Effects of Respiratory Muscle Stretch Gymnastics on Children’s Emotional Responses

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Abstract: Respiratory muscle stretch gymnastics (RMSG) are designed to decrease chest wall stiffness, reduce dyspnea at rest and improve the quality of life. The focus of this study was to determine whether a RMSG program affects the psychological state of healthy subjects. A previous study showed that there is a positive correlation between anxiety level and respiratory rate (RR). We hypothesize that RMSG will decrease the RR related to alterations in anxiety or other factors that are associated with the quality of life in healthy children. Forty-four primary school children living in Tokyo participated in the study and were randomly assigned to either gymnastics or control groups. Baseline assessment of both groups included completion of the Questionnaire for Measuring Health-Related Quality of Life in Children (Kid-KINDL) and the State-Trait Anxiety Inventories for Children (STAI-C). RRs were recorded initially and the children in the gymnastics group were instructed on how to perform RMSG. The RR was measured again and the participants completed the state anxiety scale. The gymnastics group was told to perform the gymnastics once a day for one week, whereupon post-testing using the testing protocol used for the baseline measurement was performed again on both groups. RR and anxiety level significantly decreased while Kid-KINDL increased after one week of RMSG in high trait anxiety subjects of the gymnastics group. We suggest that the decrease in RR after RMSG reduces anxiety levels in children, and contributes to an improvement in their Kid-KINDL score.

Key words: respiratory muscle stretch gymnastics, respiratory rates, anxiety, emotion, children

Introduction

Respiratory muscle stretch gymnastics (RMSG) have been proposed as a possible additional form of rehabilitation for patients with chronic obstructive pulmonary disease1). RMSG is designed to decrease chest wall stiffness especially in the chest wall respiratory muscles. It has been suggested that RMSG reduces dyspnea at rest and improves the quality of life2). The

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A mechanism for the reduction in dyspnea may be through a decrease in the respiratory rate (RR) that is caused by matching of the respiratory cycle phases between central command and afferent regulation of the intercostal muscles. A decrease in RR is consistently observed after RMSG, which might be related to the decreased sensation of breathlessness.

Several clinical studies have reported that RMSG effectively reduces patients’ breathlessness. The focus of the present study was to determine whether a RMSG program affects the psychological state of healthy subjects, particularly their level of anxiety. A previous study examined the effect of personality differences on breathing patterns during a mental stress and physical load test and found that individual anxiety levels had an effect on respiratory frequency. There was a positive correlation between anxiety level and RR with highly anxious subjects tending to have a high RR.

Our hypothesis is that RMSG results in a decrease in RR that is related to alterations in anxiety or other factors that are associated with quality of life. In this study, we investigated the effect of RMSG training on quality of life and the association with anxiety levels in healthy children living in Tokyo.

**Methods**

**Subjects**

Forty-four primary school children from Tokyo, Japan, volunteered to participate in the study. They had no history of chronic pulmonary disease and were randomly allocated to either the gymnastics group \((n = 19)\) or the control group \((n = 25)\). Nine children had missing data because of incomplete questionnaires. Therefore, analysis was performed on 35 students (14 males and 21 females, 9.73 ± 0.29 years, mean ± standard deviation, SD). All of the children and their parents provided written informed consent, and the study was approved by the Human Studies Committee of Showa University School of Medicine.

**Respiratory measurements**

Experiments were performed in a quiet room. A Velcro extension belt (MLT1132, AD Instruments, Aichi, Japan) was used to determine respiration through the measurement of changes in thoracic circumference, and RR was recorded with PowerLab (ML846, AD Instruments, Aichi, Japan). After a 5-minute adaptation period, standing resting RR was measured for over 2 minutes with eyes closed. The data were extrapolated to 1-minute values. RR was measured immediately before and after the RMSG training.

**Psychological measurements**

The Questionnaire for Measuring Health-Related Quality of Life in Children (Kid-KINDL questionnaire) was developed for measuring the quality of life (QOL) in children aged 6 to 18 years. The questionnaire comprises 24 questions that cover six areas including: physical health, emotional well-being, self-esteem, family, friends, and school. The total number of points in all six areas is the QOL score, with a higher score indicating a higher QOL. Shibata et al
The State-Trait Anxiety Inventories for Children (STAI-C)

The State-Trait Anxiety Inventories for Children (STAI-C) was used to assess the anxiety level using the subscales of state anxiety (A-State scale) and trait anxiety (A-Trait scale). The A-State scale defines the anxiety experienced under specific conditions and times, and changes according to external factors. A-Trait anxiety defines the general feelings of the individual and reflects their general predisposition to anxiety. The instrument was designed to be used with upper elementary or junior high school aged children and consists of two 20-item scales. The Japanese version of STAIC was standardized by Soga in 1983.

Procedures

The study procedure is illustrated by the flow chart in Fig. 1. The study was explained to the children and their parents by a researcher. Forty-four parents and their children signed consent forms and were informed about the testing and training schedule. The children were then randomly assigned to either a gymnastics or a control group. Baseline assessment of both groups included completion of the Kid-KINDL questionnaire and STAI-C. The RRs were then recorded for each child. The children in the gymnastics group were then instructed on how to perform RMSG using a demonstration performed by the researchers as well as by written instructions. A brief description of the movements is provided below. Each of the stretch patterns was performed four times and one RMSG session lasted approximately 5 minutes. After performing the procedure, The RR was measured again and the children completed the A-state scale. They were instructed not to inform the control group about the RMSG and to perform the gymnastics once a day for one week and to return in a week. Each child received coloring cards with seven illustrations and they were told to color in these illustrations after they performed the RMSG. The children in the control group were told to return for post measurements in one week’s time.

The post testing used the same protocol as baseline testing and was performed on the
children in the gymnastics and control groups. After testing, the students in the control group were instructed on how to perform RMSG.

**RMSG**

RMSG was designed to be easy to learn and to be performed at home on a daily basis. The technique involves stretching the inspiratory intercostal muscles during inspiration and the expiratory intercostal muscles during expiration, in an attempt to reduce chest wall stiffness\(^1\). The children performed four repetitions of each of the four stretch patterns in sequential order. This constituted one session.

**Pattern 1. Stretching the shoulders**

As the participant breathes in slowly through their nose, they should gradually elevate and pull back both shoulders. After taking a deep breath, they slowly breathe out through the mouth, relax and lower their shoulders.

**Pattern 2. Stretching the neck**

One of the participant’s hands is placed on the occiput. The elbow is pulled down and the back of the neck is stretched while inhaling a deep breath through their nose. They expire slowly through their mouth, relax and return their head to the original position. The process is repeated using the alternate hand behind the head.

**Pattern 3. Stretching the back**

The participant should hold their hands in front of their chest. As they breathe in slowly through their nose, they should move their hands frontwards, and stretch their back. After deep inspiration, they slowly breathe out and resume the original position.

**Pattern 4. Stretching the upper chest**

The participant should hold their hand behind their back. After taking a deep breath, they move their arms backwards while breathing out slowly. After full expiration, they lower their hands to their body and breathe normally.

**Data analysis**

All statistical analyses were performed using SPSS software, version 11.0J (SPSS Inc., Chicago, IL, USA). Comparisons of Kid-KINDL, STAI-C and RR between the gymnastics group \((n = 20)\) and the control group \((n = 15)\) were analyzed using non-parametric unpaired *t*-tests (Mann-Whitney test). Differences between the baseline and post-RMSG training values for all dependent variables were examined using the Wilcoxon signed-rank test. Values are presented as the mean ± SD. A *P* value of \(< 0.05\) was considered statistically significant.

**Results**

**Baseline characteristics**

There were no significant differences \((P \geq 0.05)\) between the gymnastics and the control group for subject characteristics including average age, sex, anthropometric data, RR, Kid-KINDL and STAI-C (Table 1). No statistical differences were found in RR, Kid-KINDL and STAI-C
The average A-Trait score in the gymnastics group was 32.7. We defined the children whose A-Trait scores were higher than the average A-Trait as the “higher A-Trait group” (n = 10), and the children whose A-Trait scores were lower than the average A-Trait as the “lower A-Trait group” (n = 10). The two groups did not differ significantly in mean age, sex, and anthropometric data (Table 2). There was a statistical difference in the Kid-KINDL score between the higher A-Trait group and the lower A-Trait group (P < 0.05). There were no differences in RR or A-State scores between the two groups (P < 0.05, respectively).

The effects of RMSG

A typical example of the respiration response in the resting state and after RMSG is shown in Fig. 2. Specifically, deep and slow breathing was observed after RMSG. There was a

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**Table 1.** Comparison of the mean (± SD) age, sex, anthropometric data, RR, A-state score, A-Trait score and Kid-KINDL in the gymnastics (n = 20) and control group (n = 15). M = mean; SD = standard deviation.

<table>
<thead>
<tr>
<th></th>
<th>RMSG group</th>
<th>Control group</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (years)</td>
<td>9.78 ± 0.3</td>
<td>9.70 ± 0.3</td>
</tr>
<tr>
<td>Height (cm)</td>
<td>134.8 ± 5.5</td>
<td>135 ± 5.8</td>
</tr>
<tr>
<td>Number</td>
<td>20</td>
<td>15</td>
</tr>
<tr>
<td>male / female</td>
<td>7 / 13</td>
<td>7 / 8</td>
</tr>
<tr>
<td>Respiratory rates (breath / min)</td>
<td>22.5 ± 5.9</td>
<td>21.1 ± 3.5</td>
</tr>
<tr>
<td>A-State score</td>
<td>23.4 ± 3.6</td>
<td>27.7 ± 9.4</td>
</tr>
<tr>
<td>A-Trait score</td>
<td>32.7 ± 6.9</td>
<td>34.4 ± 9.8</td>
</tr>
<tr>
<td>KINDL (%)</td>
<td>77.5 ± 8.4</td>
<td>75.8 ± 13.6</td>
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**Table 2.** Comparison of the mean (± SD) age, sex, anthropometric data, RR, A-state score, A-Trait score and Kid-KINDL in the higher A-Trait group (n = 10) and the lower A-Trait group (n = 10). M = mean; SD = standard deviation.

<table>
<thead>
<tr>
<th></th>
<th>Higher A-Trait group</th>
<th>Lower A-Trait group</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (years)</td>
<td>9.72 ± 0.3</td>
<td>9.79 ± 0.3</td>
</tr>
<tr>
<td>Height (cm)</td>
<td>134.9 ± 4.7</td>
<td>134.6 ± 6.5</td>
</tr>
<tr>
<td>Number</td>
<td>10</td>
<td>10</td>
</tr>
<tr>
<td>male / female</td>
<td>3 / 7</td>
<td>4 / 6</td>
</tr>
<tr>
<td>Respiratory rates (breath / min)</td>
<td>22.9 ± 5.8</td>
<td>22.1 ± 6.3</td>
</tr>
<tr>
<td>A-State score</td>
<td>23.6 ± 4.6</td>
<td>23.2 ± 2.4</td>
</tr>
<tr>
<td>A-Trait score</td>
<td>38.6 ± 3.4</td>
<td>26.8 ± 3.2</td>
</tr>
<tr>
<td>KINDL (%)</td>
<td>73.2 ± 7.9</td>
<td>81.9 ± 6.8</td>
</tr>
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</table>
significant difference in RR ($P < 0.05$) between the resting state and after RMSG (Fig. 3, resting state, $22.5 \pm 5.9$; after RMSG, $19.2 \pm 5.3$). Fig. 4 shows the means of the RR, A-Trait score, and Kid-KINDL percentage in the resting state, and at the one-week follow-up for the higher A-Trait, lower A-Trait, and control groups. In the higher A-Trait group, the RR decreased (resting state, $22.9 \pm 5.8$; one-week follow-up, $20.7 \pm 6.3$), the A-Trait score decreased (resting state, $38.6 \pm 3.4$; 1 week follow-up, $33.7 \pm 4.8$) and the Kid-KINDL percentage increased (resting state, $73.2 \pm 7.9$; one week follow-up, $81.8 \pm 9.8$) after one week of RMSG training (Fig. 4). There were no differences in the RR, A-Trait and Kid-KINDL scores between the resting state and at one-week follow-up for the lower A-Trait and control groups, ($P > 0.05$). We divided the control group into the higher A-Trait group ($n = 9$), and the lower A-Trait group ($n = 6$), according to the same method as the gymnastics group (average A-Trait, 34.3). In both groups, there were no differences in the RR, A-Trait and Kid-KINDL scores between the resting state and at the one-week follow-up.
The primary findings of this study were that the RR and trait anxiety level decreased while the Kid-KINDL score, which is an index of the quality of life, increased, in higher A-Trait subjects, after one week of RMSG.

A possible explanation for these results is that the chest wall is stiffer in higher A-Trait children compared with lower A-Trait children. Therefore, RMSG would have a larger effect on the breathing pattern in the higher A-Trait group. The decrease in the RR observed in the higher A-Trait group may be because of a more relaxed and comfortable state after RMSG. Another alternative explanation is that the higher A-Trait children tend to have increased RR associated with a negative emotional state, which is associated with the modification of specific

**Discussion**

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areas of the brain. Slower breathing post-RMSG may modify these areas and thereby change the psychological state of the individual. These two explanations are interconnected because chest wall stiffness may be associated with stress or anxiety levels. The relationships between the explanations are discussed below.

**RMSG and slower breathing**

There is no direct evidence that chest wall tightness occurred at baseline in the higher A-Trait children. Indeed, we assumed that baseline tightness was greater in these children compared with the lower A-Trait group because a significant decrease in RR was observed in the higher anxiety group after one week of RMSG. Chest wall tightness is commonly observed in highly anxious subjects, especially in patients with hyperventilation syndrome. Stress and anxiety enhance muscle tone by increasing intercostal muscle activity through an increase in the gamma-motor input at the muscle spindle. Our results suggest that RMSG was more effective for children with high trait anxiety. In addition to the decrease observed in RR, the trait anxiety levels and Kid-KINDL score improved after one week of RMSG training. It is possible that the slower breathing required by RMSG affects the level of anxiety as well as other emotional factors.

**Slow breathing, anxiety and quality of life**

A close relationship has been established between the rate of breathing and emotional responses. Various emotions can alter breathing patterns. In particular, studies have focused on negative emotions such as fear and anxiety and the accompanying respiratory changes. Fear and anxiety increase RR without a change in metabolic demand, which indicates that the change is due to higher brain activations. In higher brain areas, the amygdala (AMG) is the center of the limbic system, and plays an important role in emotional responses. Negative emotions together with co-activation of the AMG suggest that increased RR is part of a defense mechanism that elevates alertness and arousal level. High trait anxiety subjects have increased RR, and these individuals tend to have significant activation of the AMG in response to negative stimuli.

In contrast, slow and deep breathing has been observed in relaxed individuals, and a decrease in anxiety has been associated with a decrease in RR. In addition, even a conscious effort to slow breathing can decrease anxiety. Therefore, the decrease in RR (slow breathing) after RMSG in the present study may have reduced anxiety levels through modifying the activation of the limbic system (AMG). It is surprising that trait anxiety levels decreased in the higher A-Trait group. According to Spielberger, et al, trait anxiety is typically resistant to change but it can change if state anxiety is consistently low during everyday life. This study found that RR decreased immediately after RMSG (Fig. 2), which may have occurred because the regular RMSG training caused a continuous decrease in anxiety.

The respiratory change as well as the decrease in anxiety levels may have contributed to the improvement in Kid-KINDL. Decreased anxiety is related to increased motivation, decision-
making ability and intention. These abilities are all linked to activities of daily living.

The subjects we tested in this study were children living in the center of Tokyo. We are uncertain as to whether the children in the high anxiety group had anxiety levels similar to children living in other parts of Tokyo or children in the Tohoku area where greater stress and anxiety were experienced during the Great East Japan Earthquake and Tohoku tsunami. The results of the present study will be applied to such children in future studies in an attempt to reduce their anxiety and improve their quality of life.

Conflict of interest

The authors have declared no conflict of interest.

References


[Received January 30, 2013 : Accepted February 7, 2013]