VOLUMEN XXVIII - N.º 144 - 2011
ORIGINAL
ARCHIVOS DE MEDICINA DEL DEPORTE

Volumen XXVIII
Número 144
2011
Págs. 257-264

HEART RATE VARIABILITY AFTER THREE BADMINTON MATCHES. ARE THERE GENDER DIFFERENCES?

VARIABILIDAD DE LA FRECUENCIA CARDIACA TRAS TRES PARTIDOS DE BÁDMINTON. ¿HAY DIFERENCIAS POR SEXO?

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SUMMARY

Objectives: To analyze heart rate variability (HRV) at rest and after 3 consecutive badminton matches played in a short period of time (2 or 3 days) in order to assess the effect of accumulated tiredness and if there were differences between males and females under these conditions.
Methods: We have studied 19 badminton players divided into two groups: 11 females (age 17,88±3,01 years) and 8 males (age 18,16±2,87 years). In four different championships we took initial records in a large number of players, but we selected for the study to those players who played at least 3 matches before of being eliminated from the tournament. The heartbeat signal was recorded beat to beat for 20 minutes in supine position before the competition and after 3 matches. The initial record (baseline) was made at their own room one day after arriving in the host city and the another three records were made after finishing the match, between 15 and 25 minutes (average 17.14 + 3, 93 minutes).
The usual parameters in the time domine as well as the transverse (SD1) and the longitudinal axis (SD2) of the Poincaré plot were calculated.
Results: All parameters in time domine were significantly lower after the matches than basal but the differences between the matches were not significant. No significant differences were found between males and females in none of the parameters at the four situations. SD1, SD2 and the ratio SD1/SD2 in the Poincaré plot post-matches were lower than the baseline, but without significant gender differences.
Conclusions: HRV decreases after matches but without differences due to the number of matches and these changes are the same for men and women.

Key words: Heart rate variability. Badminton. Poincaré plot. Fatigue.

RESUMEN

Objetivos: Analizar la variabilidad de la frecuencia cardiaca (VFC) en reposo y tras 3 partidos de Bádminton consecutivos jugados en un corto periodo de tiempo (2 o 3 días) para evaluar el efecto de la fatiga acumulada y si existen diferencias entre hombres y mujeres en estas condiciones.
Métodos: Hemos estudiado a 19 jugadores de Bádminton divididos en dos grupos: 11 mujeres (17,88±3,01 años) y 8 hombres (18,16±2,87 años). Se tomaron un gran número de registros iniciales en cuatro campeonatos diferentes, pero se seleccionaron para el estudio a aquellos jugadores que jugaron al menos tres partidos antes de ser eliminados del torneo. Se registró la señal cardiaca latido a latido durante 20 minutos en posición supina antes de iniciarse la competición y después de 3 partidos consecutivos. El registro inicial (basal) se hizo en la habitación de los jugadores al día siguiente a su llegada a la ciudad sede y los otros tres registros se tomaron entre 15 y 25 minutos tras la finalización del partido (media 17.14 + 3, 93 minutes). Se calcularon los parámetros usuales del dominio de tiempo y los diámetros transversal (SD1) y longitudinal (SD2) del gráfico de Poincaré.
Resultados: Todos los parámetros del dominio de tiempo fueron significativamente más bajos tras los partidos, respecto a la situación basal, pero sin diferencias entre los tres partidos. No se encontraron diferencias entre hombres y mujeres en ninguno de los parámetros en las cuatro situaciones. Los diámetros SD1, SD2 y la relación SD1/SD2 también tuvieron valores más bajos tras los partidos y sin diferencias entre sexos.
Conclusiones: La VFC disminuye tras los partidos de Bádminton pero sin diferencias debidas al número de partidos y con los mismos cambios para hombres y mujeres.

Palabras clave: Variabilidad de la Frecuencia Cardiaca. Bádminton. Gráfico de Poincaré. Fatiga.

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Aceptado: 03.06.2011 / Original nº 588

INTRODUCTION

Assessment of heart rate variability (HRV) is based on analysis of consecutive RR intervals and it may provide quantitative information on the modulation of cardiac vagal and sympathetic nerve input. So, HRV is a result of interactions between the autonomous nervous system and the cardiovascular system and it is used as an indicator of cardiovascular health[1]. According to bibliography, the most studied factors influencing HRV are pathology[2] and aging[3,4]; in both situations HRV decreases due to a predominance of sympathetic activity. However, there are other important factors influencing HRV and, between them, we want to highlight exercise and gender. We know that autonomous control during exercise causes a predominance of sympathetic activity, increasing heart rate (HR) and modifying HRV[2,5-13] but we do not know if these changes are different both in males and females.

HRV can be analyzed through different methods. In the frequency domain , HRV has been categorized into high frequency (HF), low frequency (LF) and very low frequency (VLF). HF is considered to represent the vagal activity of heart and LF is considered to reflect the sympathetic activity. The ratio LF / HF reflects the sympathovagal balance. Parhelic, *et al*[7] analyzed the influence of autonomic control on HRV in two different exercise intensities (50% and 80% of VO2max). They showed that high-intensity exercise (80%) causes more changes in autonomic balance in post-exercise recording of HRV than low-intensity exercise. Cottin, *et al*[15] compared both HF and LF during heavy exercise (above the ventilatory threshold) and they observed a predominance of the HF component. Therefore, the autonomous control of heart rate during heavy exercise is less effective than during moderate one. Buchheit, *et al*[16] found that moderate physical activity was enough to obtain high values of the vagal component of HRV and to perceive a better health state, while high intensity activity was associated with a high prevalence of vagal activity but it was not perceived as an improvement of health status.

Another method to analyze HRV is the Poincaré plot. It is a diagram in which transverse diameter (SD1) is directly related to parasympathetic activity while longitudinal diameter (SD2) is inversely related to sympathetic activity. Mourot, *et al*[17]. observed that both SD1 and SD2 decreased after steady state exercise in 18 healthy subjects.

However, the most used parameters for assessing HRV are those in the time domine and, between them, the best prognosis information is provided by the standard deviation of RR intervals (SDRR) and the percent of differences higher than 50 msec in successive RR intervals (pRR50). SDRR lower than 50 msec and pRR50 lower than 3% identify patients with a severely decreased HRV, while SDRR higher than 100 msec and pRR50 higher than 3% indicate a normal variability[14].

Concerning the response of HRV to exercise there are two aspects which are not known in full. On the one hand the effect of both the accumulation of acute fatigue and overtraining, and on the other hand the influence of gender. In relation to the first aspect, there are several studies with different (even contradictory) results, in such a way that we can not know if HRV increases[18], decreases[19] or remains without changes[20] in over trained athletes.

About gender influence on HRV, some differences between men and women could be expected according to bibliography. That way, some studies report that men have a predominance of LF component whereas women have a predominance of HF component in the spectral analysis[21-24]. In the time domine, women have a preponderance of those parameters reflecting parasympathetic activity, such as pRR50[25]. These differences decrease over 50 years old[26,27] and disappear after 60[25].

In all these studies HRV was recorded at rest. However, if HRV is assessed after exercise, these differences do not seem to be corroborated; in fact, Brown did not found differences when HRV was examined in 13 athletes (7 men and 6 women) after a high-intensity exercise[28].

We hypothesize that the cumulative effort have to influence the HRV record during recovery but we don't know if it will be different by gender.

A badminton championship offers the advantage that players accumulate a number of matches in a very short period of time (2 or 3 days) depending on the stages that every player is able to overcome. The aim of this study was to analyze the HRV at rest and after consecutive matches played in a short period of time in order to assess the effect of accumulated tiredness and if there were differences between males and females in these conditions.

MATERIALS AND METHODS

Subjects

We have studied 19 badminton players divided into two groups: 11 females (age 17,88±3,01 years; height 165,33±5,83 cm; weight 61,01±7,17 kg) and 8 males (age 18,16±2,87 years; height 178,33±7,22 cm; weight 70,61±6,91 kg). All players were included in the world ranking and/or they have participated in their youth or senior national team of badminton. All of them were informed about the contents of the investigation and they gave written consent. The study had the approval of the ethical committee of the Centro Andaluz de Medicina del Deporte (CAMD) according to the ethical guidelines of the Declaration of Helsinki.

Procedures

The heartbeat signal was recorded in four different championships. In each championship we took initial records in a large number of players, but we selected for the study to those players who played at least 3 matches before of being eliminated from the tournament. So, the sample was configured as follows: 2 player from the XIV Children and Youth Pan-American Championships in Puerto Vallarta (Jalisco, Mexico. 2007); 6 player from the Grand Prix of Granada (Spain. 2008); 4 players from the state tournament of Monterrey (Nuevo León, Mexico. 2008) and 7 players in the qualifying heats for the Children and Young Olympics in Mexico City (Mexico. 2009).

A total of four heartbeat records were obtained from each of the players: one before starting the championship and another three after every one of the matches. The initial record (baseline) was made at their own room one day after arriving in the host city and the another three records were made after finishing every match, between 15 and 25 minutes (average 17.14 + 3, 93 minutes).

The heartbeat signal was recorded for 20 minutes in supine position using a Polar RS800sd® monitor (Kempele, Finland) in a RR mode (beat to beat). The records were incorporated to the computer through an infrared interface (Polar IR), using the Polar Precision Performance software (version 5), and then data were included in a database for statistical and graphic analysis.

According to the recommendations of the European Society of Cardiology and the North American Society of Pacing and Electrophysiology14, we calculated the following parameters: the average of all RR intervals, the standard deviation of RR intervals (SDRR), the standard deviation of average RR intervals calculated over short periods of 5 minutes (SDARR), the average standard deviation of RR interval (Index SDRR) and the number of pairs of adjacent RR intervals differing by more than 50 ms in the entire record, divided by the total number of RR intervals, expressed as percentage (pRR50).

We also studied the Poincaré plot, where the consecutive RR intervals were transferred to a scatter diagram for a two-dimensional graphic image of the behavior of HRV in each of the records . This analysis allows the quantification of autonomic activity on the heart because the transverse axis (SD1) is an indicator of parasympathetic activity and the longitudinal axis (SD2) is considered as an inverse function of the sympathetic activity[30-32].

Statistics

Data for each of the four records from every subject were subjected to descriptive analysis and they are expressed as mean and standard deviation for each variable.

The differences in the reported variables among the different recording sessions were assessed by a repeated measures ANOVA and one-way ANOVA for comparisons between men and women. The Scheffé test was used as a post-hoc test.

We considered significant a p value less than 0.05 and F <0.1.

The statistical analysis was performed with SPSS software, version 15.0.

RESULTS

Table 1 and 2 show the values in the time domain for women and men respectively. In both groups, heart rate is significantly higher after the matches than basal while all HRV parameters are significantly lower (except SDARR). However, the differences between the matches are not significant. We do not found significant differences between males and females in none of the parameters at the four situations. The parameters with best prognostic value (SDRR and pRR50) are shown in Figure 1 and 2, respectively.

Table 3 shows the values of both diameters (SD1 and SD2) in the Poincaré plot as well as the ratio SD1/SD2. In both groups the post-matches values are lower than the baseline for both axes and ratio, but without significant gender differences. This situation is shown graphically in Figure 3.

DISCUSSION

HRV has been discussed in many sports but rarely in badminton . In a full tournament of this sport one can play several matches in a short period of time (2 or 3 days) with a great physical requirement.

This study started with heartbeat records at rest from 41 players, but only 19 (who met the cri-

TABLE 1. Data for women (average ± SD) in parameters of the time domain. Asterisks show significant difference with respect to baseline: (*) p<0,05; (**) p<0,01; (***) p<0,001

Women	Basal	Match 1	Match 2	Match 3
RR Interval	832,5±145,3	647,24±161,43 ***	611,03±70,12***	616,25±98,45***
SDRR	79,67 ±30,6	43,65±29,05**	34,66±14,38***	33,25±21,24***
SDRR index	76,98±30,49	33,53±28,97***	27,13±10,78***	25,45±19,78***
SDARR	18,86±10,85	24±13,18	19,68±15,12	21,79±16,61
RMSSD	44,58± 26,29	17,33±28,92**	8,3±5,51***	8,44±9,17***
pRR50	33,34±23,78	10,16±20,11***	1,8±2,91***	2,17±4,48***
HR (beat/min)	74,04±12,73	95,81±20,53***	98,15±13,18***	98,46±13,9***

TABLE 2. Data for men (average ± SD) in parameters of the time domain. Asterisks show significant difference with respect to baseline: (*) p<0,05; (**) p<0,01; (***) p<0,001

Men	Basal	Match 1	Match 2	Match 3
RR Interval	823,85±96,8	703,4±154,12**	624,48±67,23***	648,73±58,01**
SDRR	79,61±27,39	48,94±34,43*	34,76±10,57***	42,91±7,56**
SDRR index	75,08±27,01	39±27,4**	24,92±11,74***	29,3±7,5**
SDARR	23,8±13,77	29,41±28,07	26,02±9,52	33,11±6,8
RMSSD	34,99±13,68	20,68±21,54*	8,87±7,84***	10,71±5,72***
pRR50	27,31±13,21	11,23±15,04*	4,96±8,33***	6,02±10,85**
HR (beat/min)	73,09±8,16	86,21±15,44**	94,34±10,79***	90,01±7,91**

teria for inclusion) remained in competition at least 3 matches; so, the sample was not designed previously due to the specific characteristic of case selection. In a single-elimination badminton competition, a player can play from 1 to 5 matches, depending on how many players begin the tournament (16 or 32) and when the player is removed. Thus, the number of players who play at least 3 matches will be 4 (if the competition starts with 16) or 8 (if it starts with 32); but taking into account the difficulties to register all the players who start a competition, we had to attend four different tournaments in order to guarantee a sample similar to those reported in previous papers (between 7 and 22 subjects)[7,9, 13,19,34-40].

Regarding the duration of the RR records, we followed the recommendations of the Task Force of the European Society of Cardiology and the North American Society of Pacing and Electrophysiology[14] and we decided that 20 minutes was appropriate for the study, it would not interfere with the competition and it would be well accepted by the players and coaches. The average HR values at rest are too high for the expected in trained people, but they can be explained by the age and the precompetitive anxiety.

Another important issue to be controlled was the time passed from the end of the match to the start of registration of the HRV. About this, it is accepted[37,38] that after 50 minutes the changes induced by exercise in HRV can disappear. Therefore, we decided to initiate the records as soon as possible after the match not exceeding 30 minutes. The time ranged from 8 to 21 minutes.

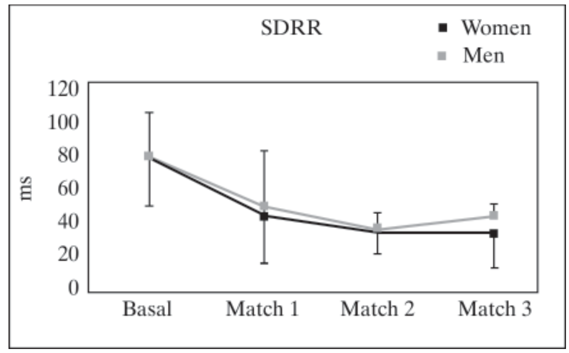

FIGURE 1. SDRR values (average ± SD) for women and men. There are significant differences (p<0,01) for every match with respect to baseline both for males and females. No significant differences are observed between consecutive matches or between men and women

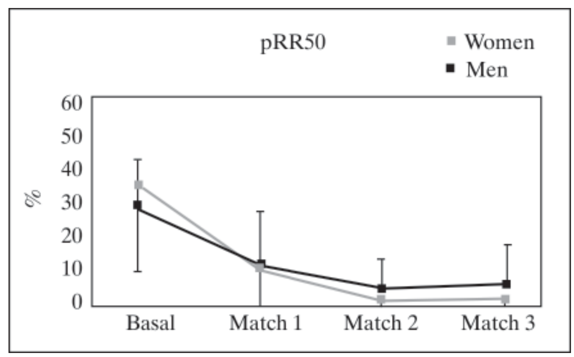

FIGURE 2. pRR50 values (average ± SD) for women and men. There are significant differences (p<0,01) for every match with respect to baseline both for males and females. No significant differences are observed between consecutive matches or between men and women

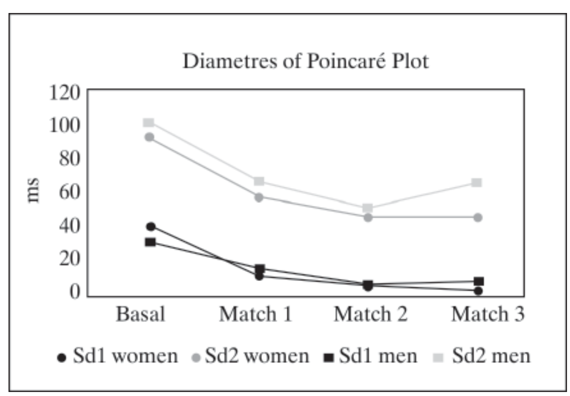

FIGURE 3. SD1 and SD2 (average ± SD) for women and men. There are significant differences (p<0,01) for every match with respect to baseline both for males and females. No significant differences are observed between consecutive matches or between men and women

Women	Basal	Match 1	Match 2	Match 3
SD 1	50,20±26,90	22,12±29,11**	16,19±7,26***	13,95±8,25***
SD 2	103,57±35,08	68,16±30,46**	56,42±21,80***	56,25±25,59**
SD1/SD2	0,48±0,77	0,32±0,96***	0,29±0,33***	0,25±0,32***
MEN	**Basal**	**Match 1**	**Match 2**	**Match 3**
SD 1	42,45±12,83	26,21±19,34*	16,30±7,93***	18,46±8,01**
SD 2	112,06±32,88	77,34±43,05*	61,75±22,39***	76,34±18,57*
SD1/SD2	0,38±0,39	0,34±0,45	0,26±0,35***	0,24±0,43***

TABLE 3. Transverse (SD1) and longitudinal (SD2) diameters in the Poincaré plot, as well as the ratio SD1/SD2, for both groups (average ± SD). Asterisks show significant difference with respect to baseline: (*) p<0,05; (**) p<0,01; (***) p<0,001

In the time domine we have observed a significant reduction in HRV after the three matches both in males and females (Tables 1 and 2) in any of the assessed parameters (except SDARR). However, no significant difference was observed between the matches neither for males nor females despite the fact that the three matches were played within 48 hours and accumulated fatigue could be expected. So, we can not confirm the fact reported by other authors that HRV decreases as accumulated workload increases[41]. When males and females were compared, no differences were observed at rest or after the matches. We have not found references to gender differences in HRV during or after exercise, although some author reported differences at rest in some parameters of the time domine[42].

It is known that SDRR[27,43-45], and pRR50 provide the best prognostic information of health state. Thus, SDRR values higher than 100 ms and pRR50 values higher than 3% are related to healthy subjects. But this must be true only for HRV records at rest because on the contrary, SDRR after the three matches for men (Table 1) and women (Table 2) as well as pNN50 for males after matches 2 and 3 (Table 1) could indicate a high cardiovascular risk and it is not. Figures 1 and 2 show the changes in these two parameters.

Concerning the Poincaré plot, we observed a significant decrease in SD1 and SD2 both for males and females after the three matches (Table 3) but without significant differences between them. This could suggest that accumulated work does not induce more changes in the autonomic control of heart rate than those reported previously after a single effort[17]. However, taking into account that a decrease in SD1 means a reduction in parasympathetic influence and a decrease in SD2 means an increase in sympathetic control, may be interesting to consider their relationships. Table 3 shows that SD1/SD2 ratio decreases (both for women and men) as the number of matches increases, in such a way that after the third match, SD1 is a quarter of SD2 when it was near a half at rest. So, we know that exercise induces a sympathetic predominance in the recovery period, but it seems to be due more to a decreased parasympathetic activity than to a sympathetic increase. Our results seem to point the fact that, after exercise, the parasympathetic activity is restored more slowly than sympathetic activity decreases and the more work is accumulated the more evident this difference is.

In conclusion, 1) HRV decreases after each Badminton match but without differences due to the number of matches; 2) the changes in HRV at rest and after the matches is the same for men and women and 3) the changes in the SD1/SD2 ratio suggest that the accumulation of physical work may affect the way in which exercise induce changes in sympathetic/parasympathetic control.

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