ORIGINAL ARTICLE

Effects of circuit training method on reactive agility and endurance in table tennis players

Hary Widodo[ABCDE], Tomoliyus[ACDE], Abdul Alim[ACDE], Muhammad K. Ansori[ABD]
Yogyakarta State University, Indonesia

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Abstract

Background and Study Aim: Reactive agility and aerobic endurance are crucial physical components for athletes' success in both competitions and training. However, traditional training programs often fail to simultaneously address both components effectively. The purpose of this study was to determine the effect of a training type using the circuit method to improve reactive agility and aerobic endurance.

Material and Methods: This research is an experimental study employing a pre-experimental one-group pretest-posttest design. The participants were fourteen junior male athletes aged 15 to 17 years. The training program was conducted three times a week for six weeks and included eight different exercises. The instruments used were table tennis reactive agility measuring devices and the beep test for assessing aerobic endurance. Data were analyzed using the paired sample T-test.

Results: The results of the data normality test showed a significance value (Sig.) greater than 0.05, indicating that the data were normally distributed and suitable for further analysis. Subsequent testing for the effectiveness of the exercise regimen using the paired sample T-test revealed significant improvements: reactive agility and aerobic endurance both achieved a p-value of 0.000.

Conclusions: The findings indicate that circuit training, involving eight types of exercises, significantly improved the athletes' reactive agility and aerobic capacity. Specifically, there was a notable average increase in both reactive agility and aerobic capacity following the training regimen. These results underscore the potential benefits of employing the circuit training method with eight diverse exercises to enhance performance in table tennis athletes.

Keywords: reactive agility, aerobic, table tennis, circuit training

Introduction

In competitive table tennis, reactive agility and aerobic endurance are critical factors that can significantly influence a player's performance. Despite their importance, traditional training methods often overlook the integration of these elements, limiting the potential for optimal athletic development. This gap highlights the need for innovative training strategies that effectively combine agility and endurance training to meet the demands of high-level competition.

Table tennis is a sport that demands quick movements and rapid adjustments in position, requiring players to execute complex movements and techniques within very short time frames [1]. To enhance their performance, table tennis athletes must excel not only technically and psychologically, but also physically [2]. Physical prowess is paramount, with several key components impacting athlete performance during competitions, particularly reactive agility and aerobic endurance [3]. A frequent issue is that athletes often struggle with reacting to long balls, attributable to suboptimal agility and reaction times. Khairil et al. [4] noted that reactive agility is a synthesis of agility and reaction time, essential for addressing common challenges in table tennis, such as decision-making difficulties and swift movement while maintaining balance.

Reactive agility is a crucial parameter for table tennis performance [5]. This performance is characterized by rapid movements, frequent changes in direction, and the execution of complex maneuvers that are challenging to perform. Specifically, table tennis requires quick directional changes in response to stimuli [6]. The necessity for high-speed directional changes is further compounded by the relatively narrow playing field, measuring 274 cm in length and 152.5 cm in width, which contributes to the high bounce of the ball from any player's shot. Furthermore, players must quickly and accurately respond to their opponents' unexpected movements. Additionally, the sport demands the execution of fast and irregular strokes, requiring high levels of performance [7].

Aerobic endurance is also a critical component of table tennis [8]. It is defined as the ability of an athlete's body to resist fatigue during prolonged sports activities or work and to recover swiftly [9]. However, athletes often encounter fatigue during practice sessions, and during matches, especially in rubber sets, they begin to lose focus. This loss

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of focus is primarily due to inadequate endurance, which leads to rapid exhaustion and impaired concentration. Therefore, improving endurance based on the specific demands of table tennis is essential.

Previous research has demonstrated the effectiveness of the Circuit Training method in enhancing endurance capabilities [10, 11, 12]. Similar studies have focused on the application of the circuit method to improve the physical abilities of athletes in specific sports [13, 14]. Circuit training consists of a series of systematic exercises performed at various stations, each with a predetermined training dose and duration. These exercises are tailored to meet the individual needs of athletes and typically involve 5 to 8 stations [11, 15, 16].

However, existing problems related to agility and response time have hindered the optimization of training programs and the effectiveness of tests measuring reactive agility. Thus, it is crucial to find solutions to enhance reactive agility performance, which is a key indicator for improving table tennis performance [5]. Although some studies have focused on improving specific aspects of performance necessary for table tennis, few have addressed the combined impact of multiple performance factors. For example, some research has tailored circuit training to improve aerobic capacity [12], while others have tested its effects on agility, anaerobic capacity, strength, and endurance [17, 18]. Many studies have explored the adjustments in physical activity programs through circuit training, specifically targeting agility, anaerobics, strength, and endurance. Overall, it can be concluded that circuit training is an exercise regimen consisting of a series of consecutive exercise stations designed to meet various physical demands.

Research Hypothesis: It is hypothesized that circuit training, involving eight types of exercises conducted three times a week for six weeks, can enhance the reactive agility and aerobic endurance of table tennis athletes, thereby improving their overall physical capabilities.

The purpose of this study is to examine the effects of the circuit training method on the reactive agility and aerobic capacity in table tennis performance.

Materials and Methods

Participants

The study included 14 junior male athletes aged 15-17 years, conducted in Yogyakarta, Indonesia. Data collection involved measurement tests using specific instruments. The reactive agility of the athletes was assessed using a table tennis reactive agility measuring instrument, which has a content validity of greater than 0.76 [19]. Aerobic endurance was measured using the Multistage Fitness Test, an instrument commonly utilized across various sports [20].

Research Design

This study utilized a pre-experimental design, specifically a One-Group Pretest-Posttest Design. Initially, participants underwent a pre-test before any intervention. Following this, they engaged in a six-week circuit-based training program designed to enhance both reactive agility and aerobic endurance. The efficacy of the treatment was assessed by comparing the post-test results with the pre-test results, allowing for an evaluation of improvements.

Protocol Design

The experimental protocol called for the group to train three times a week (on Tuesdays, Thursdays, and Fridays) over a six-week period. Each training session began with a warm-up, followed by a core workout comprising eight circuit training stations. Participants spent 15 seconds on each exercise with a 30-second rest period between exercises and a 180-second rest interval between sets. Each session concluded with a cooldown. The regimen was consistently applied throughout the study period to ensure systematic exposure to the exercises. Table 1 presents a detailed breakdown of the training protocol and session components used in the study.

Table 1 outlines the progressive training schedule implemented over a six-week period, detailing the exercises performed in each of the 18 sessions. The first two weeks involved three sets of eight exercises, including reactive ball, reactive and jump, sit-ups, shadow and sidestep, reactive step, push-ups, jump and sidestep, and reactive shadow, each for 15 seconds with a 30-second rest between repetitions and a longer 180-second rest between circuits. The frequency of the sessions was consistent at three times per week with a medium intensity level. As the program advanced into weeks 3 to 4, and then 5 to 6, the structure remained the same, but the number of sets increased to four in the final phase to further challenge the athletes and enhance their physical capabilities.

Statistical Analysis

The statistical analysis in this study utilized the Shapiro-Wilk test to assess the normality of the data. To compare the mean differences between two variables within the sample group, a paired sample t-test was employed. This test specifically calculated the differences between the paired variables for each case [21]. Additionally, it was used to determine whether significant differences exist in the variables of the test group before and after the intervention. A difference was considered statistically significant if the p-value was less than 0.05 ($p < 0.05$), as analyzed using the SPSS 25 software at a significance level of 5%.

Results

The effectiveness of the circuit training program was analyzed using a paired sample t-test. The

Table 1. Circuit Exercise Program

Week	Meeting	Activity Type		Frequency Training
1-2	1-6	1	Reactive ball	Frequency: 3 Intensity: Medium Set: 3 Time on: 15 second Rest reps: 30 seconds Rest between circuits 180 second
		2	Reactive and jump	
		3	Sit-ups	
		4	Shadow and sidestep	
		5	Reactive step	
		6	Push-ups	
		7	Jump and sidestep	
		8	Reactive shadow	
3-4	7-12	1	Reactive ball	Frequency: 3 Intensity: Medium Set: 3 Time on: 15 second Rest reps: 30 seconds Rest between circuits 180 second
		2	Reactive and jump	
		3	Sit-ups	
		4	Shadow and sidestep	
		5	Reactive step	
		6	Push-ups	
		7	Jump and sidestep	
		8	Reactive shadow	
5-6	13-18	1	Reactive ball	Frequency: 3 Intensity: Medium Set: 4 Time on: 15 second Rest reps: 30 seconds Rest between circuits 180 second
		2	Reactive and jump	
		3	Sit-ups	
		4	Shadow and sidestep	
		5	Reactive step	
		6	Push-ups	
		7	Jump and sidestep	
		8	Reactive shadow	

mean scores for reactive agility (RA) and aerobic endurance were recorded before and after the intervention (fig. 1).

Table 2 provides a detailed overview of the normality test results for reactive agility and aerobic endurance at both pre-test and post-test stages.

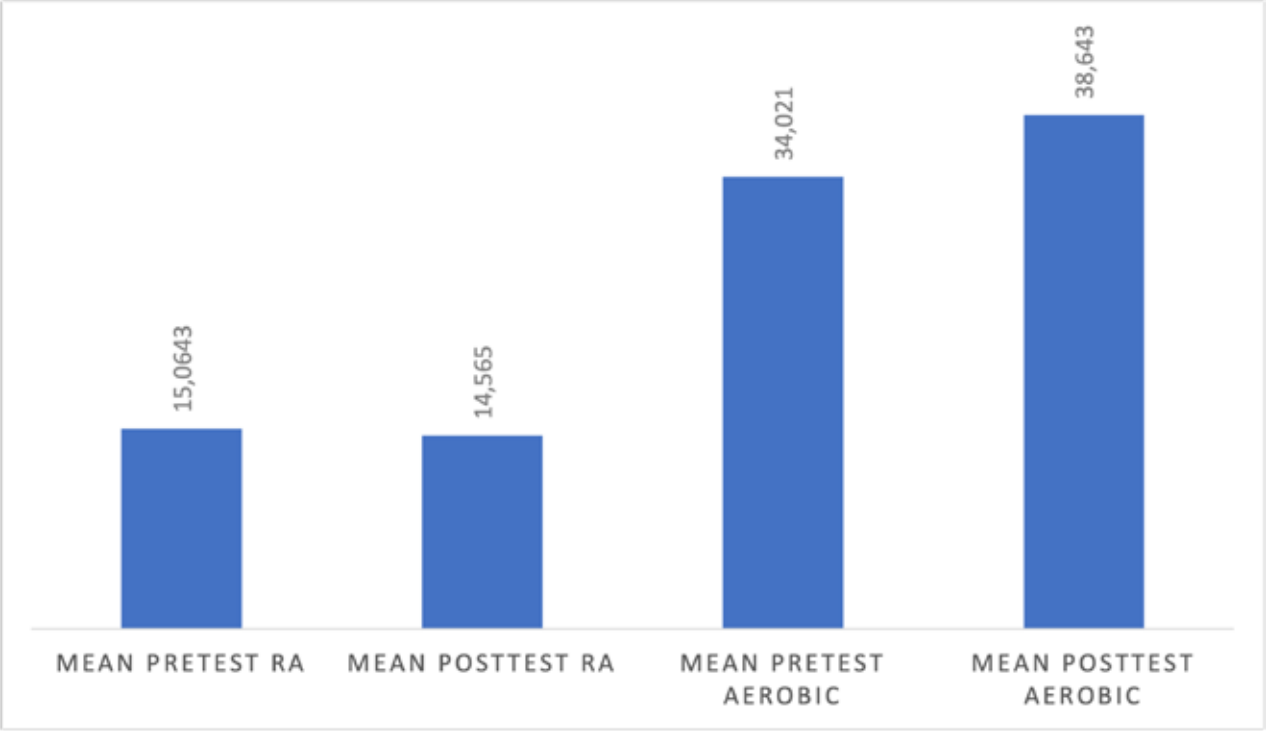
Following the table 2, the normality test results indicate that the Sig. Values for both reactive agility and aerobic endurance in the pre-tests and post-tests are greater than 0.05, suggesting that the data are normally distributed. As a result, proceeding with the paired sample t-test to evaluate the effects of the circuit training program was deemed appropriate.

Table 3 presents the paired sample test results for reactive agility and aerobic endurance, showing significant changes before and after the circuit training program.

Following the data presented in Table 3, the hypothesis tests were conducted using t-test analysis. The significant values obtained (Sig. 0.000) for both the reactive agility and aerobic endurance tests suggest significant improvements. These results indicate that the average scores for reactive agility and aerobic endurance of the junior male table tennis athletes were significantly different after undergoing the circuit training program compared to before it commenced. This demonstrates a notable improvement in their physical capabilities.

Discussion

The primary aim of this study was to determine the effects of circuit training on the reactive agility and aerobic abilities of junior table tennis athletes. The results indicated significant improvements in both reactive agility and aerobic abilities, with statistical significance observed ($p < 0.05$), before and after the implementation of the exercise regimen. These findings are consistent with previous research, underscoring the efficacy of circuit training in enhancing physical fitness. For instance, Umar [22] reported that circuit training for



MEAN PRETEST RA – average reactive agility score before the training.
MEAN POSTTEST RA – average reactive agility score after the training.
MEAN PRETEST AEROBIC – average aerobic endurance score before the training.
MEAN POSTTEST AEROBIC – average aerobic endurance score after the training.

Figure 1. Descriptive Data

Table 2. Reactive Agility Normality Test Results and Aerobic Test

Group	Variable	n	Sig	Information
Pre-test	Reactive agility	14	0.392	Usual
Pre-test	Aerobic	14	0.218	Usual
Post-test	Reactive agility	14	0.135	Usual
Post-test	Aerobic	14	0.923	Usual

Table 3. Paired Sample Test Results of Reactive Agility and Aerobic Tests

Variable		Mean	Std. Deviation	Sig.
Pair 1	Pretest Reactive Agility	15.06	0.39591	0.000
	Posttest Reactive Agility	14.56		
Pair 2	Pretest Aerobic	34.26	2.40166	0.000
	Posttest Aerobic	38.64		

four to six weeks can significantly improve physical abilities. Similarly, Bhat [23] noted substantial enhancements in athletes' agility following circuit training. Furthermore, Sonchan [11] conducted an eight-week circuit training program, involving three sessions per week with eight stations, which also demonstrated notable improvements in both agility and aerobic performance of athletes.

Specifically, the findings of this study focus on enhancing both the reactive agility and aerobic abilities of table tennis athletes, which distinguishes this research from previous studies that primarily address general agility improvements [23]. The innovative aspect of this study lies in the use of an eight-station circuit training model, which specifically targets reactive agility training. This approach not only improves reactive agility but also significantly enhances the aerobic capacity of the athletes.

Reactive agility is defined as the ability of an athlete to quickly respond to stimuli and change direction without losing balance [24]. This capability is crucial for table tennis athletes, enabling them to effectively respond to opponent's shots and execute their own strikes. In practical terms, athletes must maintain continuous movement, manage fatigue,

and recover swiftly. These requirements underscore the importance of aerobic capacity, which not only supports sustained performance in practice and competition but also helps athletes improve their skills during training sessions. Consequently, aerobic ability is a dominant aspect that enables athletes to perform at their best without succumbing to fatigue.

Exercises designed to enhance reactive agility must incorporate components of agility, the speed of direction change, and stimulus-response mechanisms. This perspective is supported by Pojskic et al. [25], who highlight the importance of direction change when athletes react to external stimuli. Furthermore, aerobic abilities can be developed through various methods, including interval and circuit training [10]. Circuit training is particularly recommended across many sports due to its effectiveness in improving physical components [17, 26]. Additionally, the specificity of physical training in sports is crucial; research conducted by Latorre et al. and Tanyeri [27, 28] demonstrates the application of physical training that aligns the characteristics of specific sports with essential physical components like reactive agility and aerobic capacity. Therefore, tailoring training to the specific characteristics of table tennis, by integrating circuit training methods that combine both reactive agility and aerobic components, is crucial for enhancing athletes' performance.

The results of the circuit training program developed in this study have successfully enhanced the reactive agility and aerobic capacity of table tennis athletes. These findings provide valuable guidance for coaches and athletes, particularly in table tennis, by demonstrating the effectiveness of circuit training methods. Such methods, which incorporate intervals of activity and rest focused on reactive agility and sustained aerobic exercise, can significantly improve performance in these areas.

A limitation of this study is its exclusive focus on male junior athletes. Future research should aim to diversify the participant pool to include different age groups and female athletes, thereby broadening the applicability and generalizability of the training methods evaluated. Additionally, exploring the impact of these methods on athletes from various sports could provide valuable insights into their effectiveness across different athletic disciplines.

Conclusions

The conclusion of this study is that training using the circuit method significantly improves reactive agility and aerobic abilities, as evidenced by a p-value of less than 0.05. These findings suggest that coaches may consider incorporating circuit training into their programs to enhance the reactive agility and aerobic capabilities of table tennis athletes, thereby achieving more effective training outcomes. Additionally, this research provides a foundation for future studies, encouraging researchers to extend these findings by exploring diverse populations and samples.

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Information about the authors:

Hary Widodo; https://orcid.org/0009-0006-5146-1861; harywidodo@uny.ac.id; Faculty of Sport and Health Sciences, Yogyakarta State University; Sleman, Indonesia.

Tomoliyus; (Corresponding author); https://orcid.org/0000-0002-8598-404X; tomoliyus@uny.ac.id; Faculty of Sport and Health Sciences, Yogyakarta State University; Sleman, Indonesia.

Abdul Alim; https://orcid.org/0000-0003-2861-4437; abdulalim@uny.ac.id; Faculty of Sport and Health Sciences, Yogyakarta State University; Sleman, Indonesia.

Muhammad K. Ansori; https://orcid.org/0009-0002-6640-879X; muhkhafid.2023@student.uny.ac.id; Faculty of Sport and Health Sciences, Yogyakarta State University; Sleman, Indonesia.

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