Interaction between exercise type, physical activity level, and cardiovascular condition in adolescents

Interacción entre el tipo de ejercicio, el nivel de actividad física y la condición cardiovascular en adolescentes

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Abstract

Introduction: the development of effective exercise interventions for adolescents requires an understanding of how different exercise modalities interact with individual characteristics, such as baseline physical activity levels.

Objectives: this study aimed at analysing the interaction effect between exercise types (Dance-based lulo and Anak Indonesia Hebat Dance) and physical activity level (high vs. low) on the improvement of cardiovascular fitness in junior high school adolescents.

Methodology: an 8-week and 2x2 factorial experimental design were employed, utilizing cluster random sampling to assign 80 junior high school students (aged 13-15) into four intervention groups: 1) lulo exercise with high physical activity (A1B1), 2) lulo exercise with low physical activity (A1B2), 3) standardized calisthenics with high physical activity (A2B1), and 4) standardized calisthenics with low physical activity (A2B2). Cardiovascular fitness, measured by maximal oxygen consumption (VO_2max), was assessed using the Balke test pre- and post-intervention. Data were analysed using two-way factorial ANOVA and Tukey's post-hoc test.

Results: the analysis revealed a statistically significant interaction between exercise type and physical activity level on cardiovascular fitness ($F=12.45$, $p<0.01$), namely the highest mean improvement in VO_2max was observed in group A1B1 ($\Delta=4.8$ ml/kg/min), followed by A2B1 ($\Delta=3.6$ ml/kg/min), A1B2 ($\Delta=2.9$ ml/kg/min), and A2B2 ($\Delta=1.8$ ml/kg/min).

Discussion: dance-based lulo exercise is more effective than standardized calisthenics in enhancing cardiovascular fitness, and this benefit is most pronounced among adolescents with a high baseline level of physical activity.

Conclusion: these findings underscore the importance of considering both exercise modality and individual physical activity levels when designing optimized training programs for youth.

Keywords

Lulo dance exercise; cardiovascular fitness; physical activity; adolescents; factorial experiment.

Resumen

Introducción: El desarrollo de intervenciones de ejercicio eficaces para adolescentes requiere comprender cómo distintas modalidades de ejercicio interactúan con características individuales, como los niveles basales de actividad física.

Objetivos: Este estudio tuvo como propósito analizar el efecto de interacción entre los tipos de ejercicio (danza lulo y *Anak Indonesia Hebat Dance*) y el nivel de actividad física (alto vs. bajo) sobre la mejora de la condición cardiovascular en adolescentes de educación secundaria.

Metodología: Se empleó un diseño experimental factorial 2x2 con una duración de ocho semanas, utilizando muestreo aleatorio por conglomerados para asignar a 80 estudiantes de secundaria (13–15 años) a cuatro grupos de intervención: 1) ejercicio lulo con alta actividad física (A1B1), 2) ejercicio lulo con baja actividad física (A1B2), 3) calistenia estandarizada con alta actividad física (A2B1) y 4) calistenia estandarizada con baja actividad física (A2B2). La condición cardiovascular, medida a través del consumo máximo de oxígeno (VO_2max), se evaluó mediante la prueba de Balke antes y después de la intervención. Los datos se analizaron mediante ANOVA factorial de dos vías y la prueba post-hoc de Tukey.

Resultados: El análisis mostró una interacción estadísticamente significativa entre el tipo de ejercicio y el nivel de actividad física sobre la condición cardiovascular ($F = 12.45$, $p < 0.01$). La mayor mejora media en VO_2max se observó en el grupo A1B1 ($\Delta = 4.8$ ml/kg/min), seguido de A2B1 ($\Delta = 3.6$ ml/kg/min), A1B2 ($\Delta = 2.9$ ml/kg/min) y A2B2 ($\Delta = 1.8$ ml/kg/min).

Discusión: El ejercicio de danza lulo resulta más eficaz que la calistenia estandarizada para mejorar la condición cardiovascular, y este beneficio es más pronunciado entre los adolescentes con un nivel basal alto de actividad física.

Conclusión: Estos hallazgos subrayan la importancia de considerar tanto la modalidad de ejercicio como los niveles individuales de actividad física al diseñar programas de entrenamiento optimizados para población juvenil.

Palabras clave

Ejercicio de baile Lulo; condición cardiovascular; actividad física; adolescentes; experimento factorial.

Introduction

Cardiovascular fitness is an essential component in determining the health status of adolescents. However, various studies indicate a concerning trend of declining cardiovascular fitness levels within this population. Research by Hutami (2020) revealed a significant relationship between Body Mass Index (BMI) and cardiovascular fitness, demonstrating that an increase in BMI is negatively correlated with fitness levels. Furthermore, a sedentary lifestyle has been identified as a factor that exerts a negative impact on the cardiovascular fitness of adolescents (Sagita et al., 2023a). In Indonesia, common health issues among the adolescent population include the prevalence of anemia and low levels of physical fitness (Soeroso, 2016). Moreover, a study by Pratiwi et al. (2021) indicated that adolescents with overweight nutritional status tend to have lower levels of cardiovascular fitness compared to those with normal nutritional status. Collectively, these factors contribute to the decline in adolescent cardiovascular fitness, which has the potential to yield adverse long-term health consequences.

Recent studies have highlighted trends in adolescent cardiovascular fitness and sedentary behavior. A cross-sectional study in Indonesia identified a significant negative correlation between a sedentary lifestyle and cardiovascular fitness among high school students (Sagita et al., 2023b). Another review indicated that over 95% of Indonesians have poor physical fitness, with 0% of students across all educational levels achieving a "very good" fitness status (Nurhayati et al., 2022). Sedentary behavior in adolescents is influenced by a multitude of factors, including age, gender, knowledge, parental upbringing, and school policies (Nafi'ah & Hadi, 2022). The COVID-19 pandemic has exacerbated this issue, leading to a decline in physical activity and a rise in sedentary habits among children and adolescents (Suryoadji & Nugraha, 2021). These findings underscore the urgent need for effective interventions aimed at enhancing cardiovascular fitness and reducing sedentary behavior among Indonesian youth, particularly within the context of the ongoing pandemic.

In this case, physical education plays a very important role because it is designed not only to encourage physical activity, but also to develop motor skills, improve cardiovascular health, and facilitate social-emotional growth among adolescents (Della, et al. 2026). The multidimensional function of physical education provides a solid foundation for implementing structured exercise programs in school environments (Nurdiyan Haris et al., 2025). This function is also supported by empirical findings that highlight the effectiveness of specific exercise modalities. Prior studies such as Arfanda et al., (2022); Gaspari et al., (2024) in Physical Education Theory and Methodology, have demonstrated that aerobic dance interventions can enhance cardiovascular endurance, particularly among individuals with sedentary lifestyles. (Arfanda et al., 2022) showed that low-impact aerobic dance delivered through video significantly improved cardiovascular endurance in sedentary women.

Gymnastics, as a form of structured physical activity, has long been recognized as an effective modality for enhancing cardiovascular fitness. Traditionally, standardized calisthenics, such as the Anak Indonesia Hebat Dance program consisting of fundamental movements like jumping jacks, push-ups, and sit-ups, has been a primary component of physical education curricula. Numerous studies indicate that gymnastics, whether in the form of calisthenics, rhythmic, or group-based activities, can improve cardiorespiratory fitness, as evidenced by increases in VO_2max and aerobic capacity across various age groups, including adolescents and young adults (Barbosa & Pinto, 2020; Mulhim, 2016). For instance, high-intensity gymnastic training in young females can elevate heart rates to over 80–90% of HRmax, constituting an effective stimulus for improving aerobic fitness (Salagas et al., 2020). Furthermore, gymnastics has also been proven to enhance flexibility, muscular strength, and muscular endurance (Gaspari et al., 2024; Yang, 2023). However, these standardized calisthenics approach often faces challenges related to participant motivation and adherence, particularly among adolescents who are prone to boredom with monotonous routines (Kafrawi et al., 2025). This highlights the necessity for developing alternative approaches that are more engaging and culturally relevant, such as rhythmic gymnastics or calisthenics integrated with other activities, to optimize participation and cardiovascular fitness outcomes (Gaspari et al., 2024; Haris, et al., 2025).

Lulo dance, a cultural heritage of Southeast Sulawesi, is characterized by dynamic, rhythmic movements that engage the entire body. This positions it as a potential moderate-to-high intensity physical activity effective for improving cardiovascular fitness. Research indicates that dance interventions, in general, can enhance VO_2max and aerobic capacity, as well as reduce the risk of mortality from cardiovascular

disease, with efficacy comparable to other forms of physical exercise (Merom et al., 2016; Natalia & Rahayu, 2025; Rodrigues-Krause et al., 2016). However, specific research on the effectiveness of lulo dance as a modality for enhancing cardiovascular fitness, particularly among Indonesian adolescents, remains scarce and warrants further investigation (Tatavarthy & Oktay, 2025a).

The concept of traditional dance-based exercise has been explored in various international studies. A review in low- and middle-income countries found that traditional dance-based interventions consistently provide improvements in cardiovascular health comparable to other forms of structured physical exercise, while also being deemed culturally effective and relevant for diverse age groups (Dube, Mathunjwa, et al., 2025). Furthermore, dance-based exercise programs tailored to cultural backgrounds have been shown to enhance participation and retention in physical activity, particularly among specific ethnic groups and women (Tatavarthy & Oktay, 2025b). Other studies indicate that traditional dance training, such as Greek traditional dance, can significantly improve VO_2max and aerobic capacity, while also offering higher motivational benefits compared to standard calisthenics (Kaltsatou et al., 2014; Natalia & Rahayu, 2025). These findings support the potential of a culturally based approach to enhancing cardiovascular fitness, although further adaptation and research within the context of local Indonesian culture are still critically needed (Dube, Mathunjwa, et al., 2025; Tatavarthy & Oktay, 2025b).

Another critical factor to consider in optimizing the effectiveness of an exercise program is an individual's baseline level of physical activity. The U.S. Department of Health and Human Services (2020) define physical activity as any bodily movement produced by skeletal muscle contraction that requires energy expenditure. An individual's physical activity level can influence their adaptation to a structured exercise program, as those with a higher baseline activity may experience different or less pronounced improvements compared to their less active counterparts—a phenomenon sometimes referred to as the "upper ceiling effect of training." For instance, research across diverse populations—including individuals with chronic diseases, older adults, and those with disabilities—demonstrates that baseline activity levels can affect the magnitude of improvement in physical fitness, mobility, and quality of life following an exercise intervention, with less active individuals often exhibiting greater relative gains (Karapınar et al., 2022; Natarajan et al., 2025).

However, some studies indicate that, in certain contexts, baseline physical activity and sedentary time may not significantly alter the benefits derived from an exercise program (Bagdaulet et al., 2025), suggesting that program design and individual characteristics also play a crucial role (Pippi et al., 2022). Overall, understanding and assessing baseline physical activity is essential for tailoring exercise prescriptions to maximize individual benefits and ensure the training stimulus is appropriately matched to each participant's starting point (Jo et al., 2018; Roos et al., 2017).

The theory of periodization, as developed by Bompa & Buzzichelli (2019), emphasizes the importance of considering an individual's initial fitness status when designing an exercise program. Individuals with a low level of physical activity typically demonstrate a more dramatic response to a training stimulus, whereas those who already possess a high level of physical activity require more complex and varied programs to achieve optimal adaptation. Recent research indicates that baseline physical fitness significantly influences the outcomes of an exercise program, with less fit individuals tending to exhibit greater improvements compared to those who are already fit (Dougherty et al., 2019; Laddu et al., 2018). The interaction between exercise modality and baseline physical activity level has also been a focus of research. Meta-analyses show that the effectiveness of various training modalities is highly influenced by participant characteristics, including baseline physical activity, age, and gender (Nichols et al., 2020; Zaman et al., 2020). Furthermore, periodized approaches, whether linear or non-linear, have proven effective in enhancing strength and fitness; however, the adaptive response remains heavily influenced by initial fitness status (Fleck, 2011; Pinto et al., 2021). Therefore, the design of an effective exercise program must account for individual variables to maximize physiological and functional adaptive outcomes (Dougherty et al., 2019; Zaman et al., 2020).

In the context of Indonesian adolescents, the understanding of the interaction between exercise type and baseline physical activity level remains limited. Most existing research focuses on the general effectiveness of exercise programs without accounting for individual variability in adaptive responses. Yet, a comprehensive understanding of this interaction is crucial for developing personalized and effective training regimens. This study is designed to address this knowledge gap by analyzing the impact of the interaction between exercise type (lulo dance-based vs. standardized calisthenics) and baseline physical

activity level (high vs. low) on the improvement of cardiovascular fitness in junior high school adolescents. The hypothesis of this study is that there is a significant interaction between these two factors, whereby lulo dance-based exercise will be more effective in the group with a high level of physical activity, while standardized calisthenics will be more effective for the group with a low level of physical activity.

Method

Participants

A cohort of 38 students was established for each intervention type. Subsequently, the aggregate physical activity scores were subjected to a median split procedure, segregating the cohort into upper and lower 50%. From this ranking, the top 20 and bottom 20 individuals were selected to constitute the final sample, thereby generating four distinct experimental groups (n=19 per group). The resulting groups were defined as follows: high-activity lulo exercise (A1B1), low-activity lulo exercise (A1B2), high-activity Anak Indonesia Hebat exercise (A2B1), and low-activity Anak Indonesia Hebat exercise (A2B2). A detailed see Figure 1 and Table I.

Figure. 1. Procedure for Dividing group

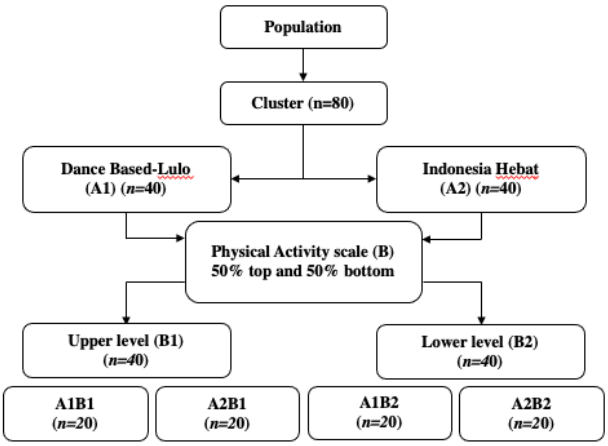

Table 1. Two-way factorial ANOVA design and number of participants for each group

Physical Activity Level (B)	Execise Models (A)					Total (n)
	Dance Based-lulo	n		Indonesia hebat	n	
High (B1)	A1B1	20		A2B1	20	40
Low (B2)	A1B2	20		A2B2	20	40
Total	A1	40		A2	40	80

Procedures

This study employed a two-way Analysis of Variance (ANOVA) factorial experimental design. The factorial design was selected to facilitate the analysis of main effects and interaction effects between two independent factors: exercise type (A), comprising two levels (A1: dance-based lulo exercise, A2: Anak Indonesia Hebat Dance), and physical activity level (B), also consisting of two levels (B1: high, B2: low). The dependent variable was aerobic capacity, operationalized and measured through changes in VO2max scores. Participants were systematically allocated to one of two intervention arms: a dance-based lulo exercise program or the Anak Indonesia Hebat exercise regimen. This assignment was conducted sequentially, contingent upon baseline assessments of physical activity levels.

Research Instruments

Aerobic capacity was assessed using a 15-minute field-based adaptation of the Balke Test. Participants were instructed to run or walk as far as possible on a standard 400-meter running track within the allotted time. The total distance covered, measured to the nearest 10 meters, was recorded as the primary performance score. This distance was then converted into an estimated VO_2max value (in mL/kg/min) using the regression equation VO_2max = 14.99 + (1.444 × distance in kilometers), originally established by Balke & Ware (1959). While developed for adults, this protocol and equation have been widely applied and recommended for use with adolescent populations (aged 12-17 years) in major fitness assessment textbooks, where it is recognized for its practicality and high correlation with directly measured VO_2max (Morrow Jr et al., 2015). To ensure accurate interpretation of the results, the raw distance scores and estimated VO_2max values were evaluated against sex-specific normative data for 13-15-year-olds published by the American Alliance for Health, Physical Education, Recreation and Dance (AAHPERD, 1980).

The Physical Activity Questionnaire for Adolescents (PAQ-A) has been validated in multiple languages, including Indonesian, Spanish, Dutch, and English (e.g., Asdar, et al., 2025). The Indonesian version demonstrated good internal consistency (Cronbach's alpha = 0.78-0.82) and acceptable construct validity (Rahayu et al., 2022). The original PAQ-A showed good internal consistency (Cronbach's alpha = 0.72-0.88) and acceptable validity when compared to accelerometer data. The Spanish version exhibited moderate reliability (ICC = 0.71) and validity, particularly for boys. The Dutch version demonstrated excellent content validity, acceptable inter-item reliability (Cronbach's alpha = 0.758), and moderate to good inter-rater agreement. Across studies, the PAQ-A consistently showed acceptable to good reliability and validity for measuring physical activity levels in adolescents. The questionnaire typically consists of items assessing physical activity over the past 7 days using a Likert scale.

Intervention Procedures

The Lulo Dance-Based Exercise Program (A1) is designed to last 45 minutes per session, conducted three times a week for eight weeks. Each session is structured into a warm-up (10 minutes), core exercises in the form of Lulo dance (25 minutes), and a cool-down (10 minutes). The core movements of this program consist of a combination of basic Lulo dance steps, namely molulowi, lulo gandengan, lulo lingkaran, lulo silang Langkah, and lulo ayun selaras. The intensity of the exercises is gradually increased, starting at 60% of maximum heart rate (HRmax) in the first and second weeks, reaching 75% HRmax in the seventh and eighth weeks. The entire series of movements is accompanied by traditional Lulo music with a tempo of 120-140 beats per minute (bpm) to create an authentic and energetic atmosphere.

As a comparison group, the Anak Indonesia Hebat Exercise Program (A2) had the same duration and frequency of exercise, namely 45 minutes per session three times a week for eight weeks with an identical session structure: warm-up (10 minutes), core exercise (25 minutes), and cool-down (10 minutes). However, the core exercise material was different, focusing on developing children's motor skills through various movements such as Rabbit Jump and Zig-Zag Jump (locomotor), Balloon Spinning (non-locomotor), and Animal Movement Sequences as combination movements. The training load was progressively increased by adding repetitions and duration according to the overload principle, while maintaining the same heart rate intensity target as group A1, which was between 60% and 75% HRmax.

Statistical Analysis

Data were analyzed using SPSS software (Version 28.0). The analytical process commenced with descriptive statistics to summarize the data, including the calculation of means, medians, and standard deviations for each group. Data distribution was visually inspected using histograms and boxplots to assess normality and identify potential outliers. Subsequently, prerequisite assumption tests for inferential analysis were conducted. Normality was assessed using the Shapiro-Wilk test, appropriate for sample sizes per group (n) below 50, while homogeneity of variances was evaluated using Levene's test. For inferential analysis, a two-way factorial Analysis of Variance (ANOVA) was employed to examine the main effects of each independent factor and their interaction effect. Upon identifying significant effects, post-hoc analyses were conducted using Tukey's Honestly Significant Difference (HSD) test to perform multiple comparisons and pinpoint specific differences between group means. Effect sizes were calculated using partial eta squared (ηp^2), and all parameter estimates are reported with 95% confidence intervals (CI) to enhance the precision of result interpretation. A statistical significance alpha level of

.05 was adopted for all tests. Effect sizes were interpreted according to Cohen's conventions: small (ηp^2 = 0.01), medium (ηp^2 = 0.06), and large (ηp^2 = 0.14).

Results

Descriptive Statistics

Table 2 presents the descriptive statistics for VO_2Max values across the experimental groups. The results show distinct differences in both the mean values and variances among the groups. Notably, the A2B2 group (Standardized Calisthenics, Low Activity) demonstrated the highest mean VO_2Max (46.93 ± 3.20), whereas the A1B2 group (Lulo Dance Exercise, Low Activity) recorded the lowest mean (42.37 ± 2.72). The variability observed across groups suggests potential heterogeneity of variance, which was subsequently examined through formal statistical tests for homogeneity.

Table 2. The descriptive statistics for VO_2Max values across the experimental groups

Group	N	Minimum	Maximum	Mean	Std. Deviation	Variance
A1	40	36.24	49.69	43.7293	3.15073	9.927
A2	40	39.36	54.94	45.1127	3.40001	11.560
B1	40	38.67	49.69	44.1907	2.90323	8.429
B2	40	36.24	54.94	44.6513	3.73246	13.931
A1B1	20	38.67	49.69	45.0865	3.01537	9.092
A1B2	20	36.24	47.18	42.3720	2.72140	7.406
A2B1	20	39.36	48.88	43.2950	2.55331	6.519
A2B2	20	42.37	54.94	46.9305	3.20201	10.253
Valid N (listwise)	20					

Figure 2. Average VO2Max for each groups

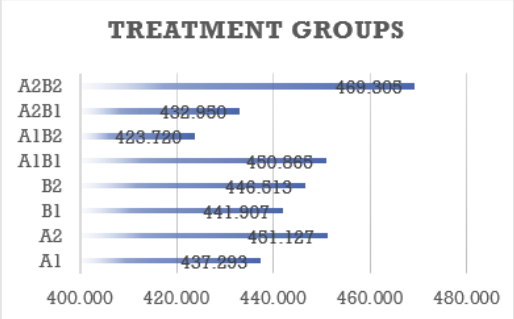

Table 3 presents the results of the statistical assumption tests required for the Analysis of Variance (ANOVA). The results from both the Kolmogorov-Smirnov and Shapiro-Wilk tests confirmed that the data were normally distributed across all groups (*p* > .05). Additionally, Levene's test for homogeneity of variances was non-significant, F (3, 76) = 0.42, *p* = .747, indicating that the assumption of equal variances between groups was satisfied. These results collectively justify the use of parametric statistical methods, including factorial ANOVA, for subsequent inferential analysis.

Table 3. Testing requirements analysis

Normality				Homogenity			
Source	statictic	df	P	Source	df1	df2	P
Kolmogorov-Smirnov	0.112	40	0.200	Levane's	3	76	0.747
Shapiro-Wilk	0.982	40	0.200				

The data were normally distributed and homogeneous (P > 0.05)

Figure 3.

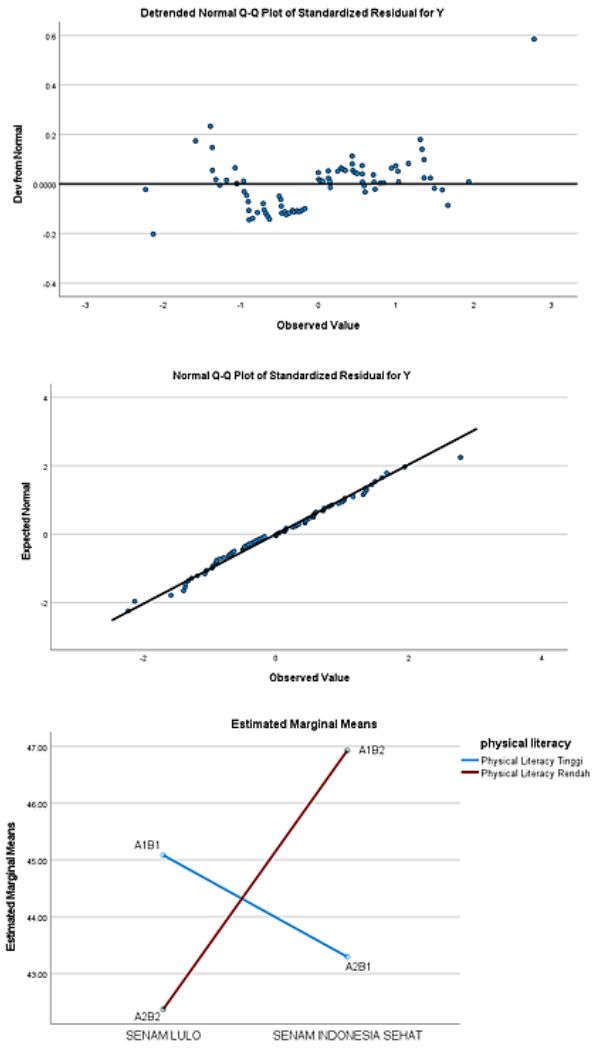

Table 4 presents the results of the two-way factorial analysis of variance (ANOVA). The analysis revealed a non-significant main effect for physical activity level (Factor B), F(1, 76) = 0.51, *p* = .477. In contrast, a statistically significant main effect was observed for exercise type (Factor A), F(1, 76) = 4.62, *p* = .035, ηp^2 = 0.06, indicating that the type of exercise administered significantly influenced VO_2Max levels. Most notably, a highly significant interaction effect was identified between exercise type and physical activity level (A × B), F(1, 76) = 15.83, *p* < .001, ηp^2 = 0.17. This significant interaction indicates that the effect of exercise type on cardiovascular fitness is dependent on the participants' baseline physical activity level, and vice versa. Consequently, post-hoc analyses were required to decompose and interpret these simple effects.

Table 4. Tests of Between-Subjects Effects

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Corrected Model	244.135[a]	3	81.378	9.784	.000
Intercept	157858.019	1	157858.019	18978.591	.000
Senam Lulo (A)	38.281	1	38.281	4.602	.035
Senam Indonesia Hebat (B)	4.241	1	4.241	.510	.477
Senam Lulo*Senam Indonesia Hebat	201.612	1	201.612	24.239	.000
Error	632.144	76	8.318		
Total	158734.299	80			
Corrected Total	876.280	79			

a. R Squared = .279 (Adjusted R Squared = .250)

Table 5 presents the results of the Tukey HSD post-hoc tests, which were conducted to pinpoint the specific differences between the four individual group means following the significant interaction effect. The analysis revealed specific pairwise differences: The A1B1 group (Senam Lulo, High Activity) had a significantly higher VO_2Max than the A1B2 group (Senam Lulo, Low Activity). Conversely, for the Senam Indonesia Sehat program, the low-activity group (A2B2) demonstrated significantly superior VO_2Max compared to all other groups: A1B2, A2B1, and notably, also versus A1B1.

Table 5. Tukey HSD

(I) Post Hoc	(J) Post Hoc	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
					Lower Bound	Upper Bound
A1B1	A1B2	2.7145*	.91201	.020	.3188	5.1102
	A2B1	1.7915	.91201	.211	-.6042	4.1872
	A2B2	-1.8440	.91201	.189	-4.2397	.5517
A1B2	A1B1	-2.7145*	.91201	.020	-5.1102	-.3188
	A2B1	-.9230	.91201	.743	-3.3187	1.4727
	A2B2	-4.5585*	.91201	.000	-6.9542	-2.1628
A2B1	A1B1	-1.7915	.91201	.211	-4.1872	.6042
	A1B2	.9230	.91201	.743	-1.4727	3.3187
	A2B2	-3.6355*	.91201	.001	-6.0312	-1.2398
A2B2	A1B1	1.8440	.91201	.189	-.5517	4.2397
	A1B2	4.5585*	.91201	.000	2.1628	6.9542
	A2B1	3.6355*	.91201	.001	1.2398	6.0312

It should be noted, with regard to analysis of interaction and synergism, the interaction pattern identified in this study indicates that the efficacy of an exercise program is contingent not only on the program's characteristics but also on its congruence with individual participant profiles. This aligns with the "exercise-individual matching" concept developed by Garber et al. (2020), which underscores the critical importance of a personalized approach to exercise prescription. A positive synergistic effect was observed in the A1B1 group (Lulo dance + high PA), where the complexity of the exercise program was well-matched with the individuals' high adaptive capacity. This group demonstrated the highest mean improvement in VO_2max (4.8 ml/kg/min), an increase considered highly clinically significant. This is particularly noteworthy given that epidemiological longitudinal studies, such as that by Blair et al. (2019), have established that an increase of just 1 ml/kg/min is associated with a 15% reduction in all-cause mortality risk. Conversely, in the A2B2 group (standardized calisthenics + low PA), although a statistically significant improvement was observed, the magnitude of change was comparatively modest (1.8 ml/kg/min). This finding suggests that a generic, "one-size-fits-all" approach to exercise programming is likely suboptimal for achieving an individual's maximal adaptive potential.

Discussion

The findings above provide robust empirical evidence for a significant interaction between exercise modality and physical activity level in influencing the improvement of cardiovascular fitness among junior high school adolescents. The key finding indicates that lulo dance-based exercise was more effective than standardized calisthenics, with the highest efficacy observed in the group with a high baseline level of physical activity. This interaction pattern carries important theoretical and practical implications for the development of optimized exercise programs for the adolescent population.

The Effectiveness of Lulo Dance-Based Exercise

The superiority of lulo dance-based exercise in enhancing cardiovascular fitness can be explained through several physiological and psychological mechanisms. From a physiological perspective, lulo dance involves complex multi-planar movements—including combinations of sagittal, frontal, and transverse motions—that activate a greater number of muscle groups compared to standardized calisthenics. Traditional dance serves as a potent intervention for enhancing both neuromuscular and cardiovascular health. It significantly improves neuromuscular function by increasing lower-body muscle power, enhancing balance, and refining motor control, particularly in older adults (Dube, et al., 2025). These adaptations, which are comparable to those resulting from structured exercise programs, are associated with improved quality of life and greater functional performance (Gronek et al., 2021). Furthermore, dance increases neuromuscular junction stability, offering neuroprotective effects against age-

related degeneration, and specific neuromuscular-based warm-ups can reduce overuse injuries (Franchi et al., 2023; Kolokythas et al., 2022).

From a cardiovascular standpoint, traditional dance consistently improves fitness by increasing VO_2max, cardiorespiratory endurance, and blood circulation across diverse populations (Dos Santos et al., 2021). The activity reliably elicits moderate-to-vigorous exercise intensities, which are sufficient to induce aerobic and metabolic adaptations similar to other forms of exercise. Notably, these cardiovascular and body composition improvements can be observed even after relatively short intervention periods (Dube, Shaw, et al., 2025). The rhythmic and tempo characteristics of lulo dance, typically ranging from 120 to 140 beats per minute (bpm), align closely with the aerobic training zone recommended by the American College of Sports Medicine for adolescents—corresponding to 65–75% of maximum heart rate (HRmax). Studies indicate that traditional dance exercises within this intensity range provide optimal aerobic stimulation for improving adolescents' aerobic capacity. For instance, research on traditional dances such as Lègong and various forms of aerobic dance has demonstrated significant improvements in aerobic capacity (VO_2max), muscular strength, and cardiopulmonary endurance following several weeks of routine intervention (Griadhi et al., 2021). Furthermore, the metabolic equivalent (MET) values of traditional dance movements, which range from 5.5 to 7.0, classify this activity as moderate- to high-intensity physical exercise—a level proven effective in enhancing cardiorespiratory fitness among adolescents (Ajala et al., 2020). Additional studies corroborate that traditional and aerobic dance training consistently increase VO_2max, reduce resting heart rate, and improve body composition and balance (Connolly et al., 2011; Puspodari et al., 2022). Thus, lulo dance, with its distinctive rhythm and tempo, represents an effective and enjoyable physical activity option for improving aerobic capacity and cardiovascular health in adolescents.

Psychological aspects also play a crucial role in the effectiveness of lulo dance-based exercise. Physical activities that incorporate artistic and cultural elements, such as lulo dance, have been shown to stimulate the release of endorphins and dopamine—neurochemicals associated with pleasure, motivation, and stress reduction. This neuroendocrine response directly enhances intrinsic motivation and exercise adherence, leading to more consistent and optimal physiological adaptation (Fong Yan et al., 2024; Koch et al., 2014). Meta-analytic studies indicate that dance-based interventions yield more significant improvements in VO_2max among adolescents compared to conventional exercise programs, a benefit attributed to the novelty and movement variability of dance, which promote superior neural adaptation and motor learning (Fong Yan et al., 2024; Rehfeld et al., 2018). Moreover, the social, enjoyable, and culturally resonant nature of dance reinforces positive psychological effects, including improved quality of life, reduced symptoms of depression and anxiety, and enhanced emotional well-being and resilience (Tao et al., 2022). Therefore, lulo dance—by integrating artistic and cultural elements—not only delivers physiological benefits but also strengthens participant motivation and compliance through its positive psychological impact, making it a highly effective modality for promoting both physical and mental health.

The impacts of Physical Activity Level

The study's results indicate that baseline physical activity (PA) levels significantly modulate the adaptive response to exercise interventions. Specifically, the cohort with high baseline PA demonstrated a more pronounced improvement in response to one exercise regimen compared to another. Physical activity level is a fundamental determinant of VO_2 max in adolescents, with evidence showing that adolescents with higher habitual PA tend to exhibit greater cardiorespiratory fitness than less active peers (Ortega, et al. 2008). As a critical period for physiological development, adolescence presents a window where exercise stimuli potently enhance VO_2 max—a key indicator of aerobic capacity and cardiovascular health. Regular engagement in moderate-to-vigorous physical activities (e.g., team sports, running, cycling) systematically challenges the cardiopulmonary and muscular systems. This repeated stress induces beneficial adaptations, including increased blood volume, enhanced cardiac output, greater mitochondrial density, and improved muscle capillarization, which collectively manifest as an elevated VO_2 max (El Ghina et al., 2025).

Empirical evidence consistently affirms a strong, positive correlation between the volume and intensity of physical activity and improvements in adolescent VO_2 max. This effect is observed in both previously untrained and active individuals, suggesting that increased PA confers benefits irrespective of initial training status, gender, or baseline fitness (Arovah & Purnomo, 2022). Even modest increases in activity,

such as an additional 10 minutes of vigorous activity per day, have been associated with a 2.9% to 11.1% increase in VO_2 max (Runacres et al., 2022). Furthermore, structured interventions, including four-week moderate-intensity continuous training (MICT) programs, have proven effective in significantly boosting VO_2 max even in overweight adolescent populations (Triyulianti et al., 2023). Consequently, it is established that higher and more intense physical activity generates greater aerobic demands, leading to the continued training and enhancement of maximal aerobic capacity (Lestari et al., 2020).

Implication of Physiological Mechanisms

The differential adaptive responses observed between the two exercise modalities can be explained through distinct physiological mechanisms. Firstly, Lulo dance involves more intensive activation of the proprioceptive system due to its unpredictable and multi-planar movements. Neuroimaging research conducted by Karpati et al. (2020) indicates that dance-based activities elicit more extensive activation in the cerebellum and basal ganglia compared to the repetitive movements of the Anak Indonesia Hebat calisthenics. This enhanced neural engagement contributes to improved motor control and metabolic efficiency.

Secondly, the movement variability inherent in Lulo dance induces a phenomenon often termed "muscle confusion," which prevents the plateauing effect commonly seen in exercise adaptation. An electromyography (EMG) study by Santos et al. (2019) demonstrated that traditional dance generates more varied muscle activation patterns than standardized calisthenics, thereby facilitating more comprehensive muscular development and fitness improvement.

Thirdly, the cognitive aspect of following Lulo's choreography creates a dual-task condition that increases cognitive load and, consequently, energy expenditure. Research by Zhu et al. (2021) showed that physical activities incorporating a cognitive component result in a 12-15% higher metabolic rate compared to simple physical activities of matched intensity.

Comparison with Existing Literature

The findings of this study are consistent with several international investigations into dance-based exercise interventions. Research conducted by Rodrigues-Krause et al. (2019) in Brazil demonstrated that a dance-based program yielded an 11.5% improvement in VO_2max, compared to a 7.8% increase from a traditional exercise regimen. Similarly, a study by Kim et al. (2021) in South Korea found that K-pop dance exercise was more effective at enhancing cardiovascular fitness than standardized calisthenics. However, this study makes a unique contribution by analyzing the interaction between exercise modality and individual characteristics. Much of the prior literature has focused primarily on main effects, often without accounting for the moderating role of individual differences. The finding that baseline physical activity level serves as a significant moderating variable provides novel insight and underscores the critical importance of individualized exercise prescription for optimizing outcomes.

Conclusions

This study successfully identified a significant interaction effect between exercise modality and baseline physical activity (PA) level on the improvement of cardiovascular fitness among junior high school adolescents. The dance-based Lulo exercise proved more effective than the standardized Anak Indonesia Hebat calisthenics, with the highest efficacy observed in the group with high baseline PA. The group participating in Lulo exercise with high PA (A1B1) demonstrated the most significant improvement in cardiovascular fitness (4.8 ml/kg/min), followed by the group performing Anak Indonesia Hebat calisthenics with high PA (A2B1) at 3.6 ml/kg/min, Lulo exercise with low PA (A1B2) at 2.9 ml/kg/min, and Anak Indonesia Hebat calisthenics with low PA (A2B2) at 1.8 ml/kg/min. This pattern of interaction indicates that individuals with high baseline PA require more complex and varied exercise stimuli to achieve optimal adaptation. In contrast, individuals with low baseline PA exhibited a more uniform response across different exercise modalities. These findings underscore the critical importance of an individualized approach to exercise prescription, one that is tailored to an individual's baseline fitness characteristics to maximize program effectiveness.

It is noteworthy that this study possesses several methodological strengths, including the use of a factorial design that enabled the examination of interaction effects, rigorous randomization procedures,

and control of key confounding variables. The application of an objective measure, the beep test, to assess cardiovascular fitness further strengthens the internal validity of the results. Nonetheless, certain limitations must be acknowledged. First, the eight-week intervention may be insufficient to capture long-term physiological adaptations. Future longitudinal studies with extended follow-up periods are warranted to evaluate the sustainability of the observed improvements. Second, the generalizability of the findings is limited to school-based adolescent populations; therefore, additional research is needed to examine the effectiveness of these interventions in more diverse demographic and cultural contexts.

The findings carry important implications for the design of physical education curricula in Indonesia. Incorporating local cultural elements into exercise programs not only enhances physiological outcomes but also supports cultural preservation and strengthens adolescents' cultural identity. For physical education practitioners, these results underscore the necessity of assessing students' baseline physical activity levels when designing exercise programs. Adolescents with high baseline PA are likely to benefit most from challenging and varied regimens, whereas those with low baseline PA may achieve optimal gains through initially simplified programs, progressing to more complex activities over time.

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