

## Cardiovascular Perceived Exertion and Blood Lactate Response after Badminton Matches

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### ملخص البحث العربي:

**العنوان :** مجهود القلب والأوعية الدموية واستجابة لأكثات الدم بعد مباريات كرة الريشة

تعد الريشة الطائرة واحدة من اسرع العاب المضرب والتي تتميز بحركاتها قصيرة المدى وشدة عالية. وهدفت الدراسة الى قياس ومقارنة تركيز اللاكتات في الدم و RPE ومعدل ضربات القلب وضغط الدم قبل وبعد تكرار مباريات كرة الريشة الطائرة. المنهج: ستة لاعبين مصنفين على المستوى الوطني (العمر =  $22.6 \pm 5.3$  سنة ؛ الطول =  $172.5 \pm 3.2$  سم ، الوزن =  $66.1 \pm 5.3$  كجم) اجرؤ أربع مباريات متتالية بالريشة الطائرة مع فترة تعافي "راحة" مدتها 30 دقيقة تم قياس معدل ضربات القلب وضغط الدم و RPE قبل وبعد نهاية المباراة مباشرة. بالإضافة إلى ذلك، تم قياس تركيز اللاكتات في الدم قبل وبعد 5 دقائق من نهاية المباراة. النتيجة: استنتجت الدراسة إلى أن تركيز اللاكتات في الدم و RPE كانا أعلى في المباراة الرابعة مقارنة بالآخرين مع وجود فروق ذات دلالة إحصائية بين كليهما قبل  $F_{3, 15} = 20.08, P=0.000$ ، و بعد المباريات  $F_{3, 15} = 14.80, P=0.000$ ،  $F_{3, 15} = 16.48, P=0.000$ ،  $F_{3, 15} = 13.71$ ،  $P=0.000$ ، لم يتم العثور على فروق ذات دلالة إحصائية في معدل ضربات القلب وضغط الدم. الخلاصة: اثارات المباريات المتكررة بالريشة الطائرة ضغوطاً على القلب والأوعية الدموية و العوامل النفسسيولوجية لدى اللاعبين. يوصى بشدة بإعادة النظر في وقت الراحة البينية بين المباريات بالإضافة الى تقليص عدد المباريات المسموح بها يومياً خلال البطولات الوطنية والدولية.

### Abstract

Badminton is the fastest racket game with action of short duration and high intensity. Purpose: to measure and compare blood lactate concentration, PRE, heart rate and blood pressure before and after repeated badminton matches. Method: Six national ranked players (age =  $22.6 \pm 5.3$  years; height =  $172.5 \pm 3.2$  cm, weight =  $66.1 \pm 5.3$  kg) played four

badminton matches in raw with recovery period of 30 minutes in which Heart Rate, Blood pressure and RPE were measured before and immediately after the end of each match. Additionally, blood lactate concentration was measured before and after 5 min from the end of the match. Result: the study indicates that blood lactate concentration and RPE were higher in the fourth match comparing to others with significant differences among them for both before  $F_{3, 15} = 20.08$ ,  $P = 0.000$ ,  $F_{3, 15} = 14.80$ ,  $P = 0.000$ , and after the end of the matches  $F_{3, 15} = 16.48$ ,  $P = 0.000$ ,  $F_{3, 15} = 13.71$ ,  $P = 0.000$ , respectively. No significant differences for heart rate and blood pressure were found. Conclusion: the repetitive badminton matches exerted high cardiovascular and psychophysiological stress on the players. Reconsidering the given recovery time and the number of games allowed per day during national and international tournaments is highly recommended.

**Key Words:** Blood Lactate, RPE, Heart Rate, Badminton

## Introduction

Badminton is an extremely demanding sport characterized by high-intensity, intermittent actions of short duration (Cabello, Padial, Lees, & Rivas, 2004; D. Raman & Dr. A. S. Nageswaran, 2012). In fact, it is the most exhausted (Alcock & Cable, 2009; Liddle, Murphy, & Bleakley, 1996) and the fastest racket sport in the world (Singh, Raza, & Mohammad, 2011). Players are required to move quickly when necessary, changing direction due to the nature of the movements required during the game (De França Bahia Loureiro & De Freitas, 2016). Elite players need to perform at their maximum limits of speed, agility, flexibility, endurance and strength (D. Raman & Dr. A. S. Nageswaran, 2012). Throughout badminton game, high demands is placed on both the aerobic and anaerobic systems during play and recovery (Phomsoupha & Laffaye, 2015). It has been found that, over badminton match, 30-40 % of the energy is derived from the anaerobic system, while 60-70 % obtained from the aerobic system (Phomsoupha & Laffaye, 2015; Van Lieshout & Lombard, 2003). Players are required to maintain a high level of intensity for as long as possible.

The concentration of blood lactate ( $[La^-]_b$ ) is one of the most often measured parameters during clinical exercise and performance of athletes (Goodwin, Harris, Hernández, & Gladden, 2007), and the lactic acid deposition in blood induces the player to decrease its strength during athlete's clinical exercise and therefore performance. Goodwin et al. (2007) observed a high level of lactate response during execution of some specific strokes in badminton. The concentration of blood lactate in single matches is 2.9–12.2 mmol/L (Cabello et al., 2004; Cabello Manrique & González-Badillo, 2003; Chen, Wu, & Chen, 2011). In a review focuses on the physical and physiological characteristics of badminton

players(Phomsoupha & Laffaye, 2015), considering the average lactate concentration from over 100 studies, maximum lactate concentration for male players was 7.0 mmol/L, and 7.1 mmol/L for females. Furthermore, Besides, during certain special badminton strokes Ghosh (2008) found a high blood lactate concentration.

Heart rate was also investigated, studies report an average HRmax of 191 beats/min in males and 197.6 beats/min in females, and an average HR of 178 beats/min in males and 172 beats/min in females (Chen et al., 2011; De França Bahia Loureiro & De Freitas, 2016; Fahimi & Vaez Mousavi, 2011; Fuchs, Faude, Wegmann, & Meyer, 2014; Heller, 2010; Hwa & Sidek, 2010; Ozmen & Aydogmus, 2016; Pearce, 2002).

Generally, badminton games are played in a tournament with one - three matches during a day over the course of 4 or 5 days (Phomsoupha & Laffaye, 2015). However, some players may participate in more than one event and therefore, more matches during the tournament. According to the Badminton World Federation, a minimum of 30 minutes rest is required between games, and therefore, a player may play more than a game within a few hours, with a Competitive matches lasting 30 min to 1 hour (Abián-Vicén, Del Coso, González-Millán, Salinero, & Abián, 2012), action intervals (performance time) between 5-8 seconds, and rest times (recovery period) between 10-16 second.

Locally and in some national competition, players might ask to play even more than 3 games in a day. This might lead to insufficient recovery period and as a result insufficient time to repair and replenish. The study aims to measure lactate concentration (La), Rating of Received Exertion (RPE), heart rate (HR), and blood pressure (BP) after a repeated badminton match. It is hypothesized that La, RPE, HR, and BP will differ between matches toward higher level after repeated badminton matches.

#### Methodology

##### Participants

Six elite badminton players were recruited for this study from Akkad Ankawa Sport club. Mean  $\pm$  1SD age, stature and body mass of the 6 included participants was  $22.6 \pm 5.3$  years,  $172.5 \pm 3.2$  cm and  $66.1 \pm 8.4$  kg. Participants average competitive experience was  $9.3 \pm 2.6$  years, training on average 5 sessions per week for an average total of 9 hours per week. Participants abstained from caffeine for 6 hours, alcohol for 24 hours and food for 2 hours prior to testing. Participants also refrained from training or heavy physical work for 24 hours before testing. Participants gave prior written informed consent to the procedures which were approved by the institutional ethics committee.

Figure 1. Shows the experimental design  
Design:

The study was conducted in 3 days at the indoor badminton court at Akad Ankawa Sport Club starting from (November the 16<sup>th</sup>, 2020), all the players were explained about the protocol. Each player played 4 consecutive matches in a tournament environment with rest of 30 minutes between matches as explained in Figure 1. The matches were played according to the current rules of the Badminton World Federation <https://bwfbadminton.com>. Measurements were taken before and after each match for each sample, thus eight samples were taken for each player. Each day two players were tested, the opponent was selected randomly and to ensure that the players were highly motivated, a gift was dedicated for the winner and the matches were included in the internal ranking competition as the team was preparing for the national tournament.

#### Procedure

Before the test (matches) participants were asked to refrain from ingesting alcohol for 24 hours, caffeine for at least 6 hours, and food for 2 hours prior to testing. Participants were also asked not to train or engage in heavy physical

		Player 1	30 min rest	Player 2	30 min rest	Player 3	30 min rest	Player 4	30 min rest	Player 5	30 min rest	Player 6
Day 1	Player 1			x		x		x		x		
	Player 2	x				x				x		x
Day 2	Player 3	x		x				x		x		
	Player 4			x		x				x		x
Day 3	Player 5	x				x		x				x
	Player 6	x		x				x		x		

work for 24 hours before testing. On the first day participants had their body mass and stature measured and were briefed as to the requirements of the experiment but not the purpose of the study. Before the warm-up a blood sample was taken for lactate concentration analysis, and they were provided with heart rate monitor. Participants also completed a short training history questionnaire. After all tests had been completed, participants were debriefed about the purpose of the study.

#### Plying Time

In total twenty-one badminton matches were played; match time was recorded using a stop watch. Matches (total playing time) were lasted for an average of 43.6 minutes  $\pm$  5.89.

#### Lactate concentration

Lactate concentration was determined in blood samples taken from the fingertip, using Accutrend Plus System. The system offers easy measurement and delivered lactate result in 1 minute. This technique is considered to be highly accurate for lactate concentrations between 0.8 – 20mmol/L. 19 20. Blood sample were taken before and at 5 minutes' interval during the recovery period (30 minutes' rest) for each match.

#### Heart Rate

The heart rate was measured using a chest strap Polar Accurex Plus heart rate monitor (Polar Electro. Kempele, Finland) connected via wireless to awatch, Average HR was calculated for the whole match.

#### Rate of perceived exertion

Participants were asked to provide an overall rating of perceived exertion before and immediately after the match using the Borg 6-20 RPE scale (G Borg, 1970). All subjects were familiarized with the RPE scale, which was administered in accordance with published standardized instructions (Gunnar Borg, 1998).

#### Blood Pressure

Systolic blood pressure (SBP) and diastolic blood pressure (DBP) were measured using a microlife professional digital sphygmomanometer model BP A2 Basic. During the measurement, the player remained seated on a comfortable chair. All the measurements were taken from the left hand and before and immediately after each match, under the direct supervision of the physician.

#### Statistical analysis

One-way repeated measure ANOVA was used to measure the interaction of (La, HR, RPE, SPB, and, DBP) between the matches using the Statistical Package for Social Sciences (SPSS) software package 26. Level of significance was kept at 0.05. Significant differences were followed by Bonferroni post hoc test.

#### Result

Mean and SD value for blood lactate, RPE, heart rate, and BP before and after badminton matches are presented in Table 1.

Table 1. Data as mean and (1SD) for Blood lactate concentration, Heart rate, blood pressure and RPE during recovery and after badminton matches.

	Badminton Matches	During Recovery		After the Matches	
		Mean	± SD	Mean	± SD
La mmol/l	M1	1.13	0.14	4.38	0.43
	M2	1.22	0.10	5.07	0.33
	M3	1.37	0.15	5.27	0.27
	M4	1.60	0.17	5.82	0.44
RPE	M1	6.67	0.52	13.67	1.21
	M2	6.83	0.75	13.83	0.98
	M3	7.33	0.52	16.00	1.67
	M4	8.50	0.55	17.83	0.98
HR Beats/min	M1	68.2	2.6	164.7	8.8
	M2	68.0	3.8	166.3	6.4
	M3	68.7	3.5	170.8	5.9
	M4	67.7	3.9	171.2	7.3
SBP mmHg	M1	118.5	2.4	144.3	4.5
	M2	117.8	2.9	145.0	5.1
	M3	119.5	3.4	147.3	5.3
	M4	119.3	3.3	149.5	4.2
DBP mmHg	M1	74.3	4.5	82.0	2.8
	M2	74.5	3.3	82.7	3.1
	M3	74.8	3.1	83.7	4.0
	M4	75.8	3.1	84.0	3.9

#### Lactate

One-way repeated measure ANOVA for lactate accumulation revealed significant differences between badminton matches in rest (Recovery period)  $F_{3, 15} = 20.08$ ,  $P = 0.000$ ,  $\eta_p^2 = 0.801$ . Bonferroni-corrected post hoc test showed statistically significant differences at 0.05 level in rest between first and fourth match ( $p = 0.008$ ), and second and fourth match ( $p = 0.012$ ), differences are presented in figure 2. One-way repeated measure ANOVA for lactate accumulation after the matches revealed significant difference  $F_{3, 15} = 16.48$ ,  $P = 0.000$ ,  $\eta_p^2 = 0.767$ . Bonferroni-corrected post hoc test showed statistically significant differences at 0.05 level after the matches between first and third match ( $p = 0.046$ ), first and fourth match ( $p = 0.035$ ), and third and fourth match ( $p = 0.029$ ), differences are presented in figure 2.



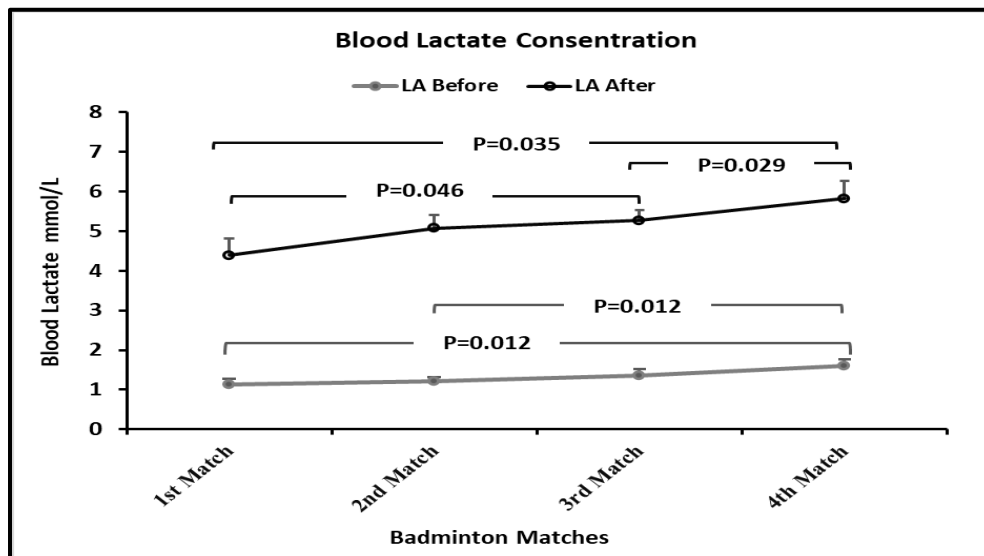


Figure 2. Shows blood lactate concentration before and after badminton matches

### RPE

One-way repeated measure ANOVA for RPE revealed significant differences between badminton matches in rest (Recovery period)  $F_{3, 15} = 14.80$ ,  $P = 0.000$ ,  $\eta_p^2 = 0.747$ . Bonferroni-corrected post hoc test showed statistically significant differences at 0.05 level in rest between first and fourth match ( $p = 0.008$ ) only, differences are presented in figure 3. One-way repeated measure ANOVA for RPE after the matches revealed significant difference  $F_{3, 15} = 13.71$ ,  $P = 0.000$ ,  $\eta_p^2 = 0.733$ . Bonferroni-corrected post hoc test showed statistically significant differences at 0.05 level after the matches between first and fourth match ( $p = 0.012$ ), second and fourth match ( $p = 0.012$ ), and third and fourth match ( $p = 0.036$ ), differences are presented in figure 3.

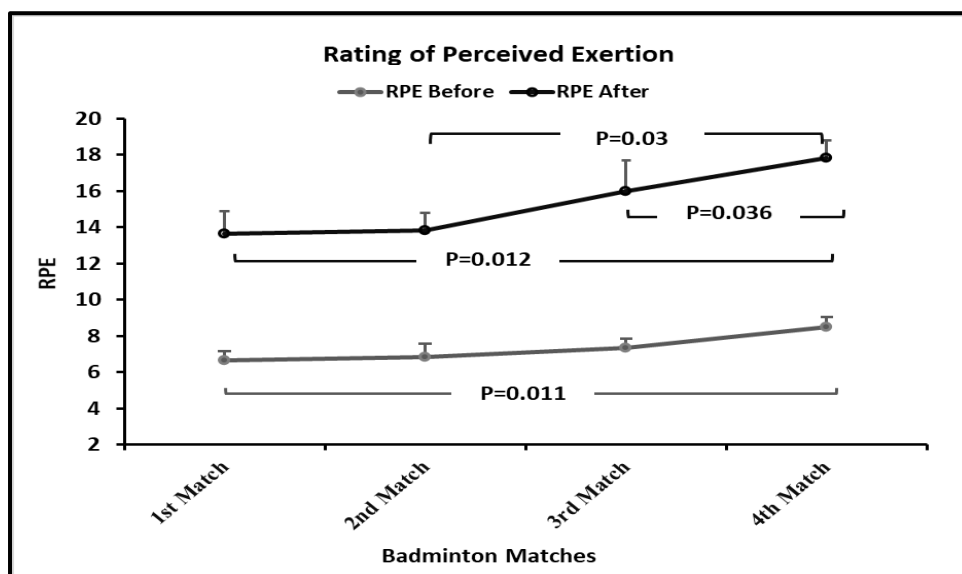


Figure 3. Shows RPE level before and after badminton matches

## Heart Rate

One-way repeated measure ANOVA for HR revealed no significant differences between badminton matches in rest (Recovery period)  $F_{3, 15}=0.147$ ,  $P=0.93$ ,  $\eta_p^2=0.028$ . One-way repeated measure ANOVA for HR after the matches revealed no significant difference  $F_{3, 15}=1.876$ ,  $P=0.177$ ,  $\eta_p^2=0.273$ .

## Blood Pressure

### Systolic Blood Pressure

One-way repeated measure ANOVA for Systolic blood pressure revealed no significant differences between badminton matches in rest (Recovery period)  $F_{3, 15}=0.871$ ,  $P=0.478$ ,  $\eta_p^2=0.148$ . One-way repeated measure ANOVA for Systolic Blood Pressure after the matches revealed significant difference  $F_{3, 15}=2.98$ ,  $P=0.065$ ,  $\eta_p^2=0.373$

### Diastolic Blood Pressure

One-way repeated measure ANOVA for diastolic blood pressure revealed no significant differences between badminton matches for both, in rest (Recovery period)  $F_{3, 15}=0.309$ ,  $P=0.819$ ,  $\eta_p^2=0.058$ . And after badminton matches  $F_{3, 15}=0.369$ ,  $P=0.720$ ,  $\eta_p^2=0.069$ .

## Discussion

The main purpose of this study was to measure lactate and physiological responses after repeating badminton match. The mean blood lactate accumulation was (1.13, 1.22, 1.37, and 1.6 mmol/l) during the recovery period. Badminton match is characterized by action of short duration and high intensity (Cabello Manrique & González-Badillo, 2003). Moreover, (Faude et al., 2007) found that badminton matches are considered as a high average intensity work, with a ratio of action time to rest time of approximately of 1:2 (Faude et al., 2007; Phomsoupha & Laffaye, 2015). The rest time between the matches was 30 mins which was according to the standard badminton regulation, this seems to be a good period if the player had up to three matches in a row, since no significant differences were observed in lactate concentration between 1<sup>st</sup>, 2<sup>nd</sup>, and 3<sup>rd</sup> match. However higher value of lactate concentration was observed in the 4<sup>th</sup> match comparing to the others and a significant difference between the matches in lactate concentration during the recovery time with mean of 1.6 mmol/l before the fourth match was found Figure 2, this difference might be due to imperfect recovery time. (Menzies et al., 2010) Found that maximum lactate clearance accrued after 30 - 32 mins of active recovery in participants conducted 5-min running bouts at 90% of maximal oxygen uptake with average lactate accumulation of 3.9. The designated rest period of 30 mins seems to be insufficient to clear the accumulated blood lactate during repeated matches. The accumulation of lactate was associated with RPE, significant difference in RPE were found in rest time between the first and



last match with mean average of 6.67 and 8.5 respectively figure 3. Studies found that perceived exertion is associated with the internal sensations of the body during physical activities (Hampson, St Clair Gibson, Lambert, & Noakes, 2001; St Clair Gibson et al., 2003). The increase in blood lactate effect the RPE, high perceived value is associated with high blood lactate value, (Moscatelli et al., 2015) found a high correlation between RPE and blood lactate.

The significant differences were also observed in blood lactate after the matches as shown in figure 2. with mean of (4.38, 5.07, 5.27, and 5.82 mmol/l), in the (1<sup>st</sup>, 2<sup>nd</sup>, 3<sup>rd</sup>, and 4<sup>th</sup>) match respectively. Considering the level of participants, the mean lactate recorded in this study was similar to those found by (Manrique, De Urbina, Gonzalez, & Fernandez, 1997) in eight medium to top level player, and (Ghosh, Mazumdar, Goswami, Ahuja, & Puri, 1990; Mikkelsen, 1979) during playing a single matches in elite players. The increase in blood lactate value through out the matches might indicate the accumulation of fatigue that might be due to insufficient recovery time and load of work that mostly occurred as a result of repeated matches. The significant differences between the fourth match and the other matches might also be due to the insufficient recovery time before the match that lead to inability of clearance blood lactate accumulation since the blood lactate accumulation was obviously higher before the match with mean of (1.60 mmol/l) comparing to the first 3 matches. RPE was also significantly different between the matches and at the end of the matches as shown in figure 2. with higher mean in the fourth match comparing to the other (13.67, 13.83, 16, and 17.83) in all the fourth matches respectively. The elevated concentrations of blood lactate is associated with impaired muscle function and exercise performance (Menziez et al., 2010; Minshull, Gleeson, Walters-Edwards, Eston, & Rees, 2007). The increase in blood lactate accumulation influence RPE, with higher value of blood lactate associated with higher PRE (Moscatelli et al., 2015). This result was supported by (Abe, Yoshida, Ueoka, Sugiyama, & Fukuoka, 2015), showing that perceived exertion is associated with blood lactate concentration during incremental running test.

### Conclusion

The result of this study demonstrates that repeated badminton matches within 30 minutes recovery time lead to a significant accumulation of blood lactate and RPE. This result point to the need of reconsidering the rest time between the badminton match special during local and international tournaments. The 30 minutes recovery time needs to be increased and reputation of badminton matches needs to be limited during competitions to no more than three matches per day.

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