Extracurricular physical activity effects on cardiovascular parameters in 11-16 years old children

Efectos de la actividad física extraescolar sobre los parámetros cardiovasculares en niños de 11 a 16 años

Authors

Assoc. Prof. Genti Pano [1]
MSc. Denis Nuriu [2]
Assoc. Prof. Oltiana Petri [1]
PhD(c). Anduela Lile [3]
MD. PhD. Eva Muja (Duraku) [4]
MSc. Artemis Bajaziti [2]

[1, 2, 3] Sports University of Tirana (Albania)
[4] Catholic University Hospital "Our Lady of the Good Counsel", Tirana (Albania)

Corresponding author:
Genti Pano
gpano@ust.edu.al

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Abstract

Introduction: In children and adolescents, cardiorespiratory fitness measures correlate with cardiometabolic risk factors, including overweight, obesity, hypertension, and cardiovascular functional parameters.
Objectives: Primary objective of this study was evaluating the cardiovascular system functional parameters before and after an exercise intervention program in 11 to 16 years old children.
Methodology: 140 youngsters, including 78 girls and 62 boys, from five distinct Albanian cities were randomly selected. Transthoracic echocardiography was performed examining in the left-lateral decubitus position. Participants engaged in a supplementary PA program five times per week for 16 weeks, with each session lasting 1.5 to 2 hours, after the conclusion of conventional physical education school hours. HR did not surpass 70% of HRmax (~145 beats per minute).
Results: A paired samples t-test was conducted to compare parameters before and after the intervention and in left ventricular ejection fraction (LVEF), results showed a modest significant increase in LVEF from pre ($M = 68.77$, $SD = 2.56$) to post-intervention ($M = 69.66$, $SD = 2.98$), $t(138) = -3.89$, $p < .001$. Moderate positive correlation was observed between pre- and post-intervention in LVEF values, $r(139) =.73$, $p <.001$, indicating acceptable stability of individual cardiovascular response to training.
Discussion: The exercise program produced a small but statistically significant increase in cardiac efficiency, as evidenced by the increase in LVEF. Finding supports the potential benefits of structured daily exercise to enhance heart function in children.
Conclusions: Physical activity is a good strategy for improving early cardiovascular function and reducing lifetime disease risk in children.

Keywords

Children; cardiovascular parameters; transthoracic echocardiography, physical activity.

Resumen

Introducción: En niños y adolescentes, las medidas de aptidão cardiorespiratória se correlacionan con factores de riesgo cardiometabólicos, incluido el exceso de peso, la obesidad, la hipertensión y los parámetros funcionales cardiovasculares.
Objetivos: El objetivo principal de este estudio es evaluar los parámetros que funcionan en el sistema cardiovascular antes y después de un programa de intervención con ejercicios en niños de 11 a 16 años. Metodología: Foro seleccionado aleatoriamente 140 jóvenes, incluyendo 78 raparigas y 62 rapazes, de cinco ciudades albanesas distintas. A ecocardiografia transtorácica foi realizada em decúbito lateral esquerdo. Los participantes realizarán un programa complementario de atividade física cinco veces por semana durante 16 semanas, con una duración de 1,5 a 2 horas cada uno, después del término del horario escolar convencional de educación física. El FC no supera el 70 % del FC máximo (~145 minutos por minuto).
Resultados: Foi realizado um teste t para amostras emparelhadas para comparar os parâmetros antes e depois da intervenção e na fração de ejeção do ventrículo esquerdo (FEVE). Los resultados muestran un aumento modesto y significativo de FEVE desde antes ($M = 68{,}77$, $DP = 2{,}56$) hasta después de la intervención ($M = 69{,}66$, $DP = 2{,}98$), $t(138) = -3{,}89$, $p < 0{,}001$. Si se observa una correlación positiva moderada entre los valores de FEVE antes y después de la intervención, $r(139) = 0{,}73$, $p < 0{,}001$, indica una estabilidad aceitável de la respuesta cardiovascular individual al tren.
Discusión: El programa de ejercicio producido un pequeño, más estadísticamente significativo, aumento de la eficiencia cardíaca, evidenciado por el aumento de FEVE. Los resultados corroboran los potentes beneficios del ejercicio diario estructurado para mejorar la función cardíaca de los niños.
Conclusión: La actividad física es una buena estrategia para mejorar la función cardiovascular precoz y reducir el riesgo de dolencia a lo largo de la vida de los niños.

Palabras clave

Niños; parámetros cardiovasculares; ecocardiografía transtorácica, actividad física.

Introduction

Cardiorespiratory fitness (CRF) is acknowledged as a very reliable measure of cardiovascular and metabolic health throughout life (Myers et al., 2014). In youth, cardiorespiratory fitness has an inverse relationship with the aggregation of cardiometabolic risk factors, such as obesity, dyslipidaemia, and insulin resistance (Adegboye et al., 2010). Recent longitudinal studies indicate that elevated cardiorespiratory fitness (CRF) in infancy correlates with reduced arterial stiffness and enhanced vascular function in adolescence, underscoring the need for early intervention to mitigate cardiovascular disease (CVD) risk (Wang et al., 2024; Guo & Wang, 2025). Adiposity, especially visceral fat accumulation, adversely affects cardiovascular health by inducing low-grade systemic inflammation and endothelial dysfunction, which facilitate the development of metabolic and cardiovascular disorders (Men et al., 2025; Green et al., 2024). Simultaneously, contemporary imaging and exercise physiology research indicate that both aerobic and resistance training can beneficially alter cardiac and vascular structures, enhancing left ventricular (LV) function and arterial compliance in youth populations (Perkins et al., 2023; Manojlović et al., 2023). The World Health Organization advises that children and adolescents participate in a minimum of 60 minutes of moderate-to-vigorous physical activity (MVPA) daily to enhance cardiovascular and metabolic health (Martin et al., 2018). Over 80% of teenagers worldwide do not adhere to this rule (Cai et al., 2017), highlighting the need for systematic interventions that may be effectively executed in educational institutions. Recent studies demonstrate that diverse exercise modalities, such as circuit-based and mixed-intensity aerobic programs, can induce advantageous cardiac adaptations without imposing excessive cardiovascular strain (Perkins et al., 2023; Green et al., 2024). A recent study that has examined the effects of recess (scheduled physical activity in schools) revealed significant disparities in physical activity intensity levels, ranging from moderate to vigorous, based on the children's gender, with boys achieving higher values than girls (Hellín-Martínez et al., 2021). Also, research conducted by Medina-Morales et al. (2022) concludes that 30% of kids exhibit cardio-metabolic risk based on the waist-to-height ratio and waist circumference ratio. Recent research on the impact of various sports on VO_{2max} in children and adolescents concluded that karate training yielded significantly superior outcomes in body composition for males, likely due to its nature as a high-intensity intermittent combat sport. Additionally, karate practice may result in greater excess post-exercise oxygen consumption and facilitate enhanced improvements in body composition. The swimming practice had superior results in VO_{2max} compared to the other groups, although karate did not vary from the no-practice group (Mercê et al., 2022). Neto et al. (2022) conducted a study examining the effects of blood pressure, heart rate, and rate pressure during high-intensity interval exercise versus continuous low-intensity exercise, revealed that high-intensity interval exercise induces greater cardiovascular stress. Data from prospective cohorts, randomized trials, and pooled analyses demonstrate that elevated physical activity and enhanced cardiorespiratory fitness in children correlate with improved arterial structure and decreased arterial stiffness indicators (e.g., pulse wave velocity). Aerobic and mixed exercise procedures enhance arterial compliance, with higher-intensity programs often yielding greater benefits. Initial enhancements in arterial stiffness may serve as a molecular route connecting physical activity to a subsequent reduction in cardiovascular disease risk (Sequi-Dominguez et al., 2023; Laitinen et al., 2025). Enhancements in cardiorespiratory fitness are among the most reliable results of physical activity treatments and provide beneficial alterations in blood pressure and vascular metrics.

Protocols used in school physical education or monitored after-school programs often exhibit clinically significant improvements in children, yielding more significant relative improvements in those with lower baseline fitness (Deng & Wang, 2024; Liang et al., 2025). On the other ide, recent echocardiographic and MRI studies in children and adolescents have demonstrated that consistent engagement in structured exercise programs results in beneficial alterations in left ventricular volumes, ejection fraction, and myocardial strain, indicative of early physiological cardiac remodelling (Wang et al., 2024; Santos-Beneit et al., 2023). These data indicate that such adaptations may arise even in healthy paediatric populations when exercise is administered regularly and well monitored. Schools serve as an optimal environment for the implementation of physical activity programs that improve cardiovascular fitness and promote enduring behavioural habits and social interaction (Mura et al., 2015). Incorporating standardized, evidence-based exercise interventions into school curriculum is a pragmatic, cost-effective approach to mitigate the increasing incidence of sedentary behaviour among kids (Manojlović et al., 2023).

Although there is a growing corpus of evidence connecting physical activity to enhanced cardiometabolic and vascular outcomes, few studies have explicitly investigated functional cardiac responses to organized, extracurricular exercise in children using echocardiography.

Objectives

The main objective of this research was to assess changes in cardiovascular functional parameters, following a structured 16-week exercise intervention among adolescents aged 11 to 16 years from five cities in Albania.

Methodology

Participants

From a total of 150 school-aged children between the ages of 9 and 16 (M = 12.94, SD = 1.41) (See table 1), only 140 (78 females and 62 males), have completed the intervention program and succeeded to do the second test measurements. After a random selection from five different cities, (elementary schools) (Ebasan, Shkodër, Vlorë, Pogradec and Tirana city) of Albania (The mandatory criteria for the schools were: to have at least 250 children in this group age and also to have available outdoor and indoor facilities for the implementation of the PE intervention program), in the end the final decision was made after their PE teacher agreed to be part of this project.

Procedure

Echocardiographic Procedures

Echocardiographic recordings and analyses of the cardiac chambers are conducted in accordance with the recommendations of the European Society of Echocardiography (Evangelista et al., 2008). Transthoracic echocardiography is performed by an experienced cardiologist, with all participants examined in the left-lateral decubitus position. A Philips Affinity 50 scanner equipped with S4-2 and S8-3 transducers is used for image acquisition. All echocardiographic data are digitally stored and analysed at the end of the study. Echocardiography parameters evaluated are: EDS, EDD, IVS, PW, LVEF, FS, LA. To minimize bias, echocardiograms are acquired and analysed with the operator blinded to group assignment and to whether the recordings are taken before or after the exhaustive exercise session. Linear measurements of the left ventricular (LV) myocardium and dimensions are obtained from parasternal long-axis views at end-diastole and end-systole, just below the level of the mitral valve leaflet tips. Fractional shortening is calculated as the change in LV diameter divided by the end-diastolic diameter. LV ejection fraction (EF) is determined using the biplane method of disk summation (Simpson's method), expressed as the percentage of blood volume ejected during systole. Color-coded Doppler imaging is used to assess all valvular orifices and vessels, enabling the identification of conditions such as regurgitation and stenosis. Mitral inflow velocities—peak early (E) and late (A) diastolic velocities are measured, along with early diastolic deceleration time. The E/A ratio is then calculated. The primary objective of the echocardiography is to assess the parameters in the pre- and post-Exercise Intervention. The same trained people and the same hospital setting conducted the measures, which are organized utilizing a shared timetable and occurred at Catholic University Hospital "Our Lady of the Good Counsel" in Tirana, over the weekends of April and May 2024.

The exclusion criteria included: involvement in structured exercise training within the last three months, engagement in supplementary leisure activities apart from physical education courses, medical contraindications to training, and/or cardiorespiratory or respiratory illnesses. Participants are directed to adhere to their usual daily routines and refrain from engaging in any additional organized physical activities outside from physical education sessions. All children and their parents are apprised of the experimental methods and furnished with signed informed consent prior to participation. Also, the study obtained the approval from the national commissioner for the right to information and protection of personal data, in Albania also from the Ministry of Education and Sports, and Sport University of Tirana, Ethical Committee.

Exercise intervention program

Participants engaged in a supplementary physical activity program five times per week (Monday to Friday) for 16 weeks, with each session lasting 1.5 to 2 hours, after the conclusion of conventional physical education school hours. Standard physical education lessons for grades 1-12, as stipulated in Article 6 of Law 79/2017 "Law for Sport," consist of three hours per week. A systematic 16-week, school-based exercise intervention was conducted to assess cardiovascular functional changes in adolescents aged 11 to 16 years. The training intensity was maintained at or below 70% of the age-predicted maximum heart rate (HRmax) over the whole program to guarantee mild cardiovascular strain and safety. Each session consisted of a 10-minute warm-up, a 70–90-minute primary activity segment, and a 5–10-minute cool-down. The program incrementally increased overall effort every four weeks by systematically expanding exercise time and circuit repetitions, while maintaining moderate intensity. The intervention aimed to enhance essential cardiovascular functional measures (See tables, 1. 2. 3).

Monitoring and safety

- Heart Rate Control: Heart rate was continually monitored using manual wrist pulse assessments every 15 to 20 minutes.
- HR Formula: 70% × (220 - age) beats per minute.
- Perceived exertion: Was sustained between 11 and 13 on the Borg Scale ("light to somewhat hard").
- Supervision: Physical education teacher.
- Hydration: Implement scheduled breaks every 20 to 25 minutes.
- Environment: Conducted in school indoor or outdoor facilities, depending upon weather conditions.

Table 1. One session structure

Phase	Duration	Main Activities	Target Intensity	Purpose
Warm-Up	10 min	Brisk walking, light running, dynamic joint mobility, active and passive stretching	50% HRmax	Gradual cardiovascular activation
Main Exercise Block	70–90 min	Aerobic drills, functional circuit training, rhythmic games, endurance-based activities	60–70% HRmax	Enhance cardiac output and functional capacity
Cool-Down	5–10 min	Slow walking, breathing and relaxation exercises, static stretching	≤ 50% HRmax	Facilitate recovery and autonomic rebalancing

Table 2. Program progression

Stage	Weeks	Focus	Weekly Workload	Key Components	Progression Method
Stage 1 – Adaptation	1–4	Develop coordination and aerobic base	~180 min/week	Brisk walking, jogging, simple circuits (bodyweight squats, lunges, step-ups, rope skipping)	Establish exercise technique, HR ≤ 60% HRmax
Stage 2 – Development	5–8	Increase aerobic endurance and muscular stamina	~210 min/week	4–6-station aerobic circuit (push-ups, planks, skipping, side lunges, balance drills)	Extend duration and add light resistance
Stage 3 – Consolidation	9–12	Improve cardiovascular efficiency and pacing	~240 min/week	Mixed circuits, aerobic intervals (4 × 4 min at 65–70% HRmax), cooperative games	Increase rounds or duration of continuous sets
Stage 4 – Optimization	13–16	Maintain adaptation, prepare for post-testing	~270 min/week	Sustained jogging/walking sets (30 min), rhythmic games, medicine-ball and resistance-band exercises	Maintain HR ≤ 70% HRmax; expand total workload

The program was executed with minimum equipment (cones, mats, skipping ropes, resistance bands, medicine balls) and used existing school infrastructure, necessitating no further financial resources. The structure and intensity guaranteed safety and compliance among participants, indicating significant potential for scalable, cost-effective implementation in school-based cardiovascular health initiatives.

Table 3. References Supporting the Exercise Program Framework

Design Aspect	Primary Supporting Sources
Duration (16 weeks) & 4-week progression	Manojlović et al., 2023; Perkins et al., 2023
HR ≤ 70 % HRmax (moderate intensity)	Forså et al., 2023; Green et al., 2024
School-based feasibility & adherence	Santos-Beneit et al., 2023; Manojlović et al., 2023
Echocardiographic outcome targets (LVEF, SV)	Perkins et al., 2023; Wang et al., 2024
Recovery / HRV & parasympathetic balance	Dias et al., 2021
Mechanistic underpinning (physiological remodelling)	Cheng 2025; Green 2024
Effect magnitude expectations	Men et al., 2025; Guo & Wang, 2025

Results

A total of 140 children (78 females and 62 males) aged between 9 and 16 years (M = 12.94, SD = 1.41) participated in the study (See Table 4). Descriptive statistics are calculated to assess changes in heart-related physiological parameters (See Table 5).

Table 4. Subjects mean age

Group		Age (years)
Total	N	140
	Minimum	9
	Maximum	16
	Median	13.00
	Mean	12.94
	Std. Error of Mean	.119
	Std. Deviation	1.405

Table 5. Measured heart-related physiological parameters and their results as follow

	EDS_Pre	EDS_Post	EDD_Pre	EDD_Post	IVS_Pre	IVS_Post	PW_Pre	PW_Post
N	140	140	140	140	140	140	140	140
Mean	27.02	27.14	44.35	44.496	8.827	8.833	7.78	7.80
Median	27.00	27.00	44.00	44.000	9.000	9.000	8.00	8.00
Std. Error of Mean	.141	.178	.206	.2124	.0647	.0658	.045	.051
Range	12	22	13	14.0	4.0	4.0	3	3
Std. Deviation	1.808	2.278	2.637	2.7198	.8287	.8401	.576	.57

Results of heart-related physiological parameters

End-Diastolic Size (EDS)

Mean EDS values remained stable between pre-test (M = 27.02, SD = 1.81) and post-test (M = 27.14, SD = 2.28). The 95% confidence intervals overlapped substantially, ranging from [26.74, 27.30] pre-intervention to [26.75, 27.32] post-intervention. Skewness and kurtosis values indicated a modest right-skewed distribution with some peaking, which remained consistent over time. These results suggest no clinically significant change in EDS during the study period.

End-Diastolic Dimension (EDD)

Pre-intervention EDD had a mean of 44.35 mm (SD = 2.64), increasing slightly to 44.50 mm (SD = 2.73) post-intervention. Confidence intervals ranged from [43.94, 44.76] and [44.08, 44.92], respectively. The distributions showed mild positive skew (0.96–0.97), with low kurtosis. This negligible increase in EDD suggests stability in ventricular chamber size during diastole, with no signs of pathological dilation or remodeling. The data indicate no clinically meaningful change in EDD during the research period.

Interventricular Septum Thickness (IVS)

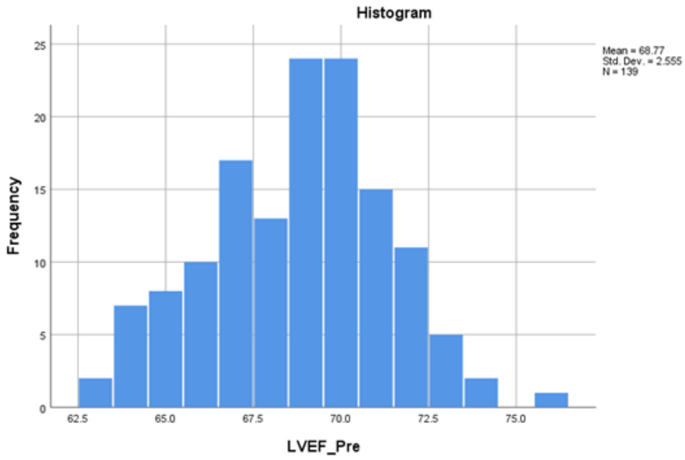
IVS measurements showed minimal change, from M = 8.83 mm (SD = 0.83) to M = 8.83 mm (SD = 0.84). The overlapping confidence intervals ([8.70, 8.96]) and symmetric distribution (skew ≈ 0.20–0.23; kurtosis ≈ -0.25 to -0.29) indicate no structural thickening or hypertrophy of the septal wall over the course of the study. The data indicate no clinically meaningful change in IVS during the research duration.

Posterior Wall Thickness (PW)

Mean PW thickness is 7.78 mm (SD = 0.58) pre-intervention and 7.80 mm (SD = 0.57) post-intervention. The data distribution is significantly negatively skewed (skew = -2.28 pre; -2.45 post) and leptokurtic (kurtosis = 4.29 pre; 5.03 post. This ceiling effect suggests good myocardial wall thickness in the sample, with no observed hypertrophic progression. The analysis revealed no statistically or clinically significant changes in any of the four cardiac structural parameters during the study period. The results suggest that participants maintained stable cardiac structure—particularly in diastolic chamber size, septal, and posterior wall. The data indicate no clinically meaningful change in PW during the research period.

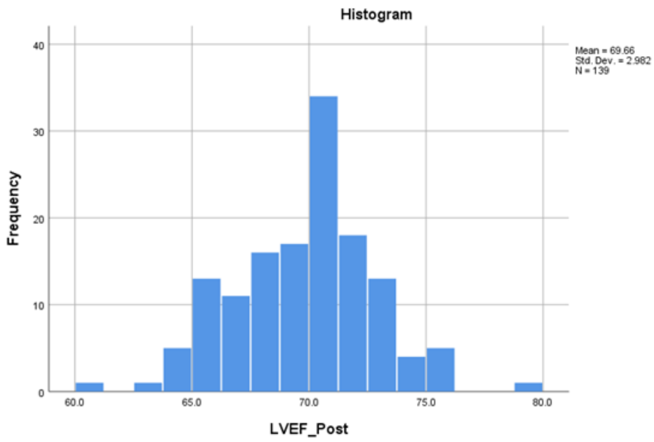
Left ventricular ejection fraction (LVEF)

Figure 1. The distribution of LVEF_Pre exercise intervention



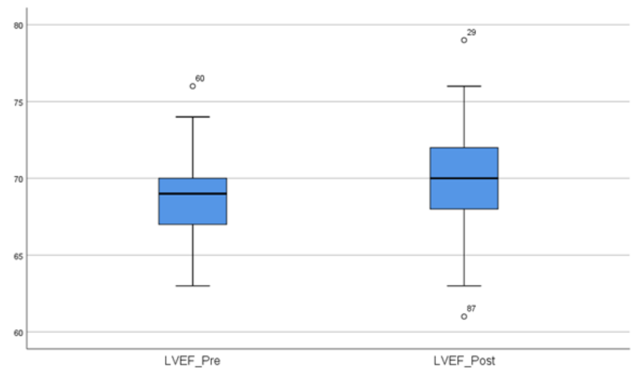
The distribution of LVEF_Post is also slightly skewed, but mostly normal and highly clustered near the mean (see Figure 1).

Figure 2. The distribution of LVEF_Post exercise intervention



The distribution of LVEF_Pre and Post exercise intervention is mostly normal as can be seen in figure 3 below.

Figure 3. The distribution of LVEF_ Pre and Post exercise intervention



The distribution of LVEF_Pre is slightly skewed, but mostly normal and highly clustered near the mean (see Figure 3)

Changes in LVEF

A paired samples t-test is also conducted to compare left ventricular ejection fraction (LVEF) before and after the intervention (see Table 6).

Table 6. t-test LVEF Pre and Post scores

Paired Samples Statistics					
		Mean	N	Std. Deviation	Std. Error Mean
Pair 1	LVEF_Pre	68.77	139	2.555	.217
	LVEF_Post	69.661	139	2.9822	.2529

Table 7. Paired Samples Test

		Paired Differences							
					95% Confidence Interval of the Difference				
		Mean	Std. Deviation	Std. Error Mean	Lower	Upper			
Pair 1	LVEF_Pre - LVEF_Post	-.8626	2.6890	.2281	-1.3136	-.4116	-3.782	138	.000

There is a significant increase in LVEF from pre-intervention (M = 68.77, SD = 2.56) to post-intervention (Table 6) (M = 69.66, SD = 2.98), $t(138) = -3.89$, $p < .0005$ (Table 7). A moderate positive correlation is observed between pre- and post-intervention LVEF values, $r(139) = .73$, $p < .001$, indicating acceptable stability of individual cardiovascular response to training. Nevertheles this improvement size indicates an consistency in individual cardiovascular responses, reflecting both stability and sensitivity to the training stimulus.

A paired-samples t-test was performed to assess left ventricular ejection fraction (LVEF) pre- and post-intervention (refer to Table 3). The findings indicated a statistically significant enhancement in LVEF from pre-intervention (M = 68.77, SD = 2.56) to post-intervention (M = 69.66, SD = 2.98), $t(138) = -3.89$, $p < .001$. The mean difference of –0.89 (95% CI [–1.34, –0.44]) indicates a small-to-moderate effect size, with Cohen's d = 0.33, suggesting that the intervention resulted in a significant enhancement in cardiac function. A significant positive correlation was observed between pre- and post-intervention LVEF values, $r(139) = .73$, $p < .001$, 95% CI [.64, .80], suggesting a large effect size. These finding underscores significant stability in individual cardiovascular responses to the intervention, while also indicating measurable sensitivity to training effects. Other echocardiographic parameters assessed concurrently, such as end-diastolic septal thickness (EDS), interventricular septum (IVS), and posterior wall (PW), did not exhibit statistically significant changes. The observed pattern indicates that the intervention primarily affected systolic function, as evidenced by LVEF, rather than causing wider structural changes during the study period.

Discussion

This research aimed to assess the effects of a 16-week organized physical activity intervention on cardiac function, particularly left ventricular ejection fraction (LVEF), in Albanian children and adolescents aged 11 to 16 years. The results demonstrate a statistically significant, if slight, enhancement in LVEF post-intervention, suggesting that consistent moderate-intensity exercise might elicit beneficial cardiac adaptations in healthy kids and may mitigate future cardiac risk. The heart dynamically reacts to exercise stimuli via a process termed exercise-induced cardiac remodelling. This research suggests that the intervention likely improved venous return during aerobic exercises, hence enhancing left ventricular preload. This physiological stress activates the Frank–Starling mechanism, enhancing myocardial fibre stretch and leading to more robust, efficient contractions and increased stroke volume. Furthermore, consistent aerobic exercise enhances myocardial capillary density, mitochondrial efficiency, and contractile function, hence improving systolic performance as shown by improved LVEF (Green et al., 2024). Exercise modifies the autonomic nervous system, enhancing parasympathetic (vagal) tone during rest and decreasing resting heart rate, perhaps facilitating increased diastolic filling time and enhanced cardiac output. Systematic reviews and meta-analyses including children and adolescents indicate enhanced heart rate variability (a measure of parasympathetic modulation) after consistent exercise engagement (Dias et al., 2021). Furthermore, puberty and sex affect the adaptation of the adolescent heart. Adolescent athletes exhibit gradual, sex-dependent remodelling, with men more often surpassing paediatric reference levels (Forså et al., 2023). The developmental factors indicate that the extent and kind of structural and functional cardiac adaptations to training differ over the examined age spectrum (Perkins et al., 2023; Forså et al., 2023). Our findings align with recent research indicating that organized physical activity initiatives in infancy and adolescence may yield significant enhancements in systolic function and cardiac deformation (Perkins et al., 2023; Luca et al., 2024). Perkins et al. (2023) shown that the adaptation of left ventricular twist mechanics in exercise-trained children becomes apparent during the teenage growth spurt, associating structural remodelling with functional mechanics post-maturation. The nature of adaptation—whether predominantly eccentric (endurance-type) or concentric (resistance/high-pressure)—is influenced by the type, intensity, and duration of training; recent mechanistic reviews consolidate these pathways and underscore the equilibrium between physiological (adaptive) and maladaptive stimuli (Cheng, 2025). These physiological reactions lead to an elevated stroke volume and, therefore, enhanced cardiac output. The small but considerable improvement in LVEF found in this research has substantial implications for the early prevention of cardiovascular disease. Despite the individuals being clinically healthy, superior cardiac function in youth may provide a basis for increased cardiorespiratory fitness (CRF) and reduced cardiometabolic risk in later life. Given that cardiorespiratory fitness (CRF) is a reliable predictor of cardiovascular and overall mortality in adulthood, encouraging regular physical exercise among school-aged children may function as a main preventative measure. In low- and middle-income nations like Albania, where sedentary habits among adolescents are increasing and access to organized sports may be restricted, school-based physical activity initiatives provide an equitable and scalable method to enhance cardiovascular health in young individuals. Additional evidence is provided by extensive meta-analyses indicating that exercise programs in children and adolescents diminish cardiovascular risk variables, including lipid and glucose profiles (Men et al., 2025). Furthermore, mechanistic investigations on humans and animals demonstrate that resistance and endurance exercise alter cardiac shape and function, resulting in enhancements in both systolic and diastolic performance (Green et al., 2024). Collectively, this body of data substantiates the hypothesis that the observed improvement in LVEF within our group likely signifies beneficial physiological response to our 16-week intervention rather than hidden disease.

Conclusions

This study's results demonstrate that a planned, school-based 16-week physical activity program resulted in a moderate although statistically significant enhancement in left ventricular ejection fraction

(LVEF) in children aged 11 to 16 years. The modest rise in LVEF, along with its constant direction and statistical significance, indicates a substantial improvement in heart efficiency over a short period. This impact, seen in a healthy paediatric group, highlights the ability of moderate-intensity aerobic exercise to provide early, quantifiable improvements in cardiovascular function. The intervention was executed in established school environments, necessitating little equipment, qualified physical education personnel, and no supplementary infrastructure, hence illustrating its considerable practicality and potential for extensive application. This pragmatism is especially pertinent in low- and middle-income settings, where access to extracurricular sports activities may be restricted. In addition to its physiological advantages, the program promoted student interest and consistent involvement, hence enhancing its sustainability within the educational setting. These findings demonstrate that even short, organized physical activity treatments may provide significant cardiovascular benefits at low cost and possess considerable scaling potential. To reinforce these results, further research should use bigger randomized controlled designs, include objective evaluation methods such as strain imaging or vascular stiffness measurements, and prolong follow-up periods to evaluate the sustainability of adaptations. Also, it is essential that the safety of cardiovascular reactions be the primary consideration prior to selecting an exercise regimen for implementation. Nonetheless, a nationwide initiative to include viable, evidence-based exercise programs in schools is necessary to be conducted as this process can serve as an effective tool to improve juvenile cardiovascular health and mitigate the long-term impact of sedentary lifestyles.

Limitations

This research has certain limitations that must be acknowledged when analysing the findings. The lack of a control group restricts the capacity to ascribe the observed enhancements in left ventricular ejection fraction (LVEF) exclusively to the intervention, since growth or environmental variables may have also played a role. The limited sample size for each location diminishes statistical power and constrains the generalizability of results to the broader young demographic. The brief intervention period may have only recorded initial functional changes instead of enduring structural remodelling. Disparities in program execution across cities and the absence of control for maturation or pubertal state may have resulted in variability in cardiovascular responses. These criteria indicate that the results should be regarded as preliminary and need validation by bigger, extended, and controlled studies.

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Authors' and translators' details:

Genti Pano	gpano@ust.edu.al	Autor/a
Denis Nuriu	dnuriu@ust.edu.al	Autor/a
Oltiana Petri	opetri@ust.edu.al	Autor/a
Anduela Lile	alile@ust.edu.al	Autor/a
Eva Muja	durakueva@yahoo.com	Autor/a
Artemis Bajaziti	abajaziti@ust.edu.al	Autor/a
Entela Kusshta	ekushta@ust.edu.al	Translator