Malaysian Journal of Medical Research, 8(4), 29-40
https://doi.org/10.31674/mjmr.2024.v08i04.004

Malaysian Journal of Medical Research
Online ISSN: 2550-1607
www.mjmr.com.my

Original Article

Physiological Profiles of Malaysian Young Male Badminton Players, Archers and Non-athletes

Irene Tong King Ming[1], Ooi Foong Kiew[1*], Chen Chee Keong[1], Rou Xian Goh[1], Mohd Rahimi Che Jusoh[1], Rosniwati Ghafar[1], Lau Jiun Sien[2]

[1]Department of Exercise and Sports Science, School of Health Sciences, Health Campus, Universiti Sains Malaysia, 16150 Kubang Kerian, Kelantan, Malaysia.

[2]Department of Health Sciences, School of Rehabilitation Sciences, Universiti Sultan Zainal Abidin, Gong Badak Campus, 21300, Kuala Nerus, Terengganu, Malaysia

**Corresponding Author's Email: fkooi@usm.my*

Abstract

Background: This study investigated physiological profiles of Malaysian young male badminton players, archers and non-athlete controls. **Methods:** Thirty-three young male participants with age ranged 13-18 years were assigned into three groups, i.e. non-athlete control, badminton and archery groups (*n=11* per group). All participants performed measurements of anthropometry, body composition, aerobic and Wingate capacities, back and leg strength, vertical jump, standing long jump and hand grip strength, coordination, flexibility and balance. The Post hoc Bonferroni test and One-Way ANOVA were used to assess how the measured parameters varied between the groups. **Results:** This study found that badminton players had significantly ($p<0.05$) higher values compared to archers in explosive power measured via standing long jump and vertical jump, balance, coordination, estimated VO_2 max, anaerobic power and anaerobic capacity. Similarly, badminton players also had significantly ($p<0.05$) higher values compared to non-athlete controls in explosive power via standing long jump, balance, coordination and estimated VO_2 max. However, there were no significant differences in hand grip strength and back and leg strength in archers compared to non-athlete controls. **Conclusion:** Badminton players were better than archers in certain physiological aspects. Participation in badminton and archery training seem to improve various physical fitness components compared to non-athletes who were less active and did not carry out formal physical training. The study findings can be used for promoting active lifestyle by engaging in badminton and archery sports and adding new knowledge in the field of sports medicine and sports science.

Keywords: *Archery; Badminton; Non-athletes; Physiological Profiles*

Introduction

Badminton and archery, as individual sports, impose distinct physiological demands on their athletes. Badminton is known for its dynamic, high-intensity nature, requiring robust anaerobic and aerobic capacities, muscular strength, explosive force, precise coordination, balance, and flexibility. Badminton players are required to execute rapid and coordinated movements while conserving energy strategically to optimize competitive performance (Phomsoupha & Laffaye, 2015). Conversely, archery demands high physical fitness level due to the extensive preparation hours and the demands of competition. Successful archers need to possess exceptional aerobic endurance, muscular control, mental resilience,

Received: 22nd September 2024; Revised version received on: 27th September 2024; Accepted: 30th September 2024

and precise motor coordination to maintain accuracy under diverse environmental conditions (Musa *et al*., 2016; Lau *et al*., 2020; Kolayis *et al*., 2014; Ayala-Guzmán *et al.,* 2024). Furthermore, the physique and body composition of athletes significantly influence their competitive performance. Athletes with optimal body types tailored to the demands of their sport often exhibit enhanced performance capabilities (Pandey & Reddy, 2019).

Badminton and archery demand unique aerobic and anaerobic capacities from athletes. Badminton requires both aerobic endurance for sustained rallies and anaerobic power for explosive movements (Phomsoupha & Laffaye, 2015; Ko *et al*., 2021). Badminton players benefit from high levels of aerobic fitness, aiding quick recovery between intense efforts. Archery prioritizes aerobic endurance for consistent accuracy over multiple rounds of shooting, alongside anaerobic energy for handling the bow and arrows (Musa *et al*., 2016). Effective heart rate management is crucial in archery for maintaining performance consistency (Kolayis *et al*., 2014). Tailored training programs are essential in both sports to optimize aerobic and anaerobic capacities for peak athletic performance.

Muscular performance encompasses strength, power, and endurance, which are crucial for athletes in sports like badminton and archery. Badminton demands high physical ability and engages both upper and lower body muscles simultaneously (Guermont *et al*., 2023). Previous studies on elite Malaysian badminton players showed that they possess higher lean body mass and shoulder muscular strength compared to non-badminton players (Ooi *et al*., 2009; Feng *et al*., 2017). Conversely, archery relies heavily on upper body strength and core strength to handle the bow's pulling force (Dhawale *et al*., 2018). These results highlight how crucial focused strength training is for improving performance and avoiding injuries in both sports.

Coordination involves selecting the appropriate muscles at the correct moment and with suitable intensity to execute a specific activity (Poizat *et al*., 2009; Nikolaidis & Son'kin, 2023). In badminton, motor coordination is vital for quick and accurate adjustments in speed and timing during strokes, improving on-court agility and balance (Dane *et al*., 2008; Dube *et al*., 2015). Similarly, in archery, precise hand-eye coordination is essential for consistent target hitting, with training shown to significantly enhance these skills (Zolkafi *et al*., 2018).

Balance, critical for mobility, integrates static and dynamic components supported by sensory inputs from eyes, ears, and body awareness (Kamarudin *et al*., 2021). In badminton, dynamic balance aids in rapid movements like lunges, enhancing shot accuracy and agility (Verschueren *et al*., 2019), while in archery, static balance ensures aiming precision and stability (Mason & Pelgrim, 1986; Suppiah *et al*., 2017). Flexibility, essential for joint health, varies among individuals and impacts performance in both sports by enabling swift movements in badminton and precise positioning in archery, thus reducing injury risk (Opplert & Babault, 2018).

Components of physiological profile is crucial to determine athletic performance as the scientific data collected can be used to design an individualized and sport-specific exercise prescription (Steinhagen *et al.*, 1998). Components of physiological profiles include both anaerobic and aerobic capacities, muscular strength and explosive power, coordination, balance and flexibility. These components are pertinent elements in an exercise prescription plan for athletes. Abidin *et al*. (2018) proposed that a higher aerobic capacity is attributed to the nature of the sports and the game duration of each sport. For instance, boxing requires athletes to sustain power at a high percentage of maximal oxygen uptake (VO_2 max) during their longer duration of matches. Next, a recent study by Samsudin *et al*. (2022) involving Malaysian Kelantan state level young male weightlifters, cyclists and squash players reported that the various physiological demands of these sport could affect the Wingate anaerobic capacity of the athletes. Besides that, Jamhari *et al*. (2022) study involving Malaysia Kelantan state level young male hockey and rugby players reported that the higher muscular strength of athletes was most likely a result of their regular strength training exercise. They also reported that the explosive power such as leg power of the athletes was attributed to their different techniques, skill and training patterns. Ooi and Anowar's (2018) study involving Malaysian Kelantan young female Taekwondo and Silat practitioners reported that the engagement in sports like martial art can improve flexibility and reduce the risk of injury.

Badminton and archery have similarity, in which both sports could be categorised as individual sports and were hand-based. The main distinction between archery and badminton is that the former is a static activity, while the latter demands players to move around the entire court. The athletes of these two sports might have difference in various physical fitness components or physiological profile due to the physiological demands for each sport. To the best of our knowledge, no research has been done comparing the physiological profiles of Malaysian young sedentary males, badminton players, and archers. Hence, the current study was proposed to examine and compare the aerobic and anaerobic capacities, muscular strength and power, coordination, balance and flexibility of Malaysian young male badminton players and archers with their sedentary counterpart as the controls (Lisum, Waluyo & Supardi, 2021). It was hypothesised that finding of this study would show that participation in badminton and archery training might improve certain physical fitness components or physiological parameters compared to a sedentary lifestyle. In addition, certain physiological traits or elements of physical fitness that badminton players and archers possess could be identified.

Methodology

Participants

In this study, participants were recruited through a purposive sampling method. A total of 33 young male Malaysians aged between 13 to 18 years were recruited. They were matched for age and then assigned into three groups: badminton group (*n*=11), archery group (*n*=11), and non-athlete control group (*n*=11). The inclusion criteria of badminton and archery participants were those who had been actively involved in their respective sports for at least 1 year, training a minimum of 3 times per week, and represented their state in national competition. Meanwhile, the non-athlete controls were those who did not engage in formal sports training or competitive sports. Those with acute or chronic illnesses and injuries were excluded from the study.

PS Power and Sample Size Calculation version 3.1.2 were used to calculate the sample size for this investigation. Rahim *et al*. (2016)'s study served as the basis for setting the power at 80% with a 95% confidence interval. The observed standard deviation was 11.27, and the mean difference was 15.2. Each group targeted 10 participants, accounting for an anticipated 10% dropout rate, leading to the recruitment of 11 individuals per group. Consequently, the study enrolled a total of 33 participants across the three groups.

Anthropometric and Body Composition Measurements

Participants' body height was measured with a stadiometer (Seca 220, Hamburg, Germany) while they were barefoot and wearing light clothing. Body height data were recorded to the nearest 0.01 meters. Using a body composition analyzer (Tanita, TBF-140 Japan), measurements of body weight and body composition, including percent body fat (%BF) and fat-free mass (FFM, in kilograms), were recorded. Participants stood upright on the footpad with contact terminals under their feet during the measurements.

Resting Heart Rate and Blood Pressure Measurements

With the aid of an automated upper arm blood pressure monitor (TM-2540, San Jose, USA), the participants' resting heart rate (beats.min^{-1}) and blood pressure (systolic and diastolic (mmHg)) were determined.

20-meter Shuttle Run Test

Using the 20-meter shuttle run test, participants estimated maximum oxygen consumption (VO_2 max), a measure of aerobic capacity, was ascertained. Participants lined up behind cones and prepared to run upon hearing a pre-recorded CD player which emitted "beep" sounds. They ran back and forth over 20 meters in time with these beeps. If participants failed to keep pace, they were required to stop running.

Using the online calculator (https://www.topendsports.com/testing/beepcalc.htm), the estimated VO_2 max was determined based on the number of laps completed.

Wingate Anaerobic Capacity Test

Participants in the Wingate anaerobic capacity test cycled maximally for 30 seconds on a cycle ergometer (H-300-RLode, Groningen, Holland). This test assessed the mean power (MP), peak power (PP), anaerobic capacity (AC), anaerobic power (AP) and fatigue index (FI) of the participants. Prior to this test, the participants were allowed to adjust the seat height of the cycle ergometer. They then warmed up by cycling at 60 revolutions per minute (rpm) for 5 minutes. Following this, participants cycled at 60 watts for 1 minute, immediately followed by a 30-second all-out effort. After the intense cycling phase, participants cooled down by cycling without resistance for approximately 3 minutes.

Handgrip Strength Test

A handgrip dynamometer was used to assess the hand grip strength of the participants. Participants grasped the dynamometer and squeezed it as hard as possible for approximately 5 seconds. Three trials were performed for each hand, and the highest recorded value was used to determine the participants' handgrip strength.

Back and Leg Strength Test

The back and leg strength of the participants was measured using a back and leg strength dynamometer. Participants stood upright on the base of the dynamometer with their feet shoulder-width apart. They grasped the focal point of the bar with both hands with knees bent at approximately 110°. Prior to testing, the dynamometer dial was reset to 'zero'. Then, the participants were instructed to pull the chain as hard as possible, maintaining straight legs and arms without twisting their backs. They were required to exert a consistent force without jerky movements against the weight. Three trials were conducted, and the highest recorded value was used for analysis.

Standing Long Jump Test

The standing long jump test was used to determine the lower body explosive power of the participants. A measuring mat was used to measure the distance of the jumps. Participants stood behind a marked line with their feet slightly apart. They swung their arms and bent their knees to generate forward momentum. Participants then jumped as far as possible and landed on both feet without losing balance. Three attempts were made, and the longest jump distance was recorded for analysis.

Vertical Jump Test

The vertical jump explosive power of participants was evaluated using the vertical jump test, conducted with a Trident Vertical Jump Tester. Participants stood beneath the apparatus and were instructed to jump vertically to reach and swipe the vanes at the highest point of their jump. The score was determined by the distance between the standing reach vane and the jump height vane. After each participant finished three trials, the statistical analysis was conducted using the highest recorded value of the three trials.

Alternate Hand Wall Toss Test

The participants' hand-eye coordination was determined with an alternate hand wall toss test. Participants began by standing a 2-meter distance from a smooth, solid wall. Upon starting the timer, they underhand tossed a tennis ball against the wall with one hand, ensuring it rebounded and was caught by the opposite hand. This sequence was repeated continuously for 30 s. The total cycle of successful toss and catch was recorded to determine the participants' performance in the test.

Standing Stork Balance Test

The standing stork balance test assesses participants' ability to maintain equilibrium in a static position. To perform the test, participants stood on the foot of their dominant leg and placed the ball of the other foot against the inside of the supporting knee, with hands positioned on their waist. The test began when the tester started the stopwatch. Participants lifted their heel off the floor and tried to maintain balance for as long as possible without moving the ball of the foot from its original position. If the balance was lost, indicated by touching the heel to the floor or shifting the foot, the timing was stopped. The best performance out of the three trials was recorded to determine the participant's balance ability.

Sit and Reach Test

Using a sit and reach box, participants' flexibility in their hamstring and lower back muscles was evaluated. Participants sat on the floor with legs extended straight, placing their bare feet flat against the box with shoulder-width apart. The test involved the participants reaching as far forward along a measuring line as they could, and three different trials were used to record the individuals' best reach distance. The best result obtained from these trials was used to determine their level of flexibility.

Statistical Analysis

The Statistical Package for Social Sciences (SPSS) version 26.0 was used for data analysis. The Post hoc Bonferroni test and One-way ANOVA were used to assess how the three groups' measured parameters differed from one another. Data are presented as mean and standard deviation (mean (SD)). The statistical significance was accepted at *p*-value < 0.05.

Ethical Consideration

This study was approved by Human Research Ethics Committee of Universiti Sains Malaysia with registration number JEPeM code: USM/JPEPeM/23010051 on 24th January 2023.

Result

Anthropometry, Body Composition, Resting Heart Rate and Blood Pressure of the Participants

The mean age of the participants involved in this study was 15.1 (1.4) years. The non-athlete control, badminton, and archery groups' mean age, body height, body weight, body mass index (BMI), percentage of body fat, fat free mass, resting heart rate, systolic and diastolic blood pressure, and resting heart rate are shown in Table 1**.** In this study, the body weight, body mass index (BMI), and fat free mass of the archery group were considerably greater (p<0.05) than those of the non-athlete control group. However, there were no significant differences in body weight and fat free mass between the badminton group and the non-athlete controls, nor between the archery and badminton groups. Regarding the body mass index, the archery group had a significantly higher value *(p*<0.05) compared to the badminton group.

The badminton group exhibited significantly lower (p<0.001) resting heart rates compared to both the non-athlete control and archery groups. Furthermore, the diastolic blood pressure value of the badminton group was significantly lower (p<0.05) than that of the non-athlete control group, and even more significantly (p<0.001) lower than that of the archery group.

Age, height, body fat percentage, and systolic blood pressure did not differ significantly between the badminton and non-athlete control groups, the archery and non-athlete groups, or the badminton and archery groups.

Table 1 Means age, body height, body weight, body mass index (BMI), percentage of body fat (%BF), fat free mass, resting heart rate, systolic blood pressure and diastolic blood pressure in non-athlete control, badminton and archery groups.

Table 1: Descriptive Statistics of Age, Anthropometric Measurements, and Cardiovascular Parameters in Non-Athlete Control, Badminton, and Archery Groups

Parameters	**Non-athlete control group (*n*=11)**	**Badminton group (*n*=11)**	**Archery group (*n*=11)**
Age (years)	14.9 (1.3)	15.6 (1.5)	14.7 (1.4)
Body height (cm)	162.4 (8.7)	165.8 (9.2)	166.6 (4.9)
Body weight (kg)	**50.7 (16.2)**	53.0 (7.7)	**67.5 (18.7)***
Body mass index (BMI) (kg.m^{-2})	**19.0 (4.8)**	**19.2 (1.6)**	**24.3 (6.2)**$^{*\#}$
Percentage of body fat (%)	16.8 (10.7)	16.1 (5.6)	24.3 (10.1)
Fat free mass (kg)	**40.9 (7.5)**	44.4 (6.3)	**49.4 (7.0)***
Resting heart rate (bpm)	**116.3 (13.5)**	**78.4 (10.2)*****	**105.7 (9.9)**$^{\#\#\#}$
Systolic blood pressure (mmHg)	114.7 (14.4)	108.3 (11.8)	122.5 (18.9)
Diastolic blood pressure (mmHg)	**65.7 (5.7)**	**55.5 (6.8)***	**74.0 (10.0)**$^{\#\#\#}$

Values are expressed as mean (SD). Bold numbers indicate statistically significant.

**$p<0.05$, ***$p<0.001$ significantly different from non-athlete control group*

$^{\#}p<0.05$, $^{\#\#\#}p<0.001$ significantly different from badminton group

Estimated Aerobic capacity (VO_2 max) and Wingate anaerobic capacity parameters in non-athlete control, badminton and archery groups

Table 2 presents the aerobic capacity, specifically estimated VO_2 max, and Wingate anaerobic capacities, i.e. mean power (MP), peak power (PP), anaerobic capacity (AC), and anaerobic power (AP) for the non-athlete control, badminton, and archery groups. The badminton group demonstrated significantly higher ($p<0.001$) estimated VO_2 max compared to both the non-athlete control group and the archery group. However, there was no significant difference in estimated VO_2 max between the non-athlete control group and the archery group. In terms of AC and AP, the badminton group had statistically higher ($p<0.05$) values than the archery group, whereas no significant difference was found between the non-athlete control group and the archery group in these measures. MP and PP did not show significant differences among the non-athlete control, badminton, and archery groups.

Table 2: Aerobic Capacity Estimated (VO_2 max) and Wingate Anaerobic Capacity Parameters in Non-Athlete Control, Badminton and Archery Group

Parameters	**Non-athlete control group (*n=11*)**	**Badminton group (*n=11*)**	**Archery group (*n=11*)**
Aerobic capacity			
Estimated VO_2 max (mL.kg^{-1}.min^{-1})	**31.52 (4.57)**	**52.42 (3.42) *****	**35.68 (7.73)**$^{\#\#\#}$
Wingate anaerobic capacity parameters			
Mean power (Watt)	323.80 (107.84)	425.26 (73.94)	341.85 (121.77)
Anaerobic capacity (Watt.kg^{-1})	6.42 (1.35)	**8.05 (0.57)**	**5.02 (4.03)**$^{\#}$
Peak power (Watt)	676.16 (241.34)	866.32 (169.68)	653.46 (213.23)
Anaerobic power (Watt.kg^{-1})	13.38 (3.66)	**16.45 (2.26)**	**10.52 (4.07)**$^{\#\#\#}$

Values are expressed as mean (SD). Bold numbers indicate statistically significant.

****$p<0.001$ significantly different from non-athlete control group*

$^{\#\#\#}p<0.001$ significantly different from badminton group

Hand Grip Strength, Back and Leg Strength, Standing Long Jump Distance, Vertical Jump Height in non-athlete control, badminton and archery groups

Table 3 tabulates the results for hand grip strength, back and leg strength, standing long jump distance, and vertical jump height across all groups. Compared to the badminton and non-athlete groups, the archery group displayed non-statistically greater values for hand grip strength for both dominant and non-dominant hands, as well as for back and leg strength. In terms of standing long jump distance, the badminton group exhibited a significantly greater value compared to the non-athlete control group ($p<0.05$) and the archery group ($p<0.01$) respectively. For vertical jump height, the badminton group demonstrated a statistically significant greater ($p<0.001$) value compared to the archery group.

Table 3: Hand Grip Strength, Back and Leg Strength, Standing Long Jump Distance, Vertical Jump Height in Non-Athlete Control, Badminton and Archery Groups

Parameters	**Non-athlete control group (*n*=11)**	**Badminton group (*n*=11)**	**Archery group (*n*=11)**
Handgrip strength of dominant hand (kg)	34.72 (10.07)	38.55 (6.56)	40.82 (7.57)
Handgrip strength of non-dominant hand (kg)	30.91 (8.23)	31.73 (5.37)	36.55 (6.22)
Back and leg strength (kg)	66.27(23.15)	80.91(17.99)	91.09(27.23)
Standing long jump distance (cm)	**172.27 (24.87)**	**211.18 (28.85)***	**164.55 (32.78)**$^{\#\#}$
Vertical jump height (cm)	55.42 (6.65)	**60.51 (4.18)**	**48.72 (7.98)**$^{\#\#\#}$

Values are expressed as mean (SD). Bold numbers indicate statistically significant.

**p<0.05 significantly different from non-athlete control group*

$^{\#\#}$*p<0.01,* $^{\#\#\#}$*p<0.001 significantly different from badminton group*

Flexibility (Sit and Reach Test), Balance (Stork Stand Test for Balance) and Coordination (Alternate Hand Wall Toss Test) in Non-Athlete Control, Badminton and Archery Groups in Non-Athlete Control, Badminton and Archery Groups

Table 4 exhibited the results for flexibility, balance, and coordination across all groups. There were no significant differences in flexibility across the three groups. The badminton group exhibited a significantly greater ($p<0.05$) value in balance compared to the non-athlete control group and archery group respectively. In terms of coordination, the badminton group demonstrated significantly higher ($p<0.001$) values compared to the non-athlete control group and the archery group respectively.

Table 4: Flexibility (SRT), Balance (SSTB) and Coordination (AHWTT) in Non-Athlete Control, Badminton and Archery Groups

Parameters	**Non-athlete control group (*n*=11)**	**Badminton group (*n*=11)**	**Archery group (*n*=11)**
Flexibility (SRT) (cm)	12.73 (5.71)	13.15 (5.77)	9.04 (6.43)
Balance (SSBT) (sec)	**18.00 (13.52)**	**47.91 (35.36)***	**20.99 (19.76)**$^{\#}$
Coordination (AHWTT) (times)	**12.36 (4.06)**	**20.27 (3.64)*****	**13.27 (4.03)**$^{\#\#\#}$

SRT= Sit and reach test, SSBT= Standing stork balance test, AHWTT= Alternate hand wall toss test

Values are expressed as mean (SD). Bold numbers indicate statistically significant.

****p<0.001 significantly different from non-athlete control group*

$^{\#\#\#}$*p<0.001 significantly different from badminton group*

Discussion

In sports, athletes with sport-specific body measures may perform better and compete at a higher level (Popovic *et al*., 2014). According to this study, the body weight and fat-free mass of the archery group were significantly higher than those of the non-athlete control group. However, there were no significant differences in these parameters between the badminton group and the non-athlete control group, as well as between the badminton and archery groups. This finding aligns with the study by Chaudhary *et al*. (2023), which highlighted greater weight and fat-free mass in elite archers compared to non-elite archers. Taha *et al*. (2009) also noted that greater body mass contributes to improved postural stability, which is crucial for achieving higher scores in archery. The present study supports this notion, observing higher body weight in the archery group compared to the non-athlete group, suggesting that increased body weight may aid in balance control and reduce body sway, advantageous in static sports like archery.

In contrast to archers and non-athlete controls, badminton players showed a lower resting heart rate, likely due to their rigorous training regimen involving six days per week of combined fitness and skill training. This finding is consistent with Kwok *et al*. (2013), who emphasized the positive correlation between exercise frequency and lower resting heart rate. Physical training enhances parasympathetic activity at rest, while simultaneously reducing sympathetic activity and catecholamine release, contributing to a lower resting heart rate. Moreover, the study by Whelton *et al*. (2002) mentioned that aerobic exercise reduces both systolic and diastolic blood pressure, which was evident in the present study where the badminton group exhibited lower diastolic blood pressure compared to the archery and non-athlete control groups. This could be attributed to the aerobic and anaerobic demands of badminton training, promoting lower diastolic blood pressure among players.

The study's other noteworthy finding was that the badminton group had a greater estimated aerobic capacity (VO_2 max) than either the archery or the non-athlete control groups. This higher aerobic capacity in badminton players reflects the sport's fast-paced, dynamic nature, requiring players to cover the entire court quickly, react promptly, and sustain high-intensity movements. This finding supports previous research emphasizing badminton players require high aerobic power for sustained physical performance, which also supports recovery from anaerobic efforts by supplying energy rapidly during and after competition (Carboch & Smocek, 2020; Tomlin & Wenger, 2001). However, this study did not show any significant difference in aerobic capacity between the archery group and non-athlete controls, suggesting that static sport such as archery may not elicit the same aerobic benefits as dynamic sport like badminton.

Our data also highlighted significant differences in Wingate anaerobic capacities among the badminton, archery, and non-athlete groups, with badminton players demonstrating significantly higher anaerobic capacity and power compared to archers and non-athlete controls. This finding underscores the anaerobic demands of badminton, characterized by short, intense rallies requiring rapid bursts of power and speed. Similar findings in other sports, such as those involving high-intensity efforts like sprinting or cycling, support the notion that sport-specific training influences anaerobic capacity and power performance (Samsudin *et al*., 2022). However, previous studies have reported mixed results regarding anaerobic power in badminton players, suggesting that competitive level and training intensity may influence these outcomes differently (Güçlüöver *et al*., 2012; Ooi *et al*., 2009).

In comparison to the badminton and non-athlete control groups, the archery group exhibited non-statistically significant stronger hand grip strength in both dominant and non-dominant hands, as well as higher back and leg strength. This aligns with Abián-Vicén *et al*. (2012), which reported higher hand grip strength in sports like tennis compared to badminton, likely due to the heavier equipment used. Similarly, archers in the present study displayed higher hand grip strength, possibly due to the heavier bows they handle compared to badminton racquets. Soylu *et al*. (2006) and Shinohara and Urabe (2017) highlighted the specific muscle usage in archery, emphasizing the role of upper-body strength, including the biceps, brachialis, and deltoid muscles, crucial for drawing and aiming the bow. The present study's findings on handgrip and upper-body strength in archers support these observations.

The enhanced activation of quadriceps and calf muscles during contralateral isometric contraction of shoulder flexion and abduction may account for the higher back and leg strength seen in archers in this study, as reported in Lee *et al*.'s (2014) exploratory experiment. These findings highlight how lower-body muscle activation and isometric contraction in the upper body interact during archery. Additionally, Handrigan *et al*. (2012) emphasized that maintaining static standing is crucial for shooting accuracy over extended periods, as it enhances recruitment of lower body muscles, stabilizing posture and reducing body sway.

Suchomel, Nimphius & Stone (2016) mentioned the importance of muscular power in functional performance, critical for tasks requiring high force or speed. Badminton players in this study demonstrated significantly greater explosive power, indicated by longer standing long jump distance and higher vertical jump height compared to archers. This explosive power could be attributed to the intensive training regimen of badminton players, involving rapid movements and powerful shots, which require robust leg muscles and coordinated lower and upper body actions. The present study finding reflects the importance of explosive power in athletes engaging in dynamic sport, highlighting the necessity of muscular power in badminton performance.

Regarding coordination, the present study demonstrated considerably greater coordination in the badminton group compared to both the archery and non-athlete control groups. This aligns with findings of Wankhade (2018), which highlighted superior eye-hand coordination in badminton players compared to table tennis players. The present study finding suggests that the dynamic nature of badminton enhances coordination skills more effectively than static sports like archery, which rely less on rapid movements and quick reactions. Furthermore, the study underscores the potential benefits of engaging in badminton for improving overall coordination compared to a less active lifestyle.

In contrast to Wong *et al*. (2019), who found similar balance performance between badminton players and controls, the results of this study showed that the badminton group had much better balance than the archery and non-athlete control groups. This superior balance in badminton players is likely due to their frequent footwork and agility training, which involves rapid changes in direction, accelerations, and decelerations. These movements enhance proprioception, stability, and core strength, crucial for maintaining balance during dynamic gameplay. Additionally, badminton players' specific core strengthening exercises may contribute to their enhanced balance on the court, distinguishing them from archers and non-athletes.

This study has several limitations. These include the participants' age range which was limited to 13–18 years, the recruitment of only male participants, and the absence of high-level competitive athletes at national or international levels. Future research should aim to include athletes across different age groups, both genders and various competitive levels, such as national and international. Additionally, comparing badminton and archery with other hand-based sports like tennis and table tennis could further elucidate the specific physical demands and benefits associated with each sport.

Conclusion

This study revealed that badminton players demonstrated significantly greater standing long jump and vertical jump height explosive power, balance, coordination, estimated VO_2 max, anaerobic power and anaerobic capacity when compared to archers. These results suggest that because of the variations in the training regimens that both teams underwent, badminton players were superior to archers in some of the physiological components. In addition, badminton players also showed significantly greater standing long jump explosive power, balance, coordination, and estimated VO_2 max compared to non-athlete controls. Archers exhibited non-significantly higher hand grip strength and back and leg strength compared to non-athlete controls. In conclusion, these findings suggest that participation in badminton and archery can enhance specific physical fitness or physiological components compared to non-athlete controls, who were less active and did not engage in structured physical training. The results of this study can be utilized to create training programs that will enhance badminton and archery performance while encouraging an active lifestyle.

Regarding the implications of the study, the study underscores the importance of tailoring training programs to the distinct physiological demands of sports like badminton and archery. Badminton's emphasis on aerobic and anaerobic capacities, explosive power, balance and coordination suggests training should prioritize activities like aerobic conditioning and plyometric training, while archery's focus on handgrip strength, and back and leg strength that enhance fine motor and control core stability. These findings can be informed to bodies and associations regarding athlete development and talent identification, helping coaches to optimize training strategies for improving athletes' performance and minimize injury risks. Overall, understanding these specific physiological profiles could enhance knowledge in sports science and sports medicine, guiding personalized approaches that aim to maximize athletic potential in competitive contexts.

Conflict of Interest

The authors declare that they have no conflicting interests.

Acknowledgements

The authors would like to thank the coaches and athletes of badminton and archery state teams of Kelantan state in Malaysia, as well as the sedentary participants for their willingness to participate in this research. Additionally, a special thanks is extended to the staff of Exercise and Sports Science Laboratory at Universiti Sains Malaysia for their technical support.

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