EFFECTS OF RECOVERY DURING INTERVAL TRAINING ON CARDIOVASCULAR FUNCTION

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Since its inception in the late 1930's, interval training has become the most widely accepted method of endurance training (Down, 1964). By manipulating the four basic elements of interval training (distance, time, repetitions, and recovery) the desired stimulus on organic function can be attained. Recent work has shown that not the least important of these is the recovery phase (Bonen, 1970).

Controversy appears evident concerning the manner of determining recovery during interval training. Several sources (Nett, 1964; Doherty, 1967; Jensen and Fisher, 1972) advocate a strict time recovery, while others (Caufield, 1965; McArdle and Patti, 1967; Mathews and Fox, 1971) prefer allowing the heart rate to return to approximately 120 beats/minute before beginning the next repetition. The use of 120 beats/minute as the criterion of physiological readiness for the next effort phase is based on the work of Gerschler (Sprecher, 1964). Apparently below that critical heart rate the peripheral capillaries begin to constrict and the expansion effect on the heart is lessened (Nett, 1964). Some authorities (Down, 1966; Wilt, 1968) claim that such a phenomenon occurs after two-to-three minutes of recovery, hence time is at least as important as heart rate in setting recovery duration.

Wilt (1968) and other coaches make the distinction between "fast" and "slow" interval training. Their contention is that fast repetitions more significantly affect muscle metabolism, while slow repetitions benefit the cardiovascular system to a greater extent. However, Yakovlev *et al.* (1961) found that repetitive, short sprints with brief recovery intervals produced substantial gains in aerobic function. Webb (1967) demonstrated that a short-distance interval training programme (50-200m) produced a significant improvement in the Harvard Step Test Recovery Index by the fifth week, while long- (600-1200m) and mixed-distance (50-1200m) interval programmes required eight weeks to achieve that end.

Following its development (Johnson, Brouha, and Darling, 1942), the Harvard Step Test (HST) has been widely used to assess cardiovascular response to heavy stress. The standard format of the test has subjects step for five minutes (or until exhausted from fatigue) at 30 steps/minute on a 50 cm. bench (Johnson, Brouha, and

Darling 1942). Recovery pulse counts are standardly taken at 1-1.5, 2-2.5, and 3-3.5 minutes after exercise, although the original article indicated the last count was taken at 4-4.5 minutes following stepping. The Recovery or Fitness Index is calculated by (Johnson, Brouha, and Darling, 1942):

$$R.I. = \frac{\text{Duration of exercise (secs)} \times 100}{2 \times \text{Sum of pulse counts for 1-1.5, 2-2.5, 3-3.5}}$$

A score of 55 or below indicates poor condition, 65-79 average fitness, and above 90 is excellent (Brouha, 1943).

Gallagher and Brouha (1944) contended that the test was not a measure of skill but of the quality of the cardiovascular response to strenuous exercise. With an energy cost and efficiency rating of 21-250 cal/kg/min and 17.5 - 21.9%, respectively, (Rovelli and Aghemo, 1963; Ricci *et al.*, 1966), and with the limited muscle mass involved, the HST may be considered "heavy" work which cannot be prolonged beyond five minutes in the average individual (Rovelli and Aghemo, 1963). Prior

Figure 1. Individual pulse counts at T-1 and T-2.

to training from 3 – 48% of the individuals tested can be expected not to complete five minutes of stepping (Johnson, Brouha, and Gallagher, 1943; Keen and Sloan, 1958), although this may reflect motivation levels and discomfort tolerance rather than cardiovascular response (Ricci *et al.*, 1966; Wilmore, 1968).

Post-exercise heart rate has been shown to be sensitive to training programmes (Montoye, 1953). Michael and Gallon (1959) observed that basketball players had made a significant improvement (.05 level) in the HST by the third week of training; they showed further improvement (0.1 level) by the third week.

Therefore, the purpose of this study was to assess the effect of two forms of recovery during fast interval training on the cardiovascular system as determined by the Harvard Step Test.

Procedure

Eighteen male volunteers were subjects for this study. Training groups were equated initially on the basis of HST scores. Group physical characteristics are shown in Table I.

All subjects trained using sprints of 50-200m. One group (N = 9) recovered to approximately 120 beats/minute heart rate between sprints. The other group (N = 9) rested 90 seconds between sprints. Training duration was 30 minutes per day, four days each week for five weeks. All subjects employed the same sprint runs on a given day, although the total distance covered may not have been equal due to the difference in recovery. In addition, individual variation in total distance within the pulse recovery group was evident.

The HST was administered according to standard procedures (Johnson, Brouha, and Darling, 1942). If a subject felt behind the stepping pace for a duration of 10-15 seconds, he was halted and the recovery phase begun (Brouha, Graybiel, and Heath, 1943). Pulse recovery counts were recorded at the radial artery by one of the investigators (RTD).

Results and Discussion

The correlations between HST and height ($r = .430$) and HST and weight ($r = -.013$) were not significant and suggested that the scores were not affected by either measure. This agreed with the contentions of Montoye (1953), Keen and Sloan (1958), and Ishiko (1967). Therefore, the HST appeared to be independent of anthropometric factors in assessment of cardiovascular function.

Following five weeks of "fast" interval training both

groups had made highly significant improvements in Recovery Index (Table II). Webb (1967) also noted that a short-distance interval training group made more rapid improvement in Recovery Index than either long-or mixed-distance interval groups, although this is contradictory to the findings of Karlsson, Åstrand, and Ekblom (1967).

The great percentage improvement shown here (Table II) agreed with the observations of Fletcher (1960). Other investigators (Brouha, Graybiel, and Heath, 1943; Gallagher and Brouha, 1943) have noted that subjects with the lowest initial scores made the greatest improvement due to training. However, mean scores as low as those reported here could not be found in the literature, although Fletcher (1960) did report brief stepping periods for older subjects. This may reflect lack of motivation or low tolerance on the part of our subjects for the stress of exercise (Ricci *et al.*, 1966; Wilmore, 1968), although if subjects cease stepping for reasons other than cardio-respiratory inadequacy, the recovery heart rates would have been lower and Recovery Index higher. Therefore, it may be assumed that the subjects were initially, through no selection process, extremely unfit.

The fact that so great an improvement in cardiovascular function was shown (Table II) may also reflect the intensity of the training stimulus (Faria, 1970). Other researchers have demonstrated that more intense training, as reflected by heart rate, produced the greatest endurance gains (Sharkey and Holleman, 1967; Sharkey, 1970). Shephard (1968) indicated that response to training depends on intensity in conjunction with initial level of fitness.

High-speed, repetitive running has been hypothesized to develop muscle metabolic processes rather than cardiovascular condition (Nett, 1964). Our findings do not confirm this opinion. Rather, these data coincide with conclusions of Åstrand *et al.* (1960), Fox, Robinson, and Wiegman (1969), and Margaria *et al.* (1969) that when high intensity work phases of short duration (10-30 secs) are punctuated by brief rest periods, the work is performed predominantly aerobically with considerable stimulus to the cardiovascular system.

The fact that there was no significant difference between the two groups in Recovery Index following training may indicate that the pulse rate was returning to 120 beats/minute within 90 seconds following each run (Figure 1). Although the duration of the pulse recovery group interval was not recorded, it may be that, following initial adjustment to exercise stress, it was equal to or less than 90 seconds.

The question of the best method of training for

optimum development of the cardiovascular system remains a formidable one. In addition, improvements in performance without corresponding gains in maximum aerobic capacity over a period of training (Dainty, Kollias, and Nelson, 1972) raise the question whether certain physiological parameters can be increased

substantially following the initial adaptive phase (Henry and Berg, 1950). More research is necessary on specific training systems before conclusive statements can be made concerning physiological parameters and performance changes.

Table I

Group physical characteristics

Group	Age (yrs)	Height (cm)	Weight (kg)	BSA (m ²)
120 Pulse Rec.	19.26 ± 0.86	179.2 ± 7.1	68.90 ± 7.08	1.86 ± 0.12
90-Sec. Rec.	19.56 ± 1.15	175.6 ± 8.0	65.93 ± 12.44	1.80 ± 0.19

Table II

Changes in HST after 5 weeks of training

Group	T-1 Mean	S.D.	T-2 Mean	S.D.	% Mean Change	t ratio
120 Pulse Rec.	26.44	5.56	94.22	10.12	+67.78	256.4
90-Sec. Rec.	25.55	5.62	91.22	3.99	+65.67	257.0

*Significant at .001 level.

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UNESCO, INTERNATIONAL COUNCIL OF SPORT AND PHYSICAL EDUCATION
PHILIP NOEL-BAKER RESEARCH PRIZE, 1974, TO DR. J. G. P. WILLIAMS

UNESCO's International Council of Sport and Physical Education have announced the award of the annual Philip Noel-Baker Research Prize, 1974 to Dr. John G. P. Williams. This award is made "in appreciation of Dr. Williams' sustained contributions in the field of sports medicine as well as his active cooperation in all matters pertaining to scientific research relating to sport and physical education". The Executive Committee of B.A.S.M. is proud to announce this honouring of its former Secretary, who is presently Medical Director of Farnham Park Rehabilitation Centre and Secretary General of the Federation Internationale de Medecine Sportive.

Dr. Williams has been active in sports medicine in Britain and abroad since 1960, has been a pioneer in running sports clinics and has published widely on sports medical topics, including the standard text "Sports Medicine". He has lectured widely at home and abroad.