

RATIONALIZATION OF MEANS FOR DEVELOPING ABDOMINAL MUSCLE STRENGTH THROUGH THE SIT-UP TEST IN THE EDUCATIONAL PROCESS FOR STUDENTS AGED 6 TO 10 YEARS

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ABSTRACT. Introduction: There are various strategies aimed at strengthening the abdominal muscles, focusing on increasing their thickness to enhance trunk stability and posture. The exercises must engage all abdominal muscles across different planes of movement and may include two types of contractions: isometric and concentric. **Objective:** The present study aims to rationalize specific means to optimize the development of abdominal muscle strength within the instructional process for students aged 6 to 10 years. **Materials and Methods:** In this stage of the study, the subjects were tested to assess the development of abdominal muscle strength. The test battery applied included the *Sit-Up Test* to evaluate abdominal strength. **Results:** Following the administration of the *Sit-Up Test* to second-grade students, group IIF showed a significant improvement in physical performance ($p = 0.022$), while the other groups (IF, IB, IIB, IIIF, IIIB, IVF, IVB) did not present significant differences. **Discussion:** The comparative analysis of the data highlights specific characteristics of abdominal strength development, confirming previous research findings and indicating the need for adapted training programs. **Conclusions:** A well-structured physical exercise program can significantly influence the development of abdominal muscles in students, provided that it is adapted to their individual needs and capacities. The methods used must be tailored to each student's strength level. This approach contributes substantially to the improvement of overall performance, both physically and cognitively.

Keywords: Psychomotricity, students, girls, boys, Si-up Test

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INTRODUCTION

It is essential to precisely understand the effects of strength training over specific periods to effectively improve muscular strength. Equally important is the ability to measure muscular strength with ease, although some body regions allow for simpler assessments than others. Muscular strength is generally classified into static strength, measured by maximal force, and dynamic strength. Determining maximal capacity is crucial for establishing training loads and methods and must be performed accurately. The abdominal muscles play a key role in intra-abdominal pressure, lumbar spine stabilization, posture maintenance, and trunk movements (flexion, torsion, lateral flexion), making them essential for both athletes and the general population (Noguchi et al., 2013).

An individual's motor abilities are represented by genetically determined motor skills, which constitute the genotypic component (innate motor skills). Acquired motor abilities developed through learning correspond to the phenotypic component (acquired motor skills) of the individual (Neagu, 2012).

Anders et al. (2020) emphasize the importance of training to strengthen the abdominal muscles, which, although significantly less developed than the back muscles, play a crucial role in trunk stability. Their performance can be assessed through muscular endurance and maximal strength. Due to the predominance of type II fibers in the abdominal region, resistance training is essential. However, there is ongoing debate regarding the most effective training methods and their influence on maximal strength.

Alavi et al. (2023) found that there are strategies for strengthening the abdominal muscles that focus on increasing their thickness to improve trunk stability and posture. Exercises should activate all abdominal muscles across different planes of movement and may include two types of contractions: isometric and concentric.

STUDY OBJECTIVES

1. General Objective

The general objective of this study is to rationalize specific means to optimize the development of abdominal muscle strength within the instructional process for students aged 6 to 10 years.

2. Specific Objectives

The specific objectives pursued in the present study are:

- To analyze current methodologies for assessing the development of abdominal muscle strength;
- To implement a program of specific means aimed at optimizing abdominal strength.

MATERIALS AND METHODS

In this stage of the study, the subjects were tested to assess the development of abdominal muscle strength. The test battery applied included:
 a) **Sit-Up Test** – to evaluate abdominal strength.

a) *Sit-Up Test – for the development of abdominal muscle strength*

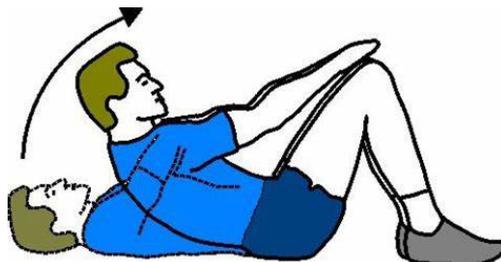


Fig. 1 - Testing of Abdominal Muscle Strength, Eurofit, C.O.E. (1993).
 The sit-up test is used to assess the development of the abdominal and hip flexor muscles.

RESULTS

In this study, we assessed the performance of students in grades I–IV on the SIT-UP test to determine the development of abdominal strength. The purpose of this analysis was to investigate whether significant differences exist between the performances of girls and boys on these tests, using non-parametric testing methods, namely the Wilcoxon and Mann–Whitney tests.

Results Obtained for Grade I – Girls and Boys

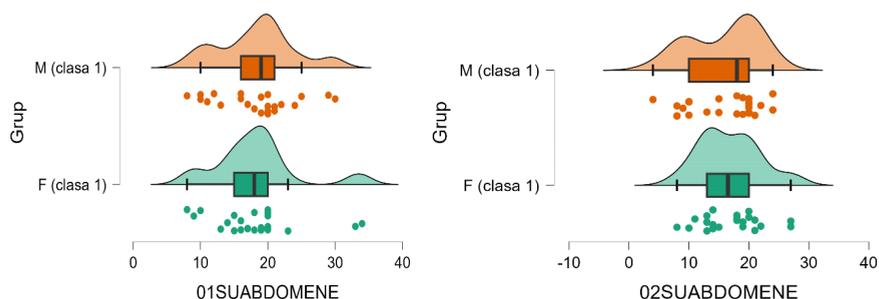
The results were analyzed and compared for both groups (girls and boys), and the findings are presented below.

CHARACTERISTIC VARIABLE	CLASA 1	CLASA 1	CLASA 1	MANN- WHITNEY p-value
	all	F	B	
	mean (standard deviation)	mean (standard deviation)	mean (standard deviation)	
01SUABDOMINALS	17.9 (4.5)	17 (4.3)	19 (4.6)	0.552
02SUABDOMINALS	19.6 (3.6)	19.4 (4.1)	19.8 (3)	0.809
P-VALUE (WILCOXON)		0.161	0.082	

Notes: *SUABDOMINALS* – score obtained in abdominal strength tests for Grade I students, (*SD*) – values are expressed as mean ± standard deviation.

Results Recorded for the SIT UP Variable Measuring Abdominal Muscle Strength (01SUABDOMINALS – 02SUABDOMINALS)

No statistically significant differences were observed in either group with respect to the Mann–Whitney variables ($p = 0.552$ and $p = 0.809$) for the tests (01SUABDOMENE and 02SUABDOMENE). The p-values obtained from the Wilcoxon test suggest that the differences for the tested characteristic are not statistically significant, with the significance threshold being non-significant for both girls ($p = 0.161$) and boys ($p = 0.082$).



Graph 1. Distribution of the variable SUABDOMENE (SIT-UP) at time points 1 and 2 according to group membership (GE = experimental group, GC = control group).

Results Obtained for Grade II – Girls and Boys

CHARACTERISTIC	CLASA 2	CLASA 2	CLASA 2	MANN-WHITNEY
	all	F	B	
VARIABLE	mean (standard deviation)	mean (standard deviation)	mean (standard deviation)	p-value
01SUABDOMINALS	18.2 (5.7)	17.4 (4.8)	18.9 (6.5)	0.399
02SUABDOMINALS	21.5 (6.8)	19.6 (5.7)	23.1 (7.5)	0.642
P-VALUE (WILCOXON)		0.022	0.417	

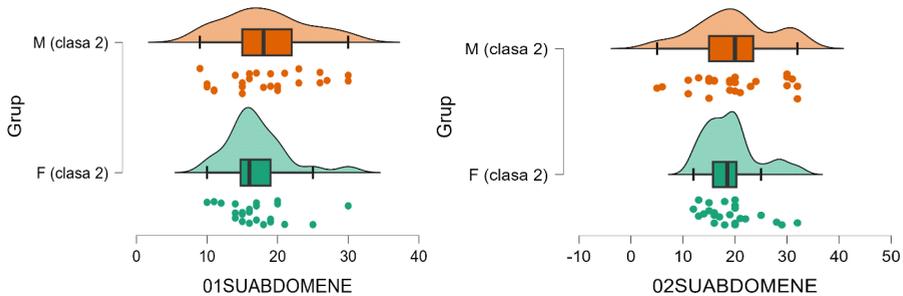
Notes: SUABDOMINALS – score obtained in abdominal strength tests for Grade I students, (SD) – values are expressed as mean \pm standard deviation.

Results Recorded for the SIT UP Variable Measuring Abdominal Muscle Strength (01SUABDOMINALS – 02SUABDOMINALS)

In the case of the variables used to determine explosive strength in the abdominal muscles, the results indicate a statistically significant difference between girls and boys ($p < 0.05$), suggesting that girls performed better in this specific test, with a p-value of 0.022 (Wilcoxon). In contrast, for the boys' group,

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no significant differences were observed between the two groups ($p > 0.05$), indicating a substantial increase in boys' performance values ($p\text{-value} = 0.417$), except for the Mann-Whitney test, where the performance differences were not statistically significant ($p = 0.399$ and $p = 0.642$, respectively).



Graph 2. Distribution of the variable SUABDOMENE (SIT-UP) at time points 1 and 2 according to group membership (GE = experimental group, GC = control group).

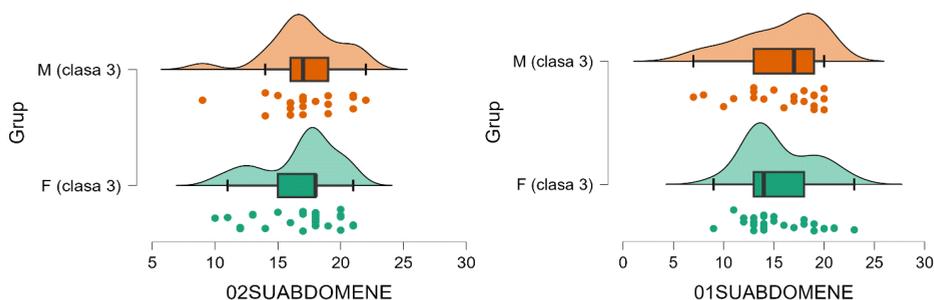
Results Obtained for Grade III – Girls and Boys

CHARACTERISTIC	CLASA 3			MANN-WHITNEY
	all	F	B	
VARIABLE	mean (standard deviation)	mean (standard deviation)	mean (standard deviation)	p-value
01SUABDOMINALS	15.6 (3.2)	15.5 (2.5)	15.8 (4.1)	0.797
02SUABDOMINALS	18 (1.6)	18.3 (1.4)	17.5 (1.8)	0.913
P-VALUE (WILCOXON)		0.386	0.952	

Notes: SUABDOMINALS – score obtained in abdominal strength tests for Grade I students, (SD) – values are expressed as mean \pm standard deviation

Results Recorded for the SIT UP Variable Measuring Abdominal Muscle Strength (01SUABDOMINALS – 02SUABDOMINALS)

We can state that there are no statistically significant differences in any of the groups regarding the Mann-Whitney variables ($p = 0.797$ and $p = 0.913$) for both the experimental and control groups.



Graph 3. Distribution of the variable SUABDOMENE (SIT-UP) at time points 1 and 2 according to group membership (GE = experimental group, GC = control group).

The p-values obtained from the Wilcoxon test suggest that the differences for the tested characteristic are not statistically significant, with the significance threshold being non-significant for both girls ($p = 0.386$) and boys ($p = 0.952$).

Results Obtained for Grade IV – Girls and Boys

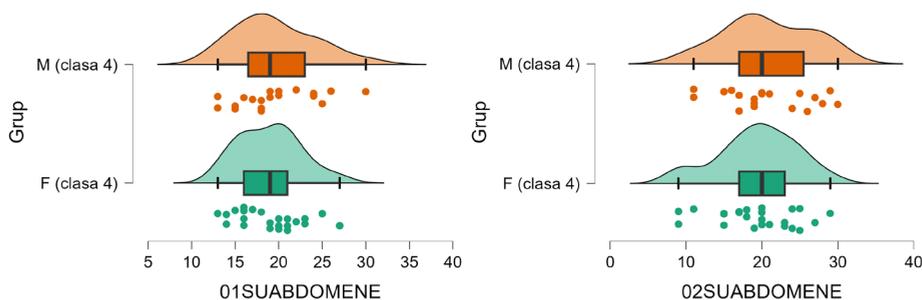
CHARACTERISTIC	CLASA 4 all	CLASA 4 F	CLASA 4 B	MANN- WHITNEY p-value
VARIABLE	mean (standard deviation)	mean (standard deviation)	mean (standard deviation)	
01SUABDOMINALS	19.2 (4.4)	18 (3.1)	20.6 (5.4)	0.821
02SUABDOMINALS	22.5 (4.9)	21.5 (4.7)	23.7 (5.1)	0.521
P-VALUE (WILCOXON)		0.428	0.654	

Notes: SUABDOMINALS – score obtained in abdominal strength tests for Grade I students, (SD) – values are expressed as mean \pm standard deviation.

Results Recorded for the SIT UP Variable Measuring Abdominal Muscle Strength (01SUABDOMINALS – 02SUABDOMINALS)

The comparative analysis of the results from the latest test indicates that there are no significant differences between girls and boys in terms of their performance on these tests. The p-values are below the significance threshold (0.05) when comparing the Wilcoxon parameters (girls: $p = 0.428$; boys: $p = 0.654$) and the Mann–Whitney test ($p = 0.821$ and $p = 0.521$, respectively), indicating statistically non-significant differences between genders in the results of the applied tests.

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Graph 4. Distribution of the variable SUABDOMENE (SIT-UP) at time points 1 and 2 according to group membership (GE = experimental group, GC = control group).

DISCUSSIONS

Discussion of the results obtained in the Sit-Up Test

In this study, the Sit-Up test results revealed that only first-grade boys demonstrated significant abdominal muscle development compared to other grades.

Psychomotricity, as described by Petrea et al. (2023), is an integrative domain encompassing both motor actions and mental processes, forming a coherent unit. It relies on sensory, perceptual, and cognitive functions, as well as on information reception and processing, significantly influencing individual behavior. Psychomotricity addresses human needs through educational, re-educational, and therapeutic processes and is conceptualized as a unified system based on movement and mental functions. It is influenced by interactions among individuals and the relationship between developmental processes and the educational system, impacting social integration.

According to Ridwan et al. (2023), physical exercise is a planned and repetitive activity aimed at improving or maintaining various physical components. Training objectives include optimizing basic physical quality, developing specific skills, refining techniques and strategies, and enhancing psychological aspects of athletes. Each exercise induces bodily adaptations proportional to the training intensity. Physical exercise is essential for both athletic performance and the physical and mental health of non-athletic individuals.

The study included 24 participants divided into two groups: Group 1 (A1) followed a VO₂ max training program, while Group 2 (A2) followed a muscular endurance program. A significant redistribution of performance categories was observed post-intervention: participants classified as “Inadequate” increased from 25% to 50%, whereas those classified as “Weak” decreased from 50% to 25%. No participants were classified as “Good” or “Very Good” in the pre-test.

VO₂Max and abdominal muscular endurance were analyzed pre- and post-intervention. Pre-test VO₂Max values were $p = 0.115$ and post-test $p = 0.169$,

both within normal limits. Abdominal muscular endurance pre-test values were $p = 0.719$. Differences in VO₂Max and abdominal endurance were statistically significant post-intervention ($p = 0.001$), indicating substantial improvements in aerobic capacity and abdominal muscle strength. These results confirm the effectiveness of the applied intervention in enhancing overall physical performance.

Afriyanti et al. (2024) emphasized that abdominal muscle strength is directly influenced by the quality of the muscular system, determined by contraction efficiency, fiber type, and fatigue levels. Abdominal strength refers to a muscle group's ability to generate maximal contraction against resistance. Based on these findings, exercises such as trunk raises and various plank positions are recommended to improve abdominal strength, particularly in the context of Pencak Silat martial arts.

Normative evaluation criteria for the Sit-Up test were established for 10–12-year-old children, differentiated by gender. Boys performing over 23 repetitions and girls over 20 repetitions were classified as “Excellent,” while the “Very Poor” category included boys with 0–3 repetitions and girls with 0–1. Intermediate categories (“Good,” “Adequate,” “Inadequate”) were defined according to repetitions, providing an objective framework for assessing performance and gender differences.

Destriana (2024) demonstrated that sit-ups are aerobic exercises that not only strengthen abdominal muscles but also reduce body fat and promote muscle mass development. In a sample of 316 seventh-grade students, most participants scored in the lower performance categories (“Very Low” and “Insufficient”), highlighting the need for targeted physical training.

Saputri (2024) reinforced the importance of fitness testing in sports training, noting that strength, endurance, and power assessments help identify athletes' strengths and weaknesses to guide training programs. Sit-Up evaluations in seventh-grade students revealed strength levels ranging from “Adequate” to “Very Low,” attributed to insufficient physical preparation.

The Shapiro-Wilk test indicated a non-normal distribution of Sit-Up results (statistic = 0.911, Sig. = 0.016), confirming significant differences in abdominal strength according to gender and age.

Overall, the comparative analysis highlights significant gender- and age-related differences in Sit-Up performance. These findings underscore the importance of implementing personalized training programs and assessment strategies to improve physical fitness and adapt educational interventions effectively.

CONCLUSION

Abdominal muscle strength development programs for students in grades I–IV can generally be applied across genders, given the similar outcomes observed in most groups.

The SIT-UP test proved to be a reliable tool for assessing abdominal strength, providing objective insights into students' physical development. Nevertheless, its utility may be enhanced when used alongside complementary assessment methods, particularly to capture gender- or age-related variations.

Post-intervention analysis revealed significant differences between girls and boys in the second grade, with girls outperforming boys. This suggests variations in motor development and abdominal strength at this age, highlighting the need to tailor training programs according to gender.

A well-structured exercise program, adapted to individual needs and capabilities, can substantially enhance abdominal muscle development and overall physical and cognitive performance.

In summary, while abdominal strength programs for grades I–IV can be broadly generalized, findings emphasize the importance of gender- and individual-specific adaptations.

Careful program design, aligned with each student's abilities, optimizes physical development, cognitive growth, and overall performance.

STUDY LIMITATIONS

The small sample size and the lack of adequate diversity significantly influenced the representativeness of the results, thereby limiting their general applicability. Furthermore, the focus on primary school students (ages 6–10) reduces the validity of the conclusions for other age groups or educational levels. The results obtained are also dependent on the reliability of the tests used (balance, laterality, spatial orientation, and spatio-temporal orientation), factors that may affect the accuracy of the data.

To validate the conclusions, correlating the findings with similar studies was essential, while analyzing variables such as gender provided an overview of the investigated phenomenon. Long-term observation and the application of the methods during different educational stages contributed significantly to clarifying their effectiveness. Expanding the research to other age groups, including middle school, high school students, and athletes, would allow testing the adaptability of the applied methods. Moreover, the use of advanced technologies, such as modern analytical tools, would enable an improvement in research quality.

AUTHORS CONTRIBUTIONS

Carla Silvia Băloi was instrumental in implementing the intervention plan and conducting the statistical analyses necessary to validate the results, significantly contributing to the formulation of the study's conclusions.

Tiberiu Silviu Puta played a key role in designing and implementing strategies to optimize the investigated component, proposing innovative methods and tools that enhanced psychomotor performance and providing a robust theoretical and practical framework adapted to participants' age and motor development level.

Silvia Popescu and Csilla Grădinaru assisted with manuscript revision, ensuring compliance with academic standards and the journal's editorial requirements.

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