Original Article

Evaluation of a four-month program of physical training designed for asthmatic children*

CRISTIANE SONCINO SILVA[1], LÍDIA ALICE GOMES MONTEIRO MARINS TORRES[2], ABEL RAHAL[3], JOÃO TERRA FILHO[4], ELCIO OLIVEIRA VIANNA[4]

ABSTRACT

Objective: The aim of this study was to evaluate physical conditioning and muscle strength before and after a four-month program of physical training. **Methods:** Two groups of children, ages 8 to 11 years, with moderate asthma were studied. All subjects were tested before and after a program of physical training, which was conducted in 90-min sessions, twice weekly, for four months and also included exercises performed in the water. Children in both groups received general information about asthma, as well as information about the management and treatment of asthma. **Results:** In the final evaluation, anthropometric parameters (height and weight) were found to have increased. Children in the exercise group presented significant gains in the distance run in nine minutes (initial 1.333 ± 0.03 km vs. final 1.440 ± 0.03 km; $p < 0.05$), number of abdominal crunches (initial 24.3 ± 1.4 abdominais vs. final 33.2 ± 1.1; $p < 0.05$), maximal inspiratory pressure (initial 73 ± 5 cmH_2O vs. final 103 ± 5 cmH_2O; $p < 0.05$), maximal expiratory pressure (initial 75 ± 4 cmH_2O vs. final 102 ± 4 cmH_2O; $p < 0.05$) and heart rate at rest (initial 84.3 ± 1.6 bpm vs. final 77.1 ± 2.7 bpm; $p < 0.05$). The control group presented no significant changes in any of these parameters. **Conclusion:** An exercise program involving longer sessions, conducted less frequently, facilitates increased participation by children, thereby leading to better physical conditioning and greater muscle strength.

Keywords: Asthma/therapy; Asthma/rehabilitation; Exercise therapy/methods; Physical education and training; Physical fitness; Vital capacity; Pulmonary gas exchange; Bronchoconstriction; Respiratory muscles; Forced expiratory volume/physiology; Maximal expiratory flow rate; Program evaluation

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* Study conducted in the Pulmonology Department of the Clinical Medicine Division of the Faculdade de Medicina de Ribeirão Preto - Universidade de São Paulo (FMRP-USP, University of São Paulo at Ribeirão Preto School of Medicine), Ribeirão Preto, Brazil.
1. Doctor in the Clinical Medicine Division of the University of São Paulo at Ribeirão Preto School of Medicine, Ribeirão Preto, Brazil
2. Head of the Pediatric Pulmonology Unit of the University of São Paulo at Ribeirão Preto School of Medicine Hospital das Clínicas, Ribeirão Preto, Brazil
3. Physical Educator at the University of São Paulo at Ribeirão Preto School of Medicine Physical Education, Sports and Recreation Center, Ribeirão Preto, Brazil
4. Pulmonologist, Full Professor in the Clinical Medicine Division of the University of São Paulo at Ribeirão Preto School of Medicine, Ribeirão Preto, Brazil
Correspondence to: Elcio Oliveira Vianna. Divisão de Pneumologia, Depto. de Clínica Médica, Hospital das Clínicas da Faculdade de Medicina de Ribeirão Preto da Universidade de São Paulo - USP. Av. Bandeirantes, 3900. CEP: 14048-900; Ribeirão Preto - SP. Phone: 55 16 602-2706. E-mail: evianna@uol.com.br
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INTRODUCTION

Patients with chronic respiratory disease tend to show less tolerance to physical exercise due to respiratory difficulty, restriction of activities itself or lack of physical activities. Asthmatic children acquire a sedentary life style and are more prone to inferior aerobic physical condition than are nonasthmatic children. In addition, such children often present social interaction problems and have a negative attitude toward exercise. These factors are combined with unsuccessful experiences in physical activities and other psychological circumstances.[1-2]

Over the years, studies involving the use of physical exercise as a complement to pharmacological treatment in asthmatic children have shown effects such as improved aerobic performance, decreased blood lactate upon exertion, decreased minute ventilation (during exertion), increased maximum oxygen consumption and decreased number of crises, as well as decreased use of relief medication and anti-inflammatory drugs.[3-5] Consequently, various programs of physical training have been evaluated, focusing on parameters such as duration of the program, as well as on the frequency, intensity and type of exercise (less asthma-inducing types, for example). If these effects of physical exercises in asthmatic children are known and are demonstrated in the literature through the practice of specific sports, there are, nevertheless, few reports on the effects of the overall physical training, including the diversity of exercises (floor and aquatic). There are also few data regarding the frequency and duration of the ideal training sessions for the asthmatic child. A great variability among the studies has been observed, as has a lack of studies focusing on these parameters. Most authors have employed three or more 50-minute sessions per week.

In view of these data, this study is justified because it examines the effects of a program, the likes of which has never been evaluated in the literature. The program employed is more appropriate for this age bracket, as well as being more compatible with the socioeconomic conditions in Brazil. This program consisted of overall physical training, including exercises performed in the water, with ludic and recreational activities, twice weekly, together with pharmacological treatment for asthma. Our objectives were to evaluate the distance run in nine minutes and the heart rate at rest (evaluation of physical conditioning), as well as the strength of the abdominal and respiratory muscles (evaluation of muscle strength), before and after a four-month program of physical exercises with the characteristics described above.

METHODS

The International Study of Asthma and Allergy in Childhood (ISAAC) questionnaire, which identifies asthma for prevalence studies,[6-7] was administered to a group of children, ranging from 8 to 11 years of age, at thirteen public schools in the city of Ribeirão Preto (SP).The children whose answers were compatible with asthma (a score of 4) were invited to undergo spirometry and clinical evaluation. Those diagnosed with moderate asthma, as defined by the National Heart, Lung and Blood Institute guidelines for the diagnosis and management of asthma,[8] were invited to participate in a four-month program of physical training, which would complement the pharmacological treatment. The last 10 children selected for the study were placed in the control group and, after the spirometry and clinical evaluation, participated in a similar training program. Two groups were formed: the exercise group (n = 23), who received medication, were clinically monitored, were given information regarding asthma and performed physical exercises; and the control group (n = 10), who received medication, clinical monitoring and information on asthma. To meet the inclusion criteria, the children had to be able to understand and carry out the procedures involved in the protocol, as well as to do the physical exercises. Children with pulmonary diseases other than asthma were excluded, as were those with severe nonpulmonary diseases, having had acute respiratory infection (suspected or documented) within the preceding six weeks or having been treated with systemic corticosteroids, as were those who were born prematurely or had presented respiratory problems in the first month of life.

The children selected were submitted to the initial evaluations, carried out in the Pulmonology Department of the Ribeirão Preto School of Medicine Hospital das Clínicas, and to the program of physical exercise, conducted at the University of São Paulo at Ribeirão Preto Physical Education, Sports and Recreation Center.

Prior to performing the physical exercises, the

children in the exercise group were submitted to an evaluation which consisted of measurement of maximal static respiratory pressures: maximal inspiratory pressure, based on functional residual capacity, and maximal expiratory pressure, based on total lung capacity. In addition, the distance run in nine minutes was recorded, abdominal muscle strength was assessed by counting the number of abdominal crunches performed in one minute, exercise-induced bronchospasm (EIB) tests were conducted, and heart rate (HR) at rest was measured. The control group was submitted to the same evaluation. At the end of the exercise program or evaluations, all measurements were repeated, except for the EIB test. The asthma treatment regimen remained constant throughout the study and consisted of an inhaled corticosteroid (400 mcg of budesonide/day) and, when necessary, relief medication (200 mcg of salbutamol). The clinical evaluations were performed by pediatricians specializing in pulmonology.

The exercises were performed in 90-minute sessions and in the following sequence: light warm-up of the upper and lower limbs; stretching through body positioning, starting from the neck, upper limbs and lower limbs, with a light start and later sustaining the position for 20 to 30 seconds; walking, with a focus on understanding the basic body movements involved in walking, facilitating the following stage; running, preceded by instructions on the correct overall body posture, for five minutes initially, gradually increasing to seven, nine, eleven and thirteen minutes by the end of the program; overall postural exercises and general muscle strengthening, performed on a mattress, on the ground or on a back rest. After these exercises, the child was sent to the swimming pool, where swimming instruction was divided into units, to cater to the basic needs of the children, as follows: adaptation to the water, holding breaths with complete immersion, progressively more prolonged; floating, swimming and basic diving. The program of physical exercises lasted four months (November through February), twice weekly (Tuesdays and Thursdays), for a total of 32 sessions. A minimum frequency of 80% was required in order to remain in the study, and more than four absences in a row were grounds for exclusion.

After being apprised of the objectives of the study, the procedures involved and the potential risks, the parents of the children gave written informed consent. The study was approved by the Ethics in Research Committee of the Ribeirão Preto School of Medicine Hospital das Clínicas (process no. 4097/2001).

The normal distribution of the parameters studied was confirmed using the Kolmogorov-Smirnov test, and the pre-exercise and post-exercise periods were compared using the paired two-tailed Student's t-test. The alterations observed in one group were compared to those observed in the other group using the unpaired two-tailed Student's t-test. The level of statistical significance was set at $p < 0.05$.

RESULTS

The general characteristics of the exercise and control groups were similar and are presented in Table 1, which shows the means of the spirometric, anthropometric and EIB variables. Comparing the control and exercise groups in this initial evaluation, no significant differences were observed ($p > 0.05$

TABLE 1

Comparison of anthropometric measurements, FEV_1 and EIB for the exercise group and for the control group

	Exercise Group $n = 23$ Mean (± SEM)	Control Group $n = 10$ Mean (± SEM)	p (paired t-test)
Age (years)	9.1 ± 0.2	9.3 ± 0.3	$p = 0.10$*
Gender M/F	10/13	4/6	
Weight (kg)	34.5 ± 1.9	35.3 ± 3.0	$p = 0.4$*
Height (cm)	136.7 ± 1.5	37.6 ± 2.2	$p = 0.3$*
FEV_1 (L)	1.66 ± 0.07	1.74 ± 0.14	$p = 0.2$*
FEV_1 (%)	83.5 ± 3.1	84.4 ± 3.9	$p = 0.4$*
EIB (%)**	"18.0 ± 3.6	"11.8 ± 3.6	$p = 0.2$*

Data presented as mean ± standard error of the mean. FEV1: forced expiratory volume in one second; EIB (%): exercise-induced bronchospasm. *No significant difference between the control group and the exercise group; **Drop in % of FEV1 after provocation test through exercise

TABLE 2

Comparison of the initial and final evaluations of general characteristics of the control group subjects (n =10)

Control Group	Initial evaluation	Final evaluation	*p* (paired *t*-test)
Weight (kg)	35.3 ± 3.0	36.4 ± 3.3*	0.0115
Height (cm)	137.6 ± 2.2	139.1 ± 2.1*	0.0008
FEV_1 (L)	1.74 ± 0.14	1.74 ± 0.13	1
FEV_1 (%)	84.4 ± 3.9	82.3 ± 3.7	0.0961

Data presented as mean ± standard error of the mean.
FEV_1: forced expiratory volume in one second
*p < 0.05 for the comparison between the initial and final evaluation values

for all the variables). The age distributions in the two groups were also balanced (p > 0.05). When EIB was evaluated in the exercise group, it was observed that 74% of the children presented a drop in forced expiratory volume in one second (FEV1) of more than 10%. In the control group, the EIB frequency was also high: 60%. Throughout the four-month period, no patient had an asthma attack.

The mean spirometric and anthropometric variables for the initial and final evaluations of the control group are shown in Table 2. When comparing mean initial and final FEV_1 (L) and FEV_1 (%), we observed no significant difference between them (p = 1 and p = 0.1). Mean anthropometric and spirometric variables for the initial and final evaluations of the exercise group are shown in Table 3, which shows that there was also no significant difference between initial and final FEV_1 (L) or FEV_1 (%) (p = 0.1) in this group.

Regarding the parameters used to evaluate physical and aerobic conditioning and number of abdominal crunches, the control group children presented no significant differences between the initial and final evaluations: distance run in nine minutes (p = 0.580), HR at rest (p = 0.62), abdominal crunches (p = 0.644), maximal inspiratory pressure (p = 0.098) and maximal expiratory pressure (p = 0.222) (Table 4). The children in the exercise group presented significant increases between the initial and final evaluations: distance run in nine minutes (p < 0.0001), HR at rest (p < 0.0001), abdominal crunches (p < 0.0001), maximal inspiratory pressure (p < 0.0001) and maximal expiratory pressure (p < 0.0001) (Table 5).

DISCUSSION

In our study, we used two of the evaluations included in the American Alliance of Health, Physical Education, Recreation and Dance test: measurement of the distance run in nine minutes and evaluation of the number of abdominal crunches performed in one minute.[9-10] The results show that, as a result of the physical exercises, the children increased the distance run and the number of abdominal crunches performed, indicating increased physical conditioning and greater abdominal muscle strength, essential indices for asthmatic children. When comparing initial and final evaluations of the control group, no significant difference was observed in the distance run in nine minutes or abdominal muscle strength.

Another simple parameter that provides important information on cardiovascular conditions is HR. After resistance training, HR at rest may decrease.[11] In the present study, we evaluated HR

TABLE 3

Comparison of the initial and final evaluations of the general characteristics of the exercise group subjects (n = 23)

Exercise Group	Initial Evaluation	Final Evaluation	*p* (paired *t*-test)
Weight (kg)	34.5 ± 1.9	35.7 ± 2.1*	0.0001
Height (cm)	136.8 ± 1.5	139.6 ± 1.6*	0.0002
FEV_1 (L)	1.66 ± 0.07	1.74 ± 0.05	0.1341
FEV_1 (%)	83.5 ± 3.1	85.2 ± 2.7	0.0821

Data presented as mean ± standard error of the mean.
FEV_1: forced expiratory volume in one second; *p < 0.05 for the comparison between the initial and final evaluation values

TABLE 4

Comparison of the initial and final evaluations of the distance run in nine minutes, heart rate and abdominal muscle strength in the control group subjects (n = 10)

Control Group	Initial Evaluation	Final Evaluation	*p* (paired *t*-test)
Distance run in nine minutes (km)	1.195 ± 0.05	1.238 ± 0.06	0.580
Abdominals (number)	21.7 ± 1.0	21.2 ± 1.3	0.644
HR (bpm)	85.6 ± 2.8	86.0 ± 2.4	0.627
MIP (cmH_2O)	71 ± 5	83 ± 5	0.098
MEP (cmH_2O)	73 ± 4	75 ± 5	0.222

Data presented as mean ± standard error of the mean.
HR: heart rate; MIP: maximal inspiratory pressure; MEP: maximal expiratory pressure
*p < 0.05 for the comparison between the initial and final evaluation values

at rest in both groups, before and after evaluation, as well as before and after physical exercise. We observed that the control group children presented no decrease in this parameter when compared to the initial evaluation. In the exercise group children, there was a significant decrease in HR at rest when compared to the initial evaluation, suggesting cardiovascular adaptation to exercise.

Other studies have demonstrated the benefits of physical training for asthmatic children, although the programs employed focused on specific activities. A study carried out in the city of São Paulo (SP) involved 42 children with moderate asthma who were submitted to spirometry and EIB testing, together with pre-exercise and post-exercise cardiopulmonary testing. These children exercised on a cycloergometer, three times a week for two months. The aerobic improvement after exercise was inversely correlated to the pre-exercise conditioning level, regardless of the disease.[12] Other authors studied eight children with moderate asthma and submitted them to a daily swimming program for six weeks. Significant changes in aerobic capacity and blood lactate were observed. However, EIB was not significantly different than that seen in the control group. Therefore, we concluded that, during this six-week program, the effect was observed in aerobic capacity but not in bronchial hyperreactivity.[13]

When the EIB in the exercise group was evaluated, it was observed that 74% of the children presented a drop in FEV_1 greater than 10%. In the control group, the frequency of the EIB was also high: 60%. Studies on the frequency of EIB demonstrate that 40% to 90% of asthmatic children present a bronchial response to exercise.[14-15] In our study, EIB was measured in order to determine the similarity between the two groups and to ensure the safety of the patients during the training sessions. Patients known to present EIB were submitted to the same exercises, although preceded by more careful warm-up and monitoring.

In various studies involving physical exercise programs for asthmatic children, the duration and frequency of the sessions, as well as the overall duration of the program, varies. In such studies,

TABLE 5

Comparison of the initial and final evaluations of the distance run in nine minutes, heart rate and abdominal muscle strength in the exercise group subjects (n = 23)

Exercise Group	Initial Evaluation	Final Evaluation	*p* (paired *t*-test)
Distance run in nine minutes (km)	1.330 ± 0.03	1.440 ± 0.03*	0.00001
Abdominals (number)	24.3 ± 1.4	33.2 ± 1.1*	0.00001
HR (bpm)	84.3 ± 1.6	77.1 ± 2.7	0.00001
MIP (cmH_2O)	73 ± 5	103 ± 5 *	0.00001
MEP (cmH_2O)	75 ± 4	102 ± 4 *	0.00001

Data presented as mean ± standard error of the mean.
HR: heart rate; MIP: maximal inspiratory pressure; MEP: maximal expiratory pressure
*p < 0.05 for the comparison between the initial and final evaluation values

twice weekly being the minimum frequency, and six times a week being the maximum, improvements in the parameters that evaluate physical conditioning have been reported. Regarding the duration of sessions and the overall duration of the program, the literature reports from ten minutes to two hours, and from four weeks to two years, respectively.[16-17] A Brazilian author who studied the effects of a treatment program, with and without physical training, for twelve months, reported improved cardiovascular adaptation to exercise and an increase in the distance run in nine minutes in the group performing exercise.(18) The choice of two sessions a week had the objective of providing more adherence to the sessions, bearing in mind that children depend on a companion, and a higher number of sessions could result in absences. The choice of 90-minute sessions had the objective of progressively increasing the intensity in the different types of exercises, diversifying exercises within the same session (stretching, aerobic, respiratory, postural, recreational and basic swimming), in addition to promoting more preventative and therapeutic benefits.

In our study, no improvement in FEV1 was found. In a study carried out in order to investigate whether a program of physical activity for asthmatic children could modify pulmonary function detected no significant alteration in forced vital capacity, FEV_1 or forced expiratory flow between 25% and 75% of forced vital capacity, indicating only a tendency toward improvement.[19] Another group of researchers, monitoring asthmatic boys who participated in a two-year program of physical exercises, reported no increase in pulmonary volumes.[20]

Quality of life is a parameter that can be improved by exercise programs, even resulting in a lessening of asthma symptoms, as well as a reduction in the need for medication, which can also be decreased as a result of the training.[21] These parameters were not evaluated in our study, and the distribution of the children between the two groups was carried out without interference or researcher preference. However, the allocation was not randomized since the control group comprised the last children included in the study.

This program had peculiarities such as lower frequency and longer duration of each session, in order to make it easier for the children to participate without decreasing the positive effects. Frequencies such as three or four times a week can be an impediment to the participation of children, since children in this age bracket depend on the adults who care for them. In addition, more attractive activities and diversification of types of exercise aid adherence.

In conclusion, a four-month physical training program involving exercises also carried out in the water, twice weekly, consisting of 90-minute sessions, leads to better physical conditioning and greater muscle strength in asthmatic children.

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