

# Performance Adaptations to Sprint, Endurance and Both Modes of Training

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## ABSTRACT

*Sprint (S, n=12) and endurance (E, n=14) training were performed independently and concurrently (C, n=6) for eight weeks to determine adaptive responses to each and their capability. Group S trained three days per week performing six 100m and six 50m sprints at 95 percent maximum speed. Group E ran continuously for 30 minutes at 85 percent HRmax three days per week. Group C trained six days per week, alternating days of sprint and endurance training. Group S improved ( $p<0.05$ ) 50m and 100m sprint times (2.5 and 4.5 percent, respectively), 30-second run distance (2.5 percent), showed no change ( $p>0.05$ ) in 30-minute run distance or  $\dot{V}O_2$  max, and decreased ( $p<0.05$ ) average power output 20.9 percent during the 30- to 45-second interval of a 60-second continuous jump test (CJT). Group E improved ( $p<0.05$ ) 30-minute run distance (12.6 percent),  $\dot{V}O_2$  max (5.9 percent), and sprint performance (2.2 percent in 50m, 2.5 percent in 100m), but showed no change ( $p>0.05$ ) in 30-second run distance. Group C showed ( $p<0.05$ ) improvements of similar magnitude to group E in  $\dot{V}O_2$  max (7.5 percent) and 30-minute run distance (9.9 percent), and to Group S in 50m (2.4 percent) and 100m (3.5 percent) times and 30-second run distance (3.5 percent). All groups decreased ( $p<0.05$ ) average power output during the 45- to 60-second interval of the 60-second CJT. Our results suggest that optimum improvements in performance are specific to the mode of training (sprint or endurance) and are independent of concurrent performance of both modes of exercise.*

**KEY WORDS:** Aerobic power, anaerobic power, compatibility, running.

## Introduction

Sprint and endurance run training induce distinct adaptive responses when performed independently (20). Sprint training requires performances of short duration, near-maximal velocity sprints with interspersed recovery periods, presents substantial power output and relies mainly on anaerobic enzyme systems for energy supply (25, 32). Endurance training, in contrast, relies on aerobic energy supply, is performed continuously for long durations and involves lower running speed and power output (20). Endurance training increases maximum oxygen uptake and the capacity of aerobic enzymes and induces cardiovascular adaptations (3, 15, 23). Sprint training increases muscular endurance and power (32) and may increase the capacity of anaerobic enzymes

(16, 25). Sprint training increases maximal running velocity, while prolonged continuous running does not (6).

Responses to concurrent sprint and endurance training, although common occurrences in training for team sports (17, 33), have not been examined. Concurrent training may enhance the performance of one or both activities. Both sprinters and distance runners have enhanced glycogen and phosphocreatine stores which may delay the onset of fatigue and increase power output during exercise (9, 14, 16). Greater aerobic capacity enhances recovery from intense exercise (10, 30), which may aid the sprinter performing repeated bouts. Increased strength, running speed and anaerobic capacity following sprint training may improve race performance of endurance athletes (20).

Concurrent training may, however, compromise responses to one or both activities. Previous studies of concurrent strength and endurance training (5, 11) show a compromise in the improvement of strength, but not in aerobic power. Sprint and strength training both require performance of exercise of short duration and high intensity, and depend on anaerobic energy sources (11, 25, 31, 32). Thus it is possible that the mechanism limiting strength development during simultaneous strength and endurance training could limit improvement of sprint ability when sprint and endurance training are performed concurrently.

The purpose of this study, therefore, was to compare adaptive responses to performance of sprint, endurance and both modes of training. Physiological adaptations to sprint and to endurance training have been examined, but data documenting the magnitude and specificity of performance changes are sparse. Thus, adaptive responses of a range of performance characteristics and of aerobic and anaerobic power were assessed in the study.

## Methods

### Subjects.

Forty-six college students volunteered to serve as subjects. They were active in recreational sports but inexperienced distance runners and sprinters. They were randomly assigned to one of three training groups: sprint (S), endurance (E) or combination (C). Information regarding risks involved was provided, and written consent was obtained from each prior to participation in training or testing. Subjects were allowed to withdraw from the study at any time. Thirty-two students (19 males and 13 females) completed the study.

Body weight, height and percentage of body fat were measured before and after training (Table 1). Percentage of body fat was estimated from skinfold measurements made using Lange calipers and the prediction formulas of Sloan and Weir (28). Test-retest reliability for body fat measurements was  $r=0.99$  ( $p<0.05$ ).

### Endurance Training

Endurance training was performed three days per week on alternate days for eight weeks, and consisted of 30 minutes of continuous running on a 400m all-weather track or measured running trail. The goal was to increase the distance covered in each successive training session, while maintaining heart rate at or above 85 percent of age-predicted maximum. Training intensity was assessed every 15 minutes by determining heart rate via carotid pulse palpation (24). All sessions were monitored and the distance run recorded.

### Sprint Training

Subjects trained on alternate days three days per week for eight weeks. Two sets of sprints, each consisting of 3x100 followed by 3x50m bouts were performed each day. Rest intervals of three minutes and 90 seconds followed each 100m and each 50m sprint, respectively. Sets were separated by a five-minute recovery period. Training goals were to decrease sprint time and to maintain velocity in successive sprints. Heart rate obtained by palpation of carotid pulse immediately before and after each sprint was used to estimate recovery (25, 29). All sprint sessions were monitored, and the time for each sprint recorded.

### Combination Training

This group trained six days per week for eight weeks, alternating days of endurance and sprint training identical to that of groups S and E.

### Testing Procedures

All subjects were familiarized with training and test procedures in the three weeks immediately prior to commencement of the study.  $\dot{V}O_2$  max, distance run in 30 seconds, power output during

60 seconds of continuous jumping, 100m and 50m sprint times were determined six, five, four, three, and two days before, and two, three, four, five, and six days after training, respectively. Distance run in 30 minutes and sprint training performance time (3x100, 3x50m) were determined on days one and two and on days 47 and 48 of training, respectively.

### $\dot{V}O_2$ Max

Each subject performed an incremental load  $\dot{V}O_2$  max test on a motor driven treadmill. An intensity of treadmill running resulting in volitional exhaustion in three to five minutes was determined for each during familiarization procedures. Oxygen uptake was determined for consecutive 30-second periods of each test by an open circuit semi-automated sampling system (34). Heart rate was monitored continuously (Gemini Telemetry System, Marquette Electronics). The highest  $\dot{V}O_2$  attained was accepted as maximal, provided that two of the following criteria (13, 26) were met: a) no increase in  $\dot{V}O_2$  with increased work load; b) attainment of maximum age-predicted heart rate; c) R value > 1.15.

### 50m and 100m Sprint Time

A series of photoelectric beams and a start switch connected to an electronic timing device were used to assess sprint ability. Fifty-meter time and split times between 0 to 20, 20 to 30, 30 to 40 and 40 to 50 meters were determined for four 50m sprints separated by two-minute rest intervals. Split times corresponding to the acceleration (0 to 30m), maximal velocity (30 to 60m) and endurance (60 to 80, 80 to 100m) phases of the 100m sprint (27) and 100m time were determined for four 100m sprints separated by four-minute rest intervals. The fastest sprint was selected for total and split time analyses. Test-retest reliability for sprint tests was  $r=0.99$  ( $p<0.05$ ).

### Jump Test

This anaerobic test consists of 60 seconds of continuous jumping (1). Hands were kept on hips, and horizontal and lateral displacements minimized by providing a small jumping surface. The jumping surface was a switch mat connected via a battery to a physiograph. Flight time and jump number were determined from physiograph records and used to calculate average power output for 60 seconds and for each consecutive 15-second time interval (1). Test-retest reliability for determination of mechanical power was  $r=0.93$  ( $p<0.05$ ).

### 30-second and 30-minute Run Distance

Each subject ran the greatest distance possible in 30 seconds and in 30 minutes on a 400m track to assess sprint and distance running ability, respectively. Total distance covered was recorded with both tests showing test-retest reliability of  $r=0.99$  ( $p<0.05$ ).

### Sprint Training Performance Test

One set of the sprint training protocol (3x100, 3x50m separated by three minutes and 90-second rest intervals, respectively) was performed by each subject. Sprints were timed individually by stopwatch.

### Blood Lactate

Blood lactate levels were determined during the seventh week of sprint training from samples obtained by finger prick at the end of the first and second sets. Analyses were performed using a 23L Lactate Analyzer (Yellow Springs Instrument Co., Inc.).

### Data Analysis

A manova design with 18 dependent variables, one between (grouping) and one within (repeated measures) variable, was used for analysis. The Tukey procedure for post hoc multiple

Table 1. Descriptive statistics of subjects

Group	Sprint n=12	Combination n=6	Endurance n=14
Age (yrs)	23.2 ± 1.0	23.8 ± 1.7	22.1 ± 1.0
Height (cm)	171.1 ± 1.9	174.8 ± 2.4	165.9 ± 2.6
% Body Fat			
Pre	12.9 ± 1.4	9.7 ± 1.4	18.1 ± 1.7
Post**	11.6 ± 1.5	8.8 ± 1.4	17.1 ± 1.7
Body Weight (kg)			
Pre	70.4 ± 3.9	70.4 ± 2.6	63.5 ± 2.8
Post	70.6 ± 3.7	70.0 ± 2.4	62.8 ± 2.7

Values are mean ± SE

\*\*Significant difference pre- vs posttraining ( $p<0.05$ )

comparison analysis was used when appropriate. Pearson's correlation analyses were used to calculate correlation coefficients. Data are reported as mean ± SE or average. An alpha level of 0.05 was used in all comparisons unless otherwise indicated.

**Results**

**Training Intensity**

Endurance training run velocity increased 10.6 percent (3.20 to 3.54 m/s,  $p < 0.05$ ). Heart rate at the end of the 30-minute run averaged  $178 \pm 3$  beats per minute (b/min) during the entire training period. Velocity for the 100m training sprints improved 5.6 percent (7.1 to 7.5 m/s,  $p < 0.05$ ), while the same variable increased 8.9 percent for the 50m training sprints (6.7 to 7.3 m/s,  $p < 0.05$ ). Velocities were maintained above 95 percent of pretraining maximal values for repeated bouts during the course of the study. Blood lactate levels of five subjects during a seventh week sprint training session were  $12.4 \pm 0.9$  after the first and  $14.4 \pm 0.6$  mmol·l<sup>-1</sup> after the second set of sprints. Heart rate ranged from 100 to 130 before and from 160 to 190 b/min after each sprint. Relative body fat decreased ( $p < 0.05$ ) with training; however, there were no differences among groups (Table 1).

**Endurance Performance**

Distance run in 30 minutes increased ( $p < 0.05$ ) 9.9 percent for Group C and 12.6 percent for Group E. Group S showed no significant change (Table 2). Ambient temperature and relative humidity for the 30-minute run tests were 20 degrees C and 70 percent before and 21 degrees C and 82 percent after training.  $\dot{V}O_2$  max (1·min<sup>-1</sup>) increased ( $p < 0.05$ ) 5.1 and 7.2 percent for Groups E and C, respectively, while relative (ml·kg<sup>-1</sup>·min<sup>-1</sup>) improvements were 5.9 and 7.5 percent, respectively. Group S showed no change ( $p > 0.05$ ) in relative or absolute maximal aerobic power.

**Sprint Performance**

All groups showed decreases ( $p < 0.01$ ) in both 50 and 100m sprint times (Tables 3 and 4). Fifty meter time decreased 2.5,

**Table 2. Effects of training on 30 min run distance and aerobic power**

Group	Sprint n=12	Combination n=6	Endurance n=14
30 min run (m)			
Pre	5890 ± 169	6731 ± 171	5465 ± 183
Post	5932 ± 178	7397 ± 167*	6152 ± 172*
$\dot{V}O_2$ max (1·min <sup>-1</sup> )			
Pre	3.856 ± 0.205	4.032 ± 0.161	3.205 ± 0.246
Post	3.818 ± 0.187	4.324 ± 0.141*	3.368 ± 0.259*
$\dot{V}O_2$ max (ml·kg <sup>-1</sup> ·min <sup>-1</sup> )			
Pre	54.82 ± 1.18	57.37 ± 1.55	49.97 ± 1.67
Post	54.30 ± 0.99	61.99 ± 1.76*	52.90 ± 1.63*

Values are mean ± SE  
\*Significant difference pre- vs posttraining ( $p < 0.05$ )

**Table 3. Effects of training on 50 m sprint ability**

Group	Sprint n=12	Combination n=6	Endurance n=14
0-20 m split time			
Pre	3.221 ± 0.057	3.222 ± 0.045	3.529 ± 0.098
Post	3.145 ± 0.055	3.189 ± 0.054	3.521 ± 0.102
20-30 m split time			
Pre	1.250 ± 0.027	1.281 ± 0.007	1.487 ± 0.056
Post**	1.222 ± 0.023	1.230 ± 0.025	1.437 ± 0.049
30-40 m split time			
Pre	1.219 ± 0.030	1.260 ± 0.011	1.473 ± 0.062
Post**	1.188 ± 0.027	1.231 ± 0.022	1.418 ± 0.052
40-50 m split time			
Pre	1.247 ± 0.031	1.270 ± 0.031	1.512 ± 0.065
Post**	1.213 ± 0.025	1.231 ± 0.013	1.449 ± 0.058
50 m time			
Pre	6.939 ± 0.145	7.035 ± 0.054	8.003 ± 0.279
Post**	6.768 ± 0.125	6.864 ± 0.112	7.826 ± 0.259

Values are mean ± SE in s  
\*\*Significant difference pre- vs posttraining ( $p < 0.01$ )

**Table 4. Effects of training on 100 m sprint ability**

Group	Sprint n=12	Combination n=6	Endurance n=14
0-30 split time			
Pre	4.441 ± 0.086	4.485 ± 0.055	5.088 ± 0.150
Post	4.383 ± 0.079	4.375 ± 0.047	5.087 ± 0.151
30-60 m split time			
Pre	3.759 ± 0.090	3.665 ± 0.068	4.502 ± 0.173
Post**	3.564 ± 0.086	3.528 ± 0.066	4.342 ± 0.166
60-80 m split time			
Pre	2.601 ± 0.063	2.515 ± 0.040	3.136 ± 0.130
Post**	2.431 ± 0.061	2.408 ± 0.026	3.007 ± 0.124
80-100 m split time			
Pre	2.693 ± 0.059	2.595 ± 0.061	3.246 ± 0.135
Post**	2.511 ± 0.062	2.482 ± 0.004	3.126 ± 0.124
100 m total time			
Pre	13.496 ± 0.295	13.262 ± 0.225	15.968 ± 0.580
Post**	12.887 ± 0.278	12.796 ± 0.200	15.562 ± 0.559

Values are mean ± SE in s  
\*\*Significant difference pre- vs posttraining ( $p < 0.01$ )

**Table 5. Effects of training on sprint training performance and 30 s run distance**

Group	Sprint n=12	Combination n=6	Endurance n=14
Sum of three 50 m (s)			
Pre	22.105 ± 0.456	21.333 ± 0.281	25.199 ± 0.803
Post	20.916 ± 0.367*	20.699 ± 0.306*	24.428 ± 0.729*
Sum of three 100 m (s)			
Pre	41.633 ± 0.848	41.033 ± 0.547	48.349 ± 1.716
Post	40.125 ± 0.910*	39.417 ± 0.581*	47.892 ± 1.791
Total sprint performance (s)			
Pre	63.783 ± 1.266	62.349 ± 0.798	73.550 ± 2.511
Post	61.041 ± 1.253*	60.177 ± 0.828*	72.321 ± 2.513*
30 s run distance (m)			
Pre	217.7 ± 5.0	212.0 ± 3.2	186.0 ± 7.4
Post	223.1 ± 5.1*	219.6 ± 1.8*	188.1 ± 7.2

Values are mean ± SE

\*Significant difference pre- vs posttraining ( $p < 0.05$ )**Table 6. Effects of training on average jump power**

Group	Sprint n=12	Combination n=6	Endurance n=14
Split 1 (0-15 s)			
Pre	28.94 ± 1.82	27.01 ± 3.03	22.08 ± 1.86
Post	26.79 ± 1.35	26.91 ± 3.41	22.62 ± 2.27
Split 2 (15-30 s)			
Pre	29.03 ± 1.95	26.50 ± 3.50	21.24 ± 1.92
Post	24.80 ± 1.39	25.46 ± 4.31	21.55 ± 2.21
Split 3 (30-45 s)			
Pre	27.55 ± 2.09	25.84 ± 3.71	21.34 ± 1.90
Post	21.80 ± 1.36*	23.40 ± 4.24	20.02 ± 1.98
Split 4 (45-60 s)			
Pre	26.14 ± 1.94	24.21 ± 3.99	20.02 ± 1.91
Post	20.99 ± 1.42*	22.92 ± 4.19*	19.33 ± 1.95*
0-60 s			
Pre	26.83 ± 1.76	25.15 ± 3.19	20.57 ± 1.71
Post	22.83 ± 1.22	24.24 ± 3.89	20.34 ± 1.92

Values (average power output over time interval) are mean ± SE in  $W \cdot kg^{-1}$ \*Significant difference pre- vs posttraining ( $p < 0.05$ )

2.4, and 2.2 percent while 100m time showed reductions of 4.5, 3.5 and 2.5 percent for Groups S, C, and E, respectively. No group showed significant improvement in the acceleration phase (first split time) of either sprint (Tables 3 and 4). All groups improved ( $p < 0.05$ ) in all other phases of each sprint.

Analyses of sprint performance times during sprint training (3x100m, 3x50m) show all groups improved ( $p < 0.05$ ) over three 50m sprints (Table 5). Group E failed to improve ( $p > 0.05$ ) in the performance of three 100m dashes, while groups S and C improved ( $p < 0.05$ ) 3.6 and 3.9 percent, respectively. All groups improved significantly in total time for three 100m and three 50m sprints: group S 4.3 percent, group C 3.6 percent and group E 1.7 percent.

### 30-second Run Distance

Groups S and C showed significant increases of 2.5 and 3.5 percent, respectively (Table 5). Group E showed no change ( $p > 0.05$ ).

### Jump Test

No significant changes were seen for any group for the 0- to 15- and 15- to 30-second intervals, or over the total 60 seconds (Table 6). However, Group S decreased ( $p < 0.05$ ) average power output for the 30- to 45-second interval (20.9 percent), and all groups significantly decreased average power output during the 45- to 60-second interval. Correlations between 100m time and 0 to 15-second jump test power output were  $r = 0.68$  before and  $r = 0.70$  ( $p < 0.05$ ) after training.

### Pretraining Group Characteristics

Fourteen subjects withdrew from the study, only three due to injuries related to training. Comparisons of groups across all variables before training show that group E had significantly lower performance ability than groups C and S, reflecting unequal withdrawal from the groups. Groups C and S showed no differences ( $p > 0.05$ ) across all sprint variables prior to training. Correlations between improvements (absolute or relative) and pretraining performance abilities were not significant.

## Discussion

Our primary interest in this study was to examine the ability of individuals to adapt to concurrent performance of sprint and endurance run training. A consideration that influenced both the choice of subjects and the development of training programs was that we did not predispose our combination group to a compromise in training responses. Pollock (23) suggests that individuals with low initial levels of fitness, as judged by  $\dot{V}O_2$  max, require several weeks for initial adaptation to training, and training five days per week is too frequent for such a population. Thus the intense nature of sprint training and the necessity of training six days per week dictated that we recruit active subjects capable of demonstrating adaptive responses to training (12, 21), yet inexperienced at sprint and distance running.

We felt it important that both types of training induce adaptive responses of similar magnitude when performed independently. Endurance training programs induce marked adaptive responses when training volume and intensity are optimized (4, 12). The relative magnitudes of improvement in sprint performance are small by comparison (6, 32). Consequently, a moderate intensity endurance training program was developed using conventional methods which would also reflect programs commonly used in sports training (17, 33). Relative exercise intensity was maintained at approximately 85 percent of heart rate maximum with subjects training 30 minutes per day, three alternate days

each week. Endurance training improved distance running speed and increased aerobic power (Table 2). The latter response was of similar magnitude to those seen previously (19, 22).

We felt that to optimize the adaptive response to sprint training, intensity of exercise had to be severe. If recovery intervals between sprints are inappropriate, sprint times increase and, consequently, intensity of training declines (35). We monitored recovery heart rate in an attempt to assess recovery between sprints. Heart rates below 130 b/min during recovery between sprints ensure that near-maximal efforts can be repeated (25). Using this method we found three minutes were required between 100m and 90 seconds between 50m sprints to ensure that all subjects could maintain sprint speed at approximately 95 percent of maximum during repeated efforts. These yield an exercise/rest ratio of 1:12. This is in marked contrast to the suggested ratios of 1:3, 1:4 or less (6, 7, 8, 25). Our sprint training program was designed to improve sprint speed; it was not interval training designed to increase aerobic power (7, 8).

Accordingly, this mode of training moderately increased sprint, but not distance, running ability (Tables 2, 3, and 4).  $\dot{V}O_2$  max, in addition, was not altered with sprint training (Table 2). These responses and the marked elevations of blood lactate during sprint training indicate substantial reliance on mainly anaerobic enzyme systems for energy supply and the extreme intensity of exercise during sprint training. Nevertheless, it should be appreciated that improvements in sprint ability induced by optimal sprint training will be less than increases in distance running ability resulting from extremely intense endurance training. In addition, it appears that recovery intervals for sprint training need to be substantially longer than is generally believed, if optimal increases in sprint ability are the goal of training, and that measurement of recovery heart rate is suitable for determining appropriate exercise/rest ratios.

Pretraining comparisons of groups may indicate that group E had greater potential to adapt to endurance training than group C. Relative improvements in aerobic power and 30-minute run distance, however, were similar between these two groups. These responses, the lack of correlation between pretraining performances and improvements and the ability to increase maximal aerobic power to a much greater extent than is generally believed (12, 21), suggest that the pretraining measures of  $\dot{V}O_2$  max did not compromise adaptive responses of groups E and C to endurance training.

Group C exhibited increases in distance running performance and aerobic power similar to group E, and improvements in sprint ability similar to group S. These results suggest that concurrent training does not significantly influence adaptive responses induced by sprint or endurance run training alone. Combination training, however, improves performance over a wider range of distances than when these different modes of running are performed independently.

Certain trends appear in the training responses that have practical applications, although these were not statistically significant. A hierarchy of responses exists across the measures of sprint ability such that group S shows the greatest improvement, followed by group C and then group E. Similarly, for distance run training group E shows slightly greater improvement than group C, and group S showed no improvement.

These results reflect the importance of the concept of specificity of training. Endurance training improves distance running performance while sprint training does not. Sprint training is more effective at improving a range of sprint abilities than endurance training.

Group E showed significant decreases in sprint times, especially over 50m. This suggests that metabolic factors in the untrained state are adequate for very short-term, intense, intermittent exer-

cise or that both types of training stimulate adaptations in ATP-PC replenishment. If metabolic factors do not limit improvement in short distance sprint ability, then changes may reflect alterations of running technique. Elliot et al (6) found that maximal sprint velocity did not increase following endurance training, and suggested that endurance training does not improve sprint performance. Our results are not necessarily in contrast to this concept. Maintaining maximal velocity for longer duration during a sprint could decrease time independent of increases in maximal velocity.

The tests used in this study were selected for their specificity to the training (50m and 100m sprints and 30-minute run) or as objective measures of aerobic ( $\dot{V}O_2$  max) or anaerobic (jump test) power. The distance run in 30 seconds was chosen because 30 seconds is a commonly used discriminator of anaerobic power, and we wanted an anaerobic test specific to the mode of exercise used in training. Correlations between performance in this test and the other sprint variables were high ( $r=0.92$  to  $r=0.96$ ,  $p<0.05$ ). Cheatham et al (2) recently demonstrated marked reliance on anaerobic metabolism during 30-second sprint running. Improvements in this test by groups S and C but not group E, probably reflect increases in skeletal muscle content of anaerobic enzymes of energy supply induced by sprint, but not distance run training (14, 15, 25). There appears to be very little relationship, however, between the results of the jump test and sprint performance. Although significant correlations exist between jump power and sprint times, all groups—especially group S—showed decreases in average jump power while increasing sprint speed. Komi et al (18) also found a diminished jump performance after eight weeks of jump training. While it may be argued that both the 30-second run and the jump test reflect anaerobic power, changes in the former, but not the latter, were sensitive to training-induced changes in sprint ability. In light of these observations, the validity of the jump test as a marker of changes in performance ability induced by training exercises that require substantial anaerobic energy supply, and the same (jumping) or a different (sprinting) locomotory pattern as the test, must be questioned.

The magnitude of increase in strength in response to resistance training in previous studies of concurrent strength and endurance training are relatively large (ie., 18 and 40 percent in the studies of Dudley and Djamil (5) and Hickson (11), respectively) in comparison to the increase (5 percent) in sprint ability following sprint training found in the present study. These responses and the ability to increase aerobic power to a much greater extent (45 percent) than was evident in the present study (8 percent) favor demonstration of compatibility or incompatibility of strength and endurance training. The results of the present study indicate that distance run training does not significantly compromise sprint training-induced changes in sprint ability, and vice versa. From a performance point of view, however, relative changes in sprint ability over a range of sprint tests and during sprint training were larger for group S than group C. This suggests that athletes engaged in activities where maximal sprint ability is important should not perform distance run training at the expense of sprint training. Interestingly, an adaptive response common to both modes of training (ie., improvement of sprint ability over short distances) is apparently not additive. Group S, if anything, improved more than group C for this range of tests.

In summary, concurrent performance of sprint and distance run training is not advantageous for either activity. For a given performance test of sprint or distance running ability, concurrent training also does not compromise adaptive responses induced by either mode of exercise. From an applied point of view, however, relative improvements of running ability over a range of performance tests appear specific to the mode of exercise used in training. Thus, sprint training is most effective at enhancing sprint ability,

as is endurance training at improving distance running performance. Sprint training with long rest intervals does not increase aerobic power, but distance training may produce some improvement in sprint performance, particularly over very short distances. Testing specificity is an important consideration in demonstrating training adaptations.

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