Chapter

Kinesitherapy and Ultrahigh-Frequency Current in Children with Bronchial Asthma

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Abstract

The aim is to compare the effect of the combination of kinesitherapy and ultrahigh-frequency current in children with bronchial asthma with a control group without rehabilitation. There were 24 children with bronchial asthma of average age of 8 followed for 10 days. They were randomized into two groups—12 children in the "physiotherapeutic" and 12 in the "control." All were treated with equal standard pharmacotherapy. The first group was treated also with kinesitherapy and ultrahigh-frequency current. At the beginning and end of the therapeutic course, the spirometric and anthropometric parameters were documented. In the statistical analysis were included the proportions between the actual and the expected spirometric parameters, adjusted for all anthropometric parameters. The ratios between the actual and the expected spirometric parameters improved significantly in both groups after 10-day treatment compared with before treatment ($P < 0.05$). In the "physiotherapeutic" group, the improvement after the treatment was significantly greater, when compared with the "control" group ($P < 0.05$). In conclusion, there is a significant therapeutic effect, upgrading that of pharmacotherapy when children with bronchial asthma were treated for 10 days with the combination of kinesitherapy and ultrahigh-frequency current.

Keywords: bronchial asthma, pediatrics, rehabilitation, physiotherapy

1. Introduction

Bronchial asthma affects about 300 million people worldwide according to the Global Initiative for Asthma (GINA) [1]. It is a serious global health problem that influences all age groups. The cost of treating these patients is increasing, especially if there is an overlying infection—pneumonia or bronchiectasis disease, as well as its social significance in the community and family [2], manifesting in the young age group. The problem is exacerbated in developing countries, in low-status families where asthma patients are exposed to harmful influences such as cigarette smoke, mold, cockroaches, and other allergens.

According to the National Heart, Lung, and Blood Institute (NHLBI) [3], of the 25 million asthma patients in the USA, 5% (1.25 million) suffer from severe asthma. Asthma is also the most common chronic disease in childhood, affecting over 7% of children [4–8]. About 500,000 people suffer from asthma In Bulgaria, 15,000 are children [4, 6–8]. About 80% of the people with bronchial asthma are diagnosed before their 6th year, and boys, in a ratio of 1:4, are more often affected than girls [7, 8].

Kinesitherapy is used in children with bronchial asthma due to its ability to counteract the consequences on the musculoskeletal system that negatively affect the respiratory system: respiratory muscle imbalance—expiratory muscles (rectus abdominis muscle, abdominal oblique muscles, internal intercostal muscles) are lengthened with decreased tone and strength, while inspiratory muscles (scalene muscles, external intercostal muscles, upper part of trapezius muscle, levator scapulae muscle) are shortened with increased tone and spasm, increased cervical lordosis, increased anterior-posterior chest size, increased thoracic kyphosis, lower rib descent, “gothic shoulders,” “barrel-shaped” chest, “shortened” neck, reduced diaphragmatic breathing, raised and forward shoulder girdle, reduced chest mobility, reduced lung volumes and capacities [1, 9–12]. These changes are preventable with adequate kinesitherapy [10, 13]. Some authors think that excessive exercise may provoke an attack, and that is a consideration against kinesitherapy in children with asthma [14, 15]. But the consequences of lack of exercise are detraining, easier fatigue, reduced tolerance to daily exertion, obesity, lethargy, and increased stress [1, 10, 13–15]. By warming up exercises, asthma attacks can be controlled [10, 13–15]. Exercise training can reduce the frequency and severity of asthma attacks induced by excessive physical exercise [1, 10, 13–15]. In addition, increased and more rapid muscle contractions and co-contractions as a consequence of exercises have a broncho-dilating effect. [1, 9–15].

Regarding the combination of ultrahigh-frequency current (UHF) and kinesitherapy, there are no studies on asthma in children, despite their hypothetical synergistic broncho-dilating effect. In adult patients with bronchial UHF, an anti-inflammatory and broncho-dilating effect was found, thanks to the endogenous heat effect, which does not burden the thermoregulatory, respiratory, and cardiovascular systems [5, 9, 11, 12]. The reason is that the skin is not a barrier to UHF, and endogenous heat is generated indirectly in depth by the transformation of electromagnetic external energy into kinetic energy of tissue dipoles [5, 9, 11, 12]. This results in tissue heating by the high-frequency oscillations of the dipoles, attempting to head with their positive and negative poles to the high-frequency reversal of the external electromagnetic polarity [5, 9, 11, 12]. Furthermore, endogenous heat from UHF is selective—it can thermally burden tissues with high or low water content, depending on the type of electrodes [5, 9, 11, 12].

The comparison of the effect of the combination of kinesitherapy and ultrahigh-frequency current in children with bronchial asthma versus a control group without rehabilitation is the aim of the work.

2. Material and methods

In the Children’s Clinic of the “Alexandrovska” University Hospital (CCAUH), there were 24 children with bronchial asthma of average age of 8 followed for 10 days. They were randomized into two groups—12 children in the “physiotherapeutic” group and 12 children in the “control” group. All children were treated with the same standard pharmacotherapy [1]. In the treatment of the first group (“physiotherapeutic”) kinesitherapy and ultrahigh-frequency current were also added.

The algorithm used in the ultrahigh-frequency current treatment was as follows: the procedures were performed in the lung area. The electrodes used were the condenser type, with a diameter of 13 cm. The method of placing is transverse on the chest and with a 3–4 cm distance between the electrodes and the chest surface. We used the oligothermal dose (medium heating) with the duration of the procedure of 10 min. The treatment course consisted of 10 treatments.

The algorithm used in the kinesitherapy was as follows: every day, two times per day the children performed three sets of 10 repetitions with a 2-min pause between each set. The program included was: increasing chest flexibility, improving posture, and correcting muscular imbalances of the respiratory and skeletal muscles through strengthening exercises for weak and lengthened dynamic muscles and relaxation of shortened static muscles, training in proper breathing [1, 5, 9–11, 12–14].

"Training in correct breathing" (**Figure 1**) aimed to correct the abnormal breathing pattern by slowing the respiratory rate at the expense of a more prolonged expiratory rate, reducing hyperventilation, using diaphragmatic-type breathing at rest (rather than abdominal or chest breathing), and using breathing through the nose (rather than the mouth) [15, 16]. "Training in correct breathing" was performed twice daily with three sets of 10 repetitions with a 2-min pause between each set [17].

Diaphragmatic breathing was facilitated by exteroceptive biofeedback (**Figure 1**). For this purpose, one hand was placed diaphragmatically. The maximal excursion was required when breathing in the diaphragmatic region rather than the abdominal or thoracic region. Diaphragmatic breathing was performed from functional residual capacity to maximal inspiratory lung volume with two consecutive interruptions while maintaining a 2:1 ratio of expiratory to inspiratory [17].

"Correction of respiratory muscle imbalance" (**Figure 2**) was performed two times daily with three sets of 10 repetitions with a pause of 2 min between each set [17]. Each repetition involved maximal inspiration through a wide open mouth (no resistance) from residual volume to total lung capacity in the lying down position [17]. To inhibit abdominal breathing, one hand was placed on the chest and no

Figure 1.
Training in correct breathing.

Figure 2.
Correction of respiratory muscle imbalance.

excursions were allowed in this area. For diaphragmatic respiration facilitation, the other hand was placed on the diaphragmatic area, and it was required that there be maximal excursions in this zone (**Figure 2**).

Expiration was performed through a narrowed slit of the mouth /between the lips/ (against resistance) within the functional residual capacity to avoid hyperventilation [17] (**Figure 2**). There were intervals of 60 seconds between these repetitions [17].

"Exercises to increase chest flexibility with postural improvement by correcting muscle imbalances" included chest extension in all planes [17, 18].

Horizontal thoracic flexibility (**Figure 3**) was exercised from a standing posture by the horizontal double arm and shoulder girdle swings in the opposite direction (initially with elbow joints flexed, then with elbow joints extended), which

Figure 3.
Horizontal flexibility of the chest.

simultaneously relaxed the upper extremity and shoulder girdle adductors (predominantly static muscles) (**Figure 3**) [15–17].

Vertical thoracic flexibility (**Figure 4**) was exercised from a standing position by the vertical double arm and shoulder girdle swings in opposite directions (one arm

Figure 4.
Vertical flexibility of the chest.

Figure 5.
Flexion sagittal flexibility of the chest.

cranially, the other caudally), which simultaneously relaxed the predominantly static upper extremity and shoulder girdle flexors [15–17].

Flexion sagittal thoracic flexibility (**Figure 5**) was exercised from standing to maximal forward and downward body tilt inducing total flexion of the entire spine, thoracic cage, and hip joints, which simultaneously relaxed the predominantly static extensors of the thoracic cage, trunk, and hip joints [15–17].

Extension sagittal thoracic flexibility (**Figure 6**) was exercised from standing to maximal backward and upward body tilt, inducing total extension of the entire spine, thorax, and hip joints, which simultaneously relaxed the predominantly static flexors of the thorax, trunk, and hip joints (**Figure 6**) [15–17].

Frontal thoracic flexibility (**Figure 7**) was exercised from a standing position by maximal bilateral lateroflexion of the body, inducing total lateroflexion of the entire spine and thorax, which simultaneously relaxed the predominantly static lateroflexors of the torso and thorax (**Figure 7**) [15–17].

Transversal rotational thoracic flexibility (**Figure 8**) was exercised from a standing posture by maximal bilateral body rotations inducing total rotation of the entire spine, the thorax, and hip joints, which simultaneously relaxed the predominantly static rotators of the trunk, thoracic cage, and the thorax (**Figure 8**) [15–17].

Three-dimensional flexibility and muscular balance of the thorax (**Figure 9**) and upper body in all planes were exercised from a standing position by full upper body circumduction circles alternating in both directions [15–17] (**Figure 9**).

Figure 6.
Extensor sagittal flexibility of the chest.

Figure 7.
Frontal flexibility of the chest.

Figure 8.
Transverse rotational flexibility of the chest.

Figure 9.
Three-dimensional thoracic flexibility and muscle balance in all planes.

"Exercises to increase chest flexibility with postural improvement by correcting muscle imbalances" were performed two times every day with three sets of 10 repetitions with a 2-min break between each set [15–17]. The total duration of these exercises was 30 min daily (2 × 15 min).

At the beginning and end of the treatment course, the spirometric [18] and anthropometric [1, 5, 9, 11, 13, 14] parameters were recorded. The spirometric test was performed as follows—at each examination, we made three consecutive examinations with a computerized spirometer, and the best one was considered and recorded [18]. The anthropometric parameters were: age (g), weight (kg), height (cm), chest circumference at maximum inspiration, during a pause, and at maximum expiration, Erisman's index (chest circumference at pause—1/2 of height in cm), Brugsh's index (mean chest circumference divided by height in cm), Ott's test (spinal mobility in cm.), Tomayer's test (toe-to-floor distance in cm.), sagittal and frontal chest diameters and their ratio [5, 9, 11, 12].

Correlation analyses with post-hoc multiple linear regression tests were used to estimate the significance of the interaction between spirometric and anthropometric parameters, yielding significant real multiple regression formulas. We calculated the estimated spirometric parameters adjusted for all anthropometric parameters, based on these. These had higher statistical flexibility than the expected spirometric parameters calculated automatically by the computerized spirometer based on only three anthropometric parameters, which were age, weight, and height, which did not change over 10 days. We additionally included the ratios in percentages between the actual spirometric results and the expected spirometric parameters according to the obtained real regression formulas in the statistical analysis. For statistical analysis, a balanced MANOVA design with 2 × 2 levels of interaction was used, "before" in comparison with "after" treatment and the "physiotherapy" group in comparison with the "control" group. Bonferroni post-hoc multiple comparison tests were used to isolate the statistical clusters that were significantly different from the others.

3. Results

Concerning individual actual spirometric parameters and concerning ratios of actual versus computer-predicted spirometer parameters adjusted for age, weight, and height, there were no statistically significant MANOVA interactions ($P > 0.05$)

Based on the statistically significant multiple correlations ($P < 0.05$) between the actual forced expiratory volume in 1 second ("FEV1 Act1") and all anthropometric parameters, we calculated the following statistically significant multiple regression formula:

$$\begin{aligned} \text{"FEV1 Act1"} = {} & 4.14 + (0.0156^{*} \, Age) + (0.0189^{*} \, \text{Height}) + (0.0260^{*} \, \text{Weight}) \\ & + (0.0790^{*} \, \text{chest circumference } at \text{ maximum inspiratory}) \\ & - (0.0796^{*} \, \text{chest circumference } at \text{ maximum expiratory}) \\ & + (0.00435^{*} \, \text{chest circumference } at \text{ pause}) - (0.329^{*} \, \text{Brugsh's index}) \\ & - (0.000605^{*} \, \text{Erisman's index}) - (0.0233^{*} \, \text{Tomayer's test}) \\ & - (0.0682^{*} \, Ott\text{'s test}) + (0.198^{*} \, \text{sagittal chest size}) \\ & - (0.188^{*} \, \text{frontal chest size}) - (4.37^{*} \, \text{sagittal / frontal chest size ratio}). \end{aligned}$$

We applied this real formula to calculate the expected "FEV1 Pred1 formula" adjusted for all anthropometric parameters. We subjected the ratio between actual and expected forced expiratory capacity in 1 second according to this formula ("FEV1% Act1/Pred formula") to statistical MANOVA analysis with Bonferroni's post-hoc multiple comparison tests.

In comparison with the results after the 10-day course therapy with the combination of kinesitherapy and ultrahigh-frequency current and before the 10-day course, there was a significant increase in "FEV1% Act1/Pre formula" in the "physiotherapy" group, which was treated with the combination of kinesitherapy and ultrahigh-frequency current ($P < 0.05$), and "control" group (without kinesitherapy and ultrahigh-frequency current) ($P < 0.05$), but the "physiotherapy" group showed a

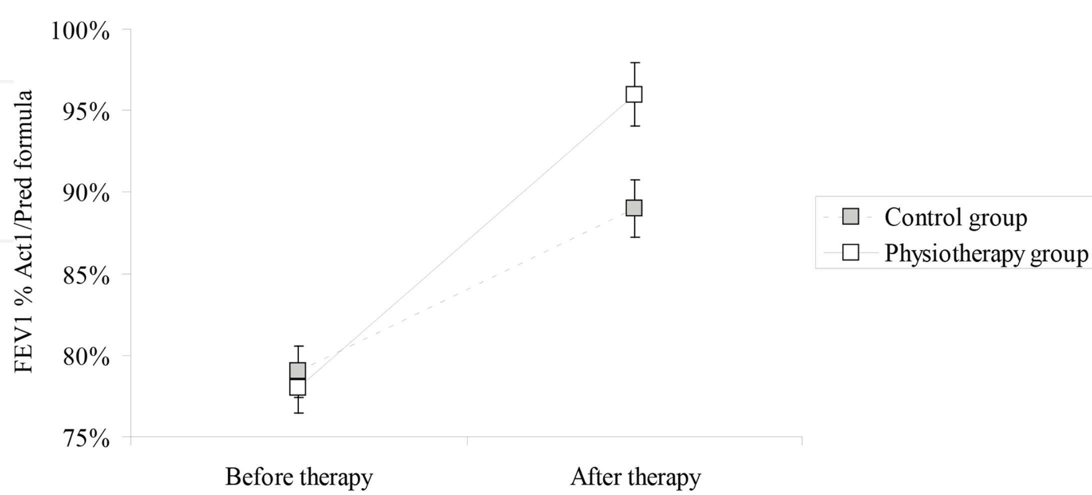

Figure 10.
The ratio between actual and expected forced expiratory volume in 1 second ("FEV1% Act1/Pre formula", adjusted for all anthropometric parameters), recorded before 10 days of treatment and after 10 days of treatment in the "physiotherapy" group (treated with the combination of kinesitherapy and ultrahigh-frequency current) and "control" group (without kinesitherapy and ultrahigh-frequency current).

statistically significantly higher value of this parameter compared with the "control" group after treatment ($P < 0.05$) (**Figure 10**).

We found out that the results of other spirometric parameters were similar when adjusted for all anthropometric parameters—chest circumference at maximum inspiration, during a pause, and at maximum expiration, Erisman's index (chest circumference at pause—1/2 of height in cm.), Brugsh's index (mean chest circumference divided by height in cm.), Ott's test (spinal mobility in cm.), Tomayer's test (toe-to-floor distance in cm.), sagittal and frontal chest diameters and their ratio.

4. Discussion

The actual spirometric parameters and the ratios of actual to computer-predicted spirometric parameters were insufficiently sensitive to reach statistically significant differences at the 10-day follow-up. The estimated spirometric parameters calculated by the computerized spirometer were based only on inert anthropometric measurements (age, height, and weight), and because of that, they could not verify improvement after the 10-day period. On the other side, the other anthropometric parameters showed sufficient flexibility and sensitivity over the 10-day follow-up.

Because we found in both groups an improvement after the 10-day treatment course in terms of the percentage ratios between actual and expected spirometric parameters, adjusted for all anthropometric parameters, this confirms the therapeutic effect of pharmacotherapy and rehabilitation with the combination of kinesitherapy and ultrahigh-frequency current in children with asthma.

But on the other side, the combination of kinesitherapy and ultrahigh-frequency current was found to have a better effect than pharmacotherapy in children with asthma, as the improvement after treatment was significantly greater in the "physiotherapy" group compared to the "control" group.

5. Conclusions

The combination of kinesitherapy and ultrahigh-frequency current has a significant therapeutic effect in a 10-day treatment of children with bronchial asthma, superior to that of pharmacotherapy.

Conflict of interest

The authors declare no conflict of interest.

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