THE INFLUENCE OF A WEEKEND WITH PASSIVE REST ON THE PSYCHOLOGICAL AND AUTONOMIC RECOVERY IN PROFESSIONAL MALE HANDBALL PLAYERS

Lucas Carvalho Leme[1], Vinícius Flávio Milanez[2], Ricardo Santos Oliveira[1], Solange de Paula Ramos[1], Anthony Leicht[3] and Fábio Yuzo Nakamura[1]

[1]Universidade Estadual de Londrina – Londrina/PR, Brazil
[2]Department of Physical Education, Universidade do Oeste Paulista (Unoeste), SP, Brazil
[3]Institute of Sport and Exercise Science, James Cook University, Townsville, Australia

Original scientific paper
UDC: 796.322:796.071:796.612

Abstract:

This study aimed to examine the influence of a weekend of passive rest on the perceived stress and heart rate variability (HRV) in professional handball players. Fourteen elite athletes participated in the study (age 26.0±4.6 years; body mass 89.0 ±10.1 kg; body height 186.5±7.2 cm; practice 12.5±6.0 years). Stress symptoms via the *Daily Analysis of Life Demands for Athletes* (DALDA) questionnaire, time and frequency-domain to HRV indices were measured on Friday morning of a normal training load week and again after 72 hours of passive recovery. In response to the weekend without a scheduled match, the handball players significantly reduced their DALDA ‘worse than normal’ responses from 6.1±3.8 to 3.4±2.5 (ES 0.85). Further, changes in the root-mean-square difference of successive normal RR intervals (RMSSD) and standard deviation of all normal RR intervals (SDNN) were greater than the smallest worthwhile change over the weekend. These results highlight the positive role of a passive rest weekend for the psychological and autonomic recovery that should be considered during athletic training periodization.

Key words: *team sports, monitoring, heart rate variability, recovery methods, male players*

Introduction

It is widely recognized by coaches and athletes that the recovery process is as important as training stress for inducing physiological and psychological adaptations aiming to improve sports performance. It is also known that stress-recovery imbalance can lead to negative states, which can culminate with the overtraining syndrome (Kentta & Hassmen, 1998). Among the most popular recovery methods, such as massage, cold water immersion and nutritional interventions, the most obvious one is passive rest. For example, passive rest during the weekends with no competitive matches among team-sports athletes may act as a naturally refreshing period that can aid to restore the stress-recovery balance. Surprisingly, investigations on the effect of passive rest on sports performance and recovery are scarce. Nevertheless, as recently reviewed by Robson-Ansley, Blannin, and Gleeson (2007), passive rest combined with sufficient sleep may act as a ‘time-out’ period for athletes, preventing them from becoming totally preoccupied with their preparation and from excessive training-related stress.

It has been suggested that heart rate variability (HRV) and questionnaires like *Daily Analyses of Life Demands for Athletes* (DALDA) may be useful in identifying the physiological and psychological stresses imposed by training as well as the recovery process due to tapering (Coutts, Slattery, & Wallace, 2007; Buchheit, et al., 2010). HRV, a non-invasive measure of the cardiac autonomic control (Task-Force, 1996) is positively related to fitness improvement (Atlaoui, et al., 2007) and negatively affected by excessive training loads (Pichot, et al., 2002). More importantly, enhancement of parasympathetic activity can be clearly observed during an active recovery period (taper) following intensive training periods (Pichot, et al., 2002). Likewise, DALDA has been shown to be sensitive to periods of training and competitive stress, with sources/symptoms being accentuated during intensified training periods (Coutts, et al., 2007) and after matches (Nicholls, Backhouse, Polman, & McKenna, 2009). The reduction of training and competitive stressors leads to a parallel reduction of the number of “worse than normal” responses in DALDA (Coutts, et al., 2007). Despite the use of these important assessment tools, the impact of passive rest on cardiac autonomic control and perceived stress in team-sport players has not been examined.

During the competitive season, athletes typically experience passive rest over a weekend without competitive matches with the physiological and psychological benefits of this recovery practice requiring further clarification. Thus, the aim of the present study was to document the changes in HRV and stress reaction symptoms of professional handball players over a typical weekend (passive rest) with no scheduled matches. It was hypothesized that following a normal weekly training load, two days of passive rest over a weekend would significantly increase HRV and reduce perceived stress symptoms for athletes in the preparation for a new training cycle.

Methods

Participants

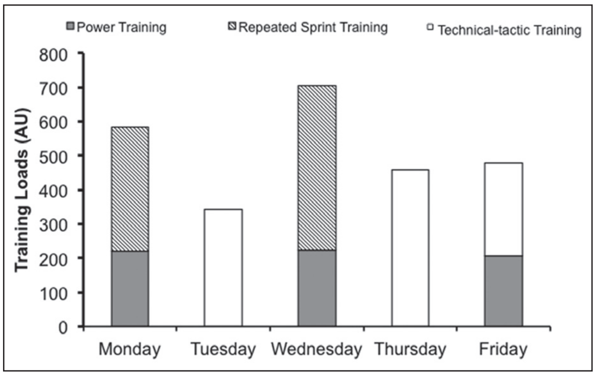
Fourteen elite male handball players (age 26.0±4.6 years; body mass 89.0 ±10.1 kg; body height 186.5±7.2 cm) volunteered for this study. They competed in the Brazilian National Division League and finished in second place at the 2011 Pan-American Championship. The study protocol was approved by the Institutional Ethics Committee and the athletes signed an informed consent form before the onset of the study.

Study design

Athletes completed the DALDA questionnaire followed by the recording of heart rate (HR) during 10 minutes of seated rest, prior to the start of the last training session of the week (i.e. Friday morning) and 72 hours later, prior to the first training session of the next week (i.e. Monday morning). There were no scheduled matches during the weekend and players were instructed to avoid exercise and activities aimed at accelerating recovery. The study was conducted at the end of the pre-season period when all athletes were of a high and similar physical fitness standard (e.g. Yo-Yo intermittent recovery test level 2: 418±120 m).

Variables

The training in the week preceding the weekend analyses was performed at the end of the 7-week pre-season, three weeks before the Pan-American Championship and was aimed at improving single and repeated sprint ability, muscular power and technical-tactical skills (Figure 1). Players undertook three sessions of power training on Monday, Wednesday and Friday mornings. On Monday and Wednesday afternoon the repeated sprint training was performed along with technic-specific activities (i.e. small-sided games with fast transitions to attack and defense). The technical-tactical sessions were administered in the afternoon of Tuesday, Thursday and Friday by the team's coach. There were no practice or competition games during the week.



Note: AU: arbitrary units.

Figure 1. The internal training load related by kind of training in the week preceding the weekend analyses.

To obtain the weekly training loads the rate perceived exertion of the session (session-RPE) method was used. For this purpose, the Portuguese version of the CR10 Borg scale (Borg, 2000) was used. The training loads were obtained daily by multiplying the duration (volume) of the session by the RPE (Foster, et al., 2001) reported by the athlete (intensity), assessed with a precision of 0.5. The RPE was obtained 30 minutes after the end of each session to minimize the influence of the last exercise bout intensity on the evaluation (Foster, et al., 2001). All athletes were previously familiarized with the use of the RPE scale as they had been using the method for approximately two months before the study. This method has been shown to be valid to measure training loads of athletes participating in team sports (Impellizerri, Rampinini, Coutts, Sassi, & Marcora, 2004).

The autonomic modulation of the sinoatrial node was assessed by HRV. For this purpose, HR and RR interval recordings were obtained from each athlete with a portable heart rate monitor (Polar RS800, Polar Electro, Kempele, Finland) at a sampling rate of 1,000 Hz (Gamelin, Berthoin, & Bosquet, 2006). The recordings were downloaded via commercial software (Polar Pro Trainer) and exported for later analysis of time and frequency domain measures of HRV. The time domain indices examined were: the root-mean-square difference of successive normal RR intervals (RMSSD), which reflects vagal modulations, and the standard deviation of all normal RR intervals (SDNN), which comprises both sympathetic and vagal cardiac modulations (Task-Force, 1996). During the 10-minute resting period, athletes remained seated with a spontaneous breathing frequency (Bloomfield, et al., 2001). The final 5-minute stationary period was analyzed for HRV with all RR intervals visually inspected, and ectopic beats (<3%) manually removed and replaced by the interpolation of adjacent RR intervals. The RR interval data was then exported for analysis of HRV using Kubios Heart Rate Variability software 2.0 (Biosignal Analysis and Medical Imaging Group at the Department of Applied Physics, University of Kuopio, Kuopio, Finland).

In order to measure athletes' perceived stress and recovery, athletes completed DALDA questionnaire on Friday and Monday at the same time of the day. Briefly, DALDA is divided into two parts (parts A and B) aimed at assessing the general stress sources and stress-reaction symptoms, respectively (Rushall, 1990). Part A contains nine general stress sources such as 'training and exercise', 'diet', and 'health'; and part B contains 26 stress-reactions such as 'muscle pain', 'tiredness', 'need for a rest', 'recovery time', 'between-sessions recovery', and 'training effort'. Athletes were asked to label, for all source and reaction symptoms, how they felt according to three possibilities: 'worse than normal', 'normal' and 'better than normal'. For analysis, the number of responses labeled 'worse than normal' was retained and analyzed separately for part A and B. The Portuguese version of DALDA questionnaire was translated and validated by Moreira and Cavazzoni (2009).

Statistical analysis

Data are presented as mean and standard deviations (SD). The effect size principle (Cohen, 1998) was used to interpret the difference in means between the days. The scale modified by Hopkins (www.sportsci.org/resource/stats) was used for the interpretation: <0.2: trivial; 0.2–0.6: small; 0.6–1.2: moderate; >1.2: large. The practical inference based on magnitudes (Hopkins, Marshall, Batterham, & Hanin, 2009) was applied to analyze the chance that the true value was beneficial, harmful or trivial. For this analysis, the minimal worthwhile change was calculated (0.20 times the between-subject variations in the first analyses) based on the Cohen's effect size principle (Cohen, 1998). The magnitude of change was expressed as a percentage (%) change with 90% confidence intervals. The chances of a beneficial increase in HRV parameters were assessed as follows: <0.5%: almost certainly not; 0.5–5%: very unlikely; 5–25%: unlikely; 25–75%: possible; 75–95%: likely; 95–99.5%: very likely; >99.5%: almost certain. If the chance that an increase was 10% for both the beneficial and harmful trends the true difference was assessed as 'unclear'. The effect size and the magnitude-based inferences were calculated by spreadsheets (Batterham & Hopkins., 2006) available at http://www.sportsci.org/.

Results

During the training week, players accumulated a total training load of 2,591±108 arbitrary units (AU) as quantified by the session-RPE method (Figure 1). There were no substantial changes in 'worse than normal' responses in Part A of the DALDA between the Friday and Monday sessions (ES 0.11). The number of 'worse than normal' responses in Part B of the DALDA was substantially reduced from Friday to Monday (Friday: 6.1±3.8; Monday: 3.4±2.5; ES 0.84). On Friday, the most common complaints in Part B of the DALDA were problems associated with between-session recovery, recovery time, need for a rest, tiredness and muscle pains.

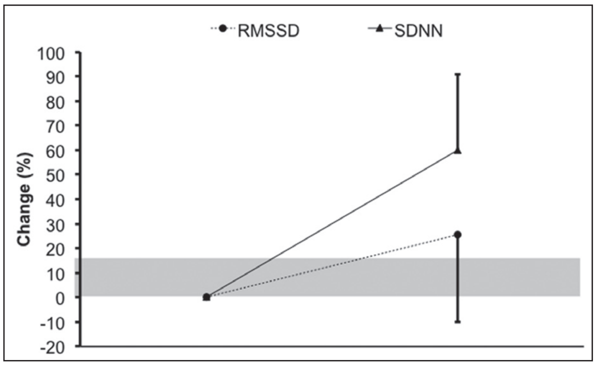
Changes in HRV indices prior to and following the 2-day rest weekend are shown in Table 1. A large ES for changes was detected for SDNN. Small ES for changes was detected for RMSSD. The magnitude of changes was considered 'almost certainly beneficial' for SDNN and 'likely beneficial' for RMSSD.

The magnitudes of change for the RMSSD and SDNN were greater than the smallest worthwhile change (Figure 2) and therefore practically important.

Table 1. Means (standards deviations) and magnitude of change for cardiac autonomic modulation indices before and after the rest weekend (n=14)

Variable	Friday	Monday	ES (90% CI) Rating	% Beneficial /trivial/ harmful	% change (90% CI)
SDNN (ms)	45.8 (16.4)	69.7 (12.3)	1.36 (0.77 – 1.94) Large	100/0/0 Almost certain	67.8 (33.1 – 93.4)
RMSSD (ms)	34.7 (20.0)	42.5 (16.4)	0.40 (-0.14 – 0.94) Small	77/21/3 Likely	38.9 (10.4 – 47.6)

ES: effect size. CI: confidence interval. %: percentage. SDDN: standard deviation of the normal RR intervals. RMSSD: the square root of the mean of the sum of the squares of differences between adjacent RR intervals.



Note: SDDN: standard deviation of the normal RR intervals, RMSSD: the square root of the mean of the sum of the squares of differences between adjacent RR intervals.

Figure 2. Percentage changes (± 90% confidence interval) for RMSSD and SDNN during a weekend of passive rest. The grey shadowed area corresponds to the smallest worthwhile.

Discussion and conclusions

Our findings indicate that professional handball players benefited significantly from passive rest over a typical weekend with no scheduled matches by increasing HRV indices and reducing perceived stress symptoms**.** This was evident by the large and very likely increase in the SDNN and 'likely beneficial' improvement of RMSSD. Further, Part B of the DALDA revealed less 'worse than normal' responses after the weekend. These results suggest that after a 2-day passive rest, players were in an enhanced physiological and psychological state for the training ahead compared to the end of the previous week.

The training load (2,591±108 AU), accumulated by the handball players during the week of observation, was in agreement with the values reported in the literature for team-sport athletes undertaking normal (habitual) training (Manzi, et al., 2009; Milanez, et al., 2011). However, during intensified training periods, the training loads can double in sports like futsal (Milanez, et al., 2011). The training loads in the current study were representative of a normal training routine and therefore unlike to be experienced during an overload period. Nevertheless, the number of 'worse than normal' responses (6.1±3.8) for Part B of the DALDA on Friday morning were consistent with those reported during intensified training periods in endurance (Coutts, et al., 2007) and team-sport athletes (Moreira, de Freitas, Nakamura, & Aoki, 2010). This higher response number appeared to be the result of several consecutive weeks of pre-season preparation and highlights significant stresses despite a normal training workload. Consequently, indicators of recovery (e.g. HRV, DALDA responses) and appropriate implementation of recovery practices are essential for athletes regardless of training workload. However, the lack of sensitivity of monthly HRV and psychometric measurements to track performance in handball athletes indicates that an approach using daily or weekly measurements is desirable for this population (Buchheit, 2014a).

Regarding DALDA responses, studies have suggested that the DALDA's part B is highly sensitive to changes in training loads. For instance, Milanez, Ramos, Okuno, Boullosa, and Nakamura (2014) have investigated the effects of alteration in training loads on the number of 'worse than normal responses' from DALDA's part B. The authors have shown a high non-linear relationship (R^2=.64–.89) between training load and the number of 'worse than normal' responses. In addition, Robson-Ansley et al. (2007) have observed increases in the symptoms of stress following periods of intensified training loads. Interestingly, increases in the number of 'worse than normal' responses of DALDA questionnaire were followed by changes in inflammatory markers suggesting that the questionnaire is more sensitive to acutely reflect the effects of highly intense training loads (Robson-Ansley, et al., 2007). Similar responses have been observed for endurance and team-sports athletes (Coutts, et al., 2007; Moreira, et al., 2010). Those results highlight the applicability of DALDA to measure stress in situations of accumulated training loads, which are essential for athletic performance.

Indeed, accumulated training load has been associated with the degree of physical fitness and performance improvement (Manzi, et al., 2009; Castagna, Impellizzeri, Chaouachi, Bordon, & Manzi, 2011). However, appropriate recovery has also been reported as necessary for stress-recovery balance for further physiological and psychological adaptations (Kentta & Hassmen, 1998; Kellmann, 2010). Accordingly, it appears intuitively that weekends without matches or other stressful commitments may provide a functional break that should be considered as an essential component of training plans. Similar to the current results, Nicholls, Jones, Polman, and Borkoles (2009) reported reduced stress symptoms on rest days when compared to training days for professional rugby union players. The reduction of stress-related symptoms in Part B of the DALDA confirms the role of passive rest for psychological well-being and readiness to begin a new training cycle.

The reduction of stress-related symptoms assessed by DALDA was also accompanied by improves in HRV. Studies have shown that HRV decreases during training periods with high training loads (Manzi, et al., 2009; Pichot, et al., 2002), and high baseline values of HRV are related to aerobic adaptability in team-sport players and individual athletes (Hautala, Kiviniemi, & Tulppo, 2009; Buchheit, 2014b). The SDNN, a global measure of both cardiac sympathetic and parasympathetic modulations (Task-Force, 1996), was significantly higher on Monday compared with Friday and represented a significant recovery of the cardiac autonomic nervous system within 72 hours. This recovery of the cardiac autonomic nervous system was further supported by the effects of passive rest 'likely beneficial' on RMSSD. Similar findings have been reported by Al-Haddad, Laursen, Ahmaidi, and Buchheit (2009), who showed that reduced night-time SDNN and high frequency (HF) after supramaximal intermittent exercise recovered 24 hours later to values similar to that exhibited prior to the exercise. Similarly, cross-country skiers demonstrated an accentuated rebound of vagal-related HRV indices two days after a 75 km race (Hautala, et al., 2001). In team sports, a recent study has shown that in young soccer players HF was lower on the match day when compared to the rest day (Bricout, Dechenaud, & Favre-Juvin, 2010). Jointly, the current and prior results emphasize the importance of passive rest during weekends for significant improvement of cardiac autonomic modulation and athletes' recovery.

As previously documented, excessive training and poor recovery can lead to non-functional overreaching and overtraining (Kentta & Hassmen, 1998) that may be manifested by the reduced HRV indices (Mourot, et al., 2004). Therefore, maintaining high levels of vagally mediated HRV for prolonged periods may exert a positive effect in the prevention of performance losses related to inappropriate overload (Pichot, et al., 2002; Atlaoui, et al., 2007; Manzi, et al., 2009). Thus, HRV monitoring may provide an important tool for the identification of training stresses and recovery course for optimal training adaptations of athletes.

Albeit not the aim of this study, mechanisms underpinning the observed improvements in HRV and perceived stress are worthy of mention. One candidate mechanism is the effects of a stressor agent on autonomic nervous system (Roemmich, Lambiase, Balantekin, Feda, & Dorn, 2014). Stress responses markedly cause the fight-or-flight reaction that is orchestrated by the autonomic nervous system (Thayer & Sternberg, 2006; Marques, Silverman, & Sternberg, 2010). Accordingly, in an intensity and duration dependent manner, both vagal-related HRV indices (Manzi, et al., 2009; Pichot, et al., 2002) and perceived stress (Milanez, et al., 2014) will respond to the training loads (stressor agent), and once the stressor has ceased, HRV will gradually return to baseline or even achieve high values reflecting the overcompensation process (Viru, 1984). However, the mechanisms by which passive rest influences HRV and perceived stress are yet to be determined.

As conclusion, one weekend of passive rest for professional handball players resulted in improvements of perceived stress symptoms and the cardiac autonomic nervous system. These results highlight the functional and vital role of weekends without matches in permitting the physiological and psychological systems to recover and prepare athletes for training loads to be undertaken in a new training cycle. Important practical applications arise from the present study indicating that two days of passive rest without scheduled matches should be considered by coaches and physical conditioning trainers as having a vital role for the reduction of stress and restoration of cardiac autonomic activity. Furthermore, HRV monitoring may provide an important tool for the identification of training stresses and recovery course for optimal training adaptations of athletes.

References

Al Haddad, H., Laursen, P.B., Ahmaidi, S., & Buchheit, M. (2009). Nocturnal heart rate variability, following supramaximal intermittent exercise. *International Journal of Sports Physiology and Performance, 4*(4), 435-447.

Atlaoui, D., Pichot, V., Lacoste, L., Barale, F., Lacour, J.R., & Chatard J.C. (2007). Heart rate variability, training variation and performance in elite swimmers. *International Journal of Sports Medicine, 28*(5), 394-400.

Batterham, A.M., & Hopkins, W.G. (2006). Making meaningful inferences about magnitudes. *International Journal of Sports Physiology and Performance, 1*(1), 50-57.

Bloomfield, D.M., Magnano, A., Bigger, J.T.Jr., Rivadeneira, H., Parides, M., & Steinman, R.C. (2001). Comparison of spontaneous vs. metronome-guided breathing on assessment of vagal modulation using RR variability. *American Journal of Physiology. Heart and Circculatory Physiology, 280*(3), 1145-1150.

Borg, G. (2000). *Borg's perceived exertion and pain scales*. Champaign, IL: Human Kinetics.

Bricout, V.A., Dechenaud, S., & Favre-Juvin, A. (2010). Analyses of heart rate variability in young soccer players: The effects of sport activity. *Autonomic Neuroscience, 154*(1-2), 112-116.

Buchheit, M. (2014a). Sensitivity of monthly heart rate and psychometric measures for monitoring physical performance in highly trained young handball players. *International Journal of Sports Medicine, 36*(5), 351-356.

Buchheit, M. (2014b). Monitoring training status with HR measures: Do all roads lead to Rome? *Frontiers in Physiology*, *27*(5), 1-19.

Buchheit, M., Chivot, A., Parouty, J., Mercier, D., Al Haddad, H., Laursen, P.B., & Ahmaidi, S. (2010). Monitoring endurance running performance using cardiac parasympathetic function. *European Journal of Applied Physiology, 108*(6), 1153-1167.

Castagna, C., Impellizzeri, F.M., Chaouachi, A., Bordon, C., & Manzi, V. (2011). Effect of training intensity distribution on aerobic fitness variables in elite soccer players: A case study. *Journal of Strength and Conditioning Research, 25*(1), 66-71.

Cohen, J. (1998). *Statistical power analysis for the behavioral sciences*. Hillsdale: Lawrence Erlbaum Associates.

Coutts, A.J., Slattery, K.M. & Wallace, L.K. (2007). Practical tests for monitoring performance, fatigue and recovery in triathletes. *Journal of Science and Medicine in Sport, 10*(6), 372-381.

Foster, C., Florhaug, J.A., Franklin, J., Gottschall, L., Parker, S., Doleshal, P., & Dodge, C. (2001). A new approach to monitoring exercise training. *Journal of Strength and Conditioning Research, 15*(1), 109-115.

Gamelin, F.X., Berthoin, S., & Bosquet, L. (2006). Validity of the polar S810 heart rate monitor to measure R-R intervals at rest. *Medicine and Science in Sports and Exercise, 38*(5), 887-893.

Hautala, A.J., Kiviniemi, A.M., & Tulppo, M.P. (2009). Individual responses to aerobic exercise: The role of the autonomic nervous system. *Bioscience and Biobehavioral Reviews*, *33*(2), 107-115.

Hautala, A., Tulppo, M.P., Mäkikallio, T.H., Laukkanen, R., Nissilä, S., & Huikuri, H.V. (2001). Changes in cardiac autonomic regulation after prolonged maximal exercise. *Clinical Physiology, 21*(2), 238-245.

Hopkins, W.G., Marshall, S.W., Batterham, A.M., & Hanin, J. (2009). Progressive statistics for studies in sports medicine and exercise science. *Medicine and Science in Sports and Exercise, 41*(1), 3-13.

Impellizzeri, F.M., Rampinini, E., Coutts, A.J., Sassi, A., & Marcora, S.M. (2004). Use of RPE-based training load in soccer. *Medicine and Science in Sports and Exercise*, *36*(6), 1042-1047.

Kellmann, M. (2010). Preventing overtraining in athletes in high-intensity sports and stress/recovery monitoring. *Scandinavian Journal of Medicine and Science in Sports, 20*(2), 95-102.

Kentta, G., & Hassmen, P. (1998). Overtraining and recovery. A conceptual model. *Sports Medicine, 26*(1), 1-16.

Manzi, V., Castagna, C., Padua, E., Lombardo, M., D'Ottavio, S., Massaro, M., Volterrani, M., & Iellamo, F. (2009). Dose-response relationship of autonomic nervous system responses to individualized training impulse in marathon runners. *American Journal of Physiology. Heart and Circulatory Physiology, 296*(6), H1733-1740.

Marques, A.H., Silverman, M.N., & Sternberg, E.M. (2010). Evaluation of stress systems by applying noninvasive methodologies: Measurements of neuroimmune biomarkers in the sweat, heart rate variability and salivary cortisol. *Neuroimmunomodulation*, *17*(3), 205-208.

Milanez, V.F., Pedro, R.E., Moreira, A., Boullosa, D.A., Salle-Neto, F., & Nakamura, F.Y. (2011). The role of aerobic fitness on session-rating of perceived exertion in futsal players. *International Journal of Sports Physiology and Performance, 6*(3), 358-366.

Milanez, V.F., Ramos, S.P., Okuno, N.M., Boullosa, D.A., & Nakamura, F.Y. (2014). Evidence of a non-linear dose-response relationship between training load and stress markers in elite female futsal players. *Journal of Sports Science and Medicine*, *13*(1), 22-29.

Moreira, A., & Cavazzoni, P.B. (2009). Monitorando o treinamento através do wisconsin upper respiratory symptom survey-21 e daily analysis of life demands in athletes nas versões em língua portuguesa. [Monitoring training by the Portuguese versions of Wisconsin upper Respiratory Symptom Survey-21 and daily analysis of life demands in athletes. In Portuguese.] *Revista da Educação Física/UEM*, *20*(1), 109-119.

Moreira, A., de Freitas, C.G., Nakamura, F.Y., & Aoki, M.S. (2010). Session RPE and stress tolerance in young volleyball and basketball players. *Brazilian Journal of Kinanthropometry and Human Performance, 12*(5), 345-351.

Mourot, L., Bouhaddi, M., Perrey, S., Cappelle, S., Henriet, M.T., Wolf, J.P., Rouillon, J.D., & Regnard, J. (2004). Decrease in heart rate variability with overtraining: Assessment by the Poincare plot analysis. *Clinical Physiology anf Functional Imaging, 24*(1), 10-18.

Nicholls, A.R., Backhouse, S.H., Polman, R.C., & McKenna, J. (2009). Stressors and affective states among professional rugby union players. *Scandinavian Journal of Medicine and Science in Sports, 19*(1), 121-128.

Nicholls, A.R., Jones, C.R., Polman, R.C., & Borkoles, E. (2009). Acute sport-related stressors, coping, and emotion among professional rugby union players during training and matches. *Scandinavian Journal of Medicine and Science in Sports*, *19*(1), 113-120.

Pichot, V., Busso, T., Roche, F., Garet, M., Costes, F., Duverney, D., Lacour, J.R., & Barthélémy, J.C. (2002). Autonomic adaptations to intensive and overload training periods: A laboratory study. *Medicine and Science in Sports and Exercise, 34*(10), 1660-1666.

Robson-Ansley, P.J., Blannin, A., & Gleeson, M. (2007). Elevated plasma interleukin-6 levels in trained male triathletes following an acute period of intense interval training. *European Journal of Applied Physiology, 99*(4), 353-360.

Roemmich, J.N., Lambiase, M.J., Balantekin, K.N., Feda, D.M., & Dorn, J. (2014). Stress, behavior, and biology: Risk factors for cardiovascular diseases in youth. *Exercise and Sport Science Reviews*, *42*(4), 145-152.

Rushall, B.S. (1990). A tool for measuring stress tolerance in elite athletes. *Journal of Applied Sport Psychology*, *2*(1), 51-66.

Task-Force. (1996). Heart rate variability: Standards of measurement, physiological interpretation and clinical use. Task Force of the European Society of Cardiology and the North American Society of Pacing and Electrophysiology. *Circulation, 93*(5), 1043-1065.

Thayer, J.F., & Sternberg, E. (2006). Beyond heart rate variability: Vagal regulation of allostatic systems. *Annals of the New York Academy of Sciences*, *1088*, 361-372.

Viru, A. (1984). The mechanism of training effects: A hypothesis. *International Journal of Sports Medicine*, *5*(5), 219-227.

Submitted: October 28, 2014
Accepted: April 20, 2015

Correspondence to:
Lucas Carvalho Leme, M.Sc.
Rua Paranaguá, 2035 apartamento 604
86015-030 Londrina, PR, Brazil
Phone: (+55) 43.3361.4907
E-mail: luca_leme@yahoo.com.br

Acknowledgements

We are grateful to the athletes who voluntarily participated in this study; to the Unopar Handball Team who contributed to the acquisition of data; the National Council of Scientific and Technological Development (CNPQ) for the financial support for the research. The study was conducted in accordance with the resolution196/96 of the National Health Council and approved by the Local Ethics Committee, resolution number (191/2011).