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Comparative Study of Cardiorespiratory Endurance, Grip Endurance, and Reaction Time in 18–25-Year-Old Badminton Players vs. Non-Athletes

Dr. Lalit Nikam[1], Dr Dipeeka P Dhumal[2], Dr.Anjali Baliram Kale[3]

[1]Additional Professor, Department of Physiology, Seth GS Medical College, Parel, Mumbai.l, Maharashtra, India
[2]Senior Resident, Department of Physiology, Seth GSMC& KEMH Mumbai, Maharashtra, India.
[3]Assistant Professor, Department of Physiology, Government Medical College, Ratnagiri, Ratnagiri , Maharashtra, India

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Corresponding Author:

Dr Dipeeka P Dhumal
Senior Resident ,Department of Physiology, Seth GSMC& KEMH Mumbai, Maharashtra, India.

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ABSTRACT

Background: Badminton is a fast-paced sport that requires superior cardiorespiratory endurance, muscular strength, and rapid sensory motor responses. Young adults with sedentary lifestyles have been associated with reduced physical fitness and delayed reaction time. There is a paucity of data on physiological and neuromuscular parameters between badminton players and non-athletes. The current study aimed to determine the cardiorespiratory endurance, handgrip strength, and auditory and visual reaction time between young badminton players and non-athletes.

Methods: This was a cross-sectional observational analytical study done on 40 participants (20 badminton players and 20 non-athletes). The physical fitness test was estimated by the Modified Harvard Step Test, a bicycle ergometer, and the FRIEND registry equation was used to estimate the maximal oxygen uptake (VO_2max). The handgrip strength and endurance were measured by the handgrip dynamometer, and auditory and visual reaction time tests were conducted using an audio-visual reaction time apparatus.

Results: Badminton players recorded higher Physical Fitness Index (86.5 ± 2.26 vs. 40.75 ±1.93; p = 0.001), and VO_2 max (51.45 ± 2.58 vs. 35.65 ± 2.01; p = 0.001) than non-athletes. The hand grip strength was (46.90 ± 0.92 vs. 29.85 ± 1.81 kg; p <0.001), and the endurance (41.45 ± 2.58 vs. 19.85 ± 2.16 s; p <0.001) was also significantly higher. Badminton players had significantly higher auditory and visual reaction times ($p < 0.001$).

Conclusion: The results of our study showed that playing badminton would improve cardiorespiratory fitness, muscular performance, and reaction times in young adults. Our study highlights the importance of participation in sport to improve overall physiological and neuromuscular health.

***Keywords**: Badminton, Cardiorespiratory Endurance, VO_2 max, Handgrip Strength, Reaction Time.*

INTRODUCTION

The determination of sport-specific physical characteristics is important for maximizing athletic performance and helps in understanding differences between an athlete and a non-athlete [1]. This knowledge can be of great interest for sports scientists and coaches because the performance in sports is a complex combination of physical, psychological, and physiological factors [2]. Physical fitness elements such as cardiorespiratory endurance, muscular strength and endurance, coordination, and reaction time are more specifically applicable in comparing athletes involved in competitive sports with non-athletes who are generally sedentary. Badminton is a popular racket sport in most parts of the world, with Asia and Europe being the leading countries because it is easily accessible, has low-cost equipment, and has an engaging nature as a sport [3]. This sport is suitable for a very broad age group, and it can be both a recreational and competitive activity. At the competitive stage, badminton is also a very intense, intermittent activity and needs good aerobic endurance, agility, muscular strength, speed, accuracy, and coordination [4]. Past studies in this field have underscored the fact that racket sports require a combination of several elements of physical fitness in order to perform at the optimum level [5]. Regular playing of badminton has many health benefits because it is predominantly an aerobic activity, which tends to enhance cardiovascular endurance, pulmonary efficiency, and overall circulatory health. Long-term exposure to such activity is known to provide several cardiovascular benefits [4-6]. Apart from the cardiovascular benefits, it helps in maintaining an ideal weight, muscular strength, flexibility, agility, and bone health. Additional benefits for mental health have been shown, including reducing stress, improving cognitive abilities, and providing positive psychological states [7]. Because of the fast-paced nature of the sport, it helps in rapid visual processing along with hand responses, therefore, improving the hand-eye coordination, reflexes, and reaction time. Contrastingly, modern lifestyles are increasingly characterized by young adults having sedentary behaviour, which includes office workers and students [8]. Sedentary behavior has already been linked to poor health effects, including metabolic syndrome, cardiometabolic risk, type 2 diabetes, and earlier death, regardless of the engagement in moderate-to-vigorous physical activities. Less vigorous exercise leads to lower cardiorespiratory fitness levels as measured by maximal oxygen consumption (VO_2max), which is the maximum capacity of the cardiovascular system as well as the respiratory system to deliver oxygen during intense exercise [9]. VO_2 max has been considered as one of the most ideal physiological predictors of aerobic fitness and work capacity and is highly adaptable to routine physical training. Grip endurance is a critical fitness parameter in racket sports such as badminton, where a sustained forearm and hand muscle activity is essential for effective strike play and shot control. Equally, reaction time is an important factor that determines the performance of sports because it indicates how effectively sensory-motor processing is carried out in the central nervous system [10-12]. Swift response time is linked with better athletic performance and neural processing functions. Both reaction time (visual) and visual and auditory reaction times have been found to have been enhanced using physical conditioning and respiratory control techniques [13]. Although the advantages of badminton and physical exercise are widely acknowledged, there are very few studies that have undertaken a detailed comparison of cardio-respiratory endurance, grip endurance, and reaction time of young adult badminton players with non-athletes. Thus, the current research aimed to comparatively analyze these parameters in badminton players and non-athletes aged 18-25 years, which will help understand the physiological adaptations that are associated with sport participation.

MATERIAL AND METHODS

This cross-sectional, observational, and comparative pilot study was conducted at Dadaji Kondadev Stadium, Thane, over a period of two years. Institutional Ethical approval was obtained for the study after duly following the protocol for human research based on the Helsinki declaration. Written consent was obtained from all the participants of the study after explaining the nature and purpose of the study in the vernacular language, with freedom for participants to withdraw from the study if they do not wish to continue at any point in time. All the information related to the participants was kept confidential.

Inclusion Criteria

1. Individuals aged 18–25 years
2. Athletes were defined as those who play badminton 4–5 days per week and have been doing so for the past year.
3. Participants receiving badminton training for competitions for minimum six months
4. Age and sex matched sedentary individuals who are not involved in any significant physical activities.
5. Willingness to participate in the study voluntarily.

Exclusion Criteria

1. Subjects with lower back pain, vestibular problems of visual problems
2. Ankle sprains and meniscal injuries
3. History of bronchial asthma, COPD, and tuberculosis
4. Known cardiac and respiratory diseases
5. Hypertensives and metabolic disorders
6. History of smoking, tobacco consumption, and alcohol use
7. History of major surgeries in the recent past
8. History of neuromuscular disorders
9. Subjects are not involved in any other kind of exercise regime, such as Gym, Zumba, or aerobics.

After the selection of subjects, a detailed medical history of each subject was obtained, followed by a complete physical examination. The procedure of each test and how to perform it was clearly demonstrated to the participants in order to make them understand how to perform optimally to obtain accurate values.

Physical Fitness Index: Physical fitness was assessed using the Modified Harvard Step Test. Participants stepped on a 20-inch platform at a rate of 30 steps per minute for up to 5 minutes. Pulse rate was measured manually at 1–1½, 2–2½, and 3–3½ minutes during recovery. The Harvard Fatigue Index was calculated using the standard formula and categorized accordingly [14].

Maximal Oxygen Uptake (VO_2 max): In this study, we used the FRIEND Registry equation for the prediction of VO_2 max using a bicycle ergometer. All the parameters of participants, such as Age, sex, height, weight, and exercise mode, were considered to obtain the final values in each individual [15]

Handgrip Strength and Endurance: A Handgrip dynamometer was used for the measurement of handgrip strength and endurance. For estimation of strength, the subject was asked to perform best in three efforts with rest in between. Next, the best of the three values was considered. The handgrip endurance was similarly assessed by the ability to hold the maximum grip for as long as possible for three attempts. The maximum duration among the three values was taken in seconds.

Auditory and Visual Reaction Time: Reaction time was measured using an audio-visual reaction time apparatus. Auditory stimuli and green light visual stimuli were used. After familiarization, three readings were recorded for each parameter with randomized stimulus intervals, and the final reading was used for analysis.

Parameters Assessed

4. Physical Fitness Index
5. Maximum oxygen uptake
6. Handgrip strength
7. Handgrip endurance
8. Auditory and visual reaction time

Statistical Analysis: All the available data were segregated, refined, and uploaded to an MS Excel spreadsheet and analyzed by IBM SPSS version 26 in Windows format. The continuous variables were expressed by mean, standard deviation, and percentages. Normality was assessed using the Shapiro–Wilk test. Categorical variables were calculated by using Student's t-test for comparison of means of two groups, and differences between two groups were calculated by the Chi-square test, and a two-tailed p value of <0.05 was considered significant.

RESULTS

The mean ± SD cardiorespiratory analysis of the cohort is presented in Table 1. A critical analysis of the fitness index showed that the physical fitness of badminton players was 86.5 ± 2.26, while that of the control group was 40.75 ± 1.92 in percentage, and the mean difference was 45.75. Using the independent t-test, a statistically significant difference (p <0.001) was observed between the mean physical fitness index of the participants in the two groups. Similarly, the mean ± SD VO_2 max in the badminton players was 51.45 ± 2.58, while that in the control group was 35.65 ± 2.01, and the mean difference was 15.8. t-test analysis showed that there was a statistically significant difference (p <0.001) between the mean VO_2 max of subjects in the 2 groups.

Table 1: Cardiorespiratory and Physical Fitness Parameters

Parameter	Study Group	N	Mean SD	Mean Difference	P value
Physical Fitness Index (%)	Badminton Players	20	86.5 ± 2.26	45.75	<0.001*
	Non-Athletes (Control)	20	40.75 ± 1.93		
Maximal Oxygen Uptake (VO_2 max)	Badminton Players	20	51.45 ± 2.58	15.8	<0.001*
	Non-Athletes (Control)	20	35.65 ± 2.01		
*Significant					

The muscular strength and endurance parameters of the participants are presented in Table 2. The analysis of the table showed that the mean± SD Handgrip strength in the badminton players was 46.9 ± 1.92 while that in the control group was 29.85 ± 1.81, and the mean difference was 17.05. Using the independent t-test, a statistically significant difference (p <0.001) was observed between the mean handgrip strength of participants in the two groups. Similarly, the mean± SD Handgrip endurance in the badminton players was 41.45 ± 2.58, while that in the control group was 19.85 ± 2.16, and the mean difference was 21.6. Using the independent t-test, a statistically significant difference (p <0.001) was observed between the mean handgrip strength of participants in the two groups.

Table 2: Muscular Strength and Endurance Parameters

Parameter	Study Group	N	Mean ± SD	Mean Difference	P Value
Handgrip Strength (kg)	Badminton Players	20	46.90 ± 1.92	17.05	<0.001*
	Non-Athletes (Control)	20	29.85 ± 1.81		
Handgrip Endurance (Tmax)	Badminton Players	20	41.45 ± 2.58	21.6	<0.001*
	Non-Athletes (Control)	20	19.85 ± 2.16		
*Significant					

The neuromuscular reaction time of the participants is given in Table 3. Analysis of the table showed that the mean ± SD Auditory reaction time in the badminton players was 177.55 ± 6.51, while that in the control group was 238.25 ±11.15, and the mean difference was -62.7. Using the independent t-test, a statistically significant difference (p <0.001) was observed between the mean auditory reaction times of the participants in the two groups. The mean± SD Visual reaction time in the badminton players was 267.05 ± 7.1, while that in the control group was 325.75 ± 10.55, and the mean difference was -58.7. The independent t-test showed a statistically significant difference ($p < 0.001$) between the mean visual reaction time of the participants in the two groups.

Table 3: Neuromuscular Reaction Time Parameters

Parameter	Study Group	N	Mean ± SD	Mean Difference	P value
Auditory Reaction Time (ms)	Badminton Players	20	177.55 ± 6.51	-62.7	<0.001*
	Non-Athletes (Control)	20	238.25 ± 11.15		
Visual Reaction Time (ms)	Badminton Players	20	267.05 ± 7.10	-58.7	<0.001*
	Non-Athletes (Control)	20	325.75 ± 10.55		

*Significant. A negative mean difference for reaction time indicates that badminton players had faster reaction times (lower values) than non-athletes. Ms milliseconds.

DISCUSSION

The results of the present study were used to determine the differences in physical fitness between badminton-playing athletes and non-athletes of the age group 18-25 years. The overall results of the study showed that parameters such as cardiorespiratory endurance, muscular strength and endurance, and reaction time were significantly better than those of non-athletes. It was also found that young adults playing badminton regularly had significantly greater VO_2 max as compared to non-athletes, which showed superior cardiorespiratory fitness. The results point towards the significant physiological adaptations that are linked with the frequent engagement in a high-intensity intermittent sport like badminton. The physical fitness index of athletes was better, which indicates that the cardiovascular recovery following exercise indicates enhanced heart and circulatory efficiency. Our findings are in agreement with previous studies, which have shown that regular sport training improves aerobic capacity and recovery profile [6, 9]. One of the key indicators of cardiovascular endurance is increased VO_2 Max, which shows the capacity of an individual to perform prolonged physical activity [9]. The presence of greater differences in mean values of athletes and non-athletes in our study suggests that habitual badminton training has substantially increased oxygen delivery and enhanced the oxygen utilization mechanisms at the cellular level because of increased cardiac output, capillary density, and mitochondrial adaptations [16]. Muscular endurance activities comparison between the two groups of the study showed significant differences. Badminton athletes were found to have more handgrip strength than non-athletes. As expected, this occurs because badminton involves repetitive gripping, rapid racket handling, and forceful strokes, which impose sustained demand on the flexor muscle of the forearm, thereby increasing its performance over a period of time. Other previous studies done on racket sports showed that trained athletes had superior grip strength and endurance due to sport-specific neuromuscular modulation with hypertrophy of the involved muscle group [17,18]. Increased handgrip endurance found in our study showed that muscular fatigue tends to occur slowly in trained athletes as compared to non-athletes because of the competitive, prolonged rallies that occur during this sport. The assessment of auditory and visual reaction times in this study showed that badminton players had significantly faster reactions. The reaction time is an indicator of the speed of processing occurring in the central nervous system and integration [10-12]. The fast pace of badminton that demands fast perception of shuttle direction and immediate motor reactions is probably the cause of better neural efficiency. Constant training on high-speed stimuli improves synaptic transmission, motor planning, and execution, leading to the shortening of response latency [17]. These results can be compared with the other studies that have demonstrated that athletes who play open-skill sports demonstrate a faster reaction time than inactive individuals [18]. The better neuromuscular coordination in badminton players could also be because of attention focus, cortical arousal, and sensorimotor coordination developed because of regular training [12]. The overall findings of this study support the existing pieces of evidence that there are multidimensional benefits of regular sports activity and there are negative health impacts associated with sedentary lifestyles [8]. Just like any other study, our study had its own limitations, which were due to the limited sample size and the cross-sectional nature of the study. Future longitudinal studies with a larger sample size are required for further deliberating the findings. At the end, the findings of the study support evidence that regular badminton participation significantly enhances cardiorespiratory fitness, muscular endurance, and reaction time in young adults.

CONCLUSION

Within the limitations of the current study, it was found that young badminton players aged 18-25 years demonstrate significantly superior cardiorespiratory endurance, muscle strength, and muscle endurance. It also reduces the auditory and visual reaction times as compared to non-athletes. Regular participation in badminton tends to improve physical fitness, aerobic capacity, and neuromuscular efficiency. These findings show the positive effects of physical activity on physiological and neurological performances. Thus, encouraging participation in such activities will promote overall health and functional fitness in young adults.

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