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Examining Qualitative Changes in Physical Fitness and Body Composition in a School-Based Physical Literacy Intervention: Methodological and Practical Considerations

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Abstract

Studying qualitative changes is important in sport and exercise sciences because it reveals how different physical traits interact and develop together over time. This study aimed to explore how a physical literacy–based intervention (PL-intervention) affects the relationships between body composition and fitness indicators in preadolescent children. The participants were 112 children (9 to 11 years old, 50 girls), divided into a control group (C group, n=61) and an experimental intervention group (E group, n=51). They were tested in anthropometrics/body composition (height, mass, body fat, and skeletal muscle mass) and fitness indicators (assessing jumping power, abdominal and upper body strengths, mobility, flexibility, and cardiovascular endurance) at initial (September), final (December), and retention measurements (May). Between the initial and final measurements, the E-group participated in a structured physical literacy-based intervention (PL-intervention) delivered as a part of their regular physical education classes (PE), while the C-group participated in standard PE. To examine changes in the intervariable associations over time, correlation matrices were computed, while factor loading matrices were compared across measurement phases using Tucker's coefficient of congruence for each study group. During the course of the study, the C-group experienced certain qualitative changes, showing early signs of structural divergence. On the other hand, factor structures and correlations among variables for the E-group were similar across measurements, suggesting that the intervention helped maintain stable relationships between body composition and physical fitness variables. The results suggest that the applied intervention program supported coordinated and balanced physical development and showed that such programs may help children develop lasting and organized patterns of physical functioning.

Keywords: *curriculum, anthropometry, motor abilities, physical education, program evaluation*

Introduction

Preadolescence is a critical developmental period marked by rapid physical, cognitive, and social changes (Rowland, 2005). During this stage, monitoring physical fitness and body composition is essential, as it provides valuable insight into children's overall health trajectories and potential risk factors for chronic diseases (Rajkovic Vuletic et al., 2024). Global trends continue to show a rising prevalence of overweight and obesity in children, often linked to sedentary behavior, insufficient physical activity, and poor dietary habits (Masanovic et al., 2020). These issues are associated with serious physical health outcomes, including insulin resistance, increased cardiovascular risk, and orthopedic complications. Additionally, there is growing evidence that excess weight and low physical fitness are related to psychosocial difficulties, such as low self-esteem and reduced academic performance (Santana et al., 2017)

Low levels of physical fitness are recognized as strong predictors of future health, independent of body weight. Meanwhile, among children and adolescents, physical activity is the most important determinant of physical fitness (Lohman et al., 2008). Given that both physical activity and fitness levels tend to track from childhood into adolescence and adulthood, early identification and timely intervention are crucial. Schools and sports programs have therefore been recognized as key environments for promoting healthy behaviors and monitoring fitness trends (Marinho et al., 2022). As a result, many studies have examined fitness trends and the effectiveness of various school-based or sport-related fitness programs in pediatric populations (Rauner, Mess, & Woll, 2013). However, most of these studies focus primarily on quantitative changes evidencing improvements in absolute values of body composition or fitness indices (e.g., cardiorespiratory endurance, strength, power, flexibility) (Errisuriz, Golaszewski, Born, & Bartholomew, 2018; Kriemler et al., 2011)

While such metrics are fundamental for evaluating intervention effects and understanding growth patterns, they represent only one side of the adaptation process. In contrast, qualitative changes refer to shifts in the internal structure of relationships between variables (i.e., how fitness and body composition measures interact and reorganize over time). For example, two children may both show improved results in a beep test (commonly used to assess aerobic capacity), yet the underlying factors driving this improvement could differ, such as increased step length from growth, gains in muscular power, or enhanced cardiovascular function (Rowland, 2005). Qualitative analysis seeks to uncover these interactions and reveal how and why performance changes occur by examining the evolving relationships among the contributing variables. From the developmental perspective, this is highly important because functional improvements may take place without major changes in variable structure — and vice versa. Therefore, a research focus on qualitative structure could provide a more comprehensive understanding of adaptation and physical development.

In other words, analyzing qualitative changes allows researchers and practitioners to "look beyond outcome measures" and investigate how a system as a whole adapts. In this context, it involves evaluating whether specific fitness and body composition variables become more or less connected over time, whether associations between variables strengthen or weaken, and whether new relationships emerge. These structural changes may reflect underlying shifts in motor control, neuromuscular coordination, or metabolic function, all of which are important for long-term health and physical competence. For instance, if improved aerobic capacity becomes increasingly related to lean muscle mass rather than just reduced fat mass, it may indicate a more efficient or robust physiological adaptation. Methodologically, such insights can be gained by comparing correlation matrices or factor structures of selected variables across different time points (e.g., before and after the intervention). These methods can also detect delayed or latent effects that may not be visible through performance outcomes alone. Ultimately, qualitative analysis offers a deeper understanding of adaptation mechanisms, durability of change, and individual variability in response to physical education and training.

In recent years, physical literacy has emerged as a promising framework for promoting lifelong engagement in physical activity and, in turn, supporting fitness development (Carl et al., 2023; Gilic, Sekulic, Munoz, Jaunig, & Carl, 2025; Lilic et al., 2024; Rajkovic Vuletic et al. 2026). In general, physical literacy goes beyond physical competence alone; it incorporates motivation, confidence, knowledge, and understanding of movement, encouraging children to value and maintain active lifestyles (Kesic et al., 2022; Sunda et al., 2022; Whitehead, 2013). Because childhood is a sensitive period for both motor development and behavior formation, physical literacy–based interventions can play a key role. Unlike traditional programs that often target isolated physical capacities, physical literacy emphasizes the development of coordinated, adaptable movement patterns that may help sustain long-term functional balance. As such, physical literacy interventions have the potential to support not only measurable performance gains but also the stability and reorganization of deeper structural dimensions related to body composition and fitness.

Studies have frequently examined the quantitative effects of physical literacy interventions and have shown promising results (Carl et al., 2022, Rajkovic Vuletic et al., 2026). However, there is an evident lack of studies that have evidenced structural/qualitative changes in specific variables as a result of physical literacy intervention in children. Therefore, the aim of this study was to investigate how a physical literacy-based intervention influences the relationships between body composition and physical fitness in preadolescent children. Specifically, the study explored whether the intervention led to qualitative changes by comparing structural relationships over time between an experimental group and a control group. Through this approach, we aimed to assess whether physical literacy education supports more coordinated and enduring physical development.

Methods

Participants

The sample of participants consisted of 112 preadolescent children (50 girls) from southern Croatia. At the time of data collection, the participants were between 9 and 11 years old and were enrolled in either the 3rd (n=71) or 4th grade (n=48) of elementary school (two schools in total). All the children were in good health and attended physical education (PE) classes on a regular basis. Those who had been ill or who had sustained a musculoskeletal injury within two weeks prior to testing were excluded. Before participation, parents or legal guardians were informed about the study objectives and procedures, and parental written consent was obtained. The research protocol was preapproved by the Ethics Committee of the Faculty of Kinesiology, University of Zagreb. The total sample was divided into a control group (n=60) and an experimental group (n=52) similarly across both schools included in the study.

Variables

Variables included a set of anthropometric/body composition indices and a set of physical fitness tests.

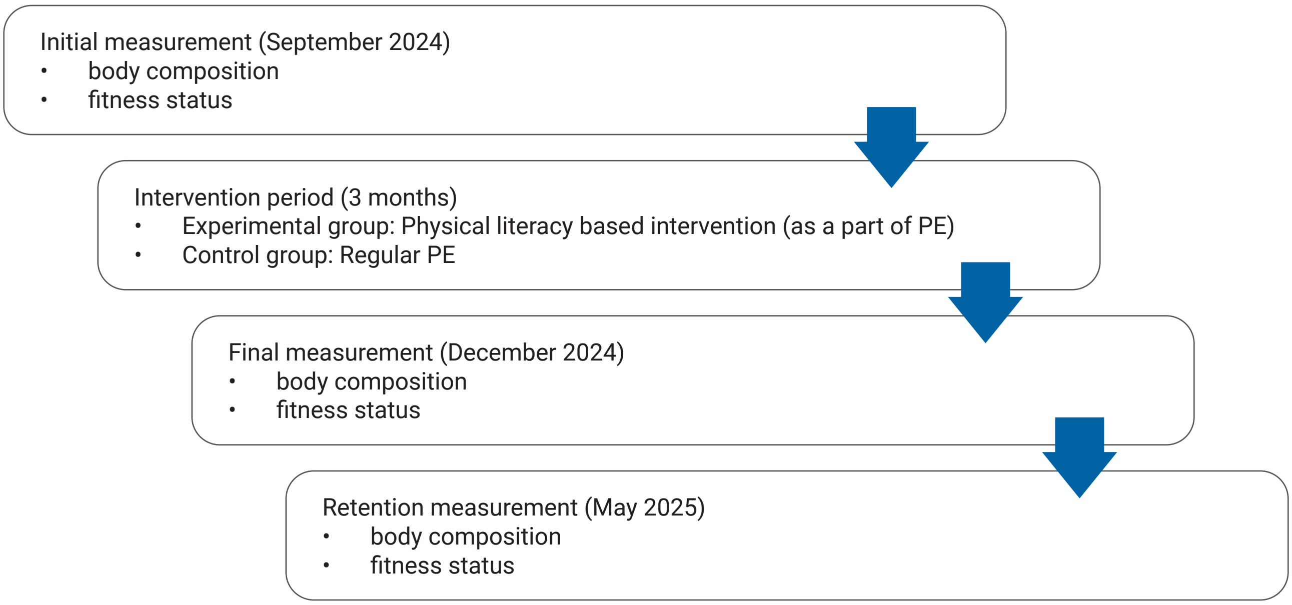
Anthropometrics included body height (measured by stadiometer in 0.5 cm) and body mass (measured in 0.1 kg by Tanita measuring scale. Body composition measures included body fat and skeletal muscle mass (both in % of body mass) by a bioelectrical impedance analyzer (Tanita TBF-300, Tokyo, Japan).

Physical fitness (PF) was assessed using selected tests evaluating aerobic endurance, muscular strength and endurance (abdominal and upper body), torso extensor strength and flexibility, overall flexibility, and jumping power. Aerobic endurance was measured using the 15-meter multistage fitness test (Beep test), which includes 21+ levels, each consisting of multiple 15-meter running intervals. Participants ran between two cones, turning and touching the line at each beep. The test ended when they could no longer reach the line in time; the final score reflected the highest level completed. Upper body strength and endurance were evaluated using the push-up test (Push-ups). From a plank position, participants lowered themselves until elbows reached a 90° angle and then returned to full extension while maintaining a straight body line. The number of correctly performed repetitions was recorded. Abdominal strength and endurance were assessed using the sit-up test (Sit-ups), where participants performed as many correct sit-ups as possible (up to a maximum of 75). Each correctly executed repetition was scored. Torso extensor strength and flexibility were measured with the torso lift test (Torso lift), in which participants raised their upper back (cervical and thoracic spine) from the floor to the maximum controllable height, keeping the head aligned with the spine. Flexibility of the lower back and hamstrings was assessed using the sit-and-reach test (Sit-reach). Seated with legs extended, participants reached forward along a measuring box, holding the position for at least two seconds. The best of three trials was used. The explosive strength was measured with the standing long jump test (broad jump). Participants jumped forward barefoot from a standing position onto a standardized mat (ELAN, Begunje, Slovenia), and the best of three jumps (in centimeters) was recorded.

Intervention

Participants were assessed at three time points: initial measurement (September 2024), final measurement (late December 2024), and retention measurement (May 2025). The intervention was conducted between the initial and final assessments. An overview of the study timeline is presented in Figure 1.

Figure 1. Timeline of the study



The educational intervention, focused on PL, was implemented within the existing PE schedule for the experimental group over a 12-week period. During this time, students received three PE sessions weekly, amounting to a total of 36 lessons. The intervention incorporated 12 short, original educational videos (3–4 minutes each), each addressing a key topic related to PL or physical health. The video content was organized into the following themes: two videos covered core PL principles (e.g., movement motivation, confidence, and understanding), three focused on cardiorespiratory fitness, five targeted motor abilities (strength, power, coordination, flexibility), and two addressed general health habits, including nutrition. Each video was shown three times to reinforce learning and ensure knowledge retention. More details on educational intervention and video materials are available elsewhere (please see supplementary materials in published study of Rajkovic Vuletic et al., 2026).

Statistics

To examine changes in the intervariable relationships over time, correlation matrices were computed for each measurement phase within both the control and experimental groups. Jennrich's test was used to statistically assess differences between correlation matrices obtained from repeated measurements on the same participants (Jennrich, 1970; Steiger, 1980).

To assess the stability and reorganization of latent factor structures, exploratory factor analysis was performed using the Varimax rotation method and the Guttman–Kaiser criterion for factor extraction (Kaiser, 1958). Factor loading matrices were compared across measurement phases using Tucker's coefficient of congruence (Lorenzo-Seva & Ten Berge, 2006). Congruence values above 0.85 were interpreted as reflecting good structural similarity, while values above 0.95 indicated near-identity. In comparisons involving a different number of factors across phases (e.g., 3 vs. 2), only the leading shared number of factors was compared to ensure interpretability. All matrix and factor comparisons were conducted separately for the control and experimental groups to determine the extent to which the intervention influenced structural stability or reorganization.

Results

Table 1 presents the Pearson's correlation coefficients calculated between study variables in the initial, final and retention measurements for the control group. Meanwhile, correlations between study variables for the experimental group are shown in Table 2.

Table 1. Correlations between study variables in the initial, final, and retention measurements for the control group (*denotes significance of p<0.05)

		1	2	3	4	5	6	7	8	9
	Initial	-								
Broad jump (1)	Final	-								
	Retention	-								
	Initial	0.47*								
Push-ups (2)	Final	0.41*								
	Retention	0.44*								
	Initial	0.32*	0.28*							
Sit-ups (3)	Final	0.42*	0.47*							
	Retention	0.32*	0.33*							
	Initial	0.04	0.04	0.11						
Trunk lift (4)	Final	0.18	-0.05	-0.12						
	Retention	0.13	0.05	0.14						
	Initial	0.08	0.05	0.33*	0.15					
Sit-reach (5)	Final	0.16	0.11	0.13	0.31*					
	Retention	0.14	0.03	0.18	0.29*					
	Initial	0.51*	0.51*	0.17	0.13	-0.16				
Beep test (6)	Final	0.23*	0.17	0.10	0.00	-0.10				
	Retention	0.10	0.05	-0.08	-0.22*	-0.05				
	Initial	0.06	-0.41*	0.13	0.02	0.16	-0.23*			
Height (7)	Final	0.12	-0.35*	-0.05	0.24*	0.20	0.04			
	Retention	-0.03	-0.41*	-0.01	-0.04	0.10	0.11			
	Initial	-0.37*	-0.42*	-0.18	0.05	-0.07	-0.28*	0.43*		
Mass (8)	Final	-0.36*	-0.45*	-0.35*	0.18	0.05	-0.15	0.64*		
	Retention	-0.41*	-0.48*	-0.28*	0.01	0.05	-0.03	0.65*		
	Initial	-0.70*	-0.52*	-0.26*	0.10	0.10	-0.52*	0.19	0.64*	
Body fat (9)	Final	-0.63*	-0.44*	-0.41*	0.12	0.08	-0.24*	0.23*	0.81*	
	Retention	-0.17	-0.09	-0.09	0.03	0.02	-0.06	0.12	0.26*	
	Initial	0.70*	0.52*	0.26*	-0.10	-0.10	0.51*	-0.19	-0.64*	-0.98*
Muscle mass (10)	Final	0.63*	0.44*	0.41*	-0.12	-0.09	0.24*	-0.23*	-0.81*	-0.98*
	Retention	0.65*	0.45*	0.29*	-0.09	-0.21*	0.12	-0.19	-0.75*	-0.33*

Table 2. Correlations between study variables in the initial, final, and retention measurements for the experimental group (*denotes significance of p<0.05)

		1	2	3	4	5	6	7	8	9
Broad jump (1)	Initial	-								
	Final	-								
	Retention	-								
Push-ups (2)	Initial	0.54*								
	Final	0.31*								
	Retention	0.60*								
Sit-ups (3)	Initial	0.30*	0.39*							
	Final	0.46*	0.25							
	Retention	0.48*	0.26							
Trunk lift (4)	Initial	0.36*	0.11	0.23						
	Final	0.08	0.07	0.02						
	Retention	0.19	-0.05	0.26						
Sit-reach (5)	Initial	0.16	0.04	0.20	0.42*					
	Final	0.18	-0.12	0.20	0.37*					
	Retention	0.24	-0.10	0.36*	0.46*					
Beep test (6)	Initial	0.55*	0.47*	0.25	0.20	-0.09				
	Final	0.60*	0.34*	0.37*	-0.03	-0.02				
	Retention	0.57*	0.71*	0.41*	0.04	-0.17				
Height (7)	Initial	-0.19	-0.41*	0.26	0.28	0.29	-0.10			
	Final	-0.28*	-0.12	0.17	0.26	0.24	-0.27*			
	Retention	-0.31*	-0.46*	0.07	0.28	0.24	-0.46*			
Mass (8)	Initial	-0.36*	-0.45*	0.16	0.07	0.16	-0.34*	0.78*		
	Final	-0.44*	-0.13	-0.01	0.33	0.09	-0.44*	0.83*		
	Retention	-0.44*	-0.43*	-0.17	0.19	0.07	-0.55*	0.80*		
Body fat (9)	Initial	-0.49*	-0.60*	-0.07	-0.07	0.12	-0.54*	0.45*	0.82*	
	Final	-0.65*	-0.21	-0.29*	0.33*	0.18	-0.61*	0.62*	0.82*	
	Retention	-0.48*	-0.56*	-0.25	0.13	0.16	-0.65*	0.58*	0.85*	
Muscle mass (10)	Initial	0.22	0.40*	-0.05	-0.29*	-0.27*	0.37*	-0.40*	-0.48*	-0.55*
	Final	0.62*	0.20	0.22	-0.34*	-0.11	0.63*	-0.63*	-0.86*	-0.96*
	Retention	0.48*	0.55*	0.25	-0.13	-0.16	0.65*	-0.58*	-0.85*	-0.98*

In the control group, the comparison between the initial and final correlation matrices revealed no significant change in the structure of intervariable relationships. Jennrich's test result was $\chi^2(45)=29.82$, $p=0.960$, indicating a very high similarity in the pattern of correlations before and after the study period. This suggests that the control group, which did not receive an intervention, maintained stable relationships among body composition and performance variables. The most notable individual changes occurred in correlations involving the Beep test, such as with Push-ups (+0.33), Broad jump (+0.28), and Body fat (+0.28). Despite these fluctuations, the overall matrix structure remained intact. For the experimental group, the initial-to-final comparison showed signs of reorganization, although it did not reach statistical significance. Jennrich's test yielded $\chi^2(45)=55.45$, $p=0.137$. The largest changes occurred in key physiological relationships, especially body fat vs muscle mass (+0.41), trunk lift vs body fat (+0.41), and broad jump vs muscle mass (+0.40). These shifts point to the intervention's impact on how variables interact structurally, even if not yet confirmed statistically at the matrix level.

From final test to retention, the control group showed a statistically significant restructuring of intervariable relationships. Jennrich's test yielded $\chi^2(45)=72.61$, $p=0.0056$, confirming that the correlation structure changed meaningfully. This was especially evident in changes involving body fat, which shifted strongly in its correlation with muscle mass (+0.67), mass (+0.55), and broad jump (+0.46). In contrast, the experimental group showed no significant matrix-wide change from the final test to retention. Jennrich's test resulted in $\chi^2(45)=42.57$, $p=0.575$. Nonetheless, some moderate pairwise shifts were observed — particularly involving push-ups, whose correlations with the Beep test (+0.36), muscle mass (+0.35), and height (cm) (+0.34) increased.

Over the longer period from initial testing to retention, the control group experienced a clear and statistically significant alteration in its correlation structure. Jennrich's test yielded $\chi^2(45)=72.61$, p=0.0056 — identical to the Final–Retention comparison. The strongest pairwise changes again involved body fat, especially its links to muscle mass (+0.67), broad jump (+0.53), and push-ups (+0.43). The experimental group maintained statistical stability in its intervariable relationships over the full study period. Jennrich's test yielded $\chi^2(45)=42.57$, p=0.575, indicating no significant deviation from the initial correlation structure. Nevertheless, notable pairwise changes included body fat (%) vs muscle mass (+0.45), mass vs muscle mass (+0.37), and height (cm) vs Beep test (+0.36).

The results of the factor analyses calculated in the initial, final and retention measurements for the control group are presented in Table 3. Jennrich's test comparison shows no significant change in the control group's factor structure between the initial and final measurements. However, Tucker's coefficient of congruence indicates partial similarity. Notably, Initial F3 vs Final F2=0.977, and Initial F2 vs Final F3=0.954. One factor (Initial F1) showed lower similarity (~0.72), suggesting partial restructuring. Strong similarity was observed between final and retention factor structures in the control group. Final F2 vs Retention F2=0.977 and Final F3 vs Retention F3=0.955, indicating good preservation of structure.

Table 3. Factor analysis calculated for the initial, final and retention measurements for the control group (F – factor structure)

	Initial measurement				Final measurement			Retention measurement		
	F1	F2	F3	F4	F1	F2	F3	F1	F2	F3
Broad jump	-0.85	0.11	0.15	0.14	-0.77	0.31	0.27	0.83	0.18	0.06
Push-ups	-0.57	0.15	-0.49	0.25	-0.58	-0.33	0.32	0.58	0.14	-0.42
Sit-ups	-0.37	0.66	0.14	0.16	-0.56	-0.11	0.32	0.53	0.43	0.02
Trunk lift	0.10	0.14	0.00	0.88	0.05	0.44	0.51	-0.02	0.74	-0.08
Sit-reach	0.11	0.88	0.03	0.05	0.02	0.11	0.83	0.08	0.68	0.25
Beep test	-0.65	-0.23	-0.16	0.46	-0.43	0.42	-0.37	0.32	-0.48	0.38
Height	0.04	0.14	0.93	-0.04	0.19	0.85	0.13	-0.08	0.02	0.91
Mass	0.55	-0.22	0.58	0.19	0.75	0.53	0.06	-0.62	0.06	0.67
Body fat	0.94	0.01	0.17	0.11	0.93	0.12	0.09	-0.39	0.17	0.08
Muscle mass	-0.94	0.00	-0.16	-0.11	-0.93	-0.12	-0.09	0.84	-0.21	-0.25
Explained Variance	3.69	1.39	1.57	1.15	3.79	1.64	1.40	2.66	1.56	1.75
Proportion Total	0.37	0.14	0.16	0.11	0.38	0.16	0.14	0.27	0.16	0.17

The results of the factor analysis calculated for the experimental group are shown in Table 4. The factor structure remained very stable in the experimental group from the initial to final measurements. Tucker's coefficient showed initial F1 vs final F1=0.986 and F3 vs F2=0.883. Only one dimension had a weaker match, suggesting minimal structural change postintervention. Moderate-to-strong similarity was observed in the experimental group between the initial and retention phases. F2 matched well (≈0.883), and F1 showed fair congruence (~0.754), supporting structural consistency. Final and retention factor structures were highly congruent in the experimental group. Tucker's coefficients: F2≈0.883 and F1≈0.754, indicating strong consistency across phases.

Table 3. Factor analysis calculated for the initial, final and retention measurements for the control group (F – factor structure)

	Initial measurement			Final measurement			Retention measurement	
	F1	F2	F3	F1	F2	F3	F1	F2
Broad jump	-0.38	0.37	0.63	-0.55	0.60	0.33	-0.61	0.56

(continued from previous page)

Table 3. Factor analysis calculated for the initial, final and retention measurements for the control group (F – factor structure)

	Initial measurement			Final measurement			Retention measurement	
	F1	F2	F3	F1	F2	F3	F1	F2
Push-ups	-0.46	0.06	0.68	-0.04	0.71	-0.29	-0.73	0.19
Sit-ups	0.36	0.13	0.75	-0.04	0.75	0.22	-0.28	0.73
Trunk lift	0.06	0.81	0.23	0.35	0.15	0.60	0.19	0.72
Sit-reach	0.14	0.79	0.00	0.08	0.01	0.89	0.21	0.74
Beep test	-0.28	-0.01	0.74	-0.52	0.61	0.05	-0.79	0.23
Height	0.85	0.22	0.10	0.82	0.18	0.19	0.76	0.31
Mass	0.94	0.04	-0.12	0.95	0.02	0.05	0.88	0.09
Body fat	0.76	0.01	-0.47	0.90	-0.31	0.09	0.92	0.01
Muscle mass	-0.51	-0.49	0.36	-0.92	0.26	-0.05	-0.92	0.00
Explained Variance	3.03	1.72	2.39	3.96	2.03	1.45	4.75	2.09
Proportion Total	0.30	0.17	0.24	0.40	0.20	0.14	0.48	0.21

Discussion

This study aimed to evaluate eventual qualitative changes in studied anthropometric/body composition and physical fitness indices in preadolescent children as a result of physical literacy-based education (intervention). The results indicated several important findings. First, the control group, which did not participate in physical literacy-based educational intervention, experienced certain qualitative changes, showing early signs of structural divergence. Meanwhile, factor structure and correlations among variables in the experimental group were negligible, indicating that the applied intervention supported foundations for sustainable, self-directed physical development.

Qualitative changes in the control group

As stated previously, the control group showed early signs of structural divergence. Specifically, from the initial to the final measurement, no statistically significant changes in the correlation matrix were observed, but several subtle shifts pointed to early disorganization in intervariable relationships. These changes likely reflect natural developmental variability, including growth, hormonal changes, and differences in unstructured activity levels. In explaining the background for these results, the context of the research should be briefly presented.

The study was performed during one school year, with initial testing performed in September, final testing in December, and retention testing in May. It is well known that during this period, a significant decrease in physical activity regularly occurs due to unfavorable weather conditions and increased academic pressure (Frömel, Šafář, Jakubec, Groffik, & Žatka, 2020; Kibbe et al., 2011). Therefore, it is reasonable to expect that without the support of a specifically designed and applied structured program oriented toward increasing (or at least retaining) the level of physical activity, internal physiological relationships may evolve inconsistently. Of particular note were shifts involving fat mass and muscular performance variables, where previously aligned patterns became weaker or more inconsistent, which almost certainly indicate fragmentation of physiological properties. It is important to note that such early signs of disintegration suggest that, even in relatively short periods, physiological systems may become less cohesive when not intentionally supported.

This trend continued and even increased in the control group during the retention phase. These dynamics were actually logical knowing the longer period between final and retention testing (five months) in comparison to the period between initial and final measurement (three months). Specifically, between the final and retention measurements, the group exhibited statistically significant changes in the correlation matrix. This clearly signals a substantial reorganization of internal relationships between anthropometric/body composition and physical fitness indices. In other words, it seems that without ongoing stimulus, previously established functional linkages between body composition and fitness began to deteriorate. The breakdown of these patterns, especially among fat mass, muscle mass, and fitness indicators, reflects a loss of physiological coordination and coherence. Such structural disorganization is not unexpected in growing children without consistent physical activity, and this is particularly possible in the winter period where previously specified factors of negative influence on physical activity are practically unavoidable (Carson & Spence, 2010).

(Lack of) qualitative changes in the experimental group

The experimental group demonstrated a markedly different pattern than the control group across all phases. First, between the initial and final measurements, no significant changes in the internal correlation structure were detected. Generally, differences between the corresponding correlation coefficients calculated for the initial and final measurements were negligible, indicating similar structures in both testing phases (e.g., September and December). Therefore, it can be said that due to exposure to a targeted physical literacy–based intervention, the relationships among key variables remained highly stable and internally coherent. This suggests that the educational program helped to reinforce existing physiological linkages. If we consider that the 2nd study phase (from final to retention measurement) lasted longer than the previous phase (five months in comparison to three months) and that during the 2nd phase, the experimental group did not receive any intervention, it is of particular importance that in this period, structural coherence was maintained, with no evidence of regression or fragmentation. This enduring alignment among body composition and performance variables implies that the benefits of the intervention extended beyond its active duration, resulting in lasting physiological organization. These findings align with the goals of physical literacy, which emphasize autonomy, competence, and sustainable movement patterns rather than short-term gains.

Indeed, by fostering a deeper understanding of movement and encouraging consistent engagement, the educational physical literacy programs applied here aimed to build durable motor patterns and internal motivation that support long-term physical development. In this context, the structural stability observed in our study reflects the formation of resilient, self-sustaining systems rooted in meaningful and developmentally appropriate activity. In other words, the observed “lack” of qualitative changes in the experimental group between the final and retention measurements suggests that the intervention supported the development of coordinated, transferable movement skills and physiological efficiency that remained intact even without continued instruction. Collectively, this suggests that by focusing on meaningful engagement, movement understanding, and confidence, the applied intervention may have enabled participants to internalize key aspects of physical functioning, leading to self-sustained physical adaptation. In this way, physical literacy acts not only as a pedagogical framework but also as a mechanism for stabilizing internal systems, allowing children to maintain balanced development across body composition and fitness domains.

The calculated factor analyses further support previous interpretations. In brief, the control group exhibited notable instability in factor structure across study phases, especially between the initial and retention measurements. Shifts in factor loadings and lower Tucker congruence coefficients suggest that the relationships among latent constructs became increasingly unstable without structured support. In contrast, the experimental group displayed high factorial stability throughout. Tucker’s coefficients reflected strong to near-identical alignment across all three measurement phases. This is particularly evident from the initial to final measurements. Variables related to body composition and functional performance consistently loaded on the same factors, reflecting a well-integrated and resilient internal structure. These findings illustrate that the intervention actually preserved and reinforced the latent architecture of physical development.

Final considerations

One could find surprising that the experimental group, despite participating in a structured intervention, showed relatively few changes in the internal structure of fitness and body composition variables. However, this stability of structure should not be seen as a lack of adaptation but rather as a positive indicator of functional consolidation. In a developmental stage characterized by rapid physical changes and natural variability, maintaining consistent intervariable relationships suggests that the system has adapted in a stable and organized manner. Structural stability, in this case, reflects efficiency and resilience, the body's ability to improve or maintain performance without disrupting underlying physiological coordination. In this context, the underlying physiological coordination refers to the natural and functional relationships between body composition (such as muscle mass, fat mass, and overall body size) and performance in physical fitness tasks. For example, higher skeletal muscle mass typically supports better outcomes in strength- and power-based tests such as push-ups or broad jumps, while excessive fat mass may negatively affect endurance or mobility. These relationships reflect how the body’s structural components contribute to movement efficiency, force production, and energy expenditure. When these interactions remain consistent over time, the body adapts in an organized and balanced way by maintaining a logical and efficient link between body dimensions and fitness performance. Such outcomes are especially valuable in youth, where coherent development across systems is a key marker of long-term physical and functional health. Therefore, the absence of significant structural change may be interpreted not as resistance to the intervention but as a desirable outcome of adaptive integration.

This interpretation is further supported by the nature of the applied intervention, which was grounded in the concept of physical literacy. Rather than focusing narrowly on fitness gains, the intervention emphasized movement competence, motivation, and the understanding of physical activity as a lifelong practice. Suggested activities were designed to be developmentally appropriate, engaging, and varied while encouraging children to explore, refine, and connect movement patterns across domains. This broad and inclusive approach likely contributed to the preservation of systemic organization, helping the experimental group internalize stable relationships between body composition and performance. In line with the philosophy of physical literacy, the observed structural consistency suggests that the intervention supported not only immediate outcomes but also the foundations for sustainable, self-directed physical development.

Limitations and strengths

This study has several limitations that should be considered. First, the assessment of physical fitness was conducted using field-based tests only. These tests are known to be practical and widely used in school settings but may lack the precision of laboratory-based measures. Second, the analysis was not stratified by gender, which may have masked sex-specific patterns in physiological development and response to the intervention. Third, the study was conducted over a relatively short duration of one academic year, which limits the ability to observe longer-term structural adaptations or delayed effects of the intervention.

Meanwhile, this is one of the rare studies to explore qualitative structural changes in fitness and body composition variables in response to a physical literacy-based intervention, offering a novel perspective in the field. The intervention was specifically designed around physical literacy principles, ensuring developmental relevance and educational value. Furthermore, all assessments were performed using standardized protocols, with the same trained experts conducting all measurements, which enhances reliability and reduces interrater variability.

Conclusion

Although rarely used in sport and exercise sciences, analyses of qualitative changes offer valuable insights into how physiological systems adapt and organize over time, revealing deeper patterns of functional development. This study supports the potential of applying analyses of qualitative changes as induced by intervention protocol in physical education settings, and showed that a physical literacy-based intervention helped maintain stable relationships between body composition and physical fitness variables. This suggests that the program supported coordinated and balanced physical development.

From a practical view, results highlight the value of using well-planned and age-appropriate activities in schools. Such programs can improve not only fitness levels but also how different physical abilities work together. Future studies should follow children for a longer time to see how stable these changes are. It would also be useful to look at differences in structural changes between boys and girls or to compare different effects among age-groups.

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Conflict of interest
The authors declare no conflicts of interest.

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