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Concurrent Strength and Endurance Training

Jason Williams*

Doctoral Teaching Assistant, United States Sports Academy, One Academy Drive, USA

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***Corresponding author:** Jason Williams, Doctoral Teaching Assistant, United States Sports Academy, One Academy Drive, Daphne, US, Tel: +1-251-626-3303; Fax: +1-251-625-1035; Email: jjwilliams@ussa.edu

Abstract

These data support reducing volume during periods of CT. Two and three-week training days seem to have a greater frequency of success when compared to four, five, and six day studies. Though not all higher volume programs attenuated strength, many did, leaving exercise practitioners a warning to program volume in CT periods with caution. Also, scheduling RT work before END work has proven a successful method. These data are encouraging for exercise practitioners who need to augment simultaneous physical qualities to compete in their respective sports. This article reviewed 19 concurrent training (CT) studies that simultaneously sought to increase strength and endurance qualities.

Introduction

Concurrent training (CT) is the simultaneous physical preparation of two or more exercise modalities. Common combinations include strength and power, hypertrophy and strength, and power and power endurance. The combination of strength and endurance (END) is common, but the efficacy of such a combination has conflicting findings. END can be defined as maximal oxygen consumption (VO2 Max) for END athletes and anaerobic power output (for field sport athletes). The purpose of this review is to discuss the abundance of research for and against the concurrent training of strength and END. A total of 19 CT studies were analyzed. The results are listed in Table 1. Based on the results, it can be inferred that CT training can be used successfully in training regimes to simultaneously improve multiple physiological qualities, namely strength, and END. However, research indicates that lower training volumes are needed. Also, completing resistance training (RT) work prior to END work is necessary to improve both END and strength simultaneously.

Table 1: Defines length of study, population used, resistance training (RT) variables mentioned, endurance (END) variables mentioned, volume (training duration and/or training frequency, and results).

Researchers & Length	Population	RT Method	END Method	Volume	Results
Alves et al. [6]	168	Twice weekly	Twice weekly	Low	CT augmented power movements (med ball throws, vertical jumps)
8 weeks	10-11 year old children	Med ball throw, box jumps, 30-40 meter sprints	20-meter shuttle runs		
Bell et al. [10]	23+ years old; physically active	3 days a week; 1 isokinetic exercise at max effort for 30 seconds	Cycle ergometer; 5 sets of 5 at VO^2 Peak	6 days a week; High	CT was inferior to RT alone
Davis, et al. [7]	28 women	3 days a week Two groups: Group 1 - RT at low heart rates. Group 2: RT at high heart rate.	Both groups performed subsequent aerobic sessions. 30 minutes of vigorous treadmill running.	3 - Moderate	Increases in lower body strength (17.2;23.3%), upper body strength (19%; 17.8) and fat free mass (1.8; 3.3) were seen in both groups. CT did not interfere.

11 weeks	Average age of 28	3 circuit sets (e.g. bench, lat pull down) Total of 9 exercises			
Chtara et al. [2] 12 weeks	48 students; Mean age of 21	Circuit Training Weeks 1 - 6 muscle endurance was trained Weeks 7-12 Power was trained. Twice weekly	Group 1 - END before RT Group 2 RT before END Group 3 - No END *5 repetition runs at 60% VO2 max.	Low	CT interfered with strength gains. No significant differences existed between Group 1 and 2 but did exist in comparison to RT only
Gravelle & Blessing [10] 11 weeks	19 women	3 x times weekly 5-6 lower body exercises for 45 minutes	3 x weekly; 45 minutes of rowing at 75% VO2 Max Group 1 - END After RT Group 2 - END before RT Group 3 - No END	Moderate	CT did not interfere with strength training. No differences in 1 rep max existed. Greater aerobic improvements were seen in group 1.
Hennessy & Watson [11]	Unspecified	3 Days a Week Unspecified	Group 1 - No END Group 2 - 2 days a week Unspecified	5 - High	Similar gains in upper body strength were made in CT group but compromised gains in the lower body (Strength and power).
Hakkinen et al. [13]	38+ year old men; moderately sedentary	2 days a week; 6-7 exercises, 50-80%, 8-12 reps.	2 days a week; First 7 weeks light cycling or walking for up to 30 minutes. Weeks 8-14 times increased to 60-90 min.	4; high	CT yielded similar strength gains
Hickson [3]	Mean age of 26; physically active	5 days a week; 2-3 exercises, 80% intensity of 1RM, 3-5 sets, 5-20 reps	Cycle ergometer, and running, 30-40 minutes near VO2 max; 6 days	6 days; Extremely High	CT was inferior to RT alone.
Izquierdo et al. [12]	43+ year old men	Unspecified; one day a week	Unspecified; one day a week	1-2 days; Low	CT yielded similar gains in first 8 weeks. However, prolonged training saw drops in strength in the CT group.
Jones et al. [4] 6 weeks	24 healthy men with >2 years of experience of RT (Mean age 25).	5-6 reps of max voluntary isometric contraction Group 1 - 3 days of RT Group 2 - 1 day of RT Group 3 - 3 days of RT	Group 1 - 1 day of END Group 2 - 1 day of END Group 3 - No END 30 minutes of repeated isokinetic unilateral leg extensions	Moderate	CT interfered with strength development
Jones et al. [4] 6 weeks	30 RT trained men Mean age of 23	Group 1 - 3 days of RT Group 2 - 3 days of RT Group 3 - 1 day of RT Weeks 1-4: 3 sets of 10 @70% Week 4-6: 4 sets of 8 @80%	Group 1 - No END Group 2 - 1 day END Group 3 - 1 day END Immediately after RT - 1% treadmill incline at 70% of VO2	Moderate	CT interferes with strength (especially lower body strength and power)

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Karavirta et al. [5]	40-67-year-old men (mean 56); sedentary	Twice a week; 7-10 exercises; Multiple phases - light cycle (40-60%, 12-20 reps, 3 sets), 2nd cycle - (60-80%, 5-12 reps, 2-4 sets). 3rd cycle - (70-85%, 5-8 reps, 2-4 sets)	Twice a week; First 7 weeks on bicycle ergometer for 30 min below aerobic threshold; last 7 weeks, 45-90 sessions at high intensity	4 days a week; high	Gains in strength were similar but hypertrophy was interrupted by CT
Laird et al. [18] 11 weeks	28 women (mean age of 20)	3 days a week unspecified	END training was performed 4 hours after RT 3 days a week Sprint interval training	Moderate	CT did not interfere with strength or power gains
McCarthy et al. [19]	Sedentary Males	3 days a week; 8 exercises; 4 sets; 5-7 reps per set	3 days a week immediately after strength training; Cycle ergometer for 50 minutes	3 days; moderate	CT yielded similar gains (substantial) in strength as the strength only group
Nelson et al. [14] 20 weeks	Untrained healthy men	4 days a week One RT exercise at max effort, 3 sets of 6	30-60 minutes on ergometer at 70%-85% max heart rate. Performed 10 minutes after RT	4; moderate to high	CT yielded similar gains in strength as the strength only group
Petros, Toubekis, & Platanou [15] 8 Weeks	Water polo players	Twice a week 85-90% of 1RM 4 sets of 5	Twice a week Group 1 - 4 x 4 min of HIIT Group 2 - 10 x 100 meter swim	Low	Maximal strength was improved in both groups indicating that CT raining did not interfere w/ strength. Swim speed increases were noted
Sale, MacDougall, & Jacobs [16] 22 Weeks	16 participants Mean age of 44	Twice a week Group 1 - 3 x 4 at 85-90% 1RM Group 2 - 3 x 10 at 70%	3 days a week Five 3 minute bouts on a cycle ergometer at a power output of 90-100% of VO2	3 days	CT training did not interfere with strength
Varela Sanz et al. [8] 8 weeks	35, predominately men. Mean age 21	3 sessions per week Group 1- 3-5 sets of 10-12 reps Group 2 - 3-5 reps of 5RM on Monday; 2-4 sets of 15RM on Fridays	Group 1 - 24-37 at 65-75% of MAS Group 2- 35-65 minutes of walking at 35-45% of MAS & HIIT Sprint Sessions at 120% MAS *END work after RT MAS = Max aerobic speed	Moderate	Both groups indicated improvements in bench press and squat. Group 2 increased jump capacity output while Group 1 saw higher aerobic improvements.
Wong et al. [9] 8 Weeks	39 Male Professional Soccer Players	Twice Weekly Use intensities in the 65-85% range. Back squat, high pull, jump squat, and chin up.	Twice Weekly 16 intervals of 15 seconds sprints at 120% max aerobic speed	Low	Vertical jump (as measure of power), 10 sprint speeds and all lifts went up. CT did not interfere

Scientific Explanation for CT Incompatibility

Hawley [1] concluded that both strength training and hypertrophy training are attenuated by endurance work because the physiological processes are diametrically opposed. According to Hawley, muscle protein anabolism occurs when the rate of protein synthesis is greater than the rate of muscle protein degradation. This process is slow because "protein synthesis must exceed protein breakdown for an extended period (weeks to months)". Hawley attributed the attenuation to an interruption of intracellular signaling pathways (E.g. Phosphatidylinositol 3-kinase, rapamycin) ultimately causing a retardation of protein synthesis.

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Running and Strength Interference

A meta-analysis by Wilson 2012 examined the interference of aerobic and resistance exercise. Of the 21 studies and total of 422 effect sizes, the authors concluded that running had the strongest relationship to interference. "For moderator variables, resistance training concurrently with running, but not cycling, resulted in significant decrements in both hypertrophy and strength". Other studies support this finding [2-5]. Other studies do not support a strong correlation between interference of strength development and running based CT [6-9]. Based upon the scientific evidence, the effect of high speed sprinting and slower running on strength cannot be determined more favorable or negative.

Cycling and Strength Interference

Of the eight studies that used cycling as an endurance modality listed in Table 1, three of the studies indicated that END attenuated strength development [3,5,10]. No discernable inferences can be made based on speed or duration of these attenuations. However, in two cases the volume of the work was high, indicating that volume may be a more important determinant than mode of exercise.

Volume and Strength Interference

Five of the nine studies that indicated an interference effect exists between END training and strength training presented situations where the weekly training volume was high [3-5,10,11]. Bell et al. [10] engaged in both END and RT training six days a week by alternating RT and END days. Likewise, both Hennessy & Watson [11] and Hickson [3] used an alternating RT and END schedule five days and six days of the week respectively. Also, using a daily alternating RT and END protocol, Karavirta et al. [5] had participants train at less frequency (4 days) but employed long duration exercise bouts (45-90 minutes). Jones et al. [4] cited the importance of accounting for total volume in CT.

High volumes of endurance training resulted in the inhibition of lower body strength, whereas low volumes did not. Lower body power was attenuated by high and low frequencies of endurance. High frequencies of endurance resulted in increased cortical responses to training. These data suggest that if strength development is the primary focus on a training intervention, frequency of endurance must be low. Not all examples of low volume CT experiences had positive outcomes [2,12] and not all high-volume studies resulted in negative outcomes [13,14]. However, several studies give great insight to exercise professionals when planning concurrent training periods. Higher volumes of endurance work may interfere with strength development and should be programmed carefully.

Successful Concurrent Training

a) Low Volumes: Whereas high exercise volumes have indicated a negative effect on CT, low to moderate volumes have shown to be beneficial in improving both strength qualities and aerobic qualities. Alves et al. [6] found success increasing strength and power measures in young children using same day training of RT and END protocols for two days a week. Davis et al. [7] indicated strength increases close to 20% by employing a three-day schedule of RT work and subsequent treadmill running. In a similar study that utilized a three-day workweek encompassing subsequent END work after RT, Gravelle and Blessing [10] indicated no strength interference effect. Petros, Toubekis and Platanou [15] combined high intensity maximal strength training (85-90%) and low volume END work (32 total minutes per week) to increase strength and swim speed in water polo players. Similarly, Sale, MacDougall and Jacobs [16] programmed only 45 minutes of weekly END work and found little interference. Lastly, Wong et al. [17] studied professional male soccer players engaged in two days of RT and two days of END work that encompassed 16 high-speed interval sprints. All lifts including bench press, squat, jump squat, and high pull increased.

b) Strength before END: In addition to lower volume, successful outcomes were seen in studies where RT training was performed before END training. Both Laird et al. [18] and McCarthy, Agre, Graf, Pozniak and Vailas [19] had participants train three days a week and scheduled END work after RT; one group four hours after and another group immediately after respectively. Both groups saw no interference effect and realized positive strength adaptations. Even under high volume training, cases where RT precedes END work resulted in positive strength adaptations [14]. Varela Sanz, Tuimil, Abreu & Boullosa [8] combined relatively low volumes of RT with subsequent volumes of END work and results indicated strength gains across all lifts. However, groups that underwent high volumes of END work did jump less high than the lower volume END group.

Conclusion

A lack of compelling evidence exists in the reviewed literature to make credible inferences about study length, mean age of population, and mode of END exercise (cycling vs running). These data support reducing volume during periods of CT. Two and three-week training days seem to have a greater frequency of success when compared to four, five, and six day studies. Though not all higher volume programs attenuated strength, many did, leaving exercise practitioners a warning to program volume in CT periods with caution. Also, scheduling RT work before END work has proven a successful method. These data are encouraging for exercise practitioners who need to augment simultaneous physical qualities to compete in their respective sports.

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