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A Pilot Study on the Effects of Volleyball Specialised Physical Education on Cardiovascular Endurance in Female Middle School Students

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Abstract

The last few years have seen widespread concern regarding declining physical fitness in adolescents and cardiovascular endurance as an essential component of overall physical fitness. This research examined the effect of volleyball-specific Physical Education (SPE) on cardiovascular endurance in female middle school adolescents. Methodology: This research utilised a cluster randomised controlled trial (CRCT) approach. A cluster of 10 secondary school girls aged 13-15 years were given participation in the pre-test (baseline) and post-test measurements. The volleyball-SPE intervention was for two weeks. Cardiovascular endurance was evaluated before (baseline) and after the intervention, using spirometry and an 800m run as the primary assessment tools. Participants were randomly allocated to either the experimental group (EG) volleyball-SPE or the control group (CG) standard physical education (STPE).

Data were analysed using a generalised estimating equations (GEE) model to assess changes in cardiovascular endurance within and between the groups over time. The results of the GEE analysis indicated that the interaction effects between time and group were not statistically significant for either spirometry ($\chi^2 = 0.123$, $p = 0.726$) or the 800m run ($\chi^2 = 0.086$, $p = 0.770$). However, the main effects of time were statistically significant for both spirometry ($\chi^2 = 78.554$, $p < .001$) and the 800m run ($\chi^2 = 6.494$, $p = 0.011$), suggesting an overall improvement in cardiovascular endurance following the intervention. Although the EG improved after the intervention, the change trend was not significantly different from the CG's.

These results imply that while a brief volleyball-SPE intervention may yield specific enhancements in physical fitness, obtaining statistically meaningful differences between experimental and control groups may necessitate refinements in the length of the intervention and the intensity of the training. Despite the limitations, this current research offers initial empirically based information on the viability of incorporating brief volleyball-SPE lessons in middle schools with limited instructional time. Additionally, the outcome provides a theoretical rationale for developing systematic physical education programs to build cardiovascular endurance in middle school students.

Keywords: middle school students, cardiovascular endurance, female, volleyball specialised physical education

1. Introduction

World Health Organization reported in a published report that more than 80% of 11-17-year-old youth fall short of the minimum of at least 60 minutes of moderate-to-vigorous physical activity per day; the issue is particularly severe in female youth (Guthold et al., 2020). Decreased cardiovascular endurance in youth has become increasingly evident in recent years. In China, the trend has also been supported by the prevalence of youth sedentary lifestyles, resulting in a steady deterioration of the overall physical state (Huang et al., 2019; Ruan & Tang, 2024).

Since it is a sport that combines intermittent aerobic and anaerobic loads, volleyball can enhance cardiovascular function in students (Akarçeşme et al., 2022; Pacholek et al., 2021). An indicator of the metabolic health of

adolescents, cardiovascular endurance is a key indicator of the cardiovascular system's ability to supply oxygen to muscle tissue during long-term exercise (Åstrand, 1976; Blomqvist & Saltin, 1983). As a result of these problems, the Chinese government has initiated reforms in the physical education curriculum by promoting specialised physical education (SPE), to improve adolescents' overall physical fitness through the implementation of targeted and systematic training programmes (Gao et al., 2024; Wang, 2020; Zhu, 2020). During adolescence - a time of physical and psychological development essential to a lifetime of development—increasing cardiovascular fitness is considered a vital intervention for the prevention of premature chronic disease development and lifelong health (Hazen et al., 2008; Özdemir et al., 2016; Scott & Saginak, 2016).

Therefore, this study will develop and implement a pilot program of volleyball SPE within the framework of China's curriculum reform to examine its effect on cardiovascular endurance in middle school students.

2. Materials & Methods

2.1 Participants

This study involved 10 female middle school students from Sichuan Province, China. Five participants were allocated to the EG (volleyball-SPE) and five to the CG (STPE).

The inclusion criteria were as follows:

a) female students aged between 13 and 15 years;

b) no acute illness or physical injury that might affect performance during testing;

c) voluntary participation and the ability to complete all required assessments.

Exclusion criteria included:

a) a history of chronic organ disease;

b) current use of medication that could influence body composition or muscular function.

Ethical approval for the study was obtained from the Human Research Ethics Committee at Universiti Putra Malaysia (Reference No: JKEUPM-2023-1364). All participants were instructed to participate solely in the volleyball-SPE sessions and to refrain from additional physical training throughout the study. Repeated measurements were carried out following the two-week intervention period to assess the effectiveness and practicality of the intervention.

2.2 Characteristics of Participants

The study carried out basic anthropometric measurements on all subjects, including height and weight assessment. The detailed measurements are shown in Table 1. The subjects' height was measured using a tape measure in cm, and their weight was recorded using a calibrated electronic scale in kg.

Table 1. Descriptive statistics for EG and CG groups

Variables	EG	CG
Age	14(1)	14(1)
Height	160.90 ±4.50	161.84 ±3.10
Weight	49.52 ±3.87	49.14 ±2.90

2.3 Intervention Programmes

The volleyball-SPE programme implemented in this study was designed according to the latest research findings and structured systematically following the FITT principle (Frequency, Intensity, Time, and Type). A panel of physical education experts reviewed the intervention to ensure its suitability for lower middle school girls' physical and psychological development and its overall educational validity. The primary aim of the volleyball-SPE intervention was to enhance participants' cardiovascular endurance within a short, two-week training period.

i. **Warm-up Phase (10 minutes):** To prepare for the main session, participants engaged in dynamic stretching, breathing control exercises, and basic mobility drills. These included circular shoulders, knees, and hip movements to enhance flexibility, coordination, and bodily awareness.

ii. **Component of the Volleyball-SPE Programme (25 minutes):** This section constituted the central part of the volleyball-SPE course and focused on volleyball-specific technical training. The following activities

were included:

a) Footwork and Defensive Movement Drills: Exercises such as side and crossover steps were used to improve participants' agility, reaction speed, and ability to adjust positioning on the court.

b) Volleyball Dig Against the Wall and Passing Practice: Emphasis was placed on core stability and upper-body coordination, with multiple ball drills designed to enhance ball control.

c) Serving and Spiking Techniques: Medium-intensity practice was combined with basic tactical applications to develop power, explosiveness, and accuracy.

iii. **Cool-down (5 minutes):** The session concluded with stretching exercises targeting the shoulders, lower back, and legs, accompanied by deep breathing techniques to aid muscle recovery and relieve fatigue.

iv. **Frequency and Duration:** The volleyball-SPE intervention lasted two weeks, with four weekly sessions. Each session was 40 minutes long, ensuring sufficient and appropriate physical stimulation to achieve the intended educational outcomes.

2.4 Test Instrument

To assess the effects of the volleyball-SPE intervention on the cardiovascular endurance of female middle school students, this study employed standardised physical fitness field tests provided by the Ministry of Education of the People's Republic of China. The testing protocols and evaluation criteria were obtained from official government documentation (China, 2014). These national standards were selected because the research was conducted in China, making government-recommended assessments more contextually appropriate and culturally relevant. The cardiovascular endurance assessment concentrated on two primary indicators: spirometry to evaluate respiratory function and the 800-meter run.

2.5 Data Analysis

In this study, SPSS 26.0 software was used to process the experimental data statistically, and all statistical tests were two-sided tests, with the significance level set at $p < 0.05$. Firstly, the researcher organised and cleaned the data to exclude anomalies and missing data and ensure the data's completeness and consistency.

a) Data were collated and validated to ensure accuracy and consistency in the entry process, removing outliers and filling in missing items (Alili & Krstev, 2019; Zhu, 2016).

b) Means and standard deviations were calculated using descriptive statistics for spirometry and the 800m run.

c) A generalised estimating equation (GEE) model was used in the study to investigate the effect of the volleyball-SPE intervention on cardiovascular endurance indices. The model was able to handle repeated-measures data and control for intra-individual correlations effectively and was suitable for statistical analyses in the longitudinal design of this study (Shao et al., 2013; Laird, 2022). The independent variables included TIME, GROUP, and the interaction term between the two, TIME*GROUP, and the dependent variables were Spirometry and 800m run, independently (Cohen et al., 2013).

3. Results

3.1 Validity and Reliability

Based on the evaluation of each item using two dimensions - instrument validity and instrument reliability - six experts in physical education and sports science separately rated the validity-reliability value of the cardiovascular endurance assessment tools used in this study. A 4-point Likert scale was used, where 1 = "not relevant" and 4 = "highly relevant and appropriate" (Knebel et al., 2020).

The 800m run received perfect scores 4.00 for validity and reliability, indicating complete consensus among experts regarding its suitability for measuring cardiovascular endurance in adolescent populations. The spirometry test also received high ratings, with a validity score of 3.67 and a reliability score of 3.83. These results suggest that it was regarded as relevant and dependable for use in this context. Overall, the expert evaluations support including the 800m run and spirometry as valid and reliable measures of cardiovascular endurance within the volleyball-SPE intervention. A detailed summary of the evaluation results is provided in Tables 2 and 3.

Table 2. Results of expert's evaluation cardiovascular endurance on validity of measurements

Variables	Measurement Method	Validity of instrument
Cardiovascular Endurance	Spirometry	3.67
	800m run	4.00

Table 3. Results of expert's evaluation cardiovascular endurance on reliability of measurements

Variables	Measurement Method	Reliability Of Instrument
Cardiovascular Endurance	Spirometry	3.83
	800m run	4.00

Table 4 presents spirometry's marginal means, standard errors (Mean ± SE), and the 800m run for both the EG and CG before and after the intervention. Regarding spirometry, both groups showed a certain degree of improvement over time, initially indicating that the intervention may have positively affected spirometry.

Table 4. Descriptive statistics of' cardiovascular endurance

Variable	Groups	Pre-Test Mean ± SE	Post-Test Mean ± SE
Spirometry (ml)	EG	2160.8 ± 69.00	2287.6 ± 35.34
	CG	2196.6 ± 29.22	2350.0 ± 21.21
800m run (s)	EG	247.9 ± 5.28	243.32 ± 7.37
	CG	247.6 ± 5.34	242.44 ± 5.12

Note: EG = experimental group; CG = control group.

This study employed generalised estimating equations (GEE) to examine the effects of group and time on cardiovascular endurance indicators, namely spirometry (ml) and 800m run (s). The results indicated that the main effects of group and time on spirometry were not statistically significant (Wald χ^2 = 0.810, p = 0.368; Wald χ^2 = 78.554, p < .001), and the interaction effect between group and time on spirometry was also non-significant (Wald χ^2 = 0.123, p = 0.726).

Similarly, in the analysis of the 800m run, the main effect of time was statistically significant (Wald χ^2 = 6.494, p = 0.011), whereas the group effect was not (Wald χ^2 = 0.003, p = 0.954). The interaction effect between group and time was also non-significant (Wald χ^2 = 0.086, p = 0.770). Overall, group and time had no significant interaction effect on cardiovascular endurance levels across the different time points. Further details are presented in Table 5.

Table 5. Results of GEE on cardiovascular endurance

Variables	Source	Wald-Chi Square	df	P-value
Spirometry (ml)	Time	78.554	1	<.001
	Groups	0.810	1	0.368
	Time * Groups	0.123	1	0.726
800m Run (s)	Time	6.494	1	0.011
	Groups	0.003	1	0.954
	Time * Groups	0.086	1	0.770

Note: df = degree of freedom; * p < 0.05 is considered statistically significant.

Post hoc tests assessed within-group changes in spirometry and 800m run performance over time in the experimental and control groups (see Table 6). Significant improvements were observed in both variables from the pre-test to the post-test. Specifically, spirometry significantly increased in the EG (p = 0.003) and the control group (p = 0.001). Likewise, the 800m run times were significantly reduced in both groups, with p-values of 0.038 and 0.014, respectively. As all p-values were below the 0.05 threshold, these results indicate statistically meaningful within-group enhancements in cardiovascular endurance following the intervention.

Table 6. Within-group comparison of cardiovascular endurance for both EG and CG

Variables	Group	Time	Mean Difference	SE	P-value	95%CI	
						Lower	Upper
Spirometry (ml)	EG	Pre vs Post	126.80	42.028	0.003	44.427	209.173
	CG	Pre vs Post	153.400	40.076	0.001	74.853	231.947
800m run (s)	EG	Pre vs Post	-4.580	2.211	0.038	-8.913	-0.247
	CG	Pre vs Post	-5.160	2.093	0.014	-9.262	-1.058

Note: CG: Control group, EG: Experimental group, * Mean difference is significant at 0.05.

Between-group comparisons were conducted to determine whether significant differences existed between the experimental and control groups at the pre- and post-test stages (Table 7). In terms of spirometry, no statistically significant differences were found between the groups either at the pre-test ($p = 0.669$) or the post-test ($p = 0.142$), with confidence intervals ranging from -199.97 to 128.37 and -145.75 to 20.95, respectively.

Similarly, for the 800m run performance, the differences between the experimental and control groups were not statistically significant at either time point ($p = 0.976$ for the pre-test; $p = 0.934$ for the post-test). These findings suggest that, although within-group improvements were observed, the between-group effects of the intervention on cardiovascular endurance were not statistically significant.

Table 7. Between-group comparison at pre and post-test for cardiovascular endurance

Variables	Test	Group Comparison	Mean Difference	SE	P-value	95% CI	
						LB	UB
Spirometry (ml)	Pre-test	EG vs CG	-35.800	83.760	0.669	-199.966	128.366
	Post-test	EG vs CG	-62.400	42.528	0.142	-145.753	20.953
800m Run (s)	Pre-test	EG vs CG	0.300	9.882	0.976	-19.068	19.668
	Post-test	EG vs CG	0.880	10.612	0.934	-19.919	21.679

Note: CG: Control group, EG: Experimental group, LB: Lower bound, UB: Upper bound; *$p<0.05$ level of significance

4. Discussion

The findings of this study indicate that after a two-week volleyball-SPE intervention, the EG demonstrated positive changes in both spirometry and 800-metre run performance, which are key indicators of cardiovascular endurance. Within-group comparisons revealed significant improvements in spirometry and 800-metre run times for students in both the experimental and control groups, suggesting that structured physical education programmes, in general, contribute positively to the development of students' physical fitness. However, between-group comparisons did not yield statistically significant differences, implying that the short-term intervention did not produce a clear advantage in enhancing cardiovascular endurance among students.

The results of this study suggest that volleyball-SPE may be helpful for students' cardiovascular endurance improvement in the short term. Still, longer intervention time may result in more significant improvement in cardiovascular endurance indicators. According to existing research findings, male college students who participated in a volleyball physical education programme intervention, which was conducted over eight weeks at a frequency of two times per week, showed significant improvements in cardiovascular endurance (Mohammed, 2020). Meanwhile, another study of a semester-long volleyball physical education programme found that the EG of college students had significantly better cardiovascular endurance than the control group, demonstrating the positive effects of volleyball interventions in improving cardiovascular endurance (Yue & Hong, 2023). Although the duration of the intervention in this study was only 2 weeks, which may not have been enough to produce a statistically significant difference between the experimental and control groups, it is possible to find that a sustained volleyball intervention can help to improve cardiovascular endurance (Mohammed, 2020).

Therefore, from the results of this study, the failure of the EG to significantly outperform the CG in terms of Spirometry and 800m run performance may be related to the short intervention period of volleyball-SPE. Combined with previous research findings, studies with extended intervention periods may have more significant results (Mohammed, 2020; Yue & Hong, 2023). Although long-term intervention is more effective in enhancing cardiovascular endurance, this study provides preliminary empirical support for applying short-term volleyball-SPE in secondary school physical education teaching. It gives some empirical basis for future research.

5. Conclusion

This study provides new empirical evidence on the effectiveness of a volleyball-SPE programme in improving cardiovascular endurance among middle school students. The results indicated that both spirometry and 800-meter run performance exhibited statistically significant main effects of time, suggesting that the cardiovascular endurance levels of female middle school students improved throughout the intervention. This demonstrates the positive impact of the volleyball-SPE intervention on cardiovascular endurance. However, neither the main effect of the group nor the interaction effect between time and group reached statistical significance, indicating that although the short-term volleyball-SPE programme may help enhance cardiovascular endurance, the improvement observed in the experimental group was not significantly greater than that of the control group.

However, existing research suggests that lengthening the duration of the intervention and enhancing the training intensity may further boost the effectiveness of volleyball-SPE. This study serves as a preliminary reference for designing a volleyball-SPE programme.

6. Research Limitations

Although this study offers initial evidence supporting the potential of volleyball-SPE to improve cardiovascular endurance in female middle school students, it is subject to several limitations.

a) The duration of the volleyball-SPE intervention used in the current study was two weeks, possibly because the intervention was too short to improve cardiovascular endurance substantially. Therefore, in future studies, a longer intervention time could be used for volleyball-SPE, such as 6 weeks, 8 weeks or even 10 weeks, to know better that volleyball-SPE has the most significant intervention effect.

b) Only 10 subjects participated in this study, all of whom were female middle school students. This represents a small sample size, limiting the external validity of the findings to some degree. Factors such as gender, age, and environment can significantly influence the effectiveness of the volleyball-SPE intervention, particularly regarding physical fitness indicators like cardiovascular endurance. There are also differences in physiological foundations and athletic performance between male and female students. Consequently, using only female middle school students for the study may not adequately represent the overall impact of volleyball-SPE on the cardiovascular endurance of middle school students across different genders.

7. Recommendations for Future Research

Considering the limitations outlined in this study, future research in this area could from the following enhancements:

a) Short intervention time. The two-week timeframe used in this study may have been too short to ignificantachieve substantial improvements in cardiovascular endurance. Future research should consider adopting longer intervention durations, such as 6, 8, or even 10 weeks, to better capture the cumulative benefits of volleyball-specific physical education and allow for a more thorough evaluation of its long-term effectiveness.

b) Increasing sample size. Future studies should include more diverse participant groups, including students of varying ages, regions, and genders. Expanding the sample base will improve the representativeness and generalisability of the findings, thereby increasing the likelihood of detecting meaningful intervention effects and helping enhance sensitivity to detect potential intervention effects.

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The data that support the findings of this study are available on request from the corresponding author. The data are not publicly available due to privacy or ethical restrictions.

Data sharing statement

No additional data are available.