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Effect of high-impact aerobics gymnastics on physical fitness and body mass index: A quasi-experimental study

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ABSTRACT

Background: Physical inactivity among adolescents contributes to declining fitness and rising obesity rates. Although aerobic exercise has proven benefits, evidence on structured high-impact gymnastics for school-aged populations remains limited. **Objectives:** This study aims to examine the effect of high impact gymnastics exercises on physical fitness and body mass index in high school students. **Methods:** This study employed a quasi-experimental pretest–posttest control group design involving 40 purposively selected students assigned to a high-impact gymnastics group and a control group. Physical fitness was measured using the Tes Kebugaran Jasmani Indonesia (TKJI), and BMI was calculated from height and weight. Normality (Shapiro–Wilk) and homogeneity (Levene's test) assumptions were met ($p > 0.05$), allowing parametric analysis. Paired-samples t-tests were used to examine within-group changes, while independent-samples t-tests tested between-group differences ($\alpha = 0.05$). Effect sizes (Cohen's d) were calculated to determine the magnitude of the intervention effects. **Results:** The high-impact gymnastics group showed significant improvements in TKJI scores ($t = 7.892$, $p < 0.001$, $d = 1.52$) and reduction in BMI ($t = 3.210$, $p = 0.004$, $d = 0.72$), whereas the control group showed no meaningful changes. Posttest comparisons confirmed that the intervention group outperformed the control group in physical fitness ($t = 5.432$, $p < 0.001$, $d = 1.70$) and had significantly lower BMI ($t = 2.845$, $p = 0.007$, $d = 0.90$). These findings indicate that high-impact gymnastics effectively improves physical fitness and reduces BMI among high school students. **Conclusion:** High-impact gymnastics was found to significantly improve students' physical fitness (TKJI scores) and reduce BMI, demonstrating strong effectiveness as a school-based physical education strategy. This programme can support the development of an active lifestyle and contribute to early prevention of overweight and obesity among adolescents. However, the generalisability of the findings is limited by the sample size and quasi-experimental design. Future studies should involve larger and more diverse populations, longer intervention periods, and comparisons with alternative training models to strengthen evidence for broader implementation.

Keywords: Gymnastic exercises; high-impact activities; physical fitness; body mass index; high school students

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INTRODUCTION

Physical fitness in adolescence is an important aspect that supports health and productivity. Adolescence is a critical period in physical development, during which healthy living habits begin to form and can affect lifestyle in the future (Joisten et al., 2025; Morcel et al., 2024). However, many high school students experience a decline in physical activity due to increased academic demands, lifestyle changes, and prolonged screen exposure, which limits opportunities for regular exercise. This condition contributes to decreased physical fitness and unfavourable body composition among adolescents. Therefore, school-based physical activity interventions are needed to maintain and improve students' physical fitness and body composition.

Previous studies have shown that physical exercises such as plyometrics, basic exercise techniques, as well as modified exercise methods, are effective in improving students' motor skills and fitness (Andibowo et al., 2022; Budiyono & Hakim, 2021). For example, Budiyono et al. (2023) reported a significant improvement in service jumping ability in adolescent volleyball athletes after a plyometric exercise intervention. In addition, Budiyono and colleagues also emphasise the importance of structured exercise methods such as traditional skills (Budiyono & Kuncoro, 2021), and sports technique training (Budiyono et al., 2024), highlighting the role of planned and systematic training in enhancing adolescent physical fitness.

Various studies confirm that body mass index (BMI) is an important indicator when assessing health risks such as obesity, frailty, and mortality (Rios-Covian et al., 2020; Yuan, 2021). In adolescent populations, BMI is commonly used to monitor overweight and obesity associated with insufficient physical activity and low fitness levels. These findings reinforce the importance of regular physical exercise in schools to maintain an ideal BMI and support healthy growth during adolescence.

In a clinical context, BMI influences the immune response in cancer patients (Kichenadasse et al., 2020), and increases the risk of complications from SARS-CoV-2 infection (Gao et al., 2021; Hendren et al., 2021). From an economic perspective, a high BMI increases healthcare costs (Ward, 2021). These findings reinforce the importance of physical activity and a healthy lifestyle in maintaining an ideal BMI.

High-impact gymnastics is a high-intensity aerobic exercise that effectively improves fitness and muscle strength, but it can lead to injury if done excessively, particularly among young athletes (Ma et al., 2024; Weizhen & Zhou, 2023). In contrast to low-impact gymnastics, which is generally designed for older adults (Fatinabila, 2023; Mu, 2025; Nurafifah, 2021; Waluyo, 2023), high-impact gymnastics has greater potential to stimulate cardiovascular endurance and muscular strength in adolescents. Given the high interest in aerobic exercise among young people (Masruroh et al., 2022), high-impact gymnastics presents strong potential for development as a school-based physical education activity (Aziz, 2023).

This study differs from previous research in several key aspects. First, it specifically examines a high-impact gymnastics training programme designed for high school students in Indonesia and adapted to the school timetable. Second, the analysis focuses on physical fitness measured using standardised national tests (*Tes Kebugaran Jasmani Indonesia*/TKJI) and body mass index, allowing for a clear evaluation of physiological outcomes (Basterfield et al., 2024; Kafrawi et al., 2025; Nobre, 2024). Third, the study targets students with average or below-average fitness levels, a population that has received limited attention in previous intervention-based research. The integration of structured exercise with an educational approach further distinguishes this study from earlier work.

This study is urgent due to the declining physical fitness and increasing body composition imbalance in adolescents, which has a long-term impact on health and quality of life. Physical inactivity during childhood and adolescence has been associated with an increased risk of obesity, musculoskeletal disorders and chronic diseases in adulthood (Larsson et al., 2020; Quinn et al., 2024). Despite the growing number of sports-based intervention studies, limited research has examined structured high-intensity gymnastics programmes implemented directly within school settings, particularly using *Tes Kebugaran Jasmani Indonesia* (TKJI) as a national fitness indicator. Therefore, evidence-based and measurable school-based interventions are needed to address this gap.

The novelty of this study lies in the systematic design and implementation of an eight-week high-impact gymnastics programme integrated into high school physical education activities. Unlike previous studies that primarily investigated general aerobic exercise, this study employs objective indicators of physical fitness and

BMI to evaluate intervention effectiveness, supporting the formation of healthy lifestyle behaviours during adolescence (Han et al., 2021; Ding, 2023).

A practical challenge in Indonesia is the lack of empirically tested high-intensity exercise models that are feasible for implementation in schools. Previous research has demonstrated that high-intensity exercise can improve physical fitness, muscle strength, bone health, and metabolic function (Albano, 2021; Feng, 2023). However, few studies have applied such models in a structured, time-bound school programme. Therefore, this study aimed to determine the effect of an eight-week high-impact gymnastics programme on physical fitness and BMI among high school students, with the hypothesis that the intervention group would show significantly greater improvements than the control group.

METHOD

Type of Research

This study employed a quasi-experimental design with a pretest–posttest control group to evaluate the effects of high-impact gymnastics exercises on students' physical fitness and body mass index. Quasi-experimental designs are commonly used in school-based intervention studies where random assignment is not feasible (Achen, 2023; Wu et al., 2021). Participants were divided into an experimental group receiving the high-impact gymnastics intervention and a control group following regular physical education activities.

Participants

The participants were 40 high school students in Surakarta aged 16-18 years who were active members of the school gymnastics programme. Purposive sampling was used with the following inclusion criteria: (1) good physical condition, (2) regular participation in school gymnastics activities for at least six months, and (3) willingness to participate and provide informed consent.

Exclusion criteria included musculoskeletal injuries, chronic illness, or participation in other structured exercise programmes during the study period. Participants were randomly assigned to the experimental group (n = 20) or the control group (n = 20). Informed consent was obtained from students and their parents/guardians. Ethical approval was granted by the institutional review board.

Instrument

To ensure comprehensive and accurate measurement of the study variables, a set of standardized and validated instruments was employed. These instruments were selected to assess key components of physical fitness and anthropometric characteristics relevant to the participants' performance. The details of the instruments used in this study are presented in **Table 1**.

Table 1. Research Instruments

Measured aspects	Instrument/test:	Description:
Physical fitness:	Indonesian Physical Fitness Test (TKJI):	This is used to measure students' physical fitness.
Run 50 metres	Sprint 50 metres	Speed
Sit-ups in 60 seconds	Number of sit-ups in 60 seconds	Abdominal muscle strength
Push-ups in 60 seconds	Number of push-ups in 60 seconds	Measuring arm and chest muscle strength
Shuttle run	Run back and forth between two lines	Agility
Body Mass Index (BMI)	Measurement of height and weight	Weight status is measured based on height
Height:	Stadium (m)	Measured in metres
Weight loss	Digital scales (kg)	Measured in kilograms
BMI calculation	Formula: BMI = weight (kg)/(height (m))^2	Results indicate underweight, normal weight, overweight or obese categories according to the standard

Physical fitness was measured using the *Tes Kesegaran Jasmani Indonesia* (TKJI), a validated and widely used Indonesian physical fitness test for adolescents (Prayoga & Nurrochmah, 2024). TKJI consists of five components: (i) 50-m sprint (speed), (ii) Sit-ups (60 s) (abdominal strength), (iii) Push-ups (60 s) (upper body strength), (iv) Shuttle run (agility), (v) 800-1000 m run (cardiorespiratory endurance). BMI was calculated

using standard procedures based on height (measured with a stadiometer; accuracy 0.1 cm) and body weight (digital scale; accuracy 0.1 kg) using the formula BMI = weight (kg)/height² (m) (Li & Tuerdi, 2024). Both instruments were administered consistently during pretest and posttest measurements.

Procedures

The study was conducted over an eight-week period and consisted of three main phases: (i) pretest assessment, (ii) intervention, and (iii) posttest assessment. Participants in the experimental group completed a structured high-impact gymnastics programme three times per week, with each session lasting 45 minutes. Each session followed a standardized format comprising a warm-up phase (10 minutes) involving dynamic stretching and mobility exercises, a core training phase (30 minutes) consisting of high-intensity movements such as jumps, rolls, squat thrusts, planks, push-ups, and combined aerobic–anaerobic activities, and a cool-down phase (5 minutes) including static stretching and breathing exercises.

Exercise intensity was maintained at 70–85% of maximum heart rate (HRmax), corresponding to a rating of perceived exertion (RPE) of 13–15 on the Borg scale. Heart rate and perceived exertion were monitored during each session to ensure adherence to the prescribed intensity. Training load was progressively increased every two weeks by adjusting the number of repetitions, extending set duration, and increasing task complexity. All training sessions were supervised by a certified gymnastics instructor to ensure safety and proper technique execution. Meanwhile, the control group continued their regular school activities without additional structured exercise. To provide a clear overview of the intervention protocol and ensure transparency in training implementation, the detailed structure of the high-impact gymnastics programme is presented in **Table 2**.

Table 2. High Impact Gymnastics Intervention Program

Component	Description
Frequency	Three sessions per week, 45 minutes per session
Session Structure	Warm-up (10 min): dynamic stretching and mobility drills. Core activities (30 min): high-impact movements (jumps, rolls, squat thrusts, planks, push-ups, aerobic–anaerobic combinations). Cool-down (5 min): static stretching and breathing exercises
Exercise Intensity	Target intensity set at 70–85% HRmax or RPE 13–15 (Borg scale)
Intensity Monitoring	Heart rate and RPE monitored during every session
Progression	Training load increased every two weeks by adding repetitions, extending set duration, or increasing task complexity
Supervision	All sessions supervised by a certified gymnastics instructor to ensure proper technique and safety
Safety Measures	Participants performed pre-session health checks, used protective mats, and were instructed to stop training if discomfort or pain occurred

Data analysis

All statistical analyses were performed using SPSS version 29. Normality (Shapiro–Wilk) and homogeneity (Levene's test) assumptions were verified prior to parametric testing. Within-group differences were examined using paired-samples t-tests, while between-group differences were analysed using independent-samples t-tests at $\alpha = 0.05$. Effect sizes were calculated using Cohen's d to determine the magnitude of the intervention effects.

RESULTS AND DISCUSSION

Results

Assumption Testing

Assumption checks were conducted prior to hypothesis testing. The Shapiro–Wilk test indicated that all variables were normally distributed ($p > 0.05$), and Levene's test confirmed homogeneity of variances across groups ($p > 0.05$). As both assumptions were met, parametric analyses using paired-sample and independent-sample t-tests were performed.

Physical Fitness Outcomes

The experimental group showed clear improvements across all TKJI components following the high-impact gymnastics intervention. Sprint performance improved, with 50-m sprint times decreasing from 9.1 ± 0.5 s to 8.2 ± 0.4 s. Muscular endurance also increased substantially, indicated by higher sit-up repetitions (from 23.5 ± 3.0 to 30.2 ± 2.8) and push-up repetitions (from 20.4 ± 2.5 to 26.8 ± 2.9). Similarly, agility improved, as shown by faster shuttle-run times, and cardio respiratory endurance increased, with long-distance running performance improving from 6.8 ± 0.6 min to 5.9 ± 0.5 min. By contrast, the control group showed only minimal or negligible changes across all components. Detailed pre–post values for each TKJI component are presented in **Table 3**.

Table 3. Physical Fitness (TKJI) Components: Pretest and Posttest

Component	Group	Pretest (Mean ± SD)	Posttest (Mean ± SD)
50-m sprint (s)	Experimental	9.1 ± 0.5	8.2 ± 0.4
	Control	9.0 ± 0.6	8.9 ± 0.5
Sit-up repetitions (n)	Experimental	23.5 ± 3.0	30.2 ± 2.8
	Control	23.8 ± 2.9	24.1 ± 2.7
Push-up repetitions (n)	Experimental	20.4 ± 2.5	26.8 ± 2.9
	Control	20.2 ± 2.7	20.7 ± 2.6
Shuttle run (s)	Experimental	18.2 ± 1.1	16.5 ± 1.0
	Control	18.0 ± 1.2	17.9 ± 1.1
800-m run (min)	Experimental	6.8 ± 0.6	5.9 ± 0.5
	Control	6.7 ± 0.5	6.6 ± 0.5

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Component	Group	Pretest (Mean ± SD)	Posttest (Mean ± SD)
50-m sprint (s)	Experimental	9.1 ± 0.5	8.2 ± 0.4
	Control	9.0 ± 0.6	8.9 ± 0.5
Sit-up repetitions (n)	Experimental	23.5 ± 3.0	30.2 ± 2.8
	Control	23.8 ± 2.9	24.1 ± 2.7
Push-up repetitions (n)	Experimental	20.4 ± 2.5	26.8 ± 2.9
	Control	20.2 ± 2.7	20.7 ± 2.6
Shuttle run (s)	Experimental	18.2 ± 1.1	16.5 ± 1.0
	Control	18.0 ± 1.2	17.9 ± 1.1
800-m run (min)	Experimental	6.8 ± 0.6	5.9 ± 0.5
	Control	6.7 ± 0.5	6.6 ± 0.5

Body Mass Index (BMI) Outcomes

The intervention group also demonstrated a meaningful reduction in BMI, decreasing from 23.4 ± 2.1 to 22.1 ± 2.0, whereas the control group remained relatively unchanged (from 23.3 ± 2.0 to 23.2 ± 2.1). These findings indicate that high-impact gymnastics contributed positively to improving students' body composition. BMI pre–post results are shown in **Table 5**.

Table 5. Body Mass Index (BMI): Pretest and Posttest

Variable	Group	Pretest (Mean ± SD)	Posttest (Mean ± SD)
BMI (kg/m²)	Experimental	23.4 ± 2.1	22.1 ± 2.0
	Control	23.3 ± 2.0	23.2 ± 2.1

Paired-Sample Analysis

Paired-sample t-tests showed significant improvements in the experimental group for both TKJI and BMI outcomes. Physical fitness increased significantly ($t = 7.892$, $p < 0.001$, $d = 1.52$), and BMI decreased significantly ($t = 3.210$, $p = 0.004$, $d = 0.72$). In contrast, the control group showed no meaningful changes in either variable ($p > 0.05$). Detailed results are shown in **Table 6**.

Table 6. Paired-Sample t-test Results (Pre–Post Within Groups)

Variable	Groups	t count	p-value	Description
Physical Fitness (TKJI)	Experimental	7.892	0.000	Significant improvement
	Control	0.871	0.391	No significant change
Body Mass Index (BMI)	Experimental	3.210	0.004	Significant reduction
	Control	0.582	0.565	No significant change

Between-Group Comparison

Independent-sample t-tests conducted on the post-test data confirmed significant differences between groups. The experimental group had significantly higher physical fitness ($t = 5.432$, $p < 0.001$, $d = 1.40$) and significantly lower BMI ($t = 2.845$, $p = 0.007$, $d = 0.73$) than the control group. These results are summarised in **Table 7**.

Table 7. Independent-Sample t-test Results (Post-test Between Groups)

Variable	t count	p-value	Effect size (d)	Description
Physical Fitness (TKJI)	5.432	0.000	1.40	Groups differ significantly
Body Mass Index	2.845	0.007	0.73	Groups differ significantly

The independent-sample t-test results (Table 6) showed significant differences between the experimental and control groups in the post-test. Physical fitness scores were significantly higher in the experimental group ($t = 5.432$, $p < 0.001$), and BMI values were significantly lower ($t = 2.845$, $p = 0.007$). These findings confirm that students who participated in high-impact gymnastics demonstrated better physical fitness and improved body composition compared to the control group.

The independent-sample t-test results (Table X) showed significant differences between the experimental and control groups in the post-test. Physical fitness scores were significantly higher in the experimental group ($t = 5.432$, $p < 0.001$), and BMI values were significantly lower ($t = 2.845$, $p = 0.007$). These findings confirm that students who participated in high-impact gymnastics demonstrated better physical fitness and improved body composition compared to the control group.

Discussion

Overweight status and low physical fitness are important issues among high school adolescents, as they are associated with increased risk of disease and reduced quality of life (Ermayani et al., 2025; Rosady & Zulfa, 2024). Lack of structured fitness exercises and decreased physical activity can worsen students' physical endurance Limited structured exercise and decreasing physical activity further contribute to declining endurance levels in students (Legarra-Gorgoñon et al., 2024). Previous studies have highlighted the benefits of both low- and high-impact exercise for improving adolescent physical fitness (Subekti & Harmoko, 2020), which aligns with current findings showing that high-impact gymnastics can enhance multiple fitness components. These results support the relevance of school-based fitness interventions for promoting active and healthy lifestyles among students (Musdalifah et al., 2022; Sari, 2020).

The significant improvements observed in the experimental group align with the general physiological principle that consistent physical activity enhances cardiovascular efficiency and contributes to healthier weight status (Larsson & Burgess, 2021). Although the present study did not directly measure mechanisms such as VO_2 max, neuromuscular adaptation, or fat oxidation, the reductions in BMI and gains in performance are consistent with outcomes reported in school-based exercise programmes. These findings underscore the value of incorporating structured, moderate-to-vigorous physical activity into the school curriculum to help mitigate rising adolescent obesity trends.

Recent reviews highlight that adolescent BMI has increased globally over the past several decades, with sharper rises in rapidly urbanising regions (Kivimäki, 2022; Rodriguez-Martinez, 2020). In this context, high-impact gymnastics represents a practical and low-cost form of exercise that can be integrated into PE classes without requiring specialised equipment. Its adaptability and group-based format make it a feasible approach for schools aiming to promote physical activity and enhance student fitness.

The results also support broader educational health policies recommending school-based interventions that combine structured exercise, health education, and supportive environments to improve BMI and academic functioning (Cohen et al., 2021). Nevertheless, several limitations must be acknowledged. First, the intervention lasted only eight weeks, making it difficult to determine long-term effects on BMI or detailed body composition. Second, fitness measures were based on field tests, which may be influenced by motivation and test familiarity. Third, dietary intake—which plays an important role in weight change—was not controlled, limiting the interpretation of BMI changes.

Despite these limitations, the study provides evidence that high-impact gymnastics offers an effective and scalable approach to improving fitness and supporting healthy weight in adolescents. This is consistent with previous school-based HIIT research demonstrating improvements in cardiometabolic indicators within short durations (Duncombe et al., 2022; Logan et al., 2014). In practical terms, such programmes can be incorporated into PE lessons or extracurricular activities and may be enhanced by teacher training and simple nutritional guidance (Mavilidi et al., 2019). Future research should include longer intervention periods, dietary monitoring, objective activity tracking, and more comprehensive body composition analyses to better understand the mechanisms underlying fitness and BMI changes. Longitudinal designs would also help determine whether the benefits of high-impact gymnastics persist over time.

Overweight status and low physical fitness are important issues among high school adolescents, as they are associated with increased risk of disease and reduced quality of life. Limited structured exercise and decreasing physical activity further contribute to declining endurance levels in students (Legarra-Gorgoñon et al., 2024). Previous studies have highlighted the benefits of both low- and high-impact exercise for improving adolescent physical fitness (Subekti & Harmoko, 2020), which aligns with current findings showing that high-impact gymnastics can enhance multiple fitness components. These results support the relevance of school-based fitness interventions for promoting active and healthy lifestyles among students.

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CONCLUSION

High-impact gymnastic exercises can improve physical fitness and significantly lower a student's body mass index. Fitness improved by 15-20% and BMI decreased by 5% after eight weeks. This form of physical intervention proved to be effective and had a positive impact on muscle strength, endurance, speed and agility. The results contribute to healthy weight management and may prevent long-term health problems in adolescent students. Suggestions for future research could be to integrate high-impact gymnastics programmes in structured physical education activities. Provide training for teachers to be able to design and deliver programmes according to the needs and capabilities of students. Collaborate with schools, parents and health professionals to create an active and healthy environment among teens. Future studies should involve a larger and gender-balanced sample, longer intervention periods, and include assessments of psychological and academic outcomes.

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CONFLICT OF INTEREST

Authors in the drafting process do not have competition with other authors.

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