Effects of an Intensive 4-Week Summer Camp on Cystic Fibrosis*

Pulmonary Function, Exercise Tolerance, and Nutrition

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Study objectives: Cystic fibrosis (CF) patients prefer exercise to most other forms of therapy, although objective improvement remains controversial. Israeli CF patients have attended a summer program in Switzerland for many years with subjective improvement. However, CF camps worldwide have been cancelled recently, due to fears of cross-infection with resistant organisms. Therefore, we evaluated the effect of attending the camp on pulmonary function, exercise tolerance, and nutritional state in CF patients.

Design: Weight, resting pulmonary function, incremental exercise test results, and sputum culture findings were assessed before and after a 4-week intensive summer camp.

Setting: Davos, Switzerland (altitude, 1,500 m).

Patients: Thirteen Israeli CF patients (seven women and six men) with an age range of 9 to 25 years who had mild-to-moderate lung disease. No patients had Burkholderia cepacia detected in their sputum.

Interventions: The program included a high-calorie diet, chest physiotherapy, daily mountain climbing, and indoor activities. Arterial oxygen saturation (SaO₂) was maintained at > 88% during exertion.

Results: Exercise tolerance improved significantly. The peak work capacity increased by 12.7%, the maximal oxygen uptake increased by 10%, and minute ventilation increased by 18.5% (p < 0.0005). Of the calculated parameters, the anaerobic threshold improved by 17%. Ventilation was always the limiting factor during exercise, although it improved. There was no significant change in resting lung function and pulse or in SaO₂ decline at maximal exercise. The mean weight gain was 1 kg. No patient acquired B cepacia.

Conclusions: An intensive summer camp improved exercise tolerance and nutrition in CF patients. This may explain improved patient well-being despite unchanged values for resting lung function. The reestablishment of summer camps, with special care to avoid cross-infection, should be considered.

Cystic fibrosis (CF) is a life-shortening disease in which pulmonary involvement accounts for > 90% of the mortality rate.¹ Viscid mucus within the bronchioles leads to bronchiolitis and infection, and eventually results in the destruction of the lung architecture and respiratory failure. Exercise intolerance and exertional dyspnea are common complaints of CF patients and generally worsen as the disease progresses.² ³ However, it is not possible to predict exercise tolerance for an individual from the results of static pulmonary function tests.⁴ ⁵

CF patients enjoy exercise and prefer it to most other therapeutic options. Physical activity as an adjunct to daily physiotherapy has long been recommended for patients with CF to enhance airway clearance of thick sputum, to decrease the incidence of infection, to prevent the deterioration of lung function, and to improve well-being and fitness.
general, both exercise and physiotherapy are considered to be necessary and complementary. In addition, the importance of good nutrition in patients with CF has been emphasized.

Despite these recommendations for CF patients, the objective effects of exercise-training programs remain controversial. Most studies do not demonstrate improved lung function, although improvement was shown following an intensive 17-day program and a brief summer camp. Exercise tolerance was not improved following a 4-week inspiratory muscle-training program but did improve in two 3-month studies of aerobic conditioning. For several years, Israeli children have been participating in a 4-week CF summer camp in Davos, Switzerland, with marked subjective improvement in well-being, endurance, and lung function. In view of the paucity of objective data regarding the effects of such programs, we undertook to study weight gain, pulmonary function, exercise tolerance, and arterial oxygen saturation before and after the program.

**Materials and Methods**

The camp was located in Davos, Switzerland, at an altitude of 1,500 m, and lasted 4 weeks. The beauty and challenge of the surrounding mountains enabled physical activity combined with great enjoyment. For this reason, as well as for the decreased levels of aeroallergens, Davos is a popular resort for patients with pulmonary disease. The cool climate was a relief from the high levels of aeroallergens, Davos is a popular resort for patients with pulmonary disease. Patients colonized with *Burkholderia cepacia* were not included in the summer camp, and none of the patients included have had *B cepacia* grown in their sputum cultures in the 2 years since attending the camp. Most patients showed mild-to-moderate reduction in FEV/FVC ratio (Table 2), although one boy had a severe obstruction. Patients with acute pulmonary exacerbations were included in the program. Patients received maintenance therapy with oral and/or inhaled antibiotics, pancreatic enzyme supplements, vitamins, and bronchodilator inhalations as required. An attempt was made to continue the therapy that had been individually prescribed by each patient’s physician.

The camp program included the following:

1. A high-energy diet with daily nutritional supplements;
2. From 1 to 3 h of intensive daily chest physiotherapy (according to disease severity);
3. Daily hikes in the surrounding mountains, gradually increasing in difficulty after a 3-day acclimatization period. After the first week, the patients were generally climbing 300 to 500 m over a period of 3 to 4 h. *SAO₂* was monitored using a pulsimeter (Biox 3700; Ohmeda; Andover, MA), and the pace of climbing was controlled to maintain *SAO₂* at > 88 to 90% most of the time;
4. Patients participated in additional indoor sport activities for 2 h three times per week, including swimming, playing ball games, and using a trampoline;
5. Adequate rest periods were ensured so that no patient reached exhaustion at any time; and
6. Care was taken to provide adequate hygiene and physiotherapy in separate rooms.

The following measurements were performed in Israel, before the camp and within 2 to 10 days after the participants returned to Israel: weight; spirometry and flow-volume analysis before and after bronchodilator inhalation; maximum voluntary ventilation (MVV); a maximal incremental exercise testing on a bicycle ergometer according to the protocol of Wasserman et al following bronchodilator therapy to prevent exercise bronchospasm. BP, heart rate, work rate, oxygen uptake (Vo₂), minute ventilation (Ve), and *SAO₂* were monitored throughout the exercise period. From these measurements, the following were calculated: oxygen pulse (ie, Vo₂/heart rate), dyspnea index based on at least three positive results of sweat tests as well as by pulmonary and/or GI symptoms. Shwachman-Kulczycki scores ranged from 40 to 90.

*Values given as mean (SE). MEF₅₀ₐ = midexpiratory flow at 50% of vital capacity.
(Ve/MVV ratio) and the anaerobic threshold (ie, the point at which Ve/Vo2 rises, expressed as the percent predicted maximal Vo2 [Vo2max]). Any weight gain was taken into consideration in calculating the results following participation in the program. Sputum cultures were repeated on the return of participants to Israel and again 6 months later.

The study was approved by the institutional committee on human research, and informed consent for participation in this study was obtained from parents of the CF patients or from the patients themselves if they were > 18 years of age.

Statistical Analysis

Analyses of data were performed using the paired Student t test comparing each patient’s data before and after the program. All values are expressed as the mean (SE) unless otherwise noted. A p value of < 0.05 was considered to be significant.

Results

All patients reported a definite subjective improvement in well-being, describing less breathlessness on exertion, more energy, less fatigue, and increased appetite. There was a significant weight gain (Table 1) for the group following the program. No patients acquired B cepacia.

The patients had mild-to-moderate pulmonary disease (although one boy had severe airway obstruction), as shown by the baseline mean vital capacity and expiratory flow rates (Table 2). Following the program, there was no significant change in resting vital capacity and maximal expiratory flow rates in both the large and small airways. Similarly, the cardiorespiratory parameters at rest did not change following the program (Table 3). In particular, there was no evidence of training bradycardia, and the resting heart rate was unchanged following the program.

The SaO2 at rest was in the normal range but fell to 94% on maximal exertion both before and after the program. Only three patients experienced a fall of > 5% in SaO2. In should be noted that the mean SaO2 in Davos was 97% (1%) at rest but fell on mild exertion to 92% (2%), and on maximal exertion (ie, rapid climbing) it fell to 89% (2%), probably due to the altitude of the location. In order to maintain oxygen saturation at ≥ 90%, the patients with more severe lung disease climbed at a slower pace and did not take part in the longer climbs.

In contrast to the resting pulmonary function, there was a marked improvement in dynamic cardiorespiratory parameters measured during the maximal incremental exercise test (Table 4) as well as in the MVV. Peak work capacity increased by 12.7% and was associated with a similar rise in Vo2max from 84% of predicted (19% of predicted) to 93% of predicted (20% of predicted). The Ve increased most significantly (18.5%; p < 0.0005). Ve, MVV, duration of the exercise test, and Vo2max are displayed graphically for each subject before and after the camp in Figures 1–4.

Of the calculated measurements (Table 4), both the oxygen pulse (ie, Vo2/heart rate) and the anaerobic threshold (measured as a percentage of the predicted Vo2max) improved. However, the Ve/MVV ratio was unchanged, indicating no significant change in ventilatory reserve.

Specimens for sputum cultures taken before the

<table>
<thead>
<tr>
<th>Parameter Before</th>
<th>After</th>
<th>p Value</th>
</tr>
</thead>
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<tr>
<td>Workload 110 (8)</td>
<td>124 (8)</td>
<td>&lt; 0.001</td>
</tr>
<tr>
<td>Ve % predicted 84 (5)</td>
<td>95 (6)</td>
<td>&lt; 0.001</td>
</tr>
<tr>
<td>mL/kg/min 34 (2)</td>
<td>38 (2)</td>
<td>&lt; 0.001</td>
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<tr>
<td>Vo2 76 (5)</td>
<td>83 (6)</td>
<td>&lt; 0.01</td>
</tr>
<tr>
<td>Ve 70 (6)</td>
<td>83 (7)</td>
<td>&lt; 0.0005</td>
</tr>
<tr>
<td>MVV 89 (7)</td>
<td>99 (3)</td>
<td>&lt; 0.005</td>
</tr>
<tr>
<td>Heart rate, beats/min 87 (3)</td>
<td>89 (2)</td>
<td>NS</td>
</tr>
<tr>
<td>Endurance, min 6.5 (0.5)</td>
<td>7.6 (0.4)</td>
<td>&lt; 0.01</td>
</tr>
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</table>

*Values given as mean (SE) percent predicted, unless otherwise indicated. See legend of Table 3 for abbreviation not used in text.

**Table 4—Cardiorespiratory Parameters at Peak Workload**

*Statistical Analyses of data were performed using the paired Student t test comparing each patient’s data before and after the program.

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Specimens for sputum cultures taken before the
camp, during the first year after the camp, and 2 years after the camp showed no evidence of *B. cepacia*. In addition, cultures of sputum taken from patients before the camp were positive for *Pseudomonas aeruginosa*, except in two patients who had not been able to expectorate (Table 5). There was no change in the incidence of panresistant *P. aeruginosa* or of methicillin-resistant *S. aureus* in the period following the camp.

**Discussion**

A 4-week program for CF patients, which included intense daily activity, physiotherapy, and a high-calorie diet, at an altitude of 1,500 m in the Swiss Alps markedly improved several respiratory and cardiovascular parameters in those patients. Peak workload, as a general measure of increased exercise tolerance, was significantly increased.

Cross-infection and, in particular, the acquisition of *B. cepacia* have been a concern about participation in such programs, which has resulted in the closing of many summer camps for CF worldwide. We took care to ensure that none of the participants in this camp were carrying *B. cepacia*. Follow-up data for patients participating in the camp indicate that there was no obvious acquisition of multiresistant *P. aeruginosa* or methicillin-resistant *S. aureus* at the camp, although DNA fingerprinting of bacteria was not performed. It may be important to acquire induced sputum samples in patients who are unable to expectorate before their inclusion in CF camps. This would ensure that patients not infected with *P. aeruginosa* do not participate with patients who have cultures that are positive for *P. aeruginosa*. In addition, this would identify patients with *B. cepacia*. It must be emphasized that strict adherence to principles of hygiene should be required in CF camps and that ultimate responsibility remains with the participants. No guarantees can be provided that cross-infection will not occur. However, our CF patients opted for participation and for reaping the

![Figure 2. MVV before and after participation in the summer camp.](image1)

![Figure 3. Exercise endurance (duration) before and after camp.](image2)

![Figure 4. VO2 max before and after participation in the summer camp.](image3)

<table>
<thead>
<tr>
<th>Patient</th>
<th>Precamp</th>
<th>Within 1 Yr Postcamp</th>
<th>2 Yr Postcamp</th>
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<tbody>
<tr>
<td>1</td>
<td>PsA (I)</td>
<td>PsA (I)</td>
<td>PsA (R)</td>
</tr>
<tr>
<td>2</td>
<td>PsA (I)</td>
<td>PsA (I)</td>
<td>PsA (I)</td>
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<td>PsA (I)</td>
<td>PsA (I)</td>
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<td>PsA (S)</td>
<td>PsA (S)</td>
</tr>
<tr>
<td>5</td>
<td>PsA (I)</td>
<td>PsA (S)</td>
<td>PsA (R)</td>
</tr>
<tr>
<td>6</td>
<td>ND</td>
<td>ND</td>
<td>PsA (S)</td>
</tr>
<tr>
<td>7</td>
<td>PsA (I)</td>
<td>ND</td>
<td>PsA (I)</td>
</tr>
<tr>
<td>8</td>
<td>ND</td>
<td>PsA (S)</td>
<td>PsA (I)</td>
</tr>
<tr>
<td>9</td>
<td>ND</td>
<td>PsA (I)</td>
<td>PsA (S)</td>
</tr>
<tr>
<td>10</td>
<td>PsA (I)</td>
<td>PsA (I)</td>
<td>PsA (I)</td>
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<tr>
<td>11</td>
<td>PsA (I)</td>
<td>PsA (I)</td>
<td>PsA (R)</td>
</tr>
<tr>
<td>12</td>
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<td>PsA (I)</td>
<td>PsA (R)</td>
</tr>
<tr>
<td>13</td>
<td>PsA (I)</td>
<td>PsA (I)</td>
<td>PsA (R)</td>
</tr>
</tbody>
</table>

*PsA = P. aeruginosa; S = sensitive to most antibiotics; I = intermediate sensitivity to some antibiotics; R = resistant to most antibiotics; ND = not done (i.e., patient did not expectorate or was known to have *P. aeruginosa*).
many benefits described here from an intensive program in a supportive group atmosphere.

The respiratory parameters that most significantly improved are $\dot{V}E$ and MVV. It would appear logical that gains in performance would be related to improvement in airway obstruction, which was the limiting factor in exercise capacity. However, the dynamic maximal flow parameters, as measured by peak expiratory flow, FEV$_1$, maximum expiratory flow, as well as FVC did not improve significantly. The lack of improvement in FEV$_1$ while the MVV and $\dot{V}E$ increased suggests a training effect on the respiratory muscles without an improvement in airway obstruction per se, in either the large or small airways. It is likely that muscle training also explains the improved endurance time. Similar findings have been described for patients with COPD, and the mechanism is unexplained.

The increased $V_o_{2 max}$, oxygen pulse, and anaerobic threshold indicate that increased cardiac output and oxygen delivery to the muscles were a further training effect of the program. The increased $V_o_{2 max}$ resulted from increased cardiac output, increased oxygen extraction at the tissue level, or both. As the maximal heart rate was not changed, despite an increased oxygen pulse after the program, any increase in cardiac output would be the result of increased stroke volume. The absence of training bradycardia, with unchanged resting heart rate, was somewhat surprising. The duration of intensive training may have been insufficient to develop this effect.

The $\dot{V}E$/MVV ratio remained high (i.e., 80% rather than the usual 60 to 70%), indicating that the CF patients utilized much of their respiratory reserve. In every case, $\dot{V}E$ remained the factor limiting effort, and patients did not reach their cardiovascular limits. Previous studies have shown similar limitations of exercise by respiratory reserve in CF patients.

Patients in this program felt that they had made a definite subjective improvement. In part, they felt that this was a result of increased sputum clearance. This was likely to be due to both intensive physiotherapy and increased activity. However, there was no concomitant objective improvement in airway obstruction. In addition, neither oxygen saturation at rest nor peak effort improved, indicating no change in the gas exchange properties of the lung. This study confirms the results of certain programs in which patients showed improved work tolerance but no change in resting pulmonary function. This result contrasts with studies in which patients showed a transient improvement in lung function test results.

An additional reason for improved patient well-being may have been nutritional improvement during the camp. Similar improvement has been reported in a CF summer camp. This improvement may be due to several factors. There was an emphasis on weight gain as an important goal throughout the program, with both peer pressure and constant encouragement from the staff. High-calorie meals were eaten three times daily along with an unlimited number of snacks and palatable supplements. In the relatively cool climate of Davos, as well as with increased activity, most patients had an increased appetite, so that the frequent problem of anorexia in CF patients was decreased. Compliance in taking pancreatic supplements with food was improved, as this was an acceptable communal activity.

The possibility that increased motivation explains the improvement in exercise capacity after the program cannot be excluded. However, this is unlikely, as the maximal heart rate of patients did not increase after the program, despite the existing cardiovascular reserve, and because patients did not increase their dyspnea indexes. Furthermore, it has been shown that the results of maximal exercise testing are reproducible > 4 weeks after such a program, with no learning effect on repeated testing in stable patients with CF.

In conclusion, this study demonstrates that an intensive activity program can improve exercise capacity and peak workload in CF patients. This appears to be due to a training effect on skeletal muscles resulting in increased ventilation and endurance time, as well as increased cardiovascular fitness with higher $V_o_{2 max}$, oxygen pulse, and anaerobic threshold.

We suggest that these improvements and the improved sense of well-being were due to the training effect of the intensive exercise and climbing program, whereas unchanged mechanics and gas exchange properties suggest a lesser effect of airway clearance, at least in this short study. Although it is not yet known whether exercise can improve longevity in CF patients or can replace the traditional, but tedious, chest physical therapy, there is no doubt that such exercise can be expected to improve work capacity. Overcoming the limitation of decreased pulmonary function by increasing fitness can decrease breathlessness, improve self-esteem, and create greater pleasure in life for patients with CF.

CF summer camps have many important roles, including education and group support. In this setting, patients can acquire the habit of exercise and sound nutrition, and can experience a significant benefit. Our study shows significant objective improvement in exercise parameters and well-being, without any evidence of cross-infection with resistant organisms. These benefits clearly outweigh the risks and strongly suggest that the policies for CF summer
camps in other countries should be reconsidered, if subjects with *B cepacia* and multiresistant organisms in their sputum are carefully excluded.

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