



Artículo Investigación

# Monitoring physiological, perceptual and temporal responses of women's and men's singles and doubles badminton matches

**Monitoreo de las respuestas fisiológicas, perceptuales y temporales de partidos de bádminton individuales y dobles femeninos y masculinos.**

**Monitoramento das respostas fisiológicas, perceptuais e temporais em partidas de badminton de simples e duplas femininas e masculinas.**

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## ABSTRACT

The present study aimed to compare the physiological, perceptual, and temporal responses of women's and men's singles and doubles badminton matches. The study included 20 badminton athletes of both sexes ( $23.2 \pm 6.1$  years), playing singles and doubles matches, who were monitored during six days of competitions. Five women's singles matches, seven men's singles matches, 11 women's doubles matches, and eight men's doubles matches were monitored, during which the athletes' heart rate (HR) and rating of perceived exertion (RPE) values were recorded. In addition, temporal variables were obtained from five women's singles, seven men's singles, three women's doubles, and two men's doubles matches. The results showed that HR was significantly higher in women's singles compared to men's singles, and also in women's singles compared to women's doubles matches. Furthermore, the total match time and rest time were significantly shorter, and the effective match time was greater in men's doubles compared to women's doubles matches. It is concluded that the intensity, assessed by HR, in women's singles matches was greater compared to men's singles matches and that women's singles matches were more intense than women's doubles matches. In addition, the responses of temporal variables in men's doubles matches were different compared to women's doubles matches.

**Key words:** Racquet Sports; Athletes; Monitoring; Performance.

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## RESUMEN

El presente estudio tuvo como objetivo comparar las respuestas fisiológicas, perceptuales y temporales de partidos de bádminton individuales y dobles de mujeres y hombres. El estudio incluyó a 20 atletas de bádminton de ambos sexos ( $23,2 \pm 6,1$  años), que jugaban en partidos individuales y dobles, y que fueron monitoreados durante seis días de competencias. Se monitorearon cinco partidos individuales femeninos, siete partidos individuales masculinos, 11 partidos de dobles femeninos y ocho partidos de dobles masculinos, durante los cuales se registraron los valores de frecuencia cardíaca (FC) y percepción subjetiva del esfuerzo (PSE) de los atletas. Además, se obtuvieron variables temporales de cinco partidos individuales femeninos, siete individuales masculinos, tres dobles femeninos y dos dobles masculinos. Los resultados mostraron que la FC fue significativamente más grande en los partidos individuales femeninos en comparación con los individuales masculinos, y también en los individuales femeninos en comparación con los partidos dobles femeninos. Además, el tiempo total de partido y el tiempo de descanso fueron significativamente más cortos, y el tiempo efectivo de partido fue mayor en los partidos de dobles masculinos en comparación con los de dobles femeninos. Se concluye que la intensidad, evaluada por HR, en los partidos individuales femeninos fue mayor respecto a los partidos individuales masculinos y que los partidos individuales femeninos fueron más intensos que los partidos de dobles femeninos. Además, las respuestas de las variables temporales en los partidos de dobles masculinos fueron diferentes en comparación con los partidos de dobles femeninos.

**Palabras clave:** Deportes de raqueta; Atletas; Monitoreo; Rendimiento.

## RESUMO

O presente estudo teve como objetivo comparar as respostas fisiológicas, perceptuais e as respostas temporais de partidas de badminton simples e de duplas das modalidades adulto masculina e feminina. Participaram do estudo 20 atletas de badminton de ambos os sexos da modalidade adulto simples e de duplas ( $23,2 \pm 6,1$  anos) que foram monitorados durante seis dias de competições. Foram analisadas cinco partidas simples feminina, sete simples masculina, 11 partidas de duplas feminina e oito de duplas masculina, no qual foram registrados os valores de frequência cardíaca (FC) e percepção subjetiva de esforço (PSE) dos atletas. Além disso, foram obtidas variáveis temporais de cinco partidas simples feminina, sete simples masculina, três duplas feminina e duas duplas masculina. Os resultados demonstraram que a FC foi significativamente maior nas partidas da modalidade simples feminina comparado à simples masculina, e também nas partidas da modalidade simples feminina em comparação à duplas feminina. Por outro lado, o tempo total da partida e o tempo de descanso foram significativamente menores e o tempo efetivo da partida foi maior na modalidade de duplas masculina comparado as duplas femininas. Portanto, conclui-se que a intensidade, avaliada pela FC, nas partidas de simples feminina foi maior em comparação às simples masculina e que partidas de simples feminina foram mais intensas que as partidas de duplas feminina. Ademais, as respostas das variáveis temporais nas partidas de duplas masculinas foram diferentes comparadas às partidas femininas de duplas.

**Palavras chave:** Esportes de raquete; Atletas; Monitoramento; Desempenho.

## INTRODUCTION

Badminton is a racquet sport played by two or four people, characterized by short-duration, high-intensity actions, and is one of the most popular sports in the world, with over 200 million enthusiasts (Madsen et al., 2018; Phomsoupha & Laffaye, 2015; Ooi et al., 2009). Regarding the format of matches, the types of competitions include: men's and women's singles, men's and women's doubles, and mixed doubles. Badminton rules establish that a match consists of the best of three games, with the winner of the game being the side that first reaches 21 points. Players are allowed a 60-second break when one side reaches 11 points, and a 2-minute break between games (Badminton World Federation, 2024).

To achieve a successful performance in Badminton matches, athletes require a combination of technical and tactical skills, as well as specific physical fitness for the sport (Madsen et al., 2018; Phomsoupha & Laffaye, 2015). During training sessions and Badminton matches, a combination of both the aerobic system (70%) and the anaerobic system (30%) are required, with the involvement of these systems depending on the nature of the rally (short or long) and the duration of the game (short or long) (Phomsoupha & Laffaye, 2015).

When considering monitoring Badminton athletes and the physiological demands of matches, few studies have sought to track these responses (Fernandez-Fernandez et al., 2013; Abdullahi et al., 2019; Faude et al., 2007). However, regarding the monitoring of the temporal responses of matches (rally time, rest time, and total game time), several studies have conducted this analysis in Badminton (Gomez et al., 2019; Torres-Luque et al., 2019; Gomez et al., 2020; Torres-Luque et al., 2020; Abdullahi & Coetzee, 2017; Valldecabres et al., 2020).

Specifically, some studies have compared the responses between women's and men's matches (Fernandez-Fernandez et al., 2013; Gomez et al., 2019; Abian-Vicen et al., 2013). For example, Abian-Vicen et al. (2013) compared the temporal responses between men's and women's singles matches. The main results showed that the total match duration, rally time, rest time between points, number of points played, and strokes per rally were greater in men's matches than in women's matches. Additionally, the men's matches demonstrated more smashes and drives (types of badminton strokes), while the women's exhibited more unforced errors and falls during matches. However, the women's matches showed a higher percentage of playing time.

Heart rate (HR), rating of perceived exertion (RPE), and temporal responses (rally time and rest time) were monitored by Fernandez-Fernandez et al. (2013) during singles badminton matches. The results showed differences between men and women regarding the temporal responses of the matches, with male athletes being involved in longer rallies, executing a greater number of strokes per rally, and having longer rest times than female athletes. However, HR and RPE responses did not show significant differences between sexes.

Gomez et al. (2019) analyzed 60 elite male and female badminton matches and monitored several temporal responses related to the match, set, and rallies of the athletes while competing. The authors found significant differences between sexes for the duration of the match, sets, strokes executed by the athletes, and the subsequent rally point, demonstrating that men performed at higher intensity than women in relation to most of the temporal parameters analyzed during the matches.

Given that few studies have sought to compare men and women regarding responses in singles and doubles badminton matches in the adult modalities, the present study aimed to compare the physiological, perceptual, and temporal responses of women's and men's singles and doubles

badminton matches. The hypothesis was that there is a difference between sexes and between singles and doubles modalities regarding the analyzed variables.

## **METHODS**

### ***Participants***

Twenty adult singles and doubles badminton Brazilian athletes (11 men and nine women) participated in this study, with the following characteristics: age:  $23.2 \pm 6.1$  years; height:  $174.3 \pm 8.4$  cm for men and  $165.0 \pm 6.2$  cm for women; body mass:  $76.9 \pm 17.0$  kg for men and  $62.0 \pm 8.4$  kg for women; body fat percentage:  $25.1 \pm 3.6$  kg·m<sup>2</sup> for men and  $22.2 \pm 2.5$  kg·m<sup>2</sup> for women; and body mass index (BMI):  $19.6 \pm 8.4$  for men and  $26.7 \pm 6.0$  for women. Inclusion criteria were: being a member of the Badminton Associação Paranaense (BFP), and participating in competitions at state level. Exclusion criteria were the occurrence of injury during the championship. All data were collected during the 3<sup>rd</sup> and 4<sup>th</sup> stages of the 2023 Paranaense Badminton Circuit that occurred in Brazil (Parana state) in the men's or women's singles or doubles matches.

Before the study, the participants were informed about the procedures and provided written informed consent and answered an identification anamnesis. This study was approved by the local Human Research Ethics Committee (#5.643.356/2022 and #4.177.256/2020).

### ***Experimental Design***

The experimental protocol lasted six days (three days in the first stage and three days in the second stage) and was carried out during competitive badminton matches. Before the start of the study, a visit was made to the place where the athletes and coaches were staying in order to present the study and explain the procedures. In addition, the bioimpedance assessment was carried out.

During the six days of competition, HR, RPE, and temporal responses were monitored during singles and doubles matches. It is important to highlight that not all athletes who were present in the matches in which we monitored temporal variables were also present when monitoring physiological and perceptual variables.

### ***Procedures***

#### ***Analyses of Single and Doubles Matches***

The singles and doubles matches were analyzed in the following phases: round of 16, quarterfinals, semifinals, and finals. Regarding the monitoring of physiological and perceptual variables, five women's singles matches, seven men's singles matches, 11 women's doubles matches, and eight men's doubles matches were analyzed, during which the HR and RPE values of the athletes who competed were recorded. For the temporal variables, five women's singles matches, seven men's singles matches, three women's doubles matches, and two men's doubles matches were filmed and analyzed.

#### ***Monitoring heart rate (HR) and rating of perceived exertion (RPE)***

The athletes' HR was recorded every minute while the matches were taking place, and the average HR during the match was determined. The HR in the intervals between points and games was recorded one minute after the pauses of the 11th point and the 21st point of the first and second sets (since no recorded match took place in the third set). RPE was recorded four times during the matches, in the

following breaks: in the 1st set during the 11-point breaks and at the end of the set after 21 points, during the 2nd set in the 11-point breaks and at the end of the set after 21 points.

The HR data were collected using a heart rate monitor (Polar® RS800, Kempele – Finland and Polar® Verity Sense) placed on each player before the match, with the assistance of the Polar Team application. RPE was monitored using the Borg scale, with scores ranging between 6 and 20 (Borg, 1982).

### Monitoring temporal variables

The following temporal variables were monitored: rally time (time in which the shuttlecock was in play), rest time (time in which the shuttlecock fell to the ground until it was put into play at the next point), total match time (total duration of the match), effective match time (total time that the shuttlecock was in play during all games), and number of strokes (all the strokes made by the athletes during the match). All variables were determined through the analysis of the video recorded during the matches by the researchers. This analysis being carried out using Lince Plus software.

### Statistical Analyses

Data were analyzed using the Statistical Package for the Social Sciences (SPSS® v.20, Inc, Chicago, IL). The normality of the data was verified using the Shapiro Wilk test and the results are presented as mean ± standard deviation (SD). Comparisons between sexes and single and double modalities were performed using the Student's t test for independent samples (HR and RPE) because these data presented normal distribution, and the Mann-Whitney U test was used for temporal variables because these data demonstrated non-normal distribution. The significance level adopted for all analyses was  $P < 0.05$ .

## RESULTS

Table 1 presents the HR data obtained during the women's and men's singles and doubles matches. Significant differences were found for all HR values between the women's singles and men's singles, except for the HR at the end of the match (end of game 2). In the doubles matches, no significant differences were demonstrated between women and men. With respect to comparisons between singles and doubles for the same sex, significant differences were found for HR<sub>21points</sub> in game 1, and HR<sub>11points</sub>, HR<sub>21points</sub>, and HR<sub>final</sub> in game 2.

**Table 1.**  
*Heart rate (HR) responses during women's and men's singles and doubles matches.*

	Singles matches		Doubles matches	
	Women (n = 5)	Men (n = 7)	Women (n = 11)	Men (n = 8)
<b>Game 1</b>				
HR <sub>11points</sub> (bpm)	171 ± 9.0	157 ± 11.3*	157 ± 17.7	147 ± 24.8
HR <sub>break</sub> (bpm)	154 ± 6.5	131 ± 13.6*	137 ± 20.5	132 ± 27.2
HR <sub>21points</sub> (bpm)	184 ± 5.4	168 ± 9.0*	159 ± 17.3*	155 ± 24.6
HR <sub>break</sub> (bpm)	149 ± 7.2	127 ± 12.1*	135 ± 19.5	131 ± 29.6
<b>Game 2</b>				
HR <sub>11points</sub> (bpm)	182 ± 3.7	165 ± 15.5*	157 ± 18.1*	155 ± 23.2
HR <sub>break</sub> (bpm)	155 ± 9.8	131 ± 19.7*	137 ± 25.0	136 ± 28.6
HR <sub>21points</sub> (bpm)	184 ± 6.1	171 ± 9.3*	158 ± 17.4*	152 ± 25.2
HR <sub>final</sub> (bpm)	157 ± 11.2	142 ± 15.5	134 ± 23.3*	132 ± 28.0

*Note:* HR<sub>11points</sub>, HR average recorded up to 11 points; HR<sub>break</sub>, HR recorded 1 minute after the break; HR<sub>21points</sub>, HR average recorded from 11 to 21 points; HR<sub>final</sub>, HR recorded 1 minute after the end of the match.

\* $P < 0.05$  in relation to the women's singles.

Table 2 presents the RPE data obtained during the women's and men's singles and doubles matches. No statistical differences were found between women and men for either modality (singles and doubles), or when comparing singles and doubles matches for the same sex.

**Table 2.**

*Rating of perceived exertion (RPE) responses during women's and men's singles and doubles matches.*

	Singles matches		Doubles matches	
	Women (n = 5)	Men (n = 7)	Women (n = 11)	Men (n = 8)
<b>Game 1</b>				
RPE <sub>11points</sub>	11.4 ± 2.5	10.4 ± 2.9	11.6 ± 2.0	10.1 ± 2.5
RPE <sub>21points</sub>	11.8 ± 3.0	11.9 ± 3.3	12.4 ± 1.6	11.0 ± 2.1
<b>Game 2</b>				
RPE <sub>11points</sub>	12.8 ± 3.1	13.1 ± 3.1	12.7 ± 1.2	11.4 ± 2.7
RPE <sub>11points</sub>	13.4 ± 3.4	14.3 ± 3.3	12.8 ± 1.0	11.8 ± 2.7

Note: RPE<sub>11points</sub>, RPE recorded during the 11-point break RPE<sub>21points</sub>, RPE recorded at the end of the set after 21 points.

The responses from the temporal data obtained in the matches are shown in table 3. Differences were found only between the women's doubles and men's doubles for total match time, effective match time, and rest time, in which the total and effective time were higher and rest time lower in men's compared to women's. No significant differences between sexes were found for single matches.

**Table 3.**

*Temporal variables obtained during women's and men's singles and doubles matches.*

	Singles matches		Doubles matches	
	Women (n = 5)	Men (n = 7)	Women (n = 3)	Men (n = 2)
Total match time (min)	27.6 ± 8.9	19.2 ± 2.0	24.3 ± 3.8	20.2 ± 1.2*
Effective match time (min)	6.0 ± 1.3	5.2 ± 1.3	4.9 ± 1.2	5.7 ± 1.5*
Rally time (s)	5.3 ± 0.8	4.8 ± 1.0	4.5 ± 0.9	4.7 ± 1.0
Rest time (min)	21.3 ± 7.6	13.6 ± 1.6	19.2 ± 2.4	14.4 ± 0.2*
Number of strokes	385.0 ± 98.3	354.6 ± 64.8	355.5 ± 90.7	389.0 ± 51.3

\* $P < 0.05$  in relation to the women's doubles.

## DISCUSSION

The present study aimed to compare the physiological, perceptual, and temporal responses of women's and men's singles and doubles badminton matches. The main findings were that HR was significantly lower in men's singles matches compared to women's singles matches, and also in women's doubles matches compared to women's singles matches. Regarding temporal variables, total match time and rest time were significantly shorter, and effective match time was longer in men's doubles compared to women's doubles matches. There were no significant differences in RPE between men and women, or between singles and doubles matches.

Specifically regarding HR in badminton matches, few studies have examined this response (Fernandez-Fernandez et al., 2013; Faude et al., 2007). The results found in our study regarding HR showed a difference between sexes only in the singles matches, where women had a higher average HR during the matches compared to men. A possible explanation for this could be due to the technical level of

women's matches being higher compared to men's matches in the championship in which the present study was carried out, therefore requiring greater effort on their part to defeat the opponent.

It is important to note that our findings with higher HR in women's singles matches compared to men's differs from what were found in previous studies (Faude et al., 2007; Fernandez-Fernandez et al., 2013). Faude et al. (2007) analyzed the physiological responses of 12 internationally ranked badminton athletes with world ranking position between 49 and 164 (eight women aged  $21.8 \pm 2.1$  years; four men aged  $21.3 \pm 1.7$  years) in six simulated singles matches. The matches consisted of two 15-minute periods with two minutes of rest between periods, and HR was monitored throughout the matches. No significant differences in the average HR were found between women ( $170 \pm 10$  bpm) and men ( $166 \pm 6$  bpm). Fernandez-Fernandez et al. (2013) monitored 16 young elite badminton athletes, nationally ranked with under-19 national position between 1 and 20 (eight men aged  $16.0 \pm 1.4$  years; eight women aged  $16.0 \pm 2.3$  years), in 9 simulated male and female singles matches. The results of the study showed that the average HR values obtained were not different between male ( $170 \pm 9$  bpm) and female ( $174 \pm 7$  bpm) matches.

Concerning the intensities of the matches, Faude et al. (2007) and Fernandez-Fernandez et al. (2013) demonstrated higher HR values compared to the present study, in addition to the non-differences between sexes for the singles matches. These different results found by these authors when compared to our results can be explained mainly by the higher physical and technical level of the badminton athletes evaluated in those studies (Faude et al. (2007) and Fernandez-Fernandez et al. (2013)

Regarding the comparisons between singles and doubles matches for the same sex, the HR values in the singles matches in the present study were higher when compared to the doubles matches. Alcock and Cable (2009) monitored 16 male badminton players (eight in singles aged  $22.0 \pm 6.1$  years and eight in doubles aged  $30.0 \pm 6.7$  years) in a total of 12 matches, six in singles and six in doubles. The authors found zones of significantly higher intensities in the singles modality (88.8% of maximum heart rate) compared to the doubles modality (75.5% of maximum heart rate).

Regarding RPE, in the current study this variable was not significantly different between the men's and women's singles and doubles matches. Fernandez-Fernandez et al. (2013) compared RPE between simulated men's singles matches and women's singles matches, in which RPE data were collected after the 11th, 15th, and 21st points of the first and third games and after the 5th, 11th, 17th, and 21st points of the second game; the results for RPE did not show significant differences between men ( $14.6 \pm 1.8$ ) and women ( $14.2 \pm 1.9$ ), similar to our findings.

Other important results of the present study were the responses of the temporal variables, in which the total match time and rest time were significantly shorter and the effective match time was significantly longer when comparing the men's doubles matches with the women's doubles matches. Regarding the comparison between men and women, our findings are different from those of Gomez et al. (2019), who found significant differences between sexes in 120 badminton matches (60 men's matches and 60 women's matches) played during the World Badminton Super Series 2016 in relation to the temporal analysis of the matches; the authors found that women had a shorter rally time ( $9.1 \pm 6.6$  s) and number of strokes ( $714.6 \pm 266.7$ ) when compared to men ( $9.9 \pm 8.0$  s and  $880.7 \pm 318.3$ , respectively). Fernandez-Fernandez et al. (2013) also compared men and women and observed significant differences in rally time ( $6.8 \pm 4.8$  s for men and  $5.7 \pm 3.1$  s for women) and rest time between rallies ( $10.5 \pm 8.8$  s for men and  $8.8 \pm 7.2$  s for women) when comparing men's matches with women's matches.

Still regarding temporal variables, no significant differences were identified between singles and doubles matches for any temporal variables analyzed in the present study. Different from our findings, Alcock and Cable (2009) found significant differences between men's singles and doubles matches for the number of strokes ( $244.5 \pm 45.8$  for singles and  $275.8 \pm 78.4$  for doubles). Another study, by Gawin et al. (2015), compared all types of badminton. The authors analyzed 50 matches in men's and women's singles, men's and women's doubles, and mixed doubles, between 2010 and 2012, in world tournaments. The results showed no significant differences between the modalities in relation to the variables total match time (men's singles:  $0:49:54 \pm 0:19:20$  h; men's doubles:  $0:45:55 \pm 0:16:27$  h; women's singles:  $0:47:28 \pm 0:16:35$  h; women's doubles:  $0:40:04 \pm 0:10:40$  h; mixed doubles:  $0:40:33 \pm 0:09:14$  h) and rest time (men's singles:  $23.1 \pm 3.9$  s; men's doubles:  $23.3 \pm 3.7$  s; women's singles:  $19.4 \pm 3.4$  s; women's doubles:  $20.0 \pm 5.3$  s; mixed pair:  $20.6 \pm 3.2$  s).

Despite the important results found, it is important to highlight that the present study has some limitations, such as a smaller amount of data collected regarding temporal variables in the men's and women's singles matches, and mainly in the men's and women's doubles matches. Therefore, future studies should explore a greater number of variables, both physiological and perceptual, as well as temporal variables related to men's and women's doubles matches.

## CONCLUSION

We conclude that the intensity, assessed by HR responses, in women's singles matches was greater compared to men's singles matches and that women's singles matches were more intense than women's doubles matches. Furthermore, in relation to temporal variables, the total match time and rest time were shorter in men's doubles matches compared to women's doubles matches, while the effective match time was longer in men's doubles matches compared to women's doubles matches. Concerning practical applications, the results of this study can be used as a reference for defining physiological, temporal and performance demands in prescribing specific badminton training for each discipline (singles or doubles). Furthermore, from this study we suggest that coaches monitor variables such as HR, RPE, and the temporal variables of their athletes in official matches and in training sessions to check adaptations resulting from training.

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