duration to provide a comprehensive measure of training load, enabling coaches and sports scientists to monitor athletes' responses to training and competition more effectively (Impellizzeri, Rampinini, Coutts, Sassi, & Marcora, 2004).

Furthermore, heart rate tracking can provide useful insights into individual differences in training responses, allowing for personalized training plans and recovery methods (Buchheit, Racinais, Bilsborough et al., 2009). Sperlich, Koehler, Holmberg, & Zinner (2011), for example, examined the link between heart rate-based training load and performance improvements in 12 top basketball players over a 6-week training session. Individualized training load adjustments based on heart rate tracking were linked with substantial increases in different performance metrics such as maximal aerobic power, sprint speed, and leap height, according to the findings.

Several studies have given statistical proof that heart rate tracking is successful in basketball. For example, Narazaki, Berg, Stergiou & Chen (2009) investigated the link between heart rate-based TRIMP scores and performance outcomes in 15 top male basketball players over the course of a competitive season. TRIMP scores were found to have substantial favorable correlations with on-court performance metrics such as points tallied, rebounds, and assists, highlighting the possible advantages of heart rate monitoring in basketball. Additionally, research has shown that heart rate monitoring can help identify early signs of overtraining or insufficient recovery in basketball players. A study by Schelling, Calleja-González, Torres-Ronda, & Terrados (2013) investigated the relationship between heart rate variability (HRV) and overtraining in 18 professional basketball players during a 4-week period of intensified training. The results revealed that players who exhibited reduced HRV were more likely to experience symptoms of overtraining, emphasizing the importance of heart rate monitoring for training load management and injury prevention.

Despite the promising data backing the use of heart rate monitoring in basketball, researchers and practitioners face several obstacles. The creation of more exact and dependable methods for interpreting heart rate data in the context of basketball-specific needs is one such challenge, which may necessitate the use of sophisticated analytical techniques and models (Buchheit, Laursen, & Ahmaidi, 2009). Another issue is a better knowledge of the connection between heart rate responses and other pertinent variables like neuromuscular fatigue, hormonal responses, and psychological stress in order to provide a more complete evaluation of players' physiological state (Claudino et al., 2019).

Heart rate tracking is an important element of basketball, as it helps to evaluate training intensity, optimize training load, and assess recovery state. The current scientific literature offers solid statistical proof supporting the effectiveness of different heart rate monitoring techniques in accomplishing these objectives, such as continuous monitoring and training impulse calculations. Several obstacles remain, however, including the need for more accurate and dependable ways of analyzing heart rate data, as well as a better grasp of the connection between heart rate reactions and other relevant factors. Future study should concentrate on overcoming these obstacles and capitalizing on the potential of new technologies to progress the field of heart rate tracking in basketball.

1.5. Rate of perceived exertion monitoring in basketball

Rate of perceived exertion (RPE) is a subjective measure of an individual's perception of exercise intensity, which has been widely employed in various sports, including basketball, as an alternative or supplementary method to physiological indicators like heart rate for monitoring training load and fatigue (Borg, 1998). Due to its simplicity and low cost, RPE has gained increasing attention in recent years for its potential applications in managing training load, preventing overtraining, and optimizing performance (Foster et al., 2001). Basketball RPE tracking can be used for a variety of reasons, including measuring training effort, optimizing training load, and determining recovery state. Coaching staff can make educated choices about training load changes, periodization and tapering strategies by tracking athletes' RPE reactions to training and competition, eventually improving athletes' performance and lowering the risk of injury (Alexiou & Coutts, 2008).

Athletes usually rate their perceived exertion during or directly after a training exercise or competition using a standardized scale, such as the Borg CR10 scale or the Category-Ratio (CR) 0-10 scale (Borg, 1998). The session RPE (sRPE) technique, which blends the RPE score with the session length, has been widely used in basketball and other team sports to measure training burden (Foster et al., 2001). sRPE has been demonstrated to correspond well with objective physiological measures such as heart rate and blood lactate concentration, making it a legitimate and dependable measure of exercise load (Impellizzeri et al., 2004).

Moreover, RPE monitoring can provide valuable insights into individual differences in training responses, allowing for the personalization of training programs and recovery strategies (Los Arcos, Yanci, Mendiguchia, & Gorostiaga, 2015). For example, a study by Scanlan, Dascombe Reaburn & Osborne (2012) investigated the relationship between RPE-based training load and performance improvements in 14 elite youth basketball players during an 8-week training period. The results revealed that individualized training load adjustments based on RPE monitoring were associated with significant improvements in various performance parameters, such as maximal aerobic power, sprint time, and jump height.

Several studies have provided statistical evidence supporting the effectiveness of RPE monitoring in basketball. For instance, a study by Manzi et al. (2010) examined the relationship between RPE-based training load and performance outcomes in 12 elite male basketball players during a competitive season. The results demonstrated significant positive correlations between sRPE scores and on-court performance parameters, such as points scored, rebounds, and assists, highlighting the potential benefits of RPE monitoring in basketball.

Furthermore, study has shown that RPE monitoring can assist in detecting early indications of overexertion or inadequate recovery in basketball players. Freitas, Nakamura, Miloski, Samulski & Bara-Filho (2014) examined the relationship between RPE, heart rate variability (HRV), and overtraining in 12 professional basketball players over a 4-week intensive training session. The findings showed that athletes with higher RPE and lower HRV were more likely to experience overtraining symptoms, stressing the significance of RPE tracking for training load management and injury avoidance.

Monitoring rate of perceived exertion has evolved as a useful instrument in basketball for measuring training intensity, optimizing training load, and examining recovery state. The existing scientific literature offers strong statistical proof that different RPE monitoring techniques, such as the session RPE method, are successful in achieving these objectives. Several challenges persist, however, including RPE's subjectivity as a measure and the need for a greater grasp of the relationship between RPE and other pertinent variables. Future study should concentrate on overcoming these obstacles and capitalizing on the promise of new technologies and sport-specific RPE scales to progress the field of RPE monitoring in basketball.

1.6. Summated heart rate zones

Monitoring heart rate (HR) during training and play is an important part of load management in basketball, giving useful insights into athletes' physiological reactions and aiding in performance optimization and injury prevention. Summated heart rate zones (SHRZ) is a technique that divides heart rate data into zones based on preset intensity thresholds and calculates the time spent in each zone, allowing for a more thorough study of training load and intensity distribution (Abt, Dickson, Mummery, & Davison, 2003). Monitoring heart rate (HR) during training and play is an important part of load management in basketball, giving useful insights into athletes' physiological reactions and aiding in performance optimization and injury prevention. Summated heart rate zones (SHRZ) is a technique that divides heart rate data into zones based on preset intensity thresholds and calculates the time spent in each zone, allowing for a more thorough study of training load and intensity distribution (Abt et al., 2003).

The first stage in implementing SHRZ in basketball is determining suitable intensity levels for categorizing heart rate data. These limits are usually calculated as a proportion of a person's maximum heart rate (HRmax) or heart rate reserve (HRR; the differential between resting heart rate and HRmax) (Karvonen, Kentala, & Mustala, 1957). HR zones that are commonly used include 50-60%, 60-70%, 70-80%, 80-90%, and 90-100% of HRmax or HRR, which correlate to various physiological reactions and energy systems such as aerobic, anaerobic, and neuromuscular (Edwards, 1993). These zones can be adjusted further based on sport-specific needs as well as individual variations in physiological characteristics and training objectives among competitors.

Furthermore, SHRZ can be used to assess the effectiveness of training interventions and recovery strategies, as well as to monitor individual differences in training responses and adaptation. For example, a study by Scott, Lockie, Knight, Clark, & Janse de Jonge (2013) investigated the effects of a 6-week high-intensity interval training (HIIT) program on the SHRZ profiles of 12 elite youth basketball players. The results demonstrated significant improvements in the time spent in higher HR zones and a reduction in the time spent in lower HR zones, indicating enhanced aerobic and anaerobic fitness.

Several studies have given statistical proof that SHRZ is beneficial in basketball. For example, Narazaki et al. (2009) investigated the link between SHRZ and on-court performance in 14 male college basketball players over the course of a competitive season. Significant correlations were found between time spent in higher HR zones and important performance measures such as points scored, rebounds, and passes, emphasizing the possible advantages of SHRZ monitoring in basketball.

Furthermore, studies have shown that SHRZ can help identify early indications of overuse or insufficient recovery in basketball players. Schelling and Torres-Ronda (2016) conducted research on the link between SHRZ, neuromuscular fatigue and injury risk in 16 elite basketball players over a 4-week intensive training time. The findings showed that players who spent more time in higher HR zones and less time in lower HR zones were more likely to experience symptoms of neuromuscular fatigue and injury risk, highlighting the importance of SHRZ monitoring for training load management and injury prevention.

Summated heart rate zones have evolved as a useful instrument in basketball for measuring the intensity and length of training sessions and competitions; giving a more detailed knowledge of players' physiological reactions, and assisting in the optimization and prevention of performance and injuries. The extant scientific literature contains substantial statistical proof supporting the efficacy of different SHRZ methodologies in accomplishing these objectives.

2. RESEARCH METHODOLOGY AND ORGANIZATION

2.1 Research object

The object of the present research was to determine the wellness status, training-load and its fluctuations experienced by high-level professional elite basketball athletes playing in premier professional basketball league in Lithuania across two different microcycle design strategies.

2.2 Subjects

The subjects of the study were 11 high-level male basketball athletes (mean±SD, age: 22.9±1.9 years, body mass: 89.2±10.9 kg, BMI: 22.6±1.6, height: 198.4±8.5cm) competing in national first division basketball league [Lietuvos Krepšinio lyga – „BetsafeLKL“] season of 2022/2023. At the time of the study all of the subjects belonged to one team, any of the subject reported injuries or any other severe limitations that could affect study results.

2.3. Research strategy

Two of the most in-season repetitive microcycle structures was taken for deeper analysis (**Figure 1**). Microcycle A consisted of 6-day period with 1 high-load day, 2 recovery & rest days, 2 maintenance & taper days, and 1 game day. Microcycle B consisted of 8-day period with 2 high-load days, 3 recovery & rest days, 2 maintenance & taper days, and 1 game day. To determine and establish optimal loading recommendations, different variables regarding players' wellness & load of high-load day(s) was compared with taper & maintenance and gameday in both microcyles (respectively GD-4 vs GD-2 & GD-1 vs Game Day in Microcycle A, and GD-6 & GD-4 vs GD-2 & GD-1 vs Game Day in microcycle B).

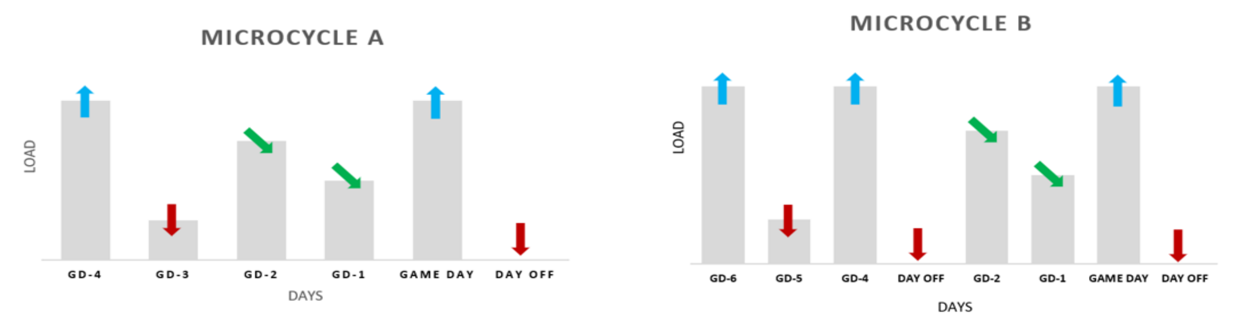

Figure 1. *Microcycle loading strategies.*
GD-1, GD-2, GD-3, GD-4, GD-5, GD-6 = Days left to the competitive match (accordingly 1 day, 2 days, 3 days, 4 days, 5 days & 6 days). Gameday = day of competitive match. Day Off = rest day; ↑ - high- load day(s); ↘ - maintenance & taper day(s); ↓ - rest day(s).

The data was collected throughout both microcycles. Across the data collection, subjects completed 7-9 training sessions (including on court, scouting and strength training sessions) with each lasting approximately 75-90minutes. Training contents and duration is presented in **Figure 2.**

Ethical approval was obtained from Lithuanian Sports University Bioethics Committee (Nr: MNL-KTV (M)-2023-616).

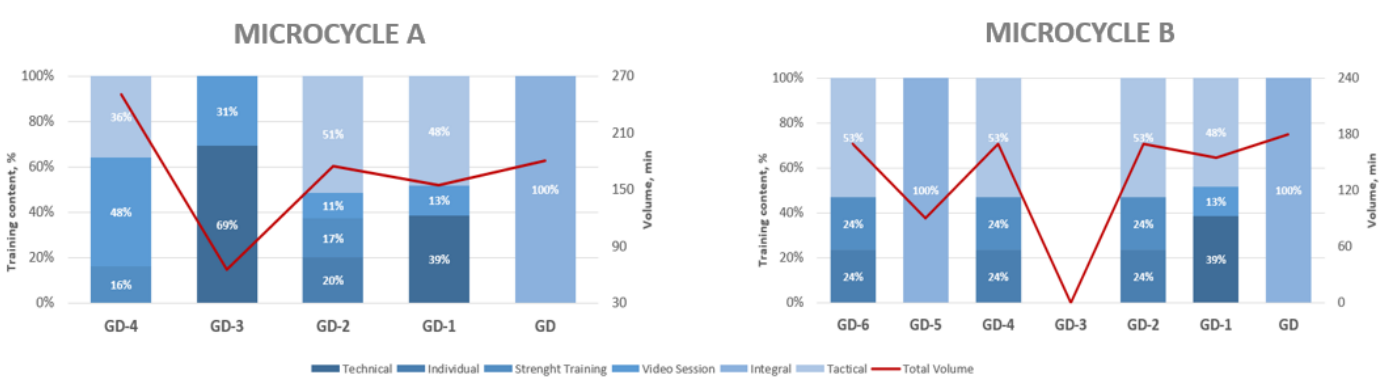

Figure 2. *Training contents, duration and its percentage in Microcycle A and Microcycle B.*
GD-1, GD-2, GD-3, GD-4, GD-5, GD-6 = Days left to the competitive match (accordingly 1 day, 2 days, 3 days, 4 days, 5 days & 6 days). GD = Game-day of competitive match.

2.4. Procedures

2.4.1 Monitoring of workload

sRPE

The workload of the players was gathered using Session Rate of Perceived Exertion (sRPE) method which was tested both for validity and reliability (Herman, L. et al; 2006) Soon after the session (~30 minutes) subjects were instructed to rate intensity of training session (or game) by completing a pre-designed questionnaire that consisted of a ratio scale (CR-10) of a question: "How intense was the training/game?". The questionnaire was sent to their phones in a form of cloud-based software (Google Forms, CA, USA). The duration of each player's training time (min) was registered by training staff. Game duration was taken from start to the end of the game including all game-related stoppages and excluding warm-up & pre-game activities. The player load expressed in Arbitrary Units (AU) was calculated by multiplying player sRPE score and the duration of the on-court and/or strength & conditioning training.

Summated Heart Rate Zones

In order to determine internal workload of on-court practices the well-know and previously researched & applied in basketball (Manzi, V. et al; 2010; Scanlan, A. et al; 2014, 2016) Summated Heart Rate Zones (SHRZ) method was used. The heart rate values were monitored during all on-curt activities using a chest-straps with attached Bluetooth heart rate sensors (Polar Team, v:1.2). Arbitrary Units (AU) of SHRZ was calculated by multiplying time spent (min) in each intensity zone by corresponding pre-determined weighting of each zone which incrementally increased. The following formulae were used for the calculation of training load:

SHRZ training load = (time spent in zone 1 x 1) + (time spent in zone 2 x 2) + (time spent in zone 3 x 3) + (time spent in zone 4 x 4) (time spent in zone 5 x 5), where: Zone 1 = 50-59% HR_{max}*; Zone 2 = 60-69%* HR_{max}*; Zone 2 = 50-59%* HR_{max}*; Zone 3 = 70-79%* HR_{max}*; Zone 4 = 80-89%* HR_{max}*; Zone 5 = 90-100%* HR_{max} *;*

time spent = time accumulated (min) in particular heart rate zone.

2.4.2. Monitoring of Wellness

Well-being of the players was collected using a custom-made wellness questionnaire which was chosen by recommendations of previous studies (Hooper SL, Mackinnon LT; 1995). The questionnaire was developed using a cloud-based software (Google Forms, CA, USA) and sent to the players each morning upon waking up before morning practice. The players were instructed to fill the questionnaire in the morning and honestly evaluate their current well-being. The questionnaire was designed to asses players' well-being scores on 5 different levels: fatigue, sleep quality, stress, muscle soreness, mood. 1–5-point scale for each of the levels was used to determine the current state of the players which was then summated in order to determine total well-being score.

2.4.3 Statistical Procedures

Standard statistical methods were used for calculation of means and presented as mean ± standard deviation. Magnitude of wellness scores and training load differences between high-load days, taper & maintenance days and game days was assessed using effect size statistics. Cohen's d effect size (ES) was calculated and interpreted as <0.20 = Trivial, 0.20-0.59 = Small, 0.60-1.19 = Moderate, 1.20-1.99 = Large, >2.0 = Very large (Hopkins, Marshall, Batterham, and Hanin, 2009). All the statistical analyses were performed using SPSS 16.0 for Windows (SPSS Inc., Chicago, IL, USA). Significance was set at $p<0.05$.

3. REASERCH FINDINGS

3.1. Training volume

Teams' average volume (min) and intensity (sRPE) displayed in **Figure 3**.

It was noticed that in Microcycle A on estimated high-load days players accumulated 173 (±18.9) minutes (GD-4) of training time, while in Microcycle B 187(±17.8) and 180 (±14.1) respectively on GD-6 and GD-4. On Taper & maintenance days in both microcycles players accumulated on average 167(±6.4) minutes of training time.

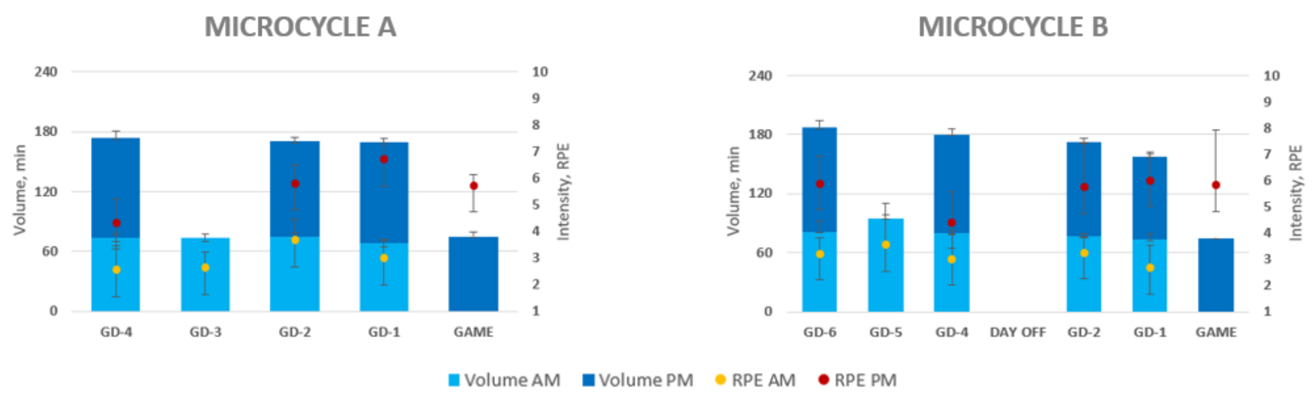

Figure 3. *Average training volume (min) and intensity (sRPE) values in Microcycle A & Microcycle B. AM = morning practice; PM = afternoon practice. GD-1, GD-2, GD-3, GD-4, GD-5, GD-6 = Days left to the competitive match (accordingly 1 day, 2 days, 3 days, 4 days, 5 days & 6 days). Game = Game-day of competitive match.*

3.2. Wellness

Teams' Wellness scores & training intensity demonstrated in **Figure 4**.

Results demonstrated that both in both Microcycle A and Microcycle B wellness score (AU) does not show clear visible fluctuations throughout the days. However, overall session intensity scores (sRPE) had a tendency to rise in both microcycles. The highest sRPE scores in both microcycles was noticed to be after the game.

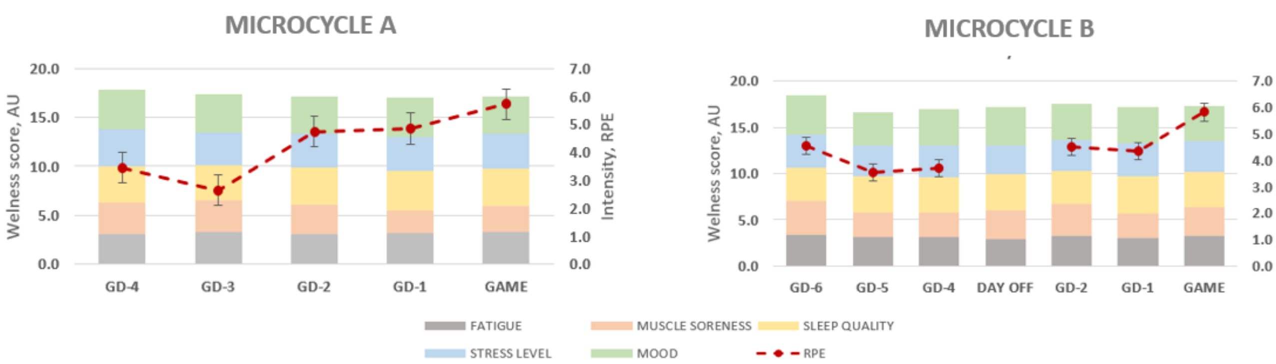

Figure 4. *Team's average wellness score (AU) & training intensity (RPE) in Microcycle A and Microcycle B. GD-1, GD-2, GD-3, GD-4, GD-5, GD-6 = n of days left to the competitive match (accordingly 1 day, 2 days, 3 days, 4 days, 5 days & 6 days). Game = Day of competitive match. Day Off = Rest Day*

Player-wise analysis demonstrated different wellness scores distribution between GD-2, GD-1 and Gameday in both microcycles (**Figure 5**).

Results showed that the average wellness score in both microcycles were: (mean±SD) 17.3(±1.8), 17.1 (±1.6) and 17.5 (±2.3) respectively on GD-2, GD-1 and Gameday in microcycle A, and 17.4 (±1.5), 16.6 (±2.2) and 18.2 (±1.8) respectively on GD-2, GD-1 and Gameday in microcycle B. It was noticed lower average team's wellness score one day prior the game in microcycle B (17.1±1.6 vs 16.6±2.2), however in the same microcyle (B) higher teams' average wellness scores were on the gameday compared to microcycle A.

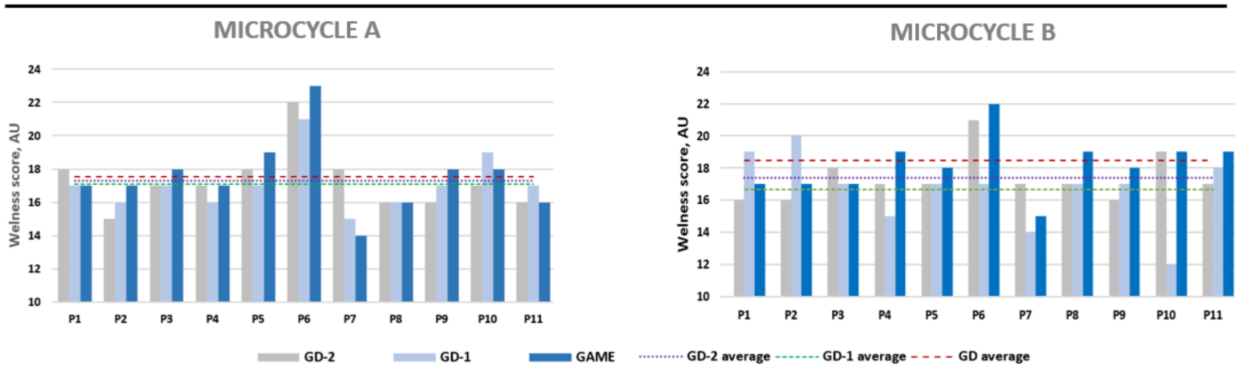

Figure 5. *Wellness score values of each player on 1 & 2 days before tha game and a gameday in Microcycle A and Microcycle B. GD-1, GD-2, GD-3, GD-4, GD-5, GD-6 = n of days left to the competitive match (accordingly 1 day, 2 days, 3 days, 4 days, 5 days & 6 days). P1-P11 = number of playrs. Game = Day of competitive match.*

3.3. sRPE

Player load (sRPE AU) and wellness score (AU) presented in **Figure 6**. Results showed that in microcycle A, on estimated high-load day (GD-4) the team averaged 624 (±171) arbitrary units of load, while on the taper & maintenance days 855 (±216) and 710 (±209) respectively on two days before gameday and one day before gameday. The average load on a game day was 510 (±233) AU.

Analysis of microcycle B demonstrated that players on estimated high-load days experienced load of 884 (±256) AU on GD-6, and 680 (±141) AU on GD-4. Taper & maintenance days accumulated 790 (±214) and 697 (±229) of AU (respectively GD-2 and GD-1). Gameday on microcycle B totaled 615 (±315) AU.

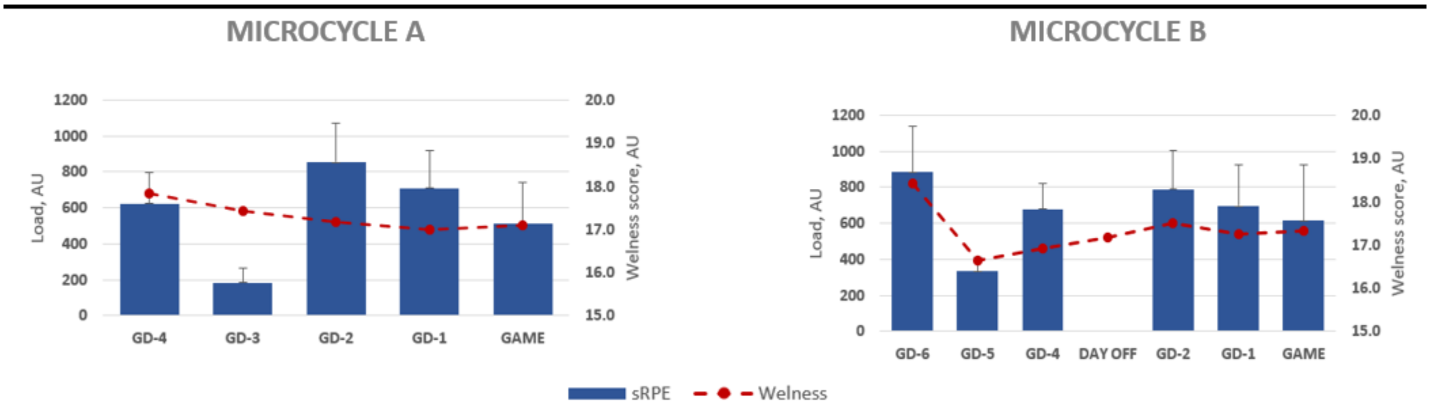

Figure 6. *Teams' avergae load (AU, sRPE) and Wellness scores (AU) in Microcycle A and Microcycle B. GD-1, GD-2, GD-3, GD-4, GD-5, GD-6 = n of days left to the competitive match (accordingly 1 day, 2 days, 3 days, 4 days, 5 days & 6 days). Game = Day of competitive match. Day off = rest day*

3.4. SHRZ

Analysis of Summated Heart Rate Zones (**Figure 7**) showed that on estimated high-load day (GD-4) the players accumulated 225 (±17) AU of load in Microcycle A, while on Microcycle B high-load days' volume were at 221 (±20) AU on GD-6 and 218 (±20) AU on GD-4. On estimated taper & maintenance days, two days before the game the volume was 228 (±28) and 194 (±18) AU respectively on microcycle A and microcycle B; One day before the game (GD-1) the volume was 193 (±18) AU in microcycle A, and 177 (±18) AU in microcycle B.

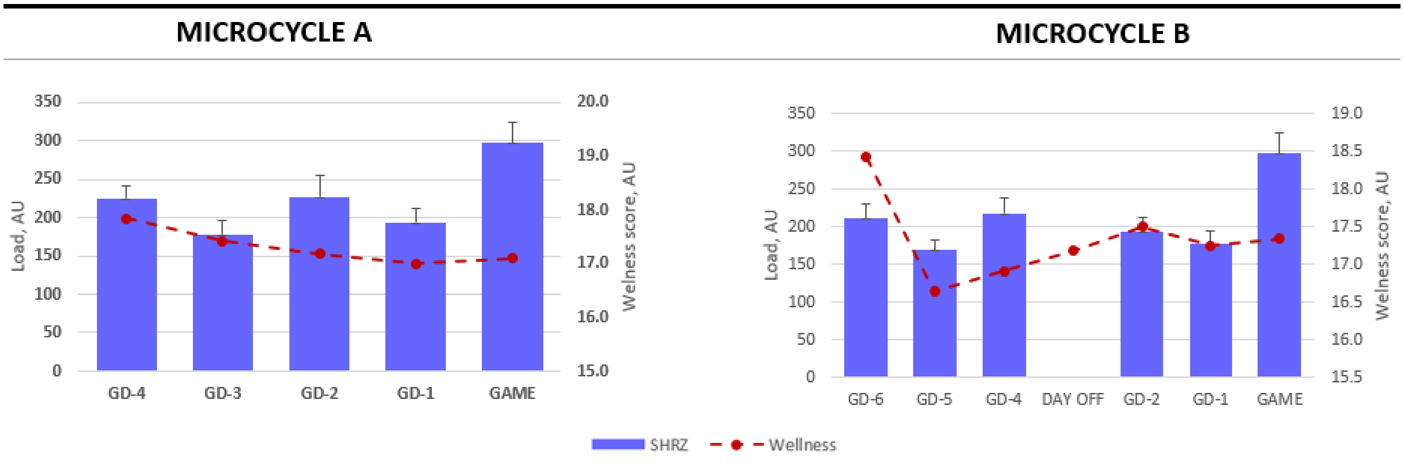

Figure 7. *Teams' average training load (AU, SHRZ) of on-court practices and Wellness scores (AU) in Microcycle A and Microcycle B. GD-1, GD-2, GD-3, GD-4, GD-5, GD-6 = n of days left to the competitive match (accordingly 1 day, 2 days, 3 days, 4 days, 5 days & 6 days). Game = Day of competitive match. Day off = rest day*

3.5. Day-wise comparison

Figure 8 demonstrates day-wise comparison of wellness scores of different variables (Fatigue, Muscle soreness, Sleep quality, Stress and Mood) between estimated high-load day(s), taper & maintenance day(s) and versus gameday.

It was noticed differences of Muscle Soreness scores on GD-4 vs GD-2 & GD-1 ($p<0.05$), respectively 3.25 (±1.06) vs 2.68 (±0.45) in *microcycle A*. Furthermore, results showed that average sleep quality score on GD-4 & GD-6 were lower ($p<0.05$) compared to GD-1 & GD-2 (respectively 3.74±0.54 vs 3.83±0.29) in *microcycle B*.

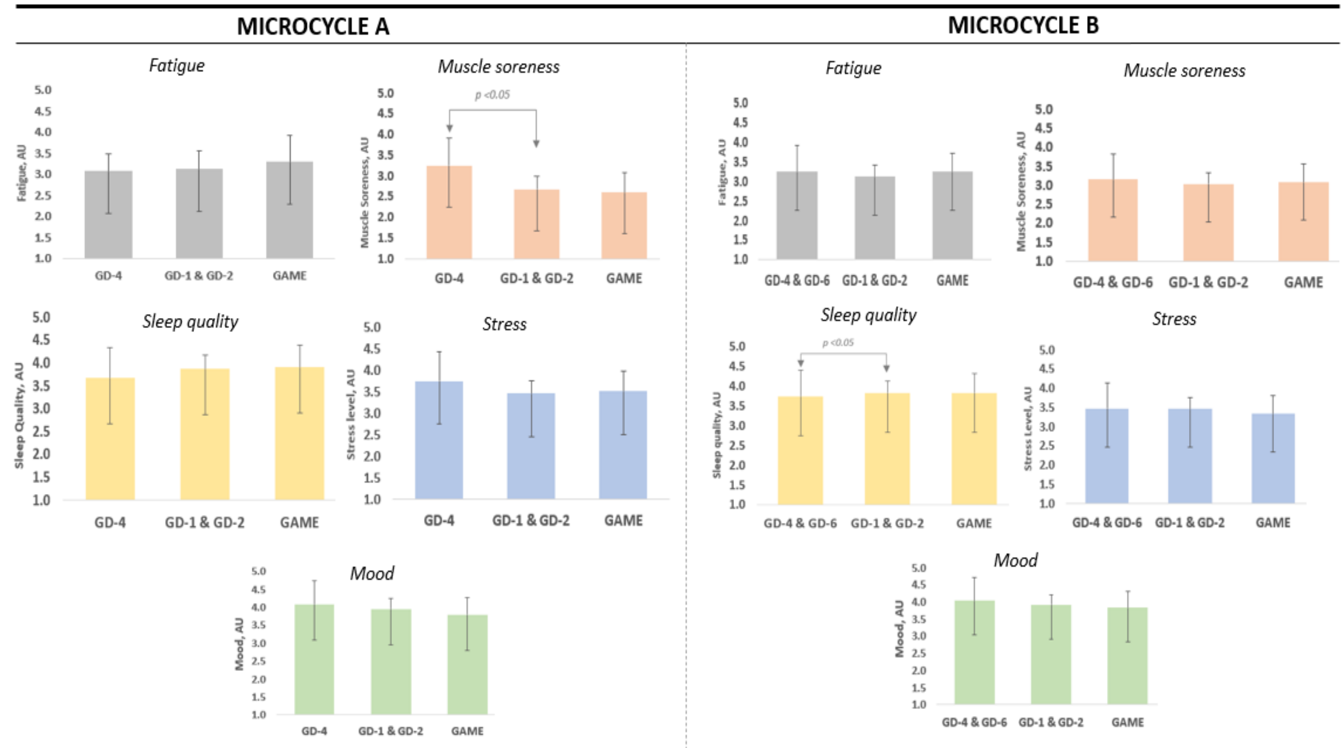

Figure 8. *Comparison of Fatigue, Muscle soreness, Sleep quality, Stress and Mood between estimated high-load day(s), taper & maintenance day(s) and versus gameday in Microcycle A and Microcycle B. GD-1, GD-2, GD-3, GD-4, GD-5, GD-6 = n of days left to the competitive match (accordingly 1 day, 2 days, 3 days, 4 days, 5 days & 6 days). Game = Day of competitive match. Significant differences marked as p<0.05.*

Day-wise comparison of sRPE and values of Summated heart rate zones (SHRZ) demonstrated load (AU) differences between the estimated high-load day(s), taper & maintenance day(s) and gameday(s) **Figure 9.**

In Microcycle A following differences ($p<0.05$) was noticed between sRPE values: GD-4 (624 ±171 AU) was lower than GD-1 & GD-2 (782 ±103 AU); on a gameday players experienced significantly lower training load than on a taper & maintenance day which where 510 (±233) AU on a gameday and 782 (±103) AU on a GD-1 & GD-2.

In Microcycle B results demonstrated lower sRPE training load values of GD-4 & GD-6 between the load that players accumulate on a gameday which respectively where 782 (±144) AU and 615 (±307) AU. Furthermore, gameday load was significantly lower on than estimated taper & maintenance days before the game, which were 743 (±66) AU on GD-1 & GD-2.

Summated Heart Rate Zones (SHRZ) analysis of on court practices showed difference in A microcycle's estimated high-load day (GD-4) and gameday (**Figure 9).** Gameday load (297±27 AU) was significantly bigger than GD-4 (225±17 AU) which was an estimated high-load day.

In Microcycle B it was noticed that SHRZ load on a gameday (297±27 AU) was significantly higher in comparison to taper & maintenance days (GD-1 & GD-2) which totaled 214(±5) AU. Furthermore, GD-4 & GD-6 which were estimated high-load days were significantly higher in training load that estimated taper & maintenance days (GD-1 & GD-2), the values were respectively 214(±5) AU and 186(±12) AU.

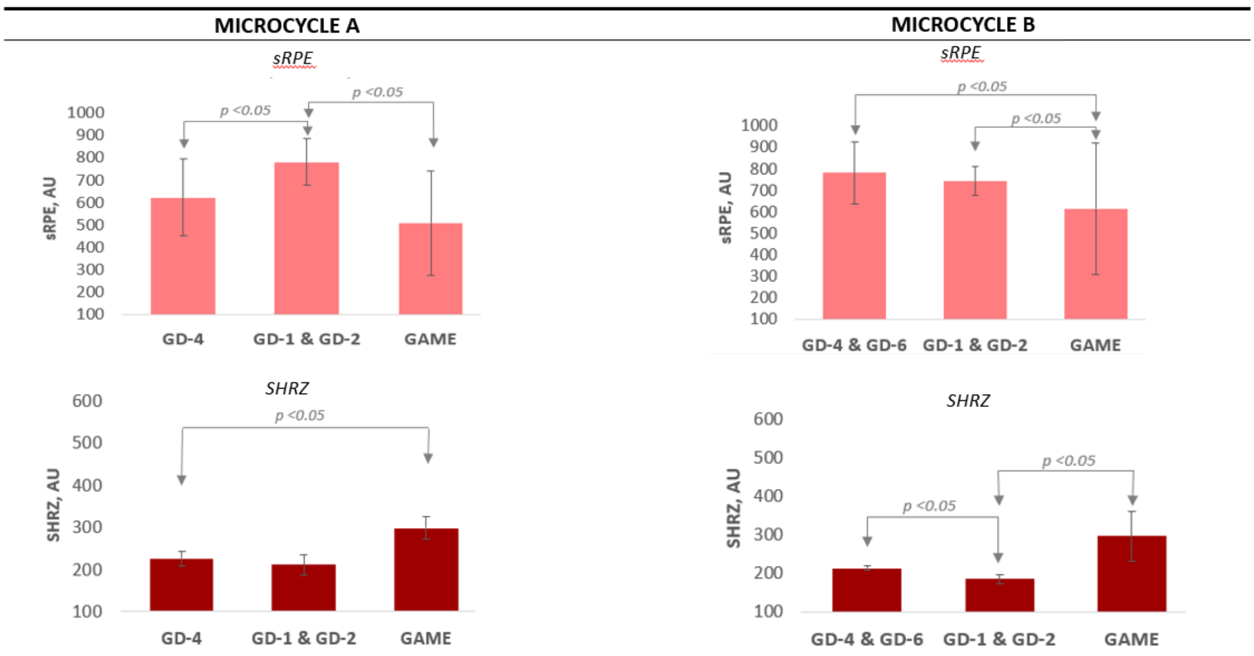

Figure 9. *Comparison of sRPE and values of SHRZ between the estimated high-laod day(s), taper & maintenance day(s) and gameday in Microcycle A and Microcycle B. GD-1, GD-2, GD-3, GD-4, GD-5, GD-6 = n of days left to the competitive match (accordingly 1 day, 2 days, 3 days, 4 days, 5 days & 6 days). Game = Day of competitive match. Significant differences marked as p<0.05.*

4. CONSIDERATIONS

The current study is one of the few that tried to contribute to overall wellness and increased performance by bringing data and valuable insights to the field of load monitoring load and wellness in a context of microcycle. Designing the high-volume microcycles is not an easy task for the coaches and practitioneers as in the literature it is a difficult task to find scientific analysis and scientifically justified recommendations. The microcycle creation method and formats is highly dependent on the philosophy of the coaching staff. There are barely any studies that examined and investigated strategies of a short-term periodization similar to the ones presented in this paper. However, several other attempts of investigating microcycles can be find and will be presented in this chapter together with other valuable insights regarding present study‘s aims, goals an findings.

In the present study we have concluded that designing an optimal microcycle is a complex process for coaches. Our study supports the ideas discussed in other studies that regarding the planning of the trainings "*One size fits all"* approach shall be avoided and more individualized approach should be considered. Study by Stojanović et al. (2020) emphasized the significance of tailoring weekly periodization according to the competition schedule, individual characteristics of athletes, and the time of the season. Despite variations in the optimal approach depending on multiple factors, this study also suggest that a well-structured weekly periodization model can enhance basketball athletes' performance which underlines even further the importance of the current study. Furthermore in the same study they found that basketball match-play required athletes to perform high-intensity movements every 21 seconds on average, suggesting the need for weekly microcycles to prepare athletes for such demands. However, they also emphasized the need for individualization in microcycle design according to factors such as the competition schedule and athlete characteristics. Additionally, a study conducte by Aoki et al. (2017) observed that a tailored, undulating periodization model was significantly effective in reducing injuries and enhancing the performance of elite basketball players.

Our study cautions the coaches and practitioners in basketball that in a high-training volume microcycle in basketball it is difficult task to foresee and plan trainings in advance without consulting load-monitoring means. The pre-planned microcycles' strategies presented in the study expected to cause training-load fluctuations. *High-load* days was expected to have a rise in total workload, while the *taper & maintenance* days and *rest days* was expected to be relatively low in total work-load. The *"ups & downs"* of the workload during the microcycle was expected to have an impact on wellness values leading up to an optimal readiness on the game day. However, findings demonstrated us that the fluctuations were rather low amplitude possibly cautioning about possibility of decreased performance or event of injury. For example, a study by Turner (2011) underscored the importance of balancing load and recovery, suggesting that excessive load without adequate recovery could increase the risk of overuse injuries. Similarly, Hulin et al. (2014) found a U-shaped relationship between acute training load and injury risk, with both very high and very low loads associated with increased injury risk. On the other hand, a longitudinal study by Gabbett (2016) highlighted the role of chronic load in building resilience and reducing injury risk. However, the study also cautioned against sudden spikes in load, which were associated with increased injury risk. Lastly, Impellizzeri et al. (2019) emphasized the need for individualizing load management strategies, taking into account factors such as player fitness, injury history, and playing position. Manzi et al. (2010) conducted seminal work in this area by documenting the weekly load profile of elite male professional basketball players, suggesting that proper distribution of load during the week can have a positive impact on performance and reduce the risk of injuries. Montgomery et al. (2018) further demonstrated that maintaining a consistent weekly load resulted in improved on-court performance in professional players. A more recent study by Svilar et al. (2021) corroborated these findings, observing that optimal load distribution during the week contributed to higher game intensity and improved physical performance.

In our study we have used the method of Summated Heart Rate Zones (SHRZ) in order to supplement session-RPE based training load measures with internal and more objective data. While the method of Summate Heart Rate Zones is not so commonly found in literature, heart rate monitoring in elite basketball has been extensively researched to understand the physiological demands of the sport and optimize training. A study by Abdelkrim et al. (2010) reported average heart rates of 167 beats per minute (bpm) during competitive games, reflecting high cardiovascular demands. Ben Abdelkrim et al. (2007) also found that heart rate responses varied based on playing position, with guards demonstrating higher mean heart rates (178 bpm) compared to forwards (172 bpm) and centers (169 bpm). A study by McInnes et al. (1995) revealed that heart rate values often exceed 85% of the player's maximum during game play, indicating the presence of high-intensity efforts. Additionally, a research by Castagna et al. (2008) suggested that training in higher heart rate zones could enhance player's match-related physical abilities. In contrast, a study by Buchheit et al. (2015) suggested individualized training based on heart rate variability to optimize performance and recovery.

Despite the promising evidence supporting the use of RPE monitoring in basketball, there are several challenges that researchers and practitioners must address. One such challenge is the subjectivity of RPE as a measure, which may be influenced by factors such as individual differences in pain tolerance, motivation, and psychological factors (Impellizzeri et al., 2004). Another challenge is the need for a better understanding of the relationship between RPE and other relevant factors, such as physiological responses, neuromuscular fatigue, and the specific demands of basketball, in order to provide a more comprehensive assessment of athletes' training and recovery status (Los Arcos et al., 2015).

Despite the promising data backing the use of SHRZ in basketball, researchers and practitioners must address a number of issues. One such challenge is a better understanding of the relationship between SHRZ and other relevant factors such as sport-specific demands, individual differences in physiological profiles, and training goals in order to provide a more comprehensive assessment of athletes' training and recovery status (Buchheit, Racinais, Bilsborough, et al., 2009). Another issue is that heart rate as a proxy for exercise exertion may be affected by variables such as hydration state, ambient weather and psychological tension (Achten & Jeukendrup, 2003).

Future research should focus on addressing these challenges and exploring the potential of combining SHRZ with other objective measures of training load, such as rating of perceived exertion (RPE), GPS tracking, and wearable sensor technology, to provide a more comprehensive understanding of athletes' responses to training and competition (Impellizzeri et al., 2004). Moreover, the development and validation of sport-specific HR zone models tailored to the unique demands of basketball may help improve the accuracy and reliability of SHRZ monitoring in this context (Schelling & Torres-Ronda, 2016).

Wellness monitoring method used in this study shares the same and often questionable issue of validity as session-RPE load monitoring strategy. Even though there are plenty of studies made that supported validity and reliability of Wellness Questionnaires still fall under subjective tests category that can be influenced by many outside factors such as athlete’s psychological state, player’s relation with the coaching staff, weather and/or number of non-training related stressors. Future research should focus on addressing these challenges and exploring the potential of emerging technologies to enhance the precision and efficiency of wellness monitoring in basketball.

CONCLUSIONS

Present investigation was partly successful in achieving its aims stated previously. Following conclusions were made:

1) During the high-training-volume microcycle professional elite basketball players:
    a. Accumulate up to 180 (±14.1) of practice time daily.
    b. Session intensity scores tend to rise gradually until the game day.
    c. The most intensive session-RPE intensity score is after the game.
    d. The players experienced a training load-of 510 (±233) on the game-day, high-load days could be up to 855 (±216) arbitrary units; taper & maintenance days can be as high as 790 (±214) arbitrary units.

2) During high-training volume microcycles in elite professional basketball training load shows visible fluctuations between pre-determined high-load days, taper & maintenance-days and game-days.

3) During high-training volume microcycle that consists of 6-day period with 1 high-load day, 2 recovery & rest days, 2 maintenance & taper days, and 1 game-day elite professional basketball players' overall wellness does not show clear fluctuations.

4) During high-training volume microcycle that consists of 8-day period with 2 high-load days, 3 recovery & rest days, 2 maintenance & taper days, and 1 game-day elite professional basketball players' overall wellness does not show clear fluctuations.

5) Designing optimal high-training volume microcycle is a complex process. In order to find optimal microcycle format a comprehensive load monitoring strategy and careful planning is needed.

SUGGESTIONS AND RECOMMENDATIONS

The present study investigated training-load and wellness among elite basketball players in two different microcycle formats. It was the first one to investigate training-load and well-being of a 6-day period with 1 high-load day, 2 recovery & rest days, 2 maintenance & taper days, and 1 game day; and 8-day period with 2 high-load days, 3 recovery & rest days, 2 maintenance & taper days, and 1 game day. To go further in the topic several perspectives for future studies can be seen:

1) For the future studies it is recommended include bigger sample size.

2) The previous study investigated 2 most repetitive microcycle formats that was taken of one professional team. Future studies should conduct deeper analysis of microcycle formats among number of professional elite teams in basketball.

3) The subject of the current study were adults. Different results might have been gotten with U-16, U-18 or other age groups therefore other studies are needed to identify those differences.

4) The current study used session-RPE and SHRZ as load monitoring means. Future studies possibly could adapt more comprehensive load monitoring strategy for the research.

5) The current study did not take into consideration training load, volume & structure of the previous weeks, time of the season and the background of bigger units of periodization. Future investigations should take that into consideration.

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ANNEXES

Annex nr. 1. Wellness questionnaire Used for the study.

HOW DO YOU FEEL TODAY?

Name:………………..

FATIGUE

1 - Very tired

2 - Tired

3 - Normal

4 - Fresh

5 - Very Fresh

MUSCLE SORENESS

1 - Very sore

2 - Increase in soreness/tightness

3 - Normal

4 - Feeling good

5 - Feeling great!

SLEEP QUALITY

1 - Insomnia

2 - Restless sleep

3 - Difficulty falling asleep

4 - Good

5 - Very Restful

STRESS

1 - Very stresfull

2 - Stresfull

3 - Normal

4 - Relaxed

5 - Very Relaxed

MOOD

1 - HIGHLY annoyed/irritable down

2 - Annoyed/irritable down

3 - Less interested in others and/or activities

4 - Generally good mood

5 - Very Positive mood

Annex nr. 2. Session-RPE questionnaire used for the study.

HOW INTENSE WAS THE PRACTICE?

Name:…………

0 – REST

1 – VERY, VERY EASY

2 – EASY

3 – MODERATE

4 – SOMEWHAT HARD

5 – HARD

6 –

7 – VERY HARD

8 –

9 –

10 - MAXIMAL

Annex nr. 3. Certificate of participation of the conference.

Šiaulių akademija

PAŽYMĖJIMAS

Nr. MVG-VUŠA-2023-703

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Jonas Mačiulis

dalyvavo jaunųjų tyrėjų tarptautinėje mokslinėje konferencijoje
„JAUNASIS TYRĖJAS IŠMANIAJAI VISUOMENEI“

Ir skaitė pranešimą tema:

„Monitoring Training Load and Well-being during High-training-volume Competitive Microcycles in Elite Basketball Players“

Direktoriaus pavaduotoja studijoms
Dr. Regina Karvelienė

Šiauliai
2023 m. gegužės 11 d.

Annex nr. 4. Ethical Approval

Mačiulis Jonas
Lietuvos sporto universiteto II pakopos **nuolatinės**
Krepšinio treniravimas ir valdymas studijų programos **2** kurso **MNLKTV-21-1** grupės studentas/ė
Tel. nr.

Bioetikos komisija
Pirmininkui

PRAŠYMAS
DĖL LEIDIMO ATLIKTI BIOMEDICININĮ TYRIMĄ IŠDAVIMO

2023-04-06 (Nr. 32441)
Kaunas

Prašymą pateikusio pagrindinio tyrėjo vardas ir pavardė **Jonas Mačiulis**
1. TYRIMO PAVADINIMAS **Monitoring training load and well-being during high training volume competitive microcycle in elite basketball players**
2. TYRĖJAI
a) INFORMACIJA APIE TYRIMO VADOVĄ (baigiamojo darbo vadovą) (Vardas ir pavardė; pareigos;
darbovietė (institutas, laboratorija, katedra); telefonas; El. adresas) **Kęstutis Matulaitis; Dr. lecturer; Lithuanian Sports University; +37067919290; Kestutis.Matulaitis@lsu.lt**
b) INFORMACIJA APIE KITUS TYRIMO TYRĖJUS (Vardas ir pavardė; pareigos; darbovietė (institutas, laboratorija, katedra)) **-**
3. PLANUOJAMO TYRIMO PRADŽIA (data) **03-04-2023**
4. PLANUOJAMO TYRIMO PABAIGA (data) **30-04-2023**
5. TYRIMO PAGRINDIMAS (Tyrimo tikslas ir uždaviniai. Tyrimo turinys ir darbo planas (tyrimo metodai, tiriamieji, aparatūra). **The aim of the study is to (1) deeply investigate load and well-being of**
the professional basketball players during the competitive high-training-volume microcycle and (2)
identify differences in load & well-being and its fluctuation during the microcycle; (3) conclude whether the microcycle was planned optimally. Subjects are experienced professional adult basketball players currently participating in premier men's basketball league in Lithuania season of 2022/2023. The following internal and external load data will be collected from randomly selected 4 different competitive high-load microcycles: -Session Rate of Perceived Extortion (Borg
Scale); -Wellness Data (Wellness-Questionnaire); -Training Time & Structure; -Heart rate data: summated heart rate zones (Polar Team TM, v1.2).
6. AR TYRIME DALYVAUS PAŽEIDŽIAMI ASMENYS (atsakyti "Taip" arba "Ne")
• nepilnamečiai **No**
• asmenys, gyvenantys globos įstaigose **No**
asmenys, turintys psichikos sutrikimų **No**
• studentai, kurių dalyvavimas tyrime susijęs su studijomis **No**
• kariai jų tikrosios karinės tarnybos metu **No**
• darbuotojai, pavaldūs tyrėjui **No**

7. TIRIAMŲJŲ SUTIKIMAS (Paaiškinkite kaip bus gaunamas tiriamųjų informuotas sutikimas) **I am a director at the club, and data collection and monitoring is a very important tool to ensure that the player is always optimally prepared.**
Pastaba. Pridėkite tiriamųjų informavimo, tiriamųjų informuoto sutikimo formą (jeigu bus naudojama).
Ar bus naudojama apgaulė informuojant tiriamuosius apie tyrimą? (atsakyti "Taip" arba "Ne") **Ne**
Jeigu TAIP, paaiškinkite kokia apgaulės forma bus naudojama. Kaip ir kuomet bus apie apgaulę informuojami tiriamieji ir kokia forma ir kas tai padarys **-**
8. ANONIMIŠKUMAS IR KONFIDENCIALUMAS (atsakyti "Taip" arba "Ne")
Ar tiriamiesiems bus užtikrintas anonimiškumas? **Taip**
Ar tiriamiesiems bus užtikrintas konfidencialumas? **Taip**
Paaiškinkite kaip bus užtikrinamas tiriamųjų anonimiškumas ir duomenų konfidencialumas tyrimo atlikimo metu ir jam pasibaigus. **Informacija bus prieinama tik darbo vertintojams.**
9. TYRIMO RIZIKA
Ar tyrime galima rizika tiriamiesiems? (atsakyti "Taip" arba "Ne") **Ne**
Jeigu TAIP, nurodykite kokia galima rizika tyrimo dalyviams ir kaip ketinate ją sumažinti, kokių priemonių imtis nutikus nelaimingiems atsitikimams **-**
10. TYRĖJO PASIŽADĖJIMAS
Suprantu, kad šioje paraiškoje pateikiama informacija yra konfidenciali ir bus naudojama tik Lietuvos Sporto Universiteto Bioetikos komiteto veikloje vertinant tyrimą ir priimant sprendimą dėl jo atitikimo tyrimų etikos reikalavimams. Paraiškoje pateikiama informacija nebus naudojama jokiais kitais tikslais bemano sutikimo.
Garantuoju, jog:
• Kad šioje paraiškoje pateikiama informacija yra pakankama ir teisinga ir prisiimu pilną atsakomybę už ją.
• Atsiradus pakeitimams tyrime susijusiems su tyrimų etika apie juos informuosiu Lietuvos Sporto Universiteto Bioetikos komitetą.

Pateikė: **Mačiulis Jonas 2023-04-14**
Priėmė: **Sporto mokslo ir inovacijų instituto mokslo darbuotoja Vaida Pokvytytė 2023-04-20**
Įvykdė: **Sporto mokslo ir inovacijų instituto Vaida Pokvytytė 2023-05-09**
Komentaras: **Biomedicininio tyrimo leidimo numeris: 2023 05 09 MNL-KTV (M)-2023-616**

Annex nr. 5. Template for publication.

ABSTRACT

MONITORING TRAINING LOAD AND WELL-BEING DURING HIGH TRAINING VOLUME COMPETITIVE MICROCYCLE IN ELITE BASKETBALL PLAYERS

Aims: (1) Deeply investigate load and well-being of the professional basketball players during the competitive high-training-volume microcycle and (2) identify differences in load & well-being and its fluctuation during the microcycle; (3) conclude whether the microcycle(s) was planned optimally. **Methods:** 11 high-level male basketball athletes (mean±SD, age: 22.9±1.9 years, body mass: 89.2±10.9 kg, BMI: 22.6±1.6, height: 198.4±8.5cm) competing in national first division basketball league [Lietuvos Krepšinio lyga – „BetsafeLKL"] season of 2022/2023 participated in the study. Two of the most in-season repetitive microcycle structures *(Microcycle A & Microcycle B)* was taken for deeper analysis and different variables regarding players' wellness & load of high-load day(s) was compared to taper & maintenance and gamedays. **Findings:** results demonstrated that in analyzed microcycles' wellness score (AU) does not show clear visible fluctuations throughout the days. Differenced were notice of Muscle Soreness scores on estimated high-load day versus two days prior game (respectively 3.25 (±1.06) vs 2.68 (±0.45)) in *microcycle A*. Average *Sleep quality* score on high-load days were lower ($p<0.05$) compared to two days prior game (respectively 3.74±0.54 vs 3.83±0.29) in *microcycle B*. Day-wise comparison of sRPE and values of Summated heart rate zones (SHRZ) demonstrated load (AU) differences ($p<0.05$) between the estimated high-load day(s), taper & maintenance day(s) and gameday(s). The intention of this study is to contribute to the growing pool of knowledge in sports science, provide valuable insights for coaches and practitioners, and help in enhancing the overall welfare and performance of elite basketball players.

Key words: basketball, wellness monitoring, training-load, sRPE, microcycle

INTRODUCTION

Relevance of the topic

Training load and wellness monitoring in basketball is gaining more attention and importance in modern sports science research, particularly in the context of maximizing elite basketball players' performance and preventing injuries. Since basketball is a sport that involves both high-intensity physical and cognitive demands, it is crucial to oversee and handle the athletes' overall well-being and training load to ensure their longevity and peak performance in their careers. According to Fox, Stanton, and Scanlan (2018), there is a growing demand for comprehensive player monitoring methodologies that include both internal and external load gauging to optimize the training and recovery processes. Svilar, Castellano, and Jukic (2019) further emphasize the significance of comprehending the connection between external and internal load indicators, as well as the necessity for individualized load supervision. Additionally, Brink, Visscher, Arends, Zwerver, Post, and Lemmink's (2010) study highlights the correlation between high training loads and increased chances of injuries, thereby emphasizing the importance of monitoring and adjusting the training load for injury prevention.

The practice of wellness & training load monitoring, which encompasses a variety of approaches, has gained increasing traction in the professional basketball realm in order to effectively manage player load, optimize performance, and mitigate injury risk. This context has prompted numerous studies that underscore the importance of such measures, however, there is still growing demand of up-to-date data and recommendations that take into consideration the actual situations and challenges that various athletes and coaching staff are facing form different levels and organizations all around the world.

Aims

The aims of the present study were to (1) deeply investigate load and well-being of the professional basketball players during the competitive high-training-volume microcycle and (2) identify differences in load & well-being and its fluctuation during the microcycle; (3) conclude whether the microcycle(s) was planned optimally.

By focusing on the subject of training load and wellness observation in basketball, this research of Master's degree will contribute to the growing pool of knowledge in sports science, provide valuable insights for coaches and practitioners, and help in enhancing the overall welfare and performance of elite basketball players.

LITERATURE REVIEW

Load monitoring in basketball

Load monitoring in basketball has evolved as an important component of sports science, helping players and coaches in optimizing performance while minimizing injury risk (Bourdon et al., 2017). Basketball is a high-intensity activity that requires a variety of physical characteristics such as strength, power, speed, and agility, necessitating an emphasis on load monitoring (Stojanović et al., 2018). Through the lens of statistical proof, this literature review will critically evaluate the extant scientific literature on load monitoring in basketball.

To successfully evaluate load tracking in basketball, both internal load (e.g., heart rate, rating of perceived exertion) and external load (e.g., accelerometers, GPS devices) metrics must be considered (Schelling & Torres-Ronda, 2016). A complete load monitoring system, according to Fox, Scanlan & Stanton (2017), should include both kinds of parameters to better comprehend the connection between the athlete's physiological stress and their performance. The selection of particular load tracking measures, however, is dependent on their validity, dependability, and practicality in the context of basketball (Stojanović et al., 2018).

Basketball's high physical demands put athletes at risk of injury, especially in the lower extremities (Drakos, Domb, Starkey, Callahan, & Allen, 2010). Load tracking can help spot crucial times when injury risk is high, such as during congested fixture schedules, enabling for the implementation of suitable interventions (Dennis, Finch, & Farhart, 2019). Furthermore, methodical tracking of individual competitors allows for the discovery of those who are more vulnerable to injury due to variables such as accumulated fatigue, allowing for customized prevention strategies (Caparrós, Casals, Solana, Peña, & Vázquez, 2018).

Coaching staff can spot times of under- or over-training and make changes appropriately to optimize athlete readiness for competition by continuously tracking training loads (Hulin, Gabbett, Caputi, Lawson, & Sampson, 2015). Furthermore, load monitoring can help guide training periodization, ensuring that competitors peak at the appropriate periods during the season (Issurin, 2010).

Scanlan, Dascombe, Reaburn & Osborne (2014) discovered that monitoring training loads aided improve performance in a study of the impacts of load monitoring on the physical performance of semi-professional basketball players

Despite the advantages of load tracking in basketball, researchers and practitioners must address a number of issues. Accurate quantification of sport-specific motions such as jumping, sprinting, and changing direction is one such problem that may necessitate the creation of innovative monitoring technologies (Schelling & Torres-Ronda, 2016).

Load tracking is an important instrument in basketball for injury avoidance and performance improvement. The current scientific literature supports the use of load tracking factors to reduce injury risk and improve performance. Several obstacles, however, persist, such as the exact quantification of sport-specific movements and the integration of load monitoring data with other pertinent variables.

Wellness monitoring in basketball

Wellness tracking has evolved into an important part of sports science, playing a critical role in assuring basketball players' well-being and optimum performance (Gallo, Cormack, Gabbett, & Lorenzen, 2015). It entails assessing a variety of physical, psychological, and mental variables in order for coaches and sports experts to make educated choices about training, recovery, and prevention of injuries (Brink et al., 2010). Basketball wellness tracking includes assessing bodily parameters such as sleep quality, muscular soreness, and fatigue, as well as psychological and emotional elements such as mood, stress and motivation (Saw, Main, & Gastin, 2016). To evaluate these parameters, a variety of instruments have been created, spanning from self-report surveys to objective physiological and performance evaluations (Gallo et al., 2015). Basketball wellness tracking can be used for a variety of reasons, including injury prevention, optimizing training load, and improving recovery. Coaching staff can spot early indications of overtraining or inadequate recovery and make suitable changes to training load by monitoring players' wellness state, lowering the risk of injury (Saw et al., 2016).

Wellness tracking can help athletes achieve optimal performance during crucial competition periods by informing training periodization (Issurin, 2010). Schelling, Calleja-González, Torres-Ronda, & Terrados, (2013), for example, examined the impacts of a 6-week training program that included wellbeing tracking on the physical performance of 18 top basketball players. The findings showed substantial improvements in a variety of performance parameters, such as sprint pace, vertical leap height and agility, emphasizing the possible advantages of wellness monitoring in basketball. Several studies have given statistical proof that wellness monitoring in basketball is successful. Gallo et al. (2015), for example, investigated the link between self-reported wellness parameters and performance results in 12 top male basketball players over a 12-week training span. Changes in fatigue, muscular soreness and sleep quality were found to have substantial unfavorable associations with changes in countermovement jump ability. These results imply that monitoring players' wellness can provide useful insights into their performance readiness and help guide training choices.

Furthermore, studies have shown that integrating wellness monitoring into basketball can help reduce injury risk. Fullagar et al. (2016) conducted research in which they examined the link between perceived sleep quality and injury risk in 12 professional basketball players during a competitive season. The findings showed that athletes who reported bad sleep quality had a substantially greater frequency of injury than those who reported improved sleep quality, highlighting the significance of tracking wellbeing metrics for injury prevention.

Furthermore, studies have shown that wellness tracking can be useful in improving exercise load and periodization. Staunton, Gordon, Custovic, Stanger, & Kingsley, (2017) conducted a 14-week research in which they investigated the link between self-reported health metrics and training intensity in ten professional basketball players. The findings showed that athletes with higher wellbeing ratings had better training burden control and were more likely to enhance their performance.

Despite the encouraging evidence backing the use of wellbeing tracking in basketball, researchers and practitioners face several obstacles. Integrating wellness tracking data with other pertinent information, such as load monitoring and accident history, is one such challenge (Gabbett, 2016).

Another challenge is the creation of more complex tools for evaluating psychological and emotional variables, which may necessitate the use of cutting-edge technologies like machine learning algorithms and wearable devices (Lupo & Tessitore, 2020).

Wellness tracking is an important part of basketball, as it helps with pain avoidance, training optimization, and performance enhancement. The current scientific literature offers solid statistical proof supporting the efficacy of different wellness monitoring techniques in reaching these objectives, such as the Profile of Mood States questionnaire and heart rate variability monitoring. Several obstacles persist, however, including integrating wellness tracking data with other pertinent variables and developing more sophisticated assessment tools. Future study should concentrate on addressing these issues and capitalizing on the potential of emerging technologies to progress the field of basketball health tracking.

Heart Rate Monitoring in Basketball

Heart rate monitoring has become an essential instrument in sports science, especially in basketball, where it is used to evaluate players' physiological responses to training and competition (Cunniffe, Proctor, Baker, & Davies, 2011). It can help with training load control, performance improvement, and preventing injuries (Buchheit, Laursen, & Ahmaidi, 2009). Heart rate monitoring in basketball can be employed for various purposes, including assessing training intensity, optimizing training load, and evaluating recovery status. By monitoring athletes' heart rate responses to training and competition, coaching staff can make informed decisions regarding training load adjustments, periodization and tapering strategies, ultimately enhancing athletes' performance and reducing the risk of injury (Coutts, Wallace, & Slattery, 2007).

A variety of techniques can be used to measure heart rate, including constant monitoring during training and competition, as well as pre- and post-exercise evaluations (Coutts et al., 2007). Wearable technology advancements, such as heart rate trackers and GPS-enabled devices, have allowed the gathering of real-time heart rate data, allowing for the study of training burden, intensity, and recuperation state (Borresen & Lambert, 2009). The calculation of training impulse (TRIMP), which measures the physiological stress encountered by players during training practices and contests, is a popular technique for analyzing heart rate statistics in basketball (Banister, 1991). TRIMP incorporates both heart rate and session duration to provide a comprehensive measure of training load, enabling coaches and sports scientists to monitor athletes' responses to training and competition more effectively (Impellizzeri, Rampinini, Coutts, Sassi, & Marcora, 2004).

Furthermore, heart rate tracking can provide useful insights into individual differences in training responses, allowing for personalized training plans and recovery methods (Buchheit, Racinais,

Bilsborough et al., 2009). Sperlich, Koehler, Holmberg, & Zinner (2011), for example, examined the link between heart rate-based training load and performance improvements in 12 top basketball players over a 6-week training session. Individualized training load adjustments based on heart rate tracking were linked with substantial increases in different performance metrics such as maximal aerobic power, sprint speed, and leap height, according to the findings.

Several studies have given statistical proof that heart rate tracking is successful in basketball. For example, Narazaki, Berg, Stergiou & Chen (2009) investigated the link between heart rate-based TRIMP scores and performance outcomes in 15 top male basketball players over the course of a competitive season. TRIMP scores were found to have substantial favorable correlations with on-court performance metrics such as points tallied, rebounds, and assists, highlighting the possible advantages of heart rate monitoring in basketball. Additionally, research has shown that heart rate monitoring can help identify early signs of overtraining or insufficient recovery in basketball players. A study by Schelling, Calleja-González, Torres-Ronda, & Terrados (2013) investigated the relationship between heart rate variability (HRV) and overtraining in 18 professional basketball players during a 4-week period of intensified training. The results revealed that players who exhibited reduced HRV were more likely to experience symptoms of overtraining, emphasizing the importance of heart rate monitoring for training load management and injury prevention.

Despite the promising data backing the use of heart rate monitoring in basketball, researchers and practitioners face several obstacles. The creation of more exact and dependable methods for interpreting heart rate data in the context of basketball-specific needs is one such challenge, which may necessitate the use of sophisticated analytical techniques and models (Buchheit, Laursen, & Ahmaidi, 2009). Another issue is a better knowledge of the connection between heart rate responses and other pertinent variables like neuromuscular fatigue, hormonal responses, and psychological stress in order to provide a more complete evaluation of players' physiological state (Claudino et al., 2019).

Heart rate tracking is an important element of basketball, as it helps to evaluate training intensity, optimize training load, and assess recovery state. The current scientific literature offers solid statistical proof supporting the effectiveness of different heart rate monitoring techniques in accomplishing these objectives, such as continuous monitoring and training impulse calculations. Several obstacles remain, however, including the need for more accurate and dependable ways of analyzing heart rate data, as well as a better grasp of the connection between heart rate reactions and other relevant factors. Future study should concentrate on overcoming these obstacles and capitalizing on the potential of new technologies to progress the field of heart rate tracking in basketball.

Rate of perceived exertion monitoring in basketball

Rate of perceived exertion (RPE) is a subjective measure of an individual's perception of exercise intensity, which has been widely employed in various sports, including basketball, as an alternative or supplementary method to physiological indicators like heart rate for monitoring training load and fatigue (Borg, 1998). Due to its simplicity and low cost, RPE has gained increasing attention in recent years for its potential applications in managing training load, preventing overtraining, and optimizing performance (Foster et al., 2001). Basketball RPE tracking can be used for a variety of reasons, including measuring training effort, optimizing training load, and determining recovery state. Coaching staff can make educated choices about training load changes, periodization and tapering strategies by tracking athletes' RPE reactions to training and competition, eventually improving athletes' performance and lowering the risk of injury (Alexiou & Coutts, 2008).

Athletes usually rate their perceived exertion during or directly after a training exercise or competition using a standardized scale, such as the Borg CR10 scale or the Category-Ratio (CR) 0-10 scale (Borg, 1998). The session RPE (sRPE) technique, which blends the RPE score with the session length, has been widely used in basketball and other team sports to measure training burden (Foster et al., 2001). sRPE has been demonstrated to correspond well with objective physiological measures such as heart rate and blood lactate concentration, making it a legitimate and dependable measure of exercise load (Impellizzeri et al., 2004).

Moreover, RPE monitoring can provide valuable insights into individual differences in training responses, allowing for the personalization of training programs and recovery strategies (Los Arcos, Yanci, Mendiguchia, & Gorostiaga, 2015). For example, a study by Scanlan, Dascombe Reaburn & Osborne (2012) investigated the relationship between RPE-based training load and performance improvements in 14 elite youth basketball players during an 8-week training period. The results revealed that individualized training load adjustments based on RPE monitoring were associated with significant improvements in various performance parameters, such as maximal aerobic power, sprint time, and jump height.

Several studies have provided statistical evidence supporting the effectiveness of RPE monitoring in basketball. For instance, a study by Manzi et al. (2010) examined the relationship between RPE-based training load and performance outcomes in 12 elite male basketball players during a competitive season. The results demonstrated significant positive correlations between sRPE scores and on-court performance parameters, such as points scored, rebounds, and assists, highlighting the potential benefits of RPE monitoring in basketball.

Furthermore, study has shown that RPE monitoring can assist in detecting early indications of overexertion or inadequate recovery in basketball players. Freitas, Nakamura, Miloski, Samulski & Bara-Filho (2014) examined the relationship between RPE, heart rate variability (HRV), and overtraining in 12 professional basketball players over a 4-week intensive training session. The findings showed that athletes with higher RPE and lower HRV were more likely to experience overtraining symptoms, stressing the significance of RPE tracking for training load management and injury avoidance.

Monitoring rate of perceived exertion has evolved as a useful instrument in basketball for measuring training intensity, optimizing training load, and examining recovery state. The existing scientific literature offers strong statistical proof that different RPE monitoring techniques, such as the session RPE method, are successful in achieving these objectives. Several challenges persist, however, including RPE's subjectivity as a measure and the need for a greater grasp of the relationship between RPE and other pertinent variables. Future study should concentrate on overcoming these obstacles and capitalizing on the promise of new technologies and sport-specific RPE scales to progress the field of RPE monitoring in basketball.

Summated heart rate zones

Monitoring heart rate (HR) during training and play is an important part of load management in basketball, giving useful insights into athletes' physiological reactions and aiding in performance optimization and injury prevention. Summated heart rate zones (SHRZ) is a technique that divides heart rate data into zones based on preset intensity thresholds and calculates the time spent in each zone, allowing for a more thorough study of training load and intensity distribution (Abt, Dickson, Mummery, & Davison, 2003). Monitoring heart rate (HR) during training and play is an important part of load management in basketball, giving useful insights into athletes' physiological reactions and aiding in performance optimization and injury prevention. Summated heart rate zones (SHRZ) is a technique that divides heart rate data into zones based on preset intensity thresholds and calculates the time spent in each zone, allowing for a more thorough study of training load and intensity distribution (Abt et al., 2003).

The first stage in implementing SHRZ in basketball is determining suitable intensity levels for categorizing heart rate data. These limits are usually calculated as a proportion of a person's maximum heart rate (HRmax) or heart rate reserve (HRR; the differential between resting heart rate and HRmax) (Karvonen, Kentala, & Mustala, 1957). HR zones that are commonly used include 50-60%, 60-70%, 70-80%, 80-90%, and 90-100% of HRmax or HRR, which correlate to various physiological reactions and energy systems such as aerobic, anaerobic, and neuromuscular (Edwards, 1993). These zones can be adjusted further based on sport-specific needs as well as individual variations in physiological characteristics and training objectives among competitors.

Furthermore, SHRZ can be used to assess the effectiveness of training interventions and recovery strategies, as well as to monitor individual differences in training responses and adaptation. For example, a study by Scott, Lockie, Knight, Clark, & Janse de Jonge (2013) investigated the effects of a 6-week high-intensity interval training (HIIT) program on the SHRZ profiles of 12 elite youth basketball players. The results demonstrated significant improvements in the time spent in higher HR zones and a reduction in the time spent in lower HR zones, indicating enhanced aerobic and anaerobic fitness.

Several studies have given statistical proof that SHRZ is beneficial in basketball. For example, Narazaki et al. (2009) investigated the link between SHRZ and on-court performance in 14 male college basketball players over the course of a competitive season. Significant correlations were found between time spent in higher HR zones and important performance measures such as points scored, rebounds, and passes, emphasizing the possible advantages of SHRZ monitoring in basketball.

Furthermore, studies have shown that SHRZ can help identify early indications of overuse or insufficient recovery in basketball players. Schelling and Torres-Ronda (2016) conducted research on the link between SHRZ, neuromuscular fatigue and injury risk in 16 elite basketball players over a 4-week intensive training time. The findings showed that players who spent more time in higher HR zones and less time in lower HR zones were more likely to experience symptoms of neuromuscular fatigue and injury risk, highlighting the importance of SHRZ monitoring for training load management and injury prevention.

Summated heart rate zones have evolved as a useful instrument in basketball for measuring the intensity and length of training sessions and competitions; giving a more detailed knowledge of players' physiological reactions, and assisting in the optimization and prevention of performance and injuries. The extant scientific literature contains substantial statistical proof supporting the efficacy of different SHRZ methodologies in accomplishing these objectives.

RESEARCH METHODOLOGY AND ORGANIZATION

Research object

The object of the present research was to determine the wellness status, training-load and its fluctuations experienced by high-level professional elite basketball athletes playing in premier professional basketball league in Lithuania across two different microcycle design strategies.

Subjects

The subjects of the study were 11 high-level male basketball athletes (mean±SD, age: 22.9±1.9 years, body mass: 89.2±10.9 kg, BMI: 22.6±1.6, height: 198.4±8.5cm) competing in national first division basketball league [Lietuvos Krepšinio lyga – „BetsafeLKL“] season of 2022/2023. At the time of the study all of the subjects belonged to one team, any of the subject reported injuries or any other severe limitations that could affect study results. Ethical approval was obtained from Lithuanian Sports University Bioethics Committee (Nr: MNL-KTV (M)-2023-616).

Research strategy

Two of the most in-season repetitive microcycle structures was taken for deeper analysis (**Figure 1**). Microcycle A consisted of 6-day period with 1 high-load day, 2 recovery & rest days, 2 maintenance & taper days, and 1 game day. Microcycle B consisted of 8-day period with 2 high-load days, 3 recovery & rest days, 2 maintenance & taper days, and 1 game day. To determine and establish optimal loading recommendations, different variables regarding players' wellness & load of high-load day(s) was compared with taper & maintenance and gameday in both microcyles (respectively GD-4 vs GD-2 & GD-1 vs Game Day in Microcycle A, and GD-6 & GD-4 vs GD-2 & GD-1 vs Game Day in microcycle B).

[INSERT FIGURE 1 AROUND HERE]

The data was collected throughout both microcycles. Across the data collection, subjects completed 7-9 training sessions (including on court, scouting and strength training sessions) with each lasting approximately 75-90minutes. Training contents and duration is presented in **Figure 2.**

[INSERT FIGURE 2 AROUND HERE]

PROCEDURES

Monitoring of workload

sRPE

The workload of the players was gathered using Session Rate of Perceived Exertion (sRPE) method which was tested both for validity and reliability (Herman, L. et al; 2006) Soon after the session (~30 minutes) subjects were instructed to rate intensity of training session (or game) by completing a pre-designed questionnaire that consisted of a ratio scale (CR-10) of a question: “How intense was the training/game?”. The questionnaire was sent to their phones in a form of cloud-based software (Google Forms, CA, USA). The duration of each player’s training time (min) was registered by training staff. Game duration was taken from start to the end of the game including all game-related stoppages and excluding warm-up & pre-game activities. The player load expressed in Arbitrary Units (AU) was calculated by multiplying player sRPE score and the duration of the on-court and/or strength & conditioning training.

Summated Heart Rate Zones

In order to determine internal workload of on-court practices the well-know and previously researched & applied in basketball (Manzi, V. et al; 2010; Scanlan, A. et al; 2014, 2016) Summated Heart Rate Zones (SHRZ) method was used. The heart rate values were monitored during all on-curt activities using a chest-straps with attached Bluetooth heart rate sensors (Polar Team, v:1.2). Arbitrary Units (AU) of SHRZ was calculated by multiplying time spent (min) in each intensity zone by corresponding pre-determined weighting of each zone which incrementally increased. The following formulae were used for the calculation of training load:

SHRZ training load = (time spent in zone 1 x 1) + (time spent in zone 2 x 2) + (time spent in zone 3 x 3) + (time spent in zone 4 x 4) (time spent in zone 5 x 5), where: Zone 1 = 50-59% HR_{max}*; Zone 2 = 60-69%* HR_{max}*; Zone 2 = 50-59%* HR_{max}*; Zone 3 = 70-79%* HR_{max}*; Zone 4 = 80-89%* HR_{max}*; Zone 5 = 90-100%* HR_{max}*;*

time spent = time accumulated (min) in particular heart rate zone.

Monitoring of Wellness

Well-being of the players was collected using a custom-made wellness questionnaire which was chosen by recommendations of previous studies (Hooper SL, Mackinnon LT; 1995). The questionnaire was developed using a cloud-based software (Google Forms, CA, USA) and sent to the players each morning upon waking up before morning practice. The players were instructed to fill the questionnaire in the morning and honestly evaluate their current well-being. The questionnaire was designed to asses players’ well-being scores on 5 different levels: fatigue, sleep quality, stress, muscle soreness, mood.

1–5-point scale for each of the levels was used to determine the current state of the players which was then summated in order to determine total well-being score.

Statistical Procedures

Standard statistical methods were used for calculation of means and presented as mean ± standard deviation. Magnitude of wellness scores and training load differences between high-load days, taper & maintenance days and game days was assessed using effect size statistics. Cohen's d effect size (ES) was calculated and interpreted as <0.20 = Trivial, 0.20-0.59 = Small, 0.60-1.19 = Moderate, 1.20-1.99 = Large, >2.0 = Very large (Hopkins, Marshall, Batterham, and Hanin, 2009). All the statistical analyses were performed using SPSS 16.0 for Windows (SPSS Inc., Chicago, IL, USA). Significance was set at $p<0.05$.

REASERCH FINDINGS

Training volume

Teams' average volume (min) and intensity (sRPE) displayed in **Figure 3**.

It was noticed that in Microcycle A on estimated high-load days players accumulated 173 (±18.9) minutes (GD-4) of training time, while in Microcycle B 187(±17.8) and 180 (±14.1) respectively on GD-6 and GD-4. On Taper & maintenance days in both microcycles players accumulated on average 167(±6.4) minutes of training time.

[INSERT FIGURE 3 AROUND HERE]

Wellness

Teams' Wellness scores & training intensity demonstrated in **Figure 4**.

Results demonstrated that both in both Microcycle A and Microcycle B wellness score (AU) does not show clear visible fluctuations throughout the days. However, overall session intensity scores (sRPE) had a tendency to rise in both microcycles. The highest sRPE scores in both microcycles was noticed to be after the game.

[INSERT FIGURE 4 AROUND HERE]

Player-wise analysis demonstrated different wellness scores distribution between GD-2, GD-1 and Gameday in both microcycles (**Figure 5**).

Results showed that the average wellness score in both microcycles were: (mean±SD) 17.3(±1.8), 17.1 (±1.6) and 17.5 (±2.3) respectively on GD-2, GD-1 and Gameday in microcycle A, and 17.4 (±1.5), 16.6 (±2.2) and 18.2 (±1.8) respectively on GD-2, GD-1 and Gameday in microcycle B. It was noticed lower average team's wellness score one day prior the game in microcycle B (17.1±1.6 vs 16.6±2.2), however in the same microcyle (B) higher teams' average wellness scores were on the gameday compared to microcycle A.

[INSERT FIGURE 5 AROUND HERE]

sRPE

Player load (sRPE AU) and wellness score (AU) presented in **Figure 6**. Results showed that in microcycle A, on estimated high-load day (GD-4) the team averaged 624 (±171) arbitrary units of load, while on the taper & maintenance days 855 (±216) and 710 (±209) respectively on two days before gameday and one day before gameday. The average load on a game day was 510 (±233) AU.

Analysis of microcycle B demonstrated that players on estimated high-load days experienced load of 884 (±256) AU on GD-6, and 680 (±141) AU on GD-4. Taper & maintenance days accumulated 790 (±214) and 697 (±229) of AU (respectively GD-2 and GD-1). Gameday on microcycle B totaled 615 (±315) AU.

[INSERT FIGURE 6 AROUND HERE]

SHRZ

Analysis of Summated Heart Rate Zones (**Figure 7**) showed that on estimated high-load day (GD-4) the players accumulated 225 (±17) AU of load in Microcycle A, while on Microcycle B high-load days' volume were at 221 (±20) AU on GD-6 and 218 (±20) AU on GD-4. On estimated taper & maintenance days, two days before the game the volume was 228 (±28) and 194 (±18) AU respectively on microcycle A and microcycle B; One day before the game (GD-1) the volume was 193 (±18) AU in microcycle A, and 177 (±18) AU in microcycle B.

[INSERT FIGURE 7 AROUND HERE]

Day-wise comparison

Figure 8 demonstrates day-wise comparison of wellness scores of different variables (Fatigue, Muscle soreness, Sleep quality, Stress and Mood) between estimated high-load day(s), taper & maintenance day(s) and versus gameday.

It was noticed differences of Muscle Soreness scores on GD-4 vs GD-2 & GD-1 ($p<0.05$), respectively 3.25 (±1.06) vs 2.68 (±0.45) in *microcycle A*. Furthermore, results showed that average sleep quality score on GD-4 & GD-6 were lower ($p<0.05$) compared to GD-1 & GD-2 (respectively 3.74±0.54 vs 3.83±0.29) in *microcycle B*.

[INSERT FIGURE 8 AROUND HERE]

Day-wise comparison of sRPE and values of Summated heart rate zones (SHRZ) demonstrated load (AU) differences between the estimated high-load day(s), taper & maintenance day(s) and gameday(s) **Figure 9.**

In Microcycle A following differences ($p<0.05$) was noticed between sRPE values: GD-4 (624 ±171 AU) was lower than GD-1 & GD-2 (782 ±103 AU); on a gameday players experienced significantly lower training load than on a taper & maintenance day which where 510 (±233) AU on a gameday and 782 (±103) AU on a GD-1 & GD-2.

In Microcycle B results demonstrated lower sRPE training load values of GD-4 & GD-6 between the load that players accumulate on a gameday which respectively where 782 (±144) AU and 615 (±307) AU.

Furthermore, gameday load was significantly lower on than estimated taper & maintenance days before the game, which were 743 (±66) AU on GD-1 & GD-2.

Summated Heart Rate Zones (SHRZ) analysis of on court practices showed difference in A microcycle's estimated high-load day (GD-4) and gameday (**Figure 9).** Gameday load (297±27 AU) was significantly bigger than GD-4 (225±17 AU) which was an estimated high-load day.

In Microcycle B it was noticed that SHRZ load on a gameday (297±27 AU) was significantly higher in comparison to taper & maintenance days (GD-1 & GD-2) which totaled 214(±5) AU. Furthermore, GD-4 & GD-6 which were estimated high-load days were significantly higher in training load that estimated taper & maintenance days (GD-1 & GD-2), the values were respectively 214(±5) AU and 186(±12) AU.

[INSERT FIGURE 9 AROUND HERE]

CONSIDERATIONS

The current study is one of the few that tried to contribute to overall wellness and increased performance by bringing data and valuable insights to the field of load monitoring load and wellness in a context of microcycle. Designing the high-volume microcycles is not an easy task for the coaches and practitioneers as in the literature it is a difficult task to find scientific analysis and scientifically justified recommendations. The microcycle creation method and formats is highly dependent on the philosophy of the coaching staff. There are barely any studies that examined and investigated strategies of a short-term periodization similar to the ones presented in this paper. However, several other attempts of investigating microcycles can be find and will be presented in this chapter together with other valuable insights regarding present study's aims, goals an findings.

In the present study we have concluded that designing an optimal microcycle is a complex process for coaches. Our study supports the ideas discussed in other studies that regarding the planning of the trainings "*One size fits all*" approach shall be avoided and more individualized approach should be considered. Study by Stojanović et al. (2020) emphasized the significance of tailoring weekly periodization according to the competition schedule, individual characteristics of athletes, and the time of the season. Despite variations in the optimal approach depending on multiple factors, this study also suggest that a well-structured weekly periodization model can enhance basketball athletes' performance which underlines even further the importance of the current study. Furthermore in the same study they found that basketball match-play required athletes to perform high-intensity movements every 21 seconds on average, suggesting the need for weekly microcycles to prepare athletes for such demands. However, they also emphasized the need for individualization in microcycle design according to factors such as the competition schedule and athlete characteristics. Additionally, a study conducte by Aoki et al. (2017) observed that a tailored, undulating periodization model was significantly effective in reducing injuries and enhancing the performance of elite basketball players.

Our study cautions the coaches and practitioners in basketball that in a high-training volume microcycle in basketball it is difficult task to foresee and plan trainings in advance without consulting load-monitoring means. The pre-planned microcycles' strategies presented in the study expected to cause training-load fluctuations. *High-load* days was expected to have a rise in total workload, while the *taper & maintenance* days and *rest days* was expected to be relatively low in total work-load. The *"ups & downs"* of the workload during the microcycle was expected to have an impact on wellness values leading up to an optimal readiness on the game day. However, findings demonstrated us that the fluctuations were rather low amplitude possibly cautioning about possibility of decreased performance or event of injury. For example, a study by Turner (2011) underscored the importance of balancing load and recovery, suggesting that excessive load without adequate recovery could increase the risk of overuse injuries. Similarly, Hulin et al. (2014) found a U-shaped relationship between acute training load and injury risk, with both very high and very low loads associated with increased injury risk. On the other hand, a longitudinal study by Gabbett (2016) highlighted the role of chronic load in building resilience and reducing injury risk. However, the study also cautioned against sudden spikes in load, which were associated with increased injury risk. Lastly, Impellizzeri et al. (2019) emphasized the need for individualizing load management strategies, taking into account factors such as player fitness, injury history, and playing position. Manzi et al. (2010) conducted seminal work in this area by documenting the weekly load profile of elite male professional basketball players, suggesting that proper distribution of load during the week can have a positive impact on performance and reduce the risk of injuries. Montgomery et al. (2018) further demonstrated that maintaining a consistent weekly load resulted in improved on-court performance in professional players. A more recent study by Svilar et al. (2021)

corroborated these findings, observing that optimal load distribution during the week contributed to higher game intensity and improved physical performance.

In our study we have used the method of Summated Heart Rate Zones (SHRZ) in order to supplement session-RPE based training load measures with internal and more objective data. While the method of Summate Heart Rate Zones is not so commonly found in literature, heart rate monitoring in elite basketball has been extensively researched to understand the physiological demands of the sport and optimize training. A study by Abdelkrim et al. (2010) reported average heart rates of 167 beats per minute (bpm) during competitive games, reflecting high cardiovascular demands. Ben Abdelkrim et al. (2007) also found that heart rate responses varied based on playing position, with guards demonstrating higher mean heart rates (178 bpm) compared to forwards (172 bpm) and centers (169 bpm). A study by McInnes et al. (1995) revealed that heart rate values often exceed 85% of the player's maximum during game play, indicating the presence of high-intensity efforts. Additionally, a research by Castagna et al. (2008) suggested that training in higher heart rate zones could enhance player's match-related physical abilities. In contrast, a study by Buchheit et al. (2015) suggested individualized training based on heart rate variability to optimize performance and recovery.

Despite the promising evidence supporting the use of RPE monitoring in basketball, there are several challenges that researchers and practitioners must address. One such challenge is the subjectivity of RPE as a measure, which may be influenced by factors such as individual differences in pain tolerance, motivation, and psychological factors (Impellizzeri et al., 2004). Another challenge is the need for a better understanding of the relationship between RPE and other relevant factors, such as physiological responses, neuromuscular fatigue, and the specific demands of basketball, in order to provide a more comprehensive assessment of athletes' training and recovery status (Los Arcos et al., 2015).

Despite the promising data backing the use of SHRZ in basketball, researchers and practitioners must address a number of issues. One such challenge is a better understanding of the relationship between SHRZ and other relevant factors such as sport-specific demands, individual differences in physiological profiles, and training goals in order to provide a more comprehensive assessment of athletes' training and recovery status (Buchheit, Racinais, Bilsborough, et al., 2009). Another issue is that heart rate as a proxy for exercise exertion may be affected by variables such as hydration state, ambient weather and psychological tension (Achten & Jeukendrup, 2003).

Future research should focus on addressing these challenges and exploring the potential of combining SHRZ with other objective measures of training load, such as rating of perceived exertion (RPE), GPS tracking, and wearable sensor technology, to provide a more comprehensive understanding of athletes' responses to training and competition (Impellizzeri et al., 2004). Moreover, the development and validation of sport-specific HR zone models tailored to the unique demands of basketball may help improve the accuracy and reliability of SHRZ monitoring in this context (Schelling & Torres-Ronda, 2016).

Wellness monitoring method used in this study shares the same and often questionable issue of validity as session-RPE load monitoring strategy. Even though there are plenty of studies made that supported validity and reliability of Wellness Questionnaires still fall under subjective tests category that can be influenced by many outside factors such as athlete’s psychological state, player’s relation with the coaching staff, weather and/or number of non-training related stressors. Future research should focus on addressing these challenges and exploring the potential of emerging technologies to enhance the precision and efficiency of wellness monitoring in basketball. For example, a study by Fox, Stanton, & Scanlan, (2017) investigated the use of a novel machine learning algorithm for predicting basketball players' readiness to perform based on subjective wellness parameters. The results demonstrated that the algorithm was able to accurately predict players' performance readiness, suggesting that machine learning approaches could be valuable tools for wellness monitoring in basketball.

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FIGURES

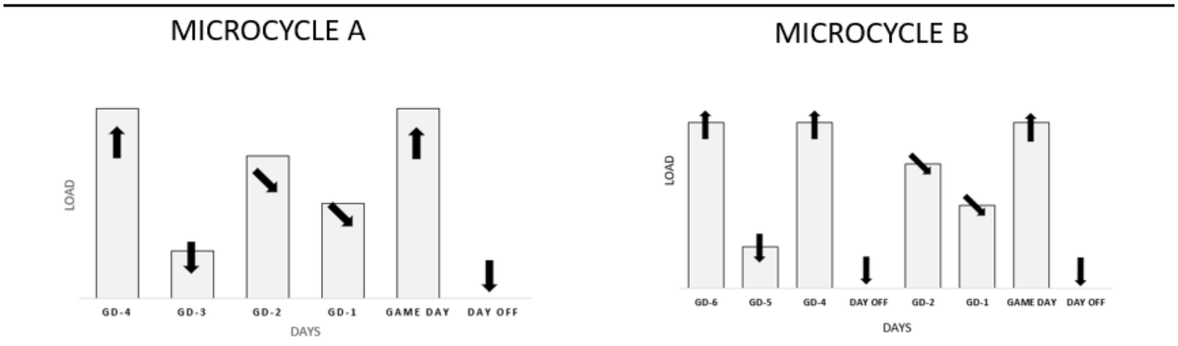

Figure 4. *Microcycle loading strategies.*
GD-1, GD-2, GD-3, GD-4, GD-5, GD-6 = Days left to the competitive match (accordingly 1 day, 2 days, 3 days, 4 days, 5 days & 6 days). Gameday = day of competitive match. Day Off = rest day; ↑ - high- load day(s); ↘ - maintenance & taper day(s); ↓ - rest day(s).

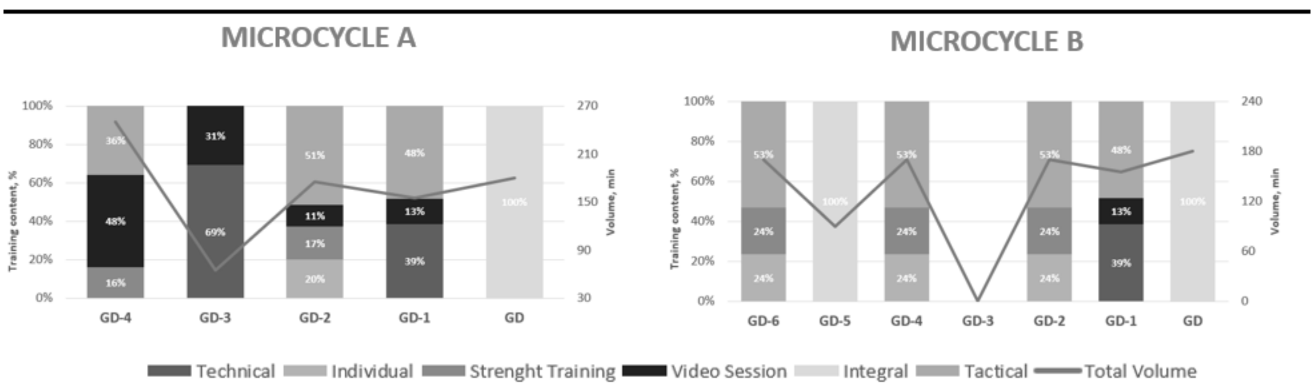

Figure 5. *Training contents, duration and its percentage in Microcycle A and Microcycle B.*
GD-1, GD-2, GD-3, GD-4, GD-5, GD-6 = Days left to the competitive match (accordingly 1 day, 2 days, 3 days, 4 days, 5 days & 6 days). GD = Game-day of competitive match.

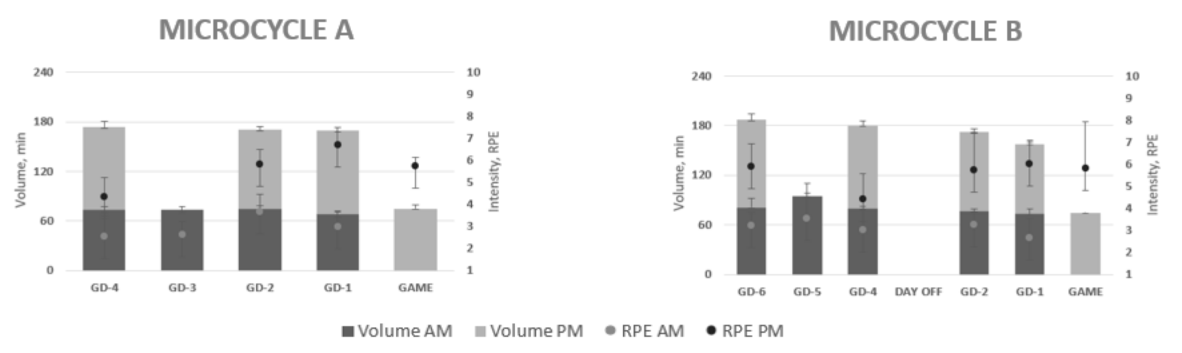

Figure 6. *Average training volume (min) and intensity (sRPE) values in Microcycle A & Microcycle B. AM = morning practice; PM = afternoon practice. GD-1, GD-2, GD-3, GD-4, GD-5, GD-6 = Days left to the competitive match (accordingly 1 day, 2 days, 3 days, 4 days, 5 days & 6 days). Game = Game-day of competitive match.*

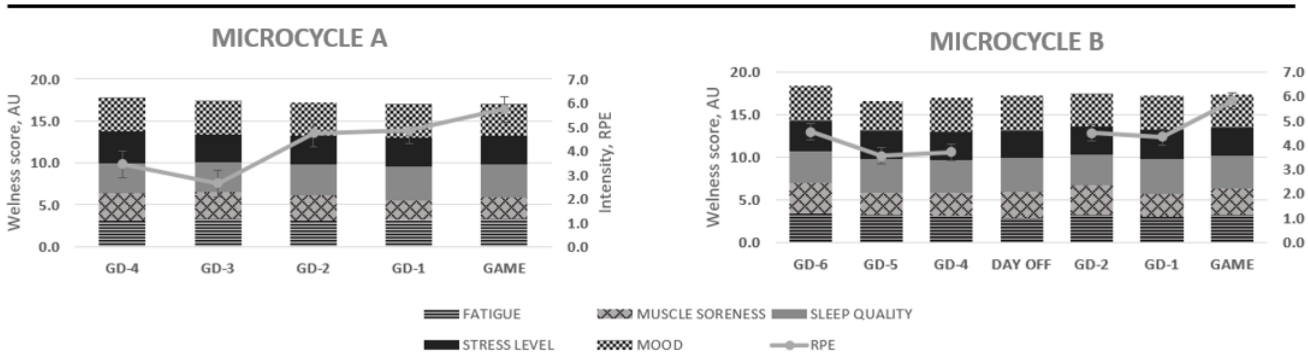

Figure 4. Team's average wellness score (AU) & training intensity (RPE) in Microcycle A and Microcycle B. GD-1, GD-2, GD-3, GD-4, GD-5, GD-6 = n of days left to the competitive match (accordingly 1 day, 2 days, 3 days, 4 days, 5 days & 6 days). Game = Day of competitive match. Day Off = Rest Day

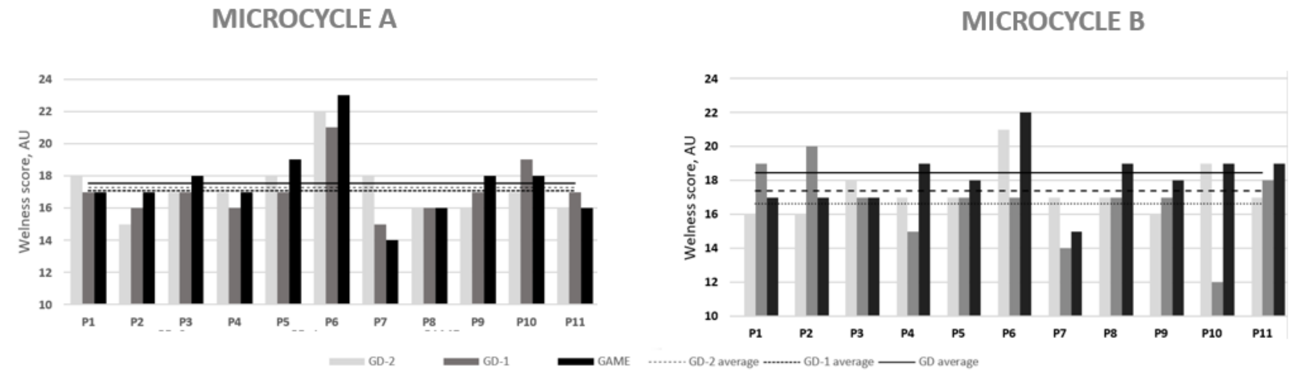

Figure 5. *Wellness score values of each player on 1 & 2 days before tha game and a gameday in Microcycle A and Microcycle B. GD-1, GD-2, GD-3, GD-4, GD-5, GD-6 = n of days left to the competitive match (accordingly 1 day, 2 days, 3 days, 4 days, 5 days & 6 days). P1-P11 = number of playrs. Game = Day of competitive match.*

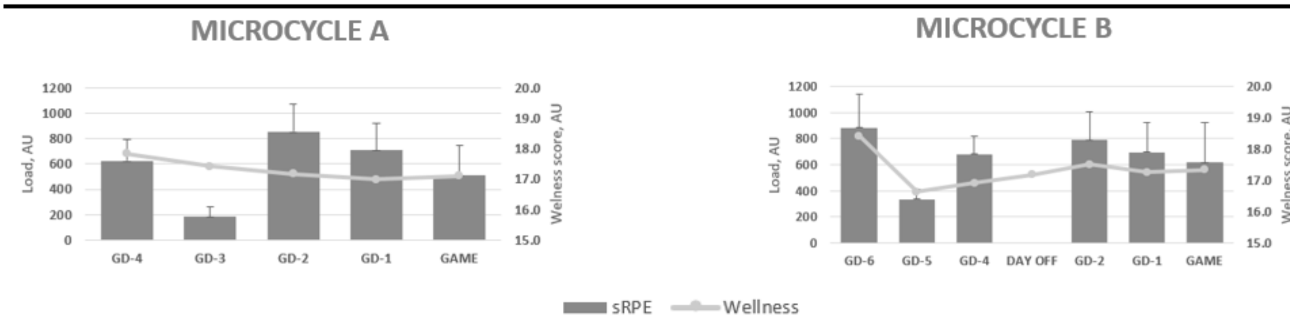

Figure 6. Teams' avergae load (AU, sRPE) and Wellness scores (AU) *in Microcycle A and Microcycle B. GD-1, GD-2, GD-3, GD-4, GD-5, GD-6 = n of days left to the competitive match (accordingly 1 day, 2 days, 3 days, 4 days, 5 days & 6 days). Game = Day of competitive match. Day off = rest day*

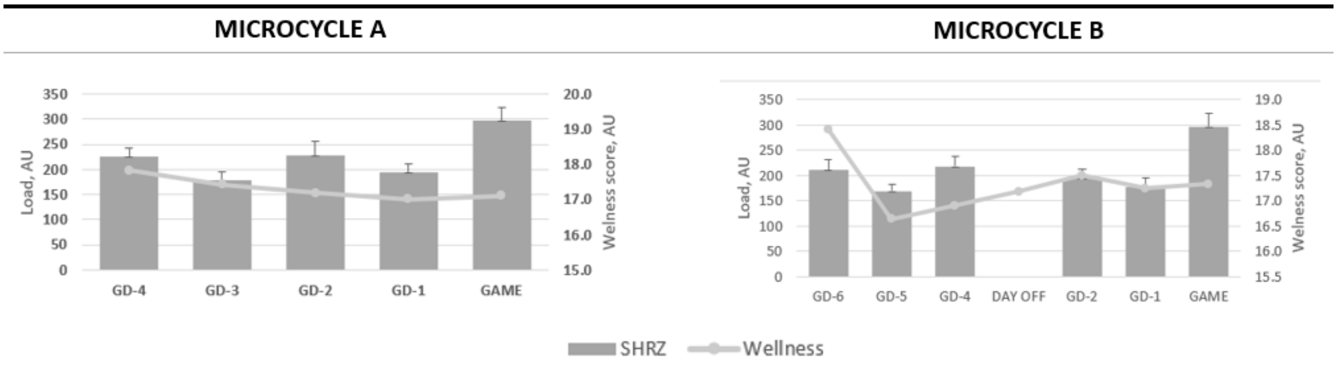

Figure 7. Teams' average training load (AU, SHRZ) of on-court practices and Wellness scores (AU) *in Microcycle A and Microcycle B. GD-1, GD-2, GD-3, GD-4, GD-5, GD-6 = n of days left to the competitive match (accordingly 1 day, 2 days, 3 days, 4 days, 5 days & 6 days). Game = Day of competitive match. Day off = rest day*

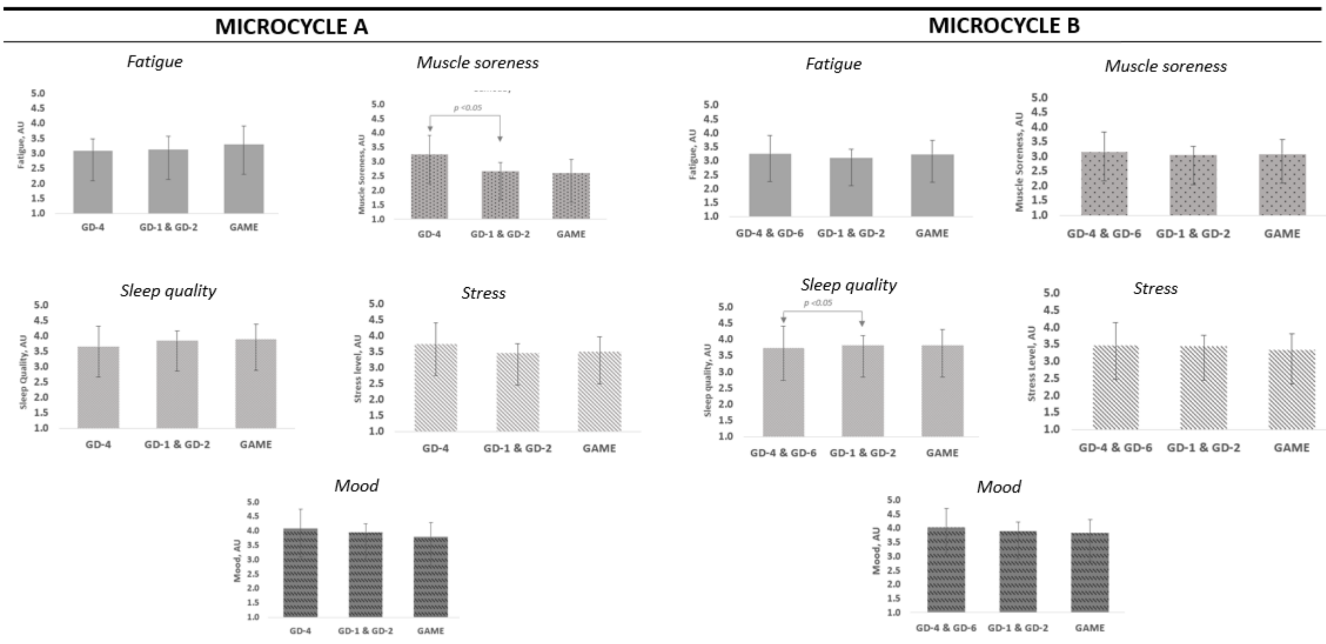

Figure 8. *Comparison of Fatigue, Muscle soreness, Sleep quality, Stress and Mood between estimated high-load day(s), taper & maintenance day(s) and versus gameday in Microcycle A and Microcycle B. GD-1, GD-2, GD-3, GD-4, GD-5, GD-6 = n of days left to the competitive match (accordingly 1 day, 2 days, 3 days, 4 days, 5 days & 6 days). Game = Day of competitive match. Significant differences marked as p<0.05.*

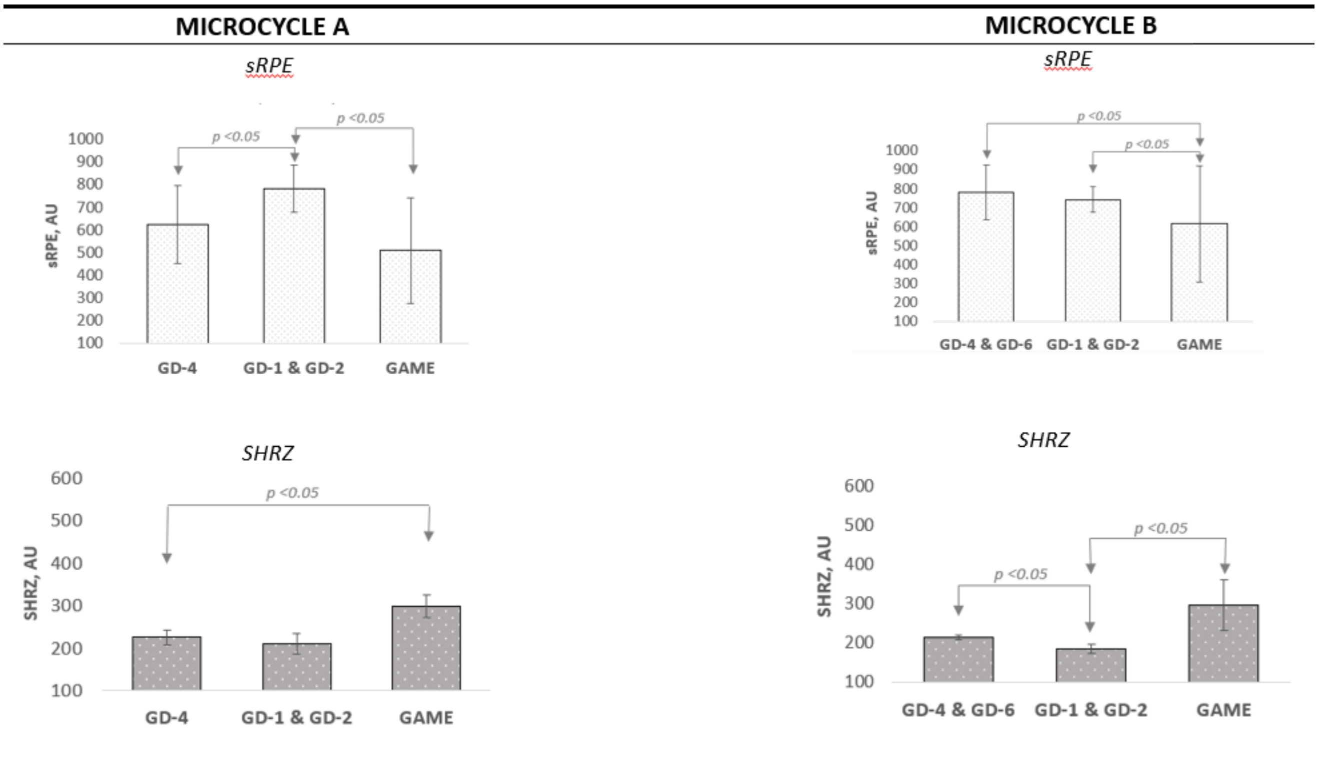

Figure 9. *Comparison of sRPE and values of SHRZ between the estimated high-laod day(s), taper & maintenance day(s) and gameday in Microcycle A and Microcycle B. GD-1, GD-2, GD-3, GD-4, GD-5, GD-6 = n of days left to the competitive match (accordingly 1 day, 2 days, 3 days, 4 days, 5 days & 6 days). Game = Day of competitive match. Significant differences marked as p<0.05.*