# Short-term tapering prior to the match: external and internal load quantification in top-level basketball

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**Summary**

The purpose of this study was to compare accelerometry-derived external load and internal load calculated as a session rate of perceived exertion (sRPE) in elite male basketball over 3-days prior to the match and assessing players' recovery status on the match-day. Thirteen professional basketball players participated in this study (age: 25.7±3.3 years; height: 199.2±10.7 cm; weight: 96.6±9.4 kg). All players belonged to a team competing in LigaEndesa (Spanish 1st Division) and Euroleague in the 2016/2017 season. Variables used in external motion analysis were: PlayerLoad (PL), accelerations and decelerations (ACC and DEC), jumps (JUMP) and changes of direction (CoD), in total (t) and high intensity (h) thresholds, while internal demands were registered using sRPE method. All variables were expressed in absolute (accumulated in the session) and relative values (per min of practice). For the evaluation of readiness, Total Quality of Recovery (TQR) questionnaire was used, measured in Arbitary Units (AU). The results showed differences in load and intensity ($p<0.01$) for almost all external (PL, hACC, tACC, hDEC, tDEC, hCoD and tCoD; in both absolute and relative values) and internal (sRPE) variables as training sessions were closer to the match day or MD (MD-3>MD-2>MD-1). Only hJUMP, tJUMP and RPE variables showed no difference between MD-3 and MD-2, while both days significantly differed from MD-1. The average TQR score for all of the match days was 7.9±1.31 AU. This study showed differences in the amount of external and internal load between three days of training, where a team can be efficiently prepared for competitions by progressively decreasing the load over the 3-days prior to the match.

**Key words:**
Training monitoring. Micro-technology. Accelerometry. Team sports.

## *Tapering* a corto-plazo antes del partido: cuantificación de carga externa e interna en baloncesto de élite

**Resumen**

El propósito de este estudio fue comparar la carga externa derivada de la acelerometría y la carga interna calculada a partir del esfuerzo percibido declarado en la sesión (sRPE) en el baloncesto masculino de élite durante los tres días previos al partido, evaluando el estado de recuperación en el día del partido. 13 jugadores de baloncesto profesionales participaron en este estudio (edad: 25,7±3,3 años, altura: 199,2±10,7 cm, peso: 96,6±9,4 kg). Todos los jugadores pertenecían al mismo equipo que compite en Liga Endesa (1ª división española) y Euroliga en la temporada 2016/2017. Las variables utilizadas para registrar la demanda externa fueron: *PlayerLoad* (PL), aceleraciones y desaceleraciones (ACC y DEC), saltos (JUMP) y cambios de dirección (CoD), tanto en el total (t) acumulado como en en rango de alta intensidad (h), mientras que las demanda interna fue registrada usando el método sRPE. Todas las variables se expresaron en valores absoluto (acumulado en la sesión) y relativos (por minuto de práctica). Para el resgistro del estado de recuperación, se utilizó el cuestionario *Total Quality Recovery* (TQR) medida en unidades arbitrarias (UA). Los resultados mostraron diferencias en la carga e intensidad ($p<0.01$) para casi todas las variables externas (PL, hACC, tACC, hDEC, tDEC, hCoD y tCoD, tanto en valores absolutos como relativos) e internas (sRPE), entre las sesiones de entrenamiento con respecto a su distancia al día de partido o MD (MD-3> MD-2> MD-1). Solo las variables hJUMP, tJUMP y RPE no mostraron diferencias entre MD-3 y MD-2, mientras que los dos días difirieron significativamente de MD-1. La puntuación promedio de TQR para todos los días de partido fue de 7,9 ±1,31 UA. Este estudio mostró diferencias en la carga total externa e interna entre los tres días de entrenamiento, donde un equipo puede prepararse eficientemente para la competición disminuyendo progresivamente la carga durante los tres días previos al partido.

**Palabras clave:**
Monitorización del entrenamiento. Micro-tecnología. Acelerometría. Deportes de equipo.

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## Introduction

Training periodization and tapering are well-known principles commonly used in professional team-sports training during the season. According to literature[1,2], "long-term" tapering in team-sports is implemented two to three weeks before important events, such as cups and play-offs, with the intention of peaking individual and team's physical and tactical performance. A recent study focusing on basketball revealed a relationship between internal training load, recovery-stress status, immune-endocrine responses, and physical performance in elite female basketball players[3] over a 12-week period, including two overloading and tapering phases. This study covered the period preceding an international championship (characterized by a short duration), providing an insight into long-term training stimulus and adaptations in elite sports. Regarding training activities, taper was applied by decrease of training volume for the resistance training, especially with parameters such as repetitions per set, goal intensity and number of sessions per week. Moreover, in the first seven weeks endurance training consisted of moderate to high intensity interval runs while in the weeks 8 to 12 endurance training was substituted with less metabolic speed-agility training. Finally, authors concluded that the application of session rate of perceived exertion (sRPE) method, as well as the recovery-stress questionnaire (REST-Q), can serve as an important tool to monitor training loads and players' recovery, thus maximizing dose-responses of the training stimulus.

However, for a team competing in seasonal championships, the coaching staff is presented with the challenge of making an optimal training schedule every single week. In this context, weekly periodization, i.e. tapering, could also refer to the practice of reducing training load in the days leading up to the weekly competition. To date, there is little scientific information available to guide coaches in prescribing efficient short-term tapering strategies for team sports players during the competitive week aimed at peaking performance on the match day.

Only one study[4] has looked at internal training load (iTL) using sRPE and heart rate (HR) monitoring methods, and it showed that, in the weeks with two games (i.e. Euroleague and Serie A1), the sRPE obtained on Tuesdays and Wednesdays were 748±71 and 275±54 AU, respectively. The short-term tapering assumed that Monday was the day-off and Thursday the match-day in Euroleague. However, the aforementioned study did not present any external load data and indicators of physical status (i.e. condition) with respect to the accumulated training load. To date, no studies examining the relationship between prescribed external training loads in micro-cycle periods have been conducted.

Numerous methods can be used to monitor the physical status of athletes. There are objective methods, such as heart rate monitoring and saliva measures[5], blood testing[6] or jumping performance[7,8], as well as subjective methods, such as various questionnaires[8-10], which could be easily implemented in everyday training. One of the questionnaires, known as Total Quality Recovery Scale (TQR), has demonstrated sufficient reliability in team sports[11].

At the moment, information on accelerometer–based data in top-level basketball is limited, especially with respect to weekly periodization and distribution of load. Therefore, the aim of this study is to compare the load of the training sessions leading up to the first match of the week, considering both external (eTL) and internal training load parameters. Furthermore, the perception related to recovery status on the match day (via TQR questionnaire) will be assessed. The assessment will be used as the indicator in the selection of appropriate training load that secures enough recovery for players' well-being, while avoiding undesired overload and overtraining. The findings of this study could help coaches set appropriate level and intensity of accelerometry-derived training load (TL) in the days leading up to the match, as such data is currently unavailable in the literature.

It was hypothesized that, with the application of a short-term 3-day taper, a progressive decrease in TL prior to the match day will positively affect players' recovery status, which would in turn lead to enhanced physical status and performance in competition.

## Material and method

### Experimental Approach To The Problem

The research was carried out between December and February of the 2016/2017 season. The players were monitored in basketball training sessions using S5 devices from Catapult Innovations (Melbourne, Australia). Furthermore, sRPE was calculated based on the individual RPE obtained 15-30 minutes after the training session multiplied by the training duration. During that period, the players participated in three to eight training sessions and two or three games every week where the total number of recorded games was 10. The investigation data set consisted of 228 observations, where the numbers of training sessions per player ranged between 11 and 22. The eTL was transferred and managed using the Openfield v1.14.0 software (Build #21923, Catapult, Canberra). The data was subsequently exported to Microsoft Excel for the final selection and analysis of individual eTL and iTL variables.

### Participants

A professional male basketball players (age: 25.7 ±3.3 years; height: 199.2 ±10.7 cm; weight: 96.6 ±9.4 kg) who play on the same team were participating in this investigation. The team competes in two basketball championships, ACB (Liga Endesa, Spanish 1st Division) and the Euroleague, in the 2016/2017 season. All of the players were verbally informed of the study requirements and they provided written consent before the study was conducted, all in accordance with the Declaration of Helsink[i]. The Ethics Committee (CEISH) gave its institutional approval before the procedures of this study took place.

### Type Of Training Session

The players typically played two games per week, with three team sessions usually conducted before the first game of the week (Euroleague) and only one or none before the second game (ACB League). Only the sessions before the first game of the week were considered in the analysis, due to individual adjustments in team sessions preceding the second game, which depended on the individual effort in the first game. Therefore, the data for the analysis was collected three days before the match day (MD-3), two days before the match day (MD-2) and one day before the match day (MD-1). The 3 consecutive days of practices

**Table 1. Usual training tasks.**

| Task | Description | Day of use |
|---|---|---|
| PREPARATION | Warm-up, myo-fascial release and stretching, balance and activation exercises with goal to functionally prepare each player for training demands. Usual time 10-15'. | MD-3, MD-2, MD-1 |
| 5x0 HC | No-contact play on half-court for learning and mastering offensive sets. Usual time of play is 15-20", work rest ratio 1:1. | MD-3, MD-1 |
| 5x0 FC | No-contact play using full court for learning and mastering offensive sets. Usual time of play is 20-40", work rest ratio 1:1. | MD-3, MD-2, MD-1 |
| SSG 3x3 HC | Contact small-sided game on half-court for learning and mastering tactical rules. Usual time of play is 30-60", work rest ratio 1:1. | MD-2 |
| SSG 4x4 HC | Contact small-sided game on half-court for learning and mastering tactical rules. Usual time of play is 30-60", work rest ratio 2:1. | MD-3, MD-2, MD-1 |
| SSG 5x5 HC | Contact small-sided game on half-court for learning and mastering tactical rules. Usual time of play is 30-90", work rest ratio 1:2. | MD-3, MD-1 |
| SSG 5x5 FC | Contact small-sided game using full court for learning and mastering tactical rules. Usual time of play is 30-120", work rest ratio 1:1. | MD-3, MD-2, MD-1 |
| SHOOTING | Spot-up shooting drills in pairs, low to medium intensity, continuous 5-10'. | MD-3, MD-2, MD-1 |

SSG is small-sided game, HC is half court, FC is full court, MD-3 is three days prior the match, MD-2 is two days prior the match and MD-1 is one day prior the match.

were proposed by conditioning specialist in order to achieve optimal short-term tapering effect. Only players who complete all three training sessions were included in the analysis.

Table 1 provides the list and brief descriptions of basketball training exercises and drills used in the reference period. After the team preparation, players participated in one of the following: shooting exercises, no-contact drills or small-sided games (SSG).

## External Training Load Monitoring

The eTL was monitored using GPS S5 devices (Catapult Innovations, Melbourne, Australia), which include the accelerometer, gyroscope and magnetometer sensors that provide data for inertial movement analysis (IMA). The obtained data included the following variables: player load (PL), player load per minute (PL/min), accelerations (ACC), decelerations (DEC), jumps (JUMP) and changes of direction (CoD).

PL was obtained using the tri-axial accelerometer (100 Hz, Dwell time 1 second) based on the player's three-planar movement, applying the established formula[12,13] previously tested for reliability[14,15], where TE (i.e. typical error) for different ranges of acceleration varies from 0.18 – 0.13[15].

The ACC variable presents inertial movements registered in a forward acceleration vector, where tACC refers to all, and hACC only to high-intensity movements registered within the high band (>3.5 $m \cdot s^{-2}$). The DEC variable refers to inertial movements registered in a forward deceleration vector, where tDEC presents total and hDEC only high-intensity movements registered within the high band (>3.5 $m \cdot s^{-2}$). The jumps were also registered as total jumps (tJUMP) and high-intensity jumps (hJUMP, over 0.4 m), the same as changes of direction, tCoD (total inertial movements registered in a rightward lateral vector), and hCoD (total inertial movements registered in a rightward lateral vector within the high-intensity band). All aforementioned variables were assessed with respect to their frequency.

Considering the varied duration of the sessions, the relative values of the variables were used, obtained by dividing the accumulated values by the minutes of practice duration. The new relative variables for the analysis were: PL/min, hACC/min, hDEC/min, tACC/min, tDEC/min, hCoD/min, tCoD/min, tJUMP/min and hJUMP/min.

## Internal Training Load Monitoring

The sRPE method, whose reliability and validity has been confirmed in previous research[16-19] as well as its simple and cost-effective use in practice with team sport athletes[20-22], was used to assess iTL. As suggested by research[17], the RPE values were collected within 15-30 minutes following the training session. The 1-10 RPE grading scale was used. In order to calculate sRPE after all sessions, RPE values were multiplied by training duration in minutes.

## Monitoring of Physical Status

The TQR questionnaire[11] was used to assess players' physical status. On the match day, after the morning team shooting practice, players were asked to grade their current physical status on a scale from 1 to 10 (where 1 means very, very poor and 10 very, very good), following this category classification: <6 = an alarming state; 6.1-7.5 = a good state; 7.6-9 = a very good state; and >9.1 = an excellent state.

## Statistical Analysis

A data analysis was performed using the Statistical Package for Social Sciences (version 23 for Windows, SPSS™, Chicago, IL, USA). Standard statistical methods were used to calculate the mean (or median) and standard deviations (SD). The data was screened for normality of distribution and homogeneity of variances using Shapiro-Wilk and Levene's tests, respectively. Differences between dependent variables and TQR values in training sessions and on the match day were analyzed using one-way ANOVA, followed by Bonferroni's post hoc test (Kruskal Wallis test followed by Mann-Whitney U test, with Bonferroni correction of alpha, in this case, dividing alpha by three comparisons). The effect size (ES) was calculated using the method proposed by Batterham and Hopkins[23]. The effect values lower than 0.2, between 0.2 and 0.5, between 0.5 and 0.8, and higher than 0.8 were considered trivial, small, moderate, and large, respectively. The $p<0.05$ criterion was used for establishing statistical significance.

## Results

The duration (mean, standard deviation and confidence interval at 95%, in hours:minutes:seconds) of the sessions were 1:23:37±0:11:40 (1:19:56-1:27:18), 1:14:43±0:12:37 (1:12:07-1:17:20) and 0:58:25±0:07:57 (0:56:48-1:00:02) for MD-3, MD-2 and MD-1, respectively. A significant difference was found between all of the days.

Figure 1 shows values for PL (in AU) on each day of the week. The differences were statistically lower for training sessions closer to the match day (MD-3>MD-2>MD-1), where the values were as follows: 436.6±70.8, 358.4±51.1 and 253.2±58.7, respectively (ES: 1.27 for MD-3 *vs.* MD-2; 1.91 for MD-2 *vs.* MD-1; 2.82 for MD-3 *vs.* MD-1). Furthermore, the PL/min values for MD-3, MD-2 and MD-1 were significantly different, 5.3±0.7, 4.9±0.8 and 4.3±0.7, respectively (ES: 0.53 for MD-3 *vs.* MD-2; 0.80 for MD-2 *vs.* MD-1; 1.43 for MD-3 *vs.* MD-1).

Table 2 shows absolute values of other external training load variables (mean, standard deviation and confidence interval at 95%) for each

**Figure 1. Median, ±standard deviation, confident interval at 95% for a) total PL (Player Load) in arbitrary units (AU) and b) PL/min (Player load per minute) in arbitrary units per minute (AU/min) regarding to the day of the week (MD-3 is match day minus 3, MD-2 is match day minus 2 and MD-1 is match day minus 1).**

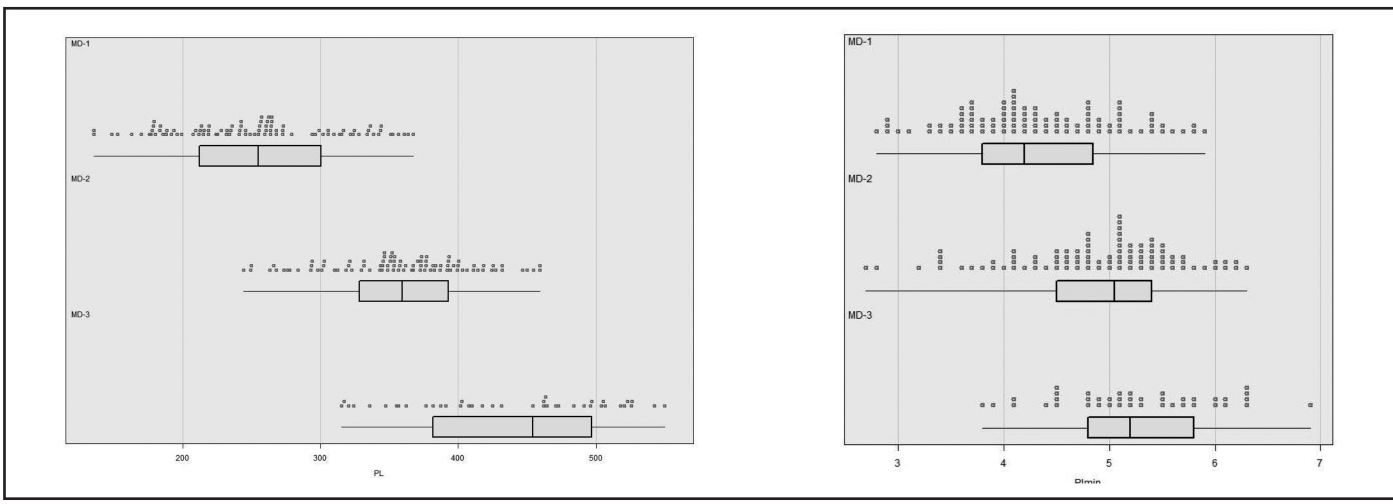



**Table 2. Mean, ±standard deviation, confident interval at 95% (in brackets) and effect size (ES) for absolute external training load variables.**

| Variables | MD-3 | MD-2 | MD-1 | ES |
|---|---|---|---|---|
| hACC (n) | 10.8±5.5$^{2,1}$ (9.0-12.5) | 8.0±3.9$^{1}$ (7.2-8.8) | 4.1±3.0 (3.4-4.7) | A=0.59, B=1.12, C=1.51 |
| tACC (n) | 72.8±22.9$^{2,1}$ (65.6-80.0) | 62.2±21.0$^{1}$ (57.8-66.5) | 33.3±15.2 (30.2-36.4) | A=0.48, B=1.58, C=2.03 |
| hDEC (n) | 16.8±8.2$^{2,1}$ (14.2-19.4) | 12.0±6.1$^{1}$ (10.7-13.2) | 7.3±4.4 (6.4-8.2) | A=0.66, B=0.88, C=1.44 |
| tDEC (n) | 125.9±28.6$^{2,1}$ (116.8-134.9) | 101.2±23.4$^{1}$ (96.4-106.1) | 71.4±25.7 (66.1-76.6) | A=0.95, B=1.21, C=2.00 |
| hCoD (n) | 33.1±12.7$^{2,1}$ (29.1-37.1) | 26.6±12.0$^{1}$ (24.1-29.1) | 15.0±8.3 (13.3-16.7) | A=0.53, B=1.12, C=1.69 |
| tCoD (n) | 480.0±103.7$^{2,1}$ (447.2-512.7) | 374.8±67.1$^{1}$ (360.9-388.7) | 247.7±80.3 (231.3-264.0) | A=1.20, B=1.72, C=2.50 |
| hJUMP (n) | 17.5±7.3$^{1}$ (15.2-19.8) | 14.8±6.1$^{1}$ (13.5-16.0) | 10.2±5.3 (9.1-11.2) | B= 0.81, C=1.14 |
| tJUMP (n) | 58.2±17.6$^{1}$ (52.7-63.8) | 55.5±16.2$^{1}$ (52.2-58.9) | 42.7±21.3 (38.4-47.0) | B= 0.68, C=0.79 |

3 means > MD-3, 2 means > MD-2, 1 means > MD-1, A means MD-3vsMD-2, B means MD-2vsMD-1 and C means MD-3vsMD-1. tACC is total forward acceleration, hACC is total forward acceleration within the high band (>3.5 $m \cdot s^{-2}$), tDEC is total deceleration, hDEC is total deceleration within the high band (<-3.5 $m \cdot s^{-2}$), tCOD is total rightward lateral movements, hCOD is total movements registered in a rightward lateral vector within the high band, tJUMP is total jumps, and hJUMP is jumps done at the high band (above 0.4 m).

**Figure 2. Median, ± standard deviation, confident interval at 95% for a) sRPE (session RPE) in arbitrary units (AU) and b) sRPE in arbitrary units per minute (AU/min) regarding to the day of the week (MD-3 in match day minus 3, MD-2 in match day minus 2 and MD-1 in match day minus 1).**

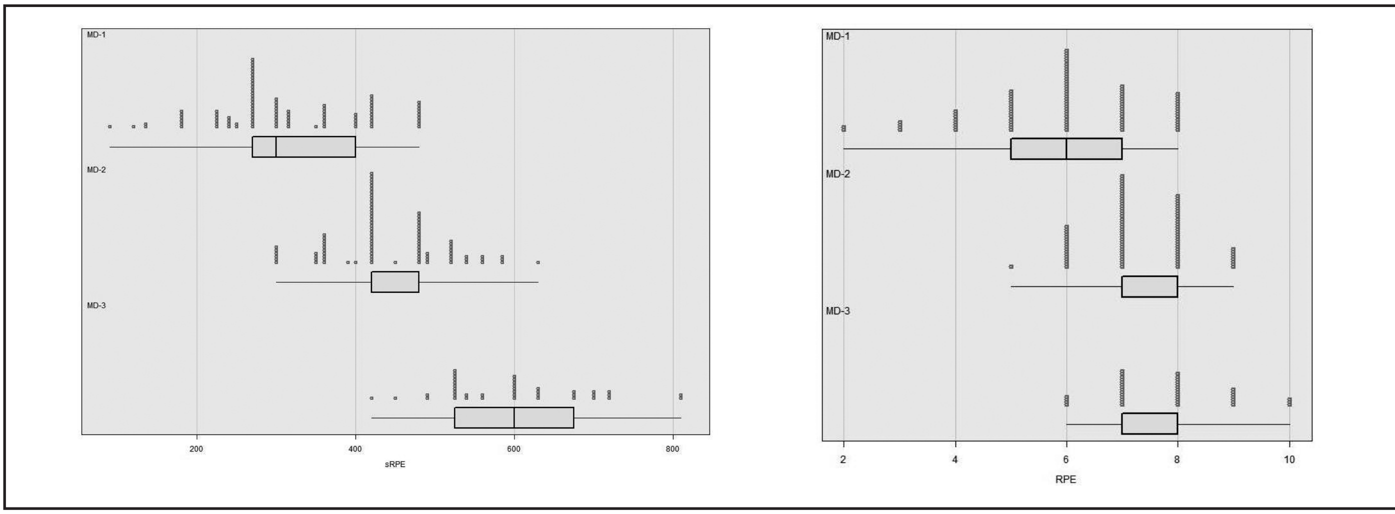



**Table 3. Mean, ±standard deviation, confident interval at 95% (in brackets) and effect size (ES) for relative (per minute) external training load variables.**

| Variables | MD-3 | MD-2 | MD-1 | ES |
|---|---|---|---|---|
| hACC/min | 0.14±0.07[2,1] (0.12-0.17) | 0.11±0.05[1] (0.10-0.12) | 0.05±0.04 (0.05-0.06) | A=0.49, B=1.33, C=1.58 |
| hDEC/min | 0.22±0.1[2,1] (0.19-0.26) | 0.16±0.08[1] (0.14-0.18) | 0.10±0.06 (0.09-0.11) | A=0.67, B=0.85, C=1.46 |
| tACC/min | 0.98±0.31[2,1] (0.88-1.07) | 0.83±0.28[1] (0.77-0.89) | 0.45±0.20 (0.40-0.49) | A=0.51, B=1.56, C=2.03 |
| tDEC/min | 1.69±0.38[2,1] (1.57-1.81) | 1.36±0.31[1] (1.29-1.42) | 0.96±0.34 (0.89-1.03) | A=0.95, B=1.23, C=2.02 |
| hCoD/min | 0.44±0.17[2,1] (0.39-0.50) | 0.36±0.16[1] (0.32-0.39) | 0.20±0.11 (0.18-0.22) | A=0.48, B=1.17, C=1.68 |
| tCoD/min | 6.43±1.39[2,1] (5.99-6.87) | 5.02±0.90[1] (4.84-5.21) | 3.32±1.08 (3.10-3.54) | A=1.20, B=1.71, C=2.50 |
| tJUMP/min | 0.68±0.27 (0.64-0.71) | 0.78±0.24[1,3] (0.71-0.85) | 0.74±0.22[3] (0.70-0.79) | A= -0.39, C= -2.24 |
| hJUMP/min | 0.18±0.09 (0.17-0.19) | 0.23±0.10[1,3] (0.20-0.26) | 0.20±0.08[3] (0.18-0.21) | A= -0.53, C= -0.23 |

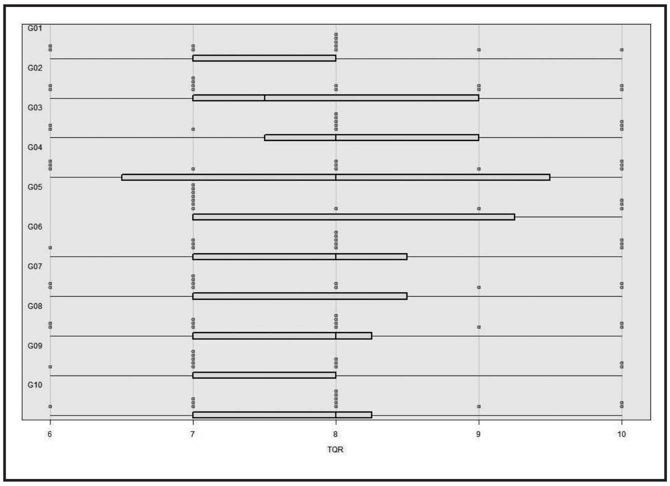
3 means > MD-3, 2 means > MD-2, 1 means > MD-1. A means MD-3vsMD-2, B means MD-2vsMD-1 and C means MD-3vsMD-1. tACC is total forward acceleration, hACC is total forward acceleration within the high band (>3.5 m•s$^{-2}$), tDEC is total deceleration, hDEC is total deceleration within the high band (<-3.5 m•s$^{-2}$), tCOD is total rightward lateral movements, hCOD is total movements registered in a rightward lateral vector within the high band, tJUMP is total jumps, and hJUMP is jumps done at the high band (above 0.4 m).

type of session in the week. In most variables, there was a statistically significant difference between the days MD-3 > MD-2 > MD-1. Only JUMP variable showed no difference between MD-3 and MD-2, while both days differed from MD-1.

When variables were expressed in minutes of practice (Table 3), almost all of the variables showed the same pattern, with statistically significant differences between MD-3 > MD-2 > MD-1. Interestingly, tJUMP/min and hJUMP/min showed no difference between MD-3 and MD-2, while both days showed a difference when compared to MD-1.

As for internal variables, the training load (sRPE) variable showed a statistically significant difference between days MD-3 > MD-2 > MD-1; 598.2±90.5 (569.6-626.7) AU, 441.4±73.4 (426.1-456.6) AU and 312.0±92.8 (293.1-330.9) AU, respectively (ES: 1.90 for MD-3 *vs.* MD-2, 1.55 for MD-2 *vs*. MD-1 and 3.12 for MD-3 *vs*. MD-1). The intensity variable RPE showed no differences between MD-3 and MD-2 with values 7.8±1.1 (7.4-8.1) AU and 7.3±0.9 (7.1-7.5) AU, respectively. However, the results for MD-1 were 6.0±1.4 (5.7-6.3) AU, what significantly differentiates from previous two days (1.10 for MD-2 *vs*. MD-1 and1.43 for MD-3 *vs*. MD-1) (Figure 2).

**Figure 3. Median, ± standard deviation, confident interval at 95% for team's TQR scores prior the match (G presents a game, while the number classifies games from the first to the tenth).**




Finally, Figure 3 presents the average scores in TQR questionnaire for all of the match days in the reference period. The average values from the first to the last game were as follows: 7.7 (6-10), 7.8 (6-10), 8.1 (6-10), 8.0 (6-10), 8.0 (7-10), 8.1 (6-10), 7.7 (6-10), 7.8 (6-10), 7.7 (6-10) and 8.0 (6-10). The average for all of the match days was 7.9 (±1.31), positioning the team in the category of a very good state. There were no significant differences in the recovery status (TQR questionnaire results) between all match days in the reference period.

## Discussion

The main aim of the present study was to describe differences between training sessions leading up to the first match of the week with respect to both eTL and iTL parameters. To the best of the authors' knowledge, this is the first study investigating short-term tapering in the elite basketball setting. The results showed differences in almost all variables (in both load and intensity) between the training sessions analyzed (MD-3>MD-2>MD-1). Furthermore, the TQR scores on the match day did not indicate any abnormality in players' optimal state of recovery. In particular, the results of the present study contributed to the improvement of specific periodization strategies with respect to different training durations, load and intensity.

Monitoring TL in basketball players is crucial in planning appropriate training programmes[24] and exposing players to adequate monotony and strain in order to reduce injury risk[25]. Additionally, in previous research on effects of specific periodization strategies to avoid overtraining syndrome or under-stimulation, it was concluded that training session duration and intensity manipulation is a very important component of tapering[2]. Experts[1] suggested that, out of the three main factors in tapering – training intensity, frequency and volume –, a decrease in the latter factor had the strongest effect on enhanced performance. In the present study, a decrease in the training duration (i.e, volume) in the days leading up to the match follows general tapering principles, where training intensity was kept at the high level when SSG were used but general training volume was decreased due to shorter training time. Additionally, from Table 1. it can be observed that 3vs3 SSG was not perfromed one day before the offical game, as it was physically more exhausting than the other drills. However, tapering included only three-day cycles and can therefore be considered as a short-term taper.

The majority of external load variables (i.e. hACC, tACC, hDEC, tDEC, hCoD and tCoD) revealed the same pattern in their inter-day relationships as the global variables, PL and sRPE. In connection with that finding, the authors suggest that these variables could be the most important eTL variables in prescribing load in basketball training sessions. Only two eTL variables of the same construct (i.e. hJUMP and tJUMP) showed different relationships between the days, with no difference found between MD-3 and MD-2, while both days differed from MD-1. This finding could be ascribed to different shooting drills, which significantly affected both hJUMP and tJUMP variables. In the future, it is important to differentiate the jumps accumulated in SSG and those from the other tasks, such as warm-up or spot-up shooting. When the total number of ACC, DEC, CoD and JUMP variables is considered in basketball training, regardless of the day, it is important to recognize that the CoD variable had the highest values by far. For that reason, CoD also had the highest impact on load accumulation.

PL, a global eTL variable, shows significant differences between all of the days, starting from MD-3, which showed the highest value (436.6±70.8 AU), through MD-2 with a moderate value (358.4±51.1 AU), and finally, MD-1 with the lowest value (253.2±58.7 AU). These findings confirm previous research into short-term tapering in other team sports[7]. Unfortunately, eTL data on daily loads and short-term tapering in basketball does not exist.

With respect to iTL variables, the present study found that sRPE shared a very strong inter-day relationship as PL, unlike a previous study[26] on elite basketball players, which found only a moderate relationship (r=0.49). sRPE, a measure of internal training load, was the highest (598.2±90.5 AU) on MD-3, followed by 441.4±73.4 AU on MD-2 and was the lowest (312.0±92.8 AU) on MD-1. These findings support the previous study on elite basketball players[4]. However, Manzi's study covered only two days leading up to a Euroleague game, since MD-3 was a day without physical activities (i.e. day-off). Over these two days, the players accumulated on average 748±71 AU on MD-2 and 275±54 AU on MD-1, with players participating in both resistance (explosive weights) and technical training on MD-2, and in tactical team training on MD-2. A significant drop in load was applied in both cases, which supports the importance of the tapering concept of training volume decrease.

The PL/min variable, which can be considered a variable representing the intensity of work, shows a downward trend, with MD-3 showing the highest value of 5.3±0.7, MD-2 a moderate value of 4.9±0.8, and MD-1 the lowest value of 4.3±0.7 (all in AU per min). Even though Pyne *et al.*[1] suggested that training intensity should be maintained for an optimal taper, it is important to know that longer rest periods were used on MD-2 and, even more so, on MD-1 in order to decrease the metabolic stress, which could explain the significant drop in PL/min values, despite the fact that almost all of the SSGs were used in all of the days leading up to the match. Additionally, the shooting drills were used in greater volume on MD-2 and MD-1 when compared to MD-3, what could further impact the PL/min values. With respect to the above said, the intention in practices was to maintain high intensity in competitive tasks, such as SSG, but this information was not provided in the current study.

Another intensity variable, the subjective RPE, did not show the exact same pattern as PL/min, and significant difference were not found between MD-3 and MD-2. However, both days differed from MD-1. This finding could be ascribed to the accumulated fatigue from MD-3, which is the most demanding day, having a direct impact on the next session on MD-2. However, a well-planned decrease in training volume and load did not have an impact on the residual fatigue on MD-1, but it did lead to a good readiness to play on the match day.

In order to evaluate the physical status (i.e. state of recovery and well-being) of players and their adaptation to training load prior to the match, a simple TQR questionnaire was used, as has been the practice in other team sports recently[27]. The team played 10 games in the reference period, with team scores ranging from 7.7 to 8.1 AU, which positions them in the category of very good physical status. There was no disturbance in the recovery status (as expressed by the TQR questionnaire) in any of the weeks prior to the matches (Figure 3). As suggested by Nunes *et al.*[3], overloading leads to poorer recovery and physical status of players. However, we hereby propose that short-term tapering using the loads specified in this study could improve players' physical status and enable them to be in good physical condition for the competition.

Even though it is important for all coaches to strive for better scores by applying different methods of both training and recovery, it is also important to understand that it is very difficult to constantly maintain an excellent physical status. Playing modern basketball at the elite level requires the players to play 2-3 games per week, and sometimes take several flights a week, early in the morning or late at night, changing the sleeping environment on a weekly basis. These are only some of the factors that interrupt players' circadian rhythm. However, it is important to consider the findings by Rabbani & Buchheit[5], who state that fitter player may experience less wellness impairment when traveling than their less fit counterparts. Moreover, members of the coaching staff should establish a positive working environment, so that players are surrounded with positive energy and maintain healthy mentality in challenging moments on a daily basis.

Therefore, as the team in this investigation constantly averaged in the 'very good state' category, the authors concluded that the accumulated training load presented could be appropriate. Additionally, to keep the players in an optimal physical condition, it is important to maintain a sound acute: chronic workload ratio between micro-cycles, while considering both training and game loads. As suggested by previous research[28], it is better to maintain a high chronic load, because, in congested fixture, players are ready to support a high amount of load. In basketball, this idea has great importance for all players, especially those with more playing time.

This study accentuates the short-term tapering as a basic principle in weekly training load management. As the results of this study show, external and internal variables are complementary methods for monitoring training load. These methods are probably more effective than using only sRPE training load and training volume when the physical fitness level of players is to be assessed[29]. In order to perform at the optimal level in competitions, players need to accumulate a high amount of load, but with a particular distribution. It can be suggested that players experience a decrement (p.e.≈42%, ≈34% and ≈24% in MD-3, MD-2 and MD-1, respectively) in training load in the three days prior to the match, which leads to the enhancement of their physical status, as a result of the so-called supercompensation phenomenon[2]. In elite basketball, as this dose-response investigation presents, a progressive decrease in training loads three days before the match could be an appropriate way of physical conditioning in a preparation of a team for competitive tasks.

One of the limitations in the current study was the lack of comparison group. However, that kind of experimental design is not available when the study is conducted in top-level performance teams. Additionally, head coach's philosophy and training planification principles influenced the load distribution presented in the study. In the future, research in elite basketball should examine the effectiveness of different models of load distribution prior to the match day in correlation with both physical and key performance indicators in games.

## Conclusion

Training load management is a crucial factor that leads to either enhanced or decreased physical condition in competitions. Basketball is an intermittent sport where accelerometry – derived data on individual accelerations, decelerations, jumps, changes of direction and PlayerLoad – provides a stable and clear platform for tracking and analyzing training load. Therefore, if training load is appropriately selected, coaches can find the most effective micro-tapering models prior to the match. According to the findings of this study, the accumulated PL of ≈1048 AU with ratio of ≈ 42%, 34% and 24% in MD-3, MD-2 and MD-1 respectively, could be appropriate load distribution, as it leads to a very good physical status on the match day. Moreover, the current study demonstrates that the use of different approaches to monitor training load provides a better micro-cycle (i.e. week) assessment and implementation of the short-term tapering prior to the games at the elite basketball level. Complementary monitoring of both external and internal loads provides a comprehensive insight about training demands and psycho-physiological responses in players. Successful training load monitoring across the pre- and in-season phases should be performed for two main reasons; to decrease injury risk and provide optimal level of stress and adaptation that leads to enhanced physical and competitive performance. Nevertheless, solely monitoring of training load is not enough to ensure a good management of the load. Complementary to load monitoring methods, coaches should assess players' state of recovery and readiness to play. In this paper, use of the TQR questionnaire was presented. However, complementary use of subjective and objective (e.g. creatin kinease values, heart rate, jumping performance) methods is advised. The practical implications may be further enhanced by understanding players' mental and physical states regarding the day of the week and its proximity to the match-day. Only in this way, coaching staff will manage to optimize the players' performance. Therefore, future research in basketball should provide more information on a) the accelerometry-derived game load, so that even better relationships can be established between training and competitive demands and b) the effects of sleep quality and mentality during travels on players' readiness and performance in competitions.

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## Conflicts of interest

The authors certify that there is no conflict of interest with any financial organization regarding the material discussed in the manuscript.

# Bibliography

1. Pyne DB, Mujika I, Reilly T. Peaking for optimal performance: Research limitations and future directions. *J Sport Sci*. 2009;27(3):195-202.
2. Marrier B, Robineau J, Piscione J, Lacome M, Peeters A, Hausswirth C, *et al*. Supercompensation Kinetics of physical qualities during a Taper in Team Sport Athletes. *Int J Sports Physiol Perform*. 2017;12(9):1163-9.
3. Nunes JA, Moreira A, Crewther BT, Nosaka K, Viveiros L, Aoki MS. Monitoring training load, recovery-stress state, immune-endocrine responses, and physical performance in elite female basketball players during a periodized training program. *J Strength Cond Res*. 2014;28(10):2973-80.
4. Manzi V, D'Ottavio S, Impellizzeri FM, Chaouachi A, Chamari K, Castagna C. Profile of weekly training load in elite male professional basketball players. *J Strength Cond Res*. 2010;24(5):1399-406.
5. Rabbani A, Buchheit M. Ground travel-induced impairment of wellness is associated with fitness and travel distance in young soccer players. *Kinesiology*. 2016; 48(2):200-6.
6. Fox JL, Scanlan AT, Stanton R. A review of player monitoring approaches in basketball: Current trends and future directions. *J Strength Cond Res*. 2017;31(7):2021-9.
7. Malone JJ, Murtagh CF, Morgans R, Burgess DJ, Morton JP, Drust B. Countermovement jump performance is not affected during an in-season training microcycle in elite youth soccer players. *J Strength Cond Res*. 2015;29(3):752-7.
8. Thorpe RT, Strudwick AJ, Buchheit M, Atkinson G, Drust B, Gregson W. The influence of changes in acute training load on daily sensitivity of morning-measured fatigue variables in elite soccer players. *Int J Sports Physiol Perform*. 2016;5:S2-107-S2-113.
9. Hooper SL, Mackinnon LT. Monitoring overtraining in athletes. *Sports Med*. 1995;20(5): 321-7.
10. Kentta G, Hassmen P. Overtraining and recovery. A conceptual model. *Sports Med*. 1998;26(1):1-16.
11. Zurutuza U, Castellano J, Echeazarra I, Casamichana D. Absolute and relative training load and its relation to fatigue in football. *Fronteirs*. 2017;8:878.
12. Casamichana D, Castellano J. Relationship between indicators of intensity in small-sided soccer games. *J Hum Kinet*. 2015;46(1):119-28.
13. Castellano J, Casamichana D. Differences in the number of accelerations between small-sided games and friendly matches in soccer. *J Sports Sci Med*. 2013;12(1):209-10.
14. Akenhead R, Hayes P, Thompson K, French D. Diminutions of acceleration and deceleration output during professional football match play. *J Sci Med Sport*. 2013;6:556-61.
15. Varley MC, Fairweather IH, Aughey RJ. Validity and reliability of GPS for measuring instantaneous velocity during acceleration, deceleration, and constant motion. *J Sport Sci*. 2012;30:121-7.
16. Foster C. Monitoring training in athletes with reference to overtraining syndrome. *Med Sci Sports Exerc*. 1998;30(7):1164-8.
17. Singh F, Foster C, Tod D, McGuigan MR. Monitoring different types of resistance training using session rating of perceived exertion. *Int J Sports Physiol Perform*. 2007;2:34-5.
18. Wallace LK, Slattery KM, Coutts AJ. A comparison of methods for quantifying training load: Relationship between modeled and actual training response. *Eur J Appl Physiol*. 2014;114(1):11-20.
19. Williams S, Trewartha G, Cross MJ, Kemp SPT, Stokes KA. Monitoring what matters: A systematic process for selecting training load measures. *Int J Sports Physiol Perform*. 2016;12(2):101-6.
20. Coutts A, Wallace L, Slatery K. Monitoring training load. *Sports Coach*. 2004;27(1):1-4.
21. Impellizzeri FM, Rampinini E, Coutts AJ, Sassi A, Marcora SM. Use of RPE-based training load in soccer. *Med Sci Sports Exerc*. 2004;36(3):1042-7.
22. Lambert MI, Borresen J. Measuring training load in sports. *Int J Sports Physiol Perform*. 2010;5:406-11.
23. Batterham AM, Hopkins WG. Making inferences about magnitudes. *Int J Sports Physiol Perform*. 2006;1:50-7.
24. Lupo C, Tessitore A, Gasperi L, Gomez M. Session-RPE for quantifying the load of different youth basketball training sessions. *Biol Sport*. 2017;34(1):11-7.
25. Anderson L, Triplett-McBride T, Foster C, Doberstein S, Brice G. Impact of training patterns on incidence of illness and injury during a women's collegiate basketball season. *J Strength Cond Res*. 2003;17:734-8.
26. Scanlan AT, Wen N, Tucker PS, Dalbo VJ. The relationship between internal and external load models during basketball training. *J Strength Cond Res*. 2014;28(9):2397-405.
27. Osiecki R, Rubio TBG, Luz Coelho R, Novack LF, Conde JHS, Alves CG, *et al*. The Total Quality Recovery Scale (TQR) as a Proxy for Determining Athletes' Recovery State after a Professional Soccer Match. *J Exerc Physiol Online*. 2015;18(3):27-32.
28. Hulin BT, Gabbett TJ, Lawson DW, Caputi P, Sampson JA. The acute:chronic workload ratio predicts injury: high chronic workload may decrease injury risk in elite rugby league players. *Br J Sports Med*. 2015;50(4):231-6.
29. Ferioli D, Bosio A, La Torre A, Carlomagno D, Connolly DR, Rampinini E. Different training loads partially influence physiological responses to preparation period in basketball. *J Strength Cond Res*. 2017;1-26.