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Physiological Responses and Match Characteristics of Men Doubles Badminton Athletes based on Playing Positions

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Abstract

Men doubles badminton has been growing rapidly, requiring a study on match characteristics and physiological responses. To arrange an effective training program design and periodization, understanding the athlete physiological responses and match characteristics are necessary. This study examined the traits of male doubles badminton players according to their court positions (front and back). Laboratory tests and on-court simulations were administered in the study. Participants were athletes from an Indonesian elite badminton club aged 17-19 years. Measurements included anthropometrics, VO2max, blood lactic acid, heart rate, energy expenditure, and match statistics. Standardized equipment was used to measure the anthropometry, while treadmill test with gas analysis was used to measure VO2max. A portable analyser measured blood lactate during simulated matches, while Polar RC 3 GPS devices tracked heart rate and energy expenditure. Video analysis with Go Pro Hero 3+ cameras collected match statistics. The average VO2max was 56.4±5.7 ml/kg/min for both front and back players. Physical responses during gameplay showed significant differences ($P<0.005$), with back players showing higher %HR max, calorie expenditure, and lactic acid levels than front players. Match statistics showed that back players had higher smashes (4.2±1.8) and unforced errors (6.3±7.3) ($P<0.005$), while front players had higher drives (4.4±1.3) and net shots (4.2±1.2) ($P<0.005$). Front and back players had different activity loads, as shown by maximum heart rate and stroke distributions, affecting lactic acid levels. Back players had higher maximum heart rates and more smashes than front players, indicating higher metabolic demands. These findings help tailor men doubles badminton position-specific trainings. The unique demands of each court position can be considered when designing more targeted and effective training programs using physiological adaptation and match data.

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INTRODUCTION

Since it was first included in the 1992 Olympic in Barcelona, badminton has become a popular sport worldwide. Badminton is characterized by quick movements, primarily relying on the anaerobic lactic energy system (Cabello et al., 2004). In 2006, there was a change in the scoring system, from the classic system to the rally point system. This change affects the intensity of a badminton match. In rally point system, badminton matches become quicker and more intense, which changes the metabolism needs in all bioenergy systems. In other words, athletes need longer resting time (Phomsoupha & Laffaye, 2015).

Various studies on the physiological characteristics of badminton athletes show that badminton is a sport that has high intermittent characteristics and uses both energy systems, i.e. 60 – 70% Aerobic system and 30% Anaerobic system. Badminton is a combination of high-intensity short rallies in anaerobic system and moderate and long rally in the aerobic system (Phomsoupha & Laffaye, 2015). This is also strengthened by the high average heart rate on both male and female athletes, which is more than 90% of HRmax or equal to 170 – 180 beats per minute (Cabello et al., 2004; Chen & Chen, 2008; Chint et al., 1995; Faude et al., 2007). The aerobic capability of a badminton athlete plays a big role in his or her performance during a match. High aerobic capability will make an athlete get tired slower in a match. Several studies show that average VO2max of badminton athletes is 63.3 ml/k/minute on elite male athletes (Heller, 2010) and 55.7 ml/kg/minute on sub-elite male athletes (Majumdar, 1997). Meanwhile, on elite female athletes, the average VO2max is 55 ml/kg/minute, and on junior female athletes the average VO2max is 54.9 ml/kg/minute (Heller, 2010). In addition, according to (Leong & Krasilshchikov, 2016) that the characteristics of the game affect the physiological response of athletes, thus athletes must be able to adjust their physical abilities according to the characteristics of the game. Further, a research shows that technical performance increases with the development of the speed-power and strength qualities in males athletes (Kilit et al., 2016). The structure of the game changes along with the changes in the rules of the game so that the tempo of the game becomes higher, and this makes athletes have to be able to adjust in choosing technical actions in matches (Ivan et al., 2015).

Despite numerous scientific studies on badminton, little is known about the physiological and match characteristics of men's doubles, particularly in relation to dominant court positions. Searches indicate a lack of studies focused on these aspects, with most research centered on singles' physiological and match characteristics (Abdullahi et al., 2019; Phomsoupha & Laffaye, 2015). In men's doubles, players' positions during offensive and defensive situations are critical. Each position in doubles affects an athlete's physiological response differently. Gawin et al., (2015) found that physiological demands in badminton vary by playing style and court position. In doubles game strategy development, players develop positional dominance. Only in attacking positions, where players are split into front and back, does positional dominance occur. These differing court positions influence physiological demands, making them a key area of interest. Manrique & Gonzalez-Badillo, (2003) emphasize the importance of understanding the demands of different positions in doubles.

Because each position in doubles requires unique skills, training methods must be tailored accordingly. According to Reilly et al., (2009), specific training programs should be position-specific in team sports. Understanding physiological and match characteristics of each position can enhance game strategies, training programs, and player management during matches, providing elite athletes with a competitive advantage (Laffaye et al., 2015). This research also differences in the physiological demands between front and back positions, which could affect injury prevention and performance optimization. Playing position and injury risk in badminton have been linked by Shariff et al., (2009), but none have examined men's doubles. This study seeks to identify the physiological and match characteristics of men’s doubles players in front- and back-dominant positions. The findings of this research are expected to contribute to the scientific understanding of badminton and help coaches and athletes enhance men’s doubles performance and strategy.

METHODS

Twelve national-level badminton athletes in the men's doubles category participated in this study. Prior to the study, all athletes signed informed consent forms.

The study procedures were approved by the ethics committee. Participants were selected using purposive sampling, where subjects were chosen based on specific criteria set by the researchers to gather the necessary data (Fraenkel et al., 1993).

Procedures

Data were collected in two stages. The first stage was conducted in the laboratory to measure anthropometry and VO2max level. The second stage was conducted on badminton courts by match simulation to asses athletes' heart rate, lactic acid levels, energy expenditure, and match statistics. The match simulation was performed in two sets of games without a rubber set. Subjects' anthropometric characteristics are presented in Diagram 1.

Aerobic Capacity (VO_2max) Assessment

The assessment of maximal oxygen uptake (VO_2max) was conducted in the sport science laboratory of the Physical Education Faculty at Universitas Pendidikan Indonesia (UPI). This test utilized the Treadmill Quark CPET Cosmed equipment, following the Bruce protocol. The laboratory-based test was chosen for its high accuracy, as it measures direct oxygen consumption via a Gas Analyzer. This method provides a gold standard measure of aerobic capacity, which is particularly relevant for understanding the endurance capabilities of badminton players. Faude et al., (2007) emphasized the importance of aerobic capacity in badminton, noting its significant contribution to performance and recovery during matches.

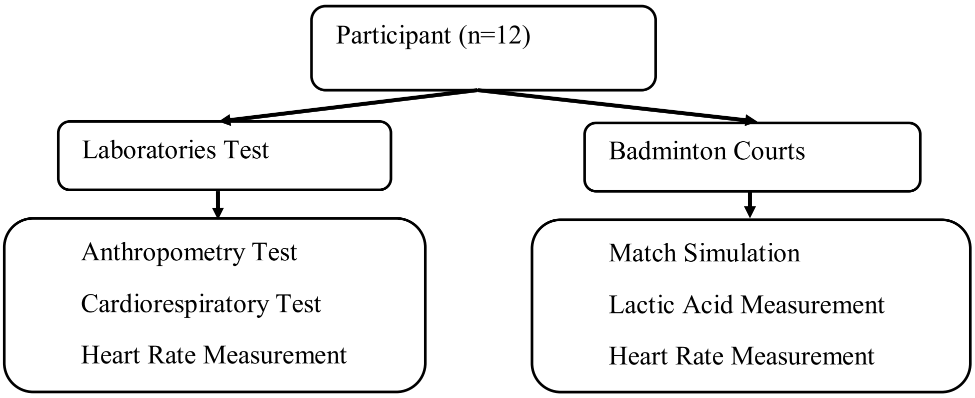

Diagram 1. Subjects' anthropometric characteristics

Anthropometric Measurements

Anthropometric data were collected to establish a physical profile of the participants. Body height and weight were measured using the ZT-120 Body Weight and Height Measurement Tool, while body fat percentage was assessed using the HBF-306C Handheld Body Fat Loss Monitor. Body Mass Index (BMI) was subsequently calculated using the standard formula: weight in kilograms divided by height in meters squared. These measurements provided a comprehensive overview of the athletes' physical characteristics, which are crucial for understanding their physiological responses during play. As noted by Phomsoupha & Laffaye (2015), anthropometric characteristics play a significant role in badminton performance and can affect playing style and physiological demands.

Blood Lactic Acid Measurement

Blood lactic acid levels were measured using the Accurend Plus Portable device. This tool was selected for its suitability for athletes, given its measurement range of 0.8 – 22 mM, which accommodates the high lactic acid concentrations often produced during intense anaerobic activity. Previous studies have shown that in singles badminton matches, athletes' blood lactic acid levels typically range from 2.9 – 12.2 mmol/l, with an average concentration of 4.4 mmol/l (Cabello et al., 2004; Chen & Chen, 2008). This measurement provides insight into the anaerobic demands of badminton and the players' ability to buffer lactic acid during intense play.

Energy Expenditure Monitoring

Energy expenditure during matches was quantified using the Polar RC 3 GPS device. This measurement aimed to determine the amount of energy athletes expended during play. It's important to note that energy expenditure can vary significantly between individuals due to differences in factors such as weight, age, body fat level, gender, physical activities, and environmental conditions (Hills et al., 2014). Alcock and Cable (2009) highlighted the importance of understanding energy expenditure in badminton for optimizing training and nutrition strategies.

Heart Rate Monitoring

Continuous heart rate monitoring was conducted during matches using the Polar RC 3 GPS system. This involved placing electrodes on the subjects' chests, which automatically connected to a watch and Polar application. This method allowed for real-time monitoring of athletes' physical status during matches, providing valuable data for coaches and researchers. Faude et al., (2007) emphasized the utility of heart rate monitoring in assessing the physiological demands of badminton, noting its correlation with energy expenditure and exercise intensity.

Figure 1. Stage 1 Laboratorium Test

Match Statistics Collection

To analyze the characteristics of men's doubles matches, comprehensive match statistics were collected. This process involved recording entire matches using a Go Pro Hero 3+ camera. Subsequently, researchers manually analyzed the video footage to extract detailed statistical data. This approach enabled a thorough post-match analysis of playing patterns, shot selection, and other relevant match characteristics. Abian-Vicen et al., (2013) highlighted the importance of match analysis in understanding the tactical and physical demands of badminton, particularly in differentiating between singles and doubles play.

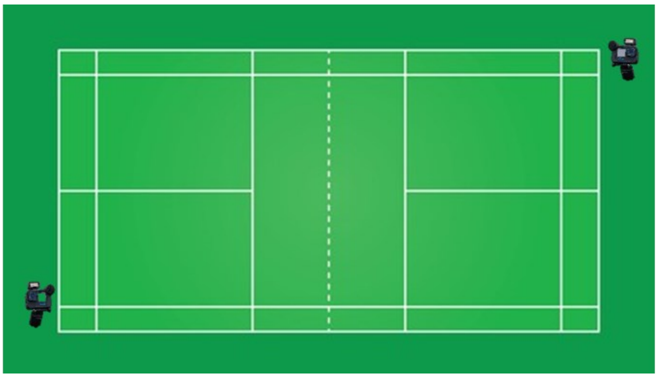

Figure 1. Stage 2 Match Simulation recorded by video

RESULT

Physiological Characteristics

As shown in Table 1, several physiological data points were obtained in the study, including maximum heart rate, lactic acid levels, VO_2max, Rate of Perceived Exertion (RPE), and anthropometric data. The men's doubles athletes had an average Body Mass Index (BMI) and fat content of 15%, indicating ideal body composition. In the VO_2max test, athletes showed an average VO_2max of 56 ml/kg/min, which is lower than the international elite athlete average of 63 ml/kg/min (Andersen et al., 2007; Ooi et al., 2009).

Table 1. Anthropometric Data (Laboratory)

Variable	Sd
Age (Years)	18.35 ± 1.73
Height (Cm)	172.4 ± 3.55
Weight (Kg)	67.13 ± 6.63
Bmi (Kg/M2)	21.78 ± 1.52
Body Fat (%)	15.81 ± 3.20
Peak VO2/Hr (Ml/Bpm)	18.33 ± 2.29
VO2max (Ml/Kg /Min)	56.08 ± 3.64
Rpe Cr-10 Scale Laboratory	9.0 ± 0.3
Max heart rate (Bpm)	197 ± 0.57

Match Simulation

The match simulation consisted of two sets. During the matches, the athletes' average heart rate, maximum heart rate, lactic acid levels, and energy expenditure (calories) were measured. As shown in Table 2, there was a significant difference between front and back-dominant players in maximum heart rate ($p < 0.05$) and calorie expenditure ($p < 0.01$) during match simulation. Back-position-dominant players exhibited higher maximum heart rates and calorie outputs, though there was no significant difference in average heart rate or RPE. Table 3 shows a significant difference in lactic acid levels between front and back positions in post-match, but no significant differences were observed in pre-match or interval periods between sets.

Table 2. Physiological Respons during Match Simulation

Variable	Dominant Front Position	Dominant Back Position
Average heart rate (beat/minute)	158.8 ± 9.73	160.8 ± 11.73
Maximum heart rate (beat/minute)	181 ± 6.22	195.2 ± 10.25*
Calorie (kcal)	249.3 ± 4.59	287.3 ± 5.52#
RPE Cr-10 Scale Match Simulation	8.08 ± 0.79	8.12 ± 0.34

*Significant difference between front and back positions in maximum HR
#Significant difference between front and back positions in calorie expenditure

Table 3. Lactic Acid Levels during Match simulation

Variable	Dominant Front Position			Dominant Back Position		
	Pre	Interval between sets	Post	Pre	Interval between sets	Post
La (mmol/l)	2.32 ± 0.59	4.25 ± 0.35	4.91 ± 0.23	2.32 ± 0.22	4.34 ± 0.75	5.53 ± 0.46*

*Significant difference in post-match lactic acid between front and back positions

Table 4. Temporal Statistics (Match Simulation)

Variable	Match 1		Match 2		Match 3		Average
	Set 1	Set 2	Set 1	Set 2	Set 1	Set 2	
Match duration (minute)	15.12	18.25	14.33	20.11	13.15	17.03	16.39
Average RD (second)	7.9	10.2	7.1	11.0	8.4	13.3	9.09
Average RT (second)	10.4	26.1	13.1	25.5	8.6	29.3	23.92
Average S/R (total)	8.4	12.2	8.0	12.6	9.0	14.1	10.04

Note: RD = rally duration, RT = rest time, S/R = shoot/rally

Table 5. Stroke Statistics

Stroke Distributions		
Variable	Front Position	Back Position
Average Drive/rally (n)	4.4 ± 1.3*	2.3 ± 0.3
Average Smash/rally (n)	2.7 ±0.6	4.2 ±1.8#
Average Net/rally (n)	4.2 ±1.2^	2.4 ±17.2
Average Drop/rally (n)	1.7 ± 7.3	2.1 ± 7.3
Total Force Error (n)	4.3 ±5.8	4.6 ±5.8
Total Unforced Error (n)	4.7 ± 7.3	6.3 ± 7.3+

* Significant difference between front and back positions in Drive/rally
# Significant difference between front and back positions in Smash/rally
^ Significant difference between front and back positions in Net/rally
+ Significant difference between front and back positions in Total Unforced Error

Match Statistics

During the court test (match simulation), all matches were recorded, allowing for the collection of match statistics for each participant. Table 4 summarizes these statistics: the average match duration per set was 16.39 minutes, the average rally duration was 9.09

seconds, the average rest time was 23.92 seconds, and the average number of shots per rally was 10.04.

In Table 5, stroke statistics based on the athletes' positions (front or back) are presented. Six stroke types were analyzed: average drop shots, average drives, average smashes, average net shots, total force errors, and total unforced errors. A t-test comparison revealed significant differences between front and back position athletes in average smashes, drives, net shots, and unforced errors ($p < 0.05$). There were no significant differences in drop shots and total force errors ($p > 0.05$).

DISCUSSION

This study aimed to investigate the effects of front and back positions in game situations on the physiological responses and match characteristics in men's doubles badminton players during a 2-set simulated badminton match. To our knowledge, this study is the first to conduct such a thorough investigation of these positional effects. The key finding was that back-position players exhibited higher physiological responses, including %HRmax, calories burned, and lactic acid levels, compared to front-position players. Additionally, we found players in both positions showed relatively high %HR values during the 2-set simulated match, highlighting the overall intensity of men's doubles badminton.

Physiological responses, particularly heart rate (HR) and lactic acid levels, were higher for back-position players compared to front-position players. This outcome can be attributed to the type and number of strokes per rally, with longer rallies placing a higher metabolic load on the back players (Kilit et al., 2016).

Heart rate monitoring remains one of the most common indirect methods for estimating exercise intensity due to its practicality and affordability (Murayama & Ohtsuka, 1999). In this study, the average heart rate during the matches was 158 bpm for front players and 160.5 bpm for back position players. This showed that both of the positions in men's doubles athletes played with the same intensity overall. However, maximum heart rates were higher for back-position players (195 bpm) compared to front-position players (181 bpm), indicating that back players occasionally played at a more intense level during specific rallies. This aligns with previous studies reporting that badminton players' heart rates during matches typically range from 80% to 91% of their maximum heart rate (Cabello et al., 2004; Docherty, 1982; Majumdar, 1997).

The elevated maximum heart rate observed in back -position players is likely due to the high frequency of smashes during rallies, with an average of 4.2 smashes per rally compared to 2.7 smashes for front players. Smashing is a high-intensity action, and its frequent occurrence significantly impacts the players' physiological responses, particularly in terms of sympathetic modulation (Pontes Morales et al., 2014)

Men's doubles badminton requires players to have rapid reactions and make quick, accurate decisions, contributing to a higher and faster match intensity than singles matches. This faster intensity is reflected in the match statistics. In this study, the average number of shots per rally was 10.4 ± 1.2, and the average rally duration was 9.09 ± 2.3 seconds. In contrast, match statistics for the singles category show an average of 5.7 ± 4.2 shots per rally and a rally duration of 6.2 ± 4 seconds (Fernandez-Fernandez et al., 2013). Comparing these two statistics, there is a significant difference in rally duration and shoot/rally. The greater number of shots per rally and longer rally duration in men's doubles is likely due to the presence of two players per side, which increases the pace and complexity of play compared to singles.

The different number of players in doubles also affects stroke distribution. Back-position players executed more smashes and attacking shots, while front-position players dominated with drives and net shots, focusing on controlling the game.

This study also examined lactic acid levels. We found a significant difference in post-match lactic acid levels between front and back players. Front-position players had an average post-match lactic acid level of 4.91 ± 0.23 mmol/l, while back-position players had a higher level of 5.53 mmol/l. Faude et al. (2007) noted that lower lactic acid levels during a match suggest minimal contribution from the anaerobic lactic energy system, given that the average rally time of 9.09 seconds in men's doubles is short enough to remain within the anaerobic alactic zone. Cabello et al (2004) showed that there was little difference in work and rest variables, with longer work intervals occurring on higher lactate concentrations. Furthermore, the difference in lactic acid levels of the front and back players is caused by different activity loads, as this can be seen from the maximum heart rate and the distribution of strokes, where the back players have a max HR and a greater number of smashes than the front players, so the back players have the higher metabolism demands than those of front players.

CONCLUSION

This study documented the physiological responses and match characteristics of men's doubles badminton players during a two-set simulated badminton match. During the match simulation, significant differences were observed between front and back positions in terms of physiological responses, including average heart rate, maximum heart rate, calorie expenditure, and lactic acid levels. Additionally, stroke distribution varied between the two positions, with back-position players performing more smashes and attacking shots, while front-position players dominated in drives and net shots to maintain control of the game. Taken together, these findings provide valuable insights into the distinct physiological demands of each position in men's doubles badminton. Understanding these differences can inform badminton-specific training programs, helping coaches plan periodization and tailor training adaptations to meet the unique requirements of both front and back players.

CONFLICT OF INTEREST

The authors declared no conflict of interest.

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