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Original Article

A low-cost and time-efficient calisthenics strength training program improves fitness performance of children

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Abstract
Purpose: The present study aimed to investigate the effects of a calisthenics strength training program implemented in a school physical education curriculum on the fitness performance of school children. *Methods:* Twenty four male and female adolescents (aged 15.70 ± 0.84 years) were distributed into Training (TG) and Control groups (CG). TG and CG were tested on the 1-min curl-up (CU), 1-min push-up (PU), medicine ball throw (MBT), and horizontal jump (HJ) tests. Both TG and CG subjects participated in two physical education classes weekly for 8 weeks. Classes for TG incorporated the calisthenics strength program, while CG followed the regular physical education curriculum. *Results:* Both TG and CG subjects achieved significant improvements in CU (CG: 9.7%; TG: 38.9%) and PU (CG: 39.3%; TG: 55.1%), but improvements in TG were significantly greater than in CG. Neither group demonstrated significant changes in the MBT (CG: 6.1%; TG: 13.7%) and HJ (CG: -0.6%; TG: 3.2%) performance, but TG subjects tended for changes with greater effect size. *Conclusion:* The practicality and the low cost of the applied calisthenics strength training program allows easy implementation in school physical education classes and leads to improved muscle strength.
Key words: resistance training, adolescents, bodyweight training, weight-bearing, Introduction

Introduction

Organized physical activity in school plays a key role in the health promotion and proper physical development of youth, especially in early adolescence, when students tend to become less active individuals (Mello et al 2004; Nelson et al 2006).

Exercise recommendations typically include aerobic training, but regular muscular fitness should also be considered for school-based physical activity settings. Strength training as a tool can be used for not only physical conditioning (Dorgo et al 2009) and health (Smith et al 2014) purposes, but also as attractive modality for students to actively participate in physical education classes (Beneli & Piagentini 2012), or to improve adherence to physical exercise programs (Faigenbaum et al 2013). Among the different exercise modalities in strength training (e.g. free weights, machines, elastic bands, manual resistance), calisthenics exercises, in which subjects use their own bodyweight as resistance, are practical and low-cost options that can stimulate the neuromuscular system of children and adolescents (La Scala Teixeira & Evangelista 2016).

Several investigations have demonstrated that strength gains induced by training are possible in this population, mainly due to neuromuscular adaptation (Dahab & McCambridge 2009; Myers et al 2017), and improved intra- and intermuscular coordination. Increased strength may lead to better sport performance and injury prevention (Faigenbaum et al 2013; Faigenbaum & Myer 2010). Incorporation of strength training through calisthenics exercises is a viable option in physical education classes due to the good cost-benefit ratio presented in a previous study (Santos et al 2015).

Despite these benefits of calisthenics strength training, relevant studies in school settings are scarce, especially in a high school environment (adolescents). Thus, the aim of the present study was to investigate the

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effects of a low-cost and time-efficient calisthenics strength training program on fitness performance of high school students, comparing the results with students attending traditional physical education classes. Our initial hypothesis was that calisthenics strength training would provide greater increases in functional fitness than traditional physical education classes.

Materials and methods

Participants

The sample consisted of twenty-four students (14 boys and 10 girls) aged 15 to 16 years (15.70 ± 0.84 years), enrolled in a public school in the city of Praia Grande, SP. The research was carried out only after approval by the institutional ethics committee. Participation in the study was only confirmed after prior written authorization of the parents or guardians of each student. Those who did not submit informed consent signed by parents and/or guardians were automatically excluded from the sample. To avoid interferences, students who practiced any organized sport outside of school were not eligible to participate. Participants were divided in two groups, respective to their original class enrollments: control group (CG, n=12, 8 boys) and training group (TG, n=12, 6 boys).

Assessments

Curl-ups

To assess abdominal strength, the 1-min curl-ups test was used. Participants layed in supine position with their knees flexed at 90°, feet on the ground, and arms crossed over the chest; the evaluator fixed the student's feet on the ground. At the signal, participants started the curl-up movements until touching the elbows to the thighs, returning to the initial position. The number of repetitions correctly executed in one minute was recorded (Rocha & Guedes Júnior 2013).

Push-ups

To assess the upper body strength, the 1-min push-ups test was used. Participants were placed in push-up position (hands and feet on floor), with hands near the shoulder line and elbows extended. Participants were asked to flex their elbows until touching their chest to the floor, repeating the movement as often as possible in one minute. For the girls, the test was performed with knee support on the ground (Rocha & Guedes Júnior 2013).

Medicine ball throw

For the upper body power test, a 3 kg medicine ball, a tape measure and a school chair were used. Sitting in the chair, with the medicine ball at chest height, participants were instructed to throw the ball forward as far as possible. The distance was recorded in centimeters as the best of three attempts (Rocha & Guedes Júnior 2013).

Horizontal jump

To evaluate the power of lower body, the horizontal jump test was used. Participants were positioned behind the starting line and at the evaluator's signal jumped as far as possible. The longest distance of 3 attempts was recorded (Rocha & Guedes Júnior 2013).

Training protocol

The TG attended two physical education classes weekly for 8 weeks. In each class, participants performed 15 minutes of calisthenics training program, after which participants attended their normal physical education classes.

Calisthenics exercises were performed in a circuit format with six stations: 1. squat or lunge, 2. push-up, 3. triceps bench dips, 4. horizontal or vertical jump, 5. plank, 6. curl-up "the rower" with 30 seconds of execution and no rest interval between them. The circuit was performed for 3 rounds with a 50-second rest interval between rounds. The circuit was preceded by warm-up, lasting approximately 2-3 minutes, based on activities such as light jogging, jumping jacks, side shifts and jumps.

The CG participated in their physical education classes in a similar format, but instead of the calisthenics exercise circuit training students performed stretching exercises. Physical Education classes were similar for both groups, following activities designated in the traditional teaching plan of the discipline.

Statistical analysis

The descriptive data were presented as median (M) and interqualite range (IQ). For inferential analysis the Shapiro Wilks test was used to verify the data normality. Collected data did not present normal distribution. To observe the homogeneity of the data we applied the Levene test, characterizing them homogeneous. In order to verify if there were significant differences intra- and inter-groups the Friedman test was used. The Wilcoxon test was applied when intra-group differences were detected and the Mann Whitney test was applied when inter-group differences were detected. Level $\alpha \leq 0.05$ was accepted. To quantify the magnitude of the responses, Cohen's effect size (*d*) was calculated based on mean and standard deviation values, and percentage change (Δ) based on mean values at the pre and post moments.

Results

There were no significant differences between groups for any of the variables analyzed at baseline (pre). In the intra-group pre- to post-test comparison, significant differences were observed in PU for both CG (p=0.011) and TG (p=0.002), as well as in CU for CG (p=0.004) and TG (p=0.003) from pre- and post-test.

Table 1. Pre to post comparison by group in each analyzed variable

Variable	GC			GT		
	Pre	Post	Δ(%)	Pre	Post	Δ(%)
PU (repetitions)	16.0(10.3)	25.5(10.0)*	39.3	20.0(11.8)	36.0(8.5)*#	55.1
CU (repetitions)	28.5(7.0)	29.5(7.3)*	9.7	24.5(11.0)	33.0(7.25)*#	38.9
HJ (meters)	1.78(0.64)	1.76(0.61)	-0.6	1.80(0.44)	1.69(0.99)	3.2
MBT (meters)	3.44(0.81)	3.64(1.12)	6.1	3.30(2.00)	3.70(2.49)	13.7

*P<0.05 *vs.* Pré; #P<0.05 *vs.* GC

Comparing group performances at post-test, the TG results were greater than the CG for PU (p=0.001) and CU (p=0.019) (Table 1). Statistical analysis did not show significant differences in HJ (p=0.075) and MBT (p=0.532) tests. Additionally, the effect size (*d*) was greater for TG than CG in all analyzed variables (Figure 1).

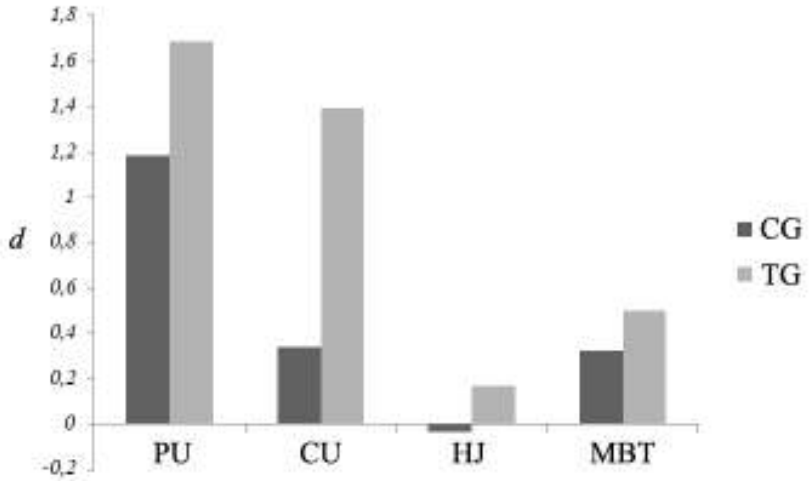

Figure 1. Pre vs. post effect size (*d*) values for both interventions. PU: push-ups; CU: curl-ups; HJ: horizontal jump; MBT: medicine ball throw; CG: control group; TG: training group.

Discussion

The purpose of this study was to analyze the effects of calisthenics strength training on fitness performance in high school students. The initial hypothesis was that this type of training would provide better effects than traditional physical education classes, which would support the insertion of calisthenics strength exercises in the school context. The hypothesis was confirmed.

Our results showed significant increases in strength (PU and CU) of school children after both interventions; however the TG provided greater changes. The increase of strength in children and adolescents can be an interesting adaptation, as it brings improvement in the performance in several physical activities and sports (Lesinski et al 2016), besides helping to prevent injuries in others sports modalities (Faigenbaum & Myer 2010). Also, high levels of neuromuscular fitness in children present inverse association with total and visceral adiposity, and cardiovascular and metabolic risk, in addition positive association with bone health and self-esteem (Smith et al 2014).

Previous literature reports that children can increase muscle strength by 30 to 50% after 8 to 12 weeks of well-designed traditional resistance training (Dahab & McCambridge 2009). Our results demonstrate that calisthenics-based strength training has reached the expectation (↑55.1% for PU and ↑38.9% for CU). Thus, considering the short time spent in physical education classes at schools, the inclusion of circuit-based calisthenics strength exercises in these classes show an interesting strategy to optimizing time and increasing the health and performance benefits.

In addition the TG showed more expressive, but not significant increases on power of upper body (MBT) than CG. Non-significant increases in the power of lower body (HJ) were also observed in TG, with no changes in CG. Although participants did not perform a specific muscle power training program (except in the horizontal/vertical jump exercise), studies indicate that strength-untrained youths seem to show improvement in

this variable as a result of traditional strength training (Lloyd et al 2014), which explains our findings. In other words, traditional strength training, with consequent enhancement of muscle strength, serves as the basis for the muscle power development (Granacher et al 2016). Our results suggest that a time-efficient calisthenics-based strength training may be a low-cost alternative for enhancement of both strength and muscular power in school children.

Previous study published by our group had already found similar results, but in younger children (~12 years) (Santos et al 2015). Other studies also observed good results from the insertion of strength training based on alternative techniques in physical education classes, such as manual resistance training (Dorgo et al 2009) and elastic bands (Annesi et al 2005). However, to our knowledge this is the first study proposing the inclusion of calisthenics strength exercises as complementary to physical education classes, comparing its effects with the traditional class protocol. Thus, considering the low-cost of this training protocol, the results observed in Santos's study (Santos et al 2015), and the health and performance benefits provided by the increased neuromuscular fitness of the participants, the inclusion of a calisthenics strength training program in a school-based physical education program may be a viable alternative.

Conclusion

In conclusion, the addition of a low-cost time-efficient calisthenics strength training to traditional physical education classes significantly improves strength and provides slight effects on power in school children. Considering the practicality and low-cost of calisthenics exercises, its use as a supplement to traditional Physical Education classes is viable and recommended.

Conflict of Interest

Authors declare there are not have any conflict of interest.

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