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# Effects of order and sequence of resistance and endurance training on body fat in elementary school-aged girls

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**ABSTRACT:** The purpose of this study was to analyse the effects of order and sequence of concurrent resistance and endurance training on body fat percentage (BFP) in a large sample of elementary school-aged girls. One hundred and twenty-six healthy girls, aged 10-11 years (10.95 ± 0.48 years), were randomly assigned to six groups to perform different training protocols per week for 8 weeks: Resistance-only (R), Endurance-only (E), Concurrent Distinct Endurance-Resistance (CDER), Concurrent Parallel Endurance-Resistance (CPER), Concurrent Parallel Resistance-Endurance (CPRE), and a Control group (C). In R and E, the subjects performed single sessions of resistance or endurance exercises, respectively (two days per week). In CDER, resistance-endurance training was performed on different days each week (four days per week). CPER and CPRE performed single-session combined endurance-resistance training or combined resistance-endurance training, respectively, each week (two days per week). After an 8-week training period, BFP decreased in all experimental groups (CPER: 13.3%, $p < 0.05$; CPRE: 13.8%, $p<0.001$; E: 1.9%, $p>0.05$; R: 5.0%, $p>0.05$; and CDER: 5.6%, $p>0.05$). However, a significant difference was found in CPER and CPRE when compared to CDER, E, and R, indicating that training sequence may influence BFP. All programmes were effective, but CPER and CPRE obtained better results for BFP than CDER, E, or R. The effects of concurrent resistance and endurance training on body fat percentage can be mediated by order and sequence of exercise. These results provide insight into optimization of school-based fat loss exercise programmes in childhood.

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## INTRODUCTION

Nowadays in developed countries, advances in technology and changes in lifestyles lead to a decrease in daily physical activity and an unsuitable diet. The incidence of diseases related to overweight has increased even among young people [1]. School offers a natural environment for intervening to increase physical activity and improve the body composition among young people [2, 3], and a number of studies support the efficacy of school-based programmes for doing so [4, 5]. However, many doubts arise as to the best physical activity programme to implement.

Endurance training is usually used for fat mass and weight loss programmes [6, 7]. Also, strength training can improve body composition and decrease body fat [8, 9]. Furthermore, both strength and endurance training are often performed concurrently in most exercise programmes in wellness, fitness and rehabilitative settings, in an attempt to achieve different physical fitness goals [10], and there exist some studies reporting a significant decrease of subcutaneous fat and body fat percentage after performing combined strength and endurance training [11, 12]. However, other studies have shown that the percentage fat mass and total fat mass remain unchanged with concurrent strength and endurance training [13-15].

According to our best knowledge, there are no studies that have compared the effects of concurrent training on body fat when this is done on the same day or on alternate days each week, and no studies investigating the effects of order and sequence of concurrent training on body composition in prepubescent children have been reported. Therefore, the aim of the current study was to investigate the effect of different methods of concurrent training (single sessions vs. separate sessions of combined strength and endurance training) on body fat percentage in prepubertal aged children, and compare the results with those obtained when resistance or endurance training is performed alone.

## MATERIALS AND METHODS

### *Subjects*

The sample consisted of 126 prepubescent girls, aged between 10 and 11 years, all of whom volunteered for this study. Inclusion criteria were: children aged 10 to 11.5 years (5th and 6th graders), who were self-assessed in Tanner stages I and II, with no chronic paediatric diseases or orthopaedic limitations, performing no regular oriented extra-curricular physical activity (e.g. practising sport at a club). Subjects were carefully informed about the design of the study and subsequently the children's parents signed an informed consent document prior to the start of the study. The study was conducted according to the Declaration of Helsinki, and was approved by the institutional review boards of the University of Beira Interior (UBI), the Polytechnic Institute of Guarda (IPG), and the Research Centre in Sports, Health and Human Development (CIDESD), Portugal. The participants' general characteristics are described in Table 1.

### *Intervention*

A randomized controlled trial was conducted in a public elementary school. Groups were determined using a random number generator, resulting in the assignment of 25 children to each group. The proportion of participants successfully completing the protocol was 88% (R: Resistance-only), 96% (E: Endurance-only), 68% (CDER: Concurrent Distinct Endurance-Resistance), 64% (CPER: Concurrent Parallel Endurance-Resistance), 96% (CPRE: Concurrent Parallel Resistance-Endurance), and 92% (C: Control group). Thus, analysis was conducted on the remaining 126 girls (R= 22; E= 24; CDER= 17; CPER= 16; CPRE= 24; and C= 23). In R and E groups, the subjects performed single sessions of resistance or aerobics exercise, respectively (two days per week). In the CDER group, resistance and endurance training were performed on different days each week (two and two days per week). CPER and CPRE groups performed single-session combined endurance and strength training or combined strength and endurance training, respectively, each week (two days per week). The control group followed the physical education classes curriculum, without a specific training programme.

Prior to training, subjects warmed up for approximately 10 min with low to moderate intensity exercises, and at the end of the training sessions subjects performed 5 minutes of static stretching exercises. The resistance training programme comprising upper body (1 and 3 kg medicine ball throws) and lower body (jumps onto a box and hurdle jumps, from 0.3 to 0.5 m) plyometric exercises, as well as a speed drill (sets of 20 to 40 m speed runs). The subjects who performed the endurance training programme were subjected to a 20 m shuttle run exercise, readjusted after 4 weeks of training (for more details see [16]). Subjects performed two familiarization sessions before the training programme. The same researcher conducted the training programme and the anthropometric assessments. A more detailed analysis of the programme can be found in Table 2.

### *Anthropometric and morphological measurements*

All anthropometric measurements were assessed according to international standards for anthropometric assessment [17]. Standing height was assessed with a precision stadiometer to the nearest 0.001 m (Seca, model 214, Hamburg, Germany). Body mass index (BMI) and body fat percentage (BFP) were assessed using a body composition analyser (Tanita TBF-300A), and the intraclass correlation coefficient (ICC) values were 0.95 and 0.90, respectively. The measurements were performed with caution following all appropriated steps to guarantee the maximum reliability of the bio-impedance method. The participants were barefoot and only wearing underwear. Tanner stages [18] were determined by self-assessment in a private room using drawings employed in a previously validated procedure [19].

**TABLE 1**. Subject characteristics by group before training (n=126).

| Group | N | Age (years), mean ± SD | Height (m), mean ± SD | Weight (kg), mean ± SD |
|---|---|---|---|---|
| E | 24 | 11.1±0.5 | 1.5±0.0 | 39.8±9.5 |
| R | 22 | 10.9±0.4 | 1.5±0.1 | 41.4±9.9 |
| CDER | 17 | 11.1±0.5 | 1.4±0.1 | 39.2±8.4 |
| CPRE | 24 | 10.8±0.4 | 1.4±0.1 | 39.8±9.4 |
| CPER | 16 | 11.1±0.5 | 1.5±0.1 | 41.9±11.6 |
| C | 23 | 11.0±0.5 | 1.4±0.1 | 37.3±6.9 |
| p-value | | 0.09 | 0.08 | 0.67 |

Mean ± SD and p-value of age (years), height (m), weight (kg) in endurance training alone (E), resistance training alone (R), concurrent distinct endurance and resistance training (CDER), concurrent parallel resistance and endurance training (CPRE), concurrent parallel endurance and resistance training (CPER), and control group (C).

**Table 2.** Training programme design (sets x repetitions/distances).

| | Sessions | | | | | |
|---|---|---|---|---|---|---|
| **Exercise** | **1** | **2** | **3** | **4** | **5** | **6** |
| 1 kg Ball Throw | 2x8 | 2x8 | 2x8 | 2x8 | 2x8 | 2x8 |
| 3 kg Ball Throw | 2x8 | 2x8 | 2x8 | 2x8 | 2x8 | 2x8 |
| SL Jump | 2x4 | 2x4 | 2x4 | 2x4 | 2x4 | 2x4 |
| CM Jump | 1x5 | 1x5 | 1x5 | 1x5 | 2x5 | 2x5 |
| 20 m Sprint | 2x20 m | 2x20 m | 2x20 m | 2x20 m | 3x20 m | 3x20 m |
| 20 m Shuttle Run (MAV) | 70% | 70% | 70% | 70% | 75% | 75% |
| | **Sessions** | | | | | |
| **Exercise** | **7** | **8** | **9** | **10** | **11** | **12** |
| 1 kg Ball Throw | 2x8 | 2x8 | 3x8 | 3x8 | 3x8 | 3x8 |
| 3 kg Ball Throw | 2x8 | 2x8 | 2x8 | 2x8 | 3x6 | 3x6 |
| SL Jump | 2x4 | 2x4 | 3x4 | 3x4 | 3x4 | 3x4 |
| CM Jump | 2x5 | 2x5 | 2x5 | 2x5 | 3x5 | 3x5 |
| 20 m Sprint | 3x20 m | 3x20 m | 3x20 m | 3x20 m | 3x30 m | 3x30 m |
| 20 m Shuttle Run (MAV) | 75% | 75% | 75% | 75% | 80% | 80% |
| | **Sessions** | | | | | |
| **Exercise** | **13** | **14** | **15** | **16** | | |
| 1 kg Ball Throw | 3x8 | 3x8 | 3x8 | 3x8 | | |
| 3 kg Ball Throw | 3x6 | 3x6 | 3x6 | 3x6 | | |
| SL Jump | 4x4 | 4x4 | 4x4 | 4x4 | | |
| CM Jump | 3x5 | 3x5 | 3x5 | 3x5 | | |
| 20 m Sprint | 3x30 m | 3x30 m | 3x30 m | 3x30 m | | |
| 20 m Shuttle Run (MAV) | 80% | 80% | 80% | 80% | | |

1 kg Ball Throw – Chest 1 kg Medicine Ball Throwing (m); 3 kg Ball Throw – Chest 3 kg Medicine Ball Throwing (m); SL Jump – Standing Long Jump (m); CM Jump – Counter Movement Jump onto a box (m); 20 m Sprint – 20 m Sprint Running (s); MAV – maximal individual aerobic volume.

### *Statistical analysis*

Standard statistical methods were used to calculate the means and standard deviations. Normality of distribution was checked by applying the Kolmogorov-Smirnov test. One-way analysis of variance (ANOVA), followed by Bonferroni's post-hoc comparison tests, was used to verify the differences of each group in the body fat percentage values in the pre-test. To analyse the differences between groups in the post-test measures a univariate analysis of variance (ANCOVA) was conducted with the pre-test variables as the covariate, followed by Bonferroni's post-hoc comparison tests. Partial eta squared was calculated. The assumption of sphericity was validated by Mauchly's test of sphericity. The statistical significance was set at $p \leq 0.05$.

## RESULTS

At baseline, no differences were found between groups for age or Tanner ratings. In addition, similar values were found between groups on the BFP ($F(5,120) = 0.58$, $p=0.71$).

There was found a medium-sized decrease from the pre- to post-training in the BFP ($F(5,120)=5.91$, $p<0.001$). There was also found a medium-sized effect on the BMI ($F(5,120)=17.74$, $p < 0.001$). There were decreases from pre- to the post-training in the CPRE ($p<0.001$) and CPER ($p<0.01$) groups. Inversely, there was an increase in the control group ($p< 0.001$). No changes in BFP from pre- to the post-training occurred for E, R and CDER groups ($p=0.79$, $p=0.05$, and $p=0.37$, respectively). The mean changes in BFP and BMI in the control and experimental groups are shown in Table 3.

**Table 3**. Descriptive statistics and univariate analysis of variance and descriptive statistics.

| Group | N | BMI Mean ± SD (Pre-training) | BMI Mean ± SD (Post-training) | BMI p-value, effect size | BFP (%) Mean ± SD (Pre-training) | BFP (%) Mean ± SD (Post-training) | BFP (%) p-value, effect size |
|---|---|---|---|---|---|---|---|
| E | 24 | 18.0±3.3 | 18.7±3.2 | <0.001, 0.43 | 21.5±9.5 | 21.1±8.5 | <0.001, 0.20 |
| R | 22 | 19.5±3.0 | 19.3±2.9 | | 24.0±6.1 | 22.8±6.8 | |
| CDER | 17 | 18.9±3.2 | 19.4±2.9 | | 23.2±10.5 | 21.9±6.8 | |
| CPRE | 24 | 19.3±3.4 | 18.1±3.2 | | 24.7±7.6 | 21.3±6.8 | |
| CPER | 16 | 19.8±3.7 | 18.6±3.6 | | 24.1±7.8 | 20.9±6.1 | |
| C | 23 | 18.8±2.6 | 19.8±3.3 | | 21.9±6.0 | 24.5±6.9 | |

Mean ± SD, p-value, and effect size of body mass index (BMI) and body fat percentage (BFP) in pre- and post-training in endurance training alone (E), resistance training alone (R), concurrent distinct endurance and resistance training (CDER), concurrent parallel resistance and endurance training (CPRE), concurrent parallel endurance and resistance training (CPER), and control group (C).

## DISCUSSION

The purpose of this study was to analyse the effects of order and sequence of concurrent strength and endurance training on body fat percentage in elementary school-aged girls. The main results suggested that both single-session and combined resistance-endurance training or combined endurance-resistance training were more efficient in decreasing fat mass in healthy prepubescent girls than resistance and endurance training alone or combined resistance and endurance training performed in separate sessions. These results have important relevance for optimization of school-based fat loss exercise programmes in childhood.

Excess adiposity is one of the main risk factors for the development of several metabolic disorders [20, 21]. In addition, the reduction of body fat with non-pharmacological interventions is the most accepted method for the majority of the population, including the paediatric one [22]. These interventions have been the focus of several studies that aimed to identify which training models are more effective in the prevention and treatment of excess adiposity and related diseases [22]. Resistance exercises increase bone and lean mass, reducing total body weight as well as absolute and relative fat mass [23-25]. In parallel to this, aerobic exercises collaborate in the reduction and control of total body fat [26, 27] and promote beneficial changes in individuals' lipid profile [28]. So, a combination of resistance and endurance training could be beneficial for weight loss and body composition [9].

After the 8-week training period, BFP decreased in all experimental groups. However, a significant difference was found in CPER and CPRE groups when compared to CDER, E, and R groups, indicating that training sequence may influence BFP. The greater loss of body fat in CPER and CPRE groups may be related to the basal metabolic rate [6]. Perhaps better recruitment of the energy reserves takes place, caused by the increased energy demands from the simultaneous training stimuli [29]. Our results were in line with the results of previous studies that also reported a significant decrease of BFP after performing 8 weeks of concurrent parallel training (CPER: 17.2%; CPRE: 23.2%, $p < 0.001$) in obese females [30], as well as in middle-aged individuals [12]. Similar results were also obtained by Arazi et al. [31] for groups of college students after performing 12 weeks of concurrent parallel training (16.5%, $p < 0.05$) and concurrent distinct training (CDER: 19.3%, $p < 0.05$). Nevertheless, these studies did not confirm which training is more efficient to change body composition. Our outcomes showed better results in the CPRE group when compared to the CPER group, which would suggest that training order may have an influence on BFP. Probably, if the duration of the training programme had been longer than eight weeks, this decrease could have been more substantial.

Concurrent training can significantly increase basal metabolism and decrease body fat relative to the obtained amounts in the before-training period [6]. The results confirmed previous evidence indicating a decrease of subcutaneous fat and body fat percentage after performing eight weeks of combined strength and endurance training in middle-aged individuals [11], as well as in pubescent children [10]. These results have important relevance for optimization of school-based fat loss exercise programmes in childhood. Concurrent training could be implemented in a school programme to contribute to fat loss, regardless of the order of resistance and endurance exercise. We should be aware that different training durations and different workouts could lead to different results. Therefore, care is needed when translating these findings to programmes for overweight/obese children. Children must be motivated to participate in physical activity programmes and these should focus on having fun and developing motor skills rather than on competition. As soon as a child reaches school age, fundamental sports skills must be taught, but emphasising the fun of sport and play [32].

## CONCLUSIONS

To sum up, it can be stated that performing concurrent resistance and endurance training in the same session is more helpful than endurance or resistance training alone, or resistance and endurance training in separate sessions, for reducing body fat percentage of non-athlete prepubescent girls. In addition, the order of concurrent parallel resistance and endurance training did not influence the body fat percentage. Thus, this evidence showed the importance of training design in optimizing school-based fat loss exercise programmes in childhood.

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