DIFFERENT MEANS TO ASSESS READINESS TO TRAIN AMONG BASKETBALL ATHLETES IN A SHORT-TERM PERIOD

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Master’s thesis in Science of Sport Coaching and Fitness Testing
Spring term 2018
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ABBREVIATIONS

HR – heart rate.

InL – internal load.

ExL – external load.

sRPE – session ratings of perceived exertion.

RPE - *Borg* ratings of perceived exertion scale.

HRV – heart rate variability.

RMSSD - Root Mean Square of the Successive Differences between *adjacent* NN intervals.

CMJ – counter movement jump.

CT – contact time.

FT – flight time.

RSI – reactive strength index.

RT – reaction time.

ABSTRACT

Grincevicius, Stanislovas 2018. Different means to assess readiness to train among basketball athletes in a short-term period. University of Jyväskylä, Master thesis in Science of Coaching and Fitness testing, 55 pages, 1 appendices.

Assessing athletes' readiness to train might be particularly interesting area because higher workloads does not always enhance performance, but it might even decrease. In worst case scenario when increasing trainings' frequency and workload, athletes can experience state of overreaching and eventually overtraining. That could stop athletes from exercising up to several months. Therefore, there are plenty of studies supporting variety of means to assess athletes' recovery. However, as far as we know, none of the studies have investigated neuromuscular, salivary and sleep assessments in basketball players. The aim of the study was to investigate different means to detect fatigue and provide some insights for future projects. Subjects of the study were matured young athletes with international basketball experiences. Athletes were assessed in drop jumps, reaction time, salivary cortisol, sleep quality and quantity, rate of perceived exertion scale and two devices, sleep quality and neuromuscular fatigue, mostly prevailed in Finland. The results showed that single one variable could not determine athletes' readiness to train. E.g., reactive strength index was not influenced by sleep, while reaction time and rate of perceived exertion were. Also, the study showed that athletes' cortisol level at the beginning of the week and at the end of the week did not differ significantly. However, significant increase was observed after the official game. In summary, it is important to assess athletes state of being (physiological and psychological) but even more importantly to understand and plan the following sessions accordingly. While complex assessments might give thorough look and more comprehensive understanding in athlete's performance, simple assessments are highly recommended for coaches to use.

Key words: assessment, fatigue, readiness, basketball.

CONTENT

INTRODUCTION

Many sport coaches are striving to make athletes run fast and jump high/far. However, just increasing the workload without letting body to recover might lead to overreaching and eventually to overtraining (Morales et al. 2014). Therefore, recovery and training load balance plays particularly important role in successful training (Plews et al. 2013).

Maximal physical performance activities (e.g., repeated sprints, maximal voluntary muscle contraction, maximal oxygen consumption, blood samples) are the most informative for recovery and fatigue evaluation (Thorpe et al. 2017). However, they might be impractical in sport environment due to its exhaustive and time-consuming nature. Therefore, other means, such as HRV (Edmonds et al. 2015), CMJ (Balsalobre-Fernández et al. 2014b) and different types of questionnaires (Gastin et al. 2013) can be used among athletes. These authors support the usage of aforementioned methods even though they might look simply.

On the other hand, due to sport practitioners' efforts to simplify the assessments, the gap between science and sport is present (Eisenmann 2017). Coutts (2016) and Buchheit (2017) advocate that the gap exists because the results derived from most of researches could hardly be implemented into the sport. Also, sometimes coaches are blamed for not following certain design in an intervention (Bucheit 2017) or they are just not included in scientific research design (Finch 2011; Pyne 2016). The possible solution for bridging the gap could be closer collaboration between higher education institutions and sport organizations/teams (Pyne 2016; Coutts 2016). However, it is worth mentioning that not only scientists have to collaborate to coaches but vice versa too.

To sum up, there seems to be a growing sport science interest in sport organizations (Eisenmann 2017). However, sport scientists and publication were ranked very low as the source of knowledge (Reade et al. 2008). The author found that for coaches it is hard to look for the right article, read it through and/or get a direct access. Therefore, the usage of social media might reduce before mentioned obstacle (Bik & Goldstein 2013). In the latter paper was showed the accessibility of different information sources, e.g., scientific conferences might have audience of less than 10.000 per month (estimated) while Facebook might have accessibility of more than 500 million of people. Thus, researchers might benefit more if they would announce their findings in social media and give direct access to full article. This could open wider the doors between coaches and scientists, could lead to better interaction between two and consequently, improved athletes' performance.

2. INTERNAL LOAD

2.1. Rate of perceived exertion

Internal load (InL) is defined as relative biological stressors that impact an athlete during training or competition (Bourdon et al. 2017). Simple examples of InL can be: HR, blood lactate, heart rate variability (HRV), *Borg* ratings of perceived exertion scale (RPE), session rating of perceived exertion (sRPE), questionnaires etc. Therefore, while all above mentioned are internal load variables, they might correlate to each other even though their complexity varies from simple questions to complex blood samples‘ analyses or oxygen consumption devices. One of the example is Borg et al. (1987) study where it was shown that RPE can predict HR and blood lactate.

Subjective rating systems (methods) can be a useful tool for assessing changes in load (Gastin et al. 2013; Svilar et al. 2018). Moreover, according to Gastin and colleagues (2013) these InL variables can also be impacted by life quality (stress) which may inhibit professional athlete’s performance. SRPE has been increasingly popular method to determine athletes’ state of fatigue (Nunes et al. 2014; Thorpe et al. 2016). SRPE is a reliable tool to assess internal load in weight room (Day et al. 2004) as well as valid and reliable for different intensity conditioning trainings (Herman et al. 2006). Therefore, this method has been used in different sport for measuring internal load: futsal (Soares-Caldeira et al. 2014), soccer (Thorpe et al. 2016), judo (Morales et al. 2014), basketball (Nunes et al. 2014; Moreno et al. 2015, Svilar et al. 2018).

2.2. Heart Rate Variability

Exercises disrupts homeostasis within the body with promoting functional and structural changes in the central and peripheral mechanisms of the cardiovascular system (Aubert et al. 2003; Da Silva et al. 2014). Thus, the HRV is often used among elite athletes in order to avoid imbalance between intense trainings and periods of recovery (Atlaoui et al. 2007; Plews et al.

2013). Recordings can be done in different conditions: during or after the training, in the morning or during the sleep and plenty of different methods can be used to present the data (Makivic et al. 2013; Da Silva et al. 2014).

Increase in cardiac parasympathetic activity, demonstrated by Root Mean Square of the Successive Differences between adjacent NN intervals (RMSSD), has positive effect on adaptation to trainings (Bellenger et al. 2016). Therefore, authors suggest that it can be sensitive markers in detecting maladaptation and assessing appropriate status of training among athletes. Moreover, coaches are suggested mostly concentrate on the RMSSD variable (Morales et al. 2014). However, HRV assessment is recommended to be a long-term, otherwise, its variability among athletes will be higher (Da Silva et al, 2014; Kiss et al. 2016). In addition, if the RMSSD variable decrease throughout the weeks (not the days), coaches must be concern that overtraining can be happening (Morales et al. 2014).

The similarity of HRV baseline level among professional athletes in different sports can be based on a factor that human body's autonomic nervous system (ANS) does not recognize difference between aerobic and anaerobic stress (Berkoff et al. 2007). Therefore, static trainings (e.g. weight training) elevates HR (Gonzalez-Badillo et al. 2015) as well as dynamic trainings, e.g., running activities (Berkoff et al. 2007). Berkoff et al. (2007) continue that even though duration of these two types of trainings may differ, the magnitude of HR elevation may be similar. Therefore, ANS adaptations to both conditions can provide consistent findings. Another explanation of HRV similarities between different sports, can be that even though team-sports have been trained anaerobically, their aerobic fitness is at high level also (Berkoff et al 2007.)

If similarly trained athletes are exposed to different work volume, HRV might fail to show significant change (Soares-Caldeira et al. 2014). Neither the volume of exercise (Kaikkonen et al. 2011) neither the duration of running activity (Saboul et al. 2015) did not show correlation between HRV values and workload. Kaikkonen et al. (2011) suggested that training load can be defined with both duration and intensity of exercise but the ability adapt to it, is individual for each athlete, therefore the change can or cannot be seen. However, there are opposing evidence that subjects who experienced higher workload had to overcome higher level of stress and therefore lower HRV values were detected (Morales et al. 2014). Therefore, it is hard for one to draw conclusion, whether HRV will increase or decrease after the intervention.

When the load is selected in progressive model, no HRV changes have been observed among volleyball players (Mazon et al. 2011) and elite swimmers (Edmonds et al. 2015). According to Mazon and colleagues study (2011), although, the HRV did not reveal any significant changes, they concluded that athletes improved their levels of assessed endogenous stress markers (cortisol, glucose, testosterone). Another study (Edmonds et al. 2015) did not detect HRV baseline changes (Figure 1) when load was applied in reasonable progressive manner to professional swimmers. The significant change of HRV was observed only in week 7 when the subjects participated in the competition.

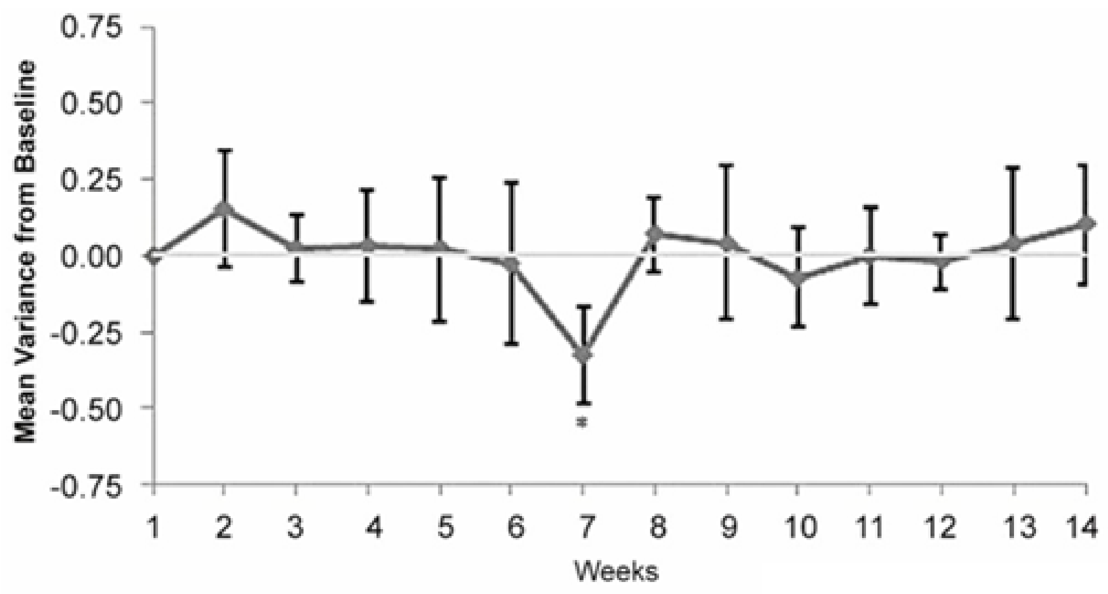

FIGURE 1. Percentage HRV variance from the baseline over the 14-weeks monitoring period (Edmonds et al. 2015).

Aging process decreases HRV (Acharya et al. 2004). However, exercising can increase baseline of HRV but only if the intensity and volume is sufficient enough to disturb the homeostasis.

Therefore, sometimes more experienced athletes have higher HRV in contrast to less experienced subjects even though they were younger (Kiss et al. 2016.) Thus, according to Plews et al. (2013) HRV is particularly individual response, therefore, comparison has to be made between individual but not averages.

2.3. Salivary cortisol

In order to understand the athlete's readiness level to train or compete the level of hormones can be used as well. However, even though blood samples are considered as "gold standard" sometimes coaches can be not expertise enough to take them (Caruso et al. 2012). Therefore, to measure fluctuation of hormones, salivary samples can be taken (O'Connor & Corrigan 1987). Authors showed that salivary cortisol could be used as non-invasive method to measure serum cortisol level.

Different training intensities, sports may have different changes in level of hormones (Balsalobre-Fernandez et al. 2014b; Edmonds et al. 2015). Higher cortisol levels were observed with increases in physical load (distance) in elite runners (Balsalobre-Fernandez et al. 2014b). However, these results were not consistent with a resistance training study (Gonzalez-Badillo et al. 2015) where higher work volume did not show higher cortisol levels. Thus, coaches must be aware that either different type of loading might have inconsistent cortisol results, or athlete's response to training load can vary.

Gradually increasing trainings' load does not always change the baseline of cortisol (Nunes et al. 2014) and alpha-amylase (Edmonds et al. 2015) concentrations. However, it has been showed that training and competitive seasons salivary cortisol increases (Balsalobre-Fernández et al. 2014a; He et al. 2010). Elevation of hormone may be explained by increased of physical and mental stress, therefore, changes may occur due to stress, not only due to physical loading (He et al. 2010; Edmonds et al. 2015). However, when taking consideration of cortisol, training experience has to be evaluated (Guilhem et al. 2015). Authors showed that the cortisol rises less in trained athletes than in untrained subjects.

According to Caruso and colleagues (2012) coaches have to consider when (in terms of day time) the sample is taken. Thus, low cortisol values were observed by Guilhem et al. (2015) and authors underlined the importance of time. They concluded that samples were taken at 3-4 p.m. when the cortisol starts to plateau at low level. Therefore, it is possible that sometimes, e.g. an exercise might have affected level of hormones, but the sample can be taken too late and daily fluctuations would have blurred the changes. In order to avoid this misunderstanding, Nunes et al. (2014) highlighted the importance of the number of taken samples.

2.4. Sleep assessments

Sleep is important recovery modality (Halson 2014). Therefore, author suggests, that sleeping habits' assessment might be important in detecting the issues before health or/and performance decreases. Sleep deprivation can have effect not only on performance but on glucose regulation, cognition, blood pressure and some hormonal regulation (Dattilo et al. 2011).

Simple assessment such as diaries of sleeping hours and internal feeling of sleeping quality can be very useful for coaches (Halson 2014). According to author, there are two commonly used means of measuring sleep. First polysomnography which shows brains', eyes', muscles' and heart's activity. This method is considered as gold standard. The second is actigraphy which is monitors of wrist activity. These wristwatches constantly record movements of the wrist and provides information about time until falling asleep, waking up time, hours of sleep and quality (Halson 2014.)

However, rather than full sleep deprivation (0 hours of sleep), contemporary society usually experiences partial sleep deprivation. Reilly and Piercy (1994) investigated athletes' performance after 3 hours of sleep for 3 days. Authors concluded that after partial sleep deprivation, performance deterioration of maximal multi segmental exercises (bench press, deadlift, leg press) was observed, however, single joint exercise (bicep curl) was not impacted significantly. In addition, it has been shown that also different type of sleep deprivation, such as early risers and late bedtime, affects muscle strength and power differently (Souissi et al. 2008;

Souissi et al. 2013). Both researchers' groups concluded that subjects who woke up early experienced higher decrease of performance than those who went to sleep late. These results are consistent with another study (Mejri et al. 2016). Authors showed that even one-night partly sleep deprivation, especially for early rising group, has detrimental effect on sport performance in intermittent sports such as, ball games, fighting and racket sports.

It is clear that lack of sleep quantity and quality affects sport performance negatively (Reilly & Piercy 1994; Souissi et al. 2008; Souissi et al. 2013; Mejri et al. 2016). However, even though physical performance is more important to elite athletes, they tend to sleep less and experience worse sleep quality in contrast to non-athletes (Leeder et al. 2012). Therefore, increasing only the sleeping time among athletes may result in better overall performance (Mah et al. 2011). The latter study with basketball players showed that longer than usual sleep time for 2 weeks positively impacted not only physical performance abilities, such as sprinting time, reaction time but also shooting percentage, mood and fatigue. This indicates that in presence of sleep deprivation, participants are capable of less work volume, however, they fell that they are putting the same efforts during exercises (Oliver et al. 2009; Skein et al. 2011).

Due to the increasing knowledge regarding the importance of sleep, sleep monitoring and assessment is becoming popular (Halson 2014). According to author, there are still lack of scientific evidences to show that athlete's performance is highly correlated to sleep deprivation, but sleep quality and quantity are important. In addition, the adage of necessity of 8 hours night sleep was supported by Van Dongen et al. (2003). Thus, Halson (2014) recommend to athletes not to impair their sleep quality by pre-sleep routines as watching television in bed, caffeine use, overthinking, planning the next day or worrying about subsequent day's competition.

3. EXTERNAL LOAD

3.1. Speed/velocity detectors

Global Positioning System (GPS) is often used in team sport to monitoring ExL (Dellaserra et al. 2014; Bourdon et al. 2017). This data must be proceed by special filters that may vary according to the manufacturer in order to reduce “noise” in the data (Bourdon et al. 2017). However, regardless the disadvantage, those type of technologies have made a huge impact on more comprehensive awareness of the sport (Dellaserra et al. 2014). According to authors coaches are able not only to improve preparation in training and recovery programs but make decisions based on real-time conducted information. Although, GPS is the most accurate during long duration, low intensity and linear movement direction exercises, it can still provide useful data for different sports’ coaches (Dellaserra et al. 2014).

In terms of strength and power training in weight room, volume of performed work can be defined by variety of different methods and McBride et al. (2009) investigated accuracy of three of them. The means that scientists used in the study were: 1) volume load (repetitions x load), 2) time under tension (repetitions’ time) and 3) total work (force [N] x displacement [m]). Authors concluded that total work is the most valid for determining overall volume of training, however, it requires special devices in order to detect the displacement. Volume load has been commonly used among strength and conditioning coaches due to its’ simplicity (McBride et al. 2009; Bourdon et al. 2017). One of the drawbacks that Bourdon and colleagues (2017) mentioned is that, even though, linear encoders, accelerometers, inertial sensors have shown to be reliable in measuring training load in the gym, sometimes teams or coaches cannot afford it because of the cost.

3.2. Horizontal and vertical force production

High physical load induces fatigue and reduces neuromuscular performance (Balsalobre-Fernandez et al. 2014a; Balsalobre-Fernandez et al. 2014b). In order to be aware about athletes' state of preparedness, specific tests are needed and one of possibilities is vertical CMJ assessment which is often used to assess neuromuscular performance (Balsalobre-Fernandez et al. 2014a; Morcillo et al. 2015; Gonzalez-Badillo et al. 2015; Wiewelhove et al. 2015). Only by measuring vertical jump height coaches can estimate neuromuscular fatigue and metabolic stress (Morcillo et al. 2015).

Athletes who had greater decrease in HRV, have experienced bigger loss in CMJ performance (Gonzalez-Badillo et al. 2015). Also, Balsalobre-Fernandez et al. (2014b) found correlation between CMJ height and stress hormone cortisol and RPE values (Figure 2). According to study the athletes who experienced higher cortisol levels prior the competition, were the ones with bigger reduction of CMJ performance post competition. This was partly confirmed by Morales et al. (2014) who showed that higher level of stress may impair maximal strength and muscular power.

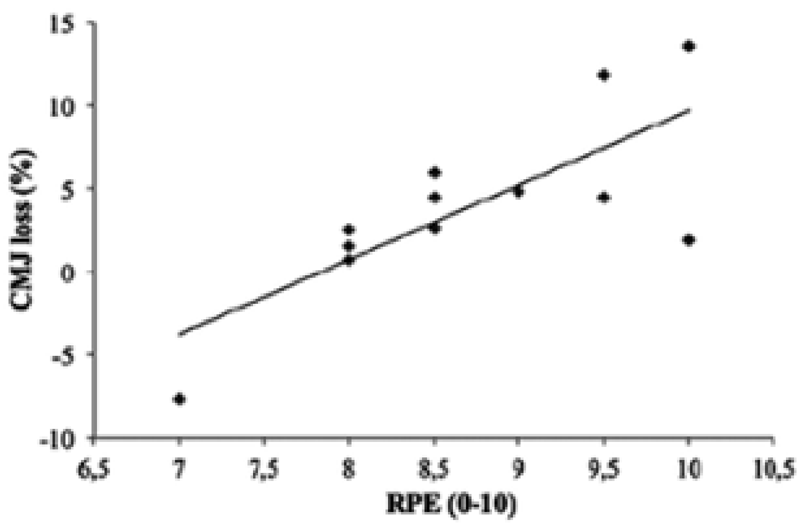

FIGURE 2. Post-competition CMJ decrease and RPE relationship (Balsalobre-Fernandez et al. 2014b).

However, although Morales et al. (2014) showed that increased work volume lead to higher decrease in strength and power, it is not always the case. Soares-Caldeira and colleagues (2014) showed that changes in CMJ, squat jump, repeated sprint ability did not change significantly even though work volume was increased.

On the other hand, athletes and coaches might care mostly about performance and winning the trophies, not about how well athletes perform the tests. Ronglan et al. (2006) doubted that small, or even significant, reduction in neuromuscular performance tests can influence sport performance in real game situations. There are more factors that might play important role during the game, such as psychology, playing position technical and tactical skill. Therefore, minor reduction in CMJ or sprint performance may not necessarily lead to reduced level in competition (Wiewelhove et al. 2015, Ronglan et al. 2006.)

What makes it hard to compare neuromuscular performance results among different researches, is different protocols that are being used (Morcillo et al. 2015). The fatigue is induced with different exercises, the tests are performed in dissimilar conditions and variety of methods are used to get the jump performance results.

3.3. Reaction time

Athletes have to react and interpret to constant changes in their specific environment, therefore, an ability to react as fast as possible is particularly important (Senel & Eroglu 2006). In a field of sport there are two prevalent signals' types that athletes have to react: auditory and visual. Commonly, auditory signal tends to be shorter than visual and they are seen to be around 216ms and 259ms respectively among 21-35 years old participants that would decrease with the process of aging (Bhanot & Sidhu 1980, Jaworski et al. 2011). Although the difference between two stimuli is significant, the correlation still exists (Senel & Eroglu, 2006). Moreover, according to latter authors, athletes tend to have even shorter reaction times.

Senel and Eroglu (2006) investigated soccer athletes and found that reaction time to auditory or visual stimulus for right and left hands were very similar. These results are consistent with a research done by Rodrigues et al. (2009) who advocated that results did not show significant effect between right and left sides but it might be because of the simplicity of the test's. However, while laterally the difference was not observed in both studies, Bhanot and Sidhu (1980) showed that reaction time derived using legs is longer than using hands.

Even though reaction time is particularly important in sport environment, it is not correlated to sprint performance (Senel & Eroglu 2006). The 20m sprint failed to show relationship with reaction time. It was supported by Paradisis et al. (2004) when correlation between reaction times and 60m hurdles, 60m and 200m running performance was not found among athletes. Although Moradi and Esmaeilzdeh (2015) also advocated that 30m sprint performance does not correlate to reaction time in school boys, he showed that reaction time has significant relationship to agility.

3.4. Reactive strength index and contact time

Reactive strength, or stretch-load (Komi & Bosco 1978; Struzik et al. 2016), is one's ability to rapidly transfer from eccentric muscle contraction to concentric (Young & Farrow 2006). This ability is likely to be desired in every sport that requires change of direction, agility and different type of power production (Suchomel et al. 2014). In order to improve reactive strength coaches have used plyometric (Jeffreys et al. 2017) and resistance trainings (Guizelini et al. 2017).

Reactive strength index (RSI) is calculated: flight time ÷ contact time (Barr & Nolte 2011). To find the maximum value for each individual, is important to use multiple dropping heights (Young 1995). Authors concluded that increasing the heights may lead to stronger pre-activation and faster eccentric muscle contraction velocities. More experienced and trained athletes tend to have higher RSI scores at any given dropping height as well as higher maximal drop height (Coh & Mackala 2013). If the eccentric load, or the dropping height, is higher than the subject can be exposed to, this might be shown by longer contact time, reduced jumping height or heels touching the mat (Flanagan & Comyns, 2008). According to authors, that could indicate strength capacity is not sufficient enough to overcome loading in eccentric movement and transfer effectively to concentric action. Usually the threshold for maximum contact time is set at 250 milliseconds in drop jumps (Byrne et al. 2017; Healy et al. 2017).

However, when analyzing RSI values, it is important to investigate contact time and jumping height (Flanagan & Comyns 2008). It was shown that given instruction can have influence on jumping performance (Young 1995) and this might change the RSI results. Sometimes, even though the given cues to athletes are standardized, coaches must be aware that some subjects can be “jumping height” dominant or some “contact time” dominant to reach the maximum RSI value (Byrne et al. 2017).

3.5. External load in injury prediction

It has been shown that dramatic increase in workload in a short period of time can lead in higher injury risk (Gabbett 2016). However, according to author not only increases in workload but sharp decreases of workload also can be predictors of possible injury. Author continues that if the work volume is decreased a lot, it may not be sufficient enough to produce adequate adaptation. Therefore, the workload imposed by a match could be too stressful to handle for one and injury may occur (Gabbett 2016).

Consequently, not only the amount of workload itself but the change in workload (known as acute:chronic ratio), could be used for spotting the possibility of injury occurrence (Blanch & Gabbett 2015; Gabbett 2016). Authors suggested that acute to chronic (A:C) workload ratio can be applied to a wide range of training measures as authors suggest, e.g. covered distance in trainings, amount of accelerations or decelerations, weight lifted etc. (Figure 3). However, a coach has to select the most specific variable for particular sport in order to monitor workload ratios. A:C ratio can be calculated as 1-week load compared to average of 4-weeks load (Bowen et al. 2016).

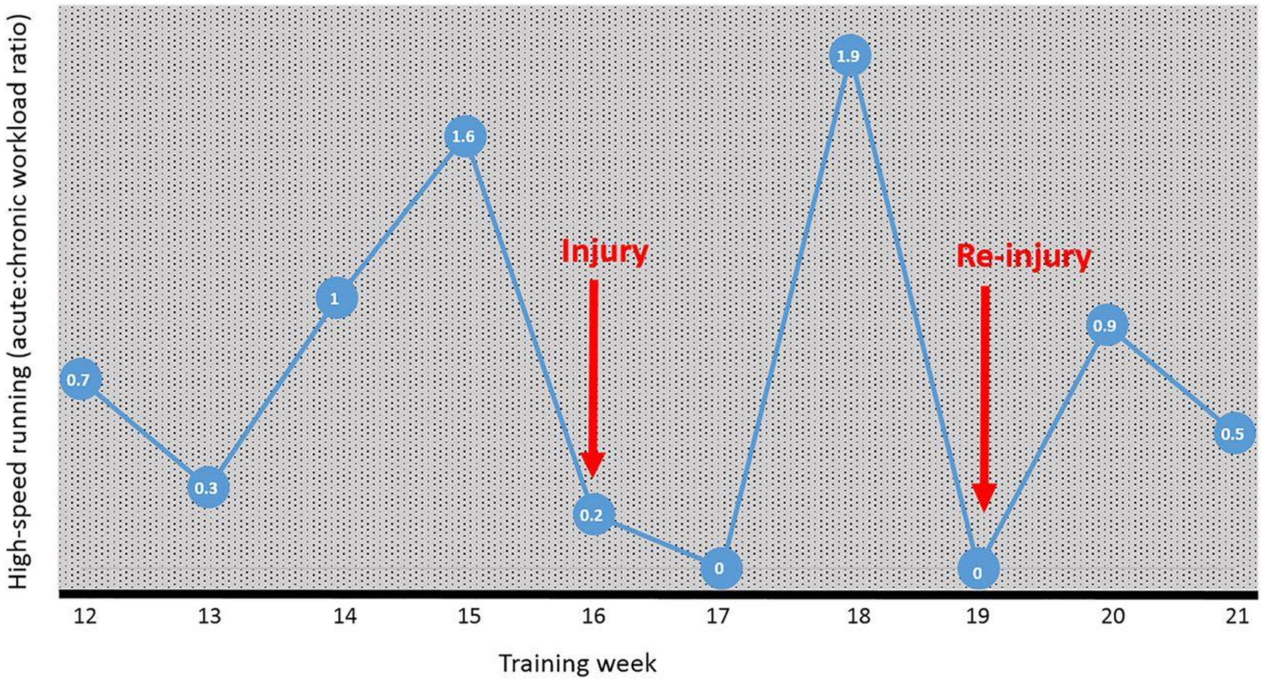

FIGURE 3. A graphical representation of the workloads of a rugby player who after 1.6 increase in training volume suffered a hamstring injury. Subsequently, after the rehabilitation phase when an acute:chronic workload ratio was 1.9, injury reoccurred (Blanch & Gabbett 2015).

There are wide variety of methods to quantify the training load and the one tool that would be accurate and reliable is not still evident (Halson 2014). The latter author indicated that monitoring depends more on the sport that is being assessed. However, some of ExL variables might be more suitable than others, therefore, according to Wallace et al. (2013) the type of assessment has to be selected also for every athlete individually, e.g., if someone is injured and not capable to run, the load can be calculated with other variables.

3.6. Load monitoring overview

Athletes must overcome high training loads, frequency of the games and often recovery time could be not sufficient (Ronglan et al. 2006). Bourdon et al. (2017) highly recommended to use valid and reliable tools, however, other means to quantify training load are prevailed and can be easily implemented in the trainings too (e.g., sRPE, volume load). Also, it is worth mentioning that the data which is collected has to be understandable not only for coaches or support staff but for athlete as well (Halson 2014). Consequently, positive collaboration between a coach and an athlete might lead to better design of training program and enhancement of performance.

The usage of both, internal and external, approaches is recommended due to athlete's adaptations to trainings (Bourdon et al. 2017; Svilar et al. 2018). For example, repeating the same training session may not provide different ExL numbers (e.g., duration, weight, number of sprints), however, InL (e.g., HR, RPE) could show dissimilar results every training because the body adapts to the stress induced by training. However, according to Bourdon et al. (2017), changes can occur not only because of muscular or neural adaptations. They emphasize that factors, such as, overall fatigue, emotional stress, illness –may affect the perception of load. Thus, coaches have to be aware that the usage of monitoring training load must be based individually (Wallace et al. 2013) and environment has to be taken into considerations in order to make more throughout conclusions.

4. RESEARCH QUESTIONS

1. Is there one tool that could determine athletes readiness to train?

   Hypothesis: no.

Halson (2014) concluded that the one tool to measure load in high-performance sports is still not evident. Therefore, there has been investigated different means to monitor recovery among athletes, such as counter movement jump (Balsalobre-Fernandez et al. 2014a; Morcillo et al. 2015; Wiewelhove et al. 2015), salivary cortisol (He et al. 2010; Moreira et al. 2012) and questionnaires (Morales et al. 2014; Moreno et al. 2015; Svilar et al. 2018). Thus, we doubt whether any of assessed tools in the recent study could be used alone as fatigue indicator. Some tests might indicate fatigue while other will not show any significant change.

2. Can athletes sustain performance variables (reaction time, RSI) after partial sleep deprivation?

   Hypothesis: yes.

Authors have showed that a single sleepless night has effect on reaction time but not on performance (Taheri & Arabameri 2012) or if deprivation is longer even performance is affected negatively (Oliver et al. 2009; Skein et al. 2011). However, we believe that less sleeping hours than usual will not have an impact to variables that we assess.

3. Can changes in drop jump performance indicate fatigue in short-term assessment?

   Hypothesis: no.

It has been shown that RSI can be manipulated by contact time (Douglas et al. 2017) and in order to detect differences within a subject, developing upper/lower contact time threshold of individual’s is recommended (Healy et al. 2017). Even though if it has been shown that counter movement jump correlates to work load (Balsalobre-Fernandez et al. 2014b), we assume that correlation will not be observed because many other factors influencing results are not controlled and assessment is a short-term.

5. METHODS

5.1. Participants

Thirteen semi-professional - professional male athletes (Table 1) participating in Finnish basketball 1st league volunteered in the study. All subjects had at least 4 years of basketball trainings and 2 years of strength and power trainings.

TABLE 1. Subjects' characteristics.

ID	Age (years)	Height (cm)	Weight (kg)	Familiarization session's reactive strength index
1	22	185.0	84.0	2.8
2	25	194.1	84.8	2.5
3	19	198.1	101.1	3.1
4	25	196.4	92.0	3.2
5	23	191.7	93.8	2.5
6	18	185.6	90.6	-
7	20	186.2	89.4	-
8	21	190.0	87.8	3.2
9	24	201.3	120.8	2.2
10	24	189.5	85.6	3.4
11	26	185.1	85.0	-
14	19	193.0	86.4	3.2
15	18	190.5	83.4	2.5
N=13	21 ± 2.8	190.7 ± 6.2	90.3 ± 11.1	2.9±0.4

Some of the athletes had pain and small injuries (knee or ankle pain) during the observation and it might had impact on some tests. However, those subjects continued their practices but with reduced intensity and test were still carried.

5.2. Research Design

This study consisted of 1 familiarization session and 4 weeks of assessments during the competitive basketball season (Table 2). Familiarization sessions were done 1 week prior the start date and reactive strength index, body weight and height were assessed during the week. In the next 4 weeks, as presented in Table 2, each day consisted of certain assessments for that day.

TABLE 2. Weekly trainings and assessments schedule. SRPE – session rate of perceived exertion; EQS – Emfit Quantified Sleep; QS – sleep quality scale; CML – Check-My-Level; RSI – reactive strength index measurements; RT – reaction time; SS – Saliva Sample; BW – Body weight; HT – height.

	Monday	Tuesday	Wednesday	Thursday	Friday	Saturday	Sunday
Familiarization week **Assessments**	**30th** RSI; BW; HT	**31st** RSI; BW; HT	**1-Nov** RSI; BW; HT	**2nd** RSI; BW; HT	**3rd**	**4th**	**5th**
Week 1 **Assessments**	**6th** sRPE; EQS; QS; CML; RSI; RT; SS	**7th** sRPE; EQS; QS; CML	**8th** sRPE; EQS; QS; CML	**9th** EQS; QS	**10th** sRPE; EQS; QS; CML; RSI; RT; SS	**11th** EQS; QS	**12th** sRPE; EQS; QS
Week 2 **Assessments**	**13th** EQS; QS; SS	**14th** sRPE; EQS; QS; CML; RSI; RT	**15th** sRPE; EQS; QS; CML	**16th** sRPE; EQS; QS; CML	**17th** sRPE; EQS; QS; CML; RSI; RT; SS	**18th** sRPE; EQS; QS	**19th** EQS; QS
Week 3 **Assessments**	**20th** sRPE; EQS; QS; CML; RSI; RT; SS	**21st** sRPE; EQS; QS; CML	**22nd** sRPE; EQS; QS	**23rd** EQS; QS	**24th** sRPE; EQS; QS; CML; RSI; RT; SS	**25th** EQS; QS	**26th** EQS; QS
Week 4 **Assessments**	**27th** sRPE; EQS; QS; CML; RSI; RT; SS	**28th** sRPE; EQS; QS	**29th** sRPE; EQS; QS	**30th** sRPE; EQS; QS; CML; RSI; RT	**1-Dec** sRPE; EQS; QS; SS	**2nd** EQS; QS	**3rd** EQS; QS

- Free day
- Training day
- Game day

Tests' baseline values were not determined due to not being able to cease or reduce the intensity of trainings while it was already the competitive season. The type of training being performed on the certain day (basketball and/or strength training) and the load of the training (time and sRPE) are presented in Appendix 1.

5.3. Methodology

Due to inability to control all the subjects and inability to have desirable number of devices there are different number of subjects at each test (Table 3).

TABLE 3. Each subject's participation in assessments. SRPE – pre/post-training session rate of perceived exertion; RSI – reactive strength index derived from drop jump; RT – reaction time measurements; EQS – Emfit Quantified Sleep measurements; CML – Check-my-level assessments; SS – saliva sample.

ID	**sRPE**	**RSI**	**RT**	**EQS**	**QS**	**CML**	**SS**
	Each training	**2 times/week**	**2 times/week**	**Daily**	**Daily**	**Each training**	**2 times/week**
1	+	+	+	+	+	+	+
2	+	+	+	+	+	+	+
3	+	+	+	+	+	+	+
4	+	+	+	+	+	+	+
5	+	+	+	+	+	+	+
6	+	+*	+			+	+
7	+	+*	+				
8	+		+			+	+
9				+	+		
10	+	+	+	+	+	+	+
11	+		+	+	+	+	+
14	+	+	+				+
15	+	+	+			+	+

**- did not have familiarization session.*

*Session rating of perceived exertion (sRPE). S*RPE values were collected before and after every session and game. While there has been developed different sRPE scales with different zones' description, the Alison's et al. (2006) version of it was used (Figure 4). Each player was familiar with the scale because it was used prior the study.

Rating	Descriptor
0	Rest
1	Very, Very Easy
2	Easy
3	Moderate
4	Somewhat Hard
5	Hard
6	*
7	Very Hard
8	*
9	*
10	Maximal

FIGURE 4. Rating of perceived exertion (RPE) scale (Alison et al. 2006).

Reactive strength index (RSI). One week prior the beginning of study, each athlete was assessed to find his maximum RSI. The test was carried in inside track and field court (Hipposhalli, Jyväskylä, Finland). RSI was calculate from drop jump (DJ). Jumping mat (1000 Hz, University of Jyväskylä) was used in order to measure contact time (CT), flight time (FT) and RSI was calculated by formula:

RSI = Flight time / Ground contact time.

RSI test was performed every first and last training of the week (if possible). Before executing the test, all athletes performed structured dynamic warmup that started with foam rolling, static stretching and proceeded to movement preparation: squatting, lunging, hinging; and dynamic running exercises: A skips, B skips, Side skips, shuffle (same structure warm up was used during observation before every practice). Just prior the test, low plyometric jumps followed by 4 high CMJ were performed. After warm up, all subjects were familiarized with drop jump technique and requirements (Figure 5).

FIGURE 5. *A subject performing drop jump.*

The athletes were instructed to hold their hands on their hips and take a step off the box. The subjects were asked to reduce the ground contact time and consequently perform a jump as high as they could. During the test instructions, such as “jump as high as you can”, “as fast as you can”, “you can be little bit faster”, were given in order to enhance the performance. If RSI was showed improvement of RSI without exceeding 250ms of contact time, the dropping height was increased by 10cm. If ground contact time was observed more than 250ms, the jump was not considered and the subject was asked to try again with stepping off the same height. If the contact time for the second attempt was still longer than 250ms, or RSI of the jump was lower than in jumps before, the test was ceased.

During actual measurements all participants performed 2 jumps from 2 different dropping height: 20cm and individual (where peak of RSI was observed). Two of the participants were not able to commit familiarization session due to military service and illness. Therefore, 30cm dropping height was selected for both. Reliability of the RSI test has been shown by Markwick et al. (2015).

Emfit Quantified Sleep (EQS). At the start of observation 10 players were given EQS packages which consisted of sensor and charging cord (Figure 6). 8 players set up devices only within first week of observation due to several technical issues that had occurred. 2 players could not launched the devices.

FIGURE 6. *Charging cord with various adapters and sensor (from websites: https://cdn.shopify.com and https://prnewswire2-a.akamaihd.net accordingly).*

All subjects put sensor under their mattress on their sleeping side of the bed (if the bed double) in approximately chest height (Figure 7). The EQS device collects information about sleeping quality in term of different variables, however, only, few of those were selected to analyze: sleep score (formula 1), HRV (RMSSD), total recovery (difference between morning and evening RMSSD values) and movements, such as average activity (e.g., sratching leg or arm, or changing position slightly) and turn (bigger movement of your body).

Sleep Score = (total duration of sleep + duration of REM sleep * 0.5 + duration of DEEP sleep * 1.5) - (sleep class awake duration / 3600 * 0.5 + number of wakening / 15) * 8.5

Formula 1. *Sleeping score calculations.*

FIGURE 7. *Set up of EQS device (from website: http://www.sleepmonitor.com.hk).*

The information was collected during the night and via internet it was transferred and stored online. Athletes were encouraged to carry devices together with them if they would stay a night not at home. However, gaps in measurements are present due to mentioned reason. Validity and reliability of EQS device has not been proven yet.

Scale of sleep quality (QS). After awakening in the morning all athletes informed about approximate time when they went to bed to sleep, when woke up. In addition to that they provided internal feeling of sleep quality (Table 4) by number from 1 to 10 (exhausted to totally recovered).

TABLE 4. Sleep quality self-evaluation questionnaires.

Numero	State (kunto)
1	Exhausted (uupunut)
2	Very tired (hyvin väsynyt)
3	
4	Tired (väsynyt)
5	
6	Not tired, not recovered (ei väsynyt, ei palautunut)
7	
8	Recovered (palautunut)
9	
10	Fully recovered (täysin palautunut)

Check My Level (CML). CML devices shows acute recovery from last few days. According to CML manual it is based on the biological phenomena of a certain muscle reflex stimulated by low-voltage current in order to detect fatigue.

At the start of observation CML devices were introduced to subjects. The devices consisted of reusable electrodes (for each subject seperately) and 2 CML assessment devices per team. Due to time restrictions subjects were allowed to do assessment at the morning or during the day before first practice. All athletes had downloaded CML app into their smart phones and logged to individual account. The electrodes were placed on non-dominant forearm skin above thumb flexors with stimulator on the thumb (Figure 8). All subjects were instructed to relax arm from shoulder down. Depending on the place where subsequent training was held, the test was performed either seated or supine positions.

FIGURE 8. *CML device set up (from website https://findingelina.files.wordpress.com)*

The first 7 assessments were done in order to determine the baseline of each subject's and afterwards instant feedback for athlete was given every time after the assessment. The CML device's calculations and formulas, in order to determined readiness of each athlete, are not clear, however, feedbacks depended on readiness meter (ranging from 0 to 100) and are shown in Table 5. Validity or reliability of this test has not been published yet.

TABLE 5. Check-my-level readiness numbers, feedbacks and explanations.

Readiness meter's number	**Feedback**	**Explanation**
100 - 90	Increase intensity	Body is fully recovered from training.
89-…	Keep going	Your body is recovered from training.
Around 50	Decrease intensity	Body have partly recovered from previous training. You can still train but decrease intensity.
…-20	Slow down	You have not recovered. You need more rest and should avoid training.
19-0	Get help	Your assessment have changed significantly. Rest and talk to your coach or a medical professional.

Salivary cortisol sample (SS). SS (Figure 9) were taken individually by athletes (n=11) within 30 minutes after awakening 2 times per week (Mondays' and Fridays' mornings). Samples were taken during athletes' recovery period therefore there was no possibility to control awakening time.

FIGURE 9. *Given saliva sample tubes to each participant (from website: https://www.salimetrics.com)*

All subjects were shown the example how samples have to be taken. After awakening subjects rinse their mouth with 100ml water and after 5 minutes they put sample into their mouth. It was not allowed to chew it and each athlete tried to get as much saliva as possible in to the sample. After 2 minutes sample was spitted back in to the tube, put in the fridge and kept until the next practice; or until it was taken by a researcher.

When samples were collected from the subjects, samples were centrifuged at 1200 rate per minute (RPM) and the actual saliva liquid was putted in the second, smaller tube and weighed. Then the first samples were centrifuged again but at 3600RPM and putted to other tubes and weighed again. All collected tubes were labeled and kept in the freezer until the study was over. After the study only those samples that were centrifuged at 1200RPM were decided to be analyzed. For salivary cortisol analysis ELISA method (DYNEX DS 2 ELISA Processing System) was used and done with special device (DYNEX technologies, Chantilly, VA, USA).

Two subjects had dropped out due to one had ankle injury and his trainings' schedule was changed that included trainings during team's rest day. The other subject brought saliva tubes back after 3 weeks because he had a surgery and was not able to come to the town where research was held.

Reaction time (RT). For assessing reaction time *Banensoft Reaction time* app on smartphone (Sony Xperia Z3 Compact) was used. The app was selected due to its' simplicity to use. The subjects' RT was assessed on the same day as DJ were performed. Each player performed reaction time before standardized warm up. On the very first test day each athlete had 5 trials to familiarize with the device and afterwards 5 reaction times were recorded. Position was not controlled, however, it was told for each subject to select that position which would be the most comfortable to produce the shortest RT.

During observation period, it was tried to maximally engage each player in participation by giving feedbacks and suggestions after every measurement. However, sometimes athletes forgot to plug EQS device before going to bed, or were late to practices, or forgot to take SS to session.

5.4. Statistical analysis

IBM SPSS software was used for data analysis. Normality test was used for all variables to check, if they are normally distributed. If Shapiro-Wilk test showed significant ($p<0.05$) value for a variable, Spearman rho correlation was used. Pearson correlation was used only, if both variable were normally distributed. Independent t-test was calculated with Microsoft Office Excel (2016) in order to define weather salivary cortisol values in 3 conditions were significantly different.

6. RESULTS

Most of the athletes participated in performance assessments and results are presented in Table 6. The absolute values reveal how averages differ between individuals in every test.

TABLE 6. Mean absolute values of each athletes' performance assessments during intervention. Data is presented in mean±SD.

Players' ID	**Average reaction time (ms)**	**Average of drop jumps at individual dropping height**		
		Flight time (ms)	Contact time (ms)	Reactive strength index
1	279±14	491±41	191±22	2.60±0.31
2	279±11	536±14	221±22	2.45±0.23
3	270±9	504±21	154±8	3.28±0.20
4	276±12	526±19	199±10	2.65±0.15
5	303±26	501±18	226±9	2.20±0.09
6	275±12	539±23*	170±11*	3.18±0.16*
7	278±8	540±27*	179±10*	3.02±0.03*
8	275±10	-	-	-
9	-	-	-	-
10	279±11	572±23	189±10	3.03±0.15
11	273±5	-	-	-
14	286±16	501±17	175±10	2.87±0.19
15	296±12	481±13	212±22	2.28±0.18
All average	280±10	514±29	196±24	2.67±0.4

*- did not have familiarization session.

As it can be seen from Table 6, the smallest difference among athletes were in reaction time (approximately 3.4% variance). While in flight and contact times variability were observed 5.7% and 12.3%, respectively.

Salivary cortisol. The differences in salivary cortisol values in 3 different conditions are shown in Figure 10.

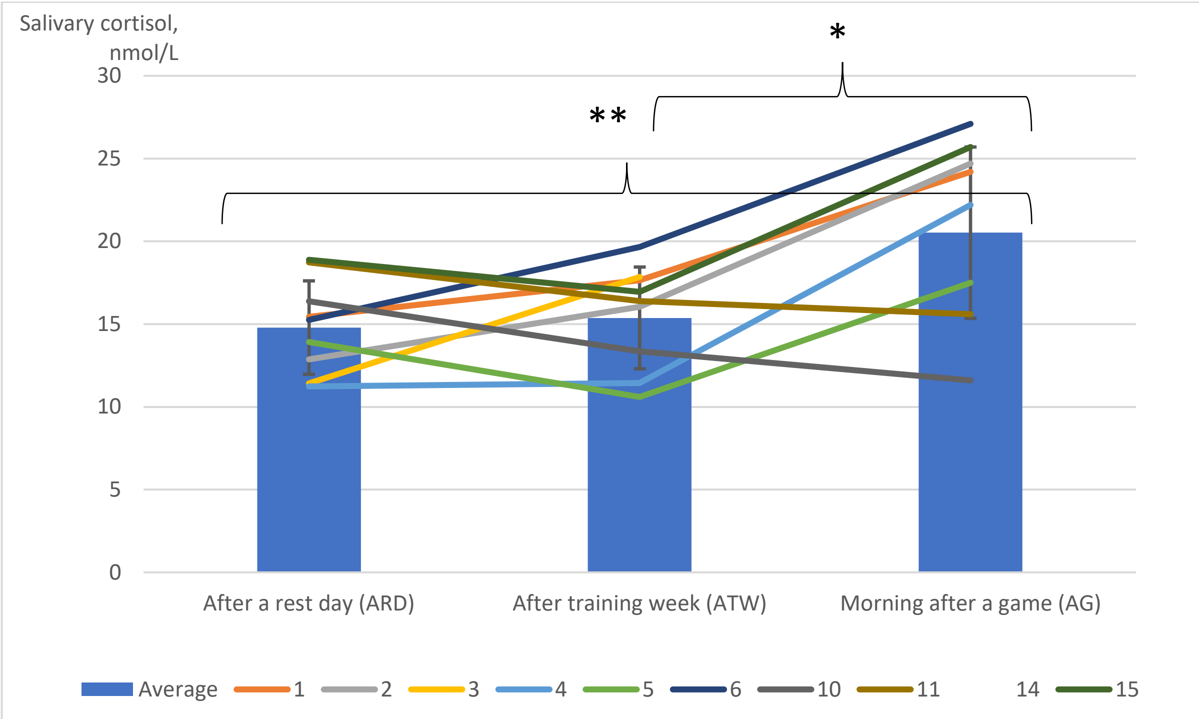

FIGURE 10. Mean salivary cortisol levels after a rest day, after training week and morning after the game. * indicates significance difference between ARD and AG conditions ($p<0.05$). ** indicates significance difference between ATW and AG conditions ($p<0.01$).

Results in bars are shown as the averages and lines represents individual response of each subject. Significant difference was found between averages of cortisol samples taken after a training week (n=16) and the morning after the game ($p<0.05$; n=9). Also the difference between cortisol values after a rest day (n=48) and morning after the game ($p<0.01$).

Correlations between sleep quality, quantity, internal feeling and reaction time can be seen in Table 7 with the most interesting results being bolded.

TABLE 7. Spearman's rho correlation between different sleep variables and indirect fatigue measures. preRPE – pre-training rate of perceived exertion; Night-sleep – amount of night sleep hours (±15 minutes); vRT – average visual stimulus reaction time; SQ – self-evaluated sleep quality. * indicates significance correlation between two variables (p<0.05). ** indicates significance correlation between two variables (p<0.01).

	preRPE	**Bed-time**	**SQ**	**Night-sleep**	**vRT**
preRPE		0.053 (n=101)	**-0.670** (n=102)**	-0.280** (n=102)	0.203 (n=64)
Bed-time	0.053 (n=101)		-0.094 (n=172)	-0.350** (n=173)	-0.109 (n=43)
SQ	**-0.670** (n=102)**	-0.094 (n=172)		**0.384** (n=174)**	**-0.307* (n=44)**
Night-sleep	-0.280** (n=102)	-0.350** (n=173)	**0.384** (n=174)**		-0.143 (n=44)
vRT	0.203 (n=64)	-0.109 (n=43)	**-0.307* (n=44)**	-0.143 (n=44)	

Weak negative significant (P<0.01) correlation was found between Night-sleep and the Bed-time and between vRT and SQ (p<0.05). No correlation between reaction time and performance variables. Moderate significant (p<0.01) correlation was observed between pre-training RPE and SQ.

Correlations between performance variables, other devices and internal feeling can be seen in Table 8 where the most interested results are bolded.

TABLE 8. Spearman's rho correlation between different performance variables. FT20 – flight time from 20cm dropping height; FTindv – flight time from individual dropping height; Activity – activity during sleep; intensity – current intensity; delay – delay between electrical stimulus and muscle contraction; preRPE – pre-training RPE. ^ indicates tendency of significance correlation (p=0.055-0.057). * indicates significance correlation between two variables (p<0.05). ** indicates significance correlation between two variables (p<0.01).

	Intensity	**Delay**	**preRPE**	**FT20**	**FTindv**	**Activity**
Intensity		0.592** (n=41)	0.115 (n=59)	**-0.374** (n=47)**	-0.180 (n=46)	**0.511** (n=42)**
Delay	0.592** (n=41)		0.203 (n=89)	-0.335^ (n=33)	-0.124 (n=32)	0.314** (n=87)
preRPE	0.115 (n=59)	0.203 (n=89)		**-0.311* (n=53)**	-0.269^ (n=51)	**0.293** (n=100)**
FT20	**-0.374** (n=47)**	-0.335^ (n=33)	**-0.311* (n=53)**		0.730** (n=54)	-0.158 (n=38)
FTindv	-0.180 (n=46)	-0.124 (n=32)	-0.269^ (n=51)	0.730** (n=54)		**-0.267 (n=37)**
Activity	**0.511** (n=42)**	0.314** (n=87)	**0.293** (n=100)**	-0.158 (n=38)	**-0.267 (n=37)**	

Moderate positive significant (p<0.01) correlation was found between Intensity and Activity. It was also found that Intensity significantly (p<0.01) weakly correlated to FT20. PreRPE was found to have weak significant (p<0.05) negative correlation with FT20.

7. DISCUSSION

The study has three main findings. First, any single test that was carried did not indicate athlete's readiness to train in all cases. Second, single night sleep deprivation does not impair jumping performance but could negatively impact average reaction time (vRT). And lastly, reactive strength index (RSI) alone cannot be used as readiness indicator but if contact time is controlled, flight time variable could be used. Secondary findings were that no correlation was found between jump performance variables and vRT. Salivary cortisol values were significantly higher in the morning after the game in contrast to both, at the end of the week and after a rest day, conditions.

Drop jump. RSI and CT were found to be strongly correlated in negative fashion ($r=-0.922$; $p<0.01$), however, no correlation was observed between RSI and flight time (FT). The results are consistent with study done by Douglas et al. (2017) who concluded that higher RSI values primary were achieved by shorter CT when comparing sprint trained and non-sprint athletes. Authors indicated that it might be achieved due to high braking forces. These findings might suggest that RSI values alone might not indicate the fatigue. If an athlete is fatigued, he/she experience shorter FT (Balsalobre-Fernandez et al. 2014a), therefore, RSI value might be reduced. However, the impairment of RSI could be *recovered* by shorter CT. This would allow athletes to reach desirable RSI with negatively changing the performance variable (FT). In order to avoid this, Healy et al. (2017) advised to determine upper and/or lower CT thresholds. According to authors, implementation of these limits would allow coaches to understand whether an athlete can achieve so short CT, or one is just trying to compensate the fatigue.

Balsalobre-Fernandez et al. (2014a) found negative correlation between pre-session RPE values and CMJ. This was supported by recent study where preRPE and FT at 20cm dropping height (FT20) correlated significantly and negatively but weakly. When players without familiarization session were excluded for data analysis, correlation between preRPE and FT at individual height (FTindv) became almost the same as FT20. These results could indicate that coaches do not need to perform drop jumps or CMJ before every session. The necessity of boxes and jumping mats to perform drop jumps might discourage coaches to perform the test, therefore, preRPE can be used instead. However, it is still recommended to perform jumping assessments once in a while in order to calibrate the target.

Reaction time. Average reaction time (vRT) did not correlate to any of performance variables during drop jumps. These findings support other researchers who did not found correlation between reaction time and performance (Senel & Eroglu 2006; Paradisis et al. 2004). Although, more recent study by Moradi and Esmaeilzadeh (2015) showed correlation between agility and reaction time, there are two factors to consider. First, agility is defined as rapid whole-body movement with change of velocity or direction after a response to a stimulus (Sheppard & Young 2006). However, jumping or sprinting assessments that were used in this study and Senel & Eroglu (2006), Paradisis et al. (2004) researches, did not require reaction to stimulus. This might explain why correlation was not observed in both studies. Secondly, the subjects in Moradi and Esmaeilzadeh (2015) study were 9-12 school boys where in other studies subjects were adult basketball players, elite soccer players and sprinters.

The reason why reaction time is still interesting might be that muscle fatigue could extend reaction time (Okkesim & Coşkun 2015). Thus, reaction time might be used as one of non-invasive tools to measure nervous' system fatigue. However, in recent study vRT did not correlated to self-reported fatigue (sRPE). One of the reasons might be that the visual stimulus for tapping reaction time is not specific, or not complex enough, in order to detect fatigue among basketball athletes. It has been proven that reaction to the sport specific stimulus does correlate to the performance in highest level athletes (Tønnessen et al. 2013). Authors, after analyzing more than 1300 elite sprinters, concluded that athletes who had shorter reaction time to auditory stimulus (specific to their sport) were those who had shorter sprinting times. Another reason might be that sRPE is very individual response and could be affected even by an athlete's chronotype (Vitale et al. 2017). Thus, athletes have to be aware of their state of being as well as they must understand the sRPE values itself. These two reasons might indicate why fatigue was not associated with vRT in this study.

On the other hand, vRT negatively and significantly but weakly correlated with self-evaluated sleep quality scale (SQ; the higher the number the better sleep quality). It was found that athletes who reported better sleep quality had shorter vRT. This goes along with Taheri & Arabameri (2012) research who showed that a single night sleep deprivation might not affect the performance variables such as mean and peak power output. However, reaction times are more vulnerable and were negatively affected.

Sleep and performance. According to the recent study, SQ correlated to preRPE values negatively and significantly at moderate-strong level. In contrast to SQ, number of hours were significantly correlated too but barely reached weak level. This would suggest that quality of sleep in this study were more influential than quantity. Even though Taheri & Arabameri (2012) showed no decrease in mean and peak power output in early morning after one-night sleep deprivation (approximately 8-9h), Skein et al. (2011) showed different results after 30h of sleep deprivation. The latter authors concluded that sleep deprivation does reduce performance capabilities, such as sprint and reaction time in intermittent team sport. Skein et al. (2011) suggested that impaired performance in intermittent sport is due to lower glycogen levels after deprivation of sleep. Lower energy levels might be because of extra energy that is required while being awake during the night. Thus, in the recent study, performance tests were only two drop jumps and according to McArdle et al. (2010, p.163) the contribution of glycogen starts only after 5-8 seconds of maximal intensity sprint. Therefore, this might be one of the reasons why correlation between SQ and drop jump variables was not found. However, flight time (FT20) derived from drop jump correlated to sRPE.

Salivary cortisol. Significantly higher salivary cortisol levels were observed in the morning after the game (AG) and after a rest day (ARD). He et al. (2010) showed that cortisol values differ significantly in recovery period and in training/competition period among basketball players. However, even though authors did not find significant difference between training and competition periods, the recent study showed that AG cortisol values were significantly higher than after the training week (ATW); $p<0.05$). However, it is mandatory to remember that AG group consists only of 9 samples.

The difference between values ATW and AG could be partly explained that official matches are more stressful than simulated ones in basketball (Moreira et al. 2012). Authors concluded that higher salivary cortisol values were observed after the real game than simulated one. This would suggest that trainings cannot produce the same stress as games do. The other contributing factor of significant difference between ATW and AG is expertise of the head coach. Most of the games were played at the end of the week, therefore, the coach held most intensive practices 2-5 days before the match (at the beginning of the week). Therefore, it might be that athletes might have experienced higher cortisol values during training week but they were not recorded. All the changes were observed regardless the awakening time of athletes which was shown to be important (Caruso et al. 2012). Neglecting the time when samples were taken does reduce the reliability of the assessment, however, recent study shows that the coaching staff might still obtain meaningful changes.

Emfit Quantified Sleep (EQS) and Check-my-level (CML). CML and EQS devices were used in the recent study. However, while none of the devices' have any reliability or validity studies, one can just speculate the results based on own experience and manuals. The CML *intensity* variable is the current intensity needed to stimulate the muscle to contract. EQS variable used in the study is *activity* which describes restless sleep, such as toss, turn, limb movements and/or scratching.

Despite aforementioned limitations of the devices, they still provided few interesting findings. The CML showed that on the days when athletes needed higher intensity prior the training, they showed shorter flight time (FT20). However, when obtaining data with cutaneous electrodes, placement and skin preparation are shown to be important in order to provide reliable data (Hermens et al. 2000). Skin preparation might be a challenge for athletes, however, marking the placement on the forehand is highly recommended for future studies. Second interesting finding was that when athletes had restless sleep (activity), higher intensity was needed to trigger the muscle on next day prior a training.

Although there is an interest in the devices, it is highly recommended to (1) develop a study that would show validity and/or reliability of devices and (2) design long-term observation study. Both recommendations would give more practical value in using the devices especially if coaching is done through distance and the coach cannot determine how an athlete adapts to the physical and psychological stress.

Strengths and limitations

Several factors are consider as positively impacting the strength of the study. First of all, the research was held in the practical environment. The head strength and conditioning coach implemented assessments in the team's daily schedule. Also, high-level athletes were assessed because most of the players have international basketball experience. And lastly, when the gathered data was analysed, the results were presented for the team and feedbacks were given to the players, e.g., how sleep quality could be improved, how sRPE, drop jumps could be used and etc.

On the other hand, several limitations are present as well. One of the main drawbacks of the study was inability to develop clear baseline level for each test. This would allow to compare results in more reasonable way. Another negative factor was inaccessibility to have devices for longer time. It seemed that by the time the athletes were totally familiarized and comfortable with assessments, the study was ceased. And lastly, poor distribution of the days when saliva samples have to be taken. This lead to uneven number of samples in each condition.

Conclusion

The recent study supports the usage of drop-jump, sRPE and SQ in order to determine athletes' readiness to train. Those methods are cheap and easy to gather and might (1) reveal some type of fatigue within the subject; (2) indicate that acute changes in results can be used to adjust intensity for the next training session. Others, more complex means are useful also, however, the coach could not adjust training instantly. The reason is that, e.g., salivary cortisol provided data how each athlete responded during intervention, but data was obtained after few months when samples were analysed. In addition, acute changes in HRV data could not been used to detect fatigue in short-term measurements. There are too many factors that influences HRV and it requires long-term assessment. Lastly, the study could not support the usage of CML and EQS devices while both are lacking scientific and/or empirical researches.

Practical applications

There are plenty devices and methods that can be used to assess athletes' readiness to play/compete: HR indices, neuromuscular performance tests, changes of hormones, questionnaires etc. It might be that most of devices, even the simplest ones, are valid and reliable at some extent and every coach must take advantage of it. However, coaches have to (1) gather long-term data in order to understand how athletes respond and (2) be expertise enough to interpret results and give feedbacks.

Moreover, coaches/sport scientists need as much data as it could be used to improve athlete's performance, not as much as it could be collected. Because some of the tests can be fatiguing, athletes must understand how particular test's results will improve his/her performance. Therefore, athlete's willingness to collaborate with sport scientists is paramount because athlete can turn the results and, consequently, conclusions to any of directions.

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APPENDIX

Appendix 1. Week 1-4 trainings' schedule.

Week 1															
Date	6/11/2017		7/11/2017		8/11/2017		9/11/2017		10/11/2017		11/11/2017		12/11/2017		
Time	17:00-18:30		15:45-19:00		15:30-17:00				15:15-17:45		14:00-15:30		14:00-15:45		
Training type	Basketball		Basketball and strength		Basketball		Free day		Basketball		Basketball		Game day		
Weekday	Monday		Tuesday		Wednesday		Thursday		Friday		Saturday		Sunday		
RPE	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Min
1		6	2	7	3	7			2.5	6			1	8	24
2		5	3	5.5	4	7			2	4			2	7.5	28
3		9	3	5	2	3*			3	5			2	3.5	13
4		8	4	7	5.5	5			4	9			2	4.5	26
5		7	4	6	4.5	9			4	4			3	6	17
6		7.5	3	6					3	4			4	7	15
7		8.5	2.5	6	2.5	8					NO DATA				
8			2	3	1	2			2	3					
9															
10		6		6.5	4.5	7			4	5			2	6	26
11					7	8			1	6			1	4	30
14		7	3	6	4	7							3	4	11
15		7.5	2.5	6									4	7	10

**- stopped session because of collision.*

Week 2															
Date	13/11/2017		14/11/2017		15/11/2017		16/11/2017		17/11/2017		18/11/2017			19/11/2017	
Time			16:00-18:00		15:30-17:30		18:00-19:15		16:00-17:30		18:00-19:45				
Training type	Free day		Basketball and strength		Basketball		Basketball		Basketball		Game day			Free day	
Weekday	Monday		Tuesday		Wednesday		Thursday		Friday		Saturday			Sunday	
RPE	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Min	Pre	Post
1			1	6	2.5	7	3	4.5	2	4		7	22		
2			4	5.5	2	7	3	4	2	3.5		5	20		
3			2	3.5	2	5	2	4	2	4		5.5	18		
4			2	6	4	7	4	6	3	5		7.5	27		
5					4	6.5	4	5	3	4		7	25		
6			4	N/A	3	6			2.5	N/A		8.5***	15		
7					3.5	9**	2	5	2.5	5		9	30		
8			5	5	5	3	3	4							
9															
10			2	5	4	7	4	5	3	4		8	25		
11					8^	8									
14			4	4.5								4	11		
15			4	N/A	4	5			2	N/A		8***	8		

N/A – not attended to main session.
^ - low back pain.
***- high score because of bad sleep quality.*
****- second game in a day.*

Week 3															
Date	20/11/2017		21/11/2017		22/11/2017			23/11/2017		24/11/2017		25/11/2017		26/11/2017	
Time	17:00-18:30		15:45-17:30		18:30-20:00					15:45-18:30		14:00-15:30		14:00	
Training type	Basketball		Basketball and strength		Game day			Free day		Basketball and strength		Free day		Free day	
Weekday	Monday		Tuesday		Wednesday			Thursday		Friday		Saturday		Sunday	
RPE	Pre	Post	Pre	Post	Pre	Post	Min	Pre	Post	Pre	Post	Pre	Post	Pre	Post
1	2	3	1.5	3	1	6	19			2.5	4				
2	3	5	2	3	3	7	32			3	4				
3	4	4	4**	3.5	3	5	13			4	4				
4	3.5	4	2	4	4	7.5	33			4	6.5				
5	5.5	5.5	4	4	4	7	21			3.5	4				
6	4	5	4	5	2.5	7	20			3	N/A				
7	2	5	3	4	1	9	33								
8			2	4	1	N/A				3	3				
9															
10	2	3	2	2	3	7	2.6			3	4.5				
11	1	2			1	N/A				1	N/A				
14	3	4	4**	6	4	2	1			3	5				
15	4	4	4	4	4	5	2			3	N/A				

N/A – not attended to main session.
***- high score because of bad sleep quality.*

Week 4															
Date	27/11/2017		28/11/2017		29/11/2017		30/11/2017		1/12/2017			2/12/2017		3/12/2017	
Time	16:45-18:30		16:15-18:00		15:30-17:30		16:00-17:30		18:00-19:45						
Training type	Basketball		Strength		Basketball		Basketball		Game day			Free day		Free day	
Weekday	Monday		Tuesday		Wednesday		Thursday		Friday			Saturday		Sunday	
RPE	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Pre	Post	Min	Pre	Post	Pre	Post
1	1	5	3	4	2	5	2	3.5	1	8	28				
2	3	5	2	2	3	4	2	4	2	9	37				
3	2	5	2	4	2	4	2	4	2	2	4				
4	2	7	4	6	4	5.5	3	4	2	10	29				
5	3.5	8	3	5	4	4.5	3	4	3	6	20				
6	2.5	6	3	5	3	5.5	2	4	3	5	13				
7															
8			3	3	3	3			1	N/A					
9			2	3											
10	2	6	2	5	4	6.5	3	4	2	8	30				
11	5	10			3	N/A	2	5	1	9	30				
14	3	5	3	4	3	4.5	3	5	2.5	5	9				
15															

N/A – not attended to main session.