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Doeven, Steven; Brink, Michel; Frencken, Wouter; Lemmink, Koen A.P.M.

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Authors: Steven H. Doeven[1,2], Michel S. Brink[1], Wouter G.P. Frencken[1,2,3], and Koen A.P.M. Lemmink[1]

Affiliations: [1]Center for Human Movement Sciences, University of Groningen, the Netherlands. [2]School of Sport Studies, Hanze University of Applied Sciences, the Netherlands. [3]Football Club Groningen, the Netherlands.

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Authors: Steven H. Doeven[1,2], Michel S. Brink[1], Wouter G.P. Frencken[1,2,3], and Koen A.P.M. Lemmink[1]

1. Center for Human Movement Sciences, University of Groningen, the Netherlands
2. School of Sport Studies, Hanze University of Applied Sciences, the Netherlands
3. Football Club Groningen, the Netherlands

Corresponding author:
Name: Steven H. Doeven
Postal address: Zernikeplein 17, 9747 AS Groningen, the Netherlands
E-mail: s.h.doeven@pl.hanze.nl
Phone: +31505953750
Fax: +31503633150

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Abstract

During intensified phases of competition, attunement of exertion and recovery is crucial to maintain performance. Although a mismatch between coach' and players' perceptions of training load is demonstrated, it is unknown if these discrepancies also exist for match exertion and recovery. ***Purpose:*** The aims of this study are to determine match exertion, subsequent recovery and to investigate to what extent the coach is able to estimate players' match exertion and recovery. ***Methods:*** Rate of perceived exertion (RPE) and Total quality of recovery (TQR) of 14 professional basketball players (age 26.7±3.8 y, height 197.2±9.1 cm, weight 100.3±15.2 kg, body fat 10.3±3.6 %) were compared with observations of the coach. During an in-season phase of 15 matches within 6 weeks, players gave RPE after each match. TQR scores were filled out before the first training session after the match. The coach rated observed exertion (ROE) and recovery (TQ-OR) of the players. ***Results:*** RPE was lower than ROE (15.6±2.3 and 16.1±1.4; $p=0.029$). Furthermore, TQR was lower than TQ-OR (12.7±3.0 and 15.3±1.3; $p<0.001$). Correlations between coach' and players' exertion and recovery were $r=.25$ and $r=.21$, respectively. For recovery within 1 day the correlation was $r=.68$ but for recovery after 1-2 days no association existed. ***Conclusion:*** Players perceive match exertion hard to very hard and subsequent recovery reasonable. The coach overestimates match exertion and underestimates degree of recovery. Correspondence between coach and players is thus not optimal. This mismatch potentially leads to inadequate planning of training sessions and performance decrease during fixture congestion in basketball.

Keywords: RPE, intensity, regeneration, competition, performance, basketball

Introduction

In elite team sports, players have to cope with extremely high physical and psychosocial demands to achieve success. Frequency, duration and intensity of training and matches are high and players have to adapt to dense playing schedules with short recovery periods between consecutive matches.[1] Next to domestic league championships and CUP-matches, players have to perform in mid-week international competitions like the Europa League in soccer or Euro league in basketball. Such congested schedules can have negative consequences for team performance[2-4] and increasing injury risk.[5]

For training and coaching staff it is imperative to monitor and control the load to optimize the recovery between matches and performance for the next one, which can be done through appropriate prescription of training. This requires an individual approach, that takes variability in playing time caused by disruptions and substitutions into account.[6] For an optimal planning of training sessions between matches, it is vital that the intended loads match the actual load of players.[7] In general, a poor relationship between planned and actual training load is reported with a general tendency of coaches to overestimate training load.[8-10] More specific, it appears that coaches underestimate player load in low intensity training and overestimate in high intensity training sessions.[10,11]

Knowledge of match exertion can help plan the training sessions but this is not yet known. Furthermore, it is unclear if coaches can accurately estimate these match loads for the planning of subsequent training. Mainly for practical reasons (e.g. no time, unresponsive players immediately after the match, match location) it is harder to gather this information in the real-match-context instead of the training context.[12] In order to guide the training process following these matches, a realistic view of the match exertion is needed for each individual player, especially during fixture congestion. Coaches that are well informed about players' match exertion are thus crucial to find the optimal balance between exertion and recovery and to subsequently prevent underperformance.

Next to specific match and training exertion, coaches need to know effects of ensuing fatigue and ability of individual players to recover for an upcoming match or training to optimize periodization plans. To illustrate, insufficient recovery time could lead to performance decrement. Moreover, accumulative effects from both matches and training have the potential to decrease performance even further.[13] To indicate recovery performance tests (e.g. sprinting, jumping), biochemical markers (e.g. creatine kinase) and self-reported instruments are used to give more insight in recovery processes.[14] Kenttä & Hassmén[15] introduced The Total Quality of Recovery scale to measure psychophysiological recovery. This self-report measure is a promising tool because it measures the total recovery state of a player, similar to RPE for exertion.

In sum, no studies have yet examined match exertion and subsequent recovery during fixture congestion in professional basketball. Furthermore, the ability of the coach to observe player match exertion is not investigated yet. Finally, no information is currently available to what extent coaches are able to estimate players' quality of recovery before the first post-match training session by observation. Yet, to carefully plan succeeding training sessions it is of high importance to acquire more insight and knowledge in this particular matter. Hence, the aim of this study is to determine match exertion, recovery and to investigate to what extent the coach is able to estimate players' match exertion and total quality of recovery within an in-season intensified competition period.

Methods

Subjects

Fourteen elite basketball players playing at the highest competition level of the Dutch Basketball Association participated in this study. Characteristics of the players are mean (±*SD*) age (years) 26.7±3.8, height (cm) 197.2±9.1, weight (kg) 100.3±15.2, body fat (%) 10.3±3.6. The head coach, assistant coach and strength & conditioning coach were responsible for the training program. The head coach is licensed and certified to coach at the highest level nationally and internationally and has more than 10 years of experience in elite basketball as a professional coach. Players underwent different types of training (e.g. technical basketball drills, tactical, specific strength and conditioning with intermittent character) during the intensive training and match period within the competitive season (Table 1). The ethical committee of the Center for Human Movement Sciences of the University of Groningen approved the study and written informed consent was obtained from the subjects.

Experimental protocol and procedures

During an intensive competition period of 15 matches (8 domestic league, 1 CUP-league and 6 Euro league) within 6 weeks (2.5 matches per week) rating of perceived exertion (RPE) on a 6 (no exertion) to 20 (extreme exertion) scale was obtained of the players thirty minutes after each match individually. Each player was asked to provide his subjective perception of the match by pointing his finger to the 6-20 scale.[16] Session-RPE is a valid method to assess individual exertion including disruptions and substitutions in professional elite-standard basketball players.[4] Playing time of each player was noted from start to end of the match excluding all interruptions in the match (e.g. time-outs, time between quarters, match stops, injury time) to calculate match load (intensity × duration, warming-up excluded).[16] Players pointed with their finger to their total quality of recovery score (TQR) on a 6 (no recovery) to 20 (maximal recovery) scale[15] before the first post-match training session. These scores were individually assessed before the morning training session (between 8-10 a.m.) of that day. It is assumed that the TQR measures individual characteristics of player recovery.[15] The coach gave his rating of observed exertion (ROE) for each individual player within the same time course (30 minutes) after the match like the players. Furthermore, the coach was instructed to provide total quality of observed recovery (TQ-OR) scores for each individual player on the same scale as the players did directly before the start of the first post-match training session. A familiarization trial of players and coach took place four weeks before data collection started. They were informed verbally on the procedures and were supervised on a daily basis during the whole period. One investigator collected all data.

Statistical analysis

Means and standard deviations were calculated for duration, RPE, ROE, match load, TQR and TQ-OR. One player was excluded in the analysis because of an injury and two players for being a non-starter/reserve with no playing time over the whole observation period. Players had to meet ≥10 minutes of actual playing time per match to include obtained scores in the analysis. Paired sample T-tests were used to analyze differences between RPE and ROE and TQR and TQ-OR. Effect sizes (ESs, Cohen's *d*) and 90% confidence intervals (CI) for effect sizes were calculated for all comparisons. Criteria for Cohen's *d* values are $0.2 \leq d \leq 0.5$, $0.5 \leq d \leq 0.8$ and $d \geq 0.8$ representing small, moderate and large effect, respectively.[17] Bivariate Pearson correlation coefficients were calculated to evaluate the relationship between RPE and ROE and TQR and TQ-OR. Recovery scores obtained within 1 day (12-24 hours) post-match and after 1-2 days (24-48 hours) post-match were separated in the analysis. Bland Altman plots were used in analyzing the agreement between the measurements and for detecting outliers. Criteria for the interpretation of correlations were set on: 0-0.3 negligible association, 0.3-0.5 low association, 0.5-0.7 moderate association, 0.7-0.9 high association and 0.9-1.0 very high association.[18] Statistical analyses were performed using SPSS software (version 23.0; SPSS Inc., Chicago IL). P-values lower than .05 were considered as statistically significant.

Results

RPE and ROE of 15 matches and TQR and TQ-OR before 12 post-match training sessions were obtained. Mean actual playing time was 25.6±6.9 (min). Match load was 403±135 (arbitrary units [AU]) and 418±130 (AU) for players and coach respectively. Mean RPE was 15.6±2.3 and ROE was 16.1±1.4. ROE (t=-2.21, df=112, p=0.029, ES=-0.26, CI=-0.48 to -0.04) was significantly higher than RPE. Mean TQR was 12.7±3.0 and TQ-OR was 15.3±1.3. TQ-OR (t=-8.36, df=87, p<0.001, ES=-1.12, CI=-1.39 to -0.85) was significantly higher than TQR.

Post-match recovery

Mean time between the match played and next planned training session was 28.0±11.4 (hours). After 7 matches was the next training within 1 day (12-24 hours) and after another 7 matches after 1-2 days (24-48 hours). TQR and TQ-OR scores within 1 day were respectively mean 13.1±2.8 and 15.4±0.8 and TQR (t=-6,61, df=42, p<0.001, ES=-1.12, CI=-1.49 to -0.73) was significantly lower than TQ-OR. After 1-2 days TQR was lower (12.3±3.2) compared to TQ-OR (15.3 ± 1.7) (t=-5,73, df=44, p<0.001, ES=-1.17, CI=-1.54 to -0.79) (Figure 1).

Figure 2 shows the Pearson correlation coefficients for RPE and ROE and TQR and TQ-OR. Correlation between RPE and ROE was r=.25 (p<0.01) and between TQR and TQ-

OR r=.21 ($p<0.05$). Data points above the lines of equality indicate overestimation of match exertion and post-match recovery by the coach.

Pearson correlation coefficients for TQR and TQ-OR within 1 day and after 1-2 days are presented in Figure 3. The association was r=.68 ($p<0.001$) and no correlation respectively. Data points above the lines of equality indicate underestimation of post-match recovery by the coach.

Discussion

The aims of the present study were to determine match exertion, subsequent recovery and investigate to what extent the coach is able to estimate players' match exertion and total quality of recovery within an in-season intensive game phase (i.e. 2.5 matches per week over several weeks).

The first finding was that the Mean Rate of Perceived Exertion of players was between hard and very hard and mean Total Quality of Recovery was reasonable. This is the first study presenting player match exertion and subsequent recovery in elite basketball during congested fixtures. For match exertion in elite team sports no reference values are available. However, extreme exertion might be expected in this intensive phase of competition. Relatively poor recovery scores by players after 1-2 days post-match could be explained by the delayed onset of muscle soreness (DOMS).[19] It is shown in elite team sports that peak scores of DOMS are reported at 24 [20] and 48 hours.[21] Results of performance tests are congruent and also report these recovery time courses.[20-25]

The second finding was that coach' and players' perceptions show variability for match exertion and recovery. This variability can partly be explained by individual differences in playing time. Divergence highlights the need to track exertion and post-match recovery individually, regularly and accurately during the training process.[14]

For match exertion, Rate of Observed Exertion of the coach was higher than the Rate of Perceived Exertion of players. In addition, results suggested a weak relationship between observed exertion of the coach and experienced exertion of players. Overestimation by the coach is in contrast with previous findings during training sessions in other sports.[26,27] In elite junior tennis players and volleyball players, coaches underestimated session-RPE after they observed training sessions.[26,27] However, it is known that when training sessions are designed to be hard by the coach, these sessions are perceived less intense by the players.[10,11,28] This suggests that the high imposed intensity levels planned by the coach might not be reached during training.[10] This may also be true for matches where coaches expect maximal exertion. During matches other contextual factors (e.g. atmosphere, crowd, motivation, match result, sponsors) may further explain the differences in perceptions. This remains to be determined.

For recovery, the coach significantly overestimated post-match recovery of the players. Moreover, results indicated a weak relationship (r=.21) of post-match recovery between coach estimates and players' perceptions. So, the coach expects good recovery before the next training session even though previous match exertion is overestimated. Along with overestimation of match exertion and underestimation of recovery in general, a remarkable difference was shown between player-coach recovery scores within 1 day and after 1-2 days. Results indicated a reasonable relationship between estimated coach recovery and players' perceived recovery within 1 day post-match (r=.68). However, no correlation was found for a recovery time after 1-2 days.

An explanation for the deviation of post-match recovery scores can be that players are out of sight of the coach after the match until the following training session. As a result, the coach has little insight in the activities that players may undertake in the days between the match and the first training session. These activities could either enhance recovery (e.g. active recovery, sleeping, compression garments, etc.)[29,30] or reduce recovery (e.g. individual training in private time or stress full events in personal life of players). The longer the player is out of sight of the coach the more activities may have happened. Moreover, because recovery time courses of 1-2 days are associated with better recovery,[30] higher coach estimates are expected after 1-2 days post-match. Finally, individual differences in recovery curves between players may be more pronounced after 1-2 days instead of within 1 day. The recovery process of players varies naturally due to individual characteristics of the player, i.e. one recovers faster than the other depending for example on physical fitness.[7] Because the coach showed a greater variation in recovery scores after 1-2 days (Figure 3), it indicates that he might take this into account. For recovery, other contextual factors like for example the potential impact of travel-induced fatigue when playing away (especially Euro league matches) may further explain differences in perceptions.

This is the first study that collected players' and coach responses of matches. Subsequent post-match recovery of players' perceptions and coach estimates are presented. Furthermore, this study adds interpretation of different recovery times to the current body of knowledge, emphasized by the strong deviation between players' perceptions and coach estimates after 1-2 days post-match recovery and its potential negative consequences for performance. Finally, our study design with 2.5 matches per week periodization accounting for within match substitutions and between successive matches player rotation is scarce and warranted.[6]

Limitations and future research

Limitation of the study is that data of one team and one coach is observed. In addition, no data on recovery activities is collected. The first limitation might affect the generalizability of the outcomes. However, it is likely that the number of players and coaches diverges in player-coach studies in team sports.[8,10,27] This observational study design meets the real practical context of a professional basketball team playing at the highest national competition level and Euro league during fixture congestion. It is important not to interfere in this process. The present study demonstrated that with simple tests for monitoring individual match exertion and post-match recovery is obtained from players and coach.[14]

The recovery process must be approached as a complex mechanism in which both physical and psychosocial processes are involved. Future research should aim to track psychophysiological recovery after matches continuously. Moreover, it is recommended to identify and apply player recovery enhancing activities during time-off. Next to physical recovery strategies (e.g. active recovery) are sleep and mental recovery strategies like debriefing an interesting field of research to apply in elite team sports. Study designs should meet congested playing schedules in elite team sports to understand its consequences on performance.

Conclusion

In conclusion, results showed that players perceived match exertion between hard and very hard and subsequent recovery was reasonable. The coach overestimated match exertion of players with poor correspondence. Overall post-match recovery was underestimated by the coach. Furthermore, for recovery within 1 day moderate association and after 1-2 days negligible association was demonstrated. The coach overestimated the ability of players to recover and adapt well after 1-2 days before a consecutive training stimulus is introduced. It can be concluded that in this in-season intensive game phase the coach was not able to give an optimal estimation of players' match exertion and total quality of recovery of professional basketball players.

Practical applications

For training and coaching staff of team sports, it is very important to have clear insight in individual match exertion and subsequent recovery of players. Tools like RPE and TQR improves understanding of players' perceptions of exertion and recovery and are therefore recommended in daily practice. When doing this, coaches should be aware of potential automatic player responses. A discrepancy between players' and coaches' perceptions might have negative consequences on the subsequent training content. Overestimation of match exertion by the coach might lead to too easy training sessions. On the other hand, underestimation of the degree of recovery for a subsequent training session potentially imposes too hard training sessions. Communication between coach, support staff and player is crucial to track exertion and post-match recovery over time. Subsequently, players can be supported with adequate recovery time and evidence-based effective recovery strategies.[30] Furthermore, coaches should adapt to congested playing schedules within their training plans. Short recovery times between successive matches are likely not to meet sufficient recovery and therefore recovery-enhancing activities are even more important to strive for optimal performance.

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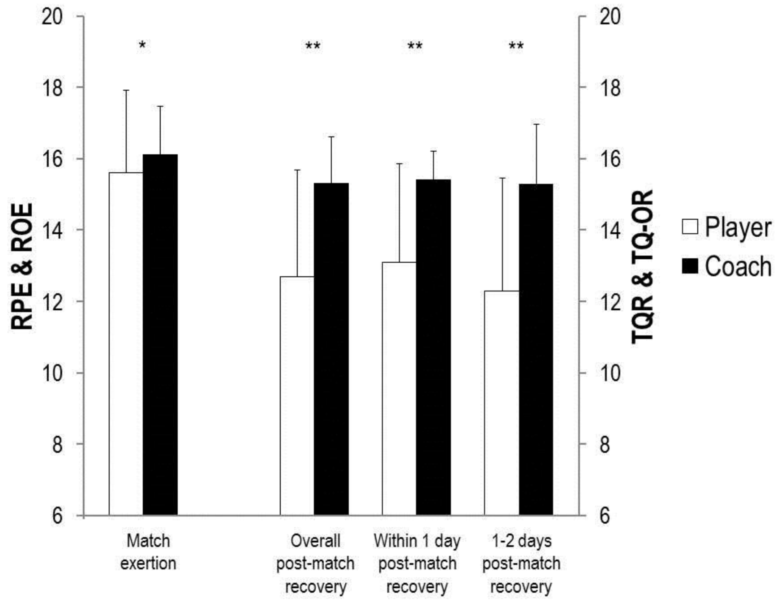

Figure 1. Comparison between players and coach on match exertion (N=113), overall post-match recovery (N=88), within 1 day post-match recovery (N=43) and after 1-2 days post-match recovery (N=45). Abbreviations: RPE, Rate of Perceived Exertion; ROE Rate of observed Exertion; TQR, Total Quality of Recovery; TQ-OR, Total Quality of Observed Recovery *P<.05; **P<.001.

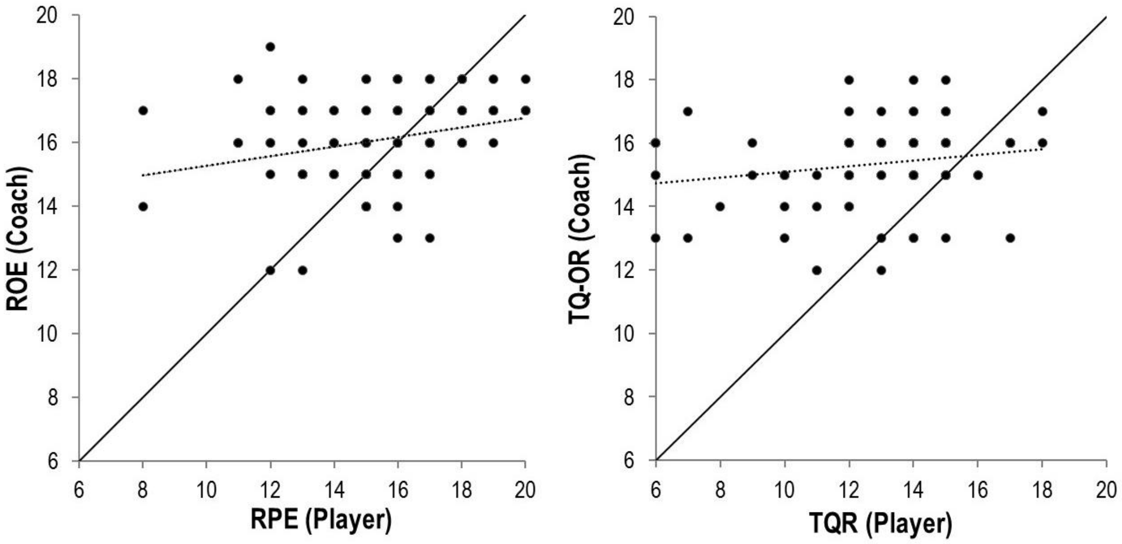

Figure 2. Relationships of Rate of Perceived Exertion (RPE) and Rate of Observed Exertion (ROE) (N=113) and Total Quality of Recovery (TQR) and Total Quality of Observed Recovery (TQ-OR) (N=88); lines of equality (—); lines of regression (---).

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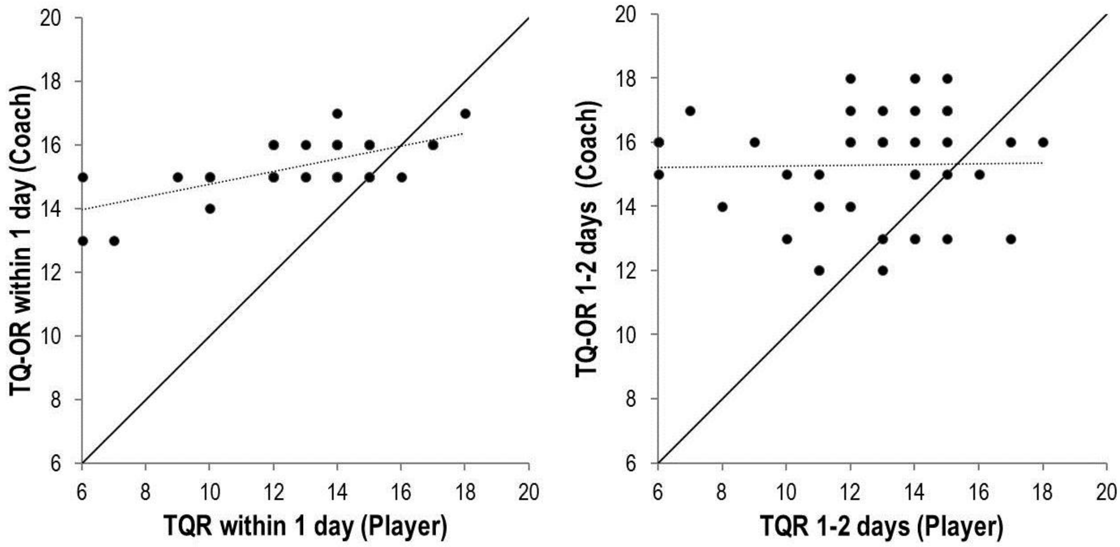

Figure 3. Relationships of Total Quality of Recovery (TQR) and Total Quality of Observed Recovery (TQ-OR) for within 1 day (N=43) and after 1-2 days (N=45); lines of equality (—); lines of regression (---).

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Table 1. Overview of player activities during a week within the study.

Day	Activities morning	Activities afternoon
Monday	Technical/Tactical training	Travelling
Tuesday	Shooting/video	Euro league match
Wednesday	Travelling	Shooting
Thursday	Shooting/video	Dutch league match
Friday	Strength and conditioning	Technical/Tactical training
Saturday	Shooting/video	Dutch league match
Sunday	Rest	Rest