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The comparison between pulmonary rehabilitation with music therapy and pulmonary rehabilitation alone on respiratory drive, cortisol level and asthma control in patients hospitalized with asthma exacerbation

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ABSTRACT

Introduction: Much emphasis is being placed on the role of music therapy as an easy-to-use, noninvasive and relatively cheap method of asthma treatment. The objective of this interventional double-blinded randomized controlled trial was to assess whether music therapy, as a complementary modality to pulmonary rehabilitation, can help to improve respiratory drive, asthma control and quality of life in patients with asthma exacerbation.

Methods: Hospitalized patients with asthma exacerbation enrolled in the study were randomly assigned to experimental (music therapy) or control (popular science program) group. Both groups during hospitalization received standard pharmacotherapy accompanied by respiratory physiotherapy. Respiratory drive, asthma control, quality of life and serum cortisol in all participants were assessed at the beginning and at the end of their hospitalizations.

Results: The experimental group consisted of 39 asthmatics and 34 subjects with asthma were assigned to the control group. During the hospitalization, the levels of the inspiratory occlusion pressure for the first 0.1 s of inspiration (P0.1) decreased ($p = 0.004$) and the maximum P0.1 increased ($p = 0.041$) only in the experimental group. The serum cortisol level decreased in both groups ($p = 0.001$). The changes in asthma control and quality of life did not reach significant levels in either subject group.

Conclusion: Passive music therapy and its effects on the mental state of patients seem to improve the efficiency of the respiratory system. The results of this experimental study demonstrate that a complementary music therapy has beneficial effects on the treatment of asthma exacerbations in adults.

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Introduction

Asthma is an important global health problem affecting all age groups. The prevalence of asthma is increasing in many countries. Due to its chronicity and periodic exacerbations, asthma places a burden on health care systems, results in loss of productivity in the workplace, and affects the quality of life in patients and their families (1).

Improvement in asthmatic symptoms, the quality of life and psychological situation of asthma sufferers was reported in a systematic review of studies on

breathing and relaxing exercises for asthma (2). Significant but small improvement in the quality of life was also revealed in a large pragmatic study on breathing training in patients with asthma-related impairment of the quality of life (3). Based on the results of the above publications, the Global Strategy for Asthma Management and Prevention (GINA), published in 2019, recommends that breathing exercises be considered as a supplementary treatment to conventional regimes in asthma management in terms of symptoms and the quality of life (Evidence A) (4).

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Studies on the quality of life in asthmatic patients have shown that symptoms depend not only on the severity and duration of the disease, but also on the social and psychological condition of asthmatic patients and their family (5,6). Additionally, they clarify the impact of stress on the perception of asthma symptoms and asthma control (7). Strong emotions can be responsible for exacerbation of the symptoms and therefore mental disorders, such as depression and stress, can affect the patient's treatment (4,8). Previous research has demonstrated that the development of treatment strategies accompanied by relaxation methods, including music therapy, can help to improve the mental well-being and physical symptoms in asthmatic patients (9). Increasing numbers of asthma sufferers are seeking complementary and alternative treatment methods (10).

According to the American Music Therapy Association, music therapy is "the (...) use of music interventions to accomplish individualized goals within a therapeutic relationship by a credentialed professional who has completed an approved music therapy program" (11). The method is easy to use in a clinical setting, noninvasive, and relatively inexpensive (12). However, the paucity, heterogeneity and significant methodological limitations of the available studies make it impossible to recommend music therapy as a treatment modality in asthma on a wider scale. The systematic review highlighted the need for further research on mixed methodology, because there are no well-planned studies that would prove the benefits of music therapy for asthmatic patients, especially during the exacerbation phase (13).

The objective of this study was to assess whether music therapy, as a complementary modality to pulmonary rehabilitation, can help to improve respiratory drive, asthma control, quality of life and influence the serum cortisol in patients with asthma exacerbation.

Methods

Study design

The study was an interventional double-blinded randomized controlled trial carried out in the University Hospital in Kraków from May 2017 to August 2019. The study protocol was published on January 18, 2017 in the ISRCTN registry of clinical trials under the number of ISRCTN17240890 (14). The study was approved by the Jagiellonian University Ethics Committee (Date 28/04/2016, No.122.6120.75.2016). The study was performed in accordance with the ethical standards as laid down in the 1964

Declaration of Helsinki and its later amendments. Because the research involved human participants, written informed consent was granted before enrollment from all the participants.

The subjects included in the study participated in the initial measurements of the outcomes and then were randomly assigned (based on a draw) to one of the following two groups, namely experimental and control. One member of the team was responsible for randomization, which was performed using a randomization program available online. The randomization results were known neither to the members of the research team measuring the subjects' respiratory drive nor to those responsible for collecting data from the subjects' medical histories and questionnaire surveys. A separate draw was held after the recruitment of each successive patient, so it was not possible to predict which group the next recruited patient will be assigned to. Next, the same person gave a blinded physiotherapist an unmarked MP3 player either with music (the experimental group) or a popular science program (the control group).

Participants

The patients who were admitted to the ward for the necessary in-patient treatment of asthma exacerbations were informed about the possibility of participating in the study after passing the medical examination and confirming the diagnosis. The patients were recruited by a pulmonologist who was not a member of the study team.

The physician checked whether the patients met the inclusion criteria and made sure that there were no grounds for their exclusion from the study. The inclusion criteria were the following: hospitalized patients with asthma exacerbation confirmed by a pulmonologist, age ≥ 18 years. The diagnosis of asthma was established according to the Global Initiative for Asthma 2017 update (1). The exclusion criteria were contraindications to pulmonary rehabilitation, such as acute phase of coronary heart disease or pulmonary hypertension, significant hepatic dysfunction, severe cognitive impairment or advanced cancer-induced damage to the auditory system, impairment of oral sphincters whose pressure is needed to keep the mouthpiece of the measuring apparatus safely in place (15).

Intervention and control

The patients in the experimental group received standard pharmacotherapy in conjunction with

respiratory physiotherapy and receptive music therapy. The applied program of treatment and pulmonary rehabilitation was carried out according to the respective guidelines of the GINA report (1) and the American Association of Cardiovascular and Pulmonary Rehabilitation (15). The physiotherapy sessions were adjusted to the patients' condition and could include: airway clearance techniques, reeducation of the breathing pattern, diaphragmatic breathing and techniques to reduce shortness of breath.

The methodology used in the music therapy was based on the data available in the literature (13). The pieces of music were selected on the basis of the results from the previous study which examined the musical preferences of 80 asthmatic patients (16). The duration of the music therapy intervention was 30 min. It was increased based on the experience from the previous study carried out in hospital conditions (17) and the experience of other researchers who used music therapy in asthmatic outpatients, which allowed for longer (60 min) intervention (18). During the music therapy, the subjects received headphones to listen to recordings of relaxing music from mp3 files prepared by music therapists. (A detailed description of the respiratory physiotherapy and the music therapy is presented in the [Supplementary material](#)).

The patients in the control group received standard pharmacotherapy in conjunction with respiratory physiotherapy. Instead of a music therapy, they were asked to listen to radio broadcasts about popular science and nature. In this group, the intervention also took place once a day for 30 min throughout the hospitalization period.

Outcome measures

The subjects from both groups were assessed before, during and after intervention. Variables such as asthma control (using the Asthma Control Test), respiratory drive, blood cortisol level, dyspnea level (using the Borg scale) and the quality of life (using the Asthma Quality of Life Questionnaire) were measured before the treatment. Throughout their hospitalization, the subjects had their dyspnea level, mood and blood saturation monitored. After the intervention, the following variables were measured: asthma control, respiratory drive, blood cortisol level, dyspnea level and the quality of life. We tested 3 hypothesis that music therapy elicits a positive effect on primary outcomes such as: respiratory drive, cortisol level and asthma control.

Asthma control test (ACT)

The ACT survey is a patient-completed questionnaire with 5 items assessing asthmatic symptoms (diurnal and nocturnal), the use of rescue medications, and the effect of asthma on the daily functioning of the sufferers (each item includes response options corresponding to a 5-point Likert-type rating scale). While evaluating the ACT survey, the responses for each of the 5 items are summed up to yield a score ranging from 5 to 25 (the higher, the better) (19–21). Scores between 20 and 25 are classified as well-controlled asthma; between 16 and 20 as not well -controlled; and between 5 and 15 as very poorly controlled asthma (1).

Asthma quality of life questionnaire (AQLQ)

AQLQ is a disease-specific quality-of-life questionnaire consisting of 32 items in the following four health domains: activity limitation (11 items), symptoms (12 items), emotional function (5 items), and environmental stimuli (4 items). This instrument measures the quality of life over the period of two weeks prior to an interview. Each item within the AQLQ is equally weighted. Patients use a 7-point Likert scale to give an answer for each item. The domain scores are computed as the means of the domain-specific items and the global AQLQ score is computed as the mean of the domain scores. The score of each domain and the global score range from 1 to 7, corresponding – respectively – to 'no impairment' and 'maximum impairment' in the quality of life (22,23).

Respiratory drive

The subjects had their respiratory drive assessed using the Care Fusion Jeager MasterScope SIN 756057 spirometer, equipped with an additional device for assessing the respiratory drive. The following variables of the respiratory drive were observed, i.e.: P0.1 (inspiratory occlusion pressure for the first 100 ms of inspiration), and P0.1max (maximal inspiratory occlusion pressure for the first 100 ms of inspiration). The results of P0.1 and P0.1max were expressed as cm H₂O.

The assessment was performed with the subjects in a sitting position, without trunk support, with their feet flat on the floor. The seat height was adjusted to each participant's lower limb length, measured in a standing position from the lateral line of the knee joint to the ground. The subjects were asked to sit down with 50% of the thigh length resting on the seat and 50% off the seat (measured from the lateral line

of the knee joint to the greater trochanter) with the knees and hips at approximately 90 degrees of flexion, shoulders in a neutral position, and hands resting on the hips. Throughout the measurement procedure, a special clip was placed on their nose to keep the nostrils closed and block the flow of air. Measurements of the mouth occlusion pressure (P0.1) were obtained according to ATS/ERS recommendations (24). The inspiratory valve was closed automatically at random intervals, without the subject knowing, every two to four respiratory cycles. In the case of each participant, we obtained a minimum of 8 P0.1 measurements. An average of those with the smallest difference was calculated using a computer program and then used for analysis. The predicted values in the respiratory drive test depended on the patient's age, sex, height, weight and race (24).

Dyspnea assessment

Dyspnea was measured using the modified 0–10 category-ratio Borg scale. The Modified Borg Dyspnea Scale a scoring system whereby patients can rate their breathing difficulties on a scale of 0 (breathing causes no difficulty at all) to 10 (breathing difficulty is maximal) (25,26).

Cortisol level

Serum cortisol levels were determined with the use of Cobas 8000 (Roche Diagnostics, Indianapolis, IN, USA) analyzer together with immunochemistry module e 801 (Roche Diagnostics, Indianapolis, IN, USA) by electrochemiluminescence immunoassay (ECLIA). The results were expressed as nmol/l. The highest physiological concentrations of cortisol are reached in the morning and maintained up to three hours after waking up. Therefore, within the framework of the study, the subjects' blood was taken at about 7:00 a.m., on an empty stomach (at least eight hours without any food and drinks), immediately after they woke up.

Oxygen saturation

Oxygen saturation was measured using a portable MightySat® Rx Fingertip Pulse Oximeter (Masimo Corporation, Irvine, CA, USA) on a daily basis, until discharge from the hospital.

Statistical methods

In the case of continuous variables, both expressed as means with standard deviations and medians, the

significance of the differences between the groups was calculated by means of the Mann-Whitney U test. Categorical variables were analyzed with the chi-square test.

Results

The number of people potentially eligible for the study, i.e. adults hospitalized due to asthma exacerbation, was 73. Since no patient refused to be examined by a doctor from the research team, the total number of asthmatics examined for eligibility amounted to 73. Eligibility was confirmed in all the patients and 73 participants were randomized. During the follow-up, one patient failed to complete the personal questionnaire and another one failed to take the re-test of the respiratory drive. Both patients were from the control group (Figure 1). None of the other patients enrolled in the study resigned for other reasons until the end of the follow-up. The missing data concerned 8 participants from the experimental group and 7 participants from the control group. The participants whose data were not used for the final analysis did not differ from those who remained in the study in terms of their baseline characteristics.

The analyzed groups did not differ significantly at the beginning of the study in any of the most important characteristics (Table 1). The characteristics of asthma exacerbations being the indication for current hospitalization in both groups were similar, with no statistically significant differences between the groups (Table 2).

The analysis of changes in the functional respiratory parameters during the hospitalization period under interventions showed a decrease in P0.1 only in the experimental group ($p = 0.004$) (Figure 2). The level of P0.1max increased only in the experimental group ($p = 0.041$) (Figure 3). The cortisol level decreased significantly in both groups ($p = 0.001$) (Figure 4).

The study groups did not differ significantly in terms of the analyzed variables at the beginning of hospitalization (Table 3). At the end of hospitalization, only the difference in the levels of P0.1max between the groups was statistically significant, which was due to an increase in the levels P0.1max in the experimental group during hospitalization. In this group, after the analyzed intervention, this variable was significantly higher than in the control group (Table 3).

Discussion

The objective of this study was to assess whether music therapy, as a complementary treatment with pulmonary

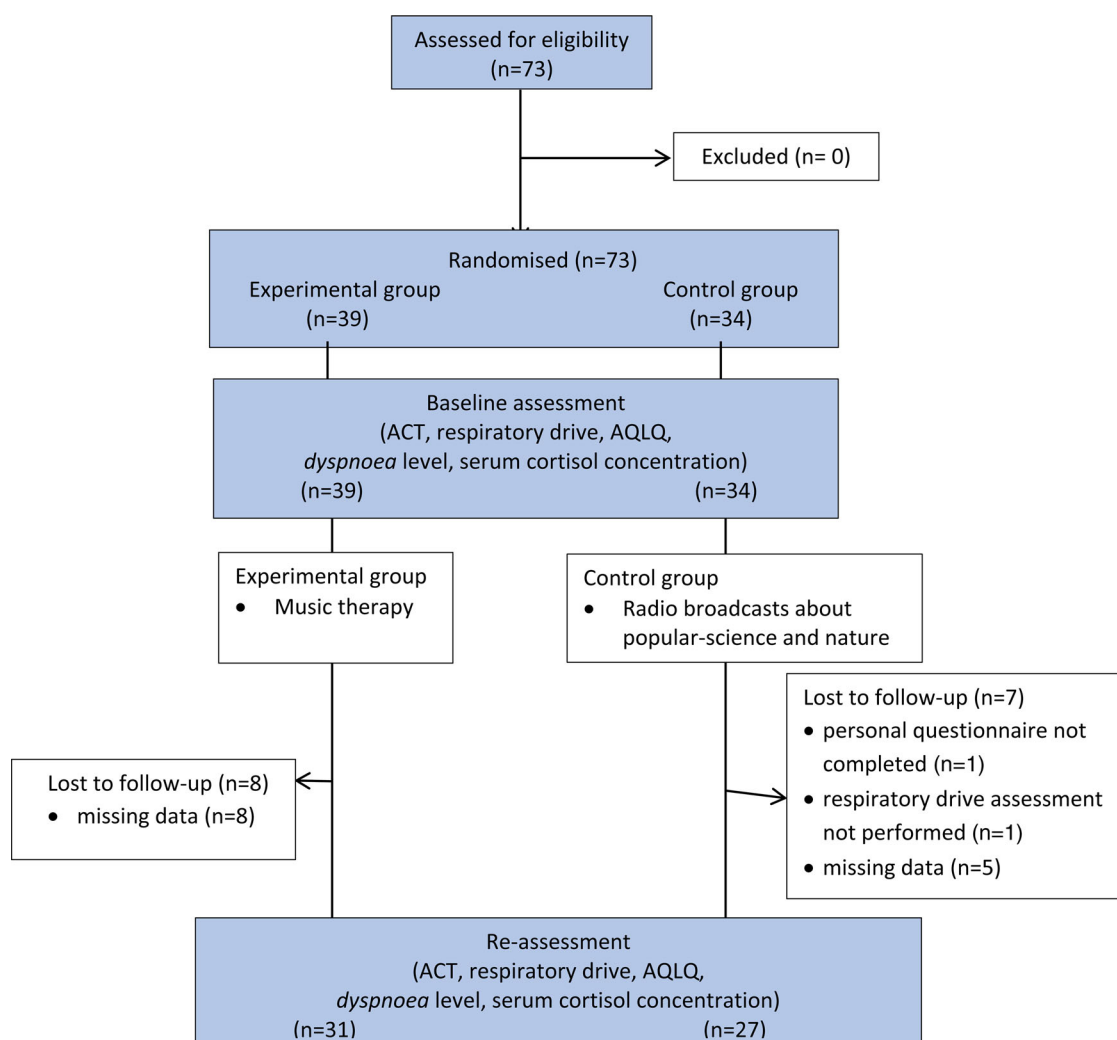


Figure 1. Design and flow of participants through the trial.

Table 1. Characteristics of the groups.

	Experimental group <i>n</i> = 31	Control group <i>n</i> = 27	<i>p</i>
Sex			0.745
- Male, <i>n</i> (%)	8 (25.81)	8 (29.63)	
- Female, <i>n</i> (%)	23 (74.19)	19 (70.37)	
Age [years]	64.00 (15.13)*	58.00 (14.45)*	0.543
BMI [kg/m ²]	27.90 (6.34)*	26.50 (5.74)*	0.413
Place of residence			0.093
- City, <i>n</i> (%)	22 (70.97)	24 (88.89)	
- Village, <i>n</i> (%)	9 (29.03)	3 (11.11)	
Smoking status			0.305
- Active smoker, <i>n</i> (%)	1 (3.23)	3 (11.11)	
- Ex-smoker, <i>n</i> (%)	14 (45.16)	8 (29.63)	
- Nonsmoker, <i>n</i> (%)	16 (51.61)	16 (59.26)	
Type of asthma			0.635
- Allergic, <i>n</i> (%)	13 (41.94)	13 (48.15)	
- Non-allergic, <i>n</i> (%)	18 (58.06)	14 (51.85)	
Time from the first symptoms of asthma [years]	20.00 (12.96)*	16.00 (14.01)*	0.325
Time from the diagnosis of asthma [years]	20.00 (13.19)*	15.00 (13.65)*	0.472
Previous oral corticosteroid use, <i>n</i> (%)	19 (61.29)	14 (51.85)	0.469

*Results expressed as median (SD); BMI – body mass index.

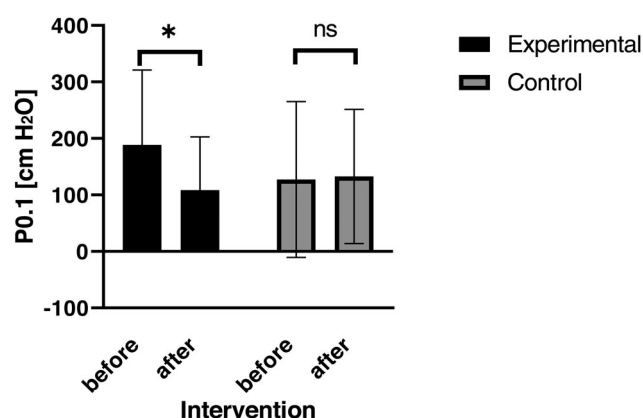
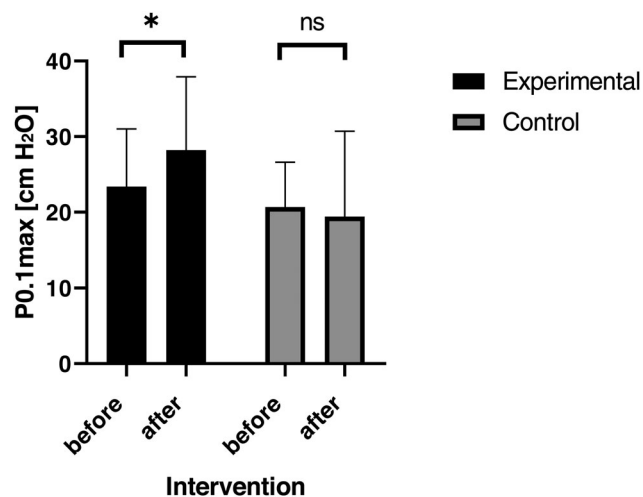
rehabilitation, could influence such parameters as occlusion pressure, cortisol level, psychological state and asthma control in patients with asthma exacerbation.

Airway occlusion pressure (P0.1) is the drop in the airway pressure 100 ms after the onset of inspiration during an end-expiratory occlusion of the airway (27).

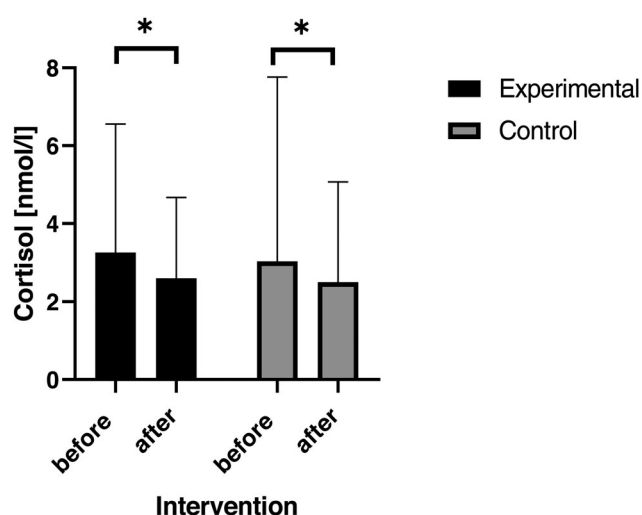
Table 2. Characteristics of the exacerbations.

	Experimental group <i>n</i> = 31	Control group <i>n</i> = 27	<i>p</i>
Severity of asthma exacerbation			0.738
- Mild, <i>n</i> (%)	18 (58.06)	16 (59.26)	
- Moderate, <i>n</i> (%)	12 (38.71)	9 (33.33)	
- Severe, <i>n</i> (%)	1 (3.23)	2 (7.41)	
- Life-threatening, <i>n</i> (%)	0 (0)	0 (0)	
Ventilation rate [/min]	21.00 (2.89)*	22.00 (3.03)*	0.626
Blood oxygen saturation level [%]	95.00 (1.43)*	96.00 (1.60)*	0.750
Average severity of dyspnea [Borg scale score]	3.00 (1.82)*	2.00 (1.80)*	0.495

*Results expressed as median (SD).

**Figure 2.** P0.1 expressed as mean $\pm$ SD (* $p = 0.004$).**Figure 3.** P0.1max expressed as mean $\pm$ SD (* $p = 0.041$).

It is generated against an occluded airway (28) and represents a crude estimation of the central respiratory drive. The P0.1 max parameter also refers to the occlusion pressure measured during inhalation, but under conditions of artificial hyperventilation, i.e. during fast and deep breaths of the person examined (as if after physical effort). The results of other studies revealed that P0.1 values were significantly higher in patients with obstructive pulmonary diseases than in controls and even higher in those subjects who experienced frequent disease exacerbations (29). This is consistent with the results of our own study, which

**Figure 4.** Serum cortisol level expressed as mean $\pm$ SD (* $p < 0.001$).

showed that the initial occlusion pressure values were significantly higher in exacerbated patients with asthma than the norm set for people of a given gender, age and body structure. It is believed that high respiratory drive can generate dyspnea (30) and influence the functioning of the diaphragm. Increased P0.1 values in subjects with chronic respiratory diseases might be caused by the possible differences in respiratory control or in the sensory processing of perceived respiratory discomfort. The mechanisms underlying dyspnea perception in humans involve a complex chain of events that require the cortical integration of several afferent/efferent signals influenced by affective processes (31). Changes in lung mechanics are an important afferent signal in this system. It is possible that the applied treatment supplemented with music therapy in the experimental group resulted in relaxation and improvement of the emotional state and mood of the subjects, which had a more positive influence on the functional aspects of the respiratory system. This is consistent with the results of previous studies, which indicated that music therapy may have a beneficial effect on the functional state of the respiratory system in asthmatic patients (17,32). The

Table 3. Characteristics of the hospitalization.

Days of hospitalization	Experimental group <i>n</i> = 31			Control group <i>n</i> = 27		
	11,19 (5,64)			10,59 (5,51)		
	Before intervention	After intervention	<i>p</i>	Before intervention	After intervention	<i>p</i>
ACT	11,52 (4,77)	12,42 (4,34)	n.s.	11,11 (4,14)	11,96 (4,14)	n.s.
miniAQLQ	3,44 (1,30)	3,90 (1,24)	n.s.	3,43 (1,15)	3,81 (1,25)	n.s.
AQLQ 1	3,02 (1,35)	3,61 (1,28)	n.s.	3,09 (1,14)	3,5 (1,26)	n.s.
AQLQ 2	3,44 (1,60)	3,72 (1,36)	n.s.	3,41 (1,29)	3,77 (1,49)	n.s.
AQLQ 3	3,91 (1,41)	4,31 (1,59)	n.s.	3,97 (1,54)	4,10 (1,63)	n.s.
AQLQ 4	3,62 (1,88)	4,23 (1,60)	n.s.	3,51 (1,72)	3,78 (1,75)	n.s.
P0.1 [cmH ₂ O]	198,96 (132,52)	141,33 (94,00)	0.004	170,79 (137,91)	165,37 (118,68)	n.s.
P0.1max [cmH ₂ O]	23,38 (7,64)	26,28 (9,70)	0.041	20,68 (5,93)	22,35 (11,31)	n.s.
Cortisol [nmol/l]	4,26 (3,30)	2,72 (2,07)	0.001	5,08 (4,73)	3,01 (2,57)	0.001

ACT – Asthma control test; AQLQ – Asthma Quality of Life Questionnaire; P0.1 – inspiratory occlusion pressure for the first 100 ms of inspiration, P0.1max – maximal inspiratory occlusion pressure for the first 100 ms of inspiration. Results expressed as mean (SD), n.s., non-significant.

significant decrease in the P0.1 value suggests easier air flow through the bronchial tree and reduced respiratory effort. This relation has also been confirmed by other authors who demonstrated a correlation between P0.1 and the inspiratory effort, providing evidence that – in patients under assisted mechanical ventilation – the P0.1 values might help to detect potentially excessive levels of inspiratory effort (33).

In addition to the occlusion pressure, other variables frequently used to assess the strength of the respiratory muscles are: maximal inspiratory and expiratory pressures (MIP and MEP, respectively). Inspiratory muscle strength is evaluated to establish inspiratory muscle weakness as a cause of the symptoms or to predict prognosis (or the need for noninvasive ventilation). MIP has also frequently been used as an outcome measure for trials of inspiratory muscle training including those in asthmatics (34,35). However, assessment of respiratory muscle strength requires both a great cooperation from the patient, as well as quantification of the reproducibility of the measurements, essential to support any clinical interpretation of the results (34). The patient is required to exhale to residual volume and then inspire against a closed glottis, without air leakage. Therefore, the assessment of maximum respiratory pressures is usually only performed in stable patients (35). In this study looking at patients with asthma exacerbations, this assessment was not used as it was considered to be potentially too difficult to perform correctly.

Dyspnea perception during exercise is influenced by many interacting variables, such as asthma severity and phenotype, bronchoconstriction, dynamic hyperinflation, respiratory drive and psychological factors (36). Our study showed a significant increase in the maximal occlusion pressure only in the experimental group. The value of this variable indicates the ability to generate stronger breaths under conditions of

increased and accelerated breathing. This is particularly important in everyday situations, where physical effort increases the oxygen demand and causes a change in the breathing pattern of asthmatics (36). Such a change was not visible in the control group, despite the fact that both groups had significantly lowered values of cortisol, or the so-called stress hormone, upon discharge from the hospital. This phenomenon might be explained by the intensive treatment applied during hospitalization. The inhibition of endogenous cortisol secretion is an important marker of systemic steroid activity. Although systemic and inhaled corticosteroids used for the management of persistent asthma can suppress adrenal cortisol secretion (37), in another study the influence of systemic methylprednisolone on cortisol levels during exacerbation was insignificant (38). As a result, it can be assumed that decreased plasma cortisol levels can be the result of not only the pharmacologically induced suppression of the adrenal cortex, but also a decrease in the level of stress and non-pharmacological interventions.

Recent studies have emphasized that asthma pathophysiology and therapeutic response amongst patients exposed to chronic stress may be influenced by biological changes such as: expression of immunologic genes, changes in expression of the beta-adrenergic (B2AR) and the glucocorticoid receptor (*GR-α*) genes, cytokine regulation, and alterations in the hypothalamic-pituitary axis and cortisol levels (39–41). Other findings indicated that depressed asthmatic patients are at a particular risk of hypercortisolism under conditions of stress (42). Apart from the abovementioned glucocorticosteroid intake, there are other possible causes of decreased cortisol serum concentration levels in both groups from our study. On the one hand, this may be due to the fact that both groups had an average score of the AQOL subscale – emotional function (3.9/7). Therefore, the asthmatics examined had no

strong depressive tendencies. On the other hand, the results of the asthma control test indicate a very poor control of the disease in the study population. Such a poor disease control correlates with the frequency of hospitalization, which may cause adaptation of this group of patients to hospitalization and hence reduce the related stress (43). Given, in particular, the fact that the patients reported a large number of exacerbations requiring in-patient treatment over the past year, it might have been less stressful for them than for those who are rarely hospitalized. A study undertaken amongst British asthmatics showed that patients reporting frequent hospitalizations tended to value professionals working there (44). At the same time, patients admitted to hospital reported high levels of psychosocial problems and life events, but tended to make few connections between these and their asthma attacks or their ability to manage their asthma (44). Similarly to our own study, such a conclusion indicates a strong and frequently observed influence of the psyche on the symptoms and treatment of asthma (45). As healthcare utilization is higher amongst asthmatic patients with psychological distress and low self-efficacy, it further emphasizes the necessity to introduce complementary forms of treatment, which can be easily implemented in hospital settings.

A systematic review on the effectiveness of music therapy in the treatment of asthma conducted in 2014 showed the paucity, heterogeneity, and significant methodological limitations of the available studies, make it impossible to recommend music therapy as a treatment modality in asthma on a wider scale (13). However, our study and the recently published high-quality pediatric studies reveal the usefulness of music therapy in successfully supporting the management of pediatric asthma, as a child-friendly and low-risk intervention (32), which also has the potential to make children feel comfortable during inhalation therapy (46).

Our study is not free from limitations. Firstly, during the performance of the ACT, account is taken of the course of the disease over the preceding 4 weeks. As a result, using this tool to assess the impact of the analyzed intervention of shorter duration on the degree of asthma control may not reflect the actual improvement in this respect, as the time between the consecutive measurements is shorter. Secondly, limitations also concern the AQLQ measurements, though to a smaller extent. The assessment of how music therapy influences the level of stress hormone (cortisol) might have been affected by the suppressive effect of steroids on the adrenal cortex, which may make it

difficult to show the differences between the groups in the response to the intervention. The failure to show significant differences in the impact of music therapy on the quality of life may result from the fact that the groups examined were not large enough. At the same time, the duration of music therapy intervention could be longer. Studies by other authors, conducted in out-patient conditions, indicate efficacy of music therapy in patients with a duration of 30 to 60 min for several weeks (18,32,47). However, hospitalization in the conditions of a university hospital results in limited time dedicated to particular therapeutic and diagnostic interventions. At the same time, ensuring an appropriate atmosphere of peace and quiet for a longer period of time would require greater synchronization of the entire staff. Such a therapeutic protocol would need to be checked in terms of its greater effectiveness and applicability.

Moreover, the treatment program included not only pharmacological treatment, but also physiotherapy and music therapy or broadcast listening, which prolonged the subjects' daily contact with the medical staff and could satisfy their need for safety, attention and care. The broadcasts themselves, which dealt with the issues of travel and nature, could also distract the subjects' attention from the dyspnea and illness they were experiencing. At the same time, the patients were not instructed in any way to limit their daily contact with other source of music. However, usually music was not emitted (played) in the ward environment.

Conclusions

The results of this experimental study are an important voice in the discussion on the effectiveness of music therapy as a complementary modality for the treatment of asthma exacerbations in adults. The applied set of relaxation recordings, based on the previously examined musical preferences of this group of patients, proved to be an effective form of therapeutic influence. Passive music therapy, affecting the mental state of patients, seems to improve the efficiency of the respiratory system. The simplicity of its implementation and the low costs make this type of therapy highly accessible, in view of the previously identified demand for relaxation methods in this group of patients.

Declaration of interest

The authors report no proprietary or commercial interest in any product mentioned or concept discussed in this article.

Ethics approval

The study was approved by the Jagiellonian University Ethics Committee (Date 28/04/2016, No.122.6120. 75.2016). The study was performed in accordance with the ethical standards as laid down in the 1964 Declaration of Helsinki and its later amendments.

Consent to participate

Written informed consent was granted before enrollment from all the participants.

Consent for publication

All authors are responsible for the content, have read and approved the manuscript and gave explicit consent to publish it.

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Data availability

All study data will be available on request.

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Appendix

Methodology of pulmonary rehabilitation

In the case of patients with asthma exacerbation accompanied by excessive production of mucus, the therapy began after inhalation with gentle vibrations delivered to the chest walls. Depending on each patient's subjective feeling, the vibration therapy was performed using a special vest in a sitting position or the Medex 3D device in a modified drainage position while lying on the sides. The patients' position depended on the location of their auscultatory changes [1]. The method of generating positive expiratory pressure [2] was selected individually for each patient. The most common technique included pursed lips breathing (PLB) by blowing into a water-filled bottle in a position reducing breathlessness. Devices such as Flutter® and Acapella® were also used [3]. A suitable airway-secretion evacuation technique, e.g. directed cough, forced expiratory technique, active cycle of breathing, and autogenic drainage [4], was selected individually for each patient. The re-education of the respiratory pattern was preceded by its assessment. Attention was paid to the correct number of breaths (10-14 per minute) taken with a proper breath volume (tidal volume), with rhythmic movement of the diaphragm set in an optimal position for its attachments [5]. The physiotherapist manually assisted the subjects in generating the respiratory rhythm and the low-rib breathing pattern. Patients who developed dyspnoea were placed in a position to facilitate breathing, such as:

- resting the feet flat on the floor, leaning the chest slightly forward, resting the elbows on the knees or resting the chin on the hands, relaxing the neck and shoulder muscles;
- Resting the feet flat on the floor, leaning the chest slightly forward, resting the arms on a table, resting the head on the forearms or on a pillow;
- The elbows or hands placed on a piece of furniture, just below the shoulder height, relaxing the neck and resting the head on the forearms, relaxing the shoulders [6].

To facilitate breathing in the case of patients experiencing *dyspnoea* at night, horizontal positions were recommended, including:

- lying on the side with a pillow between the legs and the head in a higher position resting on a pillow, keeping the back straight;
- lying on the back with the head elevated and the knees bent, with a pillow under the knees [7].

Then, breathing exercises were performed (each repeated four times) with a view to deepening the inhale and extending the exhale. Exercises performed in a sitting position included breathing in through the nose (“smelling the flower”) and breathing out calmly; breathing in through the nose and saying the letter ‘R’ while breathing out. Other breathing exercises involved movement of the upper and lower limbs (each repeated ten times). Some were performed in a standing position – with each exercise accompanied by a deep breath in taken through the nose and a breath out through the mouth – and included breaststroke movements; reverse circular movements of the shoulders; abduction of the arm to the side, with the hand resting on the opposite shoulder, a fast walk in place for 2 minutes (repeated twice). Others required a sitting position, for example alternate raising of the knees to the hands placed 10 cm above the knees; alternate straightening of the knees, sitting down and rising from the chair [8]. For patients with *dyspnoea*, exercises were used only after reducing the symptoms. Saturation and pulse were monitored during the exercises [9]. A single rehabilitation session lasted about 35-40 minutes and was performed 5 times a week [10].

Methodology of music therapy

The methodology used in the music therapy was based on the data available in the literature [11]. The pieces of music were selected on the basis of the results from the previous study which examined the musical preferences of 80 asthmatic patients [12]. In that study, the patients assessed

a selection of 24 recordings of relaxing music, previously prepared by a music therapist. A compilation was created by selecting 10 recordings with the highest rating (Appendix table 1). It was played to the patients after the rehabilitation was completed every day throughout their hospitalisation. The music therapy took part in the patients' rooms, with the subjects lying on their beds and listening to the music from their own devices (mp3 players). The co-users and medical staff were asked to remain silent during the session.

Appendix table 1. Musical compositions used in music therapy.

Title	Performer/ Album;
Country Waltz	Banda Sonora; BS The Straight Story;
Comptine d'Un Autre Été	Yann Tiersen; Amelie
Farewell for piano	Zbigniew Preisner; Preisner, 10 Easy Pieces for Piano
No 3 Andante moderato	Jean Doyen; Pavane The Music of Gabriel Faure
Pavane pour orchestra	Orchestre De Chambre De Lausanne with Armin Jordan, Jean Hubeau; Pavane The Music of Gabriel Faure
Pelleas et Melisande – Sicilienne	Orchestre De La Suisse Romande with Armin Jordan, Robert Thullier; Pavane The Music of Gabriel Faure
The water	Relax; Kojace Klimaty
Serenade; Gran Partita- 3rd Movement	Linos Ensemble; Classic Composers
Chopin Nocturno En F menor Op55	Jean Doyen; Pavane The Music of Gabriel Faure
Meditation for piano	Zbigniew Preisner; Preisner, 10 Easy Pieces for Piano

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