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HIGH-INTENSITY PHYSICAL TRAINING IN ADULTS WITH ASTHMA. A COMPARISON BETWEEN TRAINING ON LAND AND IN WATER

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ABSTRACT. The purpose of this study was to determine whether inactive asthmatic patients could perform high-intensity physical training equally well on land as in water, and to compare the effects of these training forms. Thirty-two adults with asthma, randomized into two groups, underwent a 10-week supervised rehabilitation program with emphasis on physical training. All patients, irrespective of training form, were able to exercise to maximal intensity (80–90% of estimated maximal heart rate). No asthmatic attacks occurred in connection with the training sessions. Respiratory variables remained almost unchanged in both groups. The asthma symptoms declined during the rehabilitation period, and the subjects needed less acute asthma care after the rehabilitation. The cardiovascular condition improved significantly and similarly in the two groups. Ten patients, 5 in each group, had exercise-induced asthma at the start of the rehabilitation. Only 3 patients, 2 from the water group and 1 from the land group, had exercise-induced asthma after 10 weeks. We conclude that indoor training, either on land or in water, is beneficial. The effects of these two training forms are almost equivalent.

Key words: asthma, bronchial hyperreactivity, exercise-induced asthma, physical fitness, rehabilitation, water exercise

INTRODUCTION

Many persons with asthma perceive their disease as a factor limiting their chances of improved fitness, and lack adequate knowledge about asthma and exercise (8). For these reasons, asthmatic subjects often avoid physical activity and choose an inactive lifestyle. This, in turn, may lead both to physical deconditioning (26) and to social and psychological limitations in daily life (23). In several studies, decreased physical fitness has been observed among asthmatic persons, both children and adults (4, 15, 19). However, rehabilitation, including physical training, has been shown to improve physical fitness, reduce anxiety about physical activities, alleviate asthma symptoms, and reduce the number of emergency room visits and days absent from school (13, 23, 25). In addition, our research group found in a recent study that adults with asthma were able to exercise at a maximal intensity in water without developing exercise-induced asthma (EIA) or increasing their bronchial hyperreactivity (6). After a 10-week training period in the same study, significant improvements were observed in respiratory and circulatory variables, in asthma symptoms, and in the patients' ability to cope with daily life.

Exercising in water has been recommended as a suitable form of training, since it has been reported to induce less bronchoconstriction than cycling or running (7, 21). The limited availability of suitable swimming pools, however, restricts regular use of this form of training. Moreover, many asthmatic persons are not interested in exercising in water. The present study was undertaken to determine whether inactive asthmatic patients were able to perform high-intensity physical training equally well on land as in water during a 10-week period. In addition, the different training forms were compared regarding their effects on cardiovascular condition, lung function and asthma symptoms. The impact of the training on the activity level, the number of emergency room visits, and the subjects' ability to carry out everyday activities were evaluated.

METHODS

Subjects

Thirty-two adult asthmatic patients from the Lung Clinic, Uppsala, Sweden, 14 women and 18 men, agreed to participate in the study. They fulfilled the following criteria: (a) chronic well-controlled asthma (according to ATS) (22) of a mild or moderate degree of severity, (b) FEV1% > 75 after inhalation of a $\beta2$ agonist, and (c) no concomitant disease. Their age, gender, physical condition and baseline spirometry are presented in Tables I and II. The means of the flow values and the specific conductivity were low (between 42% and 60% of predicted), and the functional capacity and residual volume were high (between 122% and 132% of predicted), as expected.

Table I. *Baseline characteristics of the study population; number of patients (n) or mean (SD)*

	Land group	Water group
No. of patients	14	18
Gender, F/M (*n*)	5/9	9/9
Age (years)	38 (12)	34 (8)
Reversibility (%)	14 (9)	14 (15)
Medication: low/medium/high (*n*)	3/8/3	4/5/9
Physical condition: low/ordinary (*n*)	2/12	6/12

* $p < 0.05$ for difference between land group and water group.
F = female; M = male.
Medication: low = inhaled corticosteroids ≤400 μg per day; medium = inhaled corticosteroids >400 μg per day, and possibly long-term $\beta2$ stimulants; high = same as for medium level plus oral corticosteroids and/or oral $\beta2$ agonists and/or theophylline.
Physical condition: low or ordinary as defined by Nordenfelt et al. 1985 (18).
Reversibility % = change in FEV1 after inhalation of a $\beta2$ agonists.

The patients were randomized into two groups, one of which was to exercise on land (land group, 14 patients) and the other in water (water group, 18 patients). There were no significant differences in baseline characteristics between the two groups at the start of the rehabilitation. The medication was kept constant during the study period.

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

Rehabilitation program

The 32 patients took part in a 10-week rehabilitation program. They were all outpatients, but attended the hospital daily from Monday to Friday during the first 2 weeks, period 1, and twice a week during the following 8 weeks, period 2. The rehabilitation program was identical in the two groups except for the physical training, which was carried out on land indoors in the land group and in water indoors in the water group.

Interval training

Each training session was carried out in a gymnastic hall (land group), at a room temperature of 22°C and relative humidity of 20–30%, or in an indoor swimming pool (water group), with a water temperature of 33°C, at a room temperature of 24°C and a relative humidity of at least 60%. The subjects were instructed to use a $\beta2$ agonist before training and, if necessary, during the exercise session. Each training session, both on land and in water, started with a warming-up period (15 minutes) with arm and leg exercises, walking, and low-intensity jogging. The exercise continued with interval training, comprising five 2-minute periods of intensive exercise separated by $1\frac{1}{2}$-minute periods of low-intensity exercise (total 16 minutes). These periods of interval training consisted of varied repetitive large-muscle dynamic exercises with a target pulse rate of 80 to 100% of maximal intensity. A cooling-down period (7 minutes) and stretching exercises (7 minutes) completed the 45-minute 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.

Period 1. Period 1, lasting for 2 weeks, comprised a daily (5 days a week) training session on land or in the pool for 45 minutes, daily theoretical lessons in anatomy, physiology, pathophysiology, medication or physical training, and daily practical sessions concerning techniques for inhalation, breathing, relaxation or incontinence. All training sessions and practical sessions were led by one of two physiotherapists, while the theoretical sessions were led by a physiotherapist, a nurse or a physician. The target pulse rate in the interval training was 80–90% of the predicted maximal heart rate. The heart rate of 100% was calculated by the formula 220 beats/minute minus age (in years) (26). The pulse rate was measured by a physiotherapist, a nurse or the patient, before the training, after the warming-up, after each interval, and immediately after the cooling-down period. The subjects also estimated their sense of exertion according to a Borg scale (2), from 0–10, with 10 as the highest degree of exertion. This was done after the warming up, after the interval period, and after the cooling-down period. Peak expiratory flow rate (PEFR) was measured by each patient before the training session and immediately after the warming-up, the interval training, and the

Table II. *Spirometry values at the start and at the end of the 10-week program; mean (SD)*

	Land group		Water group	
	$n = 14$ Start	$n = 14$ After 10 weeks	$n = 18$ Start	$n = 17$ After 10 weeks
FEV1 (l)	2.8 (0.8)	2.6 (0.7)	3.2 (0.8)	3.3 (0.8)
FEV1 (% pred.)	77 (16)	72 (13)	79 (17)	81 (16)
FRC (l)	3.7 (1.1)	3.6 (1.2)	3.6 (0.8)	3.3 (0.9)
sGaw ($l \cdot kPa^{-1} \cdot s^{-1}$)	1.04 (0.6)	1.02 (0.4)	1.2 (0.6)	1.4 (0.7)
FEF25 (l/sek)	0.75 (0.4)	0.56 (0.3)*	0.97 (0.5)	1.06 (0.6)
FEF75 (l/sek)	3.96 (1.4)	3.7 (1.1)	4.89 (1.7)	5.24 (1.9)
RV (l)	2.05 (0.7)	1.86 (0.5)	1.85 (0.7)	1.53 (0.6)*

There were no significant differences between the land group and water group at the start.
* $p < 0.05$ compared to the value at the start.

cooling-down periods. The PEFR recordings were also continued 9 hours post-exercise. Results from day 3 have been chosen to represent a training session, as we wanted to evaluate the training as early as possible, but after the patients had become familiar with the exercises.

Period 2. During the following 8 weeks, the subjects continued physical training twice a week in groups of up to 8 subjects. The intensity level was measured subjectively by the patients themselves, by estimating their sense of exertion on the 10-graded Borg scale after training. They were encouraged to exercise to a level of at least 7 to 8 on this scale.

Measurements

The subjects underwent the tests described below at the start of the program and after 2 and 10 weeks. In order to check for variations in cardiovascular condition, the patients were also tested 10 weeks before the start of the program. No significant differences were observed between pre-program values and the values at the start either of the sub-maximal cycle test, or of the 12-min walking test.

A sub-maximal 6-minute ergometry test was performed on a cycle ergometer with a mechanical friction load at a constant pedalling rate. The workload was adjusted individually. Guided by the results of the maximal exercise test (see below) and by the clinical condition of each individual subject, a load was applied with the aim of attaining a heart rate of 140–180 beats/minute after 6 minutes. The workload was the same on all subsequent test occasions, and was kept constant during the 6-minute cycle test. PEFR, the pulse rate and the breathing rate were measured before, during and after cycling. The pulse rate was measured by palpation by the physiotherapist, or by using a pulse meter (Sport Tester), and the breathing rate was measured by the physiotherapist with a stethoscope. Exertion and breathlessness were estimated on the same occasions using the 10-graded Borg scale described above for exertion.

A 12-minute walking test, in a hospital corridor, was performed to measure the distance that the subjects were able to walk in 12 minutes.

Spirometry was carried out with a body plethysmograph (Jaeger Masterlab body 175,050) for measurement of lung volume and specific airway conductance, and a wedge spirometer (Ohio) for recording of flow–volume curves.

PEFR was measured with a peak flow meter. The highest value of three attempts was used. The subjects had an individual PEFR meter (Mini-Wright), and the same one was used throughout the study.

A methacholine provocation test was carried out to measure the airway reactivity, expressed as the amount of inhaled methacholine required to cause a fall in FEV1 by 20%.

The above-mentioned tests were performed as described by Emtner et al. (6).

Questionnaires

Three different questionnaires were administered, with questions concerning physical exercise, the effects of asthma on everyday life, and the subjects' experiences of the 10-week rehabilitation period, respectively. The answers were given on a 10-cm visual analogue scale (0–10 cm), where 0 indicates the worst value and 10 the best.

The number of *emergency room visits* for acute asthmatic attacks during the 10 weeks before the rehabilitation program and the 10 weeks after the start of the program was recorded.

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

A diary was kept by each patient. Every evening during the 10-week program, the patients were to record their asthma symptoms on a 4-graded scale.

A maximal exercise test, using a cycle ergometer, was performed. The load was increased stepwise by 10 W each minute, and ECG was recorded. This was carried out 10 weeks before the start of the program in order to evaluate the physical condition—as defined by Nordenfelt et al. (18)—of each subject, and to exclude persons with cardiovascular diseases. No person had to be excluded on the grounds of a pathological maximal exercise test.

Statistical analysis

The data were analysed for statistically significant differences between the groups by the unpaired *t*-test (parametric data) and Mann-Whitney's U-test (non-parametric data). One-factor analysis of variance for repeated measurements (Fischer PLSD) was used for parametric data and Friedman's test for non-parametric data. A paired *t*-test (parametric data) and the Wilcoxon signed-rank test (non-parametric data) were used for comparison between values obtained 10 weeks before and at the start, and between those obtained at the start and after 10 weeks.

RESULTS

Training, Period 1

All 32 asthmatic subjects attended all training sessions during the first 2 weeks. In both groups, the subjects were able to maintain the very high intensity during the training sessions without getting asthma symptoms and without being afraid of having an asthma attack. The perceived exertion, PEFR and training intensity during a training session on land and in water are presented in Table III. Four hours after the training session, there was a slight but non-significant decrease in PEFR in both groups compared to the pre-session values (from 464 to 448 l/minute in the land group, and from 489 to 457 l/minute in the water group). These reductions were maintained for another 5 hours. Six subjects in the land group and 5 subjects in the water group showed a decrease in PEFR of more than 10% after the training session. This decrease persisted in 4 subjects from the land group and in 2 subjects from the water group up to 9 hours after cessation of training. No asthma symptoms were reported after this period.

Period 2

All 32 patients completed the physical training twice a week during the 8 weeks of period 2. One woman in the water group, however, was unable to continue the

Table III. *The perceived exertion according to the 10-graded Borg scale, the PEFR (l/minute), and the training intensity as indicated by heart rate (HR) in % of predicted maximal heart rate; mean (SD)*

	After warming-up			After interval training			After cooling-down		
	Borg	PEFR	HR (%)	Borg	PEFR	HR (%)	Borg	PEFR	HR (%)
Land group	2.9 (1.4)	484 (123)	77 (18)	7.2 (1.5)	481 (97)	96 (10)	4.8 (2.0)	457 (104)	73 (12)
Water group	4.2 (1.6)	536 (81)*	79 (14)	8.0 (1.0)	532 (85)*	91 (10)	4.3 (1.1)	483 (93)	70 (9)

The pre-session peak expiratory flow rate (PEFR) values were 464 (90) l/minute in the land group and 489 (87) in the water group (NS).
* $p < 0.05$ compared to the pre-session values.

physical training in water after about 3 weeks because of skin sensitivity, and completed the exercise during the remaining weeks on land. She was therefore excluded from the 10-week test. The patients exercised at a high intensity, 7–10 on the 10-graded Borg scale. Even if they had asthma symptoms before a training session, they still attended, but then exercised at a lower intensity. On three occasions when subjects were not able to attend the training session, they exercised in another way, for example, on a bicycle, or by playing badminton or tennis.

Cardiovascular condition. There were no differences in the cardiovascular condition between the two groups after the 10 weeks. The mean heart rate (beats/minute) at steady state during the cycle test decreased significantly in both groups, from 155 at the start of the program to 144 at 10 weeks ($p < 0.01$) in the land group, and from 150 to 138 in the water group ($p < 0.01$). The walking distance covered in 12 minutes increased significantly in both groups, from 1430 to 1520 m in the land group ($p < 0.05$) and from 1384 to 1485 m in the water group ($p < 0.05$).

Respiratory changes. The lung function variables remained almost unchanged in both groups. Although there was a tendency towards deterioration in the land group and a tendency towards improvement in the water group, there were few significant changes (Table II). PD 20 (= provocation dose causing a fall in FEV1 by 20%) for methacholine was unchanged in both groups.

The breathing rate at the end of the sub-maximal cycle test was significantly decreased in the two groups after the 10-week program, compared to the corresponding value at the start. The breathing rate decreased from a mean of 32 (8) to 25 (6) ($p < 0.01$) in the land group, and from 27 (8) to 22 (5) ($p < 0.05$) in the water group.

The PEFR readings during and after the ergometry test, before and after the 10-week training period, are shown in Figs. 1 (land group) and 2 (water group), and in Table IV. There were no significant differences in pre-test values between the two groups either before or after the 10-week training period. The pre-test values in both groups increased significantly during the 10-week program.

PEFR was decreased after termination of the cycle ergometry test compared to the value at the start. At the start of the 10-week period, the mean decrease in the land group was 6% ($p < 0.05$), and after 10 weeks it was 2%. In the water group, there was a decrease of 5% ($p < 0.05$) at the start and an increase of 1% after 10 weeks.

Ten of the 32 subjects (5 from each group) showed a fall in PEFR by more than 10% after the pre-program ergometry test, and were classified as having EIA. Only 2 (one from each group) of these 10 subjects had EIA after 10 weeks of training. Of the 22 subjects who did not have EIA after the pre-program test, 1 (from the water group) exhibited EIA after 10 weeks of training. Interestingly, 6 of the subjects who had EIA at the start also showed a fall in PEFR after the training session on day 3 (3 from each group).

There were no differences in asthma symptoms (measured on a 4-graded scale) between the two groups during the 10-week period. In both groups, the symptoms abated throughout the period.

Questionnaires (visual analogue scale)

At the outset, many of the patients were unfamiliar with and anxious about maximal physical training, and had difficulty in distinguishing breathlessness due to normal fatigue from breathlessness caused by bronchoconstriction. After 2 weeks of training, there were significant improvements in these respects, which persisted during the 10-week period (Table V).

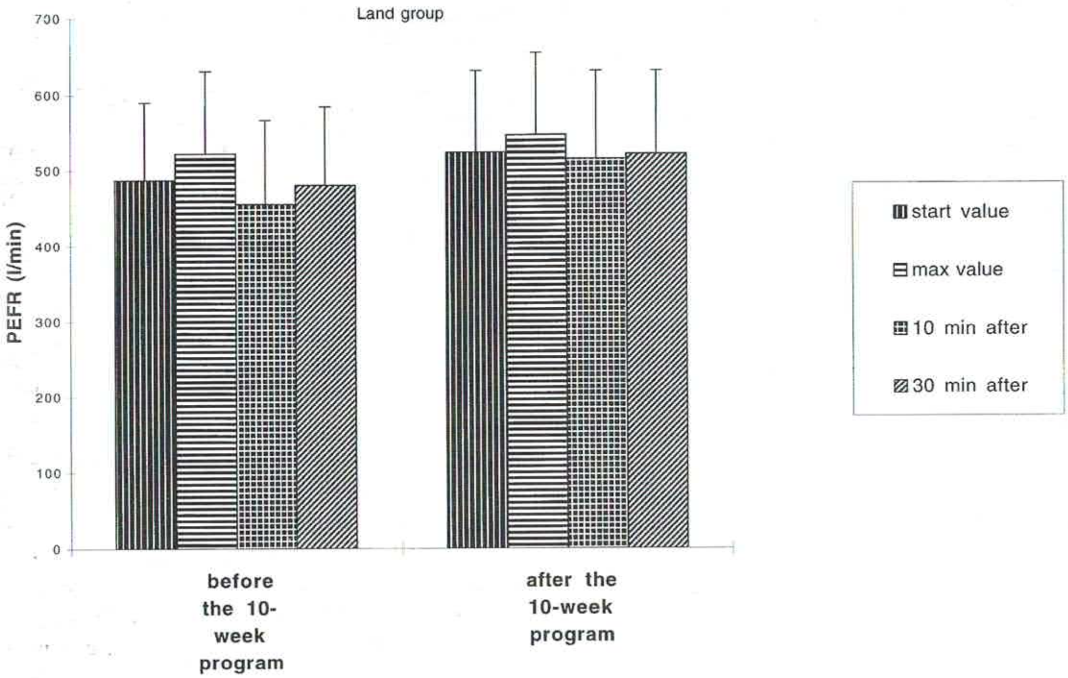

Fig. 1. Mean peak expiratory flow rate (PEFR) readings and standard deviations in the land group during and after a 6-minute cycle ergometry test before and after the 10-week rehabilitation program.

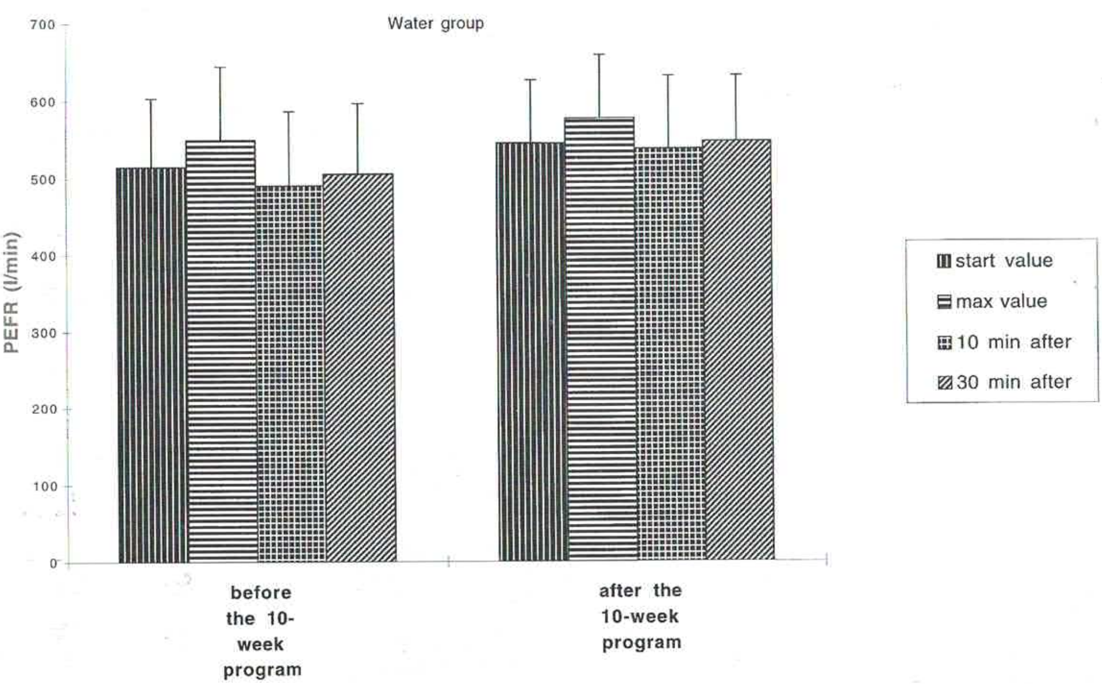

Fig. 2. Mean peak expiratory flow rate (PEFR) readings and standard deviations in the water group during and after a 6-minute cycle ergometry test before and after the 10-week rehabilitation program.

Table IV. *Mean PEFR values during the cycle test, measured before the start of the program and after the 10 weeks*

	Land group			Water group		
	Start	After 10 weeks	*p* value	Start	After 10 weeks	*p* value
Start value	487	523	<0.05	514	544	<0.01
Max value	521	546	NS	549	576	<0.05
10 minutes after	455	514	<0.05	490	537	<0.01
30 minutes after	480	520	<0.05	505	546	<0.01

There were no significant differences between the groups at the start.

Before the rehabilitation program, the patients also felt limitations in their daily lives and had inhibitions in joining in activities, but after the 10-week period these limitations had decreased (Table VI).

As seen in Table VII, almost no differences in their opinions about the training were found between the two groups. All patients reported positive experience of the 10-week period and wished to continue physical training.

Emergency room visits

During the 10 weeks before the rehabilitation program, there had been 7 occasions among the 32 subjects when emergency room visits were required, compared to 3 occasions during the rehabilitation period.

Medication

No changes in medication were reported at the tests at 2 and 10 weeks.

DISCUSSION

Physical inactivity is an important factor threatening health and well-being, whereas activity diminishes the risks of cardiovascular diseases, osteoporosis and obesity (10). This is true also for persons with asthma, who are often deconditioned (4, 15, 19), do not dare to be physically active (8) and can be physically disabled in a number of ways in their daily lives. They greatly need advice and encouragement to be able to exercise. The medical profession needs knowledge about how to advise them. Exercising in water is traditionally considered to be the most beneficial and least asthmogenic form of training (9, 17), since there is less bronchoconstriction during exercise in warm humid air than during exercise in ambient room air (7, 21). However, in these studies, the asthmatic subjects exercised in a laboratory setting, without pre-medication and without having a long warming-up period (1). Our purpose was to determine whether training could be performed on land with equally good results as in water, when the conditions were optimized. In both types of training in our study, pre-medication (5), a long warming-up period (8, 17), and training in intervals (17) were used.

During the 10 training sessions in period 1, PEFR was measured, and virtually no differences were found between the land group and the water group. PEFR increased throughout the training session and decreased

Table V. *Questionnaire 1. Physical exercise; mean VAS ratings (0–10 cm) at the start, after 2 weeks and at the end of the 10-week program*

	Land group			Water group		
Questions	$n = 14$ Start	$n = 14$ After 2 weeks	$n = 14$ After 10 weeks	$n = 18$ Start	$n = 18$ After 2 weeks	$n = 17$ After 10 weeks
1. I am able to exercise at maximal intensity. (never = 0; always = 10)	6.8	9.2*	9.5*	7.4	9.7*	9.7*
2. I often exert myself. (never = 0; always = 10)	5.6	8.3*	8.9*	5.2	8.6*	8.3*
3. I am afraid of experiencing breathlessness when exercising. (always = 0; never = 10)	6.6	8.8*	9.1*	6.8	9.3*	9*

* $p < 0.05$ compared to the initial values.

Table VI. *Questionnaire 2. Influence of asthma on everyday life; mean VAS ratings (0–10 cm) at the start and end of the 10-week program*

	Land group		Water group	
Questions	$n = 14$ Start	$n = 14$ After 10 weeks	$n = 18$ Start	$n = 17$ After 10 weeks
1. Have you ever been home from work because of asthma symptoms? (very often = 0; not at all = 10)	7.9	9.4*	6.8	8.9*
2. How have you experienced your asthma symptoms during the last 2 months? (very severe = 0; mild = 10)	7.5	8.5	6.7	8.7*
3. How do you manage to go on holiday? (not at all = 0; very well = 10)	8.3	9.2	9.4	9.5
4. My asthma disease influences my daily life. (a lot = 0; not at all = 10)	6.2	8.1*	6.4	7.9*
5. How do you manage to go for a walk? (not at all = 0; very well = 10)	8.5	9.2*	8.5	9
6. How do you manage to go swimming? (not at all = 0; very well = 10)	6.2	7.6	5.9	7.1
7. How do you manage to jog? (not at all = 0; very well = 10)	3.4	6.9**	3.6	5.5**
8. How do you manage to go cycling? (not at all = 0; very well = 10)	6.7	9.0**	6.2	7.6**
9. How do you manage to do gymnastics? (not at all = 0; very well = 10)	6	8.7**	4.8	6.1*
10. How do you manage a racket sport? (not at all = 0; very well = 10)	5.5	7.9**	5.2	6.7**

* $p < 0.05$, ** $p < 0.01$, compared to the initial values.

slightly after cessation of training. This is in accordance with results from a previous study concerning training in water (6).

The propensity to develop EIA was lessened in both groups. One explanation might be lower ventilation. The breathing rate during the cycle test was decreased in both groups after the 10 weeks. Robinson et al. (20) and Cochrane & Clark (5) have also shown that conditioning results in a reduction in ventilation during strenuous activities. Most of the patients who had EIA before the training had lost their effort-induced bronchial liability after the rehabilitation, as indicated by an increased PEFR during and a decreased PEFR after a maximal workout. In the group of patients without EIA, no difference in this respect was observed. Previously we found that EIA decreased among adults after a training period (6). Similar results have been reported from studies on children with asthma (12, 24). In contrast to the improvement with respect to EIA, non-specific bronchial responsiveness, as measured by methacholine provocation, was not affected, in accordance with the findings of other investigators (5).

Table VII. *Questionnaire 3. Experiences of the 10-week period of training; mean VAS ratings (0–10 cm)*

	Land group $n = 14$	Water group $n = 17$
1. Exercising twice a week has been a pleasant experience. (not at all = 0; very much = 10)	8.8	9.3
2. The training has taken too much time. (very much = 0; not at all = 10)	9.4	7.8*
3. I have experienced pain in connection with the exercise. (very much = 0; not at all = 10)	8.5	8.3
4. I look forward to continuing physical training. (not at all = 0; very much = 10)	8.9	8.4
5. I would like to change the type of physical training. (very much = 0; not at all = 10)	7.6	8.5
6. The solidarity in the group has been of great value. (not at all = 0; very much = 10)	7.3	8.8

* $p < 0.05$ for differences between land and water groups.

The lung function variables were virtually unchanged in both groups after the 10 weeks. However, the slight tendency towards improvement in the water group is supported by results from a previous study concerning high-intensity training in water, where FEV1, FEF25 and FEF75 increased significantly after a 10-week training period (6). The training on land did not influence the lung function variables appreciably. This is in conformity with other findings concerning training on land or sub-maximal training in water (3, 5, 19–21, 25). The cardiovascular condition of our patients improved to a similar extent in the two groups. This was evident both in the sub-maximal cycle test and in the 12-minute walking test. The results conform with those of other studies on adult asthmatic patients exercising in water (6) and on land (5, 20). Thus, as seen in this study, the cardiovascular effects of indoor land training seem to be similar to training in water.

High-intensity training was well tolerated both when performed in water (6, 25) and on land (5, 20). Most of the patients in this study were surprised to find how intensively they were able to exercise. All 32 patients continued to exercise during the final 8 weeks, for the reported reason that they felt well and had obtained experience and knowledge of how to exercise. The group support was also an important component for most of the patients.

Irrespective of the form of training, our rehabilitation program resulted in reduced anxiety about exercise, alleviation of asthma symptoms, and a decrease in the number of emergency room visits. This is in accordance with results from other training studies both in children and adults (13, 23, 25).

CONCLUSIONS

The results of this study indicate that both of the described training forms are beneficial, and that they are equivalent concerning improvements in cardiovascular condition, asthma symptoms and the patients' ability to carry out everyday activities. It has been found in several studies (11, 14, 16) and in provocation tests at laboratories (1) that physical training, especially in cold air, may influence the airways deleteriously. Thus, even if the physical training in our study did not lead to any respiratory disadvantages, we cannot assume that all training is beneficial. It is still not known what temperature and humidity of the inhaled air are required for minimal bronchoconstriction.

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