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Original Research

The Effects of Step Aerobic Training on Muscle Power and Agility in Female Badminton Players

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ABSTRACT

International Journal of Exercise Science 15(6): 1317-1325, 2022. The purpose of the study was to compare the effects of step aerobic training (SAT) on muscle power and agility in female badminton players. Twenty female badminton players were assigned to experimental groups (EG = 10) were for 30 minutes 3 days a week to perform SAT (age: 16.70 ± 1.15 yrs), and control groups (CG = 10) were regular badminton training. (age: 16.60 ± 1.17 yrs). Measures of muscle power was tested with a knee extensors (KE) and knee flexors (KF) isokinetic peak toque 180°/sec (NM) and agility was tested in badminton specific movement. Results indicate that mean KE was after 4 weeks (left leg; 42.70 ± 5.65; $p < 0.037$, right leg; 45.90 ± 6.60; $p < 0.002$), KF (left leg; 40.60 ± 8.05, right leg; 41.90 ± 6.75; $p < 0.001$), and KE after 8 weeks (left leg; 45.00 ± 7.30, right leg; 47.30 ± 7.30; $p < 0.001$), KF (left leg; 45.00 ± 7.30, right leg; 47.30 ± 7.30; $p < 0.001$) increase than before, KE after 8 weeks (left leg; $p < 0.023$, right leg; $p < 0.009$), and KF in EG (left leg; $p < 0.047$, right leg; $p < 0.014$) increased than CG was statistically significant. Agility in EG after 4 weeks (52.42 ± 1.81 sec) and 8 weeks (49.12 ± 1.96 sec) decrease than before (55.91 ± 2.74 sec; $p < 0.001$). The agility time after 4 weeks ($p < 0.004$) and 8 weeks ($p < 0.001$) decreased than in the EG compared to CG. These findings indicate the 6-8 inches height of SAT and the rhythm movement control of 130-140 beats per minute (BPM) can increase muscle power and agility in 4 weeks, which is beneficial for those badminton players and coaches who want to use a short period of training.

KEY WORDS: Step aerobic training, muscle performance, change of direction speed

INTRODUCTION

According to the Guinness World Records, badminton players must move rapidly in different directions on the court in order to hit and pick up the shuttlecock in time with an average speed of 417 kilometers per hour (7). Numerous studies have shown that athletes must use motor skills

throughout the competition such as dashing, lunging, and quickly changing direction (1, 2, 23). This requires a high level of muscle power caused by the contraction of the muscles with greater force. It increases the ability of athletes to perform skills that use movement effectively and affects their agility (4, 19). Studies have shown that practicing badminton skills alone does not improve the muscle strength necessary for athletes' agility (2). The development of motor skills in badminton requires periodic intense training to increase muscle power and motor skills in competition (24). Studies suggest that training patterns that can increase muscle power in badminton athletes require the use of intermittent high-intensity training. To optimize maneuverability to move more efficiently (1). The SAT pattern combined with the skill of an athlete that used the step 6-8 inches height, and controlled movement speed in 120-150 BPM range will help to increase the level of optimal training intensity and can develop muscle power for athletes (17, 21). Previous studies have indicated that the SAT pattern is a low-impact training that does not affect the safe knee and ankle. The players can also increase their training intensity by adjusting the target height as needed (6). This includes using a controlled movement speed in the range of 120-145 BPM or using a training intensity interval of 65-80% maximum heart rate for more muscle stimulation (9, 13). Finally, a pattern of SAT that uses proper height and speed control. It can be used in conjunction with skill training to develop muscle power, which is an important factor in the movement of badminton players (23). Therefore, this research aimed to compare the effect of SAT on muscle power and agility in female badminton players.

METHODS

Participants

Twenty female participants were badminton players aged between 15–18 years, who had undergone a pre-exercise readiness assessment to show that they were healthy and without any chronic health conditions. Inclusion, the criteria were: A female badminton players who practice badminton normally; more than 1 year of sports experience with no history of surgery or musculoskeletal injuries in the spine, wrists, elbows, shoulders, knees and ankles within 6 months prior to study participation; Must had healthy and physically fit as assessed with the Physical Activity Readiness Questionnaire (PAR–Q); and had never received. The exclusion criteria were as follows: Participants had an accident that caused musculoskeletal injuries to their spine, wrists, elbows, shoulders, knees and ankles during SAT. An *a priori* power analysis using statistical software (G*power V 3.1.9.4) was completed to determine an adequate sample size. A sample size of 10 participants per group was estimated in our main outcome, leg muscle power based on means and standard deviations from previous studies at an alpha level of 0.05 with 80% power. The participants performed the test with muscle power as a key performance criterion and recorded the test results, using the range the ability of the muscles from the most to the least. Individually matched subjects with similar muscle power were then divided into two groups, the experimental groups (n = 10, age 16.70 ± 1.15 yrs, height 164.10 ± 3.66 cm, weight 53.98 ± 3.09 kg, fat 23.32 ± 2.07 %) and the control group (n = 10, age 16.60 ± 1.17 yrs, height 164.20 ± 3.32 cm, weight 53.98 ± 3.09 kg, fat 23.52 ± 2.36%). Basic anthropometric data of the participants in both studies are presented in Table 1. All participants provided written informed consent at the beginning of the study. The experiment was approved by the Ethics Committees

of Khonkaen University (Khonkaen, Thailand), and was conducted in accordance with the ethical principles for medical research involving human subjects described in the Declaration of Helsinki and the ICH Good Clinical Practice Guidelines. Reference No. HE642128. This research was carried out fully in accordance to the ethical standards of the International Journal of Exercise Science (14).

Table 1. Basic anthropometric data of the participants in both studies (mean ± SD)

	Experimental group (*n* = 10)	Control group (*n* = 10)
Age (yrs)	16.70 ± 1.15	16.60 ± 1.17
Height (cm)	164.10 ± 3.66	164.20 ± 3.32
Weight (kg)	53.98 ± 3.09	53.98 ± 3.09
Fat (%)	23.32 ± 2.07	23.52 ± 2.36

Protocol

The experimental group performed SAT 3 days a week. For the 8-week study period, and the control group practiced the badminton program as usual. The SAT is designed according to the American College of Sports Medicine (ACSM) guidelines (11). To provide badminton players with a range of low-impact training moves consisting of seven movement patterns: 1) side tap, 2) knee up, 3) over the top, 4) turn step, 5) cross back, 6) across the top chasse, and 7) indecision which used a stride speed of 125-140 BPM, then, controlled by using rhythmic music and steps aerobic height at 4, 6 and 8 inches. SAT is divided into 3 sessions, totaling 30 minutes: 5 minutes warm-up, 20 minutes aerobic step, 5 minutes cooldown and stretching. In the 1st week to 2nd week, perform each exercise for 20 seconds, resting 20 seconds between moves, for a total of 3 sets, using a 4-inch aerobic height and 125 BPM. In 3rd week to 4th week, use 6 inches of aerobic height to 130 BPM as the speed, and the 5th week to the 8th week do each exercise for 30 seconds, resting 30 seconds between moves for a total of 2 sets, and also use a SAT height of 8 inches at a speed of 140 BPM.

Muscular power was tested with a KE and KF isokinetic peak toque 180°/sec. Did 15 repetitions of both leg extension and flexion. In newtons-meters per second (Nm/sec). Based on instrument confidence report by Habets et al, (8). Participants were asked to do 5 reps of leg extension and 5 reps of leg flexion without resistance to understand how the test was performed. Set the knee range of motion at 90°, and performed 15 reps with a maximum torque of 180°/sec. Participants exerted their full strength with both knee KE and KF (Figure 1).

The Witty SEM Reactive System Agility Test was used to test the movement of badminton by testing the specific agility of badminton (Figure 2). The agility test used a triggered light system where the tester standed in the center of the field and waited for a signal from the system's six points. When the light was on, participants must move the badminton racket directly to the signal light, and always came back to the center of the field, doing 4 moved at each point. The agility test of the study was performed using a specific movement agility test for badminton (5), which was a two-way lateral dexterity test. Four-corner agility test, each with four LED indicators for a total of 24 times. The participants tested their agility by holding their rackets at

the center of the field, facing the net, and moving towards the collision to cut-off the signal when the LED lights up in different positions with full-speed, then retreat. In the middle position, did the test twice and each time took a 5 minute rest.

Figure 1. Illustrative representation of the muscle power test with Humac NORM isokinetic dynamometer, knee extensors and flexors.

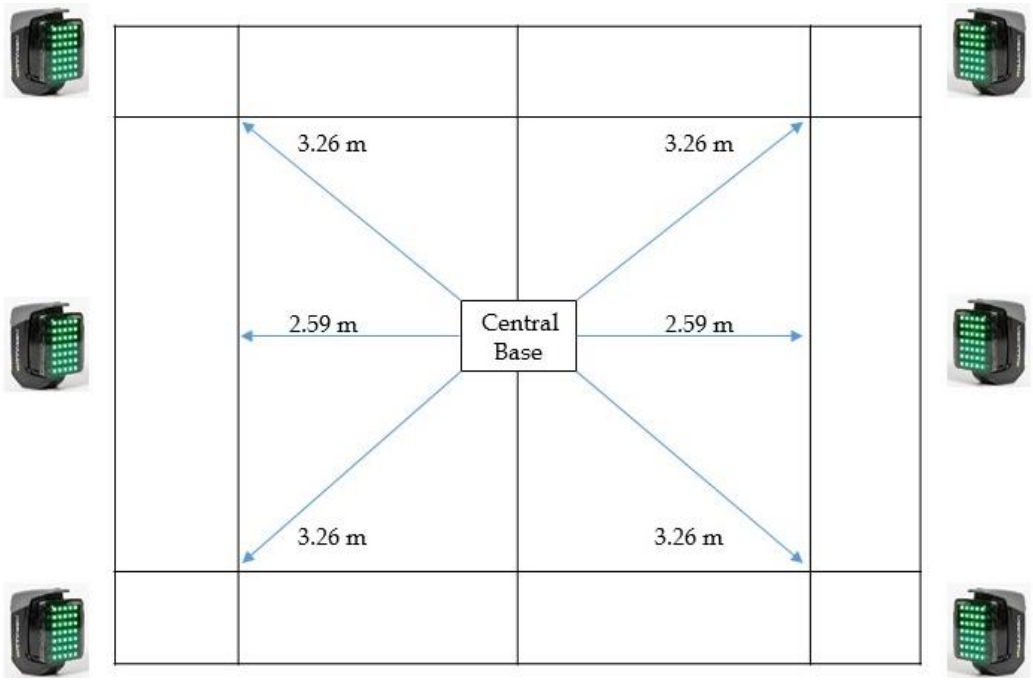

Figure 2. Illustrative representation of the participants tested the movement of badminton by badminton-specific movement agility tests.

Statistical Analysis

The data were presented as mean and standard deviation. After checking the normal distribution, the differences in mean muscle strength and intragroup agility were analyzed prior to weeks 4 and 8 by using one-way ANOVA as a repeat measurement. Independent sample tests were used to determine the significant difference first. After weeks 4 and 8 of the intergroup testing. They were statistically significant, $p < 0.05$.

RESULTS

The EG showed that mean muscle power of KE peak torque 180°/sec (Nm) of the left and right leg after 4 weeks (left leg; 42.70 ± 5.65; $p < 0.037$), (right leg; 45.90 ± 6.60; $p < 0.002$) and after 8 weeks (left leg; 45.00 ± 7.30, right leg; 47.30 ± 7.30; $p < 0.001$) significant increase from before (left leg; 37.70 ± 7.87, right leg; 38.50 ± 7.73) and after 8 weeks (left leg; 45.00 ± 7.30; $p < 0.002$), (right leg; 47.30 ± 7.30; $p < 0.001$) significant increase from weeks 4 (left leg; 42.70 ± 5.65, right leg; 45.90 ± 6.60) and mean KF peak torque 180°/sec (Nm) of the left and right leg after 4 weeks (left leg; 40.60 ± 8.05, right leg; 41.90 ± 6.75; $p < 0.001$) and after 8 weeks (left leg; 45.00 ± 7.30, right leg; 47.30 ± 7.30) significant increase from before (left leg; 33.90 ± 4.88, right leg; 35.10 ± 5.17) and after 8 weeks (left leg; 45.00 ± 7.30, right leg; 47.30 ± 7.30; $p < 0.001$) significant increase from weeks 4 (left leg; 40.60 ± 8.05, right leg; 41.90 ± 6.75). The CG showed that mean KE peak torque 180°/sec (Nm) of the left and right legs before (left leg; 37.40 ± 5.92, right leg; 37.40 ± 3.74), after 4 weeks (left leg; 40.00 ± 9.01; $p < 0.095$), (right leg; 41.90 ± 8.90; $p < 0.137$) and 8 weeks (left leg; 39.20 ± 7.62; $p < 0.253$), (right leg; 41.20 ± 7.72; $p < 0.097$) and KF peak torque 180°/sec (Nm) of the left and right legs before (left leg; 32.00 ± 6.39, right leg; 34.70 ± 6.88), after 4 weeks (left leg; 35.50 ± 9.46; $p < 0.208$), (right leg; 36.60 ± 8.85; $p < 0.530$) and after 8 weeks (left leg; 36.10 ± 10.97; $p < 0.246$), (right leg; 37.10 ± 9.32; $p < 0.437$) was not statistically significant. Compared between groups, it was found that mean KE and KF peak torque 180°/sec (Nm) in both left and right legs after 8 weeks (left leg; $p < 0.023$, right leg; $p < 0.009$) and KF peak torque 180°/sec (Nm) in both left and right legs in EG after 8 weeks (left leg; $p < 0.047$, right leg; $p < 0.014$) increased than the CG was statistically significant, $p < 0.05$ (Figure 3).

In the EG, it was found that the mean agility time after 4 weeks (52.42 ± 1.81 sec) had a significant decrease from before (55.91 ± 2.74 sec) and after 8 weeks (49.12 ± 1.96 sec) significant decrease from after 4 weeks and before ($p < 0.001$). The CG found that agility time after 4 weeks (55.24 ± 1.94 sec; $p < 0.015$) had a significant decrease from before (56.25 ± 2.54 sec), and after 8 weeks (54.11 ± 2.94 sec) had a significant decrease from after 4 weeks 55.24 ± 1.94 sec; $p < 0.048$) and before (56.25 ± 2.54 sec; $p < 0.003$). Compare between groups, was found that after 4 weeks ($p < 0.004$) and 8 weeks ($p < 0.001$), the agility time of the EG decreased than the CG was statistically significant, $p < 0.05$. (Figure 4).

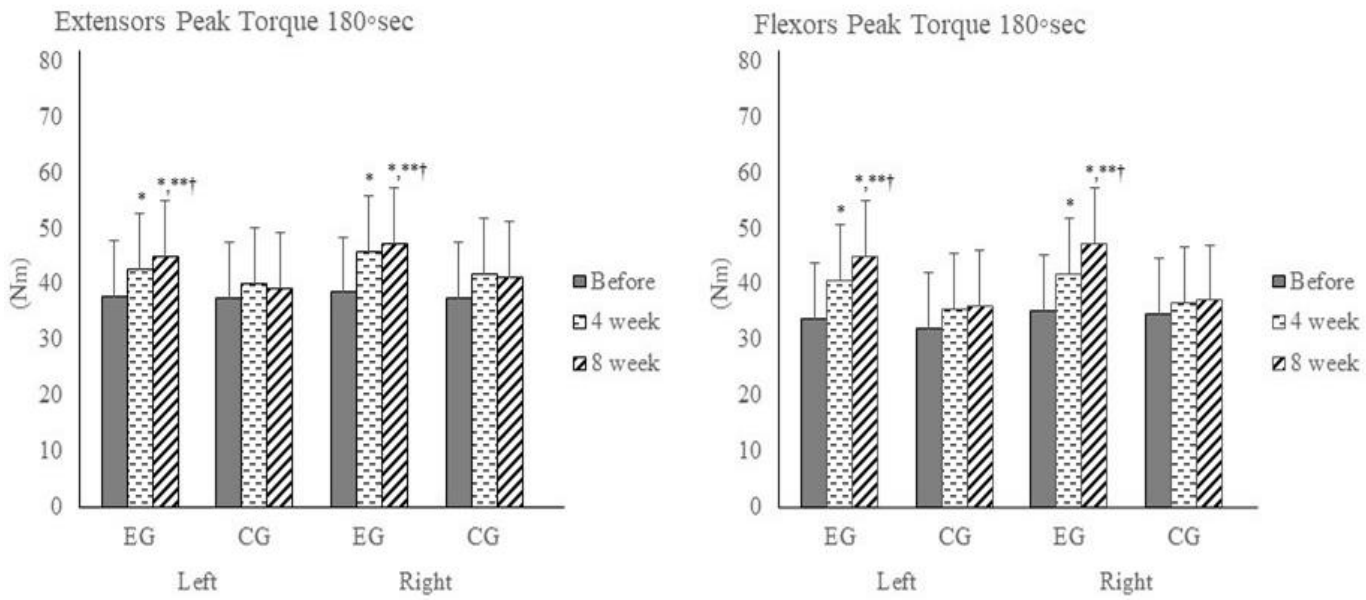

Figure 3. Muscle power of knee extensors (KE) and knee flexors (KF) peak torque 180°/sec (Nm) in the experimental group (EG) and control group (CG). Significant differences: from before *$p < 0.05$; from week 4 **$p < 0.05$; between group †$p < 0.05$.

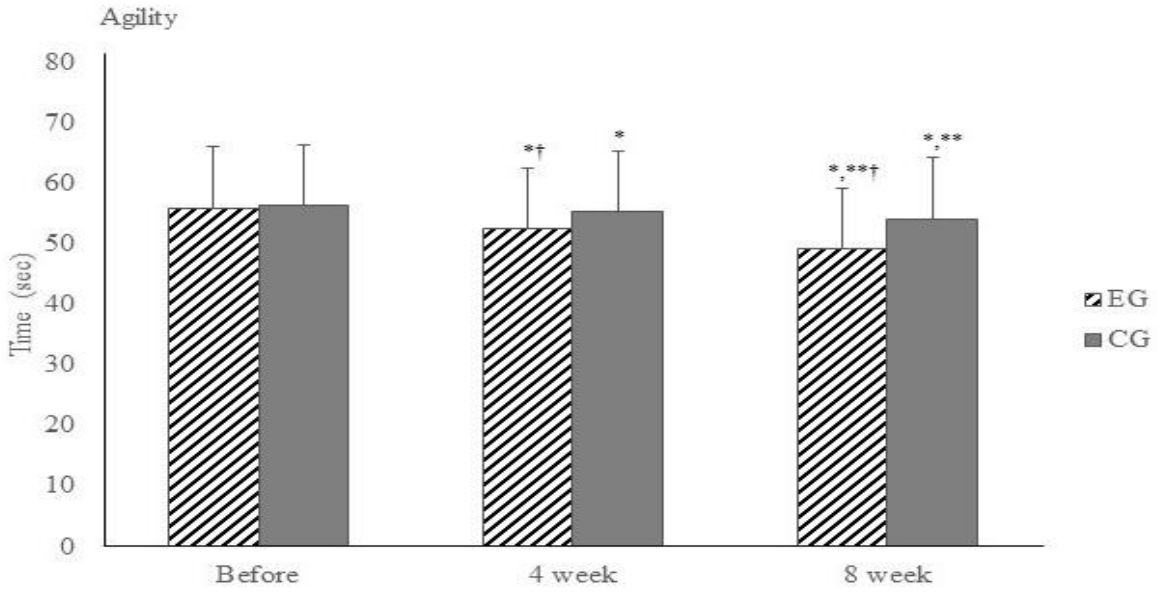

Figure 4. Agility time in the experimental group (EG) and control group (CG). Significant differences: from before *$p < 0.05$; from week 4 **$p < 0.05$; between group †$p < 0.05$.

DISCUSSION

In this study, participants were designed for 8 weeks of advanced SAT**.** All participants measured a maximum torque of 180◦/sec (Nm) to test muscle power with the Humac NORM isokinetic meter (12, 15) and agility tests. The specific movement agility test of badminton and the Witty SEM Reactive System in female badminton players was to compare the effect of SAT and a regular badminton program on muscular power and agility. Therefore, SAT is an exercise that uses rhythmic music to perform various movement. From stepping on the feet to jumping into a height-adjustable box to increase the intensity of training. 4 to 8 inches of SAT will help the muscles in the legs and the hip become more active**.** And also in combination with the fast rhythm of music in the 120-145 BPM range, it can develop. Muscle power and agility can be increased due to the design of the movement patterns used in SAT**.**

SAT can significantly increase the muscle power of the KE and KF after 4 weeks and after 8 weeks. This SAT can cause the amount of tension in the contraction of the muscles to increase gradually. Thus, causing the stimulation of the muscles that affect the power of the muscles**.** An earlier study found that a SAT pattern without progressive overload was used at 4-6 inches and a training speed of 120-128 BPM**.** There was no change in leg muscle power after 10 weeks with the Isokinetic Peak Torque test, and we also found a decrease in muscle power. Muscle power can be improved from the component of muscle strength to the speed of muscle contraction (18, 19). By 4-8 weeks of SAT, resistance was increased, respectively, by 4, 6 and 8 inches tall, and controlled at 125, 130, and 140 BPM. This allows the muscles to exert enough resistance and speed throughout the training period. Well, this makes it possible to stimulate the nervous system and muscles followed by eccentric contractions followed by contractions. When muscles contract abnormally rapidly. It causes the motor units to move to activate the fast-twitch muscle fibers, causing the muscles to contract faster and powering the muscles to give you more power. It has been shown that step aerobics training at 60-80% intensity and 122-140 BPM pace can develop muscle in high jumps (16). Proper use of resistance training can alter the neuromuscular system to mobilize motor units, activating fast-twitch muscle fibers, causing muscle contractions faster and increasing muscle power (3). This resulted in a significant increase in the muscle power of both KE and KF of female badminton players, $p < 0.05$.

SAT significantly reduced agility time after 4 weeks and 8 weeks, $p < 0.05$. The SAT pattern involves stepping up and down, jumping and sliding across aerobics from side to side with proper music rhythm according to progressive overload principle. This builds momentum and develops the main muscle groups of the legs. The movement may produce a gradual increase in the amount of muscle contraction tension from the training pattern at weeks 1-4 and from weeks 5–8. Therefore, it stimulates the work of muscles that affect muscle power, which is an important factor of agility. The development of agility is due to the relationship of bio-motor ability between strength and speed, and when the muscles have maximum power and maximum speed, it affects muscle power which the development of agility requires practice leg strength and high muscle strength**.** In addition, strength is the main factor in reducing agility time. Steven (22) found that training at different levels would allow the nervous system to adapt by

increasing the command of the motor unit and increases the frequency of transmission of nerve impulses from the central nervous system to the muscles and muscles. This adaptation facilitates the travel of nerve impulses from receptors to prominent parts of the brain and travels through neurons to muscles for fine movement, which improves dexterity (10). Therefore, after 4 weeks and after 8 weeks, the agility time was significantly reduced**.** In the badminton training program, it was found that after 8 weeks the agility time decreased. Maybe it's because of the badminton training program because the training style that moves to different positions on the field consists of footsteps or slides, running and jumping a short period of movement, and there was a moderate to high level of movement intensity over a constant range. The movement resulted in a significantly reduced agility time in the badminton training program. However, the results of this study showed that SAT reduced agility time more than statistically significant badminton-only training, $p < 0.05$.

This study has some limitations that should be considered based on past studies, which have used a small number of step aerobic training patterns for athletes' training. Most of which can be seen as studies on health-related physical fitness for the general population and the elderly. However, future studies should investigate step aerobic training in other sports where there is a need to develop variables in muscle power and agility in short training sessions.

In conclusion, this study suggests that step aerobic exercise is performed at 6-8 inches tall and employs rhythmic movement control at 130–140 BPM. It can increase muscle power and agility in 4 weeks, which is beneficial for badminton players and coaches who want to spend a short training period.

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REFERENCES

1. Abdullah S A. Effect of high intensity interval circuit training on the development of specific endurance to some of essential skills in youth badminton players. Journal of Advanced Social Research 4(3): 77-85, 2014.

2. Agirbas O, Eser Aggon, Mehmet Yazic, Sibel T. The effect of beginner badminton trainings on anaerobic power and muscle strength. World Journal of Sport Sciences 11(1): 01-04, 2016.

3. Bompa, T.O., Haff, G.G. Periodization: theory and methodology of training. 5th ed. Human kinetics. Champaign IL; 2009.

4. Cabello D, Manrique J. J, González-Badillo. Analysis of the characteristics of competitive badminton. Br J Sports Med 37: 62-66, 2003.

5. Cheong HO, Albert T, Azwanri A, Kien WK, Ruji S, Khairul AMG, Swee LL, Wen JC, Martin WT. Physiological characteristics of elite and sub-elite badminton players. Journal of Sports Sciences, December 27(14): 1591–1599, 2009.

6. DeSimone Grace. ACSM's Resources for the group exercise instructor 1st ed. American College of Sports Medicine; 2012.

7. Guinness World Reords. Fast test badminton hit in competition (male). Retrieved from https://www.guinnessworldrecords.com/world-records/fastest-badminton-hit-in-competition-(male); 2017.

8. Habets Bas, J. Bart Staal, Marsha Tijssen, Robert van Cingel. Intrarater reliability of the Humac NORM isokinetic dynamometer for strength measurements of the knee and shoulder muscles. BMC Res Notes 11(15), 2018.

9. Izabela DK, Michaa S, Aleksandra Z, Anna K, Anna S. The effects of a 10 week step aerobics training on vo2max, isometric strength and body composition of young women. Central European Journal of Sport Sciences and Medicine 4(4): 3-9, 2013.

10. John, F, Diane V. Training for speed agility and quickness. Champaign: Human Kinetics, Illinois; 2000.

11. Lippincott Williams, Wilkins. ACSM's guidelines for exercise testing and prescription.10th ed. Philadelphia (PA). American College of Sports Medicine; 2016.

12. Koening J. M, Jahn DM, Dohmeier TE, Cleland JW. The effect of bench step aerobics on muscular strength, power, and endurance. J. Strength Cond. Res (9): 43; 49, 1995.

13. Murugavel K, Nandagopal D. Influence of step aerobic training on muscular strength and explosive power of footballer 7(5), 2018.

14. Navalta JW, Stone WJ, Lyons TS. Ethical issues relating to scientific discovery in exercise science. Int J Exerc Sci 12(1): 1-8, 2019.

15. Nebojsa T, Goran S, Tomislav K, Dejan M. Madic, Spela B. The importance of reactive agility tests in differentiating adolescent soccer players. Int. J. Environ. Res. Public Health 17: 3839, 2020.

16. Nikic, N, Milenkovic D. Efficiency of step aerobic program in young women. Act. Med. Median 52(3): 25-34, 2013.

17. Nithiya TN., Saroja S. Effect of different intensity of step aerobics training on speed and cardiorespiratory endurance among school girls. International Journal of Current Research and Modern Education 2(2): 284-287, 2017.

18. O'Shea, P. Quantum Strength Fitness ll (Gaining the Wining Edge), Pattrick's book; 2000.

19. Ozen, G, Koc, H, Aksoy C. Long-term effects of different training surfaces on anaerobic power and leg strength in athletes. Kinesiologia Slovenica 23(1): 25-32, 2017.

20. Sean S., Robert U., Newton. Design and implementation of a specific strength program for badminton. Strength and Conditioning Journal 30(3): 33-41, 2008.

21. Sedigheh M, Hairul AH, Mohamed RA, Mohd RM. The effects of supervised step aerobics training combined with daily milk consumption on muscle power and cardiovascular fitness in inactive girls: a randomised controlled trial. International Journal of Collaborative Research on Internal Medicine & Public Health 8(7): 465-474, 2016.

22. Steven JF. Designing resistance training program. Illinois. Human Kinetics; 1997.

23. Wee EH, Low JY, Chan KQ, Ler HY. Effects of specific badminton training on aerobic and anaerobic capacity, leg strength qualities and agility among college players. Springer Nature Switzerland: 192-209, 2019.

24. Young W, Farrow D. A review of agility. Practical applications for strength and conditioning. National Strength and Conditioning Association 28(5): 24-29, 2006.