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Comparison of Procedures Applied on the Auditive Feedback Equipment, Neuromuscular Electrostimulation and Kinesitherapy in Kyphotic Attitudes Recovery

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Abstract:
Problem statement: The general objective of our study has the investigation of the effectiveness of three different procedures used to improve kyphotic attitudes.
Purpose of the study: to analyse and compare which correction is the most important to address the deficiency. The following procedures are analysed: auditive feedback equipment, neuromuscular electrostimulation and kinesitherapy.
Methods: subjects were 20 young people aged 15-18 years who were diagnosed with this deficiency.
Research designs: these measurements were made in three different spatial times: initially, intermediate (after one month) and at the end (after two months).
Findings and results: the most effective procedure were kinesitherapy, followed by the neuromuscular electrostimulation procedure, and the last in this hierarchy being the auditive feedback equipment procedure. Within the three groups, higher values were obtained at the initial measurement, compared to the intermediate one and the final one. The results obtained were statistically processed using the SPSS software, more precisely we used the ANOVA method to make comparisons between the three experimental groups and the T test to compare the three measurement moments. Therefore, at the end of the study, following the comparison of procedures, the most effective procedure for correcting the kyphotic attitudes was established.
Conclusion Based on the results of this study we want to see if we can track the performance of other recovery methods through a software tracking.

Keywords: *auditive feedback, neuromuscular electrostimulation, kyphotic attitudes, kinesitherapy, vertebral spine.*

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1. Introduction

The vertebral spine of people suffering from kyphotic attitudes may have swelling in the dorsal area. It is frequently associated with lumbar hyper lordosis (to maintain the balance of the trunk), the deviations of the shoulder girdle (shoulder sagging and adducted, shoulder blades detached), the thorax clogged, head and neck tilted forward, the muscles are also affected, so that meet the shortening of the muscles of the chest and elongation of the back muscles. The kyphotic attitudes is the result of developmental problems, a degenerative disease, such as arthritis of the spine, a compression fracture from osteoporosis or trauma to the vertebrae of the spine. Office work, study or stay long on a chair in a poor position of the back (and hence the spine) can result in kyphotic attitudes and eventually in kyphosis (Antonescu et al., 1993, pp. 44-162). Musculoskeletal balance is a good posture, thus protecting the supporting structures of the human body against progressive injury and deformation, structures that are in working or resting state (Britnell et al., 2005, pp. 493-500).

The kyphotic attitudes treatment depends on the age of the patient, the causes of it and complications that may occur. Thus, looking at a high incidence of kyphotic attitudes in children, this study is important as it helps to correct the kyphotic attitudes until it becomes a kyphosis, studies indicating us that bone and muscle maturity ends at age 18-19 for girls and 19-20 for boys (Petcu, 2001).

Other authors, Shamsi, Veisi, Karimi, Sarrafzadeh, & Najafi (2014), have spoken about normal Range of Thoracic Kyphosis in Male School Children.

An important indicator of musculoskeletal health is the posture, it is necessary to be consistent with the specific position of the body in space (Talaghir et al., 2020), minimizing anti-gravity stresses on the tissues of the human body (Grimmer et al., 2002).

The results indicated an equality between the two therapies, with no significant results between the two groups of patients (Kamali et al., 2016).

The measurements of people diagnosed with kyphotic attitudes was made with their agreement (those who were 18 years) and parental consent (under 18), by signing a consent form.

The study followed a sampling of the population on the basis of inclusion and exclusion of subjects. Thus, the most important inclusion criteria were an excess of the normal spinal dorsal angle between 20-50 degrees with the distance between the acromion-wall bigger than 9 cm.

Electrostimulation or neuromuscular electrostimulation (ESNM) is defined by Niculescu et al., (2007) as a transcutaneous electrical stimulation on peripheral nerves with the role of producing skeletal muscle contraction.

On the demographic characteristics of the sample, it is noted that the participants were aged 15-18. They were represented as male individuals (11 subjects) and female (9 subjects), all of whom were Caucasian. Each sample was composed of five subjects, a total of 20 subjects (15 for 5 experimental groups and other 5 for the control group), such as one random sampling method. Thus, to remove systematic errors that may occur is important a randomized selection which refers to the equal distribution of participants in four groups of three and one control. Another noteworthy feature is that the randomized treatment was open label. Both the person who performed the intervention and the subjects who were intervened knew from the beginning the characteristics of the procedures to which they were subjected.

This is not the case for single-blind or double-blind studies.

2. Problem Statement

This study was conducted based on other long studies on the kyphosis correction. The most relevant works were made from Shiraz University of Medical Sciences, Iran, which showed that manual therapy (stretching) is as effective as exercise therapy in reducing kyphosis angle. Another work in Quebec, Canada demonstrated the equipment Spine Cor Dynamic Corrective Brace can correct the angle of kyphosis only if applied to younger patients. Also, the study from State University, Michigan, USA, demonstrated that the basic exercises and posture at home carried out for 13 weeks are effective in changing the angle of kyphosis. Another research was written by Maffiuletti, Minetto, Farina, & Bottinelli, (2011), where the authors used electrical stimulation for neuromuscular testing and training: State-of-the art and unresolved issues. In a study in Canada, Quebec, 16 adolescents (12 boys and 4 girls) aged 19-21 were patients who confirmed that therapy with postural equipment is beneficial to apply only to young sufferers. SpineCor Dynamic Corrective Brace equipment was developed for this research, and subjects were evaluated with Poster Print software (Marcotte et al., 2009).

In other research conducted at the University of Medicine and Pharmacy in Iasi, 1867 students were discovered in grades V-VIII. Of these, 97 had deviations from the spine, and they accounted for 42% of the total number of students.

Rotary Club of Alba Iulia together with Alba School Inspectorate, conducted another research. A total of 413 students were examined, of

whom 236 had spinal deviations. 13.08% of all cases, which means 54 cases were detected with kyphosis.

According to the literature, the disease occurs in 60% to 14 years old children, affecting between 0.5 to 8% of the healthy population aged 10 - 14 years. This research began after a campaign of information and awareness of vicious back positions in two high schools in Alba Iulia. Following the campaign, subjects who were self-awarded probability of a vicious back positions, presented themselves to the recovery gym "SPEROMAX Alba", where they were evaluated and measured.

3. Research Questions

Each person is different in its own way as any disease cannot behave exactly. The most important thing is to follow the evolution and fight parity. Regardless of the type of disease the person or symptoms of a disease classification by type of person.

To prevent this disease, we need to do a data analysis and understand the causes. We used different classifications to perform a synthetic analysis of the data. Through these we sought to prevent and stop the affection of the early stages. The methods used are based on patient recovery column type strain, and age. This tool is designed to help modern man to undertake actions and we wanted to significantly reduce the type of analysis and decision, even to 0 if possible. Using an artificial intelligence system gave us accurate predictions. These are calculated based on complex algorithms, very quickly and in a minimum of time. These artificial intelligence systems greatly reduce the time it takes to get results and conclusions, respectively. It is very important to understand and know the causes that cause a certain condition.

4. Purpose of the Study

The application of the three procedures (auditive feedback equipment, neuromuscular electrostimulation and kinesitherapy) were performed to correct the kyphotic attitudes. Referring to the hypotheses of this study, we expect to see an improvement in the dorsal column angle and scapular belt deviation (acromion-wall distance) for all experimental groups as compared to the control group. Moreover, we expect experimental group 3 (kinesitherapy) to have more effective results than experimental group 2 (neuromuscular electrostimulation) or experimental group 1 (auditive feedback). At the same time, we assume that the measurements made for each experimental group will have higher values at the initial time compared

with the intermediate and final time. At the end all the results will be compared to determine the most efficient procedure in correcting these problems of static vertebral.

In the second phase, the three experimental groups were formed, the subjects were distributed and afterwards the three procedures were applied to the subjects, a procedure for each group. The three procedures were used independently in this study

5. Research Methods

This study included 20 subjects (N = 20), 11 males and 9 females, aged 15-18, Alba Iulia. The subjects were randomly assigned in 4 groups, as follows: 3 experimental groups (group 1 with 5 subjects - auditive feedback equipment, group 2 with 5 subjects - neuromuscular electrostimulation, group 3 with 5 subjects - kinesitherapy) and 1 control group with 5 subjects (no applied procedure). The study was conducted over a period of almost two years (February 2016 - December 2017). As for the first group, subjects used home with hearing-aid equipment for a 5-hour period (see Figure 1), for two months.

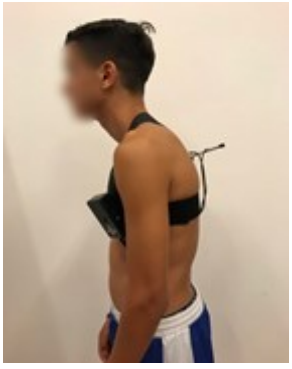


Figure 1. Auditive feedback equipment



Figure 2. Neuromuscular electrostimulation



Figure 3. Kinesitherapy procedure

Source: Authors' own conception

For the second group, the subjects used the neuromuscular electrostimulation procedure (electrodes on the dorsal area, the intensity being 6 mA/4 x 4 electrode for 10 minutes), twice daily, for two months, see Figure 2 (Maffiuletti, Minetto, Farina & Bottinelli, 2011).

The third group was present in the recovery gym for two months to perform the exercise program set by us (ten exercises) in the literature (see Figure 3). For the control group, no procedure was applied during the study.

The subjects of the four groups were evaluated at three different times, as it follows: initially, intermediate (after one month) and final (after two months). The measurements were made using the angle meter to measure the angle of the column, see Figures 4 and 5 (Perriman et al., 2010) and the measurement for the distance between the acromion wall, see Figure 6 (Nijs et al., 2005). The dynamic role is important for the spine as it is involved in numerous and ample movements (Ardelean et al., 2018), so thanks to them the body benefits from a high mobility (Marcu & Matei, 2009).



Figure 4. Inclinometer application T1-T2



Figure 5. Inclinometer application T12-L1



Figure 6. Square application

Source: Authors' own conception

After the measurements were obtained and verified the accuracy of the values, they were then processed statistically using SPSS, to make a comparison between the 4 groups and highlight the most effective of procedure.

6. Findings

A first step in the interpretation of the results refers to descriptive analysis of the column angle (see table 1) and descriptive analysis of the acromion-wall distance (see table 2). Data from which we can see a decrease in mean values at baseline, at the end of each experimental group and a constant value for the control group.

Table 1. Column angle (degrees) - statistical analysis

Method	Momentum	Mean	Std. Deviation	N
Auditive feedback	initially	47.8000	2.38747	5
	intermediar	46.2000	2.16795	5
	final	43.6000	2.07364	5
	Total	45.8667	2.72204	15
ESNM	initially	50.4000	1.14018	5
	intermediar	47.6000	1.81659	5
	final	43.4000	2.30217	5
	Total	47.1333	3.41983	15
Kinesitherapy	initially	53.6000	2.07364	5
	intermediar	50.2000	2.38747	5
	final	44.6000	2.19089	5
	Total	49.4667	4.35671	15
Control	initially	46.8000	2.94958	5
	intermediar	46.8000	2.94958	5
	final	46.8000	2.94958	5
	Total	46.8000	2.73078	15
Total	initially	49.6500	3.39155	20
	intermediar	47.7000	2.67739	20
	final	44.6000	2.60364	20
	Total	47.3167	3.54865	60

Note: Mean= average values; N= number of subjects; Std. Deviation= standard deviation

Source: Authors' own conception

In other words, the angle of the column in the first experimental group was observed a decreasing trend from baseline to the end of 4.2° for the second of 7.0°, and for the third 9.0°. Contrary to experimental groups, the control group had the same mean value of 46.8° at all three times of measurement.

Table 2. Acromion-wall distance (cm) - statistical analysis

Method	Momentum	Mean	Std. Deviation	N
Auditive feedback	initially	13.2000	1.48324	5
	intermediar	11.8000	1.48324	5
	final	10.0000	.70711	5
	Total	**11.6667**	**1.79947**	**15**
ESNM	initially	13.8000	1.09545	5
	intermediar	12.0000	1.00000	5
	final	9.8000	.83666	5
	Total	**11.8667**	**1.92230**	**15**

Kinesitherapy	initially	14.0000	.70711	5
	intermediar	11.6000	.54772	5
	final	9.4000	.54772	5
	Total	**11.6667**	**2.02367**	**15**
Control	initially	14.0000	1.22474	5
	intermediar	14.0000	1.22474	5
	final	14.0000	1.22474	5
	Total	**14.0000**	**1.13389**	**15**
Total	initially	13.7500	1.11803	20
	intermediar	12.3500	1.42441	20
	final	10.8000	2.06729	20
	Total	**12.3000**	**1.97699**	**60**

Note: Mean= average values; N= number of subjects; Std. Deviation= standard deviation

Source: Authors' own conception

More specifically, for the distance between the acromion - wall, in the case of the first experimental group there is a decreasing evolution from the initially to the final one of 3.2 cm, the second of 4.0 cm and the third of the 4.6 cm. Contrary to the experimental groups, the control group had the same average of 14.0 cm in all three measurement moments.

The ANOVA test is a method used to determine the influence of independent variables (procedure and time) on dependent variables (column angle and acromion-wall distance), more specifically, we have helped to compare the mean of the four samples independent of the subjects. In a first step we will analyse the influence of the two independent variables on the column angle (see table 3), and then on the distance between the acromion-wall (see table 4).

Table 3. Column angle - analytical analysis (group comparison); Source: Authors' own conception

Source	**Type III sum of squares**	**df**	**Mean square**	**F**	**p**
Model corrected	480.983	11	43.726	8.011	.000
Intergroup	134332.017	1	134332.017	24610.446	.000
method	105.383	3	35.128	6.436	.001
momentum	259.433	2	129.717	23.765	.000
method * momentum	116.167	6	19.361	3.547	.005
Eroare	262.000	48	5.458		
Total	135075.000	60			
Total corrected	742.983	59			

Regarding the angle of the column, following the application of the ANOVA method, we obtained three values of F, respectively F = 6.43, p = 0.001; F = 23.76, p = 0.000; F = 3.54, p = 0.005, statistically significant in each case, which allows rejection of the null hypothesis and acceptance of the research, which shows a difference between the four groups measured at the three specified moments.

Table 4. Acromion-wall distance - analytical analysis (group comparison)

Source	**Type III sum of squares**	**df**	**Mean square**	**F**	**p**
Model Corrected	177.000	11	16.091	14.410	.000
Intergroup	9077.400	1	9077.400	8129.015	.000
method	58.200	3	19.400	17.373	.000
momentum	87.100	2	43.550	39.000	.000
method * momentum	31.700	6	5.283	4.731	.001
Error	53.600	48	1.117		
Total	9308.000	60			
Total Corrected	230.600	59			

Note: Difference = the degree of freedom; F= test values ANOVA; p= the threshold of significance.

Source: Authors' own conception

In the case of the distance between the acromion - wall, following the application of the ANOVA method, we also obtained three values of F, respectively F = 17.37, p = 0.000; F = 39.00, p = 0.000; F = 4.73, p = 0.001, statistically significant in each case, which allows rejection of the null hypothesis and acceptance of the research, which shows a difference between the four groups measured at the three specified moments.

At the same time, we used the T test to see if the applied procedures caused changes in the three experimental groups. Thus, for all three procedures applied, both in the column angle and in the distance between the acromion wall, t values were obtained that allowed the rejection of the null hypothesis, acceptance of the research, which showed that the procedures applied have made changes:

• *Auditive feedback:*

- initially-intermediate (p=0.000), intermediate-final (p=0.003) -> column angle.

- initially-intermediate (p=0.005), intermediate-final (p=0.005) -> acromion distance-wall.

• *ESNM:*

- initially-intermediate (p=0.002), intermediate-final (p=0.000) -> column angle.
- initially-intermediate (p=0.009), intermediate-final (p=0.000) -> acromion distance-wall.

• *Kinesitherapy:*

- initially-intermediate (p=0.000), intermediate-final (p=0.001) -> column angle.
- initially-intermediate (p=0.004), intermediate-final (p=0.000) -> acromion distance-wall.

An important aspect to mention for both kinesitherapy and neuromuscular electrostimulation is that they were performed by the subjects under the supervision of a kinesitherapies as compared to the procedure (Babault et al., 2011). The auditive feedback equipment, which was performed by the independent subjects at home. Taking this observation into account, this is one of the reasons why this procedure has achieved the weakest results.

At the end of the study the results of the three procedures were compared. Thus, found out which one is the most effective to correct more quickly the kyphotic attitudes. In the first phase, the angle of the column was measured (the dorsal area with the inclinometer) and the scapula-humeral belt deviation (more precisely the distance between the acromion-wall with the square instrument).

After an ample analysis of these results, we tried to understand why the auditive feedback equipment procedures are ranked last. Actually, this should improve the results because is new generation method.

7. Conclusion

Through this research we wanted to investigate the effectiveness of three procedures to correct kyphotic attitudes, the results obtained were the desired ones.

Following their application, changes were made independently of the angle of the spine and the distance acromion-wall. Through this study we wanted to analyse and prioritize which is the best procedure of the three. After finalizing the results, we made a hierarchy of them: auditive feedback equipment, neuromuscular electrostimulation and kinesitherapy.

At the top of the hierarchy, the best modification was produced by the kinesitherapy program, compared to the ESNM procedure and auditive feedback equipment. The second hierarchical modification was produced by the ESNM procedure, and the last one in this hierarchy was the procedure with auditive feedback equipment. One important aspect to mention is that both kinesitherapy and ESNM were performed by the subjects under close supervision of the kinesitherapies compared to the procedure with auditive feedback equipment that was performed by independent subjects at home. So, starting from this observation, this is one of the probable reasons why this procedure has achieved weaker results compared to the other two procedures (kinesitherapy and ESNM).

Other three measuring thoracic kyphosis: implications for clinical studies, we find in Goh, Price, Leedman, & Singer (2000).

Another article by the Department of Kinesiology at Michigan State University, USA, initiated a study based on a number of 71 people, namely: 32 active group, 39 control group, for 13 weeks performed simple exercises and posture in their own homes. Being evaluated with flex curve both at the beginning of the research and at the end all subjects were diagnosed with kyphosis. Statistically significant indices could be observed in the active group of participants, from the point of view of the kyphosis angle (Vaughn & Brown, 2007).

In a study by Cuppone et al. (2018) auditive feedback has been associated with body movement that improves auditory and somatosensory orientation in space. The effects of active and passive audio-motor training on spatial orientation on 36 healthy young adults were investigated (Cuppone et al. 2016). It has been found that combined audio-motor training offers the strongest benefit, as it significantly affects both auditory and somato-sensory localization.

Following this study, a phone application will be created that will be used with the auditive feedback equipment. Specifically, this application will quantify the sound signals of the equipment, which at the end of use will produce a score based on which a representative and motivating image will be generated for the subject. Subsequently, this application will be developed in the sense that it will give the kinesitherapies the opportunity to supervise the use of the equipment by each subject.

Acknowledgement

Informed consent was obtained from all persons involved in the study. They signed a consent within the recovery gym "SPEROMAX Alba" from Alba Iulia, Romania. Also, all persons in the pictures agree to be

photographed and agreed for their image to be used and replicated into scientific articles for open access publication. It should be noted that this study is part of the author's phd Mircea-Nicolae Ordean. The authors declare no conflict of interest.

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