Impacts of rest time and heart rate on performance in tennis

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Abstract

This study investigates the relationship between heart rate and various skill performances in tennis. The participants included 12 male college players. They used a wearable device to collect heart rate data. One-way analysis of variance was employed to analyse the relationships between performance and each of heart rate and rest time. The results show that the mean ± standard deviation for heart rate in the first set was 155.84 ± 15.98 bpm, second set was 158.34 ± 16.25, and final set was 160.10 ± 16.00. Significant differences were observed in heart rate based on serve location T (p = .029) and T3 rest time (p = .031) . According to heart rate level, the first serve performance was ranked as I > II > III > IV (p = .001) , and the second serve performance was ranked as I > II > III (p = .001) . This study shows that higher the heart rate, the lower the chances of winning.

However, the performance show heart rate load of the winner is lower than of the loser in the game. Therefore, the higher heart rate lower chance of winning,with the heart rate on first serve maintained under 160 bpm and that on the second serve at under 151 bpm.

Keywords: Heart Rate, Performance, Time, Wearable Device, Analysis,

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1.Introduction

In tennis, the serve is the most important technique in the game. It has been defined as the most important stroke, as it provides the opportunity to achieve the ascendency in a point or even to win it directly (Whiteside, Elliott, Lay, & Reid, 2013 ; Hernández-Davó et al., 2019). At the beginning of each point, the serve is used to start the game and, when the server can, to win points outright. Thus, it is an important offensive weapon to master. Usually, the server must change the serve location in a timely manner in the game to maintain the server advantage. Especially in men's matches, maintain the server advantage is important, with players often losing the game when the service game is broken (Chao, & Wang, 2008) .

The tennis serve is a complex movement involving the sequential transfer of energy across different body segments. A correct transfer of this energy along the segments is required to increase tennis serve speed (Reid, Elliot, & Alderson, 2007; Hernández-Davó et al., 2019) . In serving, speed and the serve location are important. Fast serves classified as aces have an accuracy of 87.02%. Hitting aces seem more contingent on accuracy than speed (Reid, Elliot, & Alderson, 2007; Hernández-Davó et al., 2019) . Therefore, the serve location and accuracy are one of the main reasons that affect the points scored on the serve.

Tennis is a high-intensity sport, and the tennis match play is characterised by intermittent exercise involving alternating short (4–10 s) bouts of high intensity and short (10–20 s) recovery bouts, interrupted by several rest periods of longer duration (60–90 s) (Reid, Elliot, & Alderson, 2007; Hernández-Davó et al., 2019) . As per the rules of the game, the rest time between points is 25 seconds, the change end rest time is 90 seconds, and set finish is 120 seconds for rest time.

The HR monitoring is an easy and very common method of measuring intensity of activity, particularly in games involving short duration bouts of high-intensity activity (Kilit, & Arslan, 2019) . Tennis is an intermittent sport, where the players are hitting the ball about every 7 second. The work/rest relationship means that the HR is between 106 and 150 bpm., which represents 70–80% of HRmax; hence, it can be considered a moderate-to-high intensity sport (Sánchez-Pay, , Torres-Luque, & Sanz-Rivas, 2016) . The extent to which players experience fatigue during a competitive game (Mendez Villanueva, Fernandez-Fernandez, & Bishop, 2007) , and the physical condition that affects the service win rate are unclear. However, several investigations have observed that impaired performance on stroke production and court movement during a match is influential (Davey, Thorpe, & Williams, 2002; Vergauwen, Spaepen, Lefevre, & Hespel, 1998 ; Javier, Roberto, & Marcelo, 2016) .

With the constant improvements in modern tennis on strength, speed and physical fitness, players are consequently becoming faster and faster in the game; thus, to maintain competitive advantage, training must always involve high-intensity intermittent exercise. Therefore, this study aimed to understand the impacts of heart rate and the 25-second rest time between points and points on the service game and to explore the relationship between serve accuracy and the serve win rate and heart rate variability. The results of the

analysis can be used for reference by tennis coaches and players.

2.Methods

Participants

This study was given institutional ethical approval (IRB no.: 20-114-B) . The participants were 12 male college players, aged 20–22 years old, all right-handed, and had trained for over 5 years. During the experiments, each participant wore a wearable device, Scosche Rhythm24 (Figure 1) . The biometric sensor technology is proven by PerformTek and is capable to record continuous heart rates via extensive tests. The device can be used on most exercise and environment and is able to collect heart rate data on the left wrist. And synchronously record heart rate and research data in the game, fetch record the heart rate bpm value before serving and finish point bpm value. All participants were informed of the risks and benefits of the study and signed a written informed consent form prior to participation.

Figure 1 *Rhythm24 biometric sensor*

Performance characteristics

The study was conducted on a clay court in April 2021. The players were divided random into three groups and played three-set two-win singles games. A total of 18 matches were captured. The data collected included the score situation, first and second serves, serve location point (T, Body, Wide; Figure 2) , and heart rate. The 25-second rest time between every point was divided into three intervals at which to assess heart rate and performance: T1 (1–8 s) , T2 (9–16 s) and T3 (17–25 s) . A camera was set up at the back of the court to capture videos for confirmation.

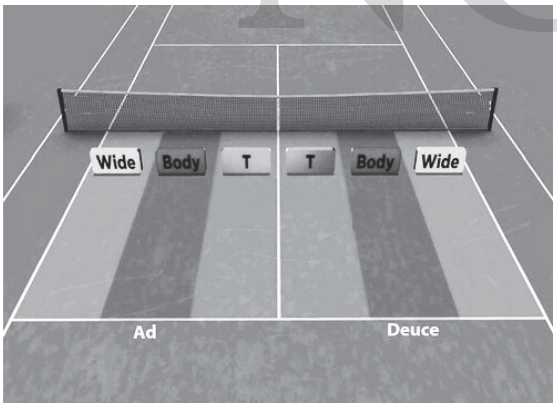

Figure 2 *Serve locations*

Data processing and data analysis

Microsoft Excel 2010 was used to process the annotations of each stroke, descriptive statistics and charts. All data were analysed using the SPSS statistical package version 20. The t-test was conducted to determine the data distribution. The heart rate was categorised into 8 levels: I (128–135 bpm) , II (136–143 bpm) , III (144–151 bpm) , IV (152–159 bpm) , V (160–167 bpm) , VI (168–175 bpm) , VII (176–185 bpm) , VIII (186–192 bpm) . Because only one point was recorded in the VIII level, it was excluded from the analysis. One-way analysis of variance was used to analyse the differences among the rest times, first serve and second serve. Pairwise comparisons were performed using the Scheffé post-hoc test. Statistical significance was set at $p < 0.05$.

3.Results

The heart rate data of the participants are shown in Table 1. The average age (mean ± standard deviation [SD]) was 21 ± 1.00 years, and the average heart rate (mean ± SD) was 155.45 ± 16.06 bpm. The heart rate was found to increase with the score and the set. The average heart rate in the first set was 155.84 ± 15.98 bpm, 158.34 ± 16.25 bpm in the second set, and 160.10 ± 16.00 bpm in the final set.

Table 1.
Study participants' average age and heart rate per set

	Mean	Standard deviation
Age	21	1.00
Total heart rate	155.45	16.06
First set	155.84	15.98
Second set	158.34	16.25
Final set	160.10	16.00

Comparisons on serve performance and heart rate in terms of location point and rest are shown in Table

2. The average heart rate for location point T in the deuce court was 155.175 ± 15.772 bpm and 154.505 ± 17.331 bpm in the advantage court. A significant difference (p = .029) was observed among the players in location point T, but not in location points Wide and Body. Serves on the T position had significantly better scores than on other positions. In No significant differences were observed in T1 (Difference 1.067 bpm) and T2 (Difference 3.193 bpm) rest times; however, scoring performance at T3 (Difference 6.454 bpm) differed significantly (p = .031) . In addition, the average rally resulting in a win was 2.615 ± 2.109 shot and 2.732 ± 2.119 for one resulting in a loss. Although no significant difference was observed, losing rallies were longer than winning ones on average.

Table 2.
Heart rate data for location points and rest times and rally length

Heart rate	Project	Mean (bpm)	Standard deviation	Difference	*p*-value
Location point T	Deuce	155.175	15.772		.029*
	Advantage	154.505	17.331		
Location point Wide	Deuce	154.000	15.980		.225
	Advantage	155.722	15.087		
Location point Body	Deuce	157.422	15.690		.964
	Advantage	158.064	16.049		
Rest time T1	Win	163.946	17.100	1.067	.582
	Lost	165.013	16.808		
Rest time T2	Win	151.362	16.163	3.193	.271
	Lost	154.555	20.634		
Rest time T3	Win	146.636	19.739	6.454	.031*
	Lost	153.090	11.148		
		Mean (shot)	Standard deviation		
Rally length (min)	Win	3.14	2.1		.294
	Loss	3.91	2.9		

*p< .05

Comparisons on first serve performance with regard to heart rate level are shown in Table 3. Significant differences were found in heart rate levels I–IV: Ⅰ > II > III > IV (F = 2783.066; p =.001) . No significant differences were observed among V, VI and VII.

Table 3.
First serve performance data

Level	Mean (bpm)	Standard deviation	F	*p*-value	Comparison
Ⅰ	131.170	2.277	2783.066	.001	Ⅰ > II > III > IV
II	139.203	2.059			
III	147.452	2.188			
IV	156.045	2.219			
Ⅴ	163.035	2.198			
VI	171.724	2.230			

VII	178.871	2.140

The winning players second serve data, are shown in Table 4. Significant differences were found in heart rate levels I–III: Ⅰ > Ⅱ > Ⅲ (F = 1021.365; p =.001) . No significant differences were found among IV, Ⅴ, VI and VII.

Table 4.
Second serve performance data

Level	Mean (bpm)	Standard deviation	F	*p*-value	Comparison
Ⅰ	130.833	2.595	1021.365	.001	I > II > III
Ⅱ	139.360	2.464			
III	146.666	2.443			
IV	155.880	2.521			
Ⅴ	163.812	2.286			
VI	171.807	2.400			
VII	178.562	2.032			

4.Discussion

This study aimed to investigate performance in terms of heart rate and serve location and to analyse the differences between players. According to previous studies, the average heart rate of tennis players during or after a match is between 144 and 165 bpm (Bergeron et al., 1991; Smekal et al., 2001; Coutts, Reaburn, & Abt, 2003; Wu, Lee, Gou, 2006) , which are similar to the results of this study (155.45 ± 16.06 bpm) . The study found that the heart rate of tennis players and the time in the game influence performance. Service games and winning matches have been found to increase physiological responses and time–motion characteristics (Kilit, & Arslan, 2017) . The results indicate that the service game situation has a significant effect on the physiological response in an hour-long simulated tennis match between professional male tennis players (Kilit, Şenel, Arslan, & Can, 2016) , that is, the average heart rate increases with game times and number of sets. The present study demonstrates that the average heart rate increased with every succeeding set. This finding indicates that increased fatigue is associated with competition. Although HR monitoring is a very common method of measuring the intensity of exercise, several factors (e.g., psychological stress, emotion, score, etc.) can affect HR responses in professional tennis matches.16 Kovacs's study investigated the impacts of heart rate and serve location on player performance and found that groundstroke hitting accuracy decreased by 69% from the start of the game to fatigue onset. Furthermore, serve accuracy declined by 30% after the intermittent test, indicating that fatigue was accompanied by a decline in tennis skills.9 The findings show that a significant difference was observed between the deuce and advantage courts in location point T. Furthermore, the wining rate was excellent when serving location T on the deuce court. These findings also corroborate the findings (Kovacs, 2007) .

A previous study found that about 60% of rallies were finished within the first four shots of the rally

(Davey, Thorpe, & Williams, 2002) , with elite players on clay courts averaging 2.7 strokes per rally(Fernandez-Fernandez et al., 2007; Mendez-Villanueva et al., 2007) , The present study adds to the literature, demonstrating that winning rallies were shorter than losing rallies. In addition, the research shows that tennis players spend 30%–36% of the total playing time at 80%–90% and 70%–80% of the maximum heart rate (Mendez-Villanueva et al., 2007) .

Furthermore, in the present study, the differences in performance heart rate were compared, and found the short rest time heart rate recover is no difference, but have a significant difference on the longer rest time, The win players heart rate have recover than lost players more by 6.454 bpm, indicating the lower heart rate or recover players have a higher winning rate.

Tennis is a high-intensity sport; thus, a longer rest time needed to slow the heart rate can result in a better performance.

A previous study showed that high-intensity interval training generated end-session decrements in tennis stroke performance (Pialoux et al., 2015) . Our study found that when the heart rate was lower than 160 bpm on the first serve or under 151 bpm on the second serve, performance significantly resulted in wins.

5.Conclusions

This study describes various factors that affect heart rate and, consequently, performance, in tennis matches. The results showed that heart rate increases with the score. The higher the heart rate, the lower was the winning rate, and the players serving to the T location while in the deuce court have a higher winning rate.

In addition, the rest time influences heart rate recover difference, longer rest time the greater the difference between win and lost average heart rate, and show the win players can start the point on the better status. Moreover, the average heart rate on the first serve should be lower than 160 bpm, whereas that on the second serve should be lower than 151 to increase the winning rate, and suggested that players can try to use the rules to increase the heart rate recovery time, and avoid warning within the legal range to achieve better performance.

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比賽休息時間與選手心率對網球發球表現之影響

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摘要

本研究調查了比賽中心率和各項技術表現的結果，並採取 12 名男性大學生球員，並使用穿戴設備收集包括心率數據。採用單因子變異數分析來探討運動員的心率與休息時間的技能表現差異之間的關係。本研究結果顯示，心跳差異數據第一盤平均值為 155.84 (±15.98)，第二盤平均值為 158.34 (±16.25) ，最後一盤平均值為 160.10 (±16.00) 。發球落點位置 T (p= .029) 有顯著差異，T3 休息時間 (p= .031) 有顯著差異；單因子分析顯示第一發球心率 Ⅰ>Ⅱ>Ⅲ>Ⅳ(p= .001) ，第二發球心率 Ⅰ>Ⅱ>Ⅲ (p= .001) 。本研究發現，選手在比賽中的心率會隨著比賽進行而增加分數，心率越高，獲勝率越低，但休息時間越長，表現就會提高。因此，有必要在高強度比賽時，嘗試爭取休息時間，在比賽中第一發球時心率保持在 160 以下，二發保持在 151 以下，較容易獲得高勝率。

關鍵詞：心跳、表現、時間、穿戴式裝置、分析