Physical Exercise Recommendations Improve Postural Changes Found in Children and Adolescents with Cystic Fibrosis: A Randomized Controlled Trial

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Objective To evaluate postural changes and the distribution of plantar pressures in patients with cystic fibrosis (CF). We also sought to evaluate the effects of an educational guideline for physical activity on body posture in children and adolescents with CF.

Study design This was a 2-phase study of individuals between age 7 and 20 years. Phase I was a cross-sectional study in which healthy subjects were selected for postural evaluation and baropodometry, aiming to perform a later comparison with patients with CF. In phase II, we performed a randomized controlled clinical trial to assess the influence of the exercise guideline on the postural changes. Patients were assigned to 2 groups: control and intervention. The intervention consisted of a handbook with instructions for aerobic exercise and stretching. Main outcomes were postural abnormalities, plantar pressure distribution, and lung function.

Results In phase I, 34 patients with CF and 34 healthy matched individuals were included. No significant baseline differences were identified. Children with CF presented more postural deviations compared with healthy subjects ($P < .05$), as to alignment of the head, shoulder girdle, and pelvis, increased cervical lordosis, and lateral chest distance. In phase II (n = 34), there were no baseline differences between groups. The intervention caused ($P < .05$) a decrease in cervical lordosis, thoracic kyphosis, lumbar lordosis, lateral chest distance, and abdominal protrusion, as well as in the baropodometric mean pressure and contact area.

Conclusions Children and adolescents with CF present postural changes when compared with healthy individuals. The educational guideline for exercise practice helped to improve posture, preventing the progression of some postural disorders. *(J Pediatr 2015;166:710-16)*.

Advances in strategies for the treatment of cystic fibrosis (CF) have increased the life expectancy. Postural changes related to the onset of secondary complications of the musculoskeletal and neuromuscular system have become more frequent[1] and are associated with problems such as bone mineralization, progression of the lung disease, and increased work of breathing, leading to muscle imbalances.[2] The relationship between posture and respiratory mechanics is being studied, and evidence suggests that the increase in musculoskeletal complications is associated with aging and worsening lung function, the most frequent being thoracic kyphosis.[1-8] However, despite the recommendations that evaluations of body posture and interventions be performed in an attempt to identify and prevent or minimize postural abnormalities,[1,9] little is known about the level of postural changes presented by children and adolescents with CF.

On the other hand, it is well-known that regular physical activity practiced under supervision during childhood and adolescence benefits the musculoskeletal, cardiovascular, and metabolic systems.[10-12] Studies show that aerobic exercises increase the maximal oxygen consumption ($VO_{2\ max}$),[10,13-15] peak oxygen consumption (VO_2 peak),[15-17] reduce the production of effort-induced lactic acid, and increase the oxidative capacity of the skeletal musculature,[13,18] besides improving psychological aspects such as increasing self-esteem.[17]

Although the benefits of the regular practice of physical exercise are clearly defined, it is unknown what effect the recommendations for the practice of unsupervised physical activity has on posture. Supervised programs have been usually difficult to implement because of the high costs and levels of involvement by the family and/or caregivers in maintaining children and adolescents enrolled in a regular physical exercise program. Therefore, alternatives such

CF	Cystic fibrosis
ES	Effect size
$FEF_{25\%-75\%}$	Forced expiratory flow between 25% and 75% of FVC
FEV_1	Forced expiratory volume in the first second
FVC	Forced vital capacity
HSL-PUCRS	Hospital São Lucas, Pontifícia Universidade Católica do Rio Grande do Sul

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as recommendations for the practice of unsupervised physical activity at home have been commonly employed at centers of reference for the treatment of patients with CF. However, there are no studies evaluating possible effects of the unsupervised practice of physical exercise and stretching on body posture and static and dynamic osteomuscular measures on children and adolescents. Our hypothesis is that verbal and written recommendations for the practice of physical activity using an individualized program, as preferred by the patient, can help reduce the progression or improve postural deformities in patients with CF. Thus, the goals of this study were to quantify the postural changes and distribution of plantar pressures in children and adolescents with CF by comparing them with healthy individuals, and to evaluate the effects of a program of guidelines for the practice of physical exercise and stretching on body posture in children and adolescents with CF.

Methods

The study was performed at the CF outpatient clinic at Hospital São Lucas, Pontifícia Universidade Católica do Rio Grande do Sul (HSL-PUCRS), and it was approved by the Ethics Committee of the institution under protocol no. 04134313.7.0000.5336. All those responsible agreed and signed the informed consent prior to inclusion. The study was then divided into 2 phases.

Phase I

Because it is difficult to interpret and normalize data on postural evaluation and baropodometry for a population with chronic respiratory disease, healthy subjects were chosen to obtain a standard of normality to compare with the patients with CF.

For this purpose, healthy subjects and subjects with CF were selected, paired according to age, sex, height, and weight. The study included patients with CF, aged 7-20 years, who were regularly followed at the CF outpatient clinic (HSL-PUCRS). The healthy children and adolescents, in the same age group, were chosen among public and private school students who did not present any respiratory disease, evaluated by the respiratory health questionnaire drawn up by pediatric lung specialists based on the questionnaire recommended by the American Thoracic Society–Division of Lung Diseases-78-C, previously adapted and validated for use in Brazil.[19] In both groups (healthy and CF), the parents or legal guardians of the children and adolescents were invited to participate in the study and gave their informed consent. After this, the respiratory health questionnaire was completed for the healthy subjects. Later, the subjects were sent to the laboratory of physical activity evaluation to undergo the anthropometric, postural, and baropodometry assessment.

The sample size was calculated taking into account the thoracic kyphosis variable, based on pediatric data, according to Yi et al,[20] demonstrating a mean of 41.33 and a SD of 4.65 degrees. Thus, adopting a 0.05 level of significance, a power of 80% and a minimal difference of 2.8 degrees, a sample size of 34 subjects was estimated for each of the groups proposed.

Phase II

Based on the results obtained in phase I, its purpose was to evaluate the effect of guidelines on the practice of physical exercise in children and adolescents with CF on body posture and distribution of plantar pressures.

Thus, a controlled, randomized clinical trial was performed and children and adolescents with a diagnosis[21] of CF were chosen. They were regularly followed at the CF outpatient clinic at HSL-PUCRS. This study was done according to the regulations of the Consolidated Standards of Reporting Trials, and it was included in the Brazilian Clinical Trials Registry, as RBR-3r4h5s. The inclusion criteria were individuals with a diagnosis of CF, aged 7-20 years, clinically stable disease, and regular follow-up at the outpatient clinic. Children and adolescents with cognitive alterations or osteomuscular changes that would make it impossible to perform the tests were excluded. A computer program (Random Allocation Software v 1.0; http://random-allocation-software.software.informer.com/1.0/) in blocks of 6 was used for the randomization process. The patients were allocated into 2 groups: control group (G1) and intervention group (G2) (**Figure 1**; available at www.jpeds.com).

The patients who were eligible for the study and/or their parents or legal guardians were invited to participate and received detailed information. After agreeing and signing the informed consent, they completed an evaluation form, were randomized, and included in the study. After a routine visit to the CF outpatient clinic, in which lung function was evaluated (spirometry), sputum or oropharynx secretion collected, and a multidisciplinary evaluation performed, the patients were taken for an anthropometric, postural, and baropodometric evaluation. In addition, self-reported data were collected on the usual practice of physical activity by the children and adolescents with CF (type of exercise, frequency, and duration). For both groups (G1 and G2), all evaluations were performed at the time of inclusion and after 3 months. The researcher performing all evaluations was blinded to the group allocation. Assessment of clinical data included quantitative postural evaluation measures, static and dynamic baropodometric variables, and lung function.

An illustrated handbook of guidelines was given to the patients included in group G2 (intervention). This was for practicing aerobic physical exercises: running, swimming, walking, dancing, playing games, cycling, skipping rope, or other activities of interest to them. Patients were allowed to choose according to their preferences. Also, the handbook contained 12 illustrated stretching figures, including stretches for the shoulder girdle, upper limbs, trunk, and lower limbs. The correct stretching technique was demonstrated to each patient. They were instructed to exercise at least 3 times per week for a minimum of 20 minutes[22] and to perform each stretch 2 times for 20 seconds each. The handbook also contained a calendar, where the patient marked the days of the

month when they performed aerobic exercises and stretching. The patients in group G2 also received phone calls from the researcher every 2 weeks reinforcing the practice of aerobic exercise and stretching, discussing doubts, and providing guidance. Group G1 (control) received the usual recommendation that is part of the routine of the care team, including verbal orientations to perform exercise and stretching, without the delivery of specific written information for the practice of physical exercise and stretching.

The sample size was defined based on the same variables used in phase I of the study, also resulting in 34 individuals to be randomized. Thus, considering an error α of 5% and a minimal difference of 2.8, a power of 79% was obtained with the sample size used.

Anthropometrics

The anthropometric measures were obtained using standardized techniques, always by the same assessor with calibrated equipment. The weight and height measures were obtained on an anthropometric balance (Filizola; Filizola S.A.; São Paulo, Brazil) and extensible stadiometer (Sanny; Sanny; São Paulo, Brazil). Both weight and height were measured in duplicate, accepting a maximum value of 1.0 cm between both measures of height and of 200 g for weight. The mean value of the 2 measures was adopted for the body mass index calculation, defined as the relationship between weight in kilograms and height in square meters (kg/m^2).[23]

Lung Function

The spirometries (KoKo spirometer; nSpire Health, Louisville, Colorado) were performed by a trained resident and the following variables were evaluated: forced vital capacity (FVC), forced expiratory volume in the first second (FEV_1), Thiffenau's index (FEV_1/FVC), and forced expiratory flow between 25% and 75% of FVC ($FEF_{25\%-75\%}$). The patient should not present respiratory exacerbation,[24] nor have used a short-acting bronchodilator 4 hours previously (or a long-acting bronchodilator 12 hours previously). All procedures and criteria used were in accordance with the American Thoracic Society guidelines.[25]

Postural Evaluation

The postural evaluation was performed using the postural assessment software (PAS/SAPO; http://puig.pro.br/sapo)[26] which, using a digitized photograph of the patient, allows measuring the position, length, angle, and alignment of the body segments of an individual. The child in a bathing costume remained in orthostatic position, on an ethylene vinyl acetate rubber carpet, next to a plumb line marked every 1 meter and fixed to the ceiling, to be photographed on the following planes: anterior and posterior frontal; and sagittal left and right. Specific anatomical points were marked with colored adhesives disposed on 1 cm-diameter Styrofoam spheres, and fixed with double face adhesive tapes (**Figure 2**; available at www.jpeds.com). The digital camera (Sony Corporation, Tokyo, Japan) 7.2 megapixel was on a tripod, 2.5 m away from the patient, and the height was calculated dividing the child's height by 2. The plantigrade imprint was recorded to preserve the position, and dimensions of the base on the different planes photographed.

The anatomic points marked were glabella, tragus, spinous process of C7, inferior angle of the scapula, spinous process of T3, T7 and L1, anterosuperior iliac spine, posterosuperior iliac spine, greater trochanter of the femur, articular line of the knee, medial point of the patella, tibial tuberosity, point over the midline of the leg, lateral malleolus, medial malleolus, point over the calcaneus tendon at the level of the malleoli, calcaneus, and the point between the head of the second and third metatarsal.[26] The photos were analyzed in the following sequence: opening the photo, 100% zoom, image calibration based on the plumb line, and marking the anatomical points. To determine cervical lordosis, an angle was formed from 3 anatomic points: tragus of the ear, C7, and acromion, the acromion being the vertex of the angle. It was characterized that the greater the angular measure, the more anteriorized the position of the head and the smaller the cervical lordosis. To determine lumbar lordosis, an angle was formed from 3 anatomic points: L1, anterior-superior iliac spine, and greater trochanter, anterior-superior iliac spine being the vertex of the angle. It was characterized that the smaller the angular measure, the greater the lumbar lordosis.[20] The anatomic points were located using a scientific tutorial of the SAPO software, always by the same assessor. The SAPO software is free of charge, developed for use in scientific postural evaluation and accessed through the internet.

Baropodometry

Static and dynamic baropodometric analyses were performed using the Electronic Baropodometer (IST Informatique, Gargas, France), consisting of a force platform with 2.074 capacitive captors, 7.62 × 7.62 mm that allow measuring plantar pressures in (kgf/cm^2), displacement of the center of gravity (in percentage of body weight), and plantar surface (in cm^2). This equipment consists of a 16-bit analog/digital converter and a sampling frequency of 150 Hz. For static baropodometric analysis, the child was told to get up on the platform without shoes, with the upper limbs along the body, looking forward at a fixed point on the wall 1 m away and at the height of the glabellar region, lips closed tight, and the mandible in a position at rest without occlusal contact. They remain with the feet parallel forming a 30° angle and a distance of 4 cm between the heels measured with a goniometer. Three recordings were performed lasting 10 seconds each and interspersed by a 1-minute rest period.[27] For dynamic analysis, the platform was positioned at a place with a minimum of 2.5 m on each side so that the child could walk. Initially, the child was asked to walk on the platform without recording, so that it would become used to the action and then the data were acquired, beginning with the right foot and then with the left foot. Three dynamic recordings were also performed, and the mean value was adopted. The pressure data acquired were interpreted by the Footwork software (IST Informatique, Gargas, France) that transforms

them into images on the computer screen, enabling analysis of the division of loads in orthostasis, posturology in static position, dynamic transfer of a load during the support phase, and the pressure peak and time of contact with the floor.[28]

Statistical Analyses

In both phases of the study, the distribution of variables was evaluated using the Kolmogorov-Smirnov test and presented a normal distribution. Thus, the continuous variables were presented as mean and SD, and the categorical variables were expressed as absolute and relative frequency. In phase I, the results were compared using the Student *t* test for independent samples. In phase II, the analysis was performed by intention to treat. The primary outcomes were postural changes, and secondary outcomes were baropodometry and lung function. The effect size (ES) was calculated using the variation obtained before and after intervention, using the ES calculator tool available on the internet. The differences between the 2 groups were evaluated using the Student t test. All the analyses and data processing were performed with program SPSS v 18.0 (SPSS Inc, Chicago, Illinois). The level of significance adopted was $P \leq .05$.

Results

Phase I

Children and adolescents with CF (n = 34) aged 7-20 years, mean age 13.2 ± 3.3, years were included; 20 patients (58.8%) were male. The patients presented a mean weight 45.8 ± 15.3 kg and height 1.50 ± 0.13 m. Healthy children (n = 34; mean age 12.9 ± 2.9, mean weight 46.8 ± 12 kg and mean height 1.52 ± 0.14) were included for pairing. There was no significant difference among the groups (Table I). In individuals of the CF group, the mean of the FEV_1 values was 99 ± 24.2 and FVC 107 ± 21.7 (values in percentage of the predicted).

Table II shows the distribution of the values of posture and baropodometry variables in groups: subjects with CF and healthy controls. In general, children with CF present greater postural deviations than healthy children. Significant differences were observed as to the alignment of the head (anteriorization of the head) and increased cervical lordosis. Further, changes were identified in the alignment of the shoulder girdle, which is an indication of scoliosis, and in the alignment of the pelvis and increased laterolateral distance of the chest. Children with CF also present higher degrees of thoracic kyphosis, although this difference has not been significant ($P = .068$). The results of baropodometry do not show statistically significant differences in the area of contact of the foot with the ground and the percentage displacement of the load.

Table I. Sample characterization regarding anthropometric data, sex, and age

	Healthy (n = 34)	CF (n = 34)	*P*
Age (y)	12.9 ± 2.9	13.2 ± 3.3	.686
Sex (female)	41.2%	41.2%	-
Weight (kg)	46.8 ± 12	45.8 ± 15.3	.759
Height (m)	1.52 ± 0.14	1.50 ± 0.13	.602
BMI	19.8 ± 2.3	19.5 ± 3.6	.664

BMI, body mass index.
Values expressed in mean ± SD.

Phase II

Children and adolescents with CF (n = 34) were studied, 41.2% were female; 17 patients were randomized to the control group (G1) and 17 to the intervention group (G2) (Figure 1). The mean age was 12.9 ± 3.9 years, with a FEV_1 92.1 ± 29.6% of the predicted in G1 and 13.6 ± 2.8 years with a FEV_1 93.2 ± 18.1% of the predicted in G2. The data with the baseline characteristics of both groups are shown in Tables III and IV (Table IV; available at www.jpeds.com). There were no statistically significant differences among the groups at the beginning of the study. The average number of days patients reported to practice the aerobic exercise and stretching prescribed was more than 3 times per week (58.8%), 3 times per week (35.2%), and 2 times per week (6%).

The results demonstrate that the intervention reduced cervical lordosis ($P = .0003$; ES = 1.41), thoracic kyphosis ($P = .01$; ES = 0.89), lumbar lordosis ($P = .05$; ES = 0.71), lateral chest distance ($P = .01$; ES = 0.91), and abdominal protrusion ($P = .04$; ES = 0.75). Besides, in the baropodometric evaluation, there was a significant difference in the mean pressure exerted by the foot on a surface ($P = .001$; ES = 1.25) and in the area of contact of the foot with the ground ($P = .01$; ES = 1.02), indicating the influence of physical exercise on the distribution of plantar pressures. The data of the pre- and postintervention variations and the results of the comparisons among the groups are shown in Table V.

Discussion

The results of this study show that the subjects with CF present a series of postural changes compared with healthy children and adolescents. The recommendation for practicing aerobic physical exercise and stretching helped improve or avoid the progression of the postural involvement in patients with CF.

The relationship between posture and respiratory mechanics has been previously reported.[1,4,7,29] The physiopathologic process, progression of lung diseases, and the increased life expectancy of these patients are pointed out as the main factors responsible for the development of body posture changes.[30] The recurring infections, with consequent reduction of the airways diameter and loss of pulmonary elasticity, induce thoracic hyperinflation and force the abdominal muscles to help the diaphragm during expiration. The anterior muscle chains contract excessively, the inspiratory muscles adapt progressively, shortening muscle fibers, and reducing the capacity to generate force.[9,29] In individuals who present a deficient nutritional state and bone mineralization problems, the development of spinal

Table II. Distribution of postural evaluation and baropodometry variables in healthy individuals and individuals with CF

Variables	Healthy (n = 34)	CF (n = 34)	P
Postural evaluation			
Head tilt (°)	1.2 ± 0.9 (0-9)	3.1 ± 2.3 (0-3.4)	.001
Scapular girdle tilt (°)	1.1 ± 1.4 (0-4.8)	1.8 ± 1.0 (0-5.9)	.015
Pelvic tilt (°)	1.04 ± 1.06 (0-6)	2.39 ± 1.8 (0-7)	.001
Trunk tilt A-P (°)	2.0 ± 1.6 (0-6.5)	2.2 ± 1.5 (0.2-6.7)	.930
Cervical lordosis (°)	51.5 ± 6.1 (39.9-62.8)	62.1 ± 5.5 (62-76.1)	.001
Thoracic kyphosis (°)	30.8 ± 3.3 (23.9-38.2)	32.6 ± 4.6 (23.8-42)	.068
Lumbar lordosis (°)	103.25 ± 6.6 (90-119.7)	103.14 ± 9.7 (88.2-122.5)	.958
Lateral chest distance (cm)	26.1 ± 3.3 (20.2-33.1)	29.3 ± 5.1 (17.9-38.6)	.002
Anteroposterior lateral chest distance (cm)	19.9 ± 2.3 (14.1-38.6)	20 ± 2.3 (16.9-33.1)	.836
Abdominal protrusion (cm)	18.9 ± 2.5 (13.7-23.8)	19.7 ± 3.4 (15.3-28.7)	.296
Static baropodometry			
Mean pressure (kgf/cm^2)	0.26 ± 0.07 (0.14-0.4)	0.27 ± 0.08 (0.13-0.5)	.610
Contact area (cm^2)	68.2 ± 14.5 (32.29-91.2)	65.9 ± 21.5 (31.6-115.8)	.619
Anterior displacement (%)	44.8 ± 10.7 (25.3-65.8)	47.3 ± 12.8 (29.3-73)	.391
Dynamic baropodometry			
Duration of the step (ms)	678 ± 105.2 (426.6-873.3)	638 ± 78.2 (503.3 ± 796.7)	.082
Maximal pressure (kgf/cm^2)	1.16 ± 0.2 (0.77-1.9)	1.18 ± 0.3 (0.6-2.1)	.773
Contact area (cm^2)	86.6 ± 17.9 (42.7-118.5)	84 ± 21.7 (49.5-136.3)	.593

Values expressed in mean ± SD; minimal and maximal values.

deformities appears to be potentiated and may cause persistent back pain.[2,29] Thoracic kyphosis appears to be one of the most often reported changes in adults with CF.[2,4,8,9] Our results show that patients with CF, compared with healthy children, present significant changes in the alignment of the head, in cervical lordosis, in the alignment of the scapular and pelvic girdle, and in the lateral distance of the chest, indicating the presence of major postural changes, which already appear at an early age. Also, our results show postural abnormalities in individuals with mild lung function impairment, as measured by spirometry, which was also demonstrated in a previous study[3] indicating that the FEV_1 is not necessarily associated with postural alterations. Taken together, we speculate that postural abnormalities would be more related to hyperinflation, nutritional, and bone mineral problems, which should be addressed in future studies. Okuro et al[3] also report postural changes in children and adolescents with CF; however, they only evaluated the presence of thoracic kyphosis and used a qualitative methodology.

The evaluation of plantar pressure distribution is one of the tools used to understand the structural and functional implications imposed by postural changes. We found no significant differences between healthy children and those with CF, both in the static and the dynamic evaluation. Henning et al[31] analyzed the distribution pattern of pressure of children's feet and compared it with adults, demonstrating that children present a greater relative load on the heel in static baropodometry, and in the dynamics the distribution of reaction forces to the ground was performed in larger contact areas. These findings were justified by the structural anatomic difference of children's feet, which have a greater amount of adipose tissue, and by the difference in gait patterns, such as length and frequency of the step.[31,32] The absence of differences between healthy individuals and those with CF in baropodometry may be related to the still mild postural involvement of the sample, considering that modifications in the distribution of plantar pressures are associated with more severe postural changes.

Studies have demonstrated that postural disorders may be treated using exercise programs and specific rehabilitation techniques, which benefit those patients.[2,9] Exercises for thoracic mobility, muscle stretching, and aerobic activities improve the posture and compliance of the thoracic wall, resulting in lung function maintenance and optimization.[1,29] Patients with more severe lung disease, less aerobic capacity, and a more sedentary lifestyle should receive greater attention from the health care professionals because they are predisposed to less bone mineral density, a greater prevalence of vertebral fractures, and the development of major increases of thoracic kyphosis.[29] In the present study, the intervention with guidelines to practice physical exercise for 3 months did not generate a significant difference in lung function (FEV_1), but this intervention was effective reducing the postural changes presented. The intervention proposed contributed to maintaining various postural variables evaluated at the beginning of the study, and the patients of the control group

Table III. Characterization of the baseline sample regarding anthropometric data, sex, age, and lung function (phase II)

	Control (n = 17)	Intervention (n = 17)	P
Age (y)	12.9 ± 3.9	13.6 ± 2.8	.577
Sex (female)	41.2%	41.2%	-
Anthropometrics			
Weight (kg)	45.3 ± 16.6	46.3 ± 14.4	.852
Height (cm)	1.48 ± 0.1	1.53 ± 0.1	.262
BMI	19.9 ± 3.6	19.1 ± 3.6	.541
Lung function (%)			
FEV_1	92.1 ± 29.6	93.2 ± 18.1	.776
FVC	104.6 ± 26.6	107.5 ± 16.2	.666
$FEF_{25\%-75\%}$	71.53 ± 33.4	78.8 ± 29.6	.508
Regular physical exercise	4 (23.5)	6 (35.2)	.465

Values expressed as mean ± SD.

Table V. Comparison of the variation between the control and intervention groups after 3 months of follow-up

Variables	Control (n = 17)	Intervention (n = 17)	*P*	ES
Lung function (Δ)				
FEV_1 (%)	2.7 ± 12.8	−1.8 ± 8.6	.24	0.41
FVC (%)	1.8 ± 12.2	−0.41 ± 6.8	.52	0.22
$FEF_{25\%-75\%}$ (%)	7.3 ± 24.2	−3.8 ± 13.9	.11	0.56
Postural evaluation (Δ)				
Head tilt (°)	0.56 ± 2.4	−0.7 ± 1.8	.59	0.07
Scapular girdle tilt (°)	0.26 ± 1.7	−0.38 ± 1.2	.21	0.43
Pelvic tilt (°)	1.74 ± 3.6	−0.05 ± 4.8	.23	0.42
A-P trunk tilt (°)	−0.34 ± 1.4	−0.09 ± 2.2	.70	0.14
Cervical lordosis (°)	1.8 ± 2.5	−1.8 ± 2.6	.0003	1.41
Thoracic kyphosis (°)	1.2 ± 2.8	−1.2 ± 2.6	.01	0.89
Lumbar lordosis (°)	3.2 ± 6.7	−0.94 ± 4.9	.05	0.71
Lateral chest distance (cm)	0.93 ± 1.0	−0.07 ± 1.2	.01	0.91
Anteroposterior chest distance (cm)	0.45 ± 1.4	0.34 ± 1.1	.08	0.63
Abdominal protrusion (cm)	0.56 ± 1.3	−0.34 ± 1.1	.04	0.75
Static baropodometry (Δ)				
Mean pressure (kgf/cm^2)	7.5 ± 8.5	0.0 ± 0.0	.001	1.25
Area of contact (cm^2)	4.3 ± 5.6	−3.2 ± 8.8	.01	1.02
Anterior displacement (%)	1.3 ± 11.4	−2.8 ± 8.1	.24	0.41
Dynamic baropodometry (Δ)				
Duration of the step (ms)	28.4 ± 166.8	48.9 ± 117	.68	0.14
Maximal pressure (kgf/cm^2)	0.23 ± 0.9	−0.04 ± 0.2	.24	0.41
Area of contact (cm)	56.4 ± 22.1	50.81 ± 13.1	.38	0.31

presented even more marked changes, which means that an intervention based on recommendations for exercise and stretching, even in a short time, was able to reduce the progression of a few important postural changes in patients with CF. These results are also supported by clinical recommendations showing that there is a high prevalence of postural disorders that can be reverted if adequately treated and that the practice of physical activity and maintenance of postural alignment may reduce the risk of lumbar pain and vertebral complications, besides preserving physical function in these patients.[33]

It appears to be clearly established that regular, supervised practice of physical exercises promotes benefits in various aspects of the health of patients with CF, including physical aptitude, quality of life, lung function, and nutritional measures.[10,13-18] Exercises such as running, swimming, bicycling, and playing ball for at least 20 minutes, at least 3 times a week play an important role in treating patients with CF.[14,22] Besides, regular physical exercise also results in training the respiratory muscles, contributing to the reduction of lung hyperinflation with the consequent increase of FVC,[16,34] in general rendering the inclusion of physical exercise as an important point in treating patients with CF. However, in children and adolescents, logistics, and family involvement to maintain the patient in a supervised physical activity program often make the necessary adherence impossible, resulting in a sedentary lifestyle. Thus, in different CF treatment centers, health care professionals have recommended that physical activity is performed, through recommendations to do physical exercise at home as an alternative to supervised practice. Although the present study did not aim at identifying which specific part of the intervention was the most effective, the results demonstrated that the proposed intervention based on instrumental and verbal guidance, which stimulated the patient to participate in an exercise program, prioritizing their preferences, was effective to reduce the postural changes identified. It is possible that the greater flexibility in choosing and practicing a physical activity created a greater interest, regularity, and motivation for doing exercise, which together with an illustrated material and a more intense monitoring may have contributed to increase adherence and to explain the results presented. Gulmans et al[35] demonstrated that a program using home bicycling training helped improve muscle force, tolerance to exercise, and a higher level of self-esteem in children with CF. Likewise, Jong et al[36] concluded that the physical exercises at home are effective and simple to do, resulting in improved physical performance and reducing limitations on activities of daily living in adolescents with CF.

In general, a few limitations of the present study may have influenced the sensitivity of identifying variations in variables that can be modified by physical exercise, such as the short follow-up period, which may have been insufficient to significantly change the behavior of plantar pressures. Considering the age group studied, the difficulty of motor coordination presented by some children during an evaluation such as dynamic baropodometry may have influenced the results. Also, taking into account that rapid health changes may occur during adolescence in patients with CF, the age range of individuals (7-20 years old) could also be considered as a limitation.

Our results indicate that children and adolescents with CF present major postural changes compared with healthy individuals. This study demonstrated that the recommendation for aerobic exercise and stretches over a 3-month period helps improve posture in children and adolescents with CF, preventing further worsening of some postural disorders. These data reinforce the importance of physical activity and point to the fact that a relatively simple intervention may help reduce postural problems, benefiting the patients with CF. ■

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Table IV. Characterization of the baseline sample regarding postural evaluation and baropodometry (phase II)

Variables	Control (n = 17)	Intervention (n = 17)	*P*
Postural evaluation			
Head tilt (°)	3.4 ± 2.3	2.8 ± 2.4	.51
Scapular girdle tilt (°)	2.5 ± 1.5	1.2 ± 0.8	.23
Pelvic tilt (°)	2.1 ± 1.8	2.6 ± 1.9	.38
A-P trunk tilt (°)	2.4 ± 1.4	1.9 ± 1.7	.89
Cervical lordosis (°)	61.4 ± 6.0	62.9 ± 5.0	.43
Thoracic kyphosis (°)	32.6 ± 5.0	32.7 ± 4.3	.92
Lumbar lordosis (°)	99.8 ± 9.2	106.4 ± 9.3	.06
Lateral chest distance (cm)	26.0 ± 3.7	26.0 ± 3.0	1.000
Anteroposterior chest distance (cm)	19.5 ± 2.1	20.5 ± 2.45	.21
Abdominal protrusion (cm)	20.1 ± 3.4	19.3 ± 3.6	.49
Static baropodometry			
Mean pressure (kgf/cm^2)	0.26 ± 0.09	0.28 ± 0.07	.60
Area of contact (cm^2)	67.7 ± 24.4	64.1 ± 18.9	.64
Anterior displacement (%)	45.5 ± 12.5	49.1 ± 13.3	.42
Dynamic baropodometry			
Duration of the step (ms)	637.7 ± 145.9	646.4 ± 120.6	.85
Maximal pressure (kgf/cm^2)	1.1 ± 0.3	1.2 ± 0.3	.90
Area of contact (cm)	87.3 ± 25.3	80.7 ± 17.5	.20

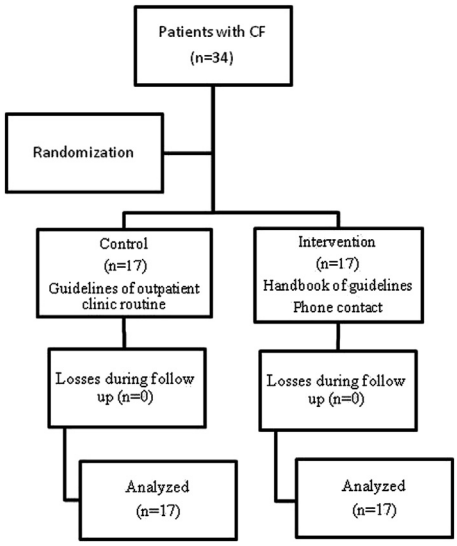

Figure 1. Randomization flowchart.

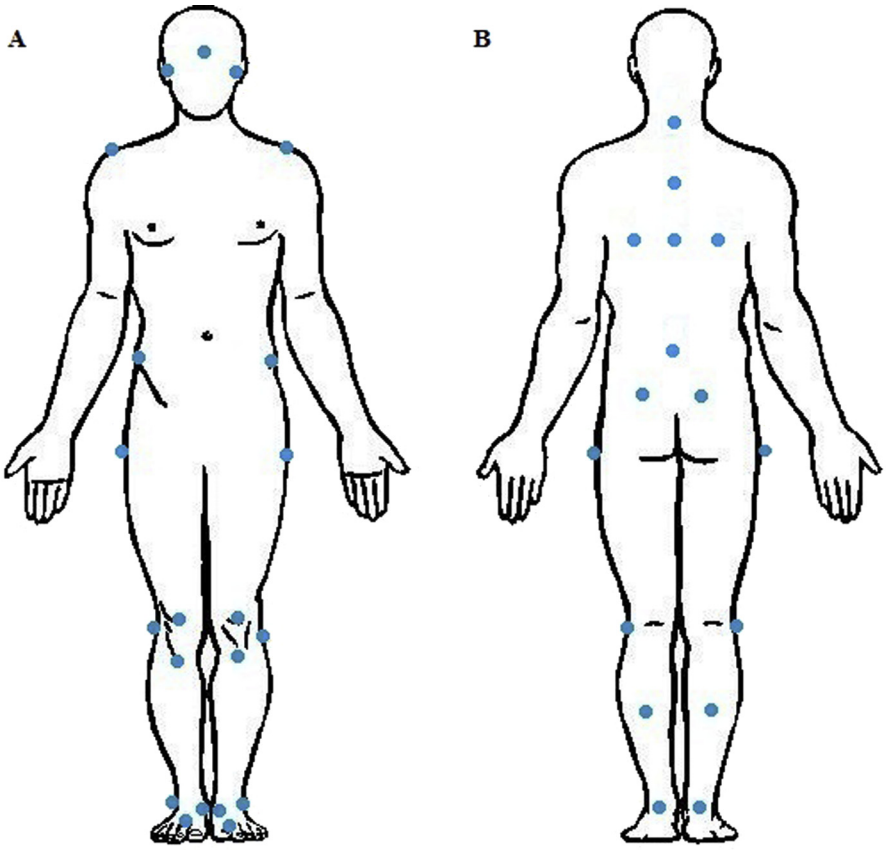

Figure 2. Anatomical points used for postural evaluation. Points were marked with colored adhesives disposed on 1cm-diameter Styrofoam spheres. **A,** anterior view; **B,** posterior view.