The Influence of Lung Function Information on Self-Reports of Dyspnea by Children with Asthma

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Studied the influence of actual and false peak flow (PEF) information on dyspnea (breathlessness) in two experiments, each with 30 children with and 30 without asthma (7–17 years). Dyspnea, PEF, and lung function were measured before and after standardized physical exercise. Dyspnea was measured with a visual analog scale. PEF was measured with a peak flow meter and used for manipulation of dyspnea. The first experiment showed that the relationship between dyspnea and lung function was not stronger when children had knowledge of PEF values. The second experiment revealed that asthmatic children who received false feedback of 30% below the actual PEF reported significantly more dyspnea. Implications for the management of asthma are discussed.

KEY WORDS: children; asthma, dyspnea; breathlessness; peak flow meter; feedback; symptom perception; self-management

Asthma is characterized by recurrent attacks of airway obstruction and dyspnea (breathlessness). Rapid identification and medication of airway obstruction is essential for adequate management. The use of peak flow meters for the objective assessment of airway obstruction in self-management of asthma has commonly been advocated (Creer, 1983; Harm, Kotses, & Creer, 1985).

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The peak flow meter is a portable plastic tube with a membrane blown into a scale during assessment of the "peak expiratory flow" (peak flow or PEF). This is the amount of the burst of air exhaled by the subject in 0.1 second. While properly standing in a straight position, the subject should close his mouth around the tube's end and blow as fast as possible. When assessed twice daily, the peak flow provides reliable feedback of pulmonary functioning. The use of PEF values as a basis for bronchodilator medication has been recommended, especially for patients with inaccurate perception of symptoms of asthma (Clark, Godfrey, & Lee, 1992; Creer, & Gustafson, 1989; Reeder, Dolce, Duke, Raczynski, & Bailey, 1990).

Although proper handling of the peak flow meter is essential for reliable results, several studies reported inaccurate use by many children, even after thorough training (Paky, & Knoblauch, 1985; Silverman et al., 1987; Sly, Landau, & Weymouth, 1985). The improper use of a peak flow meter usually results in a value below the actual value. It is also possible that children forget to return the pointer (connected to the membrane) to the zero position before a new trial, resulting in a PEF value higher than actual. With medication linked to low PEF values, improper use of the peak flow meter could be associated with inadequate dosage of medication. Children's asthma-related cognitions and emotions could be influenced as well. Children who believe that their ventilation is impaired, as reflected by the peak flow meter, may change their behavior, not attend school, and feel anxious and depressed (Creer, 1983, 1987).

The study on adult asthmatics by Higgs, Richardson, Lea, Lewis, and Laszlo (1986) revealed a strong correspondence between knowledge of PEF values and symptom reporting. They observed that the relationship between subjective symptoms and PEF was invariably stronger when PEF values were known to the subjects. The PEF values were a source of complementary information in the process of symptom perception underlying dyspnea. In other words, the subjects used external information about their internal state, rather than introspection.

School-aged children are generally capable of using a peak flow meter properly and can reliably express sensations of dyspnea. However, it remains questionable whether or not the conclusions by Higgs et al. (1986) are also valid for children (Frischer et al., 1993; Zeltzer et al., 1988).

To study the influence of knowledge of correct and false PEF information on dyspnea-reporting in school-aged children with asthma, two experiments were conducted. In the first experiment, children's self-reports of dyspnea with and without knowledge of PEF values after physical exercise were compared. In the second experiment, the influence of false PEF information on children's dyspnea-reporting after physical exercise was investigated.

Children without asthma also participated to study the influence of asthma
history on dyspnea-reporting. Yellowlees and Ruffin (1989) observed that adult asthmatics who survived a near-miss asthma death developed coping strategies that influenced symptom reporting. Consequently, it is important to determine whether the influence of PEF information on dyspnea-reporting is a general phenomenon or restricted to children with a history of asthma.

**METHOD**

**Experiment 1: Knowledge of Peak Flow Values**

The hypothesis was tested that the relationship between self-reports of dyspnea and lung function (Forced Expiratory Volume in 1 second) is stronger when PEF values are known to the children. Children with and without asthma were randomly assigned to one of two conditions: Condition 1 (no knowledge of PEF values) or Condition 2 (knowledge of PEF values).

**Subjects**

The sample consisted of 30 children with asthma (20 male, 10 female) and 30 without asthma (16 male, 14 female), of 7–17 years old ($M = 11.8, SD = 2.9$ in the asthma group, $M = 12, SD = 3.3$ in the no-asthma group). Approximately 30% of the children were of Maroc or Surinam ethnic background. Most children were referred by general physicians. However, 20% of the children with asthma and the children without asthma responded to an advertisement in a local newspaper. The criterion for participation in the asthma group was a diagnosis of asthma by a general physician, lung physician, or pediatrician. All parents gave informed consent. The children explicitly agreed to participate, and they were financially rewarded.

Severity of asthma was classified according to the scoring system of the Dutch Society of Paediatricians, section Lung Diseases (Van der Laag et al., 1991). The criteria for classification into three classes were similar to those for the five classes proposed by the International Consensus of Lung Physicians (British Thoracic Society, 1993). The main difference is that the use of corticosteroids is more differentiated in the international consensus.

There were 13 children with severe asthma, and they were treated with prednisolone, inhaled corticosteroids, and bronchodilators. Another 9 children had a diagnosis of moderate asthma. They were treated with ipratropiumbromide, cromoglycate, and bronchodilators. Eight children with mild asthma used bronchodilators on demand only. The children were requested to abstain from using bronchodilators on the morning of the experiment.
Measures

Assessment of Dyspnea. Dyspnea was defined as shortness of breath, labored breathing, tightness of the chest, or wheeziness. Dyspnea was measured with a visual analog scale, marked by the children under supervision of the lung function technician. This scale consisted of a horizontal line with 10 points, ranging from 0 (no dyspnea) to 9 (severe dyspnea) (Killian, 1988; Mass, Dahme, & Richter, 1992). A similar instrument was previously used in children by Fritz, Klein, and Overholser (1990), Sly et al. (1985), and Quirk and Jones (1990).

Assessment of Peak Flow. Peak flow values were measured with a Mini-Wright Peak Flow Meter and expressed in liters per minute. The values were used for manipulation of dyspnea-reporting only. The children with asthma were invariably familiar with the device, but most children without asthma were not. There were three trials, in Condition 2 the values were repeated with a loud voice by the lung function technician (see below).

Assessment of Airway Obstruction. The physiological criterion in the study (degree of airway obstruction) was measured by lung function testing. This was done with a pneumotachograph (Pneumoscreen II, Erich Jaeger, Germany) and expressed as forced expiratory volume in 1 second (FEV₁). The pneumotachograph was calibrated every day by the regular lung function technician. The highest of three FEV₁ trials was used for analysis. The FEV₁ was expressed in absolute value and in percentage of predicted for a (nonasthmatic) child of similar age, sex, length, and weight.

Exercise Task

The exercise task was meant to provide the children with a reason for justifying a change in dyspnea-reporting. Free running instead of treadmill running or cycling was selected because it is superior as a method for inducing airway obstruction and because it is a natural activity for children (Anderson, Silverman, Godfrey, & Konig, 1975; Kattan, Keens, Mellis, & Levison, 1978). The children ran through the empty corridor of the air-conditioned university building. The temperature at 5 feet above ground level ranged from 68–70°F and the humidity between 80–85%. To standardize the task, a heartbeat control device was strapped around the chest of the children (Polar Edge, Semex Medische Techniek, Nieuwegein, The Netherlands). Running was terminated when a heartbeat of 170 beats/minute was signaled by a sound and the children were then seated for 5 minutes (Ergood, Epstein, Ackerman, & Fireman, 1985; Killian & Campbell, 1983).

³Peak flow and FEV₁ are both parameters of lung function, but the latter is more reliable and the golden standard of lung physicians.
Influence of Lung Function Information on Dyspnea

Procedure

The experiment lasted approximately 30 minutes per child and comprised the following order of events: (a) assessment of dyspnea; (b) PEF assessment; (c) lung function testing (FEV\textsubscript{1}); (d) exercise task; (e) 5 minutes resting; (f) PEF assessment\textsuperscript{4}; (g) assessment of dyspnea; (h) lung function testing (FEV\textsubscript{1}); (i) exit interview.

Results

The exit interview data showed that all children understood the procedure and performed as well as possible. The mean dyspnea in the asthma group rose after exercise 1.9 scale points in Condition 1 (no knowledge of PEF) and 1.4 scale points in Condition 2 (knowledge of PEF). In the no-asthma group this was, respectively, 0.2 and 0.6 scale points. The mean dyspnoea and lung function (FEV\textsubscript{1}) are presented in Table I.

Contrary to expectation, the relationship between self-reports of dyspnea and lung function (FEV\textsubscript{1}) was not stronger when PEF values were known to the children. The correlations (Pearson's product-moment correlation coefficient) between dyspnea and FEV\textsubscript{1} (and predicted percentage of FEV\textsubscript{1}) were not significant, in neither condition, pre- or posttest. On the contrary, the only significant correlation was found in the no-knowledge condition for children with asthma: $r = -.41$, $p = .01$. See Table II.

Experiment 2: False Feedback of Peak Flow Values

The hypothesis was tested that self-reported dyspnea (after physical exercise) is higher when children have knowledge of PEF information below the actual value than with PEF information above the actual value. The children were randomly assigned to one of two conditions: Condition 1 (PEF information below the actual value) or Condition 2 (PEF information above the actual value).

Subjects

The sample consisted of 30 children with asthma (21 male, 9 female) and 30 without asthma (18 male, 12 female), of 7–17 years old ($M = 12.2$, $SD = 2.9$ in the asthma group and $M = 12.4$, $SD = 3.3$ in the no-asthma group). Approximately 30% of the children were of Moroc or Surinam ethnic background.

The 14 children with sever asthma were treated with prednisolone, inhaled

\textsuperscript{4}Condition 1 scale value invisible to the children, Condition 2 scale value visible to the children.
Table I. Means and Standard Deviations of Dyspnea, Forced Expiratory Volume in 1 Second (FEV\(_1\)) and Predicted Percentage FEV\(_1\) of Children with and without Asthma in Conditions without (−k) and with (+k) Knowledge of Peak Flow Values Before Dyspnea-Reporting in Experiment 1

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<tr>
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<th>Pretest</th>
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<td>Asthma (n = 30)</td>
<td>Nonasthma (n = 30)</td>
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<tr>
<td>Dyspnea</td>
<td>M</td>
<td>SD</td>
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<tr>
<td>C −k</td>
<td>0.8</td>
<td>1.0</td>
</tr>
<tr>
<td>C +k</td>
<td>1.1</td>
<td>1.3</td>
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<tr>
<td>FEV(_1)</td>
<td>C −k</td>
<td>2.32</td>
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<tr>
<td></td>
<td>C +k</td>
<td>2.31</td>
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<tr>
<td>% FEV(_1) predicted</td>
<td>C −k</td>
<td>92</td>
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<td></td>
<td>C +k</td>
<td>89</td>
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 corticosteroids, and bronchodilators. Moderate asthma was diagnosed in 6 children. They used ipratropiumbromide, cromoglycate, and bronchodilators. Another 10 children had mild asthma and they were treated with bronchodilators on demand only. See the “Subjects” section in Experiment 1.

Measures

Assessment of Dyspnea. Dyspnea was measured with a 10-point self-report visual analog scale. See the “Assessment of Dyspnea” section in Experiment 1.

Table II. Correlations between Dyspnea, with FEV\(_1\) (r\(_1\)) and Predicted Percentage FEV\(_1\) (r\(_2\)) of Children with and without Asthma in Conditions without Knowledge (C −k) and with Knowledge (C +k) of Peak Flow Values Before Dyspnea-Reporting in Experiment 1

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<td>Asthma (n = 30)</td>
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<tr>
<td>Dyspnea</td>
<td>r(_1)</td>
<td>r(_2)</td>
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<td>C −k</td>
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<tr>
<td>C +k</td>
<td>.11</td>
<td>.13</td>
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*p < .01.
Assessment of Peak Flow. Peak flow values were measured with a Mini-Wright Peak Flow Meter and used for manipulation of dyspnea-reporting only. The scale value of the peak flow meter used after exercise in Condition 1 was changed to indicate 30% below the actual value. The scale value of the peak flow meter used after exercise in Condition 1 was changed to indicate 30% above the actual value. The results of the three peak flow trials were repeated with a loud voice by the lung function technician in both conditions. See the “Assessment of Peak Flow” section in Experiment 1.

Assessment of Airway Obstruction. The degree of airway obstruction was measured by lung function testing and the result expressed as FEV₁. See the “Assessment of Airway Obstruction” section in Experiment 1.

Exercise Task

The children ran through the corridor of the university building until a heartbeat of 170 beats/minute was signaled by a sound. Following the signal, the children were seated for 5 minutes. See the “Exercise Task” section in Experiment 1.

Procedure

The experiment lasted approximately 30 minutes per child and comprised the following order of events: (a) assessment of dyspnea; (b) PEF assessment; (c) lung function testing (FEV₁); (d) exercise task; (e) 5 minutes resting; (f) PEF assessment; (g) assessment of dyspnea; (h) lung function testing (FEV₁); (i) exit interview.

Results

The exit interview data showed that none of the children expressed doubts about the genuine nature of the postexercise peak flow results.

The mean dyspnea in the asthma group rose after exercise 2.4 scale points in Condition 1 (PEF 30% below actual) and 1.5 scale points in Condition 2 (PEF 30% above actual). In the no-asthma group this was, respectively, 0.2 and 0.4 scale points. The mean dyspnoea and lung function (FEV₁) are presented in Table III.

The analysis of variance with lung function (FEV₁) as covariate (ANCOVA) revealed highly significant main effects of asthma and conditions on dyspnea,
Table III. Means and Standard Deviations of Dyspnea, Forced Expiratory Volume in 1 Second (FEV₁) and Percentage of Predicted FEV₁ of Children with and without Asthma in Conditions without False Feedback of Peak Flow Values 30% below (30−) and Above (30+) the Actual Value Before Dyspnea-Reporting in Experiment 2

<table>
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<tr>
<th></th>
<th>Asthma (n = 30)</th>
<th>Nonasthma (n = 30)</th>
<th>Asthma (n = 30)</th>
<th>Nonasthma (n = 30)</th>
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<tr>
<td></td>
<td>Pretest</td>
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<tr>
<td>Dyspnea</td>
<td></td>
<td></td>
<td>M</td>
<td>SD</td>
</tr>
<tr>
<td>C 30−</td>
<td>0.9</td>
<td>0.6</td>
<td>3.3</td>
<td>2.0</td>
</tr>
<tr>
<td>C 30+</td>
<td>1.2</td>
<td>0.2</td>
<td>2.7</td>
<td>2.6</td>
</tr>
<tr>
<td>FEV₁</td>
<td></td>
<td></td>
<td>2.34</td>
<td>0.73</td>
</tr>
<tr>
<td>C 30−</td>
<td>2.08</td>
<td>2.21</td>
<td>2.06</td>
<td>0.86</td>
</tr>
<tr>
<td>C 30+</td>
<td>0.34</td>
<td>0.90</td>
<td>2.09</td>
<td>0.29</td>
</tr>
<tr>
<td>FEV predicted</td>
<td></td>
<td></td>
<td>89</td>
<td>20</td>
</tr>
<tr>
<td>C 30−</td>
<td>99</td>
<td>101</td>
<td>78</td>
<td>30</td>
</tr>
<tr>
<td>C 30+</td>
<td>16</td>
<td>11</td>
<td>101</td>
<td>19</td>
</tr>
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respectively, $F(1, 56) = 785.6, p < .001$ and $F(1, 56) = 105.7, p < .001$. The interaction effect between asthma and conditions was also significant, $F(1, 56) = 7.58, p < .01$. The differences in lung function (FEV₁) were statistically corrected; this effect of the covariate FEV₁ was not significant, $F(1, 56) = 1.12, p > .05$.

A second ANCOVA was computed with dyspnea difference scores, defined as dyspnea posttest minus dyspnea pretest. Again there were main effects of asthma and conditions on dyspnea, respectively, $F(1, 56) = 4.56, p < .05$ and $F(1, 56) = 5.15, p < .05$. The interaction effect was also significant, $F(1, 56) = 4.21, p = .05$. The effect of the covariate FEV₁ was not significant, $F(1, 56) = 2.15, p = .95$. The mean dyspnea difference score of children with asthma was significantly higher in Condition 1 than in Condition 2, $F(1, 56) = 4.01, p = .04$. The direction of the differences between dyspnea in children with and without asthma in the conditions is illustrated in Table III.

**GENERAL DISCUSSION**

This study demonstrates that children with asthma can be influenced by lung function information when reporting dyspnea. Irrespective of actual lung function, dyspnea-reporting was successfully manipulated with relevant but false information. This influence however was restricted to lung function values in line with children's expectations. This finding provides a new perspective on the...
The results of the first experiment show that self-reports of dyspnea by children with and without asthma were not influenced by knowledge of PEF values. The results of the second experiment reveal that asthmatic children with knowledge of false PEF information 30% below the actual value reported significantly more dyspnea than did children with knowledge of PEF values 30% above the actual value.

The results of the first experiment are contrary to the findings with adult asthmatics by Higgs et al. (1986). This could be a developmental issue, because the cognitive link between lung function feedback and self-reports of dyspnea might be difficult or impossible for young children. The processing of PEF information is probably different in children and adults. However, there were also methodological differences between the two studies. In the present study, a lack of experience with peak flow meters could explain why children without asthma were not influenced by false PEF information. On the other hand, the cognitive processing and emotional involvement between children with and without asthma was obviously quite different.

Although only a minority of children developed exercise-induced airway obstruction, this was irrelevant for the testing of the hypotheses. It was only necessary to create uncertainty, that children could believe that they were having an asthma attack after running.

The results of the second condition of the second experiment suggest that lung function feedback of 30% above the actual value had no "diminishing" effect on dyspnea-reporting. Only lung function information below the actual value has the potential to influence dyspnea-reporting. Children expect a fall in PEF after running, not an increase. Pennebaker and Skelton (1981) demonstrated the impact of expectation-guided selective attention on symptom reporting. In the present study, the postexercise minutes were characterized by general bodily sensations (sighing, heart-pounding, fatigue) and in several children also real symptoms of asthma. Dirks and Schraa (1983) found that asthmatic adults commonly interpreted general bodily sensations as the symptoms of asthma. False PEF information below the actual value would be consistent with the general sensations likely to be labeled as symptoms of asthma and thus facilitate high dyspnea-reporting. On the other hand, false feedback above the actual value would be counterbalanced by general sensations as well as actual symptoms of asthma. Even in children easily influenced by feedback of lung function, unexpected or irrelevant information is probably not influential.

Higgs et al. (1986) believed that suggestion was in part causing the high correlation between subjective symptoms and PEF. The present results suggest that the effect of false feedback on dyspnea is caused by selective attention for asthma-related symptoms, expectations, and possibly emotions. Subjects in an uncertain and possibly harmful situation (the asthma patient in a physical exercise setting) use all available information that seems relevant, primary and sec-
ondary physiological information, either correct or false. In an uncertain situation, when sensory information is vague or ambiguous, inference, based on knowledge and experience, dominates the processing of sensory information underlying dyspnea.

A limitation of the present study is that children easily influenced by knowledge of PEF information could not be distinguished on the basis of specific variables, such as developmental level, asthma history, dependence on parents or caretakers, anxiety, suggestibility, and exercise tolerance. Clinical implications are obvious, since lung function assessment is the everyday ritual for many asthmatics. Experimental implications would be that subjective assessment should precede objective lung function assessment, because subjects may be influenced in symptom-reporting by information from equipment or medical assistants. In everyday self-management of asthma, many children handle peak flow meters inaccurately, usually resulting in values below the actual value. Knowledge of low PEF values eventually enhances the use of medication and may influence mood state and illness behavior. This makes children who are easily influenced by PEF information vulnerable to improper medication and inadequate self-management of asthma. The effect of training children in the accurate handling of peak flow meters is usually short-lived, emphasizing the importance of regular, preferably continuous, supervision. This implies close observation and control of bodily position, handling of the meter, and breathing maneuver by a trained supervisor.

The next step in this line of research would be elaboration on the cognitions of children following bodily feedback in a potential harmful situation. It would be especially interesting to elucidate factors that explain the interindividual differences in magnitude of dyspnea-reporting. Future research should also address the factors distinguishing subgroups of children influenced and not influenced by external information, such as feedback of lung function.

REFERENCES


