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Edpuzzle-based strength training in after-school settings: a randomized controlled trial

Entrenamiento de fuerza con Edpuzzle en horario extraescolar: un ensayo controlado aleatorizado

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Editorial schedule: *Article received 21/03/2026 Accepted: 25/05/2026 Published: 01/07/2026*

https://doi.org/10.55040/wh2m7h82

To cite this article, use the following reference:
Vaquero-Cristóbal, R.; Mateo-Orcajada, A.; López-Miñarro, P.Á.; Abenza-Cano, L. (2026). Edpuzzle-based strength training in after-school settings: a randomized controlled trial. *Sportis Sci J*, 12 (3), 1-36 https://doi.org/10.55040/wh2m7h82

Author contribution: Introduction (RVC, PALM), Material and methods (AMO, LAC), Results (AMO, RVC), Discussion (PALM, LAC) and Conclusion (RVC, AMO, PALM, LAC).

Funding: Project "Fomento de la actividad física diaria recomendada para la salud en adolescentes mediante apps móviles, wearables y una TAC gamificada" (PID2022-140245OA-I00) funded by MCIN /AEI /10.13039/501100011033 / FEDER, UE.

Conflict of interest: The authors declare that there is no conflict of interest between them.

Ethical aspects: Ethical approval was obtained from the Catholic University of Murcia institutional ethics committee prior to data collection (code: CE022102). The study protocol was registered in ClinicalTrials.gov (code: NCT06140225). All participants provided informed consent signed by themselves and their parents.

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Abstract
The school Physical Education subject has a limited class time, which is insufficient to achieve the physical activity recommendations, making complementary extracurricular interventions necessary. This study analyzed the effects of a strength-endurance training program, promoted through the Physical Education (PE) class, on anthropometric and physical fitness of adolescents; the differences based on sex; and their opinions on satisfaction, usefulness, and reasons for dropping out of the program according to sex. A randomized controlled trial was conducted with 107 adolescents randomly assigned by class cluster to an experimental (EG: n=52) or control (CG: n=55) groups. For 12 weeks, the EG was prescribed three strength-endurance weekly sessions via the Edpuzzle platform. No significant intergroup differences were found (p>0.05). However, significant intragroup improvements in primary outcomes (muscle mass, p=0.002; corrected thigh and calf girths, p<0.05) were exclusive to the EG. Both groups showed improvements in secondary growth-related variables (height and sitting height) and fitness (cardiorespiratory capacity). Exploratory analysis revealed a potential dose-response trend, with significant curl-up improvements only in students completing >4 weeks. Females reported higher platform usability (p=0.045) and satisfaction (p=0.037), while "lack of interest" was the primary dropout reason for both sexes. Therefore, while the program favored specific muscular adaptations, the lack of intergroup differences and low adherence suggest that natural biological maturation and the PE curriculum significantly influenced the results. The program’s impact should be considered limited, highlighting the need for more engaging to ensure sufficient exercise dosage in autonomous settings.

Keywords: adolescents; physical activity; strength-endurance; new technologies; Physical Education.

Resumen
La asignatura de Educación Física en la escuela dispone de un tiempo de clase limitado, el cual resulta insuficiente para alcanzar las recomendaciones de actividad física, haciendo necesarias intervenciones complementarias de carácter extraescolar. Este estudio analizó los efectos de un programa de entrenamiento de fuerza-resistencia, promovido a través de la clase de Educación Física, sobre las variables antropométricas y la condición física de adolescentes; las diferencias en función del sexo; y sus opiniones sobre la satisfacción, la utilidad y las razones de abandono del programa según el sexo. Se llevó a cabo un ensayo controlado aleatorizado con 107 adolescentes asignados aleatoriamente por conglomerados de clase a un grupo experimental (GE: n=52) o control (GC: n=55). Durante 12 semanas, al GE se le prescribieron tres sesiones semanales de entrenamiento de fuerza-resistencia a través de la plataforma Edpuzzle. No se encontraron diferencias intergrupo significativas (p>0,05). Sin embargo, las mejoras intragrupo significativas en las variables primarias (masa muscular, p=0,002; perímetros corregidos de muslo y pierna, p<0,05) fueron exclusivas del GE. Ambos grupos mostraron mejoras en las variables secundarias relacionadas con el crecimiento (talla y talla sentado) y la condición física (capacidad cardiorrespiratoria). El análisis exploratorio reveló una tendencia potencial de dosis-respuesta, con mejoras significativas en el test de abdominales únicamente en los estudiantes que completaron más de 4 semanas. Las

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Vol. 12, n. º 3; p. 1-36, July 2026. https://doi.org/10.55040/wh2m7h82

mujeres reportaron una mayor usabilidad de la plataforma (p=0,045) y satisfacción (p=0,037), mientras que la "falta de interés" fue el principal motivo de abandono en ambos sexos. Por lo tanto, aunque el programa favoreció adaptaciones musculares específicas, la falta de diferencias intergrupo y la baja adherencia sugieren que la maduración biológica natural y el currículo de Educación Física influyeron significativamente en los resultados. El impacto del programa debe considerarse limitado, subrayando la necesidad de estrategias más atractivas para asegurar una dosis de ejercicio suficiente en entornos autónomos.

Palabras clave: adolescentes; actividad física; Educación Física; fuerza-resistencia; nuevas tecnologías.

Introduction

Despite the benefits associated with physical activity, recent research indicates that approximately 80% of adolescents do not meet the minimum levels suggested by the World Health Organization (WHO), representing a significant current and future public health concern (Pechtl et al., 2022). Regarding strength training, the percentage of adolescents who meet the WHO recommendations is approximately 19% (Garcia-Hermoso et al., 2023).

Physical Education at school represents a key opportunity to promote healthy habits during adolescence (Sanz-Martin et al., 2021). However, in countries such as Spain, the time allocated to this subject in the curriculum is only two hours per week, which is insufficient to meet the WHO recommendations (Huertas-Delgado et al., 2021). Furthermore, the actual time spent engaging in moderate- or vigorous-intensity physical activity during these classes is limited (Mears & Jago, 2016). Additionally, most adolescents restrict their physical activity to the Physical Education classes, as they are not interested in playing sports (Gapa & Tagare, 2023).

The lack of extracurricular physical activities highlights the need for specific school-based interventions aimed at encouraging adolescents to participate in extracurricular physical activity programs, as it has been shown that adolescents enjoy these types of activities more than classes during school hours (Casado-Robles et al., 2025). For this reason, various studies have proposed supplementing Physical Education classes with structured programs outside of school hours, which have been shown to be effective in increasing physical activity levels (Demetriou et al., 2017). In this context,

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research involving the use of new technologies has proven to be a useful tool for advancing in this direction (Mateo-Orcajada, Abenza-Cano, et al., 2023).

In this regard, recent research has promoted increasing the number of daily steps during extracurricular hours using mobile step-counting applications, whose use was encouraged within the Physical Education curriculum (Gómez-Cuesta et al., 2024; Mateo-Orcajada, Abenza-Cano, et al., 2023). These types of interventions, in addition to being effective, are characterized by motivating students, as they perceive the apps as easy to use, entertaining, and customizable (Ponce-Ramírez et al., 2024). Notably, female adolescents appear to respond particularly well to these interventions, experiencing greater benefits in terms of physical fitness and body composition (Mateo-Orcajada, Vaquero-Cristóbal, et al., 2023).

However, one of the main limitations of extracurricular interventions is that they have focused almost exclusively on promoting cardiorespiratory exercise (Gil-Espinosa et al., 2020; Mateo-Orcajada, Abenza-Cano, et al., 2023). In this context, promoting after-school strength training would be instrumental in achieving even greater health benefits for adolescents. To this end, the use of mobile applications has proven to be effective in improving muscle endurance in adolescents (Wang et al., 2023). However, these types of devices have limitations for inclusion in the educational setting, notably the difficulty of implementing supervised training that ensures proper technique, postural safety, and the ability to monitor student participation. Also, the fact that most mobile applications used for strength training in adolescents do not consider the age and individual characteristics of this population and often promote generic protocols (Alonso-Fernández et al., 2022). Furthermore, these tools exhibit low educational potential, as they lack technical explanations, safety guidelines for exercise execution, and quality feedback (Alonso-Fernández et al., 2022; Gil-Espinosa et al., 2022).

Therefore, although they could be useful for increasing strength and improving physical condition, it seems that mobile applications are not the best alternative for promoting this type of training in the educational field. For this purpose, other types of platforms seem to be more appropriate due to their design and characteristics. In this regard, platforms such as Edpuzzle take on special relevance (Di Cesare et al., 2021). This educational platform allows videos to be converted into interactive lessons in which

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questions and tasks can be inserted to assess student performance (Mahir, 2025; Mischel, 2018). Its effectiveness in increasing interest, motivation, and enjoyment (Ramasany et al., 2022; Wati, 2024), as well as in improving comprehension among adolescents (Jiménez et al., 2021), has been demonstrated in previous studies, although always in theoretical subjects that are not as practical as physical education.

Given the effectiveness of Edpuzzle in other educational subjects, it could have great potential in physical education to promote supervised strength training among adolescents, explaining correct technique and posture. In addition, to mitigate possible selection biases, it would be necessary to propose a randomized experimental design, isolating the specific effect of using Edpuzzle, allowing the observed differences to be attributed to the intervention. However, as there is no previous research that has used this platform in the field of physical education, it is not known whether it is truly effective for this purpose. For this reason, the objectives of this study are a) to determine the changes produced by an extracurricular strength-endurance training program promoted through the Physical Education subject on anthropometric and body composition variables, as well as physical fitness among adolescents; b) to analyze sex-based differences in the effects of the intervention; and c) to examine the adolescents' opinions regarding their satisfaction with and perceived usefulness of the training program, as well as the reasons for non-compliance, according to sex.

Based on previous scientific evidence, the research hypotheses for this study are as follows: the intervention group will achieve greater improvements in body composition and physical fitness as compared to the group that does not participate in the program (H1); there will be sex-based differences in the benefits obtained from the intervention (H2); and adolescents will evaluate the program positively and exhibit an acceptable level of adherence (H3).

Material and methods

Design

A cluster randomized controlled trial (RCT) was conducted using non-probabilistic convenience sampling. Participants were randomly assigned by class to an experimental group (EG) or a control group (CG). Measurements were obtained at two

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time points (pre- and post-intervention). The 12-week intervention, delivered via the Edpuzzle platform (Edpuzzle, Inc., Barcelona, Spain), involved a strength-endurance training program performed by the EG three times per week during extracurricular hours.

Outcomes

Following the criteria of previous research on adolescent strength training (Dias et al., 2023; Ten Hoor et al., 2018), primary body composition outcomes were defined as those directly related to fat and muscle mass: sum of 3 skinfolds, fat mass (%) corrected girths (arm, thigh, and calf), and muscle mass. Conversely, body mass, height, BMI, and sitting height were categorized as secondary outcomes. Regarding physical fitness (Lesinski et al., 2020; Moreno-Torres et al., 2025), primary outcomes included variables related to muscular strength and power: handgrip, CMJ, 20-m sprint, curl-up, and push-up; while cardiorespiratory capacity (VO_2 max) was established as a secondary variable.

Participants

The study followed the Consolidated Standards of Reporting Trials (CONSORT) guidelines (Schulz et al., 2011). Ethical approval was obtained from the institutional ethics committee of the Catholic University of Murcia prior to data collection (code: CE022102) and the clinical trial was registered (code: NCT06140225). All procedures adhered to the principles of the Declaration of Helsinki and the World Medical Association.

A secondary school in the Region of Murcia (Spain) was selected by convenience sampling. After initial contact with the school administration, an informational meeting was held with the head and staff of the Physical Education department to explain the study objectives and procedures. Subsequently, a meeting with students and their parents or guardians was conducted to provide detailed information about the research. Participation was voluntary, and written informed consent was obtained from both students and their parents or legal guardians.

The inclusion criteria were (a) enrollment in the 3rd or 4th year of compulsory secondary education; (b) age between 14 and 17 years; (c) participation in both pre- and post-intervention assessments; (d) absence of medical conditions preventing participation; and (e) completion of all required forms and evaluations. Exclusion criteria included (a) transferring to another school during the intervention; (b) initiating any new

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Vol. 12, n. º 3; p. 1-36, July 2026. https://doi.org/10.55040/wh2m7h82

physical activity not previously practiced (except for the prescribed strength training in the EG); and (c) discontinuing any habitual activity practiced before the study.

The inclusion criteria specifically targeted students in the 3rd and 4th years of compulsory secondary education to minimize the confounding effect of biological maturation on strength gains. Students in the 1st and 2nd years are typically closer to their Age at Peak Height Velocity (APHV) (Beunen & Malina, 1988; Malina & Bouchard, 1991), a period characterized by rapid and non-linear changes in anthropometric and neuromuscular profiles (Kelch & Beitins, 1994; Tanner, 1990). By selecting older adolescents (3rd and 4th year), the study ensured a more stable physiological baseline, allowing for a more accurate assessment of the specific impact of the resistance training program rather than developmental growth surges.

Sample size was calculated using RStudio (version 3.15.0; RStudio Inc.) based on previous school-based strength training studies targeting body composition improvements (SD = 8.0) (Ten Hoor et al., 2018). Assuming an error (d) of 2.29 in total body fat percentage and a 95% confidence interval, the minimum required sample size was 47 adolescents per group.

Figure 1 presents the sample selection process. A total of 107 adolescents (16.09±0.98 years) participated: EG = 52 (males = 19; females = 33) and CG = 55 (males = 34; females = 21). Among the EG participants, 33 (63.5%) completed 0–25% of sessions, 11 (21.2%) completed 25–50%, and 8 (15.4%) completed 50–75%; no participant completed >75%. However, no participants were excluded from the final analysis. The mean rate of perceived exertion (RPE) for completed sessions was 3.70±1.39 overall (males = 3.70±1.39; females = 3.74±1.36).

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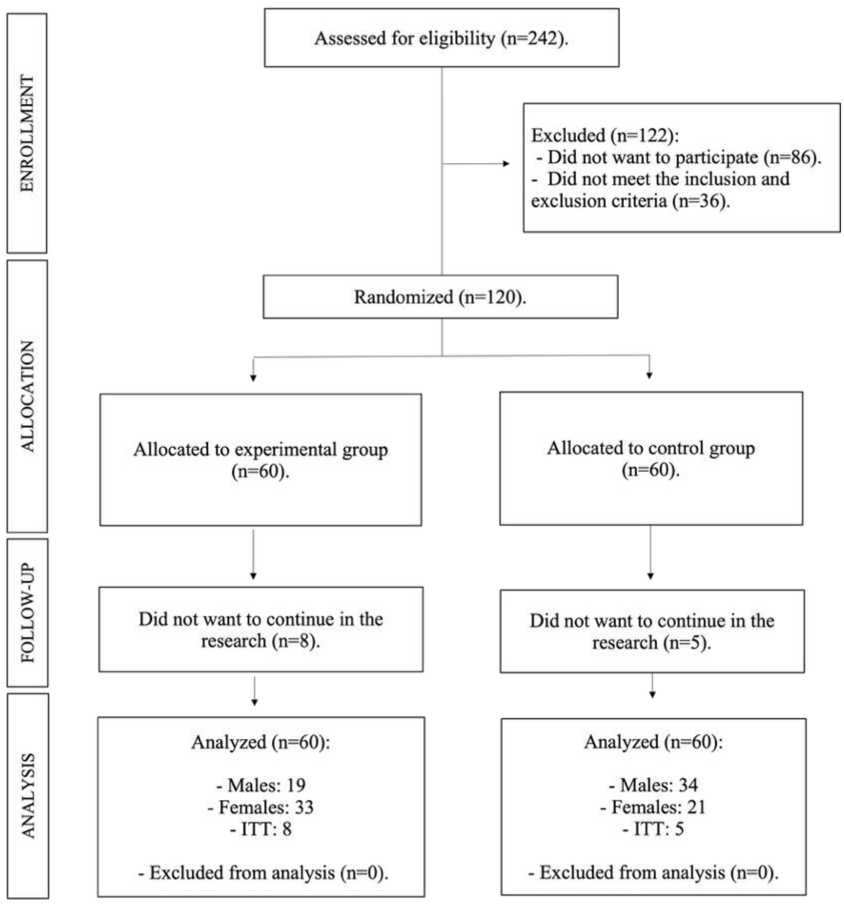

Figure 1. Sample flow diagram.

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Randomization was performed by the principal investigator using a computer-generated random number table in the presence of independent researchers. Adolescents were assigned to the EG or CG without stratification by sex, as male–female distribution was homogeneous between groups. Baseline assessments were conducted after randomization, and researchers remained blinded to group allocation and baseline scores.

Instruments

Anthropometric and body composition variables

Anthropometric measurements were conducted by three certified ISAK Level 3 and 4 anthropometrists (International Society for the Advancement of Kinanthropometry). The assessment included three basic measures (body mass, height, sitting height), three skinfolds (triceps, thigh, calf), and three girths (relaxed arm, thigh, calf). The same anthropometrist assessed each participant at both time points to minimize inter-evaluator technical error of measurement (TEM), which was 0.02% for basic measurements, 1.21% for skinfolds, and 0.04% for girths (Esparza-Ros et al., 2019).

Body mass was measured using a TANITA DC 430-SMA segmental scale (TANITA, Tokyo, Japan); height and sitting height with a SECA 213 stadiometer (SECA, Hamburg, Germany); skinfolds with a Harpenden caliper (Harpenden, Burgess Hill, UK); and girths with a Lufkin W606PM non-stretchable tape (Lufkin, Missouri, USA). All instruments were calibrated and validated before use.

Two measurements were taken for each variable; a third was performed if differences exceeded 5% for skinfolds or 1% for other measures. The final value was the mean of two readings or the median of three. Measurements followed the standardized ISAK protocol (Esparza-Ros & Vaquero-Cristóbal, 2023). Final values were used to calculate BMI, fat mass (Slaughter et al., 1988), muscle mass (Poortmans et al., 2005), the sum of three skinfolds, and corrected girths of the arm [relaxed arm girth – (π × triceps skinfold)], thigh [mid-thigh girth – (π × thigh skinfold)], and calf [calf girth – (π × calf skinfold)].

Physical fitness variables.

Cardiorespiratory fitness was assessed using the Course-Navette test (Léger et al., 1988). The test consists of running back and forth over a 20-meter distance as many times as possible, following audio beeps. The test ends when the participant reaches exhaustion

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or fails to complete the distance twice consecutively before the beep. The maximum oxygen consumption (VO_2 max) was estimated using the Léger formula (Léger et al., 1988).

Upper body strength was evaluated using two tests. First, handgrip strength was measured with both hands, as it has been shown to be a valid test for assessing physical capacity in adolescents (Matsudo et al., 2014). A portable digital dynamometer, Takei Tkk5401 (Takei Scientific Instruments, Tokyo, Japan), was used for the measurement. Second, the push-up test required participants to lie prone with their toes in contact with the floor and arms positioned beside the body, elbows flexed at 90°. From this position, participants had to lift their body off the ground by fully extending their arms while keeping their legs and back straight, performing as many repetitions as possible in 60 seconds (Castro-Piñero et al., 2010).

The countermovement jump (CMJ) was used to assess explosive lower limb power. A force platform with a sampling frequency of 200 Hz (MuscleLab, Stathelle, Norway) was employed. The test consists of performing a vertical jump aiming to reach the maximum possible height (Barker et al., 2018).

Speed was evaluated using the 20-meter sprint test. At the start, the participants positioned themselves on the starting line and decided when to begin the maximal sprint (García-Manso et al., 1996). Single-beam photocells (Polifemo Light, Microgate, Italy) placed at hip height were used to measure the time taken to cover a distance of 20 meters (Altmann et al., 2017; Cronin & Templeton, 2008).

Abdominal strength and endurance were assessed using the curl-up test. Participants laid in a supine position with knees flexed at 90º and feet flat on the floor. With arms crossed over the chest, the adolescents performed as many sit-ups as possible, counting repetitions as valid when the upper back lost contact with the floor (Garcia-Pastor et al., 2016).

Edpuzzle assessment.

During the post-test, adolescents in the EG evaluated the Edpuzzle application through a questionnaire with two sections: perceived usability (12 items) and satisfaction (10 items). Each item was rated on a five-point Likert scale (1: strongly disagree; 5: strongly agree). Usability items assessed ease of use, interactivity, usefulness as a

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teaching tool, and learning impact, whereas satisfaction items evaluated content relevance, clarity, integration within the subject, and overall perception (Da Costa et al., 2021).

To determine dropout reasons, an ad hoc questionnaire previously validated in similar studies (Ponce-Ramírez et al., 2024) was used, offering six single-choice options: "I did not have time", "I did not want to", "It did not catch my attention", "I am not interested in this subject or its related tasks", "It was not working" and "I found it boring".

Procedures

Pre- and post-test protocols followed previous adolescent studies (Mateo-Orcajada, Abenza-Cano, et al., 2023). Anthropometric measurements were taken first, followed by familiarization with the handgrip strength, CMJ, sit-up, push-up, and 20 m sprint tests. After a standardized warm-up, each test was performed twice (best score recorded), except for the Course-Navette test, performed once to prevent fatigue. Tests followed NSCA guidelines (Haff & Triplett, 2021), with two-minute rests between repetitions and five minutes between tests (Coburn & Malek, 2014). Six experienced researchers conducted familiarization, supervision, and evaluation during pre- and post-assessments.

The Edpuzzle-based resistance training intervention consisted of a 12-week (36-session) strength-endurance program performed three times per week during extracurricular hours, alternating days (Mon-Wed-Fri or Tue-Thu-Sat). The duration of the sessions increased progressively from 25-30 minutes in the first weeks to 45-50 minutes in the last weeks. The session time was divided into a dynamic warm-up (15-20% of the session, e.g. 10 minutes in the final weeks), a main workout (70-75% of the session, e.g., 30 minutes in the final weeks), and a cool-down consisting of relaxation exercises and a return to the initial state (10-15% of the session, e.g., 5-10 minutes in the final weeks). The program followed a periodized progression divided into four 3-week phases: (1) Familiarization (weeks 1–3), focusing on technical mastery with light resistance; (2) Light (weeks 4–6), increasing volume; (3) Medium (weeks 7–9), using higher resistance bands; and (4) Intense (weeks 10–12), emphasizing explosive movements and increased complexity (e.g., progressing from squats and push-ups to jump squats and single-leg deadlifts).

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The main workout featured six full-body exercises using TheraBand elastic bands (yellow, green, black, silver) in ascending resistance. To ensure exercise quality and safety, each Edpuzzle video incorporated embedded 'check-for-understanding' questions regarding postural alignment and technical cues that participants had to answer to proceed. The main workout consisted of 3 sets of 12–15 repetitions per exercise, with 60–90 seconds of rest between sets. Progression was managed through autoregulation: participants rated their perceived exertion (RPE) on a 1–10 scale after each set. Whenever an RPE below 6 was reported, the load was increased by adjusting the band grip (shortening the lever) or switching to the next band color in the resistance hierarchy. All sessions were delivered via non-skippable Edpuzzle videos to ensure full exposure to technical cues and safety instructions.

Statistical analysis

Data were analyzed following the Intention-to-Treat (ITT) principle to account for participant attrition. For the 13 subjects who did not complete the post-test, missing values were imputed using the Last Observation Carried Forward (LOCF) method. Data normality was assessed using the Kolmogorov-Smirnov test, skewness, and kurtosis. As the variables showed a normal distribution, parametric tests were applied. Mean and standard deviation were used as descriptive statistics. To ensure the robustness of the results against the potential clustering effect of the classrooms, the Intraclass Correlation Coefficient (ICC) was calculated for the variables using a Linear Mixed Model. The analysis revealed a null variance component for the cluster (Class), resulting in an ICC between 0.015 and 0.027. Consequently, the assumption of independence of observations was met, justifying the use of individual-level parametric tests (ANOVA/ANCOVA) without the risk of underestimating standard errors. For this reason, 2x2 mixed-design ANOVAs (Group × Time) examined differences between the experimental (EG) and control (CG) groups. Additionally, ANCOVAs were performed using sex as a covariate. A multivariate repeated-measures analysis with group and sex as between-subject factors assessed pre–post differences by sex in both groups. A repeated measures analysis was performed to analyze differences in EG participants in the study variables based on the degree of completion of the intervention, dividing the sample into a group that completed less than 35% of the intervention (less than 4 weeks) and a group that completed more

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than 35% (more than 4 weeks), as this is the minimum time required to begin observing changes in this type of intervention (Chatterjee et al., 2021). Partial eta squared (η2) was used to calculate effect size, following conventional benchmarks: small ($\eta^2 \geq 0.01$), medium ($\eta^2 \geq 0.06$), and large ($\eta^2 \geq 0.14$) (Richardson, 2011). An independent samples t-test compared males and females in perceived use and satisfaction with Edpuzzle, with effect size determined by Cohen's d (small 0.10–0.29, moderate 0.30–0.49, large 0.50–0.69, very large>0.70). Chi-square (χ^2) tests analyzed sex differences in reasons for not completing the intervention; standardized residuals (±1.96) and Cramer's V were used for post hoc comparisons. Statistical significance was set at $p<0.05$. Analyses were performed with SPSS v26 (SPSS Inc., IL, USA).

Results

At baseline, no significant intergroup differences were observed for any anthropometric or physical fitness variables ($p>0.05$; Table 1). Furthermore, sex did not influence these initial parameters.

Intragroup differences for all study variables are detailed in Table 2. Regarding primary outcomes, the EG showed significant improvements in muscle mass and corrected girths (thigh and calf), as well as in 20-m sprint and curl-up test ($p<0.05$). In contrast, the CG only showed significant improvements in the physical fitness components (sprint and curl up test), with no significant changes observed in their primary body composition variables. In terms of secondary outcomes, both groups exhibited significant increases in body mass, height, and sitting height, as well as in cardiorespiratory capacity.

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Table 1. Intergroup differences in anthropometric and derived variables and physical condition.

Variable	Time point	EG Mean (SD)	CG Mean (SD)	Mean diff	Time point*Group p	Time point*Group 95% CI	Time point*Group F	Time point*Group ηp²	Time point*Group*Sex F	Time point*Group*Sex ηp²	Time point*Group*Sex p
Primary outcomes											
Sum of 3 skinfolds (mm)	Pre	51.18 (26.57)	55.50 (25.04)	4.32 (4.89)	0.381	-5.31; 14.28	0.81	0.01	0.02	0.00	0.897
	Post	50.82 (24.76)	55.36 (25.07)	4.54 (4.70)	0.336	-4.76; 13.84	0.94	0.01	0.03	0.00	0.854
Corrected arm girth (cm)	Pre	23.05 (3.21)	22.52 (3.06)	-0.46 (0.59)	0.407	-1.67; 0.68	0.69	0.01	0.00	0.00	0.980
	Post	23.21 (3.76)	22.53 (2.97)	-0.68 (0.65)	0.294	-1.97; 0.60	1.11	0.01	0.04	0.00	0.849
Corrected thigh girth (cm)	Pre	42.20 (4.97)	42.27 (4.78)	0.07 (0.93)	0.948	-1.77; 1.89	0.00	0.00	0.86	0.01	0.356
	Post	42.89 (6.25)	42.29 (4.92)	-0.61 (1.09)	0.577	-2.76; 1.54	0.31	0.00	0.03	0.00	0.871
Corrected calf girth (cm)	Pre	30.52 (3.08)	30.81 (3.21)	0.29 (0.58)	0.574	-0.86; 1.47	0.22	0.00	2.78	0.02	0.098
	Post	30.77 (3.08)	30.75 (3.16)	-0.01 (0.59)	0.982	-1.17; 1.15	0.00	0.00	1.11	0.01	0.294
Fat mass (%)	Pre	21.67 (10.33)	23.90 (9.35)	2.23 (1.87)	0.242	-1.45; 5.98	1.41	0.01	0.23	0.00	0.631
	Post	21.72 (10.07)	23.90 (8.86)	2.18 (1.81)	0.262	-1.32; 5.78	1.48	0.01	0.23	0.00	0.633
Muscle mass (kg)	Pre	21.44 (5.70)	20.78 (5.42)	-0.65 (1.06)	0.539	-2.75; 1.44	0.38	0.00	0.38	0.00	0.537
	Post	22.12 (6.84)	20.90 (5.50)	-1.23 (1.20)	0.307	-3.59; 1.14	1.05	0.01	0.01	0.00	0.956
Handgrip strength right hand (kg)	Pre	32.10 (7.86)	31.77 (9.05)	-0.33 (1.57)	0.834	-3.39; 2.83	0.04	0.00	0.74	0.01	0.391
	Post	32.76 (8.99)	31.20 (8.39)	-1.57 (1.64)	0.343	-4.82; 1.69	0.91	0.01	0.01	0.00	0.930
Handgrip strength left hand (kg)	Pre	29.77 (7.99)	29.49 (8.31)	-0.28 (1.53)	0.853	-3.31; 2.74	0.03	0.00	0.68	0.01	0.412
	Post	29.99 (8.57)	28.69 (9.10)	-1.30 (1.65)	0.432	-4.58; 1.97	0.62	0.01	0.03	0.00	0.870
CMJ (cm)	Pre	26.20 (7.47)	25.47 (6.60)	-0.77 (1.40)	0.524	-3.47; 1.99	0.32	0.00	0.00	0.00	0.981
	Post	26.70 (7.78)	25.65 (6.77)	-1.05 (1.45)	0.469	-3.92; 1.82	0.53	0.01	0.07	0.00	0.791
20m sprint (s)	Pre	3.93 (0.38)	4.08 (0.43)	0.15 (0.08)	0.107	-0.03; 0.29	2.65	0.03	2.39	0.02	0.125
	Post	3.84 (0.41)	3.90 (0.41)	0.07 (0.08)	0.405	-0.09; 0.23	0.70	0.01	0.25	0.00	0.617
Curl up (reps)	Pre	26.71 (11.40)	28.34 (11.33)	1.61 (2.14)	0.450	-2.60; 5.79	0.59	0.01	0.93	0.01	0.338
	Post	30.11 (11.84)	31.92 (11.86)	1.81 (2.24)	0.416	-2.53; 6.17	0.61	0.01	1.48	0.01	0.227
Push up (reps)	Pre	8.79 (9.44)	8.56 (10.02)	-0.23 (1.83)	0.904	-3.84; 3.40	0.02	0.00	1.08	0.01	0.302
	Post	9.59 (10.83)	8.31 (10.80)	-1.29 (2.03)	0.529	-5.32; 2.75	0.40	0.00	0.07	0.00	0.799
Secondary outcomes											

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Vol. 12, n. º 3; p. 1-36, July 2026. https://doi.org/10.55040/wh2m7h82

Body mass (kg)	Pre	61.19 (12.96)	61.66 (12.28)	0.47 (2.38)	0.833	-4.19; 5.30	0.06	0.00	0.39	0.00	0.534
	Post	62.59 (12.93)	62.04 (12.15)	-0.55 (2.37)	0.817	-5.24; 4.14	0.05	0.00	0.05	0.00	0.827
Height (cm)	Pre	167.30 (8.40)	165.49 (8.47)	-1.89 (1.58)	0.250	-4.83; 1.38	1.32	0.01	0.16	0.00	0.693
	Post	167.68 (8.35)	166.03 (8.49)	-1.66 (1.58)	0.296	-4.78; 1.47	1.10	0.01	0.05	0.00	0.820
BMI (kg/m^2)	Pre	21.81 (4.16)	22.42 (3.58)	0.61 (0.74)	0.385	-0.81; 2.15	0.77	0.01	0.68	0.01	0.411
	Post	22.25 (4.01)	22.41 (3.45)	0.15 (0.71)	0.829	-1.25; 1.56	0.45	0.00	0.06	0.00	0.801
Sitting height (cm)	Pre	87.07 (3.84)	86.34 (4.19)	-0.73 (0.75)	0.332	-2.21; 0.75	0.95	0.01	0.10	0.00	0.753
	Post	87.80 (4.03)	87.10 (4.23)	-0.70 (0.77)	0.368	-2.22; 0.83	0.82	0.01	0.04	0.00	0.850
VO_2 max. (ml/kg/min)	Pre	30.04 (8.05)	28.04 (7.40)	-1.99 (1.47)	0.183	-4.95; 0.90	1.83	0.02	0.73	0.01	0.396
	Post	32.03 (8.11)	30.10 (7.92)	-1.97 (1.51)	0.231	-4.93; 1.10	1.70	0.01	0.38	0.00	0.540

BMI: body mass index; VO_2 max: maximum oxygen consumption; CMJ: countermovement jump.

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Table 2. Intragroup differences in anthropometric and derived variables and physical condition.

Variable	Group	Pre Mean(SD)	Post Mean(SD)	Mean diff.	p	Group*Pre-post 95% CI	F	ηp²	Group*Prepost*Sex F	ηp²	p
Primary outcomes											
Sum of 3 skinfolds (mm)	EG	51.18 (26.57)	50.82 (24.76)	0.34 (1.12)	0.790	-1.90;2.51	0.07	0.00	0.08	0.00	0.784
	CG	55.50 (25.04)	55.36 (25.07)	0.14 (1.30)	0.921	-2.37;2.68	0.02	0.00	0.01	0.00	0.919
Corrected arm girth (cm)	EG	23.04 (3.21)	23.21 (3.76)	-0.17 (0.13)	0.193	-0.43;0.09	1.72	0.02	1.17	0.01	0.282
	CG	22.54 (3.06)	22.53 (2.97)	0.02 (0.15)	0.902	-0.29;0.32	0.02	0.00	0.04	0.00	0.849
Corrected thigh girth (cm)	EG	42.20 (4.97)	42.89 (6.25)	-0.71 (0.33)	0.033	-1.36;-0.06	4.68	0.04	4.22	0.04	0.042
	CG	42.27 (4.78)	42.29 (4.92)	-0.02 (0.39)	0.982	-0.81;0.88	0.03	0.00	0.06	0.00	0.807
Corrected calf girth (cm)	EG	30.52 (3.08)	30.77 (3.08)	-0.25 (0.11)	0.026	-0.46;-0.03	5.07	0.04	4.78	0.04	0.031
	CG	30.81 (3.21)	30.75 (3.16)	0.06 (0.13)	0.636	-0.19;0.31	0.23	0.00	0.17	0.00	0.680
Fat mass (%)	EG	21.67 (10.33)	21.72 (10.07)	-0.05 (0.39)	0.836	-0.88;0.57	0.16	0.00	0.14	0.00	0.709
	CG	23.90 (9.35)	23.90 (8.86)	-0.00 (0.45)	0.965	-1.02;0.83	0.03	0.00	0.04	0.00	0.836
Muscle mass (kg)	EG	21.44 (5.70)	22.12 (6.84)	-0.69 (0.22)	0.002	0.88;-1.76	9.69	0.08	8.84	0.07	0.004
	CG	20.78 (5.42)	20.90 (5.50)	-0.12 (0.26)	0.658	1.40;2.45	0.20	0.00	0.46	0.00	0.499
Handgrip strength right hand (kg)	EG	32.10 (7.86)	32.76 (8.99)	-0.66 (0.40)	0.095	-1.38;0.26	2.88	0.03	2.56	0.02	0.113
	CG	31.77 (9.05)	31.20 (8.39)	0.57 (0.46)	0.217	-0.34;1.49	1.54	0.01	1.19	0.01	0.278
Handgrip strength left hand (kg)	EG	29.77 (7.99)	29.99 (8.57)	-0.22 (0.46)	0.637	-1.12;0.69	0.22	0.00	0.07	0.00	0.797
	CG	29.49 (8.31)	28.69 (9.10)	0.80 (0.54)	0.136	-0.26;1.86	2.26	0.02	1.64	0.01	0.203
CMJ (cm)	EG	26.20 (7.47)	26.70 (7.78)	-0.50 (0.42)	0.236	-1.35;0.31	1.35	0.01	1.20	0.01	0.276
	CG	25.47 (6.60)	25.65 (6.77)	-0.18 (0.48)	0.705	-1.14;0.77	0.14	0.00	0.17	0.00	0.679
20m sprint (s)	EG	3.93 (0.38)	3.84 (0.41)	0.10 (0.02)	<0.001	0.05;0.14	17.85	0.15	17.68	0.17	<0.001
	CG	4.08 (0.43)	3.90 (0.41)	0.18 (0.03)	<0.001	0.13;0.25	36.98	0.27	36.72	0.24	<0.001
Curl up (reps)	EG	26.71 (11.40)	30.11 (11.84)	-3.40 (1.23)	0.003	-5.82;-0.91	7.64	0.06	6.92	0.06	0.010
	CG	28.34 (11.33)	31.92 (11.86)	-3.58 (1.43)	0.012	-6.43;-0.78	6.16	0.05	7.09	0.06	0.009
Push up (reps)	EG	8.79 (9.44)	9.59 (10.83)	-0.80 (0.56)	0.151	-1.92;0.34	2.09	0.02	1.89	0.02	0.172
	CG	8.56 (10.02)	8.31 (10.80)	0.25 (0.65)	0.708	-1.05;1.54	0.14	0.00	0.08	0.00	0.779
Secondary outcomes											

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Vol. 12, n. º 3; p. 1-36, July 2026. https://doi.org/10.55040/wh2m7h82

Body mass (kg)	EG	61.19 (12.96)	62.59 (12.93)	-1.60 (0.27)	<0.001	-1.93;-0.94	28.42	0.20	27.32	0.19	<0.001
	CG	61.66 (12.28)	62.04 (12.15)	-0.38 (0.31)	0.229	-1.00;0.24	1.46	0.01	2.00	0.02	0.160
Height (cm)	EG	167.30 (8.40)	167.68 (8.35)	-0.38 (0.09)	<0.001	-0.54;-0.18	16.81	0.13	15.87	0.12	<0.001
	CG	165.49 (8.47)	166.03 (8.49)	-0.56 (0.11)	<0.001	-0.77;-0.34	26.05	0.19	29.30	0.20	<0.001
BMI (kg/m^2)	EG	21.81 (4.16)	22.25 (4.01)	-0.45 (0.10)	<0.001	-0.69;-0.20	20.68	0.15	19.45	0.15	<0.001
	CG	22.42 (3.58)	22.41 (3.45)	0.17 (0.18)	0.883	-0.22;0.25	0.02	0.00	0.00	0.00	0.982
Sitting height (cm)	EG	87.07 (3.84)	87.80 (4.03)	-0.73 (0.09)	<0.001	-0.91;-0.55	63.43	0.36	63.05	0.36	<0.001
	CG	86.34 (4.19)	87.10 (4.23)	-0.76 (0.11)	<0.001	-0.98;-0.55	49.80	0.30	56.20	0.33	<0.001
VO_2 max. (ml/kg/min)	EG	30.04 (8.05)	32.03 (8.11)	-1.99 (0.78)	0.009	-3.49;-0.40	6.25	0.05	5.56	0.05	0.020
	CG	28.04 (7.40)	30.10 (7.92)	-2.06 (0.91)	0.021	-3.84;-0.27	4.97	0.04	5.91	0.05	0.017

BMI: body mass index; VO_2 max: maximum oxygen consumption; CMJ: countermovement jump.

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Intragroup differences analyzed by sex are illustrated in Figure 2 (primary outcomes) and Figure 3 (secondary outcomes). Regarding primary outcomes, significant improvements in body composition (muscle mass and corrected thigh girth), as well as in curl-up and 20-m sprint test, were predominantly observed in EG males. EG females also showed significant increases in 20-m sprint. In relation to secondary outcomes, height and sitting height increased across all groups and sexes. However, significant increases in BMI were exclusive to the EG (both sexes), and body mass gains were observed in all subgroups except for CG females. Improvements in cardiorespiratory capacity (VO_2 max) were limited to males in both the EG and CG.

The exploratory analysis regarding the degree of completion of the intervention is presented in Table 3. While both adherence subgroups (high and low) showed significant growth-related increases in height and sitting height, as well as improvements in the 20-meter sprint ($p<0.05$), a potential dose-response effect was observed for curl-up. Specifically, significant improvements in the curl-up test were only evident in the subgroup that completed more than 4 weeks of the intervention ($p=0.016$). No other significant differences were found between adherence levels for the remaining primary or secondary outcomes.

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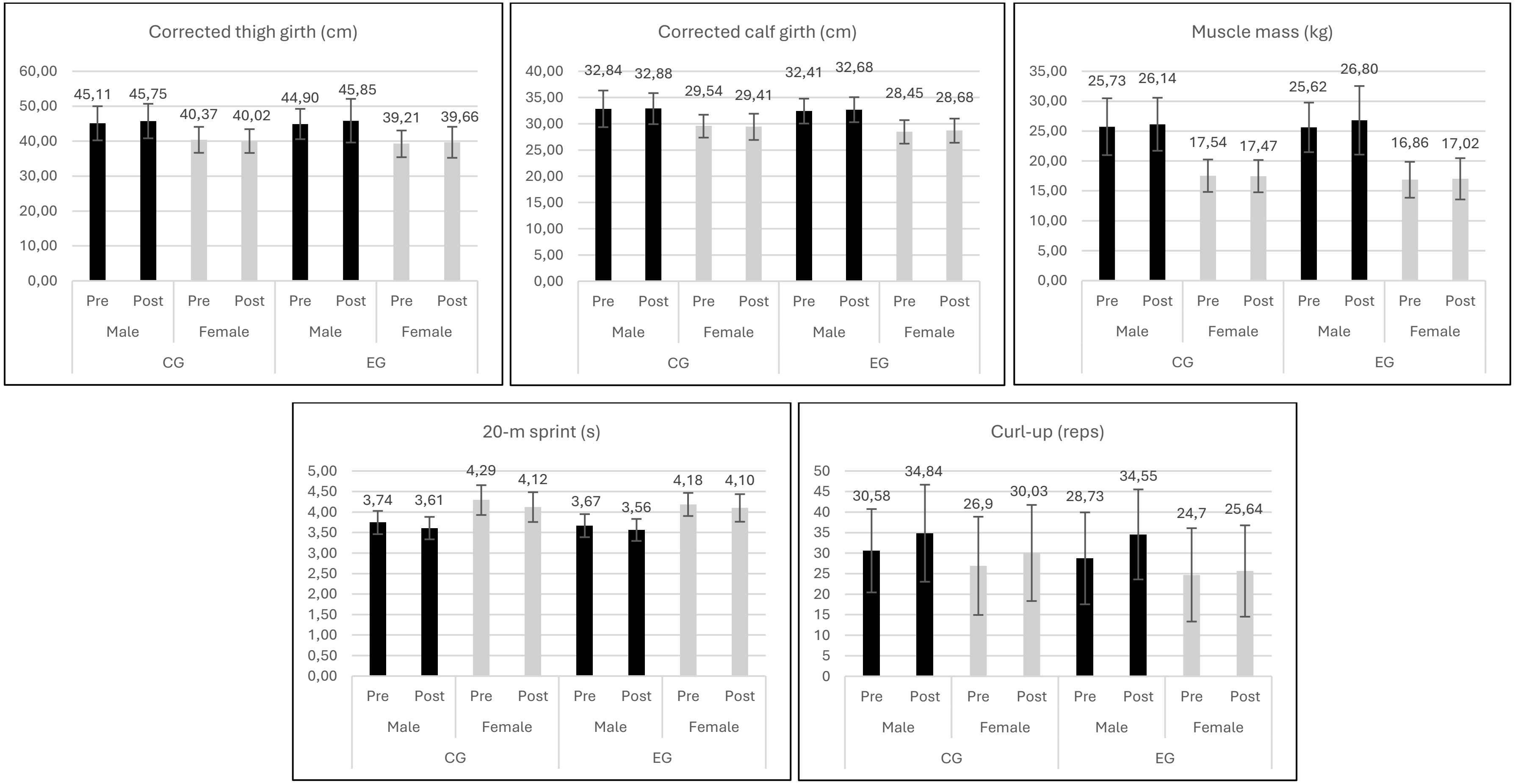

Figure 2. Intragroup differences by sex in primary anthropometric and physical fitness variables.

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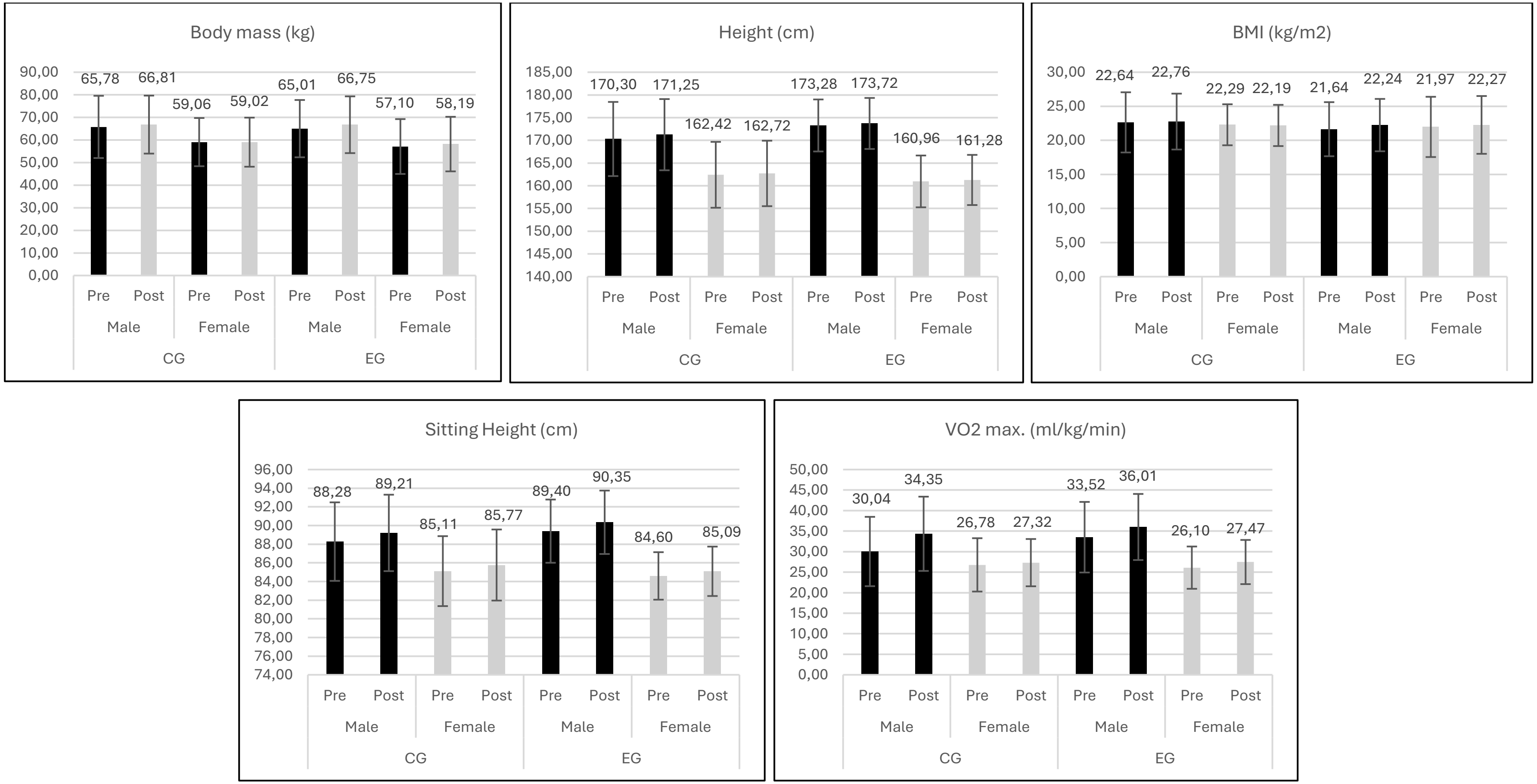

Figure 3. Intragroup differences by sex in secondary anthropometric and physical fitness variable

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Vol. 12, n. º 3; p. 1-36, July 2026. https://doi.org/10.55040/wh2m7h82

Table 3. Differences in EG participants in the study variables based on the degree of completion of the intervention.

Variable	Group	Pre Mean(SD)	Post Mean(SD)	Mean diff.	p	Group*Pre-post 95% CI	F	ηp²
Primary outcomes								
Sum of 3 skinfolds (mm)	<4 weeks	50.97 (25.39)	50.42 (24.20)	0.54 (1.51)	0.720	-2.48; 3.56	0.13	0.00
	>4 weeks	62.07 (29.87)	62.49 (30.53)	-0.42 (2.43)	0.865	-5.28; 4.44	0.03	0.00
Corrected arm girth (cm)	<4 weeks	22.48 (2.76)	22.66 (3.20)	-0.18 (0.18)	0.333	-0.54; 0.19	0.95	0.02
	>4 weeks	23.00 (3.51)	22.96 (3.11)	0.04 (0.29)	0.894	-0.55; 0.62	0.02	0.00
Corrected thigh girth (cm)	<4 weeks	41.67 (4.35)	41.73 (4.94)	-0.06 (0.29)	0.840	-0.64; 0.52	0.84	0.00
	>4 weeks	43.23 (5.43)	43.45 (5.34)	-0.22 (0.46)	0.639	-1.14; 0.71	0.64	0.00
Corrected calf girth (cm)	<4 weeks	30.42 (2.84)	30.52 (2.86)	-0.10 (0.16)	0.512	-0.42; 0.21	0.44	0.01
	>4 weeks	31.78 (3.77)	31.52 (3.92)	0.26 (0.25)	0.306	-0.24; 0.76	1.07	0.02
Fat mass (%)	<4 weeks	21.89 (9.42)	21.87 (9.05)	0.03 (0.52)	0.962	-1.01; 1.06	0.00	0.00
	>4 weeks	25.59 (11.12)	26.07 (10.73)	-0.48 (0.83)	0.568	-2.14; 1.19	0.33	0.01
Muscle mass (kg)	<4 weeks	20.45 (4.80)	19.74 (5.39)	0.72 (0.21)	0.871	1.29; 2.15	64.94	0.53
	>4 weeks	22.05 (6.52)	21.08 (6.32)	0.97 (0.34)	0.542	1.29; 2.64	33.58	0.37
Handgrip right hand (kg)	<4 weeks	31.68 (7.84)	31.40 (7.70)	0.27 (0.51)	0.592	-0.74; 1.29	0.29	0.01
	>4 weeks	33.38 (11.16)	32.82 (10.33)	0.57 (0.83)	0.496	-1.09; 2.22	0.47	0.01
Handgrip left hand (kg)	<4 weeks	29.81 (7.98)	28.92 (8.08)	0.89 (0.60)	0.141	-0.30; 2.08	2.23	0.04
	>4 weeks	30.22 (9.61)	30.03 (11.21)	0.19 (0.97)	0.847	-1.75; 2.13	0.04	0.00
CMJ (cm)	<4 weeks	26.26 (6.68)	25.83 (6.40)	0.43 (0.45)	0.344	-0.47; 1.33	0.91	0.02
	>4 weeks	24.67 (7.26)	25.75 (8.31)	-1.07 (0.76)	0.165	-2.60; 0.46	1.98	0.03
20m sprint (s)	<4 weeks	4.02 (0.38)	3.88 (0.42)	0.14 (0.03)	<0.001	0.08; 0.20	21.95	0.29
	>4 weeks	4.09 (0.53)	3.96 (0.50)	0.14 (0.05)	0.009	0.04; 0.24	7.37	0.12
Curl up (reps)	<4 weeks	28.33 (10.81)	29.76 (8.84)	-1.42 (1.46)	0.334	-4.35; 1.50	0.95	0.02
	>4 weeks	29.06 (14.39)	34.94 (16.32)	-5.88 (2.38)	0.016	-10.64; -1.13	6.12	0.09
Push up (reps)	<4 weeks	10.53 (10.20)	10.04 (11.15)	0.49 (0.58)	0.405	-0.68; 1.66	0.70	0.01
	>4 weeks	7.53 (10.12)	8.18 (11.08)	-0.65 (0.95)	0.498	-2.55; 1.25	0.47	0.01
Secondary outcomes								
Body mass (kg)	<4 weeks	59.94 (9.41)	59.83 (9.79)	-0.89 (0.30)	0.293	-1.49; 0.28	0.63	0.02
	>4 weeks	66.92 (15.40)	67.16 (15.16)	-0.24 (0.49)	0.621	-1.23; 0.74	0.25	0.00
Height (cm)	<4 weeks	165.13 (8.09)	165.73 (8.15)	-0.59 (0.12)	<0.001	-0.83; 0.36	25.30	0.30
	>4 weeks	168.24 (9.75)	168.68 (9.81)	-0.44 (0.19)	0.024	-0.83; -0.06	5.34	0.08
BMI (kg/m²)	<4 weeks	21.63 (3.28)	21.78 (3.21)	-0.14 (0.11)	0.210	-0.36; 0.08	1.60	0.03
	>4 weeks	23.41 (3.98)	23.38 (3.79)	0.03 (0.18)	0.884	-0.34; 0.39	0.02	0.00
Sitting height (cm)	<4 weeks	86.19 (3.68)	86.86 (3.77)	-0.68 (0.10)	<0.001	-0.88; -0.48	47.35	0.44
	>4 weeks	87.64 (5.00)	88.52 (4.88)	-0.88 (0.16)	<0.001	-1.20; -0.56	30.01	0.33
VO_2 max. (ml/kg/min)	<4 weeks	27.76 (6.69)	29.91 (7.80)	-2.15 (0.96)	0.078	-4.07; 0.24	2.05	0.01
	>4 weeks	26.89 (7.63)	28.94 (7.79)	-2.05 (1.54)	0.189	-5.13; 1.04	1.77	0.01

BMI: body mass index; VO_2 max: maximum oxygen consumption; CMJ: countermovement jump.

Analysis of the Edpuzzle platform's reception revealed significant sex-based differences, with females reporting higher perceived usability and satisfaction than males ($p<0.05$). Regarding intervention dropout (Table 4), the primary reasons for both sexes were a lack of interest or motivation to use the tool, with "lack of appeal" being significantly more prevalent among males ($p=0.020$).

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Vol. 12, n. º 3; p. 1-36, July 2026. https://doi.org/10.55040/wh2m7h82

Table 4. Differences in reasons for not completing the intervention according to sex.

Reason	Male	Female	Standardized corrected residual	χ2	Cramer's V
I did not have time	3 (6.7%)	0 (0%)	1.9; -1.9	13.42; 0.020	0.374
I did not want to	23 (51.1%)	42 (82.4%)	-3.3; 3.3		
It did not attract my attention	9 (20.0%)	2 (3.9%)	2.5; -2.5		
I am not interested in this subject or its related assignments	6 (13.3%)	4 (7.8%)	0.9; -0.9		
It did not work	2 (4.4%)	2 (3.9%)	0.1; -0.1		
I found it boring	2 (4.4%)	1 (2.0%)	0.7; -0.7		

Discussion

The first objective was to determine the effects of an extracurricular strength-endurance program promoted through Physical Education on anthropometric, body composition, and physical fitness variables in adolescents. Regarding primary outcomes, it is noteworthy that both the EG and the CG showed significant intragroup improvements in the 20-m sprint and the curl-up test. This common improvement in both groups, which resulted in a lack of significant intergroup differences, may be explained by the influence of the Physical Education curriculum itself, which often includes activities that enhance coordination, stride frequency, and core stability (Oliveira et al., 2017). Furthermore, the improvement in these primary fitness variables could be partly associated with the physiological maturation characteristic of this stage, which naturally enhances performance in power and endurance tests (Shirtcliff et al., 2009). Regarding secondary variables, both groups exhibited significant increases in height, sitting height, and VO_2 max. These results align with previous research showing that growth-related parameters follow similar patterns in adolescents regardless of the specific intervention (Mateo-Orcajada, Abenza-Cano, et al., 2023), as the participants are within the developmental window around the age of peak height velocity (Beunen et al., 2006). The fact that no significant intergroup differences were found in these secondary outcomes reinforces the idea that biological growth was a dominant factor during the 12-week period. However, the general absence of significant intergroup differences across the study variables, especially in primary body composition, can be interpreted as low adherence to the program and insufficient training intensity. While previous studies indicate that moderate-

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to-vigorous intensity is required to elicit meaningful changes (Cao et al., 2021), the autonomous and extracurricular nature of the Edpuzzle sessions likely led to a training "dose" that was too low to outperform the natural maturational surges and the stimulus already provided by school-based Physical Education.

However, a notable result was that only the EG showed significant increases in primary body composition outcomes, specifically in muscle mass and corrected thigh and calf girths. These results are consistent with prior studies reporting segmental muscle development following school-based strength training research (Ten Hoor et al., 2018). The fact that these improvements in primary variables occurred only in the intervention group, despite the low adherence, suggests that the strength-endurance program provided a specific stimulus for hypertrophy that was absent in the CG. These adaptations in muscle mass and corrected girths are key indicators of physical development in adolescents (Esparza-Ros & Vaquero-Cristóbal, 2025) and suggest improved muscle strength potential (Smith et al., 2014). Regarding the secondary variables of body mass and BMI, significant increases were also exclusive to the EG. While an increase in BMI is often viewed negatively in sedentary populations, in this context it aligns with the gains observed in muscle mass, reflecting a positive change in body composition rather than an increase in adiposity. This finding contrasts with earlier research on physical activity apps that found no effects on BMI (Shin et al., 2019) but is consistent with studies where strength training leads to weight gain due to the higher density of lean tissue (Micozzi & Albanes, 1988). Therefore, these results partially support the first hypothesis (H1). While the EG showed significant intragroup improvements in primary body composition outcomes (muscle mass and corrected girths) that were not observed in the CG, the absence of statistically significant differences between the two groups (intergroup) prevents from attributing these changes exclusively to the intervention. These results should be interpreted with caution, as they suggest that while the program might favor specific muscular adaptations, its effects were not robust enough, potentially due to the low adherence and intensity.

The second objective was to analyze sex-based differences in the intervention's effects. Regarding secondary outcomes, both sexes showed significant gains in height and sitting height, aligning with the expected annual growth rates for this developmental stage

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(Kelch & Beitins, 1994; Tanner, 1990). However, when examining primary outcomes, a clear dimorphism emerged because improvements in curl-up test, as well as in muscle mass were more pronounced and almost exclusive to EG males. This is consistent with prior evidence (Mateo-Orcajada, Vaquero-Cristóbal, et al., 2023) and can be explained by the sexual dimorphism of puberty, where elevated testosterone levels in males catalyze greater increases in muscle fiber size and neuromuscular adaptations (Handelsman et al., 2018; Rusek et al., 2021), leading to enhanced strength and neuromuscular adaptations (Gillen et al., 2019). It should also be noted that significant VO_2max improvements occurred only in males from both groups, consistent with prior findings showing greater aerobic adaptations in males after endurance training (Diaz-Canestro & Montero, 2019), likely due to higher muscle mass and hemoglobin levels (Jorgensen et al., 2019).

No significant changes were found in the sum of 3 skinfolds, corrected calf girth, body fat percentage, CMJ, or push-up test, differing from studies reporting improvements after mobile app–based interventions (Gómez-Cuesta et al., 2024; Mateo-Orcajada, Abenza-Cano, et al., 2023). This may be due to insufficient training intensity, as moderate-to-vigorous effort is needed to elicit adaptations (Tremblay et al., 1990), and because power tests like CMJ require specific training programs (Lamas et al., 2012).

Nevertheless, in line with a conservative interpretation, it must be noted that no significant intergroup differences were found between sexes within the EG or CG. Therefore, the second hypothesis (H2) is only partially and weakly supported. While the intragroup analysis suggests that males derived greater benefits in primary outcomes related to strength and muscle mass, the lack of statistical significance in the sex-by-group interaction prevents us from concluding that the intervention affects males and females differently in a robust manner. These results likely reflect a combination of hormonal factors and the low adherence mentioned earlier, which may have limited the expression of sex-specific adaptations.

It is important to note that an exploratory analysis regarding the degree of completion allowed for a deeper understanding of the relationship between program exposure and the obtained adaptations. While both adherence subgroups showed similar progressions in secondary growth-related variables (height and sitting height) and sprint speed, a potential dose-response effect was identified for curl-up. Specifically,

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improvements in the curl-up test appeared more consistent among adolescents who completed more than four weeks of the intervention, whereas this trend was less evident in those with lower participation. However, this finding must be interpreted with caution, as it does not imply a robust causal effect and may be influenced by the limited number of participants who reached higher levels of adherence. This suggests that while a minimum exposure time is likely required for strength-endurance stimuli to translate into measurable gains, the low overall dose achieved by the sample prevents us from drawing definitive conclusions. Ultimately, these observations reinforce the idea that the main challenge was not the training design itself, but the difficulty of ensuring sufficient and consistent engagement in an extracurricular, autonomous context.

The third objective was to analyze adolescents' satisfaction and perceived usefulness of the training program, as well as reasons for dropout. Regarding adherence, the high dropout rate observed aligns with previous research on digital physical activity programs (Egilsson et al., 2021). This reflects the challenge of maintaining intrinsic motivation for extracurricular exercise in adolescents. While prior studies using mobile apps achieved better adherence by integrating tasks as graded PE homework (Mateo-Orcajada, Vaquero-Cristóbal et al., 2024), the purely voluntary and non-monitored nature of our design likely contributed to the "lack of interest" reported by both sexes as the main reason for non-compliance.

A novel aspect of this study was the use of Edpuzzle as a delivery platform. While literature has consistently demonstrated Edpuzzle's efficacy in enhancing engagement and comprehension in theoretical subjects (Jiménez et al., 2021; Mahir, 2025; Ramasany et al., 2022), our findings provide a unique perspective on its application to a practical field like Physical Education. Despite the low adherence, females rated the platform more favorably in terms of usability and satisfaction. This mirrors findings in other educational areas where females show higher responsiveness to structured, interactive video-lessons (Jiménez et al., 2021), potentially due to the privacy and reduced social pressure that training at home provides (Petrušič et al., 2022).

However, the "lack of appeal" cited significantly more by males suggests that Edpuzzle's interface, designed for academic settings, might lack the gamified "hook" found in commercial fitness apps. Unlike personalized platforms that use badges or

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Vol. 12, n. º 3; p. 1-36, July 2026. https://doi.org/10.55040/wh2m7h82

leaderboards to maintain interest (Yang et al., 2020), the non-adapted format of our intervention may have limited its effectiveness for long-term engagement.

Consequently, the third hypothesis (H3) was rejected: although the tool was positively evaluated by a segment of the sample (particularly females), it was insufficient to ensure high levels of adherence. This underscores that while Edpuzzle is a robust tool for technical instruction and providing safety cues, its success in promoting extracurricular physical activity depends on its integration with more engaging, adolescent-centered motivational strategies

Limitations

Despite the innovative nature of promoting strength-endurance training during free time through Physical Education, the study had limitations. First, the use of a convenience sample from a single school and the restricted age range (3rd and 4th year of secondary education) limit the generalizability of the findings to broader adolescent populations. While this age selection was a deliberate methodological choice to minimize the confounding effects of biological maturation, it constrains the external validity of the results. Second, the low overall adherence significantly reduced the intervention's dose, likely diluting its potential impact and limiting the confirmatory power of the analysis. Third, there is a potential self-selection bias, as participation was voluntary, and those who maintained higher adherence might have possessed higher baseline motivation. Fourth, while the ICC analysis confirmed that the cluster effect was negligible (ICC $<$ 0.03), a design involving multiple centers would have provided greater statistical robustness. Finally, adherence and session intensity were monitored only through platform logs and self-reported RPE, which do not account for the actual quality of exercise execution in an autonomous environment.

Future research should explore strategies to increase adherence through gamified or competitive (points, badges, leaderboards) approaches (Mateo-Orcajada, Abenza-Cano, et al., 2024; Prieto Andreu, 2020), compare different app types, as done in previous studies with step-tracking mobile applications (Mateo-Orcajada, Abenza-Cano, et al., 2023), and test blended interventions combining in-person and digital formats to enhance engagement. Longitudinal designs are also needed to assess sustainability and the adoption of active lifestyles (Erives et al., 2025). Finally, examining psychosocial factors

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such as self-efficacy, perceived competence, and intrinsic motivation could clarify mechanisms influencing adherence and outcomes.

Practical applications

Regarding practical applications, this study highlights the potential of Physical Education as a tool to promote healthy habits beyond school hours through structured training programs. However, the findings suggest that the mere provision of an online platform is insufficient to ensure effectiveness; these tools should be blended with pedagogical strategies within the school curriculum, such as academic incentives or supervised hybrid sessions, to overcome the challenge of low intrinsic motivation. Furthermore, the results stress the importance of developing sex-specific and age-tailored interventions, acknowledging that males and females may perceive and respond to digital training stimuli differently.

From an institutional standpoint, schools could incorporate extracurricular programs that utilize interactive platforms like Edpuzzle to provide safe technical instruction, but these must be complemented by gamification or social interaction features to enhance engagement. In summary, promoting strength-endurance training outside the school setting is a viable strategy to combat sedentary behavior, but its success depends on transitioning from generic protocols to adolescent-centered designs that prioritize autonomy and long-term adherence through a more appealing and interactive user experience.

Conclusion

The implementation of a strength-endurance training program in an extracurricular schedule, promoted through the Physical Education school subject, may foster improvements in anthropometric and physical fitness variables in adolescents. However, the absence of significant intergroup differences suggests that the intervention's impact was largely masked by natural maturational processes and the standard Physical Education curriculum. While intragroup improvements in muscle mass and corrected girths were exclusive to the EG, particularly among males, these adaptations were likely limited by the low overall adherence and insufficient training intensity achieved. Furthermore, although the Edpuzzle platform proved to be a viable tool for delivering

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technical instruction and was positively perceived by females, it was insufficient to sustain long-term motivation in a purely voluntary, autonomous context. The high dropout rates and the "lack of interest" reported by both sexes underscore the critical need for future digital interventions to transition toward more engaging, gamified, and adolescent-centered designs. In summary, while this type of extracurricular programming is feasible, its effectiveness in generating robust changes beyond those of natural growth depends on ensuring a higher and more consistent training dose.

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REVISTA INTERNACIONAL
SPORTIS
Scientific Journal of School Sport, Physical Education and Psychomotricity
OPEN ACCESS Creative Commons
www.sportisjournal.com | v.arufe@udc.es | ISSN 2386-8333
Edited by Campus Educa Sportis. A Coruña. Spain

Rusek, W., Baran, J., Leszczak, J., Adamczyk, M., Baran, R., Weres, A., Inglot, G., Czenczek-Lewandowska, E., & Pop, T. (2021). Changes in Children's Body Composition and Posture during Puberty Growth. Children, 8(4), 1–12. https://doi.org/10.3390/children8040288

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Vol. 12, n. º 3; p. 1-36, July 2026. https://doi.org/10.55040/wh2m7h82

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