



ANALYSES OF INTERNAL LOAD DURING AN ADOLESCENT FEMALE HANDBALL SEASON

Análisis de la carga interna durante una temporada de balonmano femenino adolescente

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Abstract

This study examined the internal load based on heart rate (HR) in a teenage female handball team, which is playing in a regional league, comparing these parameters between the first and second half of the matches. A total of 10 adolescent female handball players participated in the study (age 14.70 ± 0.67 years (range, 14-15), weight 55.78 ± 6.80 kg (range, 46.70-68.90), height 160.44 ± 8.53 cm (range, 150.00-177.00), BMI 21.60 ± 1.10 kg/m² (range, 19.90-23.10), fat mass 30.89 ± 3.70 % Fat Mass (range, 24.40-35.60) and $\dot{V}O_2\max$ 35.00 ± 1.00 ml·min⁻¹·kg⁻¹ (range, 33.76-36.00). Heart Rate (n=120) analyses were registered throughout 12 official matches using Heart Rate monitors. Individual demands were categorized into six intensity zones based on % Maximum Heart Rate (HRmax): zone I: 0-50%; zone II: 51-60%; zone III: 61-70%; zone IV: 71-80%, zone V: 81-90 and zone VI: 91-100% of HRmax. Effective maximum and mean Heart Rate in the total match were 204.14 ± 6.12 and 185.71 ± 8.33 b·min⁻¹, respectively. During the second half, effective maximum (201.71 ± 5.23 vs 204.15 ± 6.57 b·min⁻¹; $p=0.001$) and effective mean (183.51 ± 8.61 vs 189.67 ± 7.47 b·min⁻¹; $p=0.000$). Heart Rate decreased comparing to the first half. Female adolescent team handball players develop a high intensity during official matches. This intensity is higher in first half compared to the second half.

Keywords: heart rate, adolescent, sports performance, competition demands.

Resumen

Este estudio examina la carga interna basada en la frecuencia cardíaca (FC) durante una liga regional en jugadoras adolescentes de balonmano, comparando estos parámetros entre la primera y la segunda parte del partido. Un total de 10 jugadoras adolescentes de balonmano participaron en este estudio (edad $14,70 \pm 0,67$ años (rango, 14-15), masa corporal $55,78 \pm 6,80$ kg (rango, 46,70-68,90), talla $160,44 \pm 8,53$ cm (rango, 150,00-177,00), IMC $21,60 \pm 1,10$ kg/m² (rango, 19,90-23,10), masa grasa $30,89 \pm 3,70$ % Masa Grasa (rango, 24,40-35,60) y $\dot{V}O_2\max$ $35,00 \pm 1,00$ ml·min⁻¹·kg⁻¹ (rango, 33,76-36,00)). El análisis de la frecuencia cardíaca (n=120) fue registrado durante 12 partidos oficiales usando monitores de frecuencia cardíaca. Las demandas individuales fueron categorizada en 6 zonas de intensidad basándose en el % Frecuencia Cardíaca Máxima (FCmáx): zona I: 0-50%; zona II: 51-60%; zona III: 61-70%; zona IV: 71-80%, zona V: 81-90 y zona VI: 91-100% de la FCmáx. La FCmáx Efectiva y Media durante el partido fueron $204,14 \pm 6,12$ y $185,71 \pm 8,33$ ppm, respectivamente. Durante la segunda parte, la frecuencia cardíaca máxima efectiva ($201,71 \pm 5,23$ vs $204,15 \pm 6,57$ ppm; $p=0,001$) y media efectiva ($183,51 \pm 8,61$ vs $189,67 \pm 7,47$ ppm; $p=0,000$) decrecieron en comparación con las primeras partes. Las jugadoras de balonmano adolescente desarrollaron una alta intensidad durante partidos oficiales, siendo más alta en la primera parte comparada con la segunda.

Palabras clave: frecuencia cardíaca, adolescentes, rendimiento deportivo, demandas en la competición.

Introduction

Handball is a complex intermittent high-intensity body-contact game. This sport requires players to have well-developed aerobic and anaerobic capacities (Delamarche, 1987). The structural characteristics of this sport are: it is played on a playing field 40m. x 20m; A match consists in 2 parts of 30 minutes with 10 minutes break between them; Each bench can also request a timeout of 1 minute once by half; A team consists of 7 players, which are 6 field players and the goalkeeper. It is possible to make an unlimited number of substitutions. This affect the rate and intensity of the game, becoming very high (Alvarez, 2002).

Knowledge about the activity profile could be useful for technicians, not only to improve the technical and tactical work, but also to optimize the preparation that could allow keeping performance in the last minutes of the matches (Delamarche, 1987; Hamilton, 1991; Hoff, Wisloff, Engen, Kemi, & Helgerud, 2002). Training should try to develop physiological systems that prevail during the competition (Fox, 1984). Given that, an exercise over a great intensity can be assumed as to decrease performance or even to reach a state of chronic overtraining (Zavorsky, 2000), being this last fact more important.

Numerous authors (Bangsbo & Lindquist, 1992; Colli, 1985; Hernandez, 1988; Terrados, 1995; Zaragoza, 1996) have provided data regarding variables to quantify the competition in team sports. One of these variables is the exercise intensity, which can be defined as the number of stimuli per time unit (Zintl, 1991). It is verified by monitoring various physiological parameters such as Heart Rate (HR). The maximum heart rate (HRmax) is a basic parameter for determining the effort and intensity to which the body is being exposed during exercise (Bouzas Marins, 2010). Furthermore, subdivision of HR records expressed as a percentage of HRmax has been used to determine time spent below, at or above the threshold during match-play (Wilkins, Petersen, & Quinney, 1991; Woolford, 1991).

The development of Polar Team System has provoked a great advance in controlling this physiological parameter because it allows a real-time and reliable HR monitoring during exercise (Karvonen, 1988). HRmax assessment in team sports is usually applied more or less close to the real game situation (Castagna et al., 2007; García, 2003; Labsy, Collomp, Frey, & De Ceaurriz, 2004; Nunez, Da Silva-Grigoletto, Castillo, Poblador, & Lancho, 2008; Souhail, Castagna, Mohamed, Younes, & Chamari, 2010). These results are often questionable since it does not take into account factors of cognitive or decisional, not offering a completely objective information (Antonacci et al., 2007).

During a handball game there are a lot of actions at high intensity, that means a value of 80% HRmax in adult elite athletes (Michalsik, Aagaard, & Madsen, 2013). Although there is little knowledge about this issue in the sport of handball, most of the studies have established an intensity above 80% HRmax in male players (Chelly et al., 2011; Chiroso, 1999; Loftin, Anderson, Lytton, Pittman, & Warren, 1996). However, at physiological level and personal performance, the physical characteristics are different between men and women and therefore a study of these parameters is necessary in both genders. Manchado-Lopez (2007) analysed HRmax during 7 matches of the German female national team. Players were above 87% of HRmax most of the game.

Regarding the evolution of physiological parameters during the competition, the literature coincides in an intensity decrement in the second half of the match (Manchado-Lopez, 2007; Povoas et al., 2014; Povoas et al., 2012). The differences are greater in the time when the players are between 50-85% HRmax and especially in the area of greatest intensity (over 90% HRmax). In the second half, players spend more time in areas of lower intensity and less time on areas of greatest intensity (Manchado-Lopez, 2007; Povoas et

al., 2014; Povoas et al., 2012). However, it is necessary to increase knowledge regarding this theme charting the internal load especially in females and in the perfection stage.

To our knowledge, no previous studies have examined the demands on exercise intensity along a competition in adolescent handball players. The aim of this study was to examine the internal load based on HR during a league of teenage female handball in a team, comparing these parameters between the first and second half of the matches.

Methods

Experimental Approach to the Problem

The HR was recorded during 12 competitive matches in 10 team players in order to analyse the internal load. A familiarization session was performed before the first match recorded. Firstly, anthropometrics data were assessed to characterize the players. Then, the players performed the Yo-Yo Intermittent Recovery Level 1 Test (YYIR1) to determine Individual HRmax and maximal oxygen uptake (VO₂peak). Lastly, players were acquainted with the use of HR monitors during a match organized in the familiarization session.

Participants

A total of 10 adolescent female handball players participated in the study. Players and coaches were informed in detail about the experimental procedures and the possible risks and benefits of the project, which was approved by the Bioethics Committee of the [name removed for review], and carried out according to the Declaration of Helsinki in 1975. Players and their parents gave voluntary written informed consent to participate in this study. Characteristics of participants are shown in Table 1.

Table 1. Characteristics of participants

	Mean	Range
Age, years	14.70 ± 0.67	14.00-15.00
Weight, kg	55.78 ± 6.80	46.70-68.90
Height, cm	160.44 ± 8.53	150.00-177.00
BMI, kg/m ²	21.60 ± 1.10	19.90-23.10
% Fat Mass	30.89 ± 3.70	24.40-35.60
VO ₂ max, ml·min ⁻¹ ·kg ⁻¹	35.00 ± 1.00	33.76-36.00

BMI: body mass index; VO₂max: maximum oxygen uptake.
Values are mean ± standard deviation and range.

Players had at least 4 years of experience in the handball practice. At the time of the evaluations, players were in the beginning of the competitive period, performing 3 training sessions per week. In these sessions comprised technical-tactical and physical fitness training exercises.

Procedures

Anthropometric evaluations. In the morning, body composition was measured fasting before the physical test. Height and weight were measured following standard procedures. BMI was derived from height and weight per the accepted method ($BMI = \text{weight}/\text{height}^2$, kg·m⁻²). Fat Mass Percentages was measured by bioelectrical impedance methods using a standardized body composition analyser (TANITA, BC 1500, Illinois, USA). Subjects maintained a standing position, with feet side-by-side on the scale and they were barefoot. They wore sport clothes, without metal objects.

VO₂peak and HRmax. VO₂peak were determined by an YYIR1. Twenty-meter shuttle runs were performed at increasing speed, with periods of 10 seconds of active recovery between runs, until the players were exhausted. The version number 1 of this test was performed because it is more appropriated for adolescents (Chelly et al., 2011). Testing was carried out on the handball court. Cones were used to mark out three lines: 20 meters and 5 meters apart. Players started on the middle line, and begun running 20m when instructed by the recorded beep. During the active recovery period the participant must walk or jog around the other cone and return to the starting point. A calibrated portable CD player provided appropriate audio cues. The test ended when the players either failed twice to reach the finish line in the required time (objective evaluation), or felt unable to complete another shuttle at the required speed (subjective evaluation). The total distance covered (including the last incomplete shuttle) was considered as the Yo-Yo test performance and the velocity associated with this final stage was considered as the individual's VO₂peak (Chelly et al., 2011), which was estimated by the equation: $VO_2\text{peak (ml/min/kg}^{-1}) = 24.8 + (0.014 \cdot \text{distance in meter})$.

Heart Rate. During 12 official matches, 120 HR records of 10 handball female players were registered with 5-second intervals using HR monitors (Team System, Polar Electro Oy, Kempele, Finland). Definitions and procedures regarding HR analysis are described elsewhere (Povoas et al., 2012). Team handball rules allow unlimited substitutions of players throughout the match. Therefore, it is unusual that 1 player plays the entire match time (Ronglan, Raastad, & Borgesen, 2006). Also, a 1-minute time-out period is allowed for each team, in each half. Several other match contingencies involve the interruption of the match time (e.g., player's injuries and suspensions). In this study, only effective HR (HR during effective match time) was assessed aiming to describe match demands only during the time in which the player was on the playing court. The half-time break was excluded from the total match time and 2-minute suspensions and time-outs were considered. One generally accepted method to describe exercise intensity is the determination of the percentage of HRmax reached during exercising. Individual demands were categorized into six intensity zones based on %HRmax: zone I: 0-50%; zone II: 51-60%; zone III: 61-70%; zone IV: 71-80%, zone V: 81-90% and zone VI: 91-100% of HRmax (Povoas et al., 2012).

Statistical Analyses

Standard statistical methods were used to calculate mean and standard deviations. Kolmogorov–Smirnov tests was realised to show distribution of the studied variables and Levene's test for homogeneity of variance. Differences between HR during halves were assessed by Student's paired t-test. Statistical Package SPSS v.21 was used for all analyses. Statistical significance was set at $p \leq 0.05$.

Results

Mean and maximum effective heart rate (HR) during the first and second halves and total match time are shown in Table 2. The effective maximum and mean HR were 204.14 ± 6.12 and 185.71 ± 8.33 $\text{b} \cdot \text{min}^{-1}$, respectively. During the second half, effective maximum (201.71 ± 5.23 vs 204.15 ± 6.57 $\text{b} \cdot \text{min}^{-1}$; $p=0.001$; d Cohen=0.41) and effective mean (183.51 ± 8.61 vs 189.67 ± 7.47 $\text{b} \cdot \text{min}^{-1}$; $p=0.000$; d Cohen= 0.77) HR decreased significantly comparing with the first half.

Table 2. Average and maximal effective heart rate (HR) during the first and second halves and total match time.

	Total match (N=89)	1 st half (N=89)	2 nd half (N=89)	p	d Cohen
HRmax, b·min ⁻¹	204.14±6.12	204.15±6.57	201.71±5.23	0.001	0.41
HRmean, b·min ⁻¹	185.71±8.33	189.67±7.47	183.51±8.61	<0.001	0.77

HRmax: maximal heart rate; HRmean: average heart rate; b·min⁻¹: beats per minute
Values are mean ± standard deviation.

Percentages of effective match time spent at different intervals in the first and second halves of the match are shown in Figure 1. During the first half the players spent more percentage of time at Zone VI (77.55±21.04 % effective time); the percentage of time spent at each Zone decreased proportionally related to the intensity (Zone I: 0.34%±1.15; Zone II: 0.25%±0.72; Zone III: 1.50%±3.60; Zone IV: 5.51%±6.09 and Zone V: 14.84%±13.74).

During the second half the players spent more percentage of time at Zone VI (66.83±22.06 % effective time); as in the first half, the percentage of time spent at each Zone decreased proportionally related to the intensity too (Zone I: 0.61%±1.80; Zone II: 0.98%±2.97; Zone III: 2.67%±5.01; Zone IV: 6.59%±7.17 and Zone V: 22.48%±14.82).

The percentage of time spent at exercise intensities above 91% HRmax decreased during the second half (66.83±22.06 vs 77.55±21.04% effective time; p<0.001). An increment of time spent at lower intensity was observed for zone II (0.98±2.97 vs 0.25±0.72% effective time; p=0.045) and also an increment at moderate intensity was observed for zone V (22.48±14.82 vs 14.84±13.74% effective time; p=0.000) in the second half comparing to the first half.

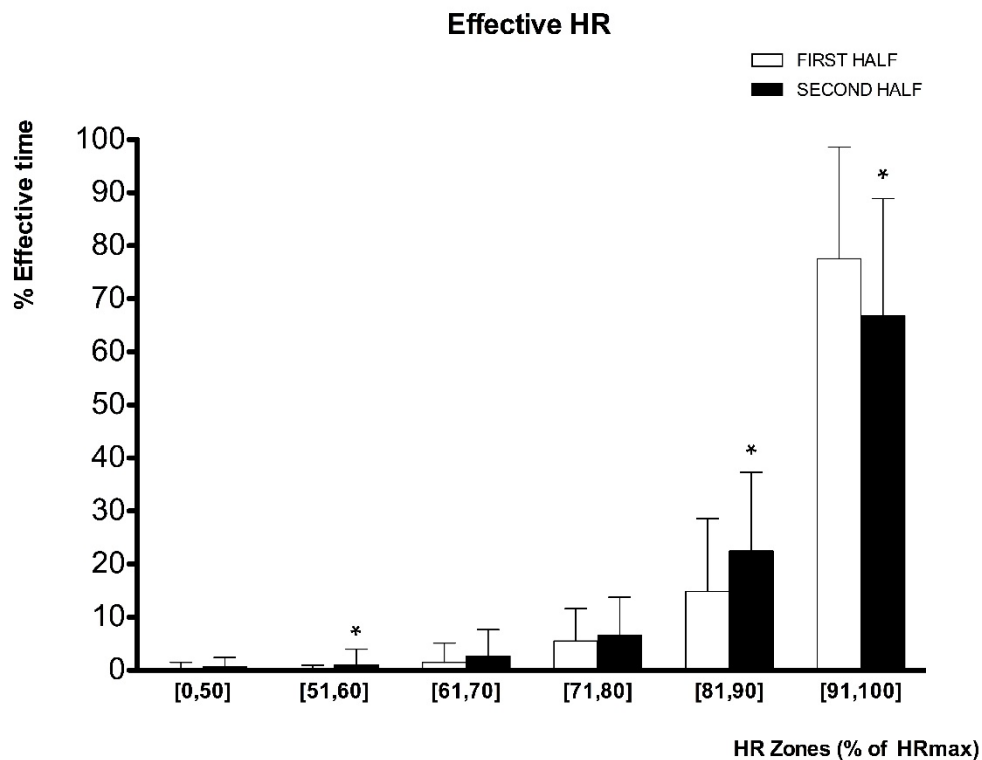


Figure 1. Percentages of effective match time spent at different intervals in the first and second halves of the match. Values are means ± SD. *p≤0.05 statistically significant differences between halves.

Discussion and conclusions

To our knowledge, this is the first study providing the detailed information about the internal load in amateur female adolescent handball players during different competitive matches of a season. The present data show that a match of female adolescent handball supposes a high-intensity for the players, such as the high values of mean and maximum HR showed during the total match. A decrease on intensity during the second half of the match was observed.

No other study to date has investigated the HR profile of female adolescent handball players during a competition. On young adolescent handball players, previous studies reported slightly lower mean HR (Chelly et al., 2011; Chiroso, 1999). In any case, a high-intensity is obtained during an adolescent handball match. These data indicate that female handball is as physically demanding as men's handball (Manchado, Tortosa-Martinez, Vila, Ferragut, & Platen, 2013). Similar results have been showed in adult handball players (Loftin et al., 1996; Manchado et al., 2013). The values found are slightly different and could be explained because the HR analysed was HR during total match time and this study only analyses HR during the effective match time. Effective and total HR refers to HR responses during the time in which the player is inside the playing court and the total game time, respectively. Povoas et al. (2012) showed that effective mean HR during a handball match was $157 \text{ b}\cdot\text{min}^{-1}$ and corresponded to the 82% of maximum HR, whereas total mean HR was 10% lower ($139 \text{ b}\cdot\text{min}^{-1}$). This difference between both measurements might be due to the higher HR of the players that are active on the playing field compared to the players that are seated on the substitute's bench.

By the other hand, effective maximum HR of this study was lower than in the above-mentioned research. The decrease in maximum HR with the age is well-known (Tibana et al., 2009). Thus, Povoas et al. (2012) analysed HR in adults while in this study the players were adolescents.

Data relative to HR indicated fatigue after the first half of the game. So, players had lower values for both maximum and mean HR during the second part of the game. This decrease could reflect an increase of muscular fatigue (Castagna et al., 2007) as confirm the results found by others authors. Chelly et al. (2011) showed lower values for both mean HR and average percentage of maximum HR that indicated fatigue related to performance in the first half of the game in elite adolescents handball players.

Regarding the HR zone, during the most of the effective match time the players exercised at intensities over 80% HRmax in both halves (first half: 91% and second half: 88%). This result indicates that physiological demands during the effective game time are higher. Adolescent handball players spent a higher percentage of effective time in the upper HR zones in the first half in comparison to the second half. In the second half, players spent more percentage of effective time in HR zones between 50-60% and 80-90%. Previous studies in handball adult players reached the same results (Manchado et al., 2013; Povoas et al., 2012). The decrease of the game intensity caused by the time-out could reduce the likelihood of performing individual high-intensity actions (Leite, 2013). The decline in muscle and core temperature during the half-break has been associated with a lowered intensity of the second half of soccer matches (Mohr, Krstrup, & Bangsbo, 2003). An increase in muscle temperature before high-intensity exercise has a beneficial effect on performance (Stewart & Sleivert, 1998). It is tempting to speculate that a re-warm-up during the half-break of a handball match could prevent the observed decrease of intensity on the second half (Povoas et al., 2012). Therefore, additional studies are needed.

However, some limitation of the present study concerns the necessity of knowing the total HR to characterize globally cardiovascular demands imposed by de handball matches. It is unusual that one player plays the

entire match time (Luig et al., 2008; Ronglan et al., 2006). Other variables related with internal load may be recommended such as the lactate concentration. Probably, the reduced number of participants is other limitation of this study.

These, along with other related with external load, could be studied in future investigations to analyse physiological demands of handball matches. We conclude that adolescent female handball players develop high intensity during official matches. This intensity is higher in the first half compared to the second half.

This study provides findings on the internal load upon female advanced handball players. These findings may suggest the importance of planning and create properly designed game-specific training exercises. Intermittent high-intensity endurance development must be taken carefully. These exercises target improvements in handball, delaying neuromuscular fatigue temporarily and at the end of the game. Also, the duration and recovery-time relationship in technical exercises and games small-sided have to be considered.

Conflict of interest

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