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Correlation of Aerobic and Anaerobic Capacities with Performance in Badminton Matches

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Abstract

The purpose of this study was to measure the aerobic and anaerobic capacities of badminton athletes, and to relate them to performances, such as the number of drive shots, lob shots, or smash shots, in badminton matches. 12 badminton athletes in the men's doubles category carried out two types of measurements, namely laboratory test and match test. Laboratory tests included the VO_{2max} test using the Lode Quark Cardio Pulmonary Exercises Test (CPET), as well as a battery test (push-up, back-up, sit-up, and half-squat). Match test was conducted using competition match system. Match performances, such as drive shots, lob shots, or smash shots were analyzed by experts. The higher the VO_{2max} level of the pair of men's doubles athletes, the better its correlation with their badminton strokes was. For example, pair 1 (native 1 and native 2) had a mean VO_{2max} of 54.2 ± 0.9 ml/kg/min and performed the average numbers of lob strokes of 35.5 ± 0.7, drive shots of 47.5 ± 0.7, and smash of 19.5 ± 7.8. The lowest result was found in pair 6, in which the VO_{2max} level was 47.6 ± 0.4. The average numbers of shots performed by this pair were 23.5 ± 2.1 for lob, 29.5 ± 0.7 for drive, and 5.5 ± 0.7 for smash. On the other hand, Pair 1 had the highest average repetition of the battery test compared to the other pairs (Push-up = 35.5 ± 0.7, Back-up = 49.5 ± 0.7, Sit-up = 55.0 ± 0.0, Half-squat = 69.5 ± 0.7), and it was directly proportional to the results of hitting performance in a match. This study shows that there is a correlation between VO_{2max} average and battery test results and the performance of badminton men's doubles athletes.

Keywords: *Badminton, Aerobics, Anaerobic, Performance, Achievement*

INTRODUCTION

Badminton is a sport with intermittent and explosive movements as characteristics (Faude et al., 2007; Lin, Lee, & Chang, 2020). Naturally, this sport requires an athlete to possess good aerobic and anaerobic capacities to support all movements they will have to perform during a badminton match (Huang et al., 2019; Ramos Álvarez, Del Castillo Campos, Polo Portes, Ramón Rey, & Bosch Martín, 2016). For instance, movements such as lunges, jumping, and quick position changesrequire anaerobic capacity as the foundation to perform them (Phomsoupha & Laffaye, 2015a). On the other hand, other occasions such as pauses during badminton match require good aerobiccapacity from the athletes considering that those occasions are steady state when the athletes supply O_2 to their bodies (Marchena-Rodriguez, Gijon-Nogueron, Cabello-Manrique, & Ortega-Avila, 2020).

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Considering these characteristics, previous studies naturally have measured the percentages of aerobic and anaerobic capacities of badminton athletes (Cabello Manrique & González-Badillo, 2003; Rampichini et al., 2018). Faccini et al., (Faccini & Dal Monte, 1996) noted that 65% of aerobic capacity was required to supply energy for a badminton athlete to perform explosivemovements. Even though that study had presented a concrete conclusion concerning the required aerobic capacity percentage for badminton athletes, further studies outlined different arguments. Phomsoupha et al., (Phomsoupha & Laffaye, 2015b) and Fuchs et al. (Fuchs, Faude, Wegmann, & Meyer, 2014) argued that it was very difficult to determine the exact volume of aerobic andanaerobic capacities that badminton athletes needed due to the intermittent nature of the sport. They further argued that a portable metabolic device was required to obtain an accurate and precise measurement of those capacities.

Aerobic and anaerobic capacities seem to be an important focus for sport scientists, coaches, and athletes. Particularly, they believe that measuring aerobic and anaerobic capacities required by the athletes will help them in selecting the appropriate training design for athletes to improve their performance (Couppé et al., 2014; Vial, Cochrane, J. Blazevich, & L. Croft, 2019). This point was proven by several studies, including Madsen et al. (Madsen, Højlyng, & Nybo, 2016) that successfully described a badminton athlete's aerobic capacity which allowed them to design a 'badminton specific endurance' training for badminton athletes (Madsen et al., 2016). In addition, Phomsoupha et al. (Phomsoupha & Laffaye, 2015a) also managed to determine the anaerobiccapacity of a badminton athlete so that they were able to create 'a multiple repeated sprint ability test for badminton players'.

Based on these facts, the researchers realized that previous studies always focused on measuring aerobic and anaerobic capacities of badminton athletes and using the results to create a training design (Miller, Felton, Mcerlain-Naylor, Towler, & King, 2013; Zhang, Li, & Jiang, 2013). A study that measures aerobic and anaerobic capacities and relates them to match performances is rarely found. Therefore, the present study aimed to measure badminton athletes' aerobic and anaerobic capacities and looked at their correlation with match performances, such as the number of drive shot, lob shot, or smash during badminton matches. The researchers hypothesized that the higher a badminton athlete's aerobic and anaerobic capacities, the better their match performance would be.

METHODS

Research Subject

This observational study involved 12 badminton athletes in men's double category, with age range of 18 – 20 years old. The anthropometric characteristics of those athletes were 69.7 ± 7.3 kg in weight, 174.8 ± 6.6 cm in height, and 22.9 ± 2.3 kg/m^2 in body mass index. All samples were selected based on certain inclusion and exclusion criteria. The inclusion criteria were (1) being a junior badminton athlete who had undergone and been involved in at least 5 years of systematic

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training, (2) having no history of musculoskeletal injury in the last 6 months, (3) doing exercises at least 3 times a week for at least 3 hours a day, and (4) having experience of competing in national or international level. Meanwhile, having a history of smoking or a history of injury in the last 6 months were the exclusion criteria. The present study had passed an ethic test from POLTEKKES Bandung (No. 06/KEPK/EC/III/2021).

Research Procedure

All participants that satisfied the inclusion criteria underwent two types of measurement, the laboratory test and the match test. Laboratory test consisted of VO_{2max} measurement using Treadmill Lode Quark Cardio Pulmonary Exercises Test (CPET) and one minute battery test (push-up, back- up, sit-up, and half-squat). Meanwhile, the match test involved a simulation of badminton match in competition system to create an atmosphere of a real match. During the match test, participants' performances (drive shot, lob shot, or smash shot) were recorded and analyzed by experts. Figure 1 shows the research design.

Research Mechanism

All participants (n = 2) were subjected to an indoor anthropometric measurement conducted by an administrator using Omron Karada Body Scan. Meanwhile, Stadiometer was used to measure height, in 0.1 cm scale. After anthropometric measurement, the athletes were asked to do warm-ups to prepare them for the laboratory test. The warm-ups consisted of static and dynamic movements for at least six minutes. After the warm-ups, the athletes were told to prepare themselves for the laboratory test.

In the laboratory test, all participants used *Treadmill Lode Quark Cardio Pulmonary Exercises Test* (CPET), with a speed protocol of maximum 12km/h and 1º increase every 2 minutes, to measure their VO_{2max} level. An administrator monitored the test all the time. After VO_{2max} measurement, the athletes were asked to have at least 3 hours of rest before moving on to the next test, i.e. the battery test (push-up, back-up, sit-up, and half-squat). While they were resting, the participants were reminded to keep rehydrate themselves. After 3 hours of resting, the participants conducted the battery test (one minute for each movement). The number of repetitions for each movement that they did in one minute was recorded as their best performance.

After one week, the study was continued with the match test, in which the athletes were grouped into six (6) teams of men's double. The match was conducted in head-to-head system, resulting in three (3) men's double matches. During the matches, performance analysis was carried out, focusing on the athletes' *drive shot, lob shot,* and *smash shot*. The matches were recorded so that participants' performance could be analyzed. Finally, experts performed statistical analysis on each match.

STATISTICAL ANALYSIS

In this quantitative descriptive study, the results were shown in the average and in the standard of deviation for each pair of badminton athletes. All data was compiled in Ms. Excel version 14 (2010) and was explained in description.

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RESULTS

In this study, the data was compiled in terms of the average results of VO_{2max} test, battery test, and shot performance of each pair of men's double athletes. As shown in Table 1, the higher the VO_{2max} level of each pair of athletes, the better correlation it had with the athletes' shot performance. For instance, the first pair of athletes (Native 1 and Native 2) had the average VO_{2max} of 54.2 ± 0.9 ml/kg/min, which was the highest level of VO_{2max} compared to the other pairs of athletes. This number correlates with their average performance of shots, which was also the highestnumber of average shots compared to other pairs. The average performance of Pair 1 was 35.5 ± 0.7 for lob shot, 47.5 ± 0.7 for drive shot, and 19.5 ± 7.8 for smash shot. The second highest level of VO_{2max} was shown by Pair 2 (Native 3 and Native 4), which was 50.6 ± 11.0 ml/kg/min. This number correlates perfectly with their average performance. Pair 2 demonstrated the second highest number of average shots, with 32.5 ± 0.7 for lob shot, 46.5 ± 0.7 for drive shot, and 14.5 ± 0.7 for smash shot. The third, fourth, and fifth positions were held by Pair 3, Pair 4, and Pair 5 respectively. The average VO_{2max} level of Pair 3 was 50.0 ± 2.7, with the average number of shots of 31.0 ± 1.4 (lob shot), 39.5 ± 3.5 (drive shot), and 12.5 ± 3.5 (smash shot). Pair 4 had the average VO_{2max} of
49.3 ± 3.2, and the average number of shots of 28.5 ± 0.7 (lob), 35.5 ± 0.7 (drive), and 9.5 ± 3.5 (smash). Pair 5 had the average VO_{2max} of 48.0 ± 4.8, with the average number of shots of 26.0 ± 9.9 (lob), 34.0 ± 1.4 (drive), and 7.5 ± 0.7 (smash). The correlation between the average VO_{2max} and performance was further confirmed by the test result of Pair 6. This pair of athletes had the lowest level of VO_{2max} as well as the lowest number of shots. The average VO_{2max} level of Pair 6 was 47.6 ± 0.4, and the numbers of shots was 23.5 ± 2.1 (lob), 29.5 ± 0.7 (drive), and 5.5 ± 0.7 (smash).

Table 2 shows the correlation between the battery test result and shot performance. Like VO_{2max} level, the battery test result of each pair of men's double badminton athletes showed a correlation with the performance. Pair 1 (Native 1 and Native 2) had the highest number of repetitions in battery test (push-up = 35.5 ± 0.7, Back-up = 49.5 ± 0.7, Sit-up = 55.0 ± 0.0, Half- squat = 69.5 ± 0.7), which was proportional to their shot performance during the match. Similar result was found with Pair 2 to 6. Pair 2 showed the average repetition of push-up = 32.5 ± 0.7, Back-up = 48.5 ± 0.7, Sit-up = 52.0 ± 1.4, and Half-squat = 62.5 ± 3.5. Pair 3 demonstrated the average repetition of push-up = 32.0 ± 0.0, Back-up = 46.5 ± 0.7, Sit-up = 52.0 ± 1.4, Half-squat =
61.5 ± 4.9. Pair 4 had the average repetition of push-up = 32.0 ± 0.0 Back-up = 46.0 ± 1.4, Sit-up = 50.5 ± 0.7, Half-squat = 59.0 ± 1.4. Pair 5 showed the average repetition of push-up = 30.5 ± 2.1, Back-up = 45.5 ± 2.1, Sit-up = 50.5 ± 0.7, and Half-squat = 61.0 ± 0.7. While Pair 6 showed the average repetition of push-up = 30.5 ± 2.1, Back-up = 45.5 ± 2.1, Sit-up = 49.5 ± 0.7, and Half-squat = 58.5 ± 0.7, which also indicated that Pair 6 had the lowest performance of shots compared to the other pairs.

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Table 1 Correlation between VO_{2max} and shot performance of men's double badminton athletes

Sample	*Lob* (Number of shots)	*Drive* (Number of shots)	*Smash* (Number of shots)	VO_{2max} (ml/kg/min)
Native 1	35.0	47.0	25.0	53.6
Native 2	36.0	48.0	14.0	54.8
Average	35.5 ± 0.7	47.5 ± 0.7	19.5 ± 7.8	54.2 ± 0.9
Native 3	32.0	46.0	15.0	58.3
Native 4	33.0	47.0	14.0	42.8
Average	32.5 ± 0.7	46.5 ± 0.7	14.5 ± 0.7	50.6 ± 11.0
Native 5	30.0	37.0	10.0	52.0
Native 6	32.0	42.0	15.0	48.1
Average	31.0 ± 1.4	39.5 ± 3.5	12.5 ± 3.5	50.0 ± 2.7
Native 7	28.0	36.0	7.0	47.1
Native 8	29.0	35.0	12.0	51.6
Average	28.5 ± 0.7	35.5 ± 0.7	9.5 ± 3.5	49.3 ± 3.2
Native 9	19.0	33.0	8.0	44.7
Native 10	33.0	35.0	7.0	51.4
Average	26.0 ± 9.9	34.0 ± 1.4	7.5 ± 0.7	48.0 ± 4.8
Native 11	25.0	30.0	6.0	47.8
Native 12	22.0	29.0	5.0	47.3
Average	23.5 ± 2.1	29.5 ± 0.7	5.5 ± 0.7	47.6 ± 0.4

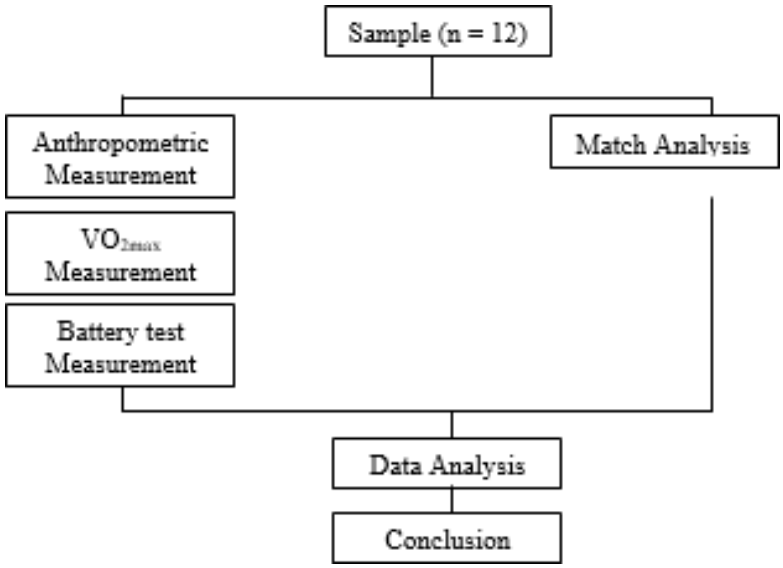

Figure 1 Research Design

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Table 2 Correlation between battery test and shot performance of men's double badminton athletes

	Lob (Number of shots)	*Drive* (Number of shots)	*Smash* (Number of shots)	*Push-up* (Repetition)	*Back-up* (Repetition)	*Sit-up* (Repetition)	*Half-squat* (Repetition)
Native 1	35.0	47.0	25.0	35.0	50.0	55.0	70.0
Native 2	36.0	48.0	14.0	36.0	49.0	55.0	69.0
Average	35.5 ± 0.7	47.5 ± 0.7	19.5 ± 7.8	35.5 ± 0.7	49.5 ± 0.7	55.0 ± 0.0	69.5 ± 0.7
Native 3	32.0	46.0	15.0	32.0	48.0	53.0	65.0
Native 4	33.0	47.0	14.0	33.0	49.0	51.0	60.0
Average	32.5 ± 0.7	46.5 ± 0.7	14.5 ± 0.7	32.5 ± 0.7	48.5 ± 0.7	52.0 ± 1.4	62.5 ± 3.5
Native 5	30.0	37.0	10.0	32.0	47.0	53.0	65.0
Native 6	32.0	42.0	15.0	32.0	46.0	51.0	58.0
Average	31.0 ± 1.4	39.5 ± 3.5	12.5 ± 3.5	32.0 ± 0.0	46.5 ± 0.7	52.0 ± 1.4	61.5 ± 4.9
Native 7	28.0	36.0	7.0	32.0	47.0	50.0	60.0
Native 8	29.0	35.0	12.0	32.0	45.0	51.0	58.0
Average	28.5 ± 0.7	35.5 ± 0.7	9.5 ± 3.5	32.0 ± 0.0	46.0 ± 1.4	50.5 ± 0.7	59.0 ± 1.4
Native 9	19.0	33.0	8.0	29.0	47.0	50.0	60.0
Native 10	33.0	35.0	7.0	32.0	44.0	51.0	62.0
Average	26.0 ± 9.9	34.0 ± 1.4	7.5 ± 0.7	30.5 ± 2.1	45.5 ± 2.1	50.5 ± 0.7	61.0 ± 0.7
Native 11	25.0	30.0	6.0	32.0	47.0	50.0	58.0
Native 12	22.0	29.0	5.0	29.0	44.0	49.0	59.0
Average	23.5 ± 2.1	29.5 ± 0.7	5.5 ±0.7	30.5 ± 2.1	45.5 ± 2.1	49.5 ± 0.7	58.5 ± 0.7

DISCUSSION

This study aimed to measure aerobic and anaerobic capacities of badminton athletes and to relate them to athletes' performance in matches, in terms of the number of drive shot, lob shot, and smash shot. The findings of this study confirmed the research hypothesis that the higher the athletes' aerobic and anaerobic capacities, the better the athletes' performance will be. This study showed that men's double badminton athletes' aerobic and anaerobic capacities proportionally correlated with their shot performance. This finding is important for badminton coach and athlete in designinga suitable training method to improve athlete's performance in badminton matches.

This study described the correlation between athlete's average VO_{2max} and battery test result and the athlete's number of shots (performance) in men's double badminton matches. The results of this study are congruent with the findings of Apriantono et al., (Apriantono et al., 2020) who stated that badminton had intermittent and explosive movements as characteristics. Apriantono et al. (Apriantono et al., 2020) stressed the importance of aerobic and anaerobic capacities for a badminton athlete. Both capacities are the main foundation to create a better badminton performance.

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Aerobic capacity is important in badminton. Previous study concluded that aerobic capacity was used as a modality for performing explosive movements during a rally in badminton matches (Fahlström & Söderman, 2007). In other words, aerobic capacity is required when there is a puse in a badminton match, in which the athletes physiologically try to supply as much oxygen to the body as they can. The oxygen supply is useful for creating the steady sate as well as a foundation to do explosive movements in the next rally (Cabello Manrique & González-Badillo, 2003). Meanwhile, anaerobic capacity is clearly needed as the foundation for explosive movements such as lunges, jumps, and quick position changes (Marchena-Rodriguez et al., 2020).

More specifically, the results of this study support the theory outlined by Faccini et al. (Faccini & Dal Monte, 1996) that it requires at least 65% of aerobic capacity to supply energy for a badminton athlete to perform explosive movements. Hence, this study recommends badminton coaches to create an appropriate training design for badminton athletes. Considering the characteristics of badminton as a sport, and the results of this study, the researchers recommend coaches and athletes to perform high-intensity interval training (HIIT) as part of the training program to improve athletes' physical performance, particularly for men's double category. It is expected that HIIT method can improve and promote badminton athletes' performances so that they can achieve their target.

The researchers acknowledge that there are things to be improved in this study. For instance, future studies could measure anaerobic characteristics using Wingate test method to achieve a more precise result and to better satisfy the physiological need of badminton athletes. Portable device such as Cosmed K5 could also be used in future studies. On the other hand, the researchers alsoencourage future studies to measure physiological characteristics and performance characteristics of badminton athletes in other categories, using better test parameter to explore questions that this study have not answered.

CONCLUSION

This study shows that there is a correlation between the average results of both VO_{2max} and battery test and the shot performance of men's double badminton athletes. To implement the result of this study, the researchers urge badminton coaches and athletes to conduct high-intensity interval training (HIIT) to get better results.

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