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Individual Recovery Profiles in Basketball Players

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Abstract. In the sport context, recovery has been characterized as a multifactor process (physiological, psychological, behavioral, social, etc.). This study takes a multidisciplinary approach to find psychophysiological markers of the stress-recovery process. It aims to determine how athletes' specific recovery actions relate to their perceptions of recovery, and Heart Rate Variability (HRV). A total of 196 assessments were analyzed from 6 players on a men's professional basketball team within the Liga LEB Oro basketball federation (2012/2013 season). Perceptions of recovery, recovery strategies, and HRV were recorded. The results show a pattern of individual differences in behavior related to athletes' recovery actions and HRV profiles throughout the season ($p < .05$). Moreover, we observed that each player had different recovery needs. In light of these results, we suggest an individualistic approach to evaluating and monitoring recovery to attend more accurately to each player's recovery needs.

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In the competitive sport sphere, recovery (Brink, Nederhof, Visscher, Schmikli, & Lemmink, 2010; Jougla, Micallef, & Mottet, 2010; Tessitore et al., 2008; Wahl et al., 2013), the study of perceptions of recovery (Brink, Visscher, Coutts, & Lemmink, 2012; Laurent et al., 2011; Venter, 2014), and injured athletes' psychological response to recovery have received considerable attention in research, the goal being to reduce the time it takes to return to play (Ardern, Taylor, Feller, Whitehead, & Webster, 2013).

On a conceptual level, there has been a lack of consensus and clarity in how the literature defines recovery itself, and what exactly that entails (Kellman, 2002). Kellman and Kallus (2001) hold that recovery is both an inter-individual and intra-individual process (psychological, physiological, social, etc.) that re-establishes performance-related skills. They add that recovery has an activity-oriented component to systematically optimize the conditions of a situation. The same authors (Kallus, 1995; Kallus & Kellman, 2000) describe recovery from a psychophysiological perspective as a gradual, cumulative process involving various strategies and needs, which depend on the individual athlete. They highlight the individualistic and situational aspects of treatment.

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One of the factors primarily responsible for overload or overtraining syndrome is insufficient recovery after intense physical training. Respondign to the need to pinpoint likely causes of overtraining and their role in the recovery process, Kenttä and Hassmén (1998) identified four main recovery-focused categories: nutrition/hydration, sleep/rest, relaxation/emotional support, and stretching/active rest. Using those categories, the authors proposed a practical, noninvasive method to monitor recovery state, the Total Quality Recovery (TQR) scale. It has two components: *perceived* recovery, tested on a scale analogous to Borg's Rating of Perceived Exertion (Borg, 1998); and recovery *actions* or behaviors, which fall into the 4 categories mentioned above, with each behavior assigned a score. While that system was innovative, people have questioned its applicability due to its difficulty and, consequently, low completion rates in athletes (Laurent et al., 2011). Furthermore, new technologies must be taken advantage of, which can also facilitate data collection in applied sport contexts (Dellaserra, Gao, & Ransdell, 2014). That being said, the aforementioned categories have been widely studied. Recent literature across different disciplines, and from different perspectives, has focused especially on examining the effectiveness of strategies to enhance athletes' recovery and well-being. Examples include nutrition and hydration (Erkmen, Taskin, Kaplan, & Sanioglu, 2010; Kreider et al., 2010), sleep and rest (Lahart et al., 2013; Leeder, Glaister, Pizzoferro, Dawson, & Pedlar, 2012; Mah, Mah, Kezirian, & Dement, 2011), and relaxation training (Elliott, Polman, & Taylor, 2014). On another note, it has been observed that steady accumulation in training load, followed by sufficient recovery, can improve performance (Halson & Jeukendrup, 2004; Meeusen et al., 2006); thus, planning training sessions is an important aspect of recovery.

On another note, to evaluate an athlete's recovery and response to training and competition, associated symptoms must be analyzed. Fry, Morton, and Keast (1991) posit four categories to analyze an athlete's response: physiological symptoms, psychological symptoms, biochemical symptoms, and immunological symptoms. On a physiological level, one of the most relevant and widely studied measures in the sport sphere is Heart Rate Variability (HRV). HRV analysis is well-established as a highly useful tool in the context of sport and health to assess states of overtraining (Kiviniemi, Tulppo, Hautala, Vanninen, & Uusitalo, 2014), fatigue (Leti & Bricout, 2013), and changes in the stress-recovery process (Morales et al., 2014). HRV has also been proposed to indicate stress, health (Capdevila et al., 2008; Thayer, Ahs, Fredrikson, Sollers, & Wager, 2012), and precompetitive anxiety (D'Ascenzi et al., 2014; Mateo, Blasco-Lafarga, Martínez-Navarro, Guzmán, & Zabala, 2012).

In addition to an interest in studying HRV as a marker in multiple phenomena, there has been growing interest in how to meaure it. HRV recording systems have ranged from electrocardiogram (ECG) (Cassirame, Stuckey, Sheppard, & Tordi, 2013; Toufan, Kazemi, Akbarzadeh, Ataei, & Khalili, 2012) to more accessible systems like heart rate monitors (Gamelin, Baquet, Berthoin, & Bosquet, 2008; Parrado et al., 2010), to indirect measures using techniques such as photoplethysmograph (Capdevila, Moreno, Movellan, Parrado, & Ramos-Castro, 2012; Poh, McDuff, & Picard, 2010) or ballistocardiograph (Friedrich, Aubert, Fuhr, & Brauers, 2010; Ramos-Castro et al., 2012). These advancements in recording methodology are making it easier to record and analyze HRV in a less invasive, less costly manner, especially in the applied sport context. Given these considerations, it is important to mention that the complexity of the process, and the various factors it involves, mean that recovery – as well as issues like Overtraining Syndrome – must be addressed from a multidisciplinary perspective (Meeusen et al., 2006), whether from the point of view of prevention or treatment.

The present study's objective is, over the course of a season, to analyze the relationship between certain recovery behaviors used by athletes, their perceptions of recovery, and HRV in a sample of elite basketball players. By way of hypothesis, we expect to observe differences between players – or individual profiles – in terms of recovery behaviors and HRV, and that recovery behaviors will correlate positively with perceived recovery and parameters that indicate high heart rate variability.

Method

The procedure and recording systems utilized in this study were approved by the Independent Ethics Committee at the authors' university. The university has an official, signed aggreement with the club to which these athletes belong specifying the conditions approved by the committee. All study data remained confidential, and the Spanish law governing the protection of personal information was upheld.

Participants

A total of 196 recordings were taken from 6 players on a men's professional basketball team belonging to the Liga LEB Oro basketball federation (2012/2013 season). The players' average age was 20 years old (*SD*: 2.28), and their average height was 200.8 cm (*SD*: 8.18). All the players voluntarily agreed to participate in this study, and we received informed consent from them and from club medical staff.

Measures and Instruments

Individual assessments measured the following aspects:

Perceptions of recovery

This was evaluated using the Total Quality Recovery perceived scale (TQRper: Kenttä & Hassmén, 1998). Scores on this instrument range from 6 to 20, where "6" corresponds to *no recovery at all*, and "20" to *maximal recovery*.

Recovery behaviors

To record specific recovery behaviors and actions, the Total Quality Recovery action (TQRact) scale was utilized; it is the second half of Kenttä and Hassmén's TQR (1998). It taps 12 specific recovery behaviors, grouped into 4 thematic areas (Nutrition/Hydration, Sleep/Rest, Relaxation/Emotional Support, and Stretching/Warm-down). Each behavior is scored out of a total of 20 possible points (Recovery Points, RPs) based on their importance (Table 1). As Kenttä and Hassmén (2002) indicate, the behaviors may be adapted to better fit the specific demands of each sport and each individual player's needs. In this study, we modified certain behaviors and explanations slightly to better fit the context of the players being assessed. After consulting with two trainers for the basketball federation, the criterion we applied was to modify any behaviors not practiced within this specific basketball club, or for which players would need further explanation. Specifically, we substituted the behavior "*rápido restablecimiento de carbohidratos en conjunción*

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Table 1. *Recovery Points (RPs) on the TQRact Scale for Each Recovery Area and Recovery Behavior*

Recovery Areas and Behaviors	RPs
Nutrition and Hydration	
Breakfast	1 point
Mid-day lunch	2 points
Dinner	2 points
Snacks between meals	1 point
Fast carbohydrate refueling in conjunction with training	2 points
Adequate hydration given training conditions	2 points
Area Total	10 points
Sleep and Rest	
Full night of quality sleep	3 points
Nap during the day	1 point
Area Total	4 points
Relaxation and Emotional Support	
Full mental/muscular relaxation after practice	2 points
Psychological recovery	1 point
Area Total	3 points
Stretching and Warm-Down	
Adequate cooldown after practice	2 points
Stretching to improve recovery	1 point
Area Total	3 points
Total of all Recovery Areas	20 points

con el entrenamiento [fast carbohydrate refueling in conjunction with training]" for "*tomar un batido energético prescrito por los servicios médicos* [drink an energy shake prescribed by medical staff]" (2 RP); and the behavior "*hidratación correcta en relación a las condiciones de entrenamiento* [adequate hydration given training conditions]" was divided in two to be more specific: "*tomar 2 litros de agua durante el día* [drinking 2 liters of water throughout the day" (1 RP) and "*realizar una correcta hidratación post entrenamiento* [adequate hydration post workouts]" (1 RP). Players were asked to respond *Yes* or *No* to each recovery behavior listed according to whether or not they had used it.

Analysis of Heart Rate Variability (HRV)

HRV data were obtained using the ballistocardiography technique, using accelerometers mounted to next-generation moving microchips (Ramos-Castro et al., 2012). Specifically, we utilized the 3-axis accelerometer built into the iPhone 4, iPhone 4S, and iPhone 5 (Apple) devices using an application developed specifically for this study. Each recording's R-R interval (time in milliseconds between consecutive heart beats for 5 minutes) was also collected through ballistocardiography, which analyzes the mechanical vibrations produced as the heart contracts with each beat, and which other studies have utilized similarly (Friedrich et al., 2010). HRV was tested for 5 minutes, with the player completely at rest, laying on his back, and breathing freely.

Procedure

Education Phase

To interfere as little as possible with the routine and training of the players and technical staff, an application was designed for mobile devices (smart phones) ad hoc so players could complete the assessments from their own smart phones. This application enabled us to collect all the measures described above in Measures and Instruments. Before beginning to collect data, a training session was held to give players information and explain how the application would work. This stage was crucial for the players, who were unfamiliar with the instruments they would use and who, as Seiler and Sjursen (2004) suggest, had to learn to calibrate their perceptions to be consistent over the course of the study.

Data Collection Phase: Measuring R-R and Calculating HRV Parameters

This paper presents a study with a repeated measures design. Those measures were collected over the course of the team's regular season. Coaching staff agreed to the study procedure. Players completed the assessments on their own between 8:00 and 10:00am, before their daily training session and after fasting, strictly adhering to the instructions provided. HRV data were analyzed individually. Z axis data from the accelerometer (mounting the device to the chest) were utilized to detect heart beat. A pass-band filter was used to filter the acceleration signal, specifically, a 4th-order Butterworth-type response filter with 6Hz and 25Hz frequency cut-off points. After filtering, the signal's energy was estimated and compared to baseline. The algorithm looks for the maximum amplitude between two consecutive threshold crossings with different slope, and its position on the energy signal. In addition to the position of the maximum, the algorithm finds the minimum of the acceleration signal corresponding to isovolumetric contraction (Ramos-Castro et al., 2012). HRV parameters were later computed according to the recommendations of the Task Force of the European Society of Cardiology, and the North American Society of Pacing and Electrophysiology (1996). Those parameters included: the mean of R-R intervals (RRmean), average heart rate (HRmean), standard deviation of R-R intervals (SDNN), root mean square of successive differences (RMSSD), percentage of consecutive R-R intervals differing by more than 50ms (pNN50), and high to low frequency ratio (LF/HF).

Data Analysis

To analyze whether the 6 players showed individual differences in terms of recovery behaviors and HRV parameters, a simple (one-way) analysis of variance was done, comparing each player's set of recordings and using a post hoc test to make partial comparisons between players. According to the Levene statistic, all the variables analyzed using this one-way ANOVA showed equality of variance. To analyze the relationship between recovery behaviors, HRV parameters, and perceptions of recovery, Spearman's correlation coefficient (Rho) was utilized. A level of significance of 0.05 was applied to both tests. For the data analysis, the SPSS statistical package (v. 21) for Mac OS X was utilized.

Results

Recovery Behaviors

Examining the 6 players' scores on all areas of recovery, as well as total scores (Table 2), significant differences were observed between them. Analyzing the partial comparisons among players, we found patterns of behavior that differentiated each player significantly from the rest. For example, players 2 and 4 had lower Nutrition scores, on average, than the others (CI 95%, mean diff. between Player 2 and Player 1: –4.33, –1.99; p = .001; CI 95%, mean diff. between Player 4 and Player 1: –5.01, –2.6; p = .001). In terms of Hydration, Player 4 scored significantly higher than the other players on average (CI 95%, mean diff. between Player 4 and Player 6: –2.03, –1.42; p = .001). It was again Player 4 who scored lower on Sleep and Rest, differing significantly from 4 players: Player 1 (CI 95%, mean diff. between Player 4 and Player 1: –1.59, –0.18; p = .003), Player 3 (CI 95%, mean diff. between Player 4 and Player 3: –1.93, –0.21; p = .004), Player 5 (CI 95%, mean diff. between Player 4 and Player 5: –2.11, –0.33; p = .001), and Player 6 (CI 95%, mean diff. between Player 4 and Player 6: –2.11, –0.56; p = .001). Last, Players 2 and 4 scored significantly lower than the others on total Recovery Points (CI 95%, mean diff. between Player 2 and Player 1: –7.09, –3.17; p = .001; CI 95%, mean diff. between Player 4 and Player 1: –10.45, –6.41; p = .001).

Heart Rate Variability

Significant differences were observed between the 6 players on all the HRV parameters analyzed (Table 3). As in the case of recovery behaviors, on HRV parameters too we found patterns distinguishing each player from the rest. Player 1 had a higher RRmean, differentiating him significantly from the other players (CI 95%, mean diff. between Player 1 and Player 2: 137.4, 294.76; $p < .05$). Similarly, Player 2's HRmean was significantly higher than the other players (CI 95%, mean diff. between Player 2 and Player 1: 8.06, 16.36; $p < .05$). On the parameter SDNN, Players 1 and 5 scored significantly lower on average than the others (CI 95%, mean diff. between Player 1 and Player 2: –97.95, –42.47; $p < .05$; CI 95%, mean diff. between Player 5 and Player 2: –130.31, –52.77; $p < .05$). The RMSSD parameter, too, significantly ($p < .05$) discriminated two distinct groups of players: low RMSSD (players 1, 5, and 6) and high RMSSD (players 2, 3, and 4).

Individual Player Profiles

Next, we analyzed the relationship between recovery behaviors, perceptions of recovery (Table 4), and the HRV parameters, finding clearly defined individual profiles. That is, based on the HRV parameters and recovery variables that were found to be significant, each player showed a distinct pattern. For Player 1, the only correlation observed was between Stretching/Warm-down and LF/HF ratio (*rho* = 0.273, p = .032). For Player 2, significant correlations occurred between Stretching/Warm-down and every HRV parameter except LF/HF: RRmean (*rho* = 0.518, p = .016), HRmean (*rho* = –0.518, p = .016), SDNN (*rho* = 0.470, p = .032), RMSSD (*rho* = 0.437, p = .047), and pNN50 (*rho* = 0.502, p = .02). For Player 3, significant differences were observed between Perceptions of Recovery and 3 areas of Recovery Action: Sleep/Rest (*rho* = 0.517, p = .012), Relaxation/Emotional Support (*rho* = 0.457, p = .028), and Stretching/Warm-down (*rho* = 0.426, p = .043). For the same player (3), correlations were observed between Nutrition and the parameters RRmean (*rho* = 0.622, p = .013) and HRmean (*rho* = –0.622, p = .013). For Player 4, the only correlation found was between Perceptions of Recovery and Sleep/Rest (*rho* = 0.551, p = .005). For Player 5, Perceived Recovery was found to correlate with Sleep/Rest (*rho* = 0.487, p = .029), as well as Recovery Points (*rho* = 0.470, p = .036). For the same player (5), correlations were also observed between Hydration and the parameters RMSSD (*rho* = 0.593, p = .033) and LF/HF (*rho* = –0.556, p = .049), and between the parameter RMSSD, and Recovery Points (*rho* = 0.759, p = .003) as well as Perceptions of Recovery (*rho* = 0.779, p = .002). Finally, for Player 6, Perceptions of Recovery was correlated with both Nutrition (*rho* = 0.473, p = .003) and Recovery Points (*rho* = 0.406, p = .013).

Discussion

This study's objective was to analyze the relationship between behaviors geared toward improving recovery,

Table 2. *Each Player's Average Points (RPs) and Standard Deviations on the TQRact Recovery Areas, and Perceptions of Recovery from the TQRper Scale, with significance level (p) of the Analysis of Variance (ONE-WAY) and the Sample's Average Total Scores*

	Player 1	Player 2	Player 3	Player 4	Player 5	Player 6		Total
Recovery Areas and Perceptions of Recovery	(66 recorded)	(26 recorded)	(23 recorded)	(24 recorded)	(20 recorded)	(37 recorded)	*p*	(196 recorded)
Nutrition								
(Ranging from 0 to 8)	6.97 ± 1.61	3.81 ± 2.1	6.61 ± 0.94	3.17 ±1.76	6.75 ± 1.07	6.08 ± 2.01	< 0.001	5.85 ± 2.2
Hydration								
(Ranging from 0 to 2 points)	1.91 ± 0.29	1.08 ± 0.48	1.61 ± 0.5	0.25 ± 0.53	1.05 ± 0.51	1.97 ± 0.16	< 0.001	1.48 ± 0.7
Sleep and Rest								
(Ranging from 0 to 4 points)	3.47 ± 1.08	2.96 ± 1.46	3.65 ± 0.49	2.58 ± 1.32	3.8 ± 0.7	3.92 ± 0.28	< 0.001	3.43 ± 1.07
Relaxation and Emotional Support								
(Ranging from 0 to 3 points)	2.62 ± 0.92	2.92 ± 0.39	2.3 ± 1.02	1.67 ± 1.01	1.75 ± 1.02	2.57 ± 0.93	< 0.001	2.41 ± 0.99
Stretching and Warm-down								
(Ranging from 0 to 3 points)	2.55 ± 1.03	1.62 ± 1.53	1.61 ± 0.89	1.42 ± 1.06	1.6 ± 0.94	2.54 ± 0.99	< 0.001	2.08 ± 1.18
Recovery Points								
(Ranging from 0 to 20 points)	17.52 ± 3	12.38 ± 3.45	15.78 ± 2.56	9.09 ± 2.69	14.95 ± 1.91	17.08 ± 2.78	< 0.001	15.26 ± 4.01
Perceptions of Recovery								
(Rango de 6 a 20 points)	15.58 ± 2.87	11.92 ± 2.42	15.04 ± 2.21	13.88 ± 1.65	17.8 ± 2.53	16.76 ± 1.85	< 0.003	15.27 ± 2.91

Note: The values indicated are Recovery Points (RPs) on the TQR, and are expressed as Mean ± SD.

Table 3. *Each Player's Mean Scores and Standard Scores on HRV Parameters, with Significance Level (p) of the Analysis of Variance (ONE-WAY), and the Sample's Average Total Scores*

	Player 1	Player 2	Player 3	Player 4	Player 5	Player 6		Total
HRV Parameters	(62 recorded)	(21 recorded)	(15 recorded)	(21 recorded)	(13 recorded)	(36 recorded)	*p*	(168 recorded)
RRmean	1159.39 ± 121.69	943.31 ± 111.51	1046.12 ± 109.5	1015.94 ± 73.34	1059.31 ± 66.4	1070.71 ± 127.42	< .001	1070.71 ± 127.42
HRmean	52.3 ± 5.4	64.51 ± 8.03	57.91 ± 5.7	59.35 ± 4.2	56.86 ± 3.72	58.19 ± 5	< .001	56.82 ± 6.76
SDNN	87.25 ± 30.07	157.46 ± 66.71	123.65 ± 20.18	137.59 ± 28.96	65.92 ± 15.78	121.42 ± 38.06	< .001	111.24 ± 45.66
RMSSD	84.54 ± 37.07	153.41 ± 64.58	121.64 ± 21.61	139.73 ± 26.74	72.69 ± 32.21	92.18 ± 50.97	< .001	104.08 ± 49.92
pNN50	38.6 ± 21.37	58.4 ± 12.57	59.77 ± 8.95	67.88 ± 8.06	42.58 ± 13.97	53.49 ± 14.24	< .001	50.12 ± 19.23
LF/HF	2.26 ± 1.56	1.09 ± 1	1.12 ± 1.02	0.68 ± 0.64	0.65 ± 0.31	1.92 ± 1.51	< .001	1.62 ± 1.43

Note: All values are expressed as mean ± SD; RRmean: mean of R-R intervals; HRmean: average heart rate; SDNN: standard deviation of R-R intervals; RMSSD: square root of the mean squared differences between sucessive R-R intervals; pNN50: percentage of consecutive R-R intervals differing by more than 50ms; LF/HF: high to low frequency ratio.

Table 4. *Correlations (Spearman's Rho) between Recovery Areas on the TQRact Scale, and Perceptions of Recovery on the TQRper Scale for Each Player*

	Perceptions of Recovery					
	Player 1	Player 2	Player 3	Player 4	Player 5	Player 6
Recovery Areas	(66 recorded)	(26 recorded)	(23 recorded)	(24 recorded)	(20 recorded)	(37 recorded)
Nutrition	Rho = −0.099 NS	Rho = 0.008 NS	Rho = −0.022 NS	Rho = 0.204 NS	Rho = 0.373 NS	Rho = 0.473 p = .003
Hydration	Rho = −0.104 NS	Rho = −0.206 NS	Rho = −0.041 NS	Rho = 0.220 NS	Rho = 0.022 p = .927	Rho = −0.058 NS
Sleep and Rest	Rho = 0.212 NS	Rho = 0.044 NS	Rho = 0.517 p = .012	Rho = 0.551 p =.005	Rho = 0.487 p = .029	Rho = 0.035 NS
Relaxation and Emotional Support	Rho = 0.141 NS	Rho = 0.136 NS	Rho = 0.457 p = .028	Rho = −0.164 NS	Rho = 0.139 NS	Rho = −0.097 NS
Stretching and Warm-down	Rho = −0.057 NS	Rho = 0.084 NS	Rho = .426 p = .043	Rho = −0.313 NS	Rho = 0.107 NS	Rho = 0.164 NS
Recovery Points	Rho = 0.038 NS	Rho = 0.036 NS	Rho = 0.352 NS	Rho = 0.260 NS	Rho = 0.470 p = .036	Rho = 0.406 p = .013

perceptions of recovery, and HRV in a sample of elite basketball players. We hypothesized that individual profiles of recovery behavior and HRV would surface. We also expected to find a positive correlation between the recovery behaviors studied and perceptions of recovery, as well as indicators of heart rate variability.

The results presented in this study expose individual differences in patterns of recovery-related behavior and HRV over the course of an elite sport season. A relationship was found between the recovery behaviors studied, perceptions of recovery, and HRV parameters, confirming our hypothesis. Nevertheless, the results reflect no systematic relationship or trend across the entire group. Instead, patterns occurred on an individual level, reiterating the need to personalize this type of data analysis.

This study evaluated the areas of recovery covered by Territorial Kenttä and Hassmén's TQR scale (1998). It is important to consider that most of the behaviors, or strategies, this scale measures – which aim to facilitate and enhance athletes' recovery – are proactive. That is, the player is responsible for carrying out the strategy himself, for example, following the rules of nutrition and hydration, or getting adequate rest. In this study, different patterns emerged of players engaging in proactive behavior. Processes of education and learning are essential for coaches and players alike to facilitate proactive recovery (Bird, 2011). Other types of recovery behavior or strategy – both passive (massage, icing, hot baths, sauna) and active (muscle relaxation or stretching) – generally take place at the training site and under the direction of sport professionals (coaches, physicians, or trainers), so they are not the player's responsibility and tend to always get done. One limitation of this study is that it did not detect those other types of strategy. Nevertheless, since all these players were on the same team, we may hypothesize that they received the same type of attention from sport professionals.

In this study, we also saw that players respond differently to the prescribed strategies, whether subjectively, through perceptions of recovery, or objectively, through alterations in heart rate variability. Thus, in some players, we observed perceptions of recovery to be significantly related to Sleep/Rest, while in others, they were significantly related to Nutrition or Stretching/Warm-down. Similarly, the benefits observed in HRV also varied by player. These different responses to the same recovery plans may reflect each player's individual needs. In that sense, some authors (Burke, Loucks, & Broad, 2006; Jeukendrup, 2011) conclude that nutritional plans ought to be individualized to enhance their benefits. We believe this could extend to other recovery-related areas and strategies. It would be interesting to prescribe adapted, personalized recovery strategies tailored to the individual player, emphasizing the most beneficial ones and having them do on a daily basis those they currently do less regularly. In that vein, we believe it is important to analyze a player's lifestyle during the recovery process since it has been identified as a factor responsible for overtraining and low sport performance (Lehmann, Foster, Gastmann, Keizer, & Steinacker, 1999). Following Kenttä and Hassmén's (2002) recommendations, we propose using the TQR scale and adapting the recovery-related behaviors or strategies to the particular context of the team or player being assessed.

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Venter (2014) studied players' perceptions of how much recovery modalities matter, reporting individual differences in the importance they attributed to different modalities. She also concluded that even members of the same team have different perceptions, suggesting players' different needs should be addressed by individualized recovery protocols. In looking at individualized patterns and indicators of recovery, Hanin (2002) recommended evaluating these needs from a multidimensional perspective. In that sense, one of the instruments with the greatest advantages is the Recovery-Stress Questionnaire for Athletes (RESTQ-Sport) by Kellman and Kallus (2001). The RESTQ-Sport, used in many follow-up studies on the stress-recovery process or overtraining (Brink et al., 2012; Di Fronso, Nakamura, Bortoli, Robazza, & Bertolio, 2013; Nederhof, Zwerver, Brink, Meeusen, & Lemmink, 2008), allows researchers to identify what recovery-related areas players perceive as lacking, among other aspects. It will be especially important to conduct studies that further explore using this type of instrument to evaluate recovery strategies' efficacy from the standpoint of individualization.

One feature of the studies and tools assessing the recovery process is that they lack in-depth analysis of the qualitative component of recovery (Bird, 2011; Laurent et al., 2011). Although the training stage of our study did emphasize the qualitative component of each behavior, data collection captured only whether or not the behavior occurred. While some of the behaviors listed include a qualitative element (e.g. "*noche completa de descanso de calidad* [good night of quality sleep]"), other areas like Nutrition do not explicitly do so. We believe it is important for future research to record and evaluate both components of recovery strategies: qualitative and quantitative. In a study analyzing the effects of sleep on performance in basketball players, Mah et al. (2011) reported that players had difficulty measuring precisely how much sleep they got, concluding that athletes have erroneous perceptions about their rest. This tells us new methods are needed – whether in the form of self-report, questionnaire, or mobile device applications (apps) – to help athletes more precisely evaluate the recovery strategies they use.

We also observed differences in the 6 players' HRV parameters over the course of the season. Some authors (Meeusen et al., 2006) argue there is a need to standardize HRV parameters. However, published studies have reported numerous HRV-related differences, especially in the sport context, as a function of sport modality (Mal'tsev, Mel'nikov, Vikulov, & Gromova, 2010; Moreno, Parrado, & Capdevila, 2013), training load (Bricout, DeChenaud, & Favre, 2010), and individual differences, as our study found. Moreover, some studies (Grant, Murray, Janse van Rensburg, & Fletcher, 2013; Toufan et al., 2012) have observed very high standard deviations on parameters like SDNN and RMSSD, indicating highly dispersed, non-homogeneous values on those parameters. The occurrence of individual differences casts doubt on whether HRV parameters really need be standardized; with that in mind, we suggest that analysis and interpretation instead be done on an individual basis. Hence, this study presented and analyzed HRV data for each player, not for the sample as a whole.

On another note, we wish to point out that in this study, HRV was recorded using the ballistocardiography technique, taking advantage of the accelerometers already built into players' smart phones. Ballistocardiography has been shown to be a valid, noninvasive, and very accessible option that avoids using heart rate monitors, chest straps rigged with electrodes, or other external sensors to detect changes in the cardiovascular system (Bruser, Stadlthanner, Brauers, & Leonhardt, 2010; Castiglioni et al., 2011), especially in HRV analysis (Friedrich et al., 2010; Ramos-Castro et al., 2012). These results indicate it may be a good way to measure HRV in applied sport contexts where fast, easy-to-use tools are required to carefully follow recording protocols. Using this type of moving microchip also enabled us to measure recovery behaviors and perceptions of recovery after training on a daily basis, making it a good tool and an alternative to self-report measures or questionnaires. Laurent et al. (2011) suggest that tools be developed to assess recovery from an interdisciplinary standpoint (based on physiological, psychological, and emotional responses), which would be particularly advantageous in the sport context. Building on that, we propose that moving microchips – like the ones embedded in smart phones and tablets (which are usually present at training and competition sites) – be used as everyday tools to record multiple variables at once. Furthermore, everyday, systematic use of this integrated methodology could be highly useful as a complementary indicator of a player's stress-recovery balance, helping to prevent states like overtraining, which do not have one single marker, but many (Meeusen et al., 2006).

We believe several implications may be derived from this study in terms of intervention and monitoring athletes' stress-recovery states. First of all, we suggest creating more individualized recovery programs. We saw that different players responded differently to the same recovery strategies, indicating that particular attention should be paid to individual differences in prescribing programs to improve recovery. With regard to HRV analysis, we observed differences in temporal and spectral paramaters across players,

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so we believe that using this indicator to generate total scores for a team, or as a barometer for an entire population of athletes, would lead to errors of interpretation. Thus, if HRV is considered an individual marker in the stress-recovery process, HRV data should be analyzed and interpreted such that only intraindividual parameters are used for reference or comparison. Finally, we propose using moving microchips to evaluate psychophysiological variables, because they facilitate data collection in the real-life sport context.

This study's results indicated individual differences in recovery-related patterns of behavior in athletes over the course of a season, and that the TQR is a good instrument to detect those differences. Similarly, HRV parameters seemed to show a specific pattern for each player. Therefore, we believe they should be interpreted on an individual basis, not as a group or in comparison to other barometers, especially in the applied context. We also saw that not all players exhibit the same relationship between recovery behaviors, perceptions of recovery, and HRV parameters, suggesting differences in recovery needs as a function of player. Furthermore, considering that recovery integrates physiological, psychological, and behavioral responses, it is important to develop tools to evaluate this phenomenon from an interdisciplinary perspective.

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