*EFFECTS OF RELAXATION TRAINING ON PULMONARY
MECHANICS IN CHILDREN WITH ASTHMA¹*

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An experiment, designed to overcome shortcomings in previous work, was conducted to investigate the potential symptomatic benefits of relaxation training in the treatment of asthma in children. Fourteen chronic, severely asthmatic children received three sessions in which they rested quietly, followed by five sessions of relaxation training, and finally three sessions of relaxing as trained previously. Pulmonary function was assessed, in a manner far more definitive than in previous studies, before and after each session, and three additional times at 30-minute intervals thereafter. Tension in the frontales muscles, heart and respiration rates, and skin temperature and conductance were also monitored. Heart rate and to some extent muscle tension results tended to confirm the attainment of relaxed states. However, the lung function results failed to substantiate the previous, preliminary findings of a clinically meaningful change in pulmonary function following relaxation. The status of relaxation in the treatment of asthma was discussed.

DESCRIPTORS: relaxation, asthma, behavioral medicine, pulmonary physiology, heart rate, EMG, children

For decades it has been commonplace for physicians and others dealing with asthmatic patients to ask them to try to relax at the onset of and/or during asthma attacks. Although no empirical support was available, patient report and clinical experience both suggested that such a procedure might help to ameliorate wheezing. Alexander, Miklich, and Hershkoff (1972) provided the first experimental evidence bearing on this assumption. They found that 20 min of modified progressive relaxation training resulted in a statistically significant, 11% improvement in peak expiratory flow rate (a measure related to the resistance to air flow in the lung) immediately following relaxation in a group of severe, chronic asthmatic children, compared to no change in a matched group of children who sim-

ply sat quietly for an identical length of time. Alexander (1972) replicated this result in a controlled experiment with a new but comparable sample of severely asthmatic children in which a 10% improvement in peak flow rate was found. Similar results in children have also been reported by Davis, Saunders, Creer, and Chai (1973), in a significantly flawed study, which again used the peak flow, and by Tal and Miklich (1976) who employed the 1-sec forced expiratory volume, a lung function measure similar to peak expiratory flow rate, but slightly less variable.

These preliminary results, though highly encouraging, raised several problems. First, the amount of change, averaging no more than 10% increase in flow rate across studies, was quite modest. Increases substantially in excess of this amount would have to be demonstrated before clinical as opposed to simple statistical significance could be claimed. In the experiments to date, the improvements found in pulmonary function would not be subjectively detectable by patients, nor do they even approach the extent of lung function or subjective benefit obtainable

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from the most commonly employed pharmacological alternatives for symptomatic relief (*e.g.*, inhaled sympathomimetics). Second, the forced expiratory flow rate measures that were employed are highly dependent on patient physical effort during the measurement; and further, they are somewhat unreliable measures reflecting predominantly large airways dynamics. Asthma is a disorder of variable, intermittent, and reversible airways obstruction in which the lung pathology occurs in at least two different loci: (a) the central, or larger, airways and (b) the peripheral, or smaller, airways including the alveoli (McFadden and Ingram, 1976). Before any obtained effects of relaxation on lung function could be confidently accepted, more definitive and complete measurement of pulmonary physiology would have to be employed, involving measures of both large and small airways, and in particular, measures that are much less effort dependent. Third, the obtained effects had been assessed immediately following relaxation only. In order for a potential symptomatic therapy to be considered clinically worthwhile, it would be necessary to demonstrate that a beneficial influence was capable of sustaining its effect for an extended period subsequent to the actual time spent relaxing.

The present experiment represented an attempt to investigate definitively the potential *symtomatic* benefits of brief relaxation training on lung function in severely asthmatic children. The study was designed to deal with the shortcomings outlined above in previous experiments.

METHOD

Subjects

Fourteen chronic, severely asthmatic children between the ages of 10 and 15 yr, seven boys and seven girls, all of whom were in residence at the National Asthma Center, served. All evidenced perennial symptoms with demonstrated reversibility, and were under good clinical control with medications. All children were receiving standard asthma therapy (Chai, 1975) consisting of daily theophylline medication (a

bronchodilator) every 6 or 8 hr, and, in the case of nine of the children, corticosteroids every other day.

Procedures

Each child received 11 sessions, divided into three experimental phases. Phase I involved three sessions of simple resting (quiet reading of comic books), in which the effects on pulmonary function of inactivity or resting quietly were assessed as a baseline. Phase II consisted of five sessions of relaxation training, and Phase III was composed of three sessions in which the child relaxed on his or her own as trained in Phase II. Phase III assessed the effects of relaxation on pulmonary function in comparison with the effects of simple resting in Phase I. With the exception of the activity specific to each phase of the experiment (*viz.*, resting, training, or relaxing) all sessions were identical. Each session consisted of a pretest pulmonary functional assessment, followed by a 40-min period in a special sound-attenuated testing room in which the child either rested, was trained, or relaxed on his or her own in the semireclined position of a reclining chair. The 40-min period was divided into a 5-min session baseline (resting with eyes closed), followed by 30 min of either resting, training, or relaxing, and a final 5 min of resting quietly or relaxing. The first posttest of pulmonary function was conducted immediately after the 40-min period in the testing room, followed by three subsequent, similar pulmonary functional assessments at 30-min intervals. In order both to substantiate reversibility of airways obstruction on each day for each child, and to be able to compare any effect of relaxation to that obtainable with the most commonly used symptomatic pharmacological treatment, following posttest 4, two whiffs of nebulized isoproterenol hydrochloride (totalling 250 micrograms) were administered. This was followed by a final posttest after the drug. Each pulmonary functional assessment involved measurement of lung volumes and airway resistance in a whole body plethysmograph, followed by a slow vital capacity,

and two satisfactory forced vital capacity efforts into a spirometer (Bates, Macklem, and Christie, 1971). The pulmonary function measuring devices were interfaced with a computer, which calculated all function scores and provided a standard printout of the values. The spirometric data employed for analysis were always obtained from the best of the two satisfactory forced vital capacity efforts as determined by the pulmonary technician primarily on the basis of the obtained forced expiratory volume in the first second (the higher value of the two indicating the best effort). Additionally a "wheezing score" by auscultation was determined at each testing point. All tests were administered, and judgements made, by a trained pulmonary technician, "blind" to experimental conditions, thus minimizing possible experimenter bias effects by taking testing completely out of the hands of the investigators.

During all Phase I and III sessions, frontales electromyographic (EMG) activity, heart rate (HR), respiratory rate (RR), skin conductance (SC), and digital skin temperature (ST) were monitored. For each measure, standard recording techniques (*cf.* Alexander, White, and Wallace, 1977) were employed.

Sessions were begun either at 8 a.m. or 1 p.m., and each session, including all posttesting, required about 2.5 hr. Any given child was always studied at the same time of day on all occasions, at a maximum frequency of two sessions per week. The starting times for a given session coincided with the time of day when the child was scheduled to receive his or her next regularly prescribed maintenance dosage of oral bronchodilator. That dose was withheld and the study commenced. Hence, the optimal pulmonary functional response attributable to the prior medication had already occurred. Consequently, at the beginning of each session, children were assumed to be on the declining limb of the functional response to the medication taken 6 to 8 hr earlier. This procedure allowed for any beneficial effects of relaxation to be manifested either as an improvement in pulmonary function following relaxation, or as a retarding or reversal

of the natural declining trend in pulmonary functions that was occasioned by the child being 6 to 8 hr away from the last dose of oral bronchodilator. On the one hand, the medication withholding procedure was followed to ensure that pulmonary function was not so close to maximum that no further improvement could be possible. On the other hand, to minimize the risk to children, medication was never withheld (nor was a session conducted) if the pre-session maximum midexpiratory flow rate was less than 40% of the predicted normal value for that child employing the norms provided by Polgar and Promadhat (1971). The latter occurred for less than 10% of scheduled sessions, and in these instances the session was simply cancelled and rescheduled.

Phases I and III of the experiment were identical for all subjects. However, in Phase II eight children were studied individually as described above, while the remaining six children were given group relaxation training for five sessions in two groups of three children per group. Children given group relaxation training (Phase II) did not receive complete pulmonary function testing as described for Phases I and III. During Phase II, spirometry only was obtained on each child before and once immediately after each training session (*i.e.*, simply pre-post assessment with no half-hourly followup for 1.5 hr as was the case for all other sessions). During Phase I, all children read "Archie" comic books. Relaxation training in Phase II was carried out by one trainer throughout the experiment in the following manner. During the first two of the five training sessions, the children were taught the commonly used abbreviated form of progressive relaxation training (Alexander *et al.*, 1972). Subsequently, two sessions of abbreviated autogenic training similar to the method developed by Luthe (1969) were conducted. The fifth training session involved teaching the child how to combine these two methods of relaxation by first going through a progressive relaxation series, and then an autogenic sequence so as to maintain a relaxed state. During Phase III, chil-

dren relaxed on their own following the protocol developed in the final training session of Phase II. This standardized procedure was employed for group as well as for individual training. In all cases during the 20- to 25-min intertesting intervals between lung function assessments for followup testing after each session, children sat comfortably in a quiet lounge area and either read comic books or watched television.

RESULTS

Pulmonary Function Data

The computer printout provided 22 lung volume and pulmonary mechanical values at each assessment. From these, 12 of the most useful, representative, and well accepted measures were selected for analysis: peak expiratory flow rate (PEFR); first second forced expiratory volume (FEV₁); maximum midexpiratory flow rate (MMEF); the time constants on the flow-volume curve at 75%, 50%, and 25% of vital capacity (TC₇₅, TC₅₀, TC₂₅); forced vital capacity (VC); total lung capacity (TLC); functional residual capacity (FRC); residual volume (RV); airway resistance (R_{aw}); and specific airway conductance (SG_{aw}). This selection included commonly employed measures that tend to indicate both large (*e.g.*, PEFR, FEV₁, R_{aw}, and SG_{aw}) and small (*e.g.*, MMEF, TC₂₅, and to some extent FRC) airways dynamics. Additionally, R_{aw}, SG_{aw}, MMEF, TC₂₅, and FRC are essentially independent of patient effort during assessment.

For purposes of analysis, all pulmonary functional data were expressed as percentages of the predicted values for that child, employing the norms available in Polgar and Promadhat (1971). The major experimental question was answered by comparing the results of Phase I (resting) with those of Phase III (relaxing on their own as trained in Phase II). For each variable, a child's resting data were averaged over the three sessions of Phase I, as were his or her relaxation data from Phase III. Group means at the pre-session, four post-session and postdrug testing points were then computed. Before overall

analysis of the data, preliminary analyses similar to those described below (two-way, Groups by Time, rather than one-way, repeated measures ANOVAs) failed to reveal any significant differences attributable to sex of child, mode of training (group *versus* individual), or the presence or absence of steroid medication. Hence, for all subsequent analyses the 14 children were treated as a single group.

Data for each of the 12 pulmonary function variables were analyzed in the following manner. Preliminary paired *t*-tests were performed on pretest data for rest *versus* relaxation, revealing no significant differences between conditions for any variable. Difference scores were then computed for each child for each of the 12 separate pulmonary function measures by subtracting the value of the average response in Phase I (rest) from the corresponding average response obtained during Phase III (relaxation) at each of the testing points: pretest and posttest 1, 2, 3, 4, and 5 (postdrug). These difference scores were then subjected to a one-way repeated measures ANOVA for each variable. Resulting *F* ratios were significant beyond the 0.05 level for PEFR and FEV₁ only. All other *F* ratios failed to reach statistical significance ($P > 0.05$).

The results are represented in Table 1, which displays the data from four of the 12 pulmonary measures analyzed. The PEFR and FEV₁ are highly effort dependent but are the most widely used measures of predominantly large airways dynamics, while SG_{aw} and MMEF represent comparably well accepted, effort independent measures of predominantly large and small airways dynamics, respectively. It can be seen that, in general, there was a tendency for lung function to decline slightly during rest from pretest to the fourth posttest. This is consistent with what would be expected as a result of the procedure of initiating testing on each occasion at a time 6 to 8 hrs after the last administration of oral bronchodilator. During relaxation there was a trend toward maintenance of function at the pretest level. As noted previously, this modest contrast in trends between conditions reached

Table 1

Group mean ($N = 14$) percentage of predicted normal values and associated standard deviations at each testing point for four representative pulmonary function measures during Phases I and III.

Measure	Phase	Pre	Post 1	Post 2	Post 3	Post 4	Post drug
PEFR	I	86.5 $\pm$ 18.3	84.0 $\pm$ 15.6	81.0 $\pm$ 16.0	81.5 $\pm$ 17.7	79.7 $\pm$ 19.4	99.0 $\pm$ 11.9
	III	85.3 $\pm$ 22.0	86.3 $\pm$ 18.9	84.3 $\pm$ 19.1	84.5 $\pm$ 17.6	86.4 $\pm$ 19.0	101.6 $\pm$ 17.7
FEV ₁	I	83.4 $\pm$ 16.1	81.8 $\pm$ 17.3	77.5 $\pm$ 18.1	76.2 $\pm$ 16.7	76.6 $\pm$ 19.5	95.3 $\pm$ 14.8
	III	84.2 $\pm$ 16.2	83.2 $\pm$ 15.8	83.3 $\pm$ 15.1	82.6 $\pm$ 15.0	83.0 $\pm$ 16.0	98.2 $\pm$ 15.0
MMEF	I	51.6 $\pm$ 16.0	50.0 $\pm$ 18.0	46.4 $\pm$ 17.3	43.9 $\pm$ 14.2	47.2 $\pm$ 19.2	71.6 $\pm$ 23.0
	III	50.5 $\pm$ 16.4	48.8 $\pm$ 17.1	48.8 $\pm$ 15.2	48.2 $\pm$ 15.6	48.3 $\pm$ 16.2	71.8 $\pm$ 23.2
SG _{aw}	I	44.6 $\pm$ 17.8	43.9 $\pm$ 17.2	40.6 $\pm$ 15.7	41.5 $\pm$ 16.0	39.4 $\pm$ 16.0	68.0 $\pm$ 15.5
	III	48.0 $\pm$ 17.4	48.7 $\pm$ 16.1	42.9 $\pm$ 14.7	43.7 $\pm$ 12.3	45.7 $\pm$ 13.9	74.5 $\pm$ 19.9

statistical significance only for PEFR and FEV₁. These changes can be compared to the postdrug results. The increases seen following the inhaled drug were dramatic and highly significant statistically ($p < 0.005$) as revealed by individual t -tests. This was the case for all measures in both conditions.

It could be argued that Phase III amounted to a generalization test, inasmuch as the children were attempting to relax as they had been trained previously but without any aid during this phase from a trainer. Furthermore, previous studies had assessed pulmonary function only following a *training* phase. Hence, different results from those just reported might have emerged from Phase II of the present experiment. Because six children were given group training, pretest and posttest 1 PEFR, FEV₁, and MMEF data only were available for all of the 14 children during Phase II. Analysis of group means during the training phase on these three measures revealed no statistically significant increases in functional values from pretest to immediately post relaxation training (posttest 1).

Asthma Related Measures

As with the pulmonary function data there were no differences in wheezing scores between Phases I and III. However, again as before, wheezing scores improved significantly following drug administration in both conditions.

Thus far, all data reported relate to the poten-

tial symptomatic or immediate benefits of relaxation training for asthmatic children. It is altogether possible that regular relaxation training might beneficially effect the long-term clinical status of an asthmatic. Though the experiment was not designed to explore adequately this possibility (a no-treatment group was not included), some relevant data were collected and analyzed. Peak flow measurements were obtained in the morning and evening for all children throughout all phases of the study. As well, the treatment and medication records were available for every child. Because each child began participation in the experiment only after he or she had been carefully evaluated medically, and only after medication requirements (and hence disease manifestation) had become quite stable, it was possible to infer that any changes across phases in overall asthma status indicators might well be due to the relaxation training. Nevertheless, no such evidence emerged. Average morning PEFR, evening PEFR, and the morning-evening difference in PEFRs (a good measure of general clinical control) failed to change, as did the number of hospitalizations and stat treatments (measures sensitive to overall asthma attack frequency) and medication requirements (a very useful measure of general asthma severity).

Other Physiological Measures

As previously described, EMG, HR, RR, SC, and ST were monitored during all Phase I and

III sessions. Evidence of greater pre-post change in some or all of these measures during Phase III in contrast to Phase I could be taken as an additional and relatively independent physiological indication that the children were indeed more relaxed during purposeful relaxation than during simple rest sessions. Data for these measures consisted of the average level for each child for the 2 min before beginning rest or relaxation and the last 2 min of each session. As with the lung function data, it was necessary to determine the comparability of pretesting levels during Phase I and III before the main analyses of these measures. Paired *t*-tests revealed no significant differences at pretest on any variable. Hence, for each measure, further paired *t*-tests were conducted between resting and relaxing on the pre-postsession difference scores. All *t*'s were nonsignificant, with the exception of EMG and HR. Forehead EMG decreased $2.49\mu\nu$ during relaxation compared to $0.06\mu\nu$ during test ($p < 0.06$), and heart rate decreased 5.52 bpm during relaxation compared to 2.01 bpm during rest ($p < 0.05$).

DISCUSSION

In addition to the fact that the children were subjected to standard and well established relaxation training procedures, the heart rate results tend to support the interpretation that they indeed attained a relaxed state during Phase III beyond that induced by simple resting during Phase I or the baseline condition. That the other physiological measures reflecting autonomic nervous system activity failed to exhibit comparable differences between resting and relaxing is not surprising, given that similar failures of autonomic indices to relate consistently to "low arousal" or relaxed states have been reliably demonstrated in other controlled relaxation studies (Alexander and Smith, *in press*). It must be pointed out, however, that the corroborating evidence provided by the EMG and HR results may be confounded. Though these measures were always taken while the subject's eyes were closed

during times of nonactivity, bracketing the period of reading or relaxing, reading during Phase I might have tended to reduce the size of the HR and EMG reduction associated with Phase I relative to Phase III.

The effects of relaxation on pulmonary mechanics obtained in these severely asthmatic youngsters were consistently unremarkable. The only evidence of any relaxation influence was found in the tendency of pulmonary functional levels to maintain their pretest values, rather than to decline gradually over the approximately 2-hr period from the start to finish of each Phase I (rest) session. This trend, where manifested, attained statistical significance only in the case of PEFR and FEV₁. There was absolutely no tendency for functions to increase beyond their baseline levels following relaxation during either Phase III or Phase II. Unfortunately, in contrast to the obtained results, clear indication of the latter would be most desirable in order to support a firm recommendation for the application of relaxation as a clinically worthwhile symptomatic treatment for asthma. Inspection of individual results, as well as the findings for the group as a whole, confirmed that any such evidence of a symptomatic benefit of relaxation failed to materialize. This overall negative impression is bolstered convincingly by the fact that both of the measures in which the maintenance trend reached statistical significance are large airways measures which are also highly effort dependent. Further, the most generally definitive, sensitive, and least effort dependent measure of large airway pulmonary mechanics employed, specific conductance, failed to conform to this trend. Finally, the measures most sensitive to small airways dynamics (MMEF, flow-volume curve analysis, and to some extent FRC and RV) did not manifest similar changes.

Several attempts were made to collect data that would help provide a context in which to interpret any obtained beneficial effects of relaxation as a supplementary treatment in asthma. This, of course, relates to the issue of clinical significance. The inclusion of a commonly used

drug comparison, wheezing scores, and daily PEFR and treatment data are examples of such data. As noted previously, neither the clinical judgement scores nor the daily asthma data indicated any significant changes supportive of the usefulness of relaxation therapy. Further, it must be pointed out that the decreases from pretest levels seen in functional values for PEFR and FEV₁, even at posttest four, are clinically very small. For these two variables, the decline in function that occurred following resting sessions over the entire 90-min period of posttesting reflects less than a 10% decrease relative to pretest values. Not only are changes of these magnitudes of absolutely no clinical significance, they would generally be subjectively undetectable by a patient, requiring a drop of about 25% or more from the pretest levels found in this experiment before the loss of function would be noticed. Hence, it is not feasible to argue that the apparent sustaining effect of relaxation is of real clinical importance. This conclusion is supported strongly by the fact that no functional improvement in excess of pretest levels, attributable to relaxation, was evidenced in either Phase II or III, even though such improvement was clearly physiologically possible. The latter was confirmed by administration of the standard shortacting bronchodilator, nebulized isoproterenol hydrochloride, following posttest 4 during all Phase I and III sessions. Without exception, pulmonary functions subsequent to this pharmacological treatment increased dramatically and significantly to predicted normal levels (*i.e.*, well above pretest values), as demonstrated by the fifth posttest following the drug. Thus, this experiment convincingly reconfirmed the clinical utility of inhaled sympathomimetics.

A point of caution regarding the experimental design used is in order. It was decided to employ a method using subjects as their own controls, rather than an independent control group design. Unless very large sample sizes are used, with random assignment of subjects to groups, it is risky and difficult at best to attempt to match groups or individuals on the basis of asthma

severity and the specific nature of the disease process in particular asthmatics. Had the results of this experiment turned out distinctly positive, it would of course have been possible to argue that repeated resting sessions (possibly involving self-initiated, untrained relaxation) might have produced effects similar to those induced by trained relaxation. However, such was not the case, and hence, arguments intended to counter this contention and to provide convincing support for the design chosen are not necessary.

There would appear to be little in the present results that is supportive of previous preliminary indications of the effectiveness of brief relaxation training as a symptomatic treatment for asthma in severely asthmatic children. Whether or not this conclusion would hold for less severely asthmatic persons regardless of age, or for adult asthmatics of any severity, obviously remains to be tested. However, the prospects would not appear to be encouraging. It can be pointed out that the hypothesis may have been naive in the first place. Relaxation is generally conceived physiologically to involve at least a decrease in sympathetic and adrenergic activity, if not a shift in the parasympathetic direction. Both conditions are distinctly detrimental to asthmatics. Adrenergic agonists form the cornerstone of therapeutics in asthma, usually causing immediate and profound bronchodilation, while cholinergics result in equally profound and rapid bronchoconstriction. Physiological relaxation might even be considered to be counter-indicated in asthma. The fact that "relaxation" of some sort is so often seen as beneficial in terms of the overall clinical picture for many asthmatics simply attests to the as yet incompletely understood complexities of both asthma and relaxation.

The most optimistic appraisal of the status of relaxation as a symptomatic therapy in asthma is that the effect may be very small indeed, if in fact it is reliable at all, even when present at full strength; and that, in any case, it is of little or no clinical significance even if real. This conclusion is consistent with existing data concerning the general lack of direct effect of psychologic vari-

ables on *pulmonary function* in asthma (Alexander, *in press*). It is not at all unlikely that the obtained effects, both in previous investigations and the present study, are due to subtle alterations of patient motivation and effort during measurement, rather than to any true pulmonary mechanical change in the lung. The fact that, of all the variables studied, the only ones to produce even weak evidence in favor of some benefit to asthma from relaxation were the two highly effort dependent, large airways lung dynamics measures (PEFR and FEV₁), and the fact that SG_{aw}, a more definitive and sensitive large airway measure which is not effort dependent, failed to substantiate the spirometric results supports this position.

A similarly pessimistic conclusion regarding the potential long-term benefits of regularly practiced relaxation was reached by the senior author in the review cited earlier (Alexander, *in press*). Studies focusing on this issue (*e.g.*, Davis *et al.*, 1973) have failed to find any long-term positive effects of relaxation training in asthmatic children. The present results are completely consistent with these findings. Similarly discouraging data were reported by Miklich, Renne, Creer, Alexander, Chai, Davis, Huffman, and Danker-Brown (1977) concerning the clinical effectiveness of systematic desensitization therapy (which includes regularly practiced relaxation) to affect significant alteration of lung function in asthmatic children. Nevertheless, both Alexander (1977) and Creer (1978) pointed out that relaxation training when employed as a component of various modes of deconditioning therapeutic strategies can be of clinically significant value in the reduction of fear responses to asthma itself. This is a fairly common aspect of the asthma syndrome (Kinsman, Dahlem, Spector, and Staudenmayer, 1977) which can yield to treatment in an uncomplicated and highly successful manner. It must be emphasized, however, that in these cases it is exclusively the maladaptive anxiety responses, which can indeed interfere profoundly with the life of the asthmatic and the effective

medical treatment of his or her asthma, that are altered, *not* lung function.

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