

## Effects of Rehabilitation Winter Camps at the Dead Sea on European Cystic Fibrosis Patients

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**Key words:** cystic fibrosis, rehabilitation camp, pulmonary function tests.

### Abstract

**Background:** Rehabilitation camps can improve exercise tolerance and nutrition in cystic fibrosis patients.

**Objectives:** To assess weight gain, pulmonary function tests and daily symptoms in European CF patients attending a rehabilitation camp at the Dead Sea, Israel.

**Methods:** We conducted a retrospective study assessing 94 CF patients who participated in winter camps held at the Dead Sea, Israel from 1997 to 2000. The camp program included daily physiotherapy, physical activities, and a high caloric diet. We assessed weight gain, pulmonary function tests, oxyhemoglobin saturation and daily symptoms before (pre), on departure (dep), and up to 3 months after the 3 week rehabilitation camp (post). All data were analyzed by ANOVA for repetitive measurements.  $P < 0.05$  was considered significant.

**Results:** Lung function tests and oxyhemoglobin saturation taken before, on departure and 3 months after camp were available for 35 patients. Forced expiratory volume in the first second (% predicted, average  $\pm$  SD) improved by  $8.2 \pm 2.3\%$  (pre, dep, post,  $P < 0.05$ ). Oxyhemoglobin saturation mildly improved ( $1 \pm 0.3\%$ , pre, dep, post,  $P < 0.05$ ). Forced vital capacity (% predicted) increased by  $3.9 \pm 1.2\%$ , but was not significant ( $P = 0.19$ ). Total body weight of 89 patients improved by  $1.9 \pm 0.9\%$  during the camp time ( $P < 0.05$ , *t*-test), and in a group of 24 patients weight continuously increased up to  $5.0 \pm 1.7\%$  at 3 months after the camp ( $P = 0.004$ , ANOVA).

**Conclusions:** In this attrition-limited retrospective study, European CF patients improved their pulmonary function and gained weight during and up to 3 months after a 3 week rehabilitation winter camp at the Dead Sea, Israel.

*IMAJ 2007;9:806–809*

Cystic fibrosis is clinically characterized by chronic obstructive lung disease and malnutrition. Physical activity in addition to daily physiotherapy is recommended for patients with CF [1] in order to enhance airway clearance of thick sputum, reduce the incidence of infection, improve well-being and fitness and, most importantly, prevent the deterioration of lung function. Moreover, nutritional status is important for the activity level of patients with CF [2]. Despite these recommendations for CF patients, the objective effects of exercise-training programs remain controversial. Although a number of studies did not demonstrate improved lung function [3-6], an improvement was shown following a short intensive program, a 3 month running program, and summer camp [7-9]. An effort scale for a training program of CF patients

will consequently show improvement in spirometry values, if planned carefully and followed cautiously [10].

Although high altitude compromises CF patients' oxygen saturation during exercise [11], a recent study observed improved exercise tolerance in CF patients attending an intensive summer camp held in high altitude conditions [12]. Furthermore, peak oxygen consumption and blood oxygen saturation during sub-maximal exercise improved at the Dead Sea, as compared with sea level, in CF patients following a brief stay at the area, suggesting physiological benefits in CF patients with moderate to severe lung disease [13]. Indeed, the barometric pressure changes due to altitude descent causes a 10 mmHg increase in inspired oxygen pressure and a subsequent increase of 4–6 mmHg in arterial oxygen tension [13]. The Dead Sea has for many years been considered a unique nature health resort since it offers potential remedial possibilities [14]. For several years, European CF patients have been participating in a 3 week CF winter camp in the Dead Sea, Israel, with marked subjective improvement in well-being and endurance. Earlier reports observed that arterial oxygenation, sleep oxymetry and quality of life improved in patients suffering from advanced lung diseases after short stays at the Dead Sea [15]. Due to the scarcity of objective data on the effects of winter camps and exercise programs at the Dead Sea on CF patients, we retrospectively assessed all data collected from patients before and up to 3 months after the camp. We hypothesized that CF patients who attended rehabilitation winter camps in the Dead Sea gained weight and improved pulmonary function tests and daily symptoms, during and following their 3 week stay at the lowest place on earth.

### Subjects and Methods

All data were collected during rehabilitation camps at the Dead Sea (390 m below sea level) in the winter months (November to March) from 1997 to 2000. Each camp ran for 3 weeks. The program was designed and directed by an experienced staff from the Cystic Fibrosis Center which operates the whole year round. The center is located in a four-star hotel on the Dead Sea shore. The European patients enjoyed the unique warm (18–25°C) climate in the middle of the cold European winter.

Ninety-four European CF patients participated in a number of camps. Fifty patients came from Germany and the rest from Switzerland; there were 40 males and 54 females. Summary letters from the subjects' physicians in Europe were reviewed in advance by the program director and a pediatric pulmonologist.

CF = cystic fibrosis

According to the program guidelines, patients were segregated before their arrival according to their colonization status with regard to *Pseudomonas aeruginosa* in order to minimize the chances of patient-to-patient transmission. Patients colonized with *Burkholderia cepacia* were excluded from all winter camps. All campers had private rooms, usually shared with one family member escorting them. Patients used only their personal inhalers. The program included chest physiotherapy for 1 hour daily, apart from the routine self-physiotherapy. Physiotherapy rooms were ventilated for 20 minutes between the sessions. Patients received maintenance therapy with oral and/or inhaled antibiotics, pancreatic enzyme supplements, vitamins, and bronchodilator inhalations as individually prescribed by each patient's physician.

Outdoor physical activities included various ball games, horse riding, cycling and bi-weekly walking tours in the Dead Sea area. All participants enjoyed a high caloric diet with daily nutritional supplements while at camp. All social activities were held outdoors in order to avoid indoor social mingling.

Patients' assessment included physical examination, body weight and oxyhemoglobin saturation measurements once a week. Spirometry was assessed (Vitalograph Ltd, Buckingham, UK), prior to arrival (pre), upon arrival, and at the end of camp (dep), and included forced vital capacity and forced expiratory volume in the first second. Spirometry and oxyhemoglobin (%) saturation were examined 2 months after the camp ended in the patient's country of residence (post). The patient's weight was measured upon arrival, at mid-camp and at the end of camp; the measurements were performed on the same scale with the patient's shoes off. The weight was also measured a week before camp and at 1, 2 and 3 months after the camp, on the same physician's scale in the patient's country of residence and in the same manner.

All 94 patients also kept a daily record describing their respiratory symptoms (day and night-time coughing as well as breathing difficulties on exertion) during the 3 weeks of the camp. The patients were notified that all data regarding the measurements obtained (i.e., body weight, pulmonary function tests, and symptoms diary) will be used for study purposes as well. The use of all data obtained for this study was approved by the Soroka University Medical Center ethics committee

### Statistical analysis

The ANOVA test for repetitive measurements followed by Neuman-Keuls post-hoc tests and Student's *t*-test were performed appropriately to analyze significance of data. Results were considered significant when  $P < 0.05$ .

### Results

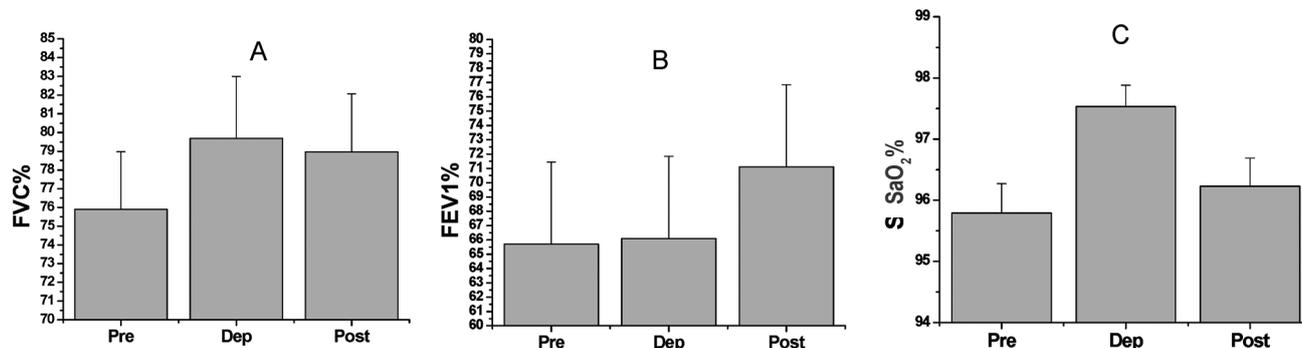
The study population included 94 CF patients. Patients who did not undergo pre-camp spirometry were excluded from the final data analysis. Only 35 patients were included for final analysis of lung function tests and oxyhemoglobin (%) saturation (for all three time points: i.e., pre, dep, post). Their mean age was 15.5 years (range 5–37); 8 patients (21%) were older than 20. Male to female ratio was 17:18.

An increase of FVC (% predicted) by  $3.9 \pm 1.2\%$  between measures obtained a week before camp and 2 months after camp were not significant ( $P = 0.19$ ) [Figure 1A]. Twenty-five patients (72%) improved their FVC (%) values during this period. A significant increase of  $8.2 \pm 2.3\%$  in FEV1 (% predicted) was measured (pre, dep, post,  $P = 0.03$  ANOVA) [Figure 1B]. Twenty-four patients (68%) improved their FEV1 (%) during this period. The significance was detected between pre versus post, and dep versus post (inter-group comparisons were done using the Newman-Keuls post-hoc test).

A mild (1%) but significant increase was also observed in the oxyhemoglobin (%) saturation level (pre, dep, post,  $P = 0.01$  ANOVA) [Figure 1C]. The significant differences were detected between pre versus dep, and dep versus post.

Average total body weight was available in 89 patients and was significantly higher ( $P < 0.05$ , *t*-test) after a 3 week winter camp by  $1.9 \pm 0.9\%$  [Figure 2A]. Furthermore, in a group of 24 patients, using their physician's scale before and after the camp (avoiding operator's bias), we observed a significant weight-gaining trend, which kept improving up to 3 months after the patients returned to their own countries, up to  $5.0 \pm 1.7\%$  ( $P = 0.004$ , ANOVA) [Figure 2B].

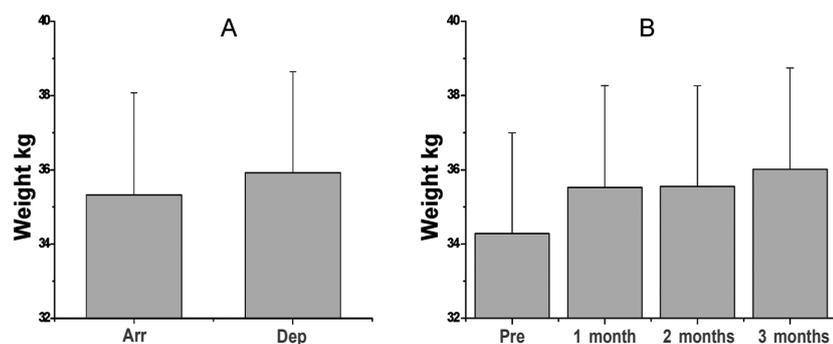
Respiratory symptoms as described by 88 patients were assessed and showed marked improvement during the 3 week



**Figure 1.** [A] FVC (% predicted), [B] FEV1 (% predicted) [C], and SaO<sub>2</sub> (%) in 35 patients before (pre), at the end (dep), and 2 months after the camp (post). Values are given as average  $\pm$  SD.

FVC = forced vital capacity

FEV1 = forced expiratory volume in the first second



**Figure 2.** Weight (kg) of patients **[A]** upon arrival (arr) and at the end of camp (dep) for 89 patients, and **[B]** before (pre), and at 1, 2 and 3 months after the camp for 24 patients. Values are given as average  $\pm$  SD.

period. Overall, daily coughing episodes improved by 21.5% ( $P < 0.001$  ANOVA), night coughing improved by 19.5% ( $P = 0.091$  ANOVA), and overall breathing difficulties episodes in exertion improved by 27.1% ( $P < 0.001$  ANOVA) [Figure 3].

## Discussion

Our study assessed three major parameters in CF patients: pulmonary function tests, weight gain, and daily symptoms. The importance of pulmonary rehabilitation and its effects on chronic pulmonary patients is well studied [16]. Patients' improvement in pulmonary function tests while attending health camps for short periods was noted by other investigators [9,10]. However, other studies did not detect improvements in spirometry values, although they did observe a reduction in the sleeping respiratory rate [17], considered by others to be a good clinical indicator in CF patients [18].

The impact of low altitude on pulmonary function tests in normal children was studied and showed significant difference in FVC and FEV1 – in favor of those living in the Dead Sea area (390 m below sea level) compared to children living in Amman, Jordan (774 m above sea level) [19]. Several studies assessing patients with chronic lung diseases including CF, within the Dead Sea area, determined that descent to low altitude can improve arterial oxygenation, exercise performance and sleep oxymetry [15,20]. Meticulous calculations show that an altitude change of 500 m, which increases the barometric pressure, causes a 10 mmHg increase in inspired

oxygen pressure and a subsequent increase of 4–6 mmHg in arterial oxygen tension [13]. This effect can improve arterial oxygen saturation in chronic respiratory patients.

Environmental factors that might contribute to improving pulmonary function tests include a smoke-free environment [21]. However, it was not a strict policy in the winter camps, and therefore the partial attribution of that cause cannot be considered a confounder. Other environmental factors that are of greater importance are the natural properties of the Dead Sea area. High barometric pressure, as described by Kramer and team [15], causes elevation of the

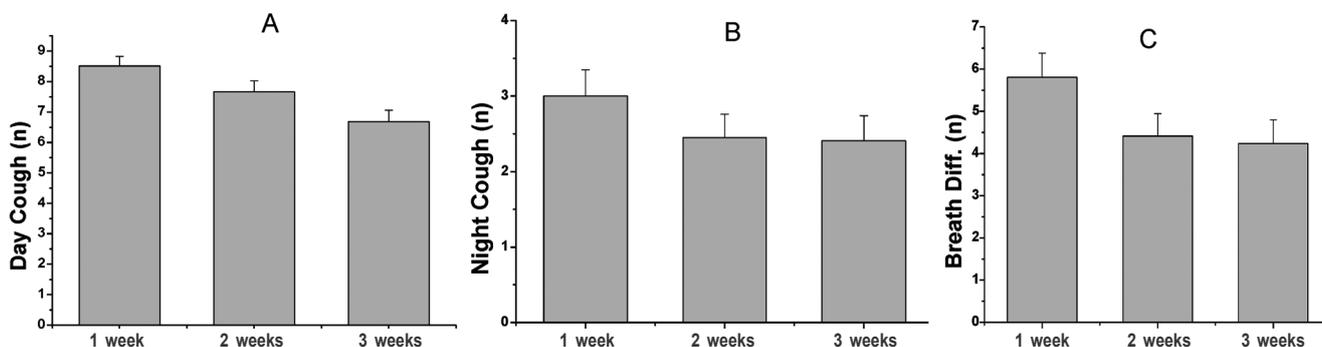
arterial oxygen saturation as discussed earlier, and improves other elements such as exercise performance and sleep oxymetry.

Magnesium compounds are found in high concentrations in this unique evaporation reservoir [22] and were reported to ameliorate asthmatic patients' daily symptoms after a 4 week stay at the Dead Sea, suggesting a role for magnesium as an anti-inflammatory and bronchodilating agent that is absorbed through the skin and via the lungs [23].

An interesting observation was the rapid and significant change of oxyhemoglobin saturation, which most probably relates to the barometric pressure, an affect that was less pronounced (but significant) after the patients' return to European sea level barometric pressure. At the same time, FEV1 values started to improve during camp but were significantly better only several weeks after the camp ended. This could be attributed to a prolonged effect due not to environmental barometric pressure or a bronchodilating effect of the surrounding magnesium, but perhaps to an overall sustained effect of physical activity and nutritional emphasis and their related effects.

It is obvious that compliance with medications, physical therapy and nutritional support in our patients was increased during camp, as in any other camp of that sort elsewhere, and the partial contribution of that compliance as a contributing factor for the observed improvement cannot be underestimated.

Of note, all the patients reported here were also evaluated



**Figure 3.** **[A]** Coughing episodes during the day (n=number per day), **[B]** coughing episodes during the night (n=number per night), and **[C]** breathing difficulties on exertion (n=number of episodes) – occurring every day at the end of every week during camp (1, 2 and 3 weeks) in 88 patients. Values are given as average  $\pm$  SD.

for their bacterial colonization status throughout their camp stay in order to assess for patient-to-patient transmission. No evidence for transmission of *Pseudomonas aeruginosa* among the cystic fibrosis patients attending the camps was demonstrated in sputum or environmental fingerprint patterns by pulsed field gel electrophoresis [24].

When considering the subject of rehabilitation camps for CF patients, it is important to note that there is a decline in the number of such programs around the world, mainly due to the fear from cross-infections of *P. aeruginosa* or other pathogens. Therefore, tight sanitary regulations and high compliance of the patients are crucial for the prevention of such a scenario.

Potential limitations in interpreting the data include the differences among patients regarding their medication maintenance programs. Furthermore, as previously mentioned, patients who missed the pre-camp spirometry were not included in the analysis (only 35 of 94). This may have biased the data by excluding the least compliant or the most severe patients.

Our patients gained weight during camp, which may well be due to increased emphasis on weight gaining and appropriate use of pancreatic enzymes; however, the weight-gaining trend did not wane even after 3 months of camp, which could not be explained solely by these factors. Since wasting is described as an independent predictor of mortality in patients with CF [25], we need to emphasize this vital long-term effect observed in our patients since that may affect their overall prognosis.

In conclusion, despite this being a small-sized, attrition-limited retrospective study, we demonstrated a significant improvement in FEV1 as well as oxyhemoglobin saturation that lasted at least 2 months after a 3 week stay at a rehabilitation camp at the Dead Sea area, accompanied by a weight-gaining trend that lasts for a longer period. We suggest that the improvement in the patients' pulmonary and nutritional status following these camps were due to the combined effect of physical activity with the distinctive environmental setting that affected the patients for a long time. Further study is needed both to elucidate the environmental effect of the lowest place on earth on CF patients and to determine the long-term effect on their prognosis.

**Acknowledgments.** We thank the patients and their families for their cooperation. We thank the Cystic Fibrosis Center at the Dead Sea, Israel, where the research took place, and Mr. Benjamin Pinkas for his cooperation.

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