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CIRCUIT TRAINING MODEL: EFFECTIVENESS IN IMPROVING CARDIOVASCULAR FITNESS OF ELEMENTARY SCHOOL STUDENTS

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Abstract

Cardiovascular fitness is an important component of physical fitness that supports health and physical activity performance among elementary school students. However, routine physical activity in physical education classes does not always provide a structured and progressive training stimulus to improve cardiorespiratory capacity. This study aimed to examine the effectiveness of a circuit training model in improving cardiovascular fitness among elementary school students. A quasi-experimental pretest–posttest control group design was employed. Sixty fifth-grade elementary school students aged 10–11 years participated in the study and were assigned to an experimental group (n = 30) and a control group (n = 30). The experimental group participated in a 12-week circuit training program conducted three times per week, whereas the control group continued regular school-based physical activities. Cardiovascular fitness was assessed before and after the intervention using the 20-m multistage shuttle run test, also known as the Multistage Fitness Test (MFT). Data were analyzed using descriptive statistics and a mixed-design analysis of variance with a significance level of $\alpha = 0.05$. The results showed that the experimental group achieved a greater improvement in MFT performance than the control group. A significant time-by-group interaction was observed ($p < 0.001$), with the effect size indicating a practically meaningful impact of the intervention on cardiovascular fitness. These findings indicate that a 12-week structured circuit training program is effective in improving cardiovascular fitness among elementary school students and may serve as a practical and progressive alternative for physical education programs in school settings.

Keywords: Circuit Training, Cardiovascular Fitness, Elementary School Students, Multistage Fitness Test, School-Based Intervention

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INTRODUCTION

Circuit training is a training method that combines several forms of exercise in a number of positions that are carried out sequentially with predetermined work durations and rest periods. Another study of a 12-week circuit training program in elementary school students also showed that structured circuit training can provide benefits to components of physical fitness, particularly muscular endurance (Stojanovi´c et al., 2023) ; (Sukron & Firjatulloh, 2025). Circuit training allows for the simultaneous development of cardiorespiratory capacity, muscular strength, muscular endurance, coordination, agility, balance, and motor skills (Wu et al., 2023). The circuit training program must apply the principles of progressive overload, individualization, variation, and long-term athletic development

(LTAD) to be able to improve cardiovascular fitness safely and effectively (Lloyd et al., 2012). Manipulative activities, such as throwing, catching, dribbling, or carrying light objects, help develop eye-hand coordination, object control, and motor skills needed in a variety of sports (Logan et al., 2011). In addition to integrating fundamental movement skills, circuit training also combines several components of physical fitness into a single training session. These components include aerobic exercise, strength training, muscular endurance training, agility training, and coordination training.

A healthy cardiovascular system plays a central role in providing oxygen and nutrients throughout the body, as well as optimizing the heart's function as the main pump (Aziz & Awaluddin, 2024) ; (Seo et al., 2019). Cardiovascular fitness is a physical component that plays a crucial role in every body movement (Simanjuntak & Abady, 2022) ; (Ortega et al., 2008). Cardiovascular fitness is an important indicator in maintaining body health, particularly in preventing various heart and blood vessel diseases (Hanipah et al., 2025) ; (Lavie et al., 2015). Cardiovascular fitness is a benchmark of physical fitness, which is an important component in supporting health (Sagita et al., 2023) ; (Ross et al., 2016). Regular exercise improves cardiovascular efficiency, lung capacity, and muscle metabolism, thereby improving endurance performance over time (Kholis et al., 2025). For a student, cardiovascular fitness is very important for carrying out their academic activities. Without a fit cardiovascular system, a student will be susceptible to various diseases, and vice versa (Mukminin & Wisnu, 2017). In addition to its relationship to physical capacity, cardiovascular fitness in childhood is also associated with metabolic health, body composition, cognitive function, and the risk of cardiometabolic disease later in life (WHO, 2020); (Wu et al., 2023). Improving and maintaining cardiovascular fitness needs to be instilled from an early age, because physical fitness plays a crucial role in improving children's quality of life, growth, and development (Priadana & Suwandi, 2023). Cardiovascular fitness for elementary school students is very helpful in carrying out daily activities such as walking every day, thus forming strong body organs.

The WHO recommends that children and adolescents aged 5-17 years engage in at least 60 minutes of moderate-to-vigorous physical activity per day, with regular inclusion of high-intensity activities and muscle and bone strengthening activities (WHO, 2020). However, meeting these physical activity recommendations remains a challenge, necessitating effective, structured, engaging, and applicable exercise models in school contexts. School-based physical activity interventions have demonstrated significant potential for improving the physical fitness of children and adolescents. A meta-analysis by (Wu et al., 2023) of 66 studies involving 8,578 participants showed that various forms of school-based exercise interventions positively impacted several components of physical fitness, including cardiorespiratory fitness. These findings suggest that the school environment is an effective setting for implementing exercise programs aimed at improving students' physical capacity. However, the effectiveness of a program is strongly influenced by the type of exercise, intensity, frequency, duration, and the program's ability to actively engage students. Therefore, effective and efficient exercise models are needed for implementation in the school environment.

One training model that has the potential to be applied in physical education (PJOK) learning is circuit training. The circuit training model allows for the simultaneous engagement of various muscle groups and energy systems, thereby improving overall physical fitness. The circuit training model consists of several exercise sessions performed sequentially with predetermined work and rest periods. Theoretically, circuit training has the advantage of integrating multiple components of physical fitness into a single training program. This approach is relevant because WHO recommendations emphasize consistent daily activity in children and adolescents (WHO, 2020). In addition to health benefits, a systematic review in school-aged children also showed that physical activity does not negatively impact academic achievement and, in some cases, has positive associations, suggesting that school-based interventions have the potential to provide multiple benefits (James et al., 2023) ; (Sudirjo & Sudrazat, 2024). Furthermore, a systematic review and meta-analysis showed that school-based physical activity interventions generally have a positive impact on the physical fitness of children and adolescents, including cardiorespiratory capacity (Wu et al., 2023) ; (HL, 2022).

Although research on school-based physical activity interventions has been growing, research is still needed specifically to test the effectiveness of a 12-week structured circuit training model on the cardiovascular fitness of elementary school students, particularly using a quasi-experimental design involving an experimental group and a control group. This is important because not all school physical activity programs provide the same training stimulus. Routine school physical activity can provide health benefits, but a systematically designed exercise program with a specific setting of training pace, intensity, volume, and progression has the potential to produce more optimal cardiovascular adaptations.

Based on these issues, this study aims to analyze the effectiveness of a circuit training model in improving the cardiovascular fitness of elementary school students. This study used a pretest-posttest control group design to compare changes in cardiovascular fitness between students participating in a circuit training program and students participating in regular school physical activity. The novelty of this study lies in testing a systematically designed circuit training model implemented in an elementary school context over a 12-week intervention period, with cardiovascular fitness as the primary outcome measured using the Multi-Function Functional Training (MFT). The results are expected to provide empirical evidence for physical education teachers and schools in developing practical, structured, and evidence-based exercise programs to improve the cardiovascular fitness of elementary school students.

METHODS

This study employed a quantitative quasi-experimental design using a pretest–posttest control group design. Sixty fifth-grade elementary school students aged 10–11 years participated in the study and were assigned to an experimental group (n = 30) and a control group (n = 30). The experimental group participated in a structured circuit training program for 12 weeks, three sessions per week, whereas the control group continued with regular school physical activities. Participants were selected based on predefined inclusion criteria, including active enrollment in fifth grade, parental consent,

willingness to participate in all study procedures, and the absence of conditions limiting physical activity participation.

Cardiorespiratory fitness was assessed using the 20-m multistage shuttle-run test. The test was conducted on a 20-m marked course following standardized audio pacing. The final completed stage and number of completed shuttles were recorded as the primary performance outcomes. The same testing procedures were applied during the pretest and posttest. The 20-m shuttle-run test has been widely used in school-based fitness assessment, although the interpretation of predicted VO_2peak should be made cautiously because prediction accuracy may vary according to age, sex, body composition, and the equation used (Brito et al., 2022); (Aertssen et al., 2024).

The circuit training intervention consisted of a warm-up, main training phase, and cool-down. The main phase included multiple stations involving aerobic, muscular endurance, agility, coordination, and body-weight exercises. Each station was performed for 30-45 s with 15-30 s of recovery between stations. Training volume and intensity were progressively increased through manipulation of work duration, number of circuits, exercise complexity, and recovery intervals. Attendance and adherence to the intervention were monitored throughout the 12-week program.

Descriptive statistics were calculated for all study variables. Data normality was assessed using the Shapiro-Wilk test, while homogeneity of variance was examined using Levene's test. The primary intervention effect was analyzed using a mixed-design analysis of variance with time (pretest vs. posttest) as the within-subject factor and group (experimental vs. control) as the between-subject factor. The time × group interaction was considered the primary indicator of differential intervention effectiveness. Effect sizes were calculated using partial eta squared and standardized mean differences where appropriate. Statistical significance was set at $p < 0.05$, and 95% confidence intervals were reported where applicable.

RESULTS AND DISCUSSION

Results

1. Participant Characteristics

This study involved 60 fifth-grade elementary school students divided into an experimental group and a control group, each consisting of 30 students. All participants completed pretest and posttest measurements. The experimental group participated in a 12-week circuit training program, while the control group participated in regular school physical activity.

Table 1. Preparation Characteristics

Variables	Eksperimental (n = 30)	Control (n = 30)
Age (years)	10,63 ± 0,49	10,60 ± 0,50
Height (cm)	141,80 ± 6,12	142,10 ± 5,87
Weight (kg)	38,20 ± 7,10	39,10 ± 6,85
IMT (kg/m²)	18,90 ± 2,45	19,20 ± 2,38

Baseline characteristics data indicate that both groups had relatively comparable characteristics. Equivalence of baseline characteristics is important to reduce the possibility that differences in posttest results are solely due to differences in participants' baseline conditions. In school-based intervention studies, controlling for baseline conditions is crucial because age, gender, anthropometric status, and initial fitness level can influence response to exercise.

2. Changes in Cardiovascular Fitness

Cardiovascular fitness was measured using the Multistage Fitness Test (MFT). Descriptive analysis results showed improvements in MFT performance in both groups, but greater improvements were seen in the experimental group.

Table 2. Changes in MFT Scores Before and After the Intervention

Group	Pretest	Posttest	Δ Change	p
Eksperimental	4,82 ± 0,91	6,41 ± 1,02	1,59	<0,001
Control	4,76 ± 0,88	5,12 ± 0,94	0,36	0,041

Based on these results, the experimental group experienced a 1.59-level increase in MFT scores, while the control group only experienced a 0.36-level increase. These results indicate that the circuit training program provided greater improvements in cardiovascular fitness than routine school physical activity. The results of the mixed-design ANOVA analysis showed a significant interaction between measurement time and study group, $F(1,58) = 28.64$, $p < 0.001$, $\eta^2p = 0.33$. These findings indicate that changes in cardiovascular fitness from pretest to posttest differed significantly between the experimental and control groups. The effect sizes obtained indicate that the circuit training intervention had a significant practical impact on improving cardiovascular fitness performance.

3. Analysis of the Effectiveness of the Circuit Training Model

The main findings of the study indicate that the circuit training model is effective in improving the cardiovascular fitness of elementary school students. This improvement can be explained by the characteristics of circuit training, which combines several forms of physical activity within a series of exercises with regulated work and rest intervals. During the training program, students engage in activities involving locomotor movements, aerobic activity, bodyweight strength training, agility, and coordination. This combination creates an intermittent training stimulus and allows students to perform activities at relatively high intensities repeatedly. The resulting adaptations can include an increase in the body's ability to maintain physical activity, the efficiency of the cardiorespiratory system, and an increased tolerance for activities at increasing intensities.

The results of this study align with those of (Perdinanto et al., 2024), which showed that circuit training positively impacted the physical fitness of elementary school students and provided superior results compared to interval training methods in the context of that study. However, these

results should be interpreted with caution when compared with studies using other training models. A meta-analysis (Wu et al., 2023) of 66 studies and 8,578 participants showed that school-based exercise interventions were generally effective in improving physical fitness. For shuttle run performance, the overall intervention had a positive effect, although the specific effects of circuit training were not always significant in the network analysis. These findings suggest that the effectiveness of a program is determined not only by the label of the training method, but also by the training dose, intensity, duration, frequency, form of activity, and level of participant engagement.

Thus, the improvement in cardiovascular fitness in this study was likely due not only to the use of the circuit training model in general, but also to the structure of the training program applied, namely a training frequency of three times per week, an intervention duration of 12 weeks, the use of several training stations, the arrangement of work and rest intervals, and the application of the principle of progression.

4. Comparison with the Control Group

The control group also experienced a small increase in MFT scores. This increase could be due to the regular physical activity maintained during physical education (PEK) lessons, the students' natural growth and development, and the effects of learning or familiarization with the testing procedure. However, the increase in the control group was smaller than that of the experimental group. This difference suggests that regular school physical activity does not necessarily provide the same training stimulus as a systematically designed program. Circuit training programs allow for more structured regulation of volume, intensity, work time, rest periods, and progression.

These findings support the results of school-based intervention studies showing that improving the quality and structure of physical activity in the school environment can improve students' cardiorespiratory fitness. Large-scale studies of school-based physical education programs also show that improving the quality of physical activity implementation in schools can impact students' cardiorespiratory fitness.

5. Research Questions

Based on the analysis, the research question can be answered: the circuit training model is effective in improving the cardiovascular fitness of elementary school students. Students who participated in the 12-week circuit training program showed greater improvements in MFT performance compared to students who only participated in regular school physical activities. Therefore, the research hypothesis stating that there is a difference in cardiovascular fitness improvement between students who participated in the circuit training model and those who participated in regular school physical activities is accepted.

Discussion

The main findings of this study indicate that the circuit training model resulted in greater improvements in cardiovascular fitness compared to regular Physical Education, Sports, and Health (PJOK) activities. This difference can be explained by the characteristics of circuit training, which is designed based on training principles, specifically overload, progression, specificity, variation, and individualization, which allow for more optimal physiological adaptations compared to routine school physical activity (Lloyd et al., 2012)

From an exercise physiology perspective, the improvement in cardiovascular fitness in the circuit training group occurred because participants received a more consistent and measurable aerobic stimulus during the intervention. Each training station was structured with a predetermined work duration, rest period, intensity, and number of rounds so that participants' heart rates could be maintained in a sufficient training zone to stimulate cardiorespiratory adaptations. Repeated physical activity at moderate to high intensity increases stroke volume, cardiac output, oxygen transport efficiency, and skeletal muscle oxygen utilization capacity. These adaptations ultimately improve aerobic capacity, reflected in improved performance on the Multistage Fitness Test (MFT) (WHO, 2020).

In contrast, regular physical education (PJOK) activities are generally more oriented toward achieving curriculum learning objectives, such as mastery of sports skills, games, and recreational activities. Although these activities still involve physical movement, exercise intensity often fluctuates due to time spent explaining material, teacher demonstrations, forming groups, changing activities, and waiting in line to use facilities. As a result, the time spent on moderate-to-vigorous physical activity (MVPA) is shorter than in training programs specifically designed to improve cardiorespiratory fitness. This condition results in the physiological stimulus received by the cardiovascular system not reaching the optimal training dose to produce significant aerobic adaptations (WHO, 2020) ; (Wu et al., 2023).

Another factor explaining the effectiveness of the circuit training model is the application of the principle of progressive overload. In this study, the training load was gradually increased by increasing the duration of work, the number of stations, the complexity of the movements, and the arrangement of work and rest intervals. According to training adaptation theory, systematically increasing the load allows the body to continuously receive new stimuli, thus sustaining the physiological adaptation process. Without progression, the body will reach an adaptation phase (training plateau), thus limiting fitness gains (Lloyd et al., 2012). In contrast, regular physical education (PJOK) activities are generally not designed with a measurable principle of progression because the primary focus is on achieving learning competencies, not increasing physiological capacity.

In addition to physiological aspects, the effectiveness of circuit training is also influenced by the combination of multicomponent activities implemented during the intervention. The training model used integrates aerobic activity, bodyweight strength training, coordination, agility, balance, and fundamental movement skills into a single set of exercises. This combination of activities results in

simultaneous stimulation of the cardiorespiratory and neuromuscular systems, thereby increasing movement efficiency simultaneously with increased aerobic capacity. According to the Youth Physical Development Model, elementary school-aged children benefit more from exercises that develop multiple components of fitness in an integrated manner than from exercises that focus solely on a single physical ability (Lloyd et al., 2012). A meta-analysis by (Wu et al., 2023) also showed that school-based interventions that combine various forms of physical activity have a greater impact on fitness improvement than single-use programs.

Another advantage of the circuit training model is the high level of active learning time during the lesson. At each station, all students engage in activities simultaneously, minimizing inactive time due to waiting for their turn. In contrast, in regular physical education (PJOK) lessons, part of the time is often spent explaining material, organizing the class, or waiting for their turn to use equipment, resulting in a lower proportion of moderate- to high-intensity physical activity. From a sports pedagogy perspective, increasing active learning time is a contributing factor to fitness improvement because it increases the accumulated training load received by students during a single learning session (Fairclough & Stratton, 2005).

Another possible explanation for the results of this study is the high level of student motivation and engagement during circuit training. The variety of activities at each station, the transitions between stations, and the gradually increasing challenges created a more engaging learning environment compared to monotonous activities. Based on Self-Determination Theory, the variety of activities and experiences of success during training can increase intrinsic motivation, feelings of competence, and active participation. High student engagement will increase exercise adherence, resulting in greater accumulation of training stimuli and an impact on cardiovascular fitness (Ryan & Deci, 2020).

These research findings are consistent with those of (Stojanovi´c et al., 2023), who reported that a 12-week school-based circuit training program significantly improved physical fitness components compared to conventional physical education instruction. Similarly, a meta-analysis by (Wu et al., 2023) concluded that structured school-based physical activity interventions have positive effects on the physical fitness of children and adolescents, particularly when the program incorporates the principles of progression, activity variation, and adequate exercise intensity. Thus, the results of this study strengthen the evidence that the success of improving cardiovascular fitness is determined not only by the amount of physical activity performed, but also by the quality of the exercise program design, including the structure of the exercises, the dosage, the progression, and the characteristics of the activities provided.

Practically, the results of this study indicate that the circuit training model can be an effective alternative to improve the quality of Physical Education (PJOK) learning in elementary schools. Compared to regular PJOK activities, which are more oriented towards achieving learning competencies, circuit training provides a more measurable physiological stimulus, increases students' active time, and is more easily modified to suit the students' developmental level. Therefore, integrating

the circuit training model into the PJOK curriculum has the potential to be an evidence-based strategy for improving cardiovascular fitness while supporting the achievement of health-oriented physical education goals.

CONCLUSION

This study demonstrates the effectiveness of the circuit training model in improving the cardiovascular fitness of elementary school students. Students participating in a 12-week circuit training program experienced greater improvements in Multistage Fitness Test (MFT) performance compared to students who only participated in regular school physical activity. The analysis revealed differences in cardiovascular fitness between the experimental and control groups, indicating that circuit training positively contributed to improving students' cardiorespiratory capacity. The effectiveness of the circuit training model in this study was related to the structured program characteristics, including training frequency, duration, work and rest intervals, activity variation, and the application of the principle of progression. The combination of aerobic activity, endurance training, agility, coordination, and bodyweight exercises provided repeated and continuous physical stimulation, thereby improving students' ability to maintain physical activity at increasingly higher intensities.

Therefore, the circuit training model can be considered as an alternative, practical and structured training program for Physical Education (PJOK) teaching in elementary schools. Implementing this model has the potential to help PJOK teachers increase student engagement while simultaneously developing cardiovascular fitness through varied activities tailored to students' abilities. However, the results of this study need to be understood in the context of the sample characteristics and the intervention program used. Future research is recommended to involve a larger number of participants, schools with diverse characteristics, longer follow-up duration, and additional measures such as directly measured daily physical activity and aerobic capacity. Furthermore, evaluation of participant compliance, the quality of program implementation, and the sustainability of the intervention are important, as implementation aspects can influence the effectiveness of school-based physical activity programs.

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