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RESEARCH ARTICLE

Effect of One Month Periodisation Program on Cardiovascular Fitness of Badminton Players

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ABSTRACT

The purpose of this study is to explain the importance of cardiovascular fitness in badminton fitness, measure and collect cardiovascular fitness fitness data from 30 badminton players, identify their weaknesses thus design a program for improvement. A 20m multistage shuttle run was conducted to test the cardiovascular fitness level of badminton players. Then the results are converted to VO2max level. Weaknesses of players are evaluated and a one-month periodisation program is designed to improve the cardiovascular fitness fitness of the athletes. Post-test results show that the program was effective in improving players' cardiovascular fitness level.

INTRODUCTION

Importance of cardiovascular fitness in badminton

Cardiovascular fitness is an essential component in badminton fitness. When considering a full match duration, the aerobic energy contribution is critical for the ability to recover and avoid fatigue between rallies (Madsen, Højlyng & Nybo, 2016). Although explosive movements in a single rally or action appear to be dependent on a player's anaerobic power and neuromuscular characteristics, a player's ability to resist fatigue and repeat intense actions throughout the game is highly dependent on their cardiovascular fitness capacity (Madsen, Højlyng & Nybo, 2016; Raharjo et al., 2023).

Also, other important components in badminton are also dependent on cardiovascular fitness. In previous studies, it is found that increased cardiovascular fitness has been reported to improve various domains of cognitive function, with the underlying concept that aerobic capacity facilitates neuroplasticity (Chen et al, 2022).

In terms of consistency, a well-developed aerobic cardiovascular fitness capacity is regarded as vital for speedy recovery between rallies when playing a whole match (Fuchs, et al., 2014; Abdullah et al., 2024). If the cardiovascular fitness level is lower, there is a greater chance of making mistakes due to earlier muscle fatigue and lack of stamina to maintain proper posture, thus a lower consistency of strokes. In terms of explosive power, according to Faccini et al. (Faccini & Dal Monte, 1996; Beqiraj et al., 2023), a badminton athlete needs 65% of one's aerobic capacity to accomplish explosive moves.

Therefore, we can see that cardiovascular fitness of badminton players actually plays an important role in badminton matches and is interrelated with other important fitness components as well, cardiovascular fitness of badminton players should be trained regularly.

Objectives

1. To collect data for the cardiovascular fitness of 30 badminton players
2. To design a fitness program to enhance cardiovascular fitness of 30 badminton players
3. To evaluate the effectiveness of one-month periodization training program via comparison between control and experimental group after the implementation of one-month periodization plan

METHODS

Subjects

This study involved 30 badminton players. Ageing from 20-25 years old (mean=21.5 SD=0.25), 19 male players and 11 female players. Participants were active badminton players and free of injuries. The 30 players were randomly divided into 2 groups, 15 players in control (n=15) and experimental group (n=15) respectively. 15 players followed the periodization program and 15 did not follow the program, while all 30 players continued with their regular training sessions.

Experimental approach: 20m multistage shuttle run

20m multistage shuttle run is used to test the cardiovascular fitness level of the athletes, it's a test that involves running between two lines that are 20m apart with recorded beep sounds. Flat, non-slip surface, marking cones, 20m measuring tape and the 20m multistage shuttle run audio are the equipment needed in the test. Pre-test and post-test are done before and after a periodisation training program. The design of the program is based on the analysis of weaknesses of players and the effectiveness of the program is evaluated.

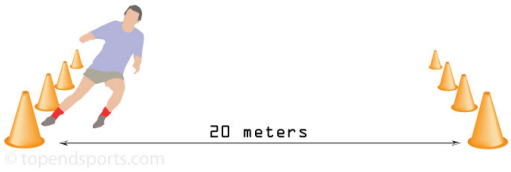


Image 1: 20m multistage shuttle run (2008, Topend Sports Website)

Before the start of the 20m multistage shuttle run , consent forms and pre-screening forms are given to participants, basic information such as age, gender, height, weight are recorded. Before the test, athletes were asked to do at least 5-10 minute adequate warm-ups to prepare for the test.

Athletes will take a starting position behind one of the lines, facing the other line, then begin running when the recording says. The pace will continue to increase as the test progresses, if the athlete couldn't reach the opposite line before the beep sound, a warning was given. If one received 2 warnings then he/she would be eliminated (Otieno & Mutwol, N.D.).

20m multistage shuttle run pre-test

Image 2: 20m multistage shuttle run (pre-test) on 13 April, 2022

20m multistage shuttle run post-test

Image 3: 20m multistage shuttle run (post-test) on 13 May, 2022

After the pre-test, players in the control group were asked to follow a one-month periodization program to improve their performance. Players in the control group will just follow their own training schedule without any specific improvement programs. A post-test will be done after one-month to evaluate the effectiveness of the periodization program.

Statistical analysis

The 20m multistage shuttle run results are then used to determine VO2 max level. The subject's shuttles and levels were recorded (e.g. 9–10 means he stopped on the 10th shuttle of the 9th level), and VO2 max was computed using the formula VO2Max = 3.46 * (L + S / (L * 0.4325 + 7.0048)) + 12.2, and presented in the following table (Topendsports, 2022).

Table 1: Conversion of 20m multistage shuttle run results into VO2max Level

Level (L)	Shuttle (S)	Distance	VO2max		Level (L)	Shuttle (S)	Distance	VO2max
6	6	940	35.1225		9	1	1460	43.6575
6	7	960	35.483		9	2	1480	43.975
6	8	980	35.8434		9	3	1500	44.2925
6	9	1000	36.2038		9	4	1520	44.61
6	10	1020	36.5642		9	5	1540	44.9275
7	1	1040	36.7649		9	6	1560	45.2451
7	2	1060	37.1098		9	7	1580	45.5626
7	3	1080	37.4547		9	8	1600	45.8801
7	4	1100	37.7995		9	9	1620	46.1976
7	5	1120	38.1444		9	10	1640	46.5151

7	6	1140	38.4893		9	11	1660	46.8326
7	7	1160	38.8342		10	1	1680	47.1054
7	8	1180	39.1791		10	2	1700	47.4108
7	9	1200	39.524		10	3	1720	47.7162
7	10	1220	39.8689		10	4	1740	48.0216
8	1	1240	40.2106		10	5	1760	48.3269
8	2	1260	40.5413		10	6	1780	48.6323
8	3	1280	40.8719		10	7	1800	48.9377
8	4	1300	41.2025		10	8	1820	49.2431
8	5	1320	41.5332		10	9	1840	49.5485
8	6	1340	41.8638		10	10	1860	49.8539
8	7	1360	42.1944		10	11	1880	50.1593
8	8	1380	42.5251		11	1	1900	50.5542
8	9	1400	42.8557		11	2	1920	50.8483
8	10	1420	43.1863		11	3	1940	51.1425
8	11	1440	43.517		11	4	1960	51.4366
					11	5	1980	51.7308
					11	6	2000	52.025

The difference between pre-test and post-test of control group and experimental group vo2max level is calculated respectively and SPSS version 26 was used to analyze the data. For continuous variables, mean and standard deviations were determined. To compare mean values and statistical significance between groups, SPANOVA (Split-plot ANOVA) was used.

SPANOVA is used to evaluate the effect of the one-month periodization program. By determining whether there is significant difference within pre-test and post-test, and whether is there significant difference between control and experimental group on the test.

RESULTS

The assumptions required for the analyses (normality, homogeneity of variances and sphericity) were met. The Kolmogorov-Smirnov/Shapiro-Wilk tests, Box's M test and Mauchly's sphericity test was used to examine the conformity of the variables to normal

Distribution.

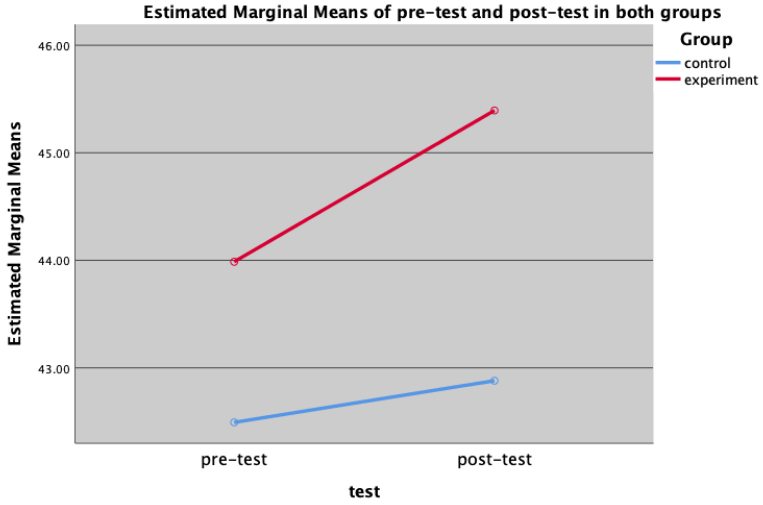
Table 4: Cardiovascular fitness measurement results within and between groups

Test	Experimental group (n=15)		Control group (n=15)		Group effect	Time effect	Interaction Effect
	Mean	SD	mean	SD			
Pre-test	43.99	4.92	42.49	5.30	F= 1.172, P=0.288 ηp^2=0.040	F= 52.17, P<0.001* ηp^2=0.651	F=16.876, p<0.001* ηp^2=0.376
Post-test	45.39	4.83	42.88	5.16			

* p<0.05. F: Split Plot ANOVA (SPANOVA) test.

Experimental group shows a more significant improvement in post-test results (M=45.39 ±4.83) than pre-test results (M=43.99 ± 4.92), with a change of +1.4 . Control group shows slight increase from M=42.49 ± 5.30 in pre-test to M=42.88 ± 5.16 in post-test, with a change of +0.39.

The data collected were analysed with a split-plot ANOVA with Group as the between participants factor and Time as the within participants factor. The test indicated a main effect of Time (F (1, 28) = 52.17, p < 0.01), with an effect size of 0.651 and the interaction between Group and Time was significant as well (F(1,28) = 16.876, p < 0.01), with an effect size of 0.376; the effect of Group was not significant (F(1,28) = 1.172 p = 0.288) and the effect size was 0.04 (table 4).



Graph 1: Estimated marginal means of pre-test and post-test in both groups

DISCUSSION

Pre-test:

When we compare the data collected in the pre-test with the 20m multistage shuttle run norm (Topendsports, 2022), the results of control group (M=42.49 ± 5.30) and experimental group

(M=43.99 ± 4.92) lies within the 'Average' category only, which indicates that there is still a lot of room for improvement in the cardiovascular fitness capacity for both groups.

The weakness in a relatively low cardiovascular level reflects players may not be good at playing long rallies and long matches. Long rallies means higher intensity, muscle engagement, shorter recovery time between strokes, and a higher heart rate. A player with a solid aerobic base will be able to train longer, harder, and more effectively, and will be able to tolerate the fatigue of extended rallies. A fatigued player with a weakened aerobic foundation is more likely to make more and more frequent errors during the game. Therefore, it is important to improve aerobic endurance.

Training program

The training program is set according to the FITT principle. For frequency, badminton specific footwork was two times per week (for specific endurance, power, and speed), HIIT workout (for speed, agility, coordination, explosive power) two times per week and long distance running once per week (for endurance). Long distance running, HIIT, Badminton skills specific drills are the three main types of training, two rest days are incorporated in the program. The periodization program lasted for one month, 5 training sessions per week and each session lasted for 30-45 minutes.

In badminton, all major muscle groups are used, training all major muscle groups helps attaining muscle balance, reducing risk of injuries and optimizing athletic performance.

In the one-month program, not only can cardiovascular fitness level be improved, endurance of major muscle groups can also be improved as well.

In addition, in badminton games, short rest periods (around 15 seconds) are interspersed between rallies to facilitate partial recovery from the previous rally and may last at least 45 minutes. So badminton is a mix of speed (anaerobic fitness) in rallies and cardiovascular fitness (aerobic fitness) in between rallies to allow for continuous efforts and encourage recovery. It's also necessary to have a lot of strength, power, agility, and flexibility. All of these fitness elements should be included in a player's fitness program. Therefore, HIIT with different exercises is incorporated into the programme to improve several components.

Training 1. HIIT

According to Abdullah (2014), it is suggested that in youth badminton players, high intensity interval circuit training leads to a significant increase in specialized endurance to perform some of the most important skills. It was also found that for badminton players, circuit style interval training is an important training approach (abdullah, 2014).

HIIT is a type of interval training that involves short bursts of all-out exercise followed by rest intervals of 10-30 seconds. It's a low-volume approach to gain aerobic power and cardiovascular fitness that's usually connected with longer training sessions (abdullah, 2014). Another study also found that HIIT improves muscle buffer capacity, maximal aerobic power, phosphocreatine resynthesis rate, and lactate tolerance, which leads to an improvement in specific endurance performance (Glaister, 2005). The study also suggested that HIIT in on court technical training that lasted for 40 to 50s, could be a duration that is useful to result in better endurance level. Not only endurance level can be improved from HIIT but also strength and range of motion, since HIIT exercises require multiple muscle groups to work together to carry out cardiovascular workouts in high intensity.

Workouts

Exercise and instructions	demonstrations
Jumping jacks Muscles targeted: Full-body Benefits: coordination, agility, cardiovascular fitness instructions: 1. Stand tall with legs together and arms at sides. 2. Jump high while bending knees slightly. 3. Spread legs to shoulder width apart while jumping. Extend arms above the head. 4. Return to the starting position.	 *Image 4a, 4b. Jumping Jacks demonstration*
Split lunges jump Muscles worked: Quadriceps, Gluteals, Hamstrings, Calves Benefits: strength, explosive power Instructions: 1. Lunge with left leg forward. 2. Push off with both feet, jumping together, then hopping into a lunge with right leg in front .	  *Image 5a,5b,5c. Split Lunges Jump demonstration*

Plank Muscles worked: full-body Benefits: core-strength, balance Instructions: 1. get into the pushup position with the forearms, with the elbows parallel to the shoulders. 2. Tighten the abs and glutes. 3. Maintain a straight spine and neck. Make a flat line from head to toes. 4. Maintain the posture.	 *Figure 6. Plank demonstration*
Double swing jump rope: Muscles worked: Full-body Benefits: strength, agility, coordination, cardiovascular fitness 1. Keep hands at waist level while holding the rope. 2. jump with both feet, and get two rotations of the jump rope every time you jump.	 *Image 7a, 7b. Double swing jump rope demonstration*
Tuck jumps Muscles worked: Quadriceps, Gluteals, Hamstrings, Calves, Hip Flexors Benefits: strength, explosive power Instructions: 1. Stand with feet shoulder width apart, toes pointing forward, and your weight in heels. 2. Squat down, then drive through your heels to reverse the movement and jump as high as possible. 3. Return to the squat position gently.	 *Figure 8a, 8b. Tuck jumps demonstration*

Mountain climbers Muscles worked: shoulder muscles, triceps, chest muscles, serratus anterior, abdominal muscles Benefits: cardio endurance, core strength, agility Instructions: 1. start with a high plank position 2. Quickly switch between legs by bringing one knee up toward the middle of the stomach. 3. Keep alternating until the set is finished.	 *Image 8a, 8b. Mountain climbers demonstration*
Jump squats Muscles worked: Quadriceps, Gluteals, Hamstrings, Calves Benefits: Power, Strength Instructions: 1.Stand with your feet shoulder-width apart and your toes pointed outward slightly. 2. Bend your knees and push your hips back as if you were sitting in a chair. 3. Jump straight up by pushing through your heels. 4. Return to your squat stance with your knees slightly bent.	 *Image 9a, 9b. Jump squats demonstration*

Training 2. Badminton skills specific training: full court footwork shadowing

Footwork shadowing is a drill that is like playing badminton games without striking a shuttle. If done correctly, it is immensely advantageous in many parts of the game, including court endurance, speed, anticipation, timing, and physical condition will all improve (Nirendan & Murugavel, 2019). Shadowing sets are done in a way that the number of strokes are longer than the majority of rallies in a game. As a result, this prepares your legs for extended rallies and helps players to maintain speed regardless of how long the rallies last.

Full court footwork shadowing

Image 10: Week 1 - Full court footwork shadowing

Training 3. Long-distance running

Long-distance running is one of the most easy and simplest ways to improve cardiovascular fitness level of badminton players, which typically perform at around 75–85% of peak aerobic capacity. Especially for singles players, long-distance runs are a must and should be integrated into every player's training routines. Therefore, in our program, we included one session every week.

One-month periodization program

Monday	Tuesday	Wednesday	Thursday	Friday	Saturday	Sunday
5km run Pace: 6:15/km	HIIT ·45sx8 exercises ·10s rest interval ·3 sets	Badminton skills specific training ·full court footwork shadowing ·20 times ·3 sets	Rest day: Stretching	HIIT ·45sx8 exercises ·10s rest interval ·3 sets	Badminton skills specific training ·full court footwork shadowing ·20 times ·3 sets	Rest day: Stretching
5km run Pace: 6:00/km	HIIT ·45sx9 exercises ·10s rest interval ·3 sets	Badminton skills specific training ·full court footwork shadowing ·20 times ·3 sets	Rest day: Stretching	HIIT ·45sx9 exercises ·10s rest interval ·3 sets	Badminton skills specific training ·full court footwork shadowing ·25 times ·3 sets	Rest day: Stretching
5.5km run Pace: 6:15/km	HIIT ·45sx10 exercises ·10s rest interval ·3 sets	Badminton skills specific training ·full court footwork shadowing ·25 times ·3 sets	Rest day: Stretching	HIIT ·45sx10 exercises ·10s rest interval ·3 sets	Badminton skills specific training ·full court footwork shadowing ·25 times ·3 sets	Rest day: Stretching

5.5km run Pace: 6:00/km	HIIT ·45sx10 exercises ·8s rest interval ·3 sets	Badminton skills specific training ·full court footwork shadowing ·30 times ·3 sets	Rest day: Stretching	HIIT ·45sx10 exercises ·8s rest interval ·3 sets	Badminton skills specific training ·full court footwork shadowing ·30 times ·3 sets	Rest day: Stretching

Progressive overload

To avoid adaptations and lack of variations, progressive overload is adapted in the one-month program. According to Hagerman (2012), there should be an increase in frequency, intensity, or length that is limited to 10% as a general rule of progressive overloading, and should be made only once the body has adjusted to the programme.

Therefore, for the long distance running program, the distance and pace are increased progressively. As for the HIIT workouts, the rest interval decreases between bouts and the number of exercises increases progressively from 8 to 10. Lastly for the full court footwork shadowing, the numbers for each set increase from 20 to 30 times progressively.

Post-test

After implementation of the one-month program, 20m multistage shuttle run test is conducted again. The data collected was processed through SPSS. From the results, in both control and experimental groups, the results also indicate that there is an improvement in cardiovascular fitness.

The cardiovascular fitness levels in experimental group showed significant improvement

Compared to before the exercise ($F=52.17$, $p<0.001$). This result was also valid for the

Control group even though no exercises were given to this group (Table 1).

The improvement in the control group should be due to the effect of their daily regular training sessions. However, since their regular sessions are not targeted at improving cardiovascular fitness, there is relatively smaller improvement when compared to the experimental group. Therefore, we can also conclude that the greater extent of improvement in the experimental group is due to the designed program.

In addition, the post-test results of the control group ($M=42.88\pm5.16$) and experimental group ($M=45.39\pm4.83$), there is a significant difference, which indicates that the one-month periodization program is effective to improve cardiovascular fitness to an extent. According to a research done by Donie and & Hermanzoni (2017), their findings also show that footwork training combined with the HIIT (High-Intensity Interval Training) method can raise Vo2max in badminton athletes.

Limitations and Improvements

Despite there is a more significant improvement in the experimental group, when we compare the data collected in the pre-test with the 20m multistage shuttle run norm (Topendsports, 2022), it still lies within the 'Average' category only, which indicates that there is still a lot of room for improvement in the cardiovascular fitness capacity for both groups.

This may be due to the short duration of the whole training program, such that no much improvement could be seen. If athletes keep up the program for a longer period of time, there can be more significant results.

CONCLUSION

Aerobic fitness plays an important role in badminton, it affects other important components like cognitive function, explosive power and consistency. Also, players with a strong aerobic foundation will be able to train longer, harder, and more effectively, as well as handle the fatigue of long rallies.

To conclude, the one-month program is effective to improve cardiovascular fitness to a certain extent. Therefore, training programs for badminton players are important to include cardiovascular fitness. HIIT workout, long distance running and badminton specific footwork shadowing are effective ways to improve badminton player's cardiovascular fitness level.

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