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Postural stability in patients with cystic fibrosis

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Summary

Aim of the study: The aim of the study was to evaluate the postural stability in a group of patients with cystic fibrosis.

Material and methods: The study included a group of 44 patients with cystic fibrosis with the analysis of parameters in the age groups under 16 years (mean 10,1 ± 3,6) and over 16 years (mean 23,6 ± 7,3). For stabilometric measurements, a two-plate CQ Stab posturograph and for body posture measurements Posturometr-S was used.

Results: The mean value of the SP body balance COP index in the measurement with open eyes was 336,1 ± 123 mm in the younger group and 201,3 ± 47 mm in the older age group. The results differed significantly in the measurement with closed eyes in both age groups, similarily to the other indicators of the balance in the assessment for each planes. The indicators associated with the assessment of COP displacement significantly correlated negatively with the age of the subjects, where for the measurement with eyes closed this relationship was the highest in the group up to 16 years and was r = - 0,90 (p <0,0001) and the size of the chest kyphosis angle (for the whole group: r = - 0,45, p = 0,002) and some indicators of the pulmonary system. The correlation value for FEV_1% pred., for the whole group, was r = 0,41 (p = 0,005). It was observed that with the age of the subjects, the kyphosis angle increased (for the group > 16 years: r = 0,77, p <0,0001). **Conclusions:** The results of the study show that with age of the cf patients, changes in the spine in the sagittal plane, the parameters related to postural stability of the body may be improved.

Key words: postural stability, cystic fibrosis

Introduction

Cystic fibrosis is the most common autosomal recessive disease among white Caucasian, the course of which is associated with a permanent deterioration of multi-organ functions, mainly regarding digestion and respiration [1]. With age and the development of the disease, variability in the function of many organs and systems, mainly respiratory and digestive, is observed [1,2]. Complications that occur with the development of the disease relate, inter alia, to osteoarticular and muscular apparatus. One of the commonly observed consequences of these disorders is delayed somatic development, bone demineralization and structural and functional changes in the spine [2,3,4]. Evaluation and monitoring of changes in the structure and body posture of children, adolescents and adults is an important element in the assessment of health. A very important factor that guarantees the proper functioning of people is also the efficiency and effectiveness of the postural control system [5]. Continuous active adjustment of the body posture through the balance control system ensures its correct stability. Balance control consists in static and dynamic balancing of the destabilizing forces of gravity and inertia by stimulating appropriate muscle groups [6]. Under pathological conditions, balance, coordination and posture are disturbed.

Under normal conditions, the balance is the result of subconscious reflex reactions requiring the cooperation of the following systems: vestibular, visual, proprioceptive, which record deviations of the center of body mass from the set point, with the executive implementing corrections that minimize these deviations [7].

A lot of scientific research show that it is difficult to determine unequivocally whether and how postural stability is related to the posture of the body in the sagittal plane, and also to define norms for posturographic parameters. Searching for the causes of disturbances in the ability to maintain body balance is a process that requires the diagnosis of broad specialist medical and biomechanical knowledge [8]. It should also be remembered that imbalances are not always related only to the functioning of the equilibrium system, for the causes of these disorders may be, for example, chronic diseases [9].

Aim of the study

The aim of the study was to assess the body balance in patients with cystic fibrosis with the use of a posturograph enabling registration of motion of the point of application of the resultant foot pressure of the tested person on the ground, illustrating the body center of gravity.

Material and method

The study included a group of 44 patients with cystic fibrosis between 5 and 41,5 years, including 20 female and 24 male. Measurements were made at the Institute of Tuberculosis and Lung Diseases in Rabka-Zdrój in the period from July to October 2016. and from September to October 2017. All subjects were on a one-day control visit or treatment at the IGiChP Clinic in Rabka-Zdrój. In the latter case, measurements were made between 1-3 days after admission to the Clinic. The average age of the whole group of respondents was 17,5 ± 8,9 years. In terms of the analysis of the research results, two age groups were separated: under 16 (n = 20, mean 10,1 ± 3,6), including 11 girls and 9 boys and over 16 (n = 24, average 23,6 ± 7,3), 9 female and 15 male. In the case of the most important posturographic indexes, the division into age groups and sex was taken into account (Table 2,3), while for the assessment of somatic development, the age group of respondents was narrowed to 6,5 to 18,5 years, i.e. according to the scope of standards according to Kułaga and co-workers [11] (Table 1). For stabilometric measurements, a two-plate CQ Stab posturograph (CQ Elektronik System) was used. The test procedure consisted of measuring body balance parameters with the eyes open and then closed in the tested person standing on the platform without footwear in an upright position with the hands along the trunk, with the feet parallel to each other, spaced at the width of the hips. The measurement lasted 30 seconds for each item and was performed once. Measured, among others the following parameters: length of the statokinezjogram (SP) delineated by the foot pressure center (COP), ie the total distance traveled by the foot pressure center (mm), the average speed (MV) with which the foot pressure (COP) was moved during the test (mm / s) as well as the percentage difference in weight distribution (OS) per left and right lower limb [10]. In addition, spine measurements were made in the sagittal plane using the posturometer-S. The values of the chest kyphosis angle were estimated based on the sum of the angles α and β determined automatically by the scan2 posturometer-S program. The assessment of deviations in the frontal plane was made on the basis of X-ray and CT scans with Cobb angle measurement using the Esculap program tools. The value of scoliosis in the thoracic or thoracolumbar part was used for the analysis. All measurements were made in the morning hours. The analysis also included standard data of somatic and functional respiratory system measurements performed at the Institute for Tuberculosis and Lung Diseases, i.e. spirometry with the analysis of FEV_1 and FVC indicators as well as bodyplethysmography for the RV index (this measurement was performed in 36 subjects). In the data analysis, the Statistica 10 program was used and it concerned the determination of mean values and standard deviations, differences in the measurement for open and closed eyes using the student's t test and the level of dependence of measured indicators using Pearson's linear regression, with statistically significant difference at $p < 0,05$.

List of the most important abbreviations used in the work related to the assessment of postural stability: OS L / OS R - left / right foot load (%), (EO) - eyes open, (EC) - eyes closed, SP (Sway path) COP (center of pressure) (mm) - length of the path delineated by COP, AP - anterior-posterior / displacement in the sagittal plane, ML - medio-lateralis / displacement in the frontal plane, L / R - left / right foot. MV - average speed of COP movement. FEV_1 - forced expiratory volume in 1 second, FVC - forced vital capacity, RV - residual volume.

Table 1. Characteristics of somatic indexes with the inclusion of values in percentiles [11], including gender in the examined group of children and adolescents aged 6,5 - 18,5 years.

Variable	**All (n = 24) ± SD**	**Male (n = 11) ± SD**	**Fem. (n = 13) ± SD**
Age	12,6 ± 3,8	12,9 ± 4,2	12,4 ± 3,8
Body weight (kg)	39,0 ± 15,4	42,4 ± 17,4	36,2 ± 13,4
Body weight perc.	22,4 ± 26,9	23,8 ± 28,6	21,2 ± 26,5
Body Height (cm)	148,6 ± 22,5	154,4 ± 26,4	143,7 ± 18,4
Body Height percentile	32,5 ± 31,1	39,5 ± 33,3	26,7 ± 29,2
BMI	16,9 ± 2,5	16,9 ± 2,5	16,7 ± 2,6
BMI percentile	25,5 ± 23,3	24,6 ± 26,9	26,1 ± 20,9

Results

The mean values of the measured somatic development index obtained in the investigated group of 44 patients with cystic fibrosis were 48,0 ± 17,5 (kg) for the body mass of the male subjects and 41,4 ± 14,6 for the females. The body height was on the same level: 157,5 ± 24,3 and 148,4 ± 24,3 (cm) (Table 2). The results obtained in the group of children and adolescents in the age range 6,5 - 18,5 years (n = 24) were on the level of 23,8 (boys) - 21,2 centile (girls) for body weight and 39,5 and 26,7 percentile for the body height of the subjects. The BMI index was similar in the analyzed groups at 24,6 and 26,1 percentile (Table 1). On the basis of the X-ray image, the size of the curvature of the spine was assessed. For analysis, the size of Cobb curve was used for the Th, Th - L section. For the whole group, it was 6,6 ± 6,7 (°) (0 - 29 °) and this value was similar in particular age groups (Table 2)). The measured value of chest angle was 23,4 (°) in the studied group of boys <16 years (n = 9) and 25,2 (°) among girls (n = 11). In groups> 16 years, these values were respectively in groups by sex: 28,6 (°) and 30,5 (°) (n = 15/9). Among selected indicators assessing respiratory function, the FEV_1 index was at the level of 66% in the male group and 81% in female for age <16 years, and 59% and 41% respectively in the age range > 16 years (Table 2).

Table 2. Values of obtained somatic indexes, body posture and respiratory function for the whole group of 44 subjects (ALL), under 16 years (<16) 20 subjects, over 16 years (> 16) 24 subjects. FEV_1 - forced expiratory volume in 1 second, FVC - forced vital capacity, RV - residual volume

Variable	**Age group**	**All Mean± SD**	**Male Mean± SD**	**Female Mean± SD**	**min, max**
Age	< 16 >16 ALL	10,1±3,6 23,6±7,3 17,5±8,9	9,5±3,9 23,8±8,0 18,4±9,7	10,6±3,5 23,3±6,2 16,3±8,0	5, 15 16, 41,5
Body weight (kg)	< 16 >16 ALL	32,5±14,4 55,4±9,0 45,0±16,4	30,5±14,9 58,6±7,7 48,0±17,5	34,2±14,5 50,3±9,0 41,4±14,6	16, 57 39, 70
Body height (cm)	< 16 >16 ALL	137,6±22,0 166,8±10,3 153,5±22,0	134,9±25,0 171,6±7,7 157,8±22,0	139,9±19,9 158,7±9,0 148,4±24,3	106, 180 143, 186
Cobb Degree (Th– L)	< 16 >16 ALL	6,6±5,8 6,7±7,6 6,6±6,71	6,1±6,5 7,0±8,0 6,7±6,71	7,1±5,4 6,1±7,2 6,6±6, 1	0, 18 0, 29
Th. Kyphosis (°)	< 16 >16 ALL	24,4±6,4 29,3±6,9 27,1±7,0	23,4±6,4 28,6±7,2 26,7±7,0	25,2±5,7 30,5±6,6 27,6±6,5	17, 39 18, 45
FVC (l)	< 16 >16 ALL	1,86±0,9 3,14±1,4 2,55±1,34	1,70±1,0 3,73±1,3 2,97±1,6	1,99±0,9 3,14±0,8 2,0±0,8	0,78, 3,6 0,9, 6,5
FVC % pred.	< 16 >16 ALL	87,1±24,3 70,2±22,0 77,9±24,3	84,3±34,1 76,5±21,4 79,5±26,4	89,4±13,5 59,7±19,8 76,1±22,1	40, 137 28, 104
FEV1 (l)	< 16 >16 ALL	1,43±0,6 1,98±1,0 1,73±0,89	1,26±0,6 2,38±1,0 1,97±1,0	1,57±0,6 1,3±1,6 1,46±0,6	0,57, 2,78 0,5 3,7
FEV1 % pred.	< 16 >16 ALL	74,8±28,7 52,6±24,1 62,7±28,3	66,6±35,3 59,1±25,9 61,9±29,2	81,5±21,6 41,9±17,1 63,7±27,8	30, 112 13, 97
RV % pred. (n=36)	< 16 (n=12) >16 (n=24) ALL	189,2±97,8 180,7±53,9 183,5±70,2	225,6±106 166,5±59,9 183,4±77,9	152,6±81 204,4±33 183,7±60,6	101, 402 103, 281

The average value of the SP body balance COP index in the measurement with open eyes for the entire group of 44 subjects was 262,6 ± 112,0 mm and was significantly different in the measurement with eyes closed (p <0,0001 ± 81,5). In the group of <16 years, the SP COP index was 336,1 mm and in the group > 16 years 201,3 mm and in both cases significantly increased in the measurement with eyes closed (Table 4). In the group of <16 years among the examined girls (n = 11), the SP COP index was 315,6 ± 119,0 mm in the measurement with open eyes and 378,0 ± 110,9 mm with closed eyes.

In the group of <16 years among the examined boys (n = 9), the SP COP index was 361,2 ± 130,9 mm in the measurement with open eyes and 406,04 ± 154,8 mm with closed eyes. Differences in both cases were statistically significant in the groups: p = 0,01 ± 65,5 and p = 0,01 ± 40,6 (Table 3).

Table 3. The values of the COP index in the age groups, taking into account the division into the sex of the respondents. Statistical significance in the measurement with open (EO) and closed eyes (EC)

SP (Sway path) COP (center of pressure) (mm) - length of the path delineated by COP, (EO) - eyes open, (EC) - eyes closed.

Variable	**Age group by gender: < 16 year M, n =9, F, n = 11 and > 16 year M, n =15, F, n = 9**	**Mean**	**± SD**	**p ± SD**
SP COP (mm) (EO)	< 16 M	361,2	130,94	0,01 ± 40,6
	< 16 F	315,6	119,0	0,01 ± 65,5
	> 16 M	202,5	43,2	0,02 ± 117,2
	> 16 F	199,2	56,8	n.s
SP COP (mm) (EC)	< 16 M	406,0	154,8	
	< 16 F	378,0	110,9	
	> 16 M	282,8	139,0	
	> 16 F	239,0	65,9	

In the group > 16 years among female subjects (n = 9), the SP COP index was 199,2 ± 56,8 mm in the measurement with open eyes and 239,0 ± 65,9 mm with closed eyes. In the group > 16 years among the male subjects (n = 15), the SP COP index was 202,5 ± 43,2 mm in the measurement with open eyes and 282,8 ± 139,0 mm with closed eyes. In the case of the male group, the difference was statistically significant (p = 0,02 ± 117,2) (Table 3).

The measurements of SP COP made for each of the limbs separately did not significantly differ, while the statistical significance was obtained in% of the load difference between both limbs in the measurement for open and closed eyes. This difference was observed the most in the group > 16 years in the measurement with eyes closed (4,8%), with the left leg load being 52,4%, and the right 47,6% ($p = 0{,}04 \pm 10{,}8$)) (Table 4). SP COP measurement with open eyes in the frontal plane (ML) was 220,6 mm in the younger and 118,2 mm in the older group, in which it was significantly higher in the measurement with eyes closed, as in the assessment for the whole group. The same index for the sagittal plane (AP) was significantly different in the measurement with open and closed eyes in all groups. The value of SP COP (AP) in the first measurement (EO) for the whole group was 165.6 mm ($p < 0{,}0001 \pm 70{,}3$). (Table 4). Significant differences in the measurement with open and closed eyes also concerned the so-called the average speed of the MV COP displacement and most concerned the sagittal plane. Individual indicators for the assessment of COP changes did not significantly differ in the separate measurement for each limb. The indicators related to the assessment of COP displacement significantly correlated with the age of the respondents, the most important was the age correlation with the length of the path delineated by the COP with eyes closed in the group <16 years ($r = -0{,}90$, $p < 0{,}0001$) (Fig. 1.). In the group > 16 years, this relationship was not statistically significant. Similar relationships were demonstrated for the assessment of the path length delineated by the COP and the speed of displacement in relation to the age of the subjects in the frontal plane and these relationships were significant for the whole and in both age groups (Table 5). Stabilometric indices to a slightly lesser degree than with age of respondents correlated with the value of chest angle, which in posturometric measurements amounted to an average of 29,3 ° in the group > 16 years. For the whole group of respondents, the value of the SP COP index in the measurement for open eyes correlated negatively with the kyphosis angle at: $r = -0{,}45$ ($p = 0{,}002$) and parameters describing the severity of broncho-pulmonary tract, especially in the group <16 years for FVC ($r = -0{,}75$, $p = 0{,}0001$) and FEV_1 ($r = -0{,}57$, $p = 0{,}008$) (Table 5). The above relationship did not occur for the RV% value indicator due. In turn, this index correlated significantly with the size of the thoracic kyphosis angle (<16 years $r = 0{,}54$, $p = 0{,}06$, for the whole group: $r = 0{,}39$, $p = 0.02$). The size of thoracic kyphosis also significantly correlated with the age of the subjects. The relationship was the most severe in the group > 16 years and was: $r = 0{,}77$ ($p < 0{,}0001$). The size of the curvature measured according to Cobb, regardless of whether it does not determine which side it is on, does not correlate with the measured body balance parameters.

Table 4. Values of obtained indicators for the whole group of 44 subjects (ALL), under 16 years (<16) 20 subjects, over 16 years (> 16) 24 subjects and statistical significance in the measurement with open (EO) and closed eyes (EC).

Variable	**Age group**	**Mean**	**± SD**	**p ± SD**
OS L (EO) (%)	< 16	50,1	5,3	n.s
	>16	52,1	3,7	0,013 ± 7,4
	ALL	51,1	4,5	n.s
OS R (EO) (%)	< 16	49,9	5,3	
	>16	47,9	3,7	
	ALL	48,8	4,5	
OS L (EC) (%)	< 16	51,9	6,2	n.s
	>16	52,4	5,4	0,04 ± 10,8
	ALL	52,1	5,7	0,016 ± 11,4
OS R (EC) (%)	< 16	48,1	6,2	
	>16	47,6	5,4	
	ALL	47,8	5,7	
SP COP (mm) (EO)	< 16	336,1	123,4	0,0003 ± 55,0
	>16	201,3	47,5	0,0004 ± 99,4
	ALL	262,6	112,0	< 0,0001 ± 81,5
SP COP (mm) (EC)	< 16	390,8	129,5	
	>16	266,4	117,3	
	ALL	322,9	136,7	
SP COP (AP) (mm) (EO)	< 16	206,5	72,0	< 0,001 ± 77,3
	>16	131,9	34,7	0,001 ± 85,7
	ALL	165,6	65,8	< 0,0001 ± 70,3
SP COP (AP) (mm) (EC)	< 16	266,8	86,3	
	>16	197,5	103,9	
	ALL	229,0	104,4	
SP COP (ML) (mm) (EO)	< 16	220,6	85,3	n.s
	>16	118,2	47,3	0,03 ± 37,3
	ALL	164,8	79,8	0,0076 ± 36,6
SP COP (ML) (mm) (EC)	< 16	233,6	85,3	
	>16	135,8	47,3	

	ALL	180,3	82,6	
MV COP (AP) (mm/s) (EO)	< 16 >16 ALL	6,47 4,39 5,3	2,5 1,1 2,1	< 0,0001 ± 1,9 0,001 ± 2,8 < 0,0001 ± 2,4
MV COP (AP) (mm/s) (EC)	< 16 >16 ALL	8,89 6,6 7,6	2,8 3,4 3,4	
MV COP (ML) (mm/s) (EO)	< 16 >16 ALL	7,3 3,9 5,4	2,9 0,6 2,6	n.s 0,02 ± 1,3 0,006 ± 1,3
MV COP (ML) (mm/s) (EC)	< 16 >16 ALL	7,7 4,6 6,0	2,8 1,6 2,7	

OS L / OS R - left / right foot load (%), (EO) - eyes open, (EC) - eyes closed, SP (Sway path) COP (center of pressure) (mm) - length of the path delineated by COP, AP - anterior-posterior / displacement in the sagittal plane, ML - medio-lateralis / displacement in the frontal plane, L / R - left / right foot. MV - average speed of COP movement.

Table 5. Values of correlation of indicators for the whole group of 44 subjects (ALL), under 16 years (<16) 20 subjects, over 16 years (> 16) 24 subjects.

Variables	**Age group**	**r**	**p**
SP COP (mm) (EO) / Age	< 16 >16 ALL	- 0,86 - 0,33 - 0,69	< 0,0001 n.s < 0,0001
SP COP (mm) (EC) / Age	< 16 >16 ALL	- 0,90 - 0,16 - 0,56	< 0,0001 n.s < 0,0001
SP COP / ML (mm) (EO) / Age	< 16 >16 ALL	- 0,84 - 0,57 - 0,71	< 0,0001 0,003 < 0,0001
MV COP / AP (mm/s) (EO) / Age	< 16 >16	- 0,82 - 0,13	< 0,0001 n.s

	ALL	- 0,54	0,0001
MV COP / ML (mm/s) (EO) / Age	< 16	- 0,84	< 0,0001
	>16	- 0,52	0,0008
	ALL	- 0,71	< 0,0001
FEV1 % pred. / Age	< 16	- 0,47	0,04
	>16	- 0,56	0,004
	ALL	- 0,59	< 0,0001
Age / Th. Kyphosis (°)	< 16	0,48	0,03
	>16	0,77	< 0,0001
	ALL	0,67	< 0,0001
SP COP (EO) / Th. Kyphosis (°)	< 16	- 0,37	n.s
	>16	- 0 ,34	n.s
	ALL	- 0,45	0,002
SP COP (mm) (EO) / FEV1 (l)	< 16	- 0,57	0,008
	>16	- 0,14	n.s
	ALL	- 0,41	0,005
SP COP (mm) (EO) / FVC (l)	< 16	- 0,75	0,00013
	>16	- 0,11	n.s
	ALL	- 0,56	< 0,0001
SP COP (mm) (EO) / FEV1 % pred.	< 16	0,40	n.s
	>16	0,12	n.s
	ALL	0,41	0,005
RV % pred. / Th. Kyphosis (°)	< 16	0,54	0,06
	>16	0,35	< 0,08
	ALL	0,39	< 0,02

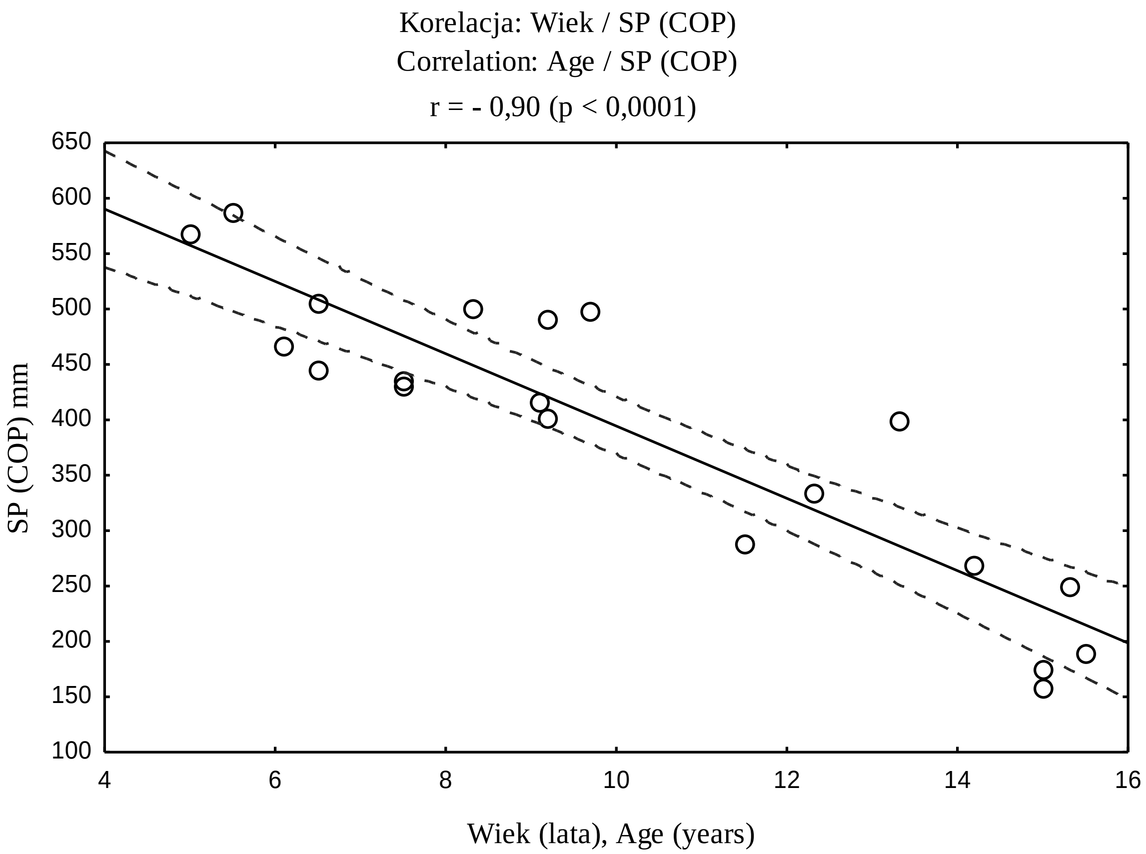

Fig. 1. Correlation of indicators: Age / SP COP (in the measurement for eyes closed) in the group of patients with cystic fibrosis (<16 years, n = 20).

Discussion

The posture control system is characterized by a high compensation capacity in the case of the impairment of one component. However, if the functioning of a larger number of cooperating mechanisms becomes worse at the same time, then imbalances may occur. During visual inspection, a more stable posture is obtained, and turning off the eyesight increases the body swaying by about 20-70% [12].

The drugs used and the physical fitness of the subject may influence the posture control system [12,13]. Good physical condition, active lifestyle, increased muscle mass and strength by performing physical exercises favour better control of posture and ability to maintain balance, improve the perception of stimuli, including visual, shorten the reaction time and allow you to create the proper muscle tone [14].

Referring to the results obtained by Walicka-Cupryś [15] in pre-school children and Puszczałowska-Lizis [16] in young players training jumping into the water and the control group described by the author, the average values of parameters describing the body balance obtained in this study in individual age ranges in the measurement with open eyes does not differ significantly from those obtained in the above work. The results obtained in this study in cystic fibrosis patients indicate a slightly lower postural stability of the subjects compared to the results obtained in the groups of young athletes: alpine skiers [10] and control group of healthy people in the Kosiba study [17], but these groups were significantly different in terms of the average age of the respondents in relation to the one assessed in this study. In the results available in the literature in the closest age group in the measurement of postural stability among jumpers to water [16] middle-aged 9 years, differences were obtained in the results in the measurement with open and closed eyes (in the case of some parameters statistically significant) and there were disproportions between the results between the female and male groups in favour of better stability in the female group. In the study of Kurzeja et al. [18] in the homogeneous age group of 10-year-olds, the result of SP COP measurement with closed eyes was 475,6 and 512,6 mm, respectively, among the examined boys and 453,6 and 516,4 mm among the respondents girls. In the case of girls, the difference in the measurement was statistically significant. In the present study, in the group < 16years in the mean age of 10 years, although with a significantly higher standard deviation than in the cited works, SP COP measurements with open eyes (EO) the results were 315,6 mm in girls and 361,2 mm in boys and in both in these cases, this measurement deteriorated significantly in the measurement with eyes closed, amounting to 378,0 mm and 406,0 mm respectively (p = 0,01) (Table 3). In the obtained results there is also a large disproportion in the percentage distribution of body weight between both lower limbs, especially in the measurement with eyes closed, which in the studied group of patients with cystic fibrosis aged > 16 years was 4,8% (Table 4), as in of healthy 15-year-olds in Bujas measurements [10]. However, as in the above author, there was no significant difference in the assessment of the length of the SP path delineated by the COP or its average speed of movement between the lower left and right limb. An attempt to assess the dependence between the size of the curvature of the spine measured according to the Cobb method did not show any relation to the above-mentioned the disproportion in limb load, according to some authors happens for healthy children. Quoting Walicka-Cupryś [15], people with spinal deformation in the frontal plane may be disturbed in a complex system regulating equivalent reactions. In this study, in the examined group of patients with cystic fibrosis, the abovementioned dependence. The cited author also observed that increasing the angle of thoracic kyphosis may influence the reduction of the stabilometric parameters in the sagittal plane in the study with open and closed eyes, which results in better postural control. In this study in CF patients, this correlation is confirmed by the negative correlation of the SP COP index with the chest angle, which in the measurement for the whole group was: r = - 45 (p <0,0004). The level of regression was particularly high in the case of the SP COP index and the age of the respondents. In both measurements the greatest relationship was recorded in the group <16 years (Table 5). In the first measurement the level of dependence was: r = - 0,86, in the second with eyes closed: r = - 0,90 and was the highest among all measured correlations. Because there is a confirmed relationship between progressive pulmonary emphysema and increased antero-posterior thoracic size and deeper chest angle [3,4] (correlation of the RV% pred. index and angle of thoracic kyphosis, Table 5) in patients with CF, features increase with age, it should be expected that the test group will depend on stabilometric parameters with the kyphosis angle. In these measurements, the size of chest kyphosis also significantly correlated with the age of the respondents at the level: $r = 0{,}67$ ($p < 0{,}0001$) for the whole group, most strongly in the group > 16 years, where the value was: $r = 0{,}77$ ($p < 0{,}0001$). Among the indicators assessing the functions of the respiratory system, which also change with the age of the respondents, the greatest relationship with the stabilometric score was demonstrated for the FVC (l) ratio, which in the group <16 years was: $r = -0{,}75$ ($p < 0{,}0002$). The FEV_1 index, the most important among the functional indicators defining the overall progressive and worsening changes in the broncho-pulmonary function in patients with cystic fibrosis (including % of the FEV_1 correlations with the age of respondents was for the whole group: $r = -0{,}59$, $p < 0{,}0001$, Table 5) correlated with the SP COP indicator at the level of: $r = 0{,}41$ ($p = 0{,}005$) in the assessment of the whole group. The results of the present study indicate that in patients with cystic fibrosis, the values of indicators assessing postural stability show a negative correlation with the age of the patients (especially until the end of the developmental period), the size of the chest kyphosis angle and the severity of lesions defined by spirometric indicators. On the basis of the obtained results it should be concluded that among the studied children and adolescents in the group < 16 years the improvement of body stability indexes is associated primarily with the increase in age (Table 5, Fig. 1). In adolescents and adults (group > 16 years) dependence this is smaller and is associated with such factors as the formation of the spine in the sagittal plane. With increasing the angle of thoracic kyphosis, postural stability is improved in these subjects. It seems significant that the postural stability of CF patients is less influenced by such factors as age-related loss of muscle mass or worsening tissue oxygenation, which factors should be believed to be determined by the greater disproportion of these stabilometric parameters in relation to healthy subjects. To assess the impact of the above however, additional measurements should be made for the postural stability of CF patients. It should also be taken into account that research works in the field of assessment of postural stability in healthy subjects are very small and have not been created for the described indicators due to what significantly made it difficult to evaluate comparative assessment regardless of the disease entity in question.

Conclusions

The results of the study show that with age of the cystic fibrosis patients and changes in the spine in the sagittal plane, the parameters related to postural stability of the body may be improved.

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