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Muscle Power and Agility Following Step-Aerobic Training in Male Badminton Players

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ABSTRACT

Background: Step-aerobics training is one of the most exercise popular which is safe, a low-impact form of exercise, and does not cause any impact on the knee and ankle joints, it is ideal for developing the power of muscle and agility in a change of direction, that is essential for athletes. **Objective:** This study was to examine muscle power and agility following step-aerobic training in male badminton players. **Methods:** The study was an experimental research design conducted on a study recruited twenty male badminton players (aged 19-22) who were randomly divided into two groups. The subjects were initially tested for muscle power by a vertical jump and agility test. Thereafter, the experimental group underwent step-aerobic training for 30 minutes three days a week for eight weeks, and the control group continued its badminton training routine without step-aerobic training. After eight weeks, the study tested all groups for muscle power and agility. **Result:** A group x time interaction for the muscle power of the experimental group after four weeks (p $<$ 0.003) and eight weeks ($p < 0.001$) increased than before and after eight weeks ($p < 0.001$) was significantly increased than the control group. The agility time of the experimental group after step-aerobic training for four weeks ($p < 0.001$) and eight weeks ($p < 0.001$) decreased than before and after eight weeks ($p < 0.002$) was significantly decreased than the control group. **Conclusion:** This study showed that the step-aerobic training pattern in increasing the rhythm movement of 125-140 beats per minute and the 6-8 inches height of step-aerobic can help badminton players enhance their muscle power and agility in four weeks.

Key words: Muscle performance, Agility, Step-aerobic, Exercise, Vertical jump, Badminton specific movement

INTRODUCTION

Badminton is the most popular racket sport worldwide (Ibrahim & Ibrahim, 2017). This sport must change direction quickly in moving around the court to hit and receive the shuttlecock immediately, which is the basis of the competition games, showing that players must be moved in a short period with high acceleration, followed by a fast-moving reaction, and hit all the time to the main target position of the six directions of a badminton court (Manrique et al., 2003; Yuen & Youlian, 2000). The requiring skill throughout the competition, consists of jumping smashes, lunging steps, and quickly changing direction with receive and hits to gain an advantage over your opponent in scoring (Sean et al., 2008).

In the past studies have shown that badminton specific-movement patterns require muscular power to high performance to increase muscle contraction with generate force used in the movement and contribute to the agility of a badminton player in changing direction effectively (Kukolj et al., 1999; Sean et al., 2008; Ozen et al., 2017). Muscular power is generated by contracting muscles at maximum speed, which directly affects the performance of players in various skills (Newton et al., *1994*). Studies have shown that the specific movement skills development in badminton requires high-intensity training in a short period to stimulate muscle work that reaches the point of developing muscle power and playing skills during the game to be more ef-

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fective (Wee et al., 2019), it has been proven that practicing players skills alone cannot develop the muscle power that is essential to developing agility (Agirbas et al., 2016; Ozen et al., 2017; Bupesh & Vikranth, 2018).

Previous studies have indicated that step-aerobic training uses an intensity range of 60-80% heart rate reserve (HRR) (ACSM, 1998) and controlled movement speed ranges of 125-150 beats per minute (BPM) and movement speed range at 125-150 BPM (Isler & Kosar, 2006; Sedigheh et al., 2016), combined with a height of 6-12 inches, increases training intensity to stimulate more muscular exertion, thereby improving muscular power and agility for athletes (Bupesh & Vikranth, 2018; Murugavel & Dharmarajan, 2018). In a study report by Jansupom et al. (2022), it was found that female badminton athletes in the experimental group who received step-aerobic training by controlling the training speed in the range of 130 - 140 beats per minute, and height of step-aerobics at 6-8 inches, indicates that step-aerobic training can increase muscle power and agility significantly more than the group that received skill training alone. Step-aerobics is one of the most popular forms of exercise and low-impact training, which is safe and does not affect the knee and ankle joints of athletes (Santos et al., 2002).

Finally, a badminton-specific movement pattern must have good leg muscle power. Muscle power and agility are needed in badminton to have effective skills to perform jumping smashes, lunging steps, and changing direction quickly to receive hits. Previous studies have shown that badminton players who practice only their playing skills have less muscle performance than athletes who receive high-intensity training in short periods. If muscle efficiency is poor, these specific skills may also be impaired. Step-aerobics is an exercise where the height and speed of the movement can be adjusted to increase the intensity to stimulate the muscles to exert more force. However, when applying the step-aerobics training patterns to athletes, the training intensity level must be considered, namely the proper selection of altitude and movement speed to develop muscle effectiveness, which is regarded as the top priority for badminton players. Therefore, this research aims to investigate the effects of step-aerobic training on muscle power and agility in male badminton players. Therefore, the objective of this study was to examine muscle power and agility following step-aerobic training in male badminton players.

METHODS

Participants and Sample Size Determination

A total of twenty healthy male volunteers of the present study. They were recruited from university badminton players aged between 19 - 22 years. All participants were pre-exercise assessed as healthy and had no chronic health problems. The inclusion criteria were a male badminton player with at least 1 year of competitive experience, no history of musculoskeletal injury within 6 months before participation, and not even of step-aerobic training pattern before. The inclusion criteria were a male badminton player with at least 1 year of competitive experience, no history of musculoskeletal injury within 6 months before participation, and not even of step-aerobic training pattern before. The exclusion criterion for the participant was an accidental musculoskeletal injury that occurred while participating in step-aerobic training.

The sample size was ten subjects per group was the key outcome assessed was the vertical jump based on means and standard deviations from previous studies (Georgios et al., 2023) at an alpha level = 0.05, power = 0.80, and effect size d = 1.17. Based on a previously conducted a priori power analysis using statistical software (G*Power 3.1.9.4) was completed to determine an adequate sample size. Participants performed a vertical jump test and recorded their results using the highest to lowest muscle scoring, and subsequently divided the subjects into two groups for similar values, the experimental groups (n = 10; age 19.90 ± 0.99 yrs, height 170.80 ± 3.39 cm, weight 67.30 ± 4.21 kg, body mass index 22.74 ± 0.90 kg/m2) and the control group (n = 10, age 20.50 ± 1.08 yrs, height 171.00 ± 2.86 cm, weight 67.80 ± 1.93 kg, body mass index 23.08 ± 0.61 kg/m2). The physical characteristics data of subjects in both studies are presented in Table 1.

All subjects provided written informed consent at the beginning of the study. The experiment was approved by the Human Research Ethics Committees, Rajamangala University of Technology Isan, Nakhon Ratchasima, Thailand, and was conducted by the ethical principles for medical research involving human subjects described in the Declaration of Helsinki, The Belmont Report; CIOMS Guideline, International Conference on Harmonization in Good Clinical Practics (ICH-GCP) and 45CFR 46.101(b). Reference No. HEC-01-66-028.

Step-aerobic training protocol

The step-aerobic training pattern used in this study was designed according to the American College of Sports Medicine guidelines (ACSM, 2016). Step-aerobic training consists of a 5-minute warm-up, a 20-minute step-aerobic routine, and a 5-minute cool down and stretching. The experiment was performed three days per week for eight weeks. Step-aerobic movement pattern details include side tap, knee up, over the top, turn step, cross back, across the top chasse, and indecision, for weeks 1-2, perform each training for 20-seconds, resting 20-seconds between patterns, a total of 3 sets, using 4-inch height step-aerobics and a training speed at 125 BPM, for weeks 3-4, using step aerobics 6 inches height, training speed at 130 BPM and weeks 5-8, perform each training for 30- seconds, resting 30-seconds

Table 1. Physical characteristics data (mean ± SD)

Variables	Experimental group (*n* = 10)	Control group (*n* = 10)
Age (yrs)	19.90 ± 0.99	20.50 ± 1.08
Height (cm)	170.80 ± 3.39	171.00 ± 2.86
Weight (kg)	67.30 ± 4.21	67.80 ± 1.93
Body mass index (kg/m^2)	22.74 ± 0.90	23.08 ± 0.61

between moves for a total of 2 sets, use step-aerobics height 8 inches and a training speed at 140 BPM. The increasing workload can be done by using the exercise principles of F I T T as follows: the most influential training frequency from research studies was at least 2-3 days a week, and in this study, training was 3 days a week. Training intensity ranges between 60-80% heart rate reserve and controlled movement speed ranges of 125-140 BPM combined with a step- aerobic height of 4, 6, and 8 inches, increases training intensity to stimulate more muscular exertion, in weeks 1-2, weeks 3-4 and weeks 5-8 respectively. Time or Training duration may include the cumulative amount of training used for the duration of the training session was 20-30 seconds per step-aerobic movement pattern, and the type of activity used for specific training goals to be developed in training is maximum strength or power.

Vertical jump test

The muscle power was tested by the Optojump System (vertical jump test). The test was to start standing straight, bending the knees at 90°, and jumping up vertically as high as possible. The muscle power was tested by the Optojump System (vertical jump test). The test was to start standing straight, bending the knees at 90°, and jumping up vertically as high as possible. The subject stands from an upright position and follows the instructions before the jump test by gradually knee flexion down to approximately 90°, and when told to jump up, counter by swinging arms while jumping freely extended knees and ankles and landing on the ground (Glatthorn et al., (2011). Based on the instrument confidence report by Glatthorn et al. (2011). They were performed on the Optojump System for the measurement of muscle power. All participants performed three times the vertical jump height with a 3-minute rest interval. The highest score of the three jumps was recorded and used for analysis (Figure 1).

Figure 1. Experimental showing the muscle power test with the Optojump System

Badminton-specific agility test

The agility test in this study used a badminton-specific movement agility test (Cheong et al., 2009), which was tested with the Witty SEM Reactive Agility System as a lighting LED signaling system. Equipment is set up in six directions on the court, comprising two front, two side, and two back badminton court areas. Participants held the badminton racket in the center of the court when the signal lights for each position were lit, they moved quickly to cut off the signal and return to the starting point, four times the lights were displayed, totaling twenty-four times. Participants are asked to test twice, for 5-minutes each. (Figure 2).

Figure 2. Experimental showing the badminton-specific movement agility test with the Witty SEM Reactive System

Statistical Analysis

Data are presented as means and standard deviation. The normality of data distribution was confirmed using the Shapiro-Wilk test. After normal distribution was examined, a two-way repeated measure ANOVA (group x time) on vertical jump and agility test with a within-group factor (before, after four weeks and eight weeks), and a between-group factor (experiment and control group) was performed to compare differences in the vertical jump performance and agility at the before, after four weeks, and eight weeks. The statistical analysis was conducted using SPSS IBM 22. The significance threshold was set at $p < 0.05$.

RESULTS

Physical Characteristics Data

Changes are above Table 1.

Muscle Power

Vertical jump height measures are presented in Figure 3. There was a group x time interaction for vertical jump height in the experimental group after four weeks (42.00 ± 3.41 cm; $p < 0.003$) and eight weeks (45.01 ± 3.33 cm; $p < 0.001$) was a significant increase from before (41.19 ± 3.47) and after eight weeks (45.01 ± 3.33; $p < 0.001$) was a significant increase from four weeks (42.00 ± 3.41). There was no significant difference in the control group after four weeks (41.71 ± 2.38; $p < 0.361$) and after eight weeks (42.09 ± 2.33; $p = 0.069$). There were significant differences found between groups after eight weeks in the experimental group (45.01 ± 3.33 cm) with a greater increase in the experimental group than the control group (42.09 ± 2.33) was a significant difference ($p < 0.035$).

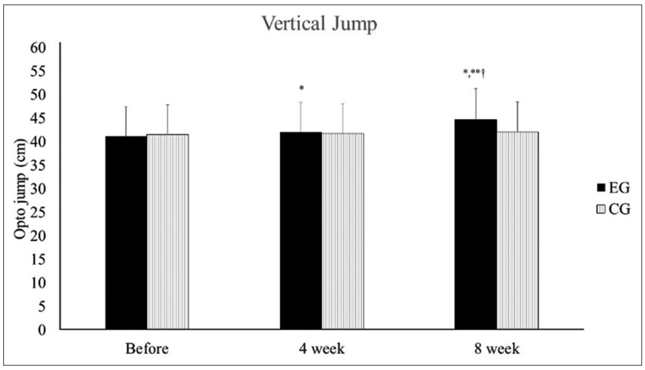

Figure 3. A significant group x time interaction in muscle power of the experimental group (EG) and control group (CG). Significant differences: from before *p < 0.05; from week 4 **p < 0.05; between group †p < 0.05

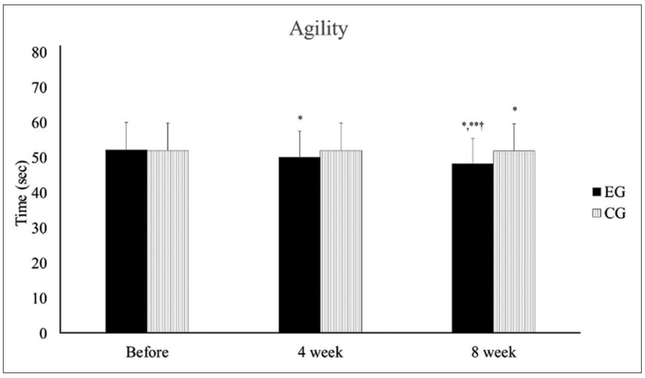

Figure 4. A significant group x time interaction in agility of the experimental group (EG) and control group (CG). Significant differences: from before *p < 0.05; from week 4 **p < 0.05; between group †p < 0.05

Agility

Agility measures are presented in Figure 4. There was a group x time interaction for agility time in the experimental group after four weeks (50.04 ± 2.53 sec; $p < 0.001$) and eight weeks (48.19 ± 2.18 sec; $p < 0.001$) was a significant decrease from before (52.14 ± 2.58 sec) and after eight weeks (48.19 ± 2.18 sec; $p < 0.001$) was a significantly decreased from four weeks (50.04 ± 2.53 sec) and the control group after eight weeks (51.85 ± 2.18 sec; $p < 0.046$) was a significant decrease from before (52.07 ± 2.16 sec). There were significant differences found between groups after eight weeks in the experimental group (48.19 ± 2.18 sec) with a greater decrease in the experimental group than the control group (51.85 ± 2.18 sec) was a significant difference ($p < 0.002$).

DISCUSSION

In this study, participants were to practice step-aerobics patterns, the eight weeks researcher designed. All participants measured their vertical jump performance to test their muscle power with the Optojump System, and a badminton-specific movement agility test with the Witty SEM Reactive System was used to compare the effects of step-aerobic training and regular badminton training on muscular power and agility in male badminton players. Step-aerobic training is an exercise that combines the musical rhythm and the movement of the feet in different directions by stepping and jumping up and down the step-aerobic box that can adjust the height to increase the intensity of the training pattern. Using a step-aerobic height of 4-8 inches in conjunction with the use of rhythmic music in the range of 125-140 BPM will provide a lot of movement in the legs and hips, which can develop muscle function. Muscle power and agility can be developed from the movement patterns used in step-aerobic training.

Muscle Power

Muscle power from the vertical jump tested was significantly increased after four weeks and eight weeks of step-aerobic training, and the amount of tension from the gradual muscle contraction increase was a result of the step-aerobic training pattern, which causes the muscles to be stimulated more efficiently and thus affects the muscle power. Over the course of 4-8 weeks of training, the step-aerobic training progressively increased resistance with step aerobics height 4, 6, and 8 inches and speed controlled at 125, 130, and 140 BPM. This pattern of training results in the muscles contracting to exert optimal resistance and speed over the course of the training period. These processes can stimulate the neuromuscular system followed by the muscle's rapid eccentric contraction. This causes the motor unit to excite the fast-twitch muscle fibers, resulting in faster muscle contraction and increased efficiency of the muscle power at 60-80% of the maximum heart rate intensity and control speed movement from step-aerobic training at a range of 120-150 BPM can develop muscle performance (Isler & Kosar, 2006; Sedigheh et al., 2016). Previous studies have found that only a training speed of no more than 130 BPM and a step-aerobic height of only 6 inches couldn't increase muscle stimulation. However, muscle power can be developed from a component of muscle strength that is an important factor leading to muscle contraction speed (O'Shea, 2000; Ozen et al., 2017). Therefore, when athletes receive step-aerobic training that uses a height of 6-8 inches and movement speed control of 130-140 BPM, which is an appropriate training intensity level that can increase muscle power for badminton players (Jansupom et al., 2022). Appropriate use of patterns and intensity of practices causes changes and development of the neuromuscular system, affects the mobilization of motor units, activates fast-twitch muscle fibers, and thus increases muscle power (Bompa, 2009). Therefore, the current study showed that the step-aerobic training pattern requires proper height and movement speed, to will be able to increase muscle power in athletes.

Agility

Step-aerobic training is significantly different in a reduced time of agility after four weeks and eight weeks, $p < 0.05$. The pattern of step-aerobic training involves stepping up and down, jumping, and sliding across the top from side to side with proper music cadence according to the progressive principle. These processes contribute to the development of the main muscle groups of the legs. In the 1-4 weeks and from the 5-8 weeks, the developed movement pattern causes the muscle contraction to increase gradually. Therefore, the work of properly trained muscles is stimulated, causing contraction, and resulting in increased agility. Agility can be developed through strength and speed, which is a relationship of bio-motor abilities, if athletes develop their muscles for maximum strength and speed, they will result in power and efficient muscles (Bompa, 2009). The reason for the development of agility is muscle power. However, to stimulate the development and adaptation of the nervous system, patterns of training with an appropriate level of training intensity must be used to increase the amount of command of the motor unit to send nerve impulses to target muscles by controlling the central nervous system, and there is an adaptation of the nervous system that will allow athletes to move the body and affect agility (Fleck & Kraemer, 1997; John & Diane, 2000). Therefore, when the agility of moving to change direction is more efficient, it takes less time to move. That is, change of direction speed increases. It can be seen that in four weeks and eight weeks, there was an increase in the height and movement speed in step-aerobic training, it increased the training intensity, therefore resulting in increased agility, and the control group was found to have increased agility after eight weeks of regular badminton training. This may be due to the badminton skill training style, which has the characteristics of footsteps to run, jump, and slide in different directions. It is moderate-to-high-intensity training, thus increasing agility and reducing movement time. However, the results of this study indicated that the improved step-aerobic training pattern can significantly increase agility and reduce movement time. However, the results of this study showed that a step-aerobic training format that uses appropriate height and movement speed can increase agility and reduce movement time in athletes.

Limitations

This study shows that there are still a small number of studies on training styles that use step-aerobics. Most of which can be seen as studies on the general population, the elderly, and young athletes. However, although the results obtained from the study indicated that muscle power and agility in male badminton players of the experimental group were significantly higher than those of the control group, there were no significant differences between groups in four weeks. Therefore, in future studies, it is recommended to increase the step-aerobics height and training speed movement to increase the performance appropriate for male badminton players and other athletes such as those who need more strength will need to use a step-aerobic platform height in the range of 6-12 inches and a movement speed in the range of 125-150 BPM. In addition, you must choose to use the step-aerobic movement pattern in a consistent manner for each sport for maximum efficiency.

CONCLUSION

This study suggests that the cadence movement speed control of 125-140 BPM and the 6-8 inches height of step-aerobics can increase muscle power and agility in four weeks, which is beneficial for badminton players who want to apply diverse training to increase the performance level required during movements in badminton and most importantly, take the time to practice in a short time.

AUTHOR CONTRIBUTIONS

TK, AH, and CJ participated in the study design and drafted and critically revised the manuscript. PP, KT, and MK were responsible for the literature search and data collection. TK, AH, and CJ were responsible for results analysis and statistical analysis and helped to revise the manuscript. All authors read and approved the manuscript.

ETHICAL COMMITTEE INFORMATION

The experiment was approved by the Human Research Ethics Committees, Rajamangala University of Technology Isan, Nakhon Ratchasima, Thailand, and was conducted by the ethical principles for medical research involving human subjects described in the Declaration of Helsinki, The Belmont Report; CIOMS Guideline, International Conference on Harmonization in Good Clinical Practics (ICH-GCP) and 45CFR 46.101(b). Reference No. HEC-01-66-028.

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