Effect of progressive muscle relaxation in adolescent female bronchial asthma patients: A randomized, double-blind, controlled study

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Abstract

Objective: The aim of this study is to examine the efficacy of progressive muscle relaxation (PMR) on change in blood pressure, lung parameters and heart rate in female adolescent asthmatics.

Method: In a prospective, randomized, double-blind, controlled study, adolescent female asthmatics ($n=31$) were tested to find out how the systolic blood pressure (SBP), forced expiratory volume in the first second (FEV\textsubscript{1}), peak expiratory flow (PEF) and heart rate change after PMR. The control group (CG; $n=30$) received a placebo intervention.

Results: A significant reduction in SBP and a significant increase in the FEV\textsubscript{1} and PEF were observed after PMR. The heart rate showed a significant increase in the coefficient of variation (CV), root-mean-square of successive differences (RMSSD) and at the high frequency (HF) range, in addition to a significant reduction at the low and middle frequency (LF and MF, respectively) ranges. Conclusion: PMR appears to be effective in improvement of blood pressure, lung parameter and heart rate in adolescent female asthmatics.

Keywords: Bronchial asthma; Progressive muscle relaxation; Heart rate; Lung parameter

Introduction

Heart rate and respiration are governed by the regulation of the autonomic nervous system [1]. Parasympathetic nerve impulses lead to a slower heart rate, more regular respiration and general relaxation [1,2]. Asthma patients experience shortness of breath and a sensation of asphyxiation due to bronchial constriction, with simultaneously enhanced vagal drive, leading to an imbalance of sympathetic/parasympathetic influences [2]. Various emotional states and stress increase oscillatory resistance [2]. Stress can also exacerbate significant increase in the FEV\textsubscript{1} and PEF were observed after PMR. The heart rate showed a significant increase in the coefficient of variation (CV), root-mean-square of successive differences (RMSSD) and at the high frequency (HF) range, in addition to a significant reduction at the low and middle frequency (LF and MF, respectively) ranges. Conclusion: PMR appears to be effective in improvement of blood pressure, lung parameter and heart rate in adolescent female asthmatics. © 2005 Elsevier Inc. All rights reserved.
has, in the literature, resulted in the greatest effects on behavioural and self-report measures of relaxation [9]. The procedure consists of having patients sit comfortably in a quiet room, tense a group of muscles, such as those in the right arm, hold the contraction for about eight seconds, and then relax it for about 30 seconds while breathing out. After a short rest, this sequence is repeated with another set of muscles [9]. Through repetitive practice, the patients learn to recognize the associated feelings of a tensed muscle and completely relaxed muscle [9]. The extent of relaxation experienced by asthma sufferers can be depicted through the measurement of systolic blood pressure (SBP), lung parameter and heart rate variability (cf. Refs. [1–4,13–18]).

There have been hints of the effectiveness of relaxation in asthma patients for a considerable time [19–24]. The review by Huntley et al. [25] showed significant effects of PMR or mental and muscular relaxation therapy in asthma patients in two out of five studies. Ritz [26] analysed several studies on this topic in adults, and McQuaid and Nassau [27] in children. They concluded that relaxation training may contribute to the standard treatment of asthma for some individuals [26]. However, owing to the inherent problems of conducting such trials, there is still a lack of evidence for the efficacy of relaxation therapies in the management of asthma [25,27].

The aim of this study was, therefore, to examine the efficacy of PMR on changes in SBP, lung parameter and heart rate variability in female adolescent asthma patients in a randomized, double-blind, controlled trial.

Method

Participants

Female adolescents with a history of mild or moderate bronchial asthma were recruited through advertisements in churches, doctors’ practices and schools. Eighty-four participants, all natives of Bavaria, agreed to take part in the study (Fig. 1). A general medical history was taken at the time of the first telephone contact. Sociodemographic data from adolescents from the same ethnic group and a similar degree of severity of asthma were compared. In our opinion, these sociodemographic data were adequate for this age group (Table 1).

The criteria for exclusion were severe bronchial asthma, use of medication other than common asthma medication during the previous 4 weeks, psychosis, severe anxiety and/or depression, substance abuse, the current use of psychotropic medication (cf. Refs. [28,29]) or psychotherapy, as well as smoking and hypertension. Common antiasthma agents, e.g., beta-2 agonists such as salbutamol, may not influence heart rate variability [30]. However, there are studies that have shown the opposite [31].

Design

Participants were next invited to participate in face-to-face interviews. The Structured Clinical Interview (SCID I and II) was then carried out for each participant, to exclude diagnosable psychiatric disorder. The participants then underwent a physical and laboratory examination.

The necessary sample size was calculated for a Type I error of 5% ($z_1=1.96$) and a power analysis of 80% ($z_2=0.842$), based on the mean values ($m_1=25.7$ and $m_2=22.0$) and standard deviations ($s_1=7.9$ and $s_2=7.0$) for the root-mean-square of successive differences (RMSSD; see below), which were obtained from a small pilot study. The formula is $n$(per group)=$[(z_1+z_2)^2(s_1^2+s_2^2)]/(m_1−m_2)^2$ [32]. This resulted in a group size of $n=64$ patients: 32 of them were chosen for the PMR group (PMR-G) and 32 for the control group (CG), using randomized numbers generated by an Excel table (Fig. 1). The clinic patients’ administrative office

<table>
<thead>
<tr>
<th>Table 1</th>
<th>Sociodemographic data at time of randomization</th>
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<tbody>
<tr>
<td></td>
<td>Age (years)$^a$</td>
</tr>
<tr>
<td>PMR-G ($n=31$)</td>
<td>19.0±2.5</td>
</tr>
<tr>
<td>CG ($n=30$)</td>
<td>18.5±3.0</td>
</tr>
</tbody>
</table>

$^a$ Mean values±S.D.
conducted the randomization procedure confidentially. After a complete description of the study to the participants, written informed consent was obtained. It was explained to both blinded patient groups that simple relaxation techniques, based on physical exercises, were to be investigated with regard to a possible effect on their asthma symptoms. It was stressed that this was very important for asthma research. No reimbursement was provided for participating in the study.

All participants participated in PMR or sham training (see below) and were tested in the morning (8:00 or 9:00 a.m.) under controlled room temperature and light conditions. Participants were instructed not to eat or drink (only water was allowed) and to abstain from sport, alcohol and caffeine during the 24-h period preceding the experiment, so that all the test participants would have practically the same vegetative status at the start. If the functions of the autonomic nervous system were to have been seriously influenced prior to the study, it might not have been possible to generalize from the results.

After the patients had sat down comfortably in a half-lying position on a chair and three electrodes had been placed on them for conduction to the extremities, they had to wait quietly for a 10-min period. Afterwards, they were told not to speak, but just to lie quietly and to continue to breathe evenly. While this was happening, the first measurement at rest was recorded over a 5-min period. The measurement was followed by a 25-min exercise. The PMR procedure consisted of two steps. First, the participants deliberately applied tension to certain muscle groups, and then they stopped the tension and focused on how the muscles relaxed as the tension flowed away. The sequence was following: right foot, right lower leg and foot, entire right leg, left foot, left lower leg and foot, entire left leg, right hand, right forearm and hand, entire right arm, left hand, left forearm and hand, entire left arm, abdomen, chest, neck and shoulders, face. Three participants were left handed and began with their left foot. We took care to ensure that the relaxation exercises were the only content of the session.

A procedure involving common movement with the extremities was carried out in the CG as a placebo intervention. The order and duration of individual exercises were standardized. No cues were given regarding momentary muscle tension or mental relaxation. We took care to ensure that the structured exercises were the only content of the session.

Both the PMR and the placebo intervention were limited to a single session. After the exercise period, the second 5-min measurement was carried out.

**Equipment and measures**

The groups were compared by means of blood pressure and lung parameter measurement and through ECG recording by measuring the autonomous heart rate parameter. All measurements were arranged by blinded medical/technical personnel.

The SBP (mm Hg) was tested automatically (Hellige ECB 561).

Peak expiratory flow (PEF, l/min) and forced expiratory volume in the first second (FEV1, l) were measured with an electronic pocket spirometer (Vitalograph 2120). The instrument incorporated diary facilities, with a microcomputer display for questions preprogrammed by the staff.

The measurement of heart rate variability took place with the Pro Sci Card computer programe. A trend quotient was formed from the relationship of the average of the first 40 to the average of the last 40 measured \( R−R \) intervals and had a normal range between 0.94 and 1.06. Only those measurements for which the number of the artifacts and extra systoles was under 3% were valid. The heart frequency (HR) at rest (bpm: beats/minute), the coefficient of variation (CV; %) and the RMSSD were calculated as:

\[
\text{RMSSD} = \sqrt{\frac{\sum (R - R')^2}{n}}
\]

where \( (R - R') \), is the length of the \( i \)th \( R−R \) interval in ms, \( n \) is the number of the \( R−R \) intervals at rest in ms, and the frequency bands of spectral analysis with the ranges low (LF: 0.01–0.05 Hz), middle (MF: 0.05–0.15 Hz) and high frequency (HF: 0.15–0.50 Hz). The HR was entered as a mean value of the measurement over a 5-min rest period. The CV under conditions of rest was calculated from 150 \( R−R \) intervals. Spectral analysis of the sequence of the \( R−R \) intervals over a 5-min period took place using the Fast Fourier Transformation (FFT) procedure, with eight series of data with 256 and 128 overlapping points each (total 1152).

Three participants (Fig. 1) who did not appear for the evaluation dropped out of the study, and their data were not further analysed. Data from 61 participants were finally evaluated.

During the course of the trial, the intermediate results were not analysed. The data were fed independently to the computer twice and automatically checked for deviations; 3.1% of the entries were identified as erroneous and adjusted. The study was concluded according to plan.

**Statistical evaluation**

All data from the study were sent to an independent statistics company (MoRedata, Giessen, Germany). There, the blinding was broken and the calculations carried out. The statistical program SPSS, Version 11 (SPSS, Chicago, IL, USA) was used. Because the data were not normally distributed, the Mann–Whitney \( U \) test was performed for comparison of continuous variables. We employed difference in change between the two groups (DI) with its 95% confidence intervals (95% CI) and probability (\( P \)) for reporting the treatment results [32].
**Ethical considerations**

The study was planned and conducted in accordance with the Declaration of Helsinki and ethical laws pertaining to the medical professions, and its design was approved in 2004 by the clinic’s “Ethikkommission” (the German equivalent of the Committee on Human Subjects). The study was conducted in 2004 independently of any institutional influence and was not funded.

**Results**

No major differences were found in the sociodemographic data (Table 1). Salbutamol, 16 mg daily or 1–3 inhalations daily, and terbutaline, 1 inhalation, if required, were used as antiasthma medications by 11 probands from the PMR group and 9 probands from the CG in the last 4 weeks prior to study entry.

Table 2 shows the initial and final measurements of the blood pressure, lung and heart parameters, as well as the statistical analysis of the difference in the changes between the PMR-G and the CG.

Among this study population, the SBP was significantly reduced after PMR (Table 2). The FEV$_1$ and PEF rose significantly (Table 2). Heart rate fell after relaxation (Table 2). The CV and RMSSD values, as well as the HF range in the spectral analysis, were higher than before relaxation in terms of increased parasympathetic activity (Table 2). Average LF and MF values decreased after relaxation (Table 2), consistent with a possible reduction in sympathetic activity.

**Discussion**

The two groups were comparable regarding their sociodemographic data and initial values of tested variables. PMR was significantly more effective than placebo intervention on all parameters tested when compared to the CG. This supports the results of earlier trials that indicated that participants with bronchial asthma could benefit from relaxation techniques [8–12,18–27]. It is interesting that the measures changed in the same direction for both the PMR-G and the CG. This would suggest that the peaceful atmosphere and even exercises also led to relaxation and improvement in the parameters under investigation in the CG, although nowhere near as much as the PMR.

Our study confirmed earlier study findings showing an enhancing effect of relaxation training on lung parameters [11,12]. Lung function after PMR was significantly improved, although airway hyperactivity in asthma patients is able to contribute additional pathways for increases in resistance in response to therapy (cf. Ref. [2]).

A significant decline in heart rate was apparent in the PMR group following 10 min of relaxation. The data for asthma patients showed an increase in RMSSD, CV and HF values. This speaks for enhanced parasympathetic control, e.g., as an effect of relaxation. Average LF and MF values decrease significantly after relaxation, which is consistent with a possible reduction in sympathetic activity. Lehrer et al. [33] found that heart rate variability biofeedback has strong influences on pulmonary function. Because the parasympathetic nervous system contributes to the control of respiration through the autonomic nervous system, asthma patients can indirectly influence relaxation through PMR. Relaxation training with added resistive loads may help patients to detect an increase in air flow obstruction due to asthma before it becomes severe [13]. The positive influence of stress management has also been demonstrated in various stressful situations or with other mentally influenced diseases [20,33–36]. The possibility we have indicated needs to be validated in a long-term observation study.

Our findings provide evidence that female adolescent bronchial asthma patients may benefit from PMR. Results from this study and from previous studies provide supportive evidence for the usefulness of relaxation in bronchial asthma. PMR may be an effective, inexpensive intervention
for improving bronchial asthma and its accompanying adverse physiological effects. It is a potentially useful intervention because it is fairly easy to learn and to use on one’s own. Our results have implications for clinical practice. These findings could help adolescents by offering them an additional alternative for asthma management that is not based on medication but on their own resources. However, this study had several methodological limitations. First, the sample size was relatively small. Second, the survey consisted only of female participants suffering from mild or moderate asthma. The reason for this was that our research group focuses almost exclusively on women’s and female adolescents’ mental health. Whether these PMR treatment results could also be seen in male adolescents suffering from bronchial asthma or adolescents with severe asthma is unknown. Generalizability is also limited to patients with asthma in late adolescence. In general, we could assume that the good results are related, at least partially, to our particular participant population. Third, the effects in this study are acute and measured after an active intervention. There is no evidence yet that PMR will have similar effects during the exacerbation of asthma. There is no evidence either that the effects of the intervention are lasting.

Additional research and, in particular, studies containing more participants, participants experiencing exacerbation of asthma and also male adolescent asthmatics are needed to see if these results can be replicated.

References


