High-Intensity Physical Training in Adults with Asthma*
A 10-Week Rehabilitation Program

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Twenty-six adults (23 to 58 years) with mild to moderate asthma underwent a 10-week supervised rehabilitation program, with emphasis on physical training. In the first 2 weeks, they exercised daily in an indoor swimming pool (33°C) and received education about asthma, medication, and principles of physical training. In the following 8 weeks, they exercised in the pool twice a week. Every training session lasted 45 min. The training sessions were made as suitable as possible for the individual subjects, in order to minimize “drop outs” from the program. The aim of the study was to evaluate the efficacy of the rehabilitation program and to determine if inactive asthmatic adults can exercise at high intensity. The rehabilitation program was preceded by a 6-min submaximal cycle ergometry test, a 12-min walking test, spirometry, and a methacholine provocation test. The subjects also responded to a five-item questionnaire related to anxiety about exercise, breathlessness, and asthma symptoms using a visual analogue scale. All subjects were able to perform physical training at a very high intensity, to 80 to 90% of their predicted maximal heart rate. No asthmatic attacks occurred in connection with the training sessions. Twenty-two of the 26 subjects completed the rehabilitation program, felt confident with physical training, and planned to continue regular physical training after the 10-week program. Improvements in cardiovascular conditioning, measured as a decreased heart rate at the same load on the cycle ergometer (average of 12 beats/min), and as a longer distance at the 12-min walking test (average of 111 m), were observed during the program. FEV1 increased significantly from 2.2 to 2.5 L. Forced expiratory flow at 25% of vital capacity also increased slightly but significantly. Methacholine provocation dose causing a fall in FEV1 by 20% was unchanged. Seventeen subjects had a peak expiratory flow reduction of more than 15% after the preprogram ergometry test and were classified as having exercise-induced asthma (EIA). Only three of these subjects had EIA after 10 weeks. The asthmatic subjects were less afraid of experiencing breathlessness during exercise and less anxious about exercising at a high intensity after 10 weeks (p<0.05). The asthma symptoms abated significantly during the rehabilitation program and the subjects needed less acute asthma care after the rehabilitation program. The results indicate that asthmatic persons benefit from a rehabilitation period, including physical training. Rehabilitation programs are therefore of value as a supplement to conventional pharmacologic treatment of asthma. This rehabilitation program can be adapted for use in clinical practice.

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It is well known that physical training supports health.1,2 Besides improving cardiovascular function,3-7 regular aerobic exercise also leads to a variety of psychological and sociological benefits.2,8,9

Both adults and children with asthma are less fit than their peers.6,10,11 Few people with asthma exercise regularly and many asthmatic adults have a negative experience with physical training and great difficulties in accomplishing sports.1 Even children with asthma are more inactive than their peers and may become isolated because they do not join others in sport activities.12 Practically all individuals with asthma show a reduced ventilatory capacity after physical exercise. When a large increase in airway resistance occurs in response to exercise, the reaction is described as exercise-induced asthma (EIA).13 It is even postulated that EIA occurs in all asthmatic individuals if the workload

Key words: adult; anxiety; bronchial asthma/rehabilitation; bronchial hyperreactivity; exercise-induced asthma; exercise therapy; physical fitness
is sufficiently high. Many asthmatic subjects have difficulties in distinguishing breathlessness associated with bronchoconstriction from breathlessness associated with increased ventilation caused by external loads. Since they could not distinguish between the two, they became anxious about both experiences. This insecurity may contribute to a reduced level of activity and deconditioning.

As in healthy individuals, regular physical training supports health in persons with asthma. Even if asthmatic subjects in general have been aware of the value of regular exercise, a large number of them have never received any instruction as to the amount and type of exercise that they should have. Though many investigators have found good effects of physical training, the description of training programs is still inadequate. It is difficult enough to stimulate healthy people to establish regular physical exercising habits, and it is even harder to stimulate persons with asthma. For this reason and with the aim of encouraging and helping inactive asthmatic individuals to start and continue physical training and gradually change their lifestyle, we constructed a rehabilitation program with emphasis on physical training. This program was designed to minimize EIA and injuries, and to be enjoyable, varied, and stimulating.

The present study was undertaken to evaluate the efficacy of the rehabilitation program and determine whether inactive adults with asthma were capable of exercising at a high intensity, to 80 to 90% of the maximal heart rate. We also studied whether asthmatic subjects were able to continue regular physical training, at least twice a week, for 10 weeks. In addition, evaluation was made of the effects of the program on the cardiorespiratory function, asthma symptoms, acute asthma care, patients’ anxiety about exercise, and the impact of their feelings about their disease on everyday activities.

### Table 1—Lung Function, Mean (±SD), and 12-min Walking Test, Mean*

<table>
<thead>
<tr>
<th></th>
<th>Start (0)</th>
<th>2 wk</th>
<th>6 wk</th>
<th>10 wk</th>
</tr>
</thead>
<tbody>
<tr>
<td>Lung function</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>FEV1, L</td>
<td>2.2 (0.8)*</td>
<td>2.5 (0.7)*</td>
<td>3.2 (0.7)*</td>
<td>4.3 (0.7)*</td>
</tr>
<tr>
<td>FEV1, % predicted</td>
<td>63 (22)*</td>
<td>73 (19)*</td>
<td>80 (20)*</td>
<td>86 (21)*</td>
</tr>
<tr>
<td>FEF25, L</td>
<td>0.6 (0.4)*</td>
<td>0.7 (0.4)*</td>
<td>0.8 (0.5)*</td>
<td>0.9 (0.6)*</td>
</tr>
</tbody>
</table>

12-min walking test

<table>
<thead>
<tr>
<th>Walking distance, m</th>
<th>Perceived exertion, Borg’s scale</th>
<th>Heart rate (beats/min) pretest</th>
<th>Heart rate (beats/min) posttest</th>
</tr>
</thead>
<tbody>
<tr>
<td>1,350</td>
<td>6.7</td>
<td>81</td>
<td>146</td>
</tr>
<tr>
<td>1,444</td>
<td>7.7</td>
<td>80</td>
<td>153</td>
</tr>
<tr>
<td>1,486</td>
<td>7.2</td>
<td>84</td>
<td>159</td>
</tr>
<tr>
<td>1,461</td>
<td>7.5</td>
<td>79</td>
<td>161</td>
</tr>
</tbody>
</table>

*pNumbers in parentheses represent SD.

Subjects

The study comprised 26 adult asthmatic subjects (20 women, 6 men), who were patients from the Lung Clinic, Uppsala, Sweden. Their average age was 41 years (range, 23 to 58 years) and they fulfilled the following criteria: (1) chronic well-controlled bronchial asthma of a mild or moderate degree of severity (Table 1); (2) reversibility of at least 20% as measured by an increase in peak expiratory flow rate (PEFR) after treatment with a β2-agonist; and (3) no concomitant disease. The level of medication was as follows for 10 subjects, low (low=inhaled β2-stimulants and inhaled corticosteroids); for 15 subjects, medium (medium=same as for low level plus oral β2-stimulants and/or theophylline); and for 1 subject, high (high=same as for medium level plus oral corticosteroids). All subjects had inhaled β2-agonists and corticosteroids for at least 2 weeks before the start of training. The medication was kept constant during the study period.

In 11 of the subjects (ordinary conditioned group [OCG]), the degree of physical fitness was about the same as, and in the other 15 (the less conditioned group [LCG]) it was lower than that of a Swedish population of the same age. A subgroup of 7 of the 26 asthmatic subjects served as their own controls.

All the subjects gave their informed consent. The study protocol was approved by the Ethics Committee of the Medical Faculty of Uppsala University.

### Table 2—Timetable for the Tests*

<table>
<thead>
<tr>
<th>Subgroup (n=7)</th>
<th>Rehabilitation Program (0-10 wk)</th>
</tr>
</thead>
<tbody>
<tr>
<td>-10 wk</td>
<td>0</td>
</tr>
<tr>
<td>Maximal exercise test</td>
<td>x</td>
</tr>
<tr>
<td>Submaximal ergometry test</td>
<td></td>
</tr>
<tr>
<td>12-min walking test</td>
<td></td>
</tr>
<tr>
<td>Questionnaire (VAS)</td>
<td>x</td>
</tr>
<tr>
<td>Training log</td>
<td></td>
</tr>
<tr>
<td>Medication</td>
<td></td>
</tr>
<tr>
<td>Medical examination</td>
<td>x</td>
</tr>
<tr>
<td>Spirometry</td>
<td></td>
</tr>
<tr>
<td>Methacholine test</td>
<td>x</td>
</tr>
</tbody>
</table>

*x-time points when different tests were performed; >>>=continues notes and medication.
ing rate were measured before, during, and after cycling. Exertion and breathlessness were estimated at the same occasions using ten-graded category Borg scales. No special instructions about the use of β₂-agonists before the tests were given, except for the test at 2 weeks when they all had inhaled β₂-agonists before.

A 12-min walking test, carried out in a hospital corridor, was performed to measure the distance that the subjects were able to walk in 12 min. PEF, the heart rate, the breathing rate, and the sense of exertion and breathlessness estimated by the subjects using the Borg scale were recorded before the walk and immediately after completion of the walk. No special instructions about the use of β₂-agonists before the tests were given, except for the test at 2 weeks when they all had inhaled β₂-agonists before.

Spirometry was performed with a body plethysmograph (Jaeger Masterlab body 175 050) for measurement of lung volumes and specific airway conductance, a wedge spirometer (Ohio) for recording of flow-volume curves, and a pneumotachograph connected to a carbon monoxide and helium analyzer for measurement of the diffusion capacity of carbon monoxide. The measurements were repeated after inhalation of 2.5 mg salbutamol administered with a high dose nebulizer (Fari inhaler boy; Fari-Werk GmbH; Starnberg). Reference values were obtained from Hedenström et al.

A methacholine provocation test was performed according to the method described by Carlson. The result is expressed as the provocation dose causing a fall in FEV₁ by 20% (PD20).

A questionnaire designed specifically for this study related to feelings about asthma symptoms and the ability to work and to carry out physical training was administered. The subjects responded to each item on a visual analogue scale (VAS, 10 cm). The questionnaire consisted of five items. The endpoints of the VAS are given for each question (Table 3). The reliability coefficient for each item is shown in Table 3.

The number of emergency department visits for acute medical care during the 10 weeks before the rehabilitation program and during 10 weeks after its termination was recorded from a scrutiny of the medical records.

A training log was kept by each subject to record the frequency of training, the asthma symptoms, and the perceived exertion after each exercise session.

PEFR was measured with a peak flowmeter (Mini-Wright; Clement Clarke International Ltd; Buckingham, England). The highest value of three efforts was used. The subject had an individual PEFR meter and the same one was used throughout the study. The heart rate was measured by palmpation.

A subgroup of 7 of the 26 subjects was evaluated with respect to spontaneous variations in the study parameters and the questionnaire administered. The group was tested 10 weeks before the start of the rehabilitation program (~10 weeks) and at the start (0) (Table 2).

Rehabilitation Program

The 26 asthmatic subjects took part in a 10-week rehabilitation program. The subjects were inpatients during the first 2 weeks and outpatients during the last 5 weeks of the study. During the inpatient period, they exercised at a high intensity and education was provided 5 days a week. The education was theoretical, with lessons in anatomy, physiology, pathophysiology, medication, and physical training, and also practical, concerning techniques for inhalation, breathing, and relaxation. Each training group consisted of two or three subjects.

Training: Each training session was carried out in an indoor swimming pool, with a water temperature of 33°C. The subjects were instructed to use β₂-agonists before training and if necessary throughout the exercise session. The training session started with a warming-up period (12 min) with arm and leg exercise, including intense "running" in the pool. The exercise continued with interval training, comprising five periods with 2 min of intensive exercise separated by 1½-min periods with mild exercises (total, 16 min). These periods in the interval training consisted of varied repetitive large-muscle dynamic exercise. A cooling-down period (7 min) and stretching exercises (10 min) in the pool completed the 45-min session. In order to offer a varied, enjoyable, and interesting training session, all gymnastic exercises were accompanied by encouraging music and the exercises were varied from time to time.

The target heart rate was 80 to 90% of the predicted maximal heart rate. This was calculated by the formula 220 beats/min minus age (in years).

The heart rate was measured before the training session, after the warming up, after each interval, and immediately after the cooling-down period. The subjects estimated their sense of exertion according to Borg’s scale after the warming up, after the interval training period, and after the cooling-down period. PEFR was measured before the training session and immediately after the warming up, the interval training, and the cooling-down periods. The PEFR recordings were also continued 5 h postexercise.

Most of the rehabilitation program was led by one of two physiotherapists. Great effort was made to encourage the subjects to

### Table 3—Analysis of the Different Items in the Questionnaire (n=26) *

<table>
<thead>
<tr>
<th>Items</th>
<th>Reliability Coefficient, rt</th>
<th>A Comparison With the Values at Start, wk</th>
<th>A Comparison With the Values at 2 wk, wk</th>
<th>A Comparison With the Value at 6 wk, wk</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>r</td>
<td>2 6 10</td>
<td>6 10</td>
<td>10</td>
</tr>
<tr>
<td>(1) I am able to exercise at maximal intensity (always—never)</td>
<td>0.78</td>
<td>S S S</td>
<td>NS NS</td>
<td>NS</td>
</tr>
<tr>
<td>(2) I am afraid of experiencing breathlessness when exercising (never—always)</td>
<td>0.68</td>
<td>S S S</td>
<td>NS NS</td>
<td>NS</td>
</tr>
<tr>
<td>(3) I have asthma symptoms (never—always)</td>
<td>0.87</td>
<td>S S S</td>
<td>S S</td>
<td>S</td>
</tr>
<tr>
<td>(4) I can cope with my job/studies (without restrictions—not at all)</td>
<td>0.87</td>
<td>NS NS</td>
<td>NS NS</td>
<td>S</td>
</tr>
<tr>
<td>(5) I am able to leave home for more than 24 h (always—never)</td>
<td>0.81</td>
<td>NS NS</td>
<td>NS NS</td>
<td>NS</td>
</tr>
</tbody>
</table>

*Items 4 and 5 were not analyzed at 2 weeks. S=p<0.05; NS=not significant.
exercise, as almost all of them were unfamiliar with physical training.

Outpatient Period: During the outpatient period, the subjects continued physical training twice a week in groups of up to eight subjects. They exercised in the same way as during the inpatient period. During this outpatient period, the intensity level was measured by each subject only by estimating their sense of exertion after training according to Borg's scale. They were encouraged to exercise to a level of at least 7 to 8 on the Borg scale.

Statistical Analysis

Data were analyzed for statistical significance using one-factor analysis of variance for repeated measurements (Fisher PLSD; analysis of variance). A paired t test was used for comparison of measurements made before and after the study in each group. Effects were considered significant at p<0.05. The Borg scale was measured with an ordinal scale and nonparametric statistical methods were used. Correlations were evaluated by simple regression analysis. Twenty-nine asthmatic subjects from another hospital completed the questionnaire twice, with 1 week in between, in order to test its reliability. Spearman's rank correlation test was used for the calculation of this reliability.

Results

Interval Training

All 26 asthmatic subjects attended all training sessions during the first 2 weeks. Even though the gymnastics were unfamiliar and the intensity was high, they managed to participate. None of the subjects was injured, though most of them had delayed muscle soreness after training, as they were unaccustomed to physical exercise and had low fitness at the start. The subjects were also able to maintain the very high intensity during the training sessions without getting asthma symptoms and without being afraid of developing asthma. The mean heart rate relative to the predicted maximal heart rate was 69% after warming up, 93% during the interval training, and 68% after cooling down. The perceived exertion values after warming up, interval training, and cooling-down periods were 3, 8, and 3 on the Borg scale. There was significant bronchodilation during the training sessions, and the bronchodilation lasted more than 1 hour postexercise. Two hours after the sessions, there was a slight decrease in PEFR compared with the initial presession values. This PEFR decline was maintained for a further 3 hours. Five hours after termination of the exercise, the reduction was at most 6% and thus no late reaction (FEV₁ decrease more than 15%) occurred. Only one patient needed supplementary asthma medication, on two occasions, after training.

Outpatient Period

Two asthmatic subjects dropped out after the inpatient period and another two dropped out after a further 6 weeks. The reason for ceasing to participate was lack of time. The 22 subjects who completed the physical training twice a week during the outpatient period exercised at a high intensity, 7 to 10 on the Borg scale, on all occasions. Even if they had asthma symp-

tons before a training session, they still attended, though exercising at a lower intensity. Exercising in the swimming pool never worsened the asthma symptoms. On a few occasions, when subjects were not able to attend the swimming pool sessions, they exercised in another way, for example on a bicycle, but at the same intensity. Eight persons reported that they exercised three times a week, either by walking or cycling the third time.

Cardiovascular Conditioning

On three occasions, the maximal exercise test was interrupted by breathlessness or chest tightness and in all others it was due to fatigue.

Circulatory improvements were observed in the submaximal cycle test and in the 12-minute walking test after the 10-week rehabilitation program. The mean heart rate at the end of the cycle test was significantly decreased from 167 beats/min at the start of the program to 155 after 10 weeks of training. The perceived exertion also decreased from 8 to 6 (p<0.05). Moreover, the mean heart rate measured 5, 15, and 30 minutes after the test was lower after the 10-week rehabilitation program than before (p<0.05). The walking distance increased significantly from 1,350 m at 0 W to 1,486 m at 6 W and 1,461 m at 10 W (Table 1).

Respiratory Improvements

There was a significant improvement in mean FEV₁ forced expiratory flow at 25% of vital capacity (FEF₂₅), and forced expiratory flow at 75% of vital capacity (FEF₇₅) after the 10-week training period (Table 1). The values for specific airway conductance and diffusion capacity of carbon monoxide were unchanged. Methacholine PD₂₀ was also unchanged after 10 weeks. There were almost no differences between the breathing rates, on the submaximal cycle test, before and after 10 weeks of training. Both at start (0 weeks) and after the rehabilitation period (10 weeks) the initial breathing rate, before the walking test, was 17 and after the test it was 39 at 0 weeks and 37 at 10 weeks. However, the score for perceived breathlessness on the Borg scale during the last minute of cycling decreased from 7.5 (median) to 6. The subjects had not stopped exercise due to chest tightness but did stop when heavy breathing as a result of fatigue occurred.

The breathing at the preprogram walking test before the 10-week program increased significantly from 19 breaths/min at rest to 27 breaths/min immediately after the walk. The score for breathlessness on the Borg scale after termination of the walking test was 5. At the walking test after 10 weeks, the breathing rate was again 19 breaths/min and increased to 33 breaths/min. The score for breathlessness on the Borg scale also increased to 6. The difference in the increase in breathing rate was significant (p<0.05).
termination of the training.

value showed in stopped, bronchoconstriction tests, before compared with the initial Figure was PEFR
test.

14% readings during Figure 2. Mean VAS values from the questionnaire (see Table 3), together with the results of the analysis of the VAS values. Figure 2 gives the mean VAS values at different times during the rehabilitation program.

The questionnaire items are presented in Table 3, according to the answers in the questionnaire, the asthmatic subjects were unfamiliar with and afraid of maximal exercise when the rehabilitation program started. After 2 weeks of training, they felt no anxiety about exercising maximally (item 1) and the change was statistically significant. The idea of possibly experiencing breathlessness when exercising (item 2) was unpleasant and frightening at the outset. Most of the subjects stated that they had difficulties in distinguishing breathlessness due to fatigue from breathlessness caused by dyspnea. After only 2 weeks of training, there was no longer any fear of training-induced breathlessness. This improvement was significant (p<0.05). Despite the high intensity of the training, the asthma symptoms abated significantly throughout the study. All subjects were working or studying when the rehabilitation program began, which may explain why there were almost no changes in item 4 and 5.

Subjective Data (Questionnaire)

Of the 26 subjects, 17 showed a fall in PEFR by more than 15% after the preprogram ergometry test and were classified as having EIA. Only three of these 17 subjects had EIA after 10 weeks of training; in two of these three, the decrease in PEFR was also reduced. Of the nine subjects who did not have EIA after the preprogram test, two exhibited EIA after 10 weeks of training.

The PEFR readings during and after the ergometry tests, before and after the 10-week training period, are shown in Figure 1. During the 6 min of cycling, a comparison of the highest PEFR value and the initial value showed bronchodilatation. The mean increase in PEFR was 14% before and 12% after the 10 weeks of training. PEFR never decreased. When the cycling was stopped, bronchoconstriction took over and maximal reductions in PEFR were noted 10 to 15 min after termination of the test. The maximal decrease in PEFR compared with the initial value was 18% before the training program, and was reduced to 12% after 10 weeks of training. Exercise lability (percent rise + percent fall) was 32% before the 10-week training period and 24% after.

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The PEFR readings during and after the ergometry test before and after the 10-week rehabilitation program.
Table 4—The LCG Compared With OCG, Mean (±SD)*

<table>
<thead>
<tr>
<th></th>
<th>LCG</th>
<th>OCG</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Start</td>
<td>10 wk</td>
</tr>
<tr>
<td></td>
<td>(n=15)</td>
<td>(n=13)</td>
</tr>
<tr>
<td>FEV₁, L</td>
<td>2.0 (0.8)</td>
<td>2.3 (0.7)</td>
</tr>
<tr>
<td>FEV₁, % predicted</td>
<td>58 (23)</td>
<td>68 (18)</td>
</tr>
<tr>
<td>Walking distance, m</td>
<td>1,293 (61)</td>
<td>1,385 (128)†</td>
</tr>
<tr>
<td>Submaximal cycle test†</td>
<td>165 (21)</td>
<td>152 (22)†</td>
</tr>
</tbody>
</table>

*Numbers in parentheses represent SDs.
†p<0.05.

Emergency Department Visits

Ten weeks after termination of the 10-week training program, there had been only three occasions among the 26 subjects when emergency department visits were required, compared with nine occasions during the 10 weeks before the training period. Hospitalization was never required.

Medication

No changes in medication were reported when the subjects accomplished their follow-up tests at 2, 6, and 10 weeks.

Subgroup

The seven subgroup subjects tested 10 weeks before the start of the rehabilitation program (−10 weeks) showed no significant changes in the submaximal ergometry test, in the 12-min walking test, in methacholine test, or in FEV₁ when tested 10 weeks later (0 weeks). They answered the items in the questionnaire in the same way at the start of the program as they had done 10 weeks previously.

The OCG Compared With the LCG

Though the groups were different in physical capacity at the beginning of the rehabilitation program, there were no differences in training intensity or in PEFR variation during training. Respiratory values increased in both groups, but significantly better in the OCG. Cardiovascular values also increased in the two groups, but significantly better in the LCG (Table 4).

Discussion

The goal of the treatment of asthma is to help the individual to lead a normal life without restrictions. Strunk and Mascia8 suggest that asthma therapy should include adequate medication, education about asthma, at least normal activity, and psychological support. In most places, the treatment of asthma today includes adequate medication and education about the disease. Increased knowledge about asthma and its medication will give the asthmatic person a sense of security and will also motivate independence and encourage self-control of the asthmatic condition.26 Regular activity has been shown to bring several benefits, including increased physical fitness; decreased frequencies of asthma attacks, asthma symptoms, and school absenteeism; enhanced tolerance of attacks; and greater social and psychological independence.7,8,12,26

For children with asthma, there are many examples of rehabilitation programs,6,7,12,30,31 but there are few rehabilitation programs published and evaluated for adult asthmatic persons.4

The high-intensity training performed in an indoor pool was well tolerated, even though most of the asthmatic subjects had no experience of training as children or as adults. A recent study showed that asthmatic children were capable of exercising maximally, but the maximal training was started only after an initial 3-month period of submaximal training.7 In the present study, we found that asthmatic adults can start with very high-intensity training directly without an initial period of low-intensity exercise. No respiratory limits were evident except during asthma symptoms, when the subjects preferred to exercise at a lower intensity level.

The required heart rate for improving aerobic fitness is as low as 50 to 60% of the predicted maximum. Higher intensity, however, is considered to give still better results.25,32 As inpatients during the first 2 weeks, the subjects were encouraged to exert themselves to a maximal intensity level, to give them the experience of being able to exercise maximally. Our subjects were able to individualize their training intensity. After experiencing confidence and security when exercising at an almost maximal intensity level, they usually preferred to exercise at a higher intensity level for the remaining training period. The participants developed skill and confidence to follow the physical training, and spontaneously stated that they were pleased to be given knowledge and experience of how to exercise when they had asthma symptoms. They also stated that after the 10-week program, they were better able to distinguish between the sensation associated with a demand for increased ventilation caused by the external loads and that associated with bronchoconstriction.15

Based on reports from other studies, our program was constructed in order to offer a rehabilitation in which all subjects could succeed. Factors of importance from other studies were premedication with a β₂-agonist,1,4 use of a warm indoor pool,29,33,34 long warming-up,1,10,20 and cooling-down periods,8 and training in intervals.29 The training was accomplished at the hospital under controlled forms,4 it took place in a group with other asthmatic persons,8 and regular follow-up tests were performed.9,28
After the rehabilitation period, the mean heart rate was decreased at the end of the submaximal ergometry test and the mean walking distance was increased, indicating an increased physical capacity. Subjects with an initially low degree of fitness improved most, and those with initially normal fitness less, in accordance with previous reports on both asthmatic and healthy subjects.\textsuperscript{4,5,24,35,36} This is reflected in a much lower SD in mean heart rate at the end of the cycle test after 10 weeks than at the start. The walking distance, the experienced exertion and breathlessness, and the breathing rate after the completed walk increased during the 10 weeks. This suggests that the subjects were less anxious to force themselves and had ventilatory reserves to increase their walking distance and exertion. As the exertion score increased more (from 5.5 to 8) than the breathlessness (from 5 to 6) in 10 weeks, it appears that significantly greater exertion needed only a slight increase in ventilation, indicating that the walk was limited by fatigue rather than dyspnea.

We found that 17 of our subjects had EIA on commencement of the rehabilitation program. Interestingly, 14 of these 17 had no EIA when tested again after the 10-week period. Although two of the subjects without EIA at the start of the program did have EIA after 10 weeks, the airway reactivity and the propensity to develop EIA were undoubtedly lessened. Since the increase in breathing rate and breathlessness during cycling were almost the same before and after 10 weeks, the decreased EIA cannot be explained by lower ventilation.

Some studies have demonstrated that EIA can be treated successfully by training physically.\textsuperscript{5,37} We suggest that this alleviation of EIA is an important effect of improvement in physical fitness. However, these studies showing positive effect on EIA have been focused on childhood asthma. It has not been confirmed that physical training does in fact diminish EIA in adults.\textsuperscript{4,38}

Spirometry showed small but significant increases in FEV\textsubscript{1}, FEF\textsubscript{25}, and FEF\textsubscript{75} after the 10-week rehabilitation program. This indicates an attenuation of airflow obstruction. Other authors have also found an improvement in lung function after a training program,\textsuperscript{4,37} but in some studies no such benefit has been observed.\textsuperscript{5,7,38} In a recent investigation, Cochrane and Clark\textsuperscript{4} noted an improvement in pulmonary function, but explained this by a correction of the prophylactic treatment used. All our subjects reported that they had been taking inhaled B\textsubscript{2}-agonists and corticosteroids regularly for at least 2 weeks before the preprogram spirometry. Also, our subgroup of seven subjects studied 10 weeks before starting the rehabilitation program showed no change in FEV\textsubscript{1} between the examination 10 weeks before the examination and immediately before the start of the program. These facts point to an improvement in lung function. Probably this small improvement in FEV\textsubscript{1} was not a major reason for the increase in functional capacity.

The 10 weeks of training had no effect on the non-specific bronchial responsiveness, however, as there was no change in PD\textsubscript{20}. This is in agreement with other findings.\textsuperscript{4} However, there was an improvement in exercise-induced bronchoconstriction. This might indicate that obstruction is mediated by different mechanisms in the two forms of provocation (methacholine provocation and exercise training).\textsuperscript{39}

Only a few studies have claimed that asthmatic persons can alleviate their symptoms\textsuperscript{12,40} and decrease the number of emergency department visits and hospital admissions\textsuperscript{12} by exercise. As our subjects showed a reduction in the severity of their asthma and needed less acute asthma care after the rehabilitation program, it seems that the program also had a positive effect on the underlying asthma disease.

A rehabilitation program including regular physical training is an important component in the management of asthma. Persons with asthma and healthy individuals need regular physical activity to maintain their level of health.\textsuperscript{2}

All asthmatic persons, both active and inactive, should be made aware of the benefits of regular physical training. Inactive asthmatic subjects should get advice and help in how to exercise. They should be encouraged to exercise more often and the training should be prescribed by the patient's physician. This seems very important, as Garfinkel et al\textsuperscript{16} recently reported that 80% of the asthmatic subjects in their study claimed that they had never received any advice on how to exercise.

Merely providing advice and information to persons with asthma is not enough. They also need experience of regular physical training.\textsuperscript{5} We consider that this rehabilitation program fulfills the criteria for useful and suitable rehabilitation of persons with asthma and we have shown that the participants felt better and were motivated to continue regular physical training.

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