EFFECT OF WATER-TRAINING IN THE MAINTENANCE OF CARDIORESPIRATORY ENDURANCE OF ATHLETES

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ABSTRACT

The effectiveness of water-training in maintaining cardiorespiratory endurance was investigated in 16 cross country athletes, 18-24 years. Following a competitive season, subjects were stress-tested (T1) and divided into three equated groups based on VO2 max. Group I (n=5) continued training as it had during the competitive season. Group II (n=5) underwent an experimental period of water-training, and Group III (n=6) let their training lapse. Subjects in the water-training group exercised in deep water for 40 minutes, 6 days/week for 3 weeks, supported by a flotation device which permitted them to engage in a running type activity, resembling their natural running form. All subjects were retested after 3 weeks (T2). A non-significant F ratio from an analysis of variance at T1 confirmed the equality of the three groups in terms of VO2 max. Analysis of covariance at T2 using T1 VO2 max values as covariates revealed a significant (p < .05) F ratio reflecting a significant (p < .05) difference between the regular training group and the group which let its training lapse. The water-training group did not differ significantly from the regular training group indicating that the water-training programme prevented a significant decline in VO2 max.

INTRODUCTION

Injuries caused by overuse or overtraining are a major problem in competitive sports and a variety of methods, including swimming and cycling, have been employed by athletes to maintain cardiorespiratory fitness while they are unable to follow their regular training regimen. A relatively recent method is that of water-training (Buss, 1976) in which the injured athlete runs through deep water supported by a flotation device as close to normal running style as possible. The purpose of this study was to investigate the effectiveness of the water-training method in maintaining VO2 max in a group of first year cross country athletes.

METHODS

Subjects

Sixteen male members of the Washington University cross country team, 18-24 years, volunteered to participate in this study. Following the competitive season they took a graded exercise test (T1) and on the basis of VO2 max scores, were divided into three equated treatment groups. Group I (n=5) continued training as it had during the season. Group II (n=5) underwent an experimental period of water-training, and Group III (n=6) discontinued training. After three weeks the subjects were retested (T2) to determine VO2 max levels. All training sessions prior to commencement of the study were supervised by the principal author, as were all sessions of water-training. Subjects were advised not to participate in other activities involving strenuous physical exercise during the period of study.

Determination of VO2 max

Maximal oxygen uptake was determined using the modified Astrand-Saltin treadmill test (1967). Before actual testing, each subject exercised on a Collins variable speed treadmill to become acclimatized to the machine and to determine the appropriate speed and grade to be used during testing. On the test days, subjects warmed up by running on the treadmill for 10 minutes at 8 mph and 3% grade. This was followed by a 5 minute rest period. The subject then ran for 5 minutes at 10 mph at 3% grade. When necessary, the speed and grade were adjusted according to the results of the initial test. Expired air was collected during the 4th and 5th minute using a Douglas bag. Subjects rested for 10 minutes while the volume of the expired air was determined. The percent O2 and CO2 were determined using mass spectrometry.

Subjects then performed a second 5 minute trail at 10 mph and 5% grade. Expired air was again collected and analyzed as described above. The highest VO2 max value was used in the statistical analysis.

Water-Training

Group II trained in the deep end of the University’s pool for 40 minutes, 6 days/week for a period of 3 weeks. Subjects were supported by a flotation device, so that
their bodies were essentially vertical, permitting them to engage in a running type activity resembling their natural running form. Every other day the workout was a steady paced "run through the water" during which the subject counted his own heart rate at various intervals by palpating the carotid artery. Heart rates attained during these training sessions ranged from 135-140 beats/minute. On the other training days each subject ran a paced run through the water for 20 minutes followed by 20 minutes of interval training. These intervals consisted of 2 minutes of hard running followed by 2 minutes of easy running (5 of each, for a total of 20 minutes). Immediately following each interval, the subject noted his heart rate and attempted to run at a pace which raised it to at least 160 beats/minute. The easy run between intervals elicited a heart rate of approximately 125 beats/minute.

Statistical Analysis
The analysis of variance technique was used to determine significant differences, if any, among the VO2 max means of the three groups at T1. At T2, an analysis of covariance was performed using T1 VO2 max values as covariates.

RESULTS
The physical characteristics of each group are presented in Table I.

### TABLE 1
Physical characteristics of each group (Mean ± S.E.)

<table>
<thead>
<tr>
<th></th>
<th>Regular Training</th>
<th>Water-Training</th>
<th>Discontinued Training</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age (yrs)</td>
<td>22.6 ± 0.9</td>
<td>19.8 ± 0.6</td>
<td>20.7 ± 0.7</td>
</tr>
<tr>
<td>Height (cms)</td>
<td>174.1 ± 2.6</td>
<td>178.5 ± 3.2</td>
<td>176.3 ± 2.8</td>
</tr>
<tr>
<td>Weight (kgs)</td>
<td>68.5 ± 2.6</td>
<td>64.0 ± 2.2</td>
<td>69.1 ± 4.9</td>
</tr>
</tbody>
</table>

The T1, T2 and adjusted T2 VO2 max means for each group are presented in Table II.

### TABLE 2
VO2 max (ml/kg/min) means at T1 and T2

<table>
<thead>
<tr>
<th></th>
<th>Regular Training</th>
<th>Water-Training</th>
<th>Discontinued Training</th>
</tr>
</thead>
<tbody>
<tr>
<td>T1</td>
<td>59.4 ± 1.5</td>
<td>59.2 ± 2.5</td>
<td>58.1 ± 2.3</td>
</tr>
<tr>
<td>T2</td>
<td>57.5 ± 0.8</td>
<td>54.8 ± 1.8</td>
<td>52.5 ± 1.8</td>
</tr>
<tr>
<td>Adjusted T2</td>
<td>57.2 ± 1.0</td>
<td>54.6 ± 1.0</td>
<td>52.9 ± 0.9</td>
</tr>
</tbody>
</table>

The results of the T1 analysis of variance are presented in Table III. No significant differences were found among the groups confirming their equality in terms of VO2 max level.

### TABLE 3
Analysis of Variance of VO2 max at T1

<table>
<thead>
<tr>
<th>Source</th>
<th>d.f.</th>
<th>M.S.</th>
<th>F</th>
</tr>
</thead>
<tbody>
<tr>
<td>Between</td>
<td>2</td>
<td>3.11</td>
<td>.12</td>
</tr>
<tr>
<td>Within</td>
<td>13</td>
<td>25.14</td>
<td></td>
</tr>
</tbody>
</table>

### TABLE 4
Analysis of covariance of VO2 max at T2

<table>
<thead>
<tr>
<th>Source</th>
<th>d.f.</th>
<th>M.S.</th>
<th>F</th>
</tr>
</thead>
<tbody>
<tr>
<td>Between</td>
<td>2</td>
<td>24.39</td>
<td>4.77*</td>
</tr>
<tr>
<td>Within</td>
<td>12</td>
<td>5.11</td>
<td></td>
</tr>
</tbody>
</table>

* p < 0.05

The results obtained from the analysis of covariance on the T2 data (Table IV) revealed a significant difference (p < .05) among the groups. When the adjusted means representing each group were analysed by the Newman-Keuls procedure, the regular training group (57.18 ± 1.01) and the group which discontinued training (52.94 ± 0.93) differed significantly (p < .05). The water-training group (54.57 ± 1.01) did not differ significantly from the regular training group.

DISCUSSION
The effects of endurance training on cardiorespiratory fitness have been well documented (Pollock, 1973) and clearly shown to be related to intensity, frequency and duration (Davies and Knibbs, 1971; Gettman, et al., 1976; Milesi, et al., 1976; Olree, et al., 1969; Pollock, et al., 1977). Several studies have attempted to ascertain how much exercise is required to maintain VO2 max. For example, Liang, et al. (1977) found that active students who exercised at 60% of VO2 max (mean HR = 150 beats/minute) with a duration of 45-60 minutes, 3 sessions/week were able to maintain VO2 max at their initial level. In contrast, intensities of 40 to 60% with 15 to 30 minute duration appeared to have a negative effect on the cardiorespiratory parameters. Chaloupka and Fox (1975) found that frequency of exercise could be reduced using interval training while maintaining the same benefits. Similarly, Brynteson and Sinning (1973) showed that gains made in VO2 max following a 5 day/week, 5 week training programme could be maintained by training only 3 days/week.

In this study there was no difference in VO2 max between the three groups at T1. This was to be expected
since the groups were matched on the basis of VO₂ max. When they were compared after the three week experimental (T₁) the group which discontinued training had decreased significantly but the water-training group did not differ significantly from the group that continued regular training. The water-training programme therefore was of sufficient intensity, frequency and duration to prevent a significant drop in VO₂ max level. However, since the number of subjects in each group was very small, eventual confirmation of these findings will require the use of large numbers of subjects.

Several studies have noted the physiological effects of a lapse in training (Drinkwater and Horvath, 1972; Fringer and Stull, 1974; Michael, et al, 1972; Smith and Stransky, 1976; Taylor, et al, 1949). Michael, et al (1972) found that two months after the cessation of training the cardiorespiratory adaptations made during a conditioning period were essentially lost. Smith and Stransky (1976) found that 7 weeks of bicycle training at 73% of max. HR range 16 minutes/day, 3 days/week resulted in significant gains in cardiovascular efficiency, but after letting training lapse for 7 weeks all subjects approached initial levels. Taylor, et al (1949) found that the VO₂ max of students confined to bed for 3 weeks declined by 17%. In this study the group which discontinued training declined by 9% after 3 weeks and at T₂ had a significantly (p < .05) lower VO₂ max than the group regularly exercising.

The subjects in the water-training group indicated that they felt that the water training method was effective in keeping them in condition. Such perceptions may be crucial in the rehabilitation of an injured athlete; however, it should be noted that the experimental subjects were not suffering from any injury at the time of the study. We might speculate, however, that if an athlete's injury does not prohibit the type of water exercises described in this paper, the decline in VO₂ max associated with the interruption of regular training can be minimized.

ACKNOWLEDGEMENTS

The authors wish to express their gratitude to Drs. James Hagberg and Ollie Ehsani; Irene Walter Johnson Rehabilitation Center, Washington University Medical School, St. Louis, for their valuable technical assistance.

REFERENCES


MEETINGS OF OTHER ORGANISATIONS

SYMPOSIUM ON PHYSICAL TRAINING IN HEALTH PROMOTION AND MEDICAL CARE

Kuopio University, and the Finnish Physiological Society and Society for Research in Sport and Physical Education
August 6th – 8th, 1980

Communications are invited for this symposium, designed to bring together both from Finland and other countries results of research on the effects of physical training on common health problems. The programme will consist of invited papers and free communications, and the official language will be English. It is intended to publish the proceedings in book form. The deadline for submission of abstracts is March 31st, 1980, and they should be typed on the appropriate form, obtainable from the organisers. A programme for accompanying guests is arranged. Hotel reservations should be made through the organisers before June 30th.

PARTICIPATION FEE: $100 (or $120 for late applications — after June 30th, 1980)

PROGRAMME:

Wednesday, August 6th

Physiology of physical training. Speakers include Drs. J. Durnin, P. Cerretelli, M. Härkönen and P. Komi.

In the afternoon:

Tests of exertion and training systems; K. Lange Andersen, K. Cooper, D. Kabisch, H. Tiik, and a team from the USSR Research Institute of Physical Culture.

Thursday


In the afternoon:

R. Shepherd, and free communications.

Friday

D. Dorossiev, M. Karvonen, J. Huttunen, I. Vuori, J. Boyer, M. Harri, E. Länsimies, and free communications. The whole day will be devoted to cardiovascular diseases and exercise.

Applications and Enquiries to:

Dr. KATRIIINA KUKKONEN,
Dept. of Physiology, University of Kuopio — PO Box 138,
SF — 70101 KUOPIO — 10, Finland

(Notice of this symposium received by BASM — November 16th, 1979)
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doi: 10.1136/bjsm.13.4.161

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