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PHYSICAL EXERCISE PROGRAM TO REDUCE TRUNK ASYMMETRY IN ADOLESCENCE

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ABSTRACT. ***Background*:** Depending on the severity, the nature and the type of the trunk asymmetry, three types of treatment are currently used: (1) conservative treatment with orthopedic brace, (2) physiotherapy and (3) surgical intervention. The efficiency of physical exercises in rehabilitation of spinal deformities is well known. They have been systematically used since the beginning of the 20th century. ***Objectives:*** The main objective of our study was to reduce the trunk asymmetry using an interventional program of physical exercises. ***Study design*:** This study follows a pretest-posttest design with an experimental and a control group. ***Materials and Methods:*** Forty one pupils (27 girls and 14 boys) aged 11.77 (± 0.96) years) were included. The experimental group consisted of 20 pupils and the control of 21 students. Participants were assigned non-randomly to the experiment or control groups. In order to determine the level of physical activity of the subjects, the FELS and PAQ-C questionnaires were applied. Experimental intervention consisted of a physical activity program based on basic gymnastics. Between October 2015 and June 2016 the members of the experimental group participated in our intervention twice a week (50 minutes a session), after their school program, for 8 months. ***Results:*** The mean value of the angle of trunk rotation in the case of experimental group was 6.15º (± 1.56) and 6.52º (± 1.66) in the case of control group. In the final test, it was found that the size of the asymmetry was reduced in both groups. In the case of experimental group the trunk asymmetry value was 4.05º (± 1.66), and in the case of control group 6.00º (± 1.94), meaning a decrease of 2.10º to experimental group and 0.52º to control group. ***Conclusions:*** The main findings are that basic gymnastics exercises can have a beneficial effect on trunk asymmetry, which is the hump will decrease. We recommend the use of these exercises to treat people with moderate or severe trunk asymmetry.

Keywords: *trunk asymmetry, scoliosis, adolescence, physical therapy, exercise.*

REZUMAT. În funcție de gravitatea, natura și tipul asimetriei toracelui, în prezent sunt utilizate trei tipuri de tratament: tratamentul ortopedic prin utilizarea corsetelor corective, tratamentul cinetic și cel chirurgical. Eficiența exercițiilor fizice în reabilitarea deformărilor coloanei vertebrale este bine cunoscută. Acestea au fost folosite sistematic de la începutul secolului al XX-lea. ***Objectives:*** Obiectivul principal al studiului a fost diminuarea asimetriei toracelui folosind un program de

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intervenţie bazate pe exerciţii fizice. ***Study design***: Studiul are un design experimental cu un grup experimental şi unul de control şi cu testare iniţială şi finală. ***Materials and Methods****:* Patruzecişiunu de elevi (27 de fete şi 14 băieţi) cu vârsta de 11.77±(0.96) ani au fost incluşi în studiu. Grupa experimentală a fost alcătuit din 20 de elevi şi cel de control din 21 de elevi. Participanţii au fost repartizaţi în mod nealeatoriu în grupa experimentală sau cea de control. Pentru a determina nivelul activităţii fizice al subiecţilor au fost aplicate chestionarele FELS ŞI PAQ-C. Intervenția experimentală a constat dintr-un program de activitate fizică bazat pe mijloacele gimnasticii de bază. Între octombrie 2015 şi iunie 2016, membrii grupei experimentale au participat la intervenţie de două ori pe săptămână (câte 50 de minute pe fiecare sesiune), după programul şcolar al elevilor, timp de 8 luni. ***Results***: Valoarea mediei unghiul de rotaţie al trunchiul la testarea iniţială la Ge a fost de 6.15º (±1.56) şi de 6.52º (±1.66) în cazul Gc. La finalul intervenției la ambele grupe s-a diminuat mărimea asimetriei, în cazul Ge rezultatul post-testului fiind de 4.05º (±1.66), iar în cazul Gc de 6.00º (±1.94), însemnând o diminuare de 2.10º la Ge şi de 0.52º la cel de control. ***Conclusions***: Constatările principale sunt că exerciţiile fizice din gimnastica de bază pot avea un efect benefic asupra asimetriei toracelui, adică diminuarea acesteia. Recomandăm utilizarea acestor exerciţii în tratarea persoanelor cu asimetria moderată sau severă a toracelui.

Cuvinte cheie: *trunk asymmetry, scoliosis, adolescence, physical therapy.*

Introduction

Trunk asymmetry (TA) as an important indicator of scoliosis recommends the orthopedic assessment of the children if the asymmetry exceeds 7° at the scoliometer. This asymmetry is caused by the existence of a hump in one of the regions of the spine (Grivas et al., 2006). Numerous studies assessed the relationship between the gibbosity and Cobb angle (CA), and found significant correlation between them (Coelho, Bonagamba, & Oliveira, 2013; Griffet, et al., 2000. For example, Lars and Lars (1997) found a moderate strong correlation between the angle of trunk rotation (ATR) and CA in right convex curves p = 0.65 compared to p = 0.57 in left convex curves. Korovessis and Stamatakis (1996) tried to predict a CA from the result of the scoliometer readings, and the authors have constructed two mathematic formulas, which provide accuratelly the scoliotic Cobb angle in young adolescents using only the scoliometer.

The proper use of physical exercises, in addition to decreasing the deviation of the vertebral column (Hawes, 2003; Otman, Kose, & Yakut, 2005), contributes to reducing the risk of progression (Negrini, et al., 2008), develops the aesthetic appearance of the body (Negrini, et al., 2006) and reduces the number of patients requiring orthopedic treatment and surgical treatment (Negrini, Atanasio, et al., 2008).

Cordun (1999) distinguishes the following types of scoliosis: functional scoliosis, scoliotic posture, habitual scoliosis and pathological scoliosis. The pathological scoliosis is a complex deformation of the spine, because the volume of the vertebral body is reduced on the concave side, becomes cuneiform and the presence of the truncal hump is constant. These are irreducible, the flexion of the trunk exacerbates and accentuates the prominence of the existing hump. They comprise two distinct subgroups: (1) structural scoliosis, which etiology is known; (2) structural scoliosis with unknown etiology, also called idiopathic or essential scoliosis. The essential scoliosis represents 85-90% of all scoliosis. According to the same author, these are: infantile scoliosis, juvenile scoliosis and adolescent scoliosis.

Depending on the severity, the nature and the type of TA, three treatments are used: (1) conservative treatment with orthopedic brace, (2) physiotherapy and (3) surgical intervention. The role of physical exercises in rehabilitation of spinal deformities is well known. They are used consistently since the early twentieth century, but the basis has already been made in antiquity (Vasiliadis, Grivas & Kaspiris, 2009). Weiss (2010, p.4) considers that "exercise base therapies, alone or in combination with orthopaedic approaches, are a logical mean to improve and maintain fexibility and function in patients at risk for pain, pulmonary dysfunction, and progression".

The effectiveness of physiotherapy for idiopathic scoliosis is discussed because we do not have enough scientific evidence to confirm this (Mordecai & Dabke, 2012). According to Kotwicki et al (2013, p. 62), "... there is a lack of adequate scientific data confirming the effectiveness of physiotherapy in reducing the risk of progression of scoliosis, on the other, a number of publications indicate the positive influence of exercises on the course of scoliosis".

They are of the opinion that specific physical exercise exercises should be conducted by a trained and certified physiotherapist. These exercises have to be adapted to the individual curvature pattern of the child and treatment phase. The effectiveness of the therapy depends on the child's willingness to cooperate, as well as on the model of the management selected. Also, an objective documentation and verification of the results are necessary.

The American Academy of Orthopedic Surgeons and the American Academy of Pediatrics recommend scoliosis screening (using the Adam's test) for girls aged 11 and 13 for boys once at 13 or 14 years old (Grivas et al., 2007).

Objectives and hypothesis

The primary objective of our study was to reduce the ATR by using basic gymnastic exercises. In the present study, it is assumed that the use of exercises from basic gymnastics in physical education lessens the frequency of TA and decreases the ATR in adolescence with TA.

Materials and methods

Participants

The study included a sample of 41 subjects (27 girls and 14 boys). All participants were students of the Báthory István Theoretical High School in Cluj-Napoca, with an average age of 11.77 (± 0.96) years [min: 10 years and max: 14 years], divided into two groups: Experimental group (Eg) control group (Cg). Eg was formed of 20 subjects (13 girls and 7 boys) with a mean age of 11.71 (± 0.93) years and the Cg of 21 students (14 girls and 7 boys), average age of 11.83 (± 1.01) years.

In order to include a subject in the experiment, the following criteria's were applied:

1. the ATR should exceed ≥5°;
2. the age was between 10 and 15 years;
3. without restrictions to medium-intensity physical activities.

Subjects with TA were previously identified following a school screening program attended by 487 students aged 12.94 (± 1.45) years (Balla & Hanţiu, 2016). Participation in the research was voluntary, it was done with the approval of the county school inspectorate, school leadership and parents.

In the Eg were included 12 pupils (60%) with right thoracic hump and 8 pupils with left thoracic hump (40%), and in the Cg 16 pupils (76%) were with right thoracic hump and 5 pupils with left thoracic hump (24%).

Sampling method

The participants were not randomly assigned to the groups of experiment, because we had a limited number of subjects with an ATR exceeding 5º, and not all of the subjects with the necessary ATR wanted to take part in the experiment. Therefore, in the Eg were included subjects which intended to participate in the intervention (an afterschool program of selected physical exercises), and in the Cg were included those who did not want to take part in the intervention, but both of them had the approval to participate in the experiment.

Methods

Each group was tested at both the beginning and the end of the study. At the beginning, each subject was evaluated (pretest), measured by the ATR, height and body weight At the same time, the subjects completed two questionnaires measuring the level of physical activity: The Physical Activity Questionnaire for Older Children (PAQ-C), which measures physical activty for

the last seven days, and FELS Physical Activity Questionnaire for Children which measures the level of physical activity in children aged 7-19 in the last year before completing the questionnaire These evaluations were repeated after 8 months of the intervention, at the end of the study (post-test).

Statistical analysis

For the analysis of the results, were used the following tests to compare the mean values, depending on the data distribution: independent sample t-Test, dependent sample t-Test, Mann Witney U test for independent samples and Wilcoxon test for pair samples. Gaussian distribution was evaluated using the Shapiro-Wilk test. For the statistical analysis, the 20th version of SPSS was used.

Intervention program

Between October 2015 and June 2016 the members of the experimental group participated at our intervention twice a week (50 minutes a session), after their school program. The exercises included in this program were exclusively from basic gymnastics.

The sessions were divided in four parts. The first one was dedicated to the organization of the subjects and to raise attention. We held a short conversation about their day or past days, and then the themes of the respective session were presented.

The second one was the warming-up phase of the activity. A general warming up and then a special warming up for the trunk (vertebral column) were conducted by the leader of the activity. This part of the session included exercises in walking or in place.

The third one was the most important phase of the session, in which the selected strengthening or stretching exercises were applied. These exercises were executed in place, independently by the established groups. The last one contains a lot of stretching exercises and often entertaining games.

Constitution of the groups by the type of the truncal hump

The TA's were localized during the scoliometer reading. Based on these findings the participants of the experiment were divided in four groups depending on the place of the asymmetry.

1. Right asymmetry on the upper part of the back.
2. Right asymmetry on the lower part of the back.
3. Left asymmetry on the upper part of the back.
4. Left asymmetry on the lower part of the back.

The dosage of the physical effort was stabilized depending on gender, on the level of the motor abilities and on the somatic particularities.

There were also used exercises based on both isometric and isotonic muscle contraction. The majority of the applied exercises was asymmetric (executed just for the left or the right part of the body), but a series of symmetric exercises were also used. Usually, each group had to execute the same exercises, but in different directions and with different amplitudes.

Results

Following the Shapiro-Wilk test, the variables of weight and questionnaire scores (PAQ-C and FELS) were normally distributed, and those of height, BMI and ATR were not normally distributed (see Table 1). Consequently, we will use both non-parametric and parametric significance tests, depending on the type of the tested variable.

Table 1. Mean, standard deviation and Shapiro-Wilk test at initial testing

Variables	Initial values M (±sd)	Shapiro-Wilk df	Shapiro-Wilk Sig.	Result of normality test
Height [cm]	155.6 (±9.30)	41	0.017	NND
Weight [kg]	46.21 (±12.10)	41	0.059	ND
BMI [kg/m^2]	18.91 (±3.78)	41	0.004	NND
ATR [º]	6.34 (±1.60)	41	0.000	NND
Score of PAQ-C	2.84 (±0.65)	41	0.378	ND
Score of FELS	6.37 (± 1.57)	41	0.407	ND

Note: ND – normally distributed; NND – not normally distributed

Table 1 shows the initial mean values of the sample and the result of the normality test.

The FELS questionnaire score at the initial Eg testing was 6.67 (± 1.66), and for Cg of 6.09 (± 1.46), the difference between the mean values being statistically insignificant (t = 1.193, p = 0.240). The difference between group mean values remained insignificant at the end of the experiment *(*t = 1.449, p = 0.155).

Applying the PAQ-C questionnaire was necessary to see whether significant changes occurred or not during the experiment on habits related to students' physical activities. In case of the Eg, the activity score in the pre-test was 2.73 (± 0.66) and in the case of Cg 2.94 (± 0.63), the difference between the two mean values was not significant *(*t = - 1.001, df = 39, p = 0.323). This score of physical activity did not change significantly neither at the end of the

experiment, the values remain similar across the groups: Eg 2.71 (±0.60), and Cg 2.96 (±0.52). The difference between the mean values of the final test was still insignificant *(t* = - 1.400, df = 39, *p* = 0.169). For the testing of intragroup changes, the dependent sample *t* test was used, but neither of the two groups confirmed significant changes in the mean values, the results of the statistical analysis being: *t* = 0.689, *p* = 0.499 for Eg and *t* = - 0.544, *p* = 0.593 for Cg.

The mean value of the ATR in the case of Eg was 6.15º (± 1.56) and 6.52º (± 1.66) in the case of Cg, there was no statistically significant difference between the mean group values *(U* = 177.5, N = 41, *p* = .380). In the final test, it was found that the size of the asymmetry was reduced in both groups. In the case of Eg the TA value was 4.05º (± 1.66), and in the case of Cg 6.00º (± 1.94), meaning a decrease of 2.10º to Eg and 0.52º to Cg. The difference between the mean values of ATR at the end of the experiment (2.10 - 0.52 = 1.58) became statistically significant *(U* = 92.5, *p* = .002), the effect size was estimated by Cohen coefficient (d = 0.95). Table 2 presents the results of the comparative analysis using the *t* test for independent samples and the Mann-Whitney test.

Table 2. Comparative analysis of the results of the measurements at the beginning and end of the experiment for the experimental and control group

Variables	Pre-test			Post-test		
	Eg (N=20) M (±sd)	Cg (N= 21) M (±sd)	Independent sample t-test or Mann-Whitney U test	Eg (N=20) M (±sd)	Cg (N= 21) M (±sd)	Independent sample t-test or Mann-Whitney U test
Height [cm]	155.8 (±10.5)	155.4 (±8.1)	$U = 196, p = .715$	162.3 (±9.5)	161.5 (±7.5)	$U = 208.5, p = .969$
Weight [kg]	45.5 (±13.0)	46.9 (±11.4)	$t = -.366, df = 39, p = .716$	50.8 (±13.7)	52.2 (±12.3)	$t = -.365, df = 39, p = .717$
BMI [kg/m²]	18.4 (±3.8)	19.2 (±3.7)	$U = 168.0, p = .273$	19.0 (±3.9)	19.8 (±3.6)	$U = 179, p = .419$
PAQ-C	2.73 (±0.66)	2.94 (±0.63)	$t = -1.001, df = 39, p = .323$	2.71 (±0.60)	2.96 (±0.52)	$t = -1.400, df = 39, p = .169$
FELS	6.67 (±1.66)	6.09 (±1.46)	$t = 1.193, df = 39, p = .240$	6.84 (±1.69)	6.10 (±1.57)	$t = 1.449, df = 39, p = .155$
ATR [º]	6.15 (±1.56)	6.52 (±1.66)	$U = 177.5, p = .380$	4.05 (±1.66)	6.00 (±1.94)	$U = 92.5, p = .002$

The Wilcoxon signed rank test was used to analyze whether there was any significant difference between the results of the initial measurements and the final results in the subjects who participated at the therapeutic program (Eg). In the post-test, the mean values of TA were found to be significantly lower (*Z* = - 3.710, *p* = 0.000). In case of Cg the difference remained insignificant (*Z* = - 1.555, *p* = 0.120. Table 3 presents the results of the comparative analysis after the *t* test for the dependent samples and the Wilcoxon test.

In September 2016, the groups were retested by scoliometric measurement to assess the consistency of the effects caused by the intervention program. The mean value of TA at Cg at the end of the experiment was 6.0°, and at 4.05 ° in Eg. Over the next four months, minor changes occurred in the mean values of TA in both groups. The value of TA fell to 5.76° in Cg, and to 3.95° in Eg. The statistical analysis shows that no significant changes occurred in the mean values of TA, nor for Cg *(t* = 1.156, df = 20, *p* = 0.261), or Eg *(t* = 0.623, df = 19, *p* = 0.541).

Table 3. Comparative analysis of the results of the measurements at the beginning and end of the experiment for the experimental and control group

Variables	Experimental group			Control group		
	Pre-test	Post-test	Paired sample t-test or Wilcoxon Signed-Rank Test	Pre-test	Post-test	Paired sample t-test or Wilcoxon Signed-Rank Test
Height [cm]	155.8 (±10.	162.3 (±9.5)	*Z = - 3.926, p = .000*	155.4 (±8.1)	161.5 (±7.5)	*Z = - 3.941, p = .000*
Weight [kg]	45.5 (±13.0	50.8 (±13.7)	*t = -8.431, df = 19, p = .000*	46.9 (±11.4)	52.2 (±12.3)	*t = -9.649, df = 20, p = .000*
BMI [kg/m	18.4 (±3.8)	19.0 (±3.9)	*Z = - 2.782, p = .005*	19.2 (±3.7)	19.8 (±3.6)	*Z = - 2.798, p = .005*
PAQ-C	2.73 (±0.66	2.71 (±0.60)	*t = -.689, df = 19, p = .499*	2.94 (±0.63)	2.96 (±0.52)	*t = -.544, df = 20, p = .593*
FELS	6.67 (±1.66	6.84 (±1.69)	*t = -2.353, df = 19, p = .030*	6.09 (±1.46)	6.10 (±1.57)	*t = -.172, df = 20, p = .865*
ATR [º]	6.15 (±1.56	4.05 (±1.66)	*Z* = - 3.710, p = .000	6.52 (±1.66)	6.00 (±1.94)	*Z* = - 1.555, p = .120

Discussion

After analyzing the results of the subjects, it was found that the value of the initial mean ATR at the Eg decreased from 6.15º (± 1.56) to 4.05º (± 1.66) at the end of the experiment, this being an improvement of 2.10º. Also, the ATR was diminished at the CG by 0.52º. This phenomenon of spontaneous improvement has been reported by numerous studies (Brooks, Azen, Gerberg, Brooks, & Chan, 1975; Pin, et al., 1985).

Modi et al (2010) followed-up the progression of scoliosis curves in 169 children (mean age was 9.2 years) during one year. According to this study, the amount of the curve decreased at 32.5% in case of the examined subjects, remained unchanged at 41.4% and progressed at 26%. We have mentioned that the effectiveness of physical therapy in treating severe spine deficiencies is the most controversial of all treatment modalities. However, our study demonstrated that by applying basic gymnastics exercises, the ATR decreased by 2.10º while subjects in the control group had a decrease of only 0.52º.

Negrini et al (2006) conducted a prospective study on 110 patients diagnosed with adolescent idiopathic scoliosis. The initial value of ATR was 14.4° (±6.0), but after they went through a special exercise program (Scientific Exercises Approach to Scoliosis), the ATR was reduced with 2º .

It is important to emphasize that the physical exercises we used from basic gymnastics were carefully selected. They were mostly executed asymmetrically, and most of them were trunk exercises. Although, we did not manage to individualize all the exercises, the subjects were grouped according to the type of the TA, each group received specific indications regarding the direction, amplitude and dosage of the exercises.

The applied questionnaires have shown that the level of physical activity has not changed compared to the pre-experimental period. Consequently, we can conclude that the decrease in ATR was generated by physical activities within the intervention program.

Conclusions

As a result of this study, it has been found that the application of exercises from basic gymnastics, especially exercises with portable objects, free exercises, gymnastics bench and on stall bar, can have beneficial effect on TA, ie the result will be the decrease of the thoracic hump.

We recommend the use of these exercises in the treatment of people with moderate or severe TA, if the general principles of treatment are respected (symmetrical tightening of the muscles on the convex part of spine and lengthening the muscles on the concave side).

We also recommend the performing of a screening by the school doctor or the physical educators at the beginning of each school year for all pupils in case of girls at the age of 10-13 and in case of boys at 11-13 years, as well as the use of corrective gymnastics exercises by the teachers in the physical education lessons. This is possible in the third part of the lesson (the selective influence of the locomotor apparatus) or by the differential treatment of the pupils in the physical education lesson.

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