Noncompatibility of Power and Endurance Training Among College Baseball Players

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Abstract

Exercise professionals seeking to develop evidence-based training programs rely on several training principles demonstrated through research and professional experience. In an effort to further research examining these principles, an investigation was designed and completed to evaluate the compatibility of cardiovascular endurance and neuromuscular power training. Sixteen Division-I collegiate baseball players were divided into two training groups with lower body power measured before and after their college playing season. The two groups differed in training in that one group performed moderate- to high-intense cardiovascular endurance training 3–4 days per week throughout the season, while the other group participated in speed/speed endurance training. A significant difference between groups ($P < .05$) was identified in the change in lower body power during the baseball season. During the season, the endurance training group decreased an average of 39.50 ± 128.03 watts while the speed group improved an average of 210.63 ± 168.96 watts. These data demonstrate that moderate- to high-intense cardiovascular endurance and neuromuscular power training do not appear to be compatible when performed simultaneously. For baseball players, athletes who rely heavily on power and speed, conventional baseball conditioning involving significant amounts of cardiovascular endurance training should be altered to include more speed/power interval training.

Key Words noncompatibility, speed, power, cardiovascular endurance, specificity, sport conditioning, concurrent training, strength training

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Introduction

Exercise physiology, much like other disciplines, is governed by a number of principles. Where physics relies on principles such as gravity and inertia, exercise physiology is grounded by principles such as overload, progression, and specificity. These principles provide exercise scientists and professionals a foundation for the structure and design of exercise training programs.

Overload refers to a physiological system encountering a stress to which it is unaccustomed. In order to stimulate adaptation, it is necessary for the system or part of a system to be placed in a state of overload. For example, physiological stress encountered by muscle tissue during a resistance training workout may cause micro-tissue damage. In preparation for future stress, the body repairs the tissue and overcompensates by adding additional tissue resulting in hypertrophy. Muscle fiber development leads to an increase in power strokes and therefore strength.

In order for a system to continue to adapt over a long period of time, the level of stress placed on the system must increase in order to continue to result in overload. Progression implies that the training intensity, volume, duration, or stress must be increased relative to development of the system. Many resistance trainers find that, after several months of training, they cease to see improvements in strength. It is not uncommon to see recreational resistance trainers performing the same level of work several years into a training program. Consequently, these individuals will see little, if any, improvement due to the lack of overload placed on the neuromuscular system. In a position statement made by the American College of Sports Medicine in 2002, progression was of preeminent importance (1). After reviewing hundreds of resistance training studies, this ACSM panel stated, "The common theme of most resistance training studies is that the training program must be 'progressive' in order to produce substantial and continued increases in muscle strength and size."

The principle of specificity states that the training program needs to be sport- or fitness-specific. When training, an athlete needs to push the physiological system applicable to the stress of the athletic event. For example, aerobic training has been shown to stress the oxidative energy system, resulting in the construction of new mitochondria and replacement of anaerobic enzymes with oxidative enzymes while anaerobic training has the opposite affect (19). Therefore, the training program must target specific training systems or adaptations and these adaptations should relate to the sport, occupation, or demand for which training is meant to improve.

A particular issue related to specificity–the compatibility of different training stimuli–is deserving of greater research attention, especially among highly trained athletes. Athletes seeking maximal performance in one fitness area may suffer if training modes/adaptations are not compatible with each other. This principle is based on the different physiological adaptations that occur with different fitness training modes. For instance, Kraemer et al. (13) examined the physiological effects of strength, endurance, and combined training with particular interest in changes in muscle fiber characteristics. They found that strength training elicited an increase in muscle fiber diameter of type I, IIC, and IIA fibers while endurance training elicited a decrease in diameter of type I and IIC fibers. The combined training group demonstrated only an increase in type IIA fibers. It is apparent that different modes of training result in different physiological changes that may hamper fitness development of a competing or noncompatible fitness component.

Previous research has examined whether strength and cardiovascular endurance training can be performed simultaneously. This research has found conflicting results, with some studies (3,4,5,11,14,17,18) showing no negative influence on either strength or endurance with concurrent training, while others (9,16) have shown a negative effect on strength development with no adverse impact on aerobic endurance. One factor that may have influenced the findings of some of these studies was the inclusion of both aerobic and anaerobic stress in the endurance training protocols. It is possible that the inclusion of high intense, interval-type training could offset the negative impact of long-continuous training for aerobic endurance.

One study (7) demonstrated an attenuation of force development with concurrent strength and endurance performance, but only at high velocity movements suggesting that compatibility problems may exist between endurance and power development with concurrent training. However, participants in this study performed conventional strength, not power, training. A study by Baker (2) examined concurrent, in-season training among rugby athletes and found that strength and power remained unchanged throughout a rugby season. There was no improvement in strength and power but decrements were not measured. In this study, again, both aerobic and anaerobic metabolic conditioning was performed in an annual periodized plan. It is possible that this methodology avoided the interference of endurance training with regards to force and power development. The purpose of our study was to examine the influence of concurrent power (fast velocity resistance and plyometric training) and moderate- to high-intense cardiovascular endurance training in the same in-season training cycle.

Methods

Experimental Approach to the Problem

To examine the affect of concurrent training on muscular power, college baseball players were recruited to participate in this training study. To our knowledge, this is the first study to examine the compatibility of intense power and cardiovascular training among college athletes. This investigation tracked lower body power among college baseball players throughout a playing season in two different training groups. The only difference in their conditioning was the form of metabolic training performed. One group performed sprint training, while the other participated in intense, lengthy cardiovascular endurance training.

Subjects

Sixteen male Division-I collegiate baseball players (age: 21 ± 2.9 years) were randomly assigned to 1 of 2 in-season training groups. All players had consistently performed resistance training for at least 3 years prior to participating in this study. None reported any contraindications to resistance, speed, or cardiovascular endurance exercise training. All athletes were examined for existing injury or limitations, which might influence their participation or adaptation to physical conditioning and were excluded if such limitations were suspected. The methods utilized in this study were reviewed and approved by an Institutional Review Board for research with human subjects. All participants provided written informed consent prior to beginning the study.

Procedures

Power Testing. Lower body power was measured at the beginning and end of the baseball season (January and May) during a counter-movement vertical jump test using the TENDO® FiTROdyne Powerlizer (Fitro-Dyne; Fitronic, Bratislava, Slovakia) according to protocols suggested and validated by Jennings et al. (12). Athletes performed a standard warm-up prior to testing and were given 5 practice jumps to become accustomed to the testing procedures. Following practice repetitions, players rested until completely recovered and then performed 3 separate vertical jump repetitions. One alteration made to the suggested protocol by Jennings et al. (12) was the utilization of the highest power achieved in any of the 3 repetitions instead of an average of several jumps being recorded. If the highest power measure was more than 30 watts higher than the other measures, the entire testing process was repeated after a 5 minute rest break in order to obtain 3 consistent measures.

Training Programs

Both groups performed resistance training for neuromuscular power involving high speed, complex movements with free weights and accommodated resistance (bands and chains) performed 2 to 3 days per week over an 18-week baseball season. Exercise such as back squat, walking lunges, box step-ups, and powercleans were performed for the lower body. Training volume and intensity for such exercises was periodized daily ranging from 4–12 sets at loads to elicit failure on the final repetition of 2–6 repetitions. In addition, plyometric exercises such as resisted jumps, hurdle jumps, split jumps, and bounding were performed 2 days per week. The only difference between the 2 groups was the type of metabolic training performed. A sprint training group (SPT; n = 8) performed repeated maximal sprints ranging from 15 to 60 meters with 10 to 60 seconds rest between each sprint. Workouts were performed 3 days per week and consisted of 10–30 sprints. The second group (END; n = 8) performed moderate- to high-intensity (Borg RPE 12–18) aerobic exercise (jogging or cycling) 3–4 days per week for 20–60 minutes per day. The average length of an aerobic workout was 45 minutes.

Statistical Analyses

Descriptive data, along with the change in lower body power (watts), were calculated for each group. Analysis of variance with repeated measures was performed to examine for differences in power between groups and across time. If needed, Tukey's post hoc analysis was performed. Level of statistical significance was set a $P \leq 0.05$. SPSS statistical software package (SPSS Inc., Chicago, IL) was used for all statistical calculations. Data are expressed as means ± standard deviations. Statistical power for the analyses averaged 0.76.

Results

A significant difference between groups ($P < .05$) was identified in the change in lower body power during the baseball season (Table 1). During the season, the END group decreased an average of 39.50 ± 128.03 watts while the SPT group improved an average of 210.63 ± 168.96 watts. None of the 9 athletes in the SPT training group decreased in power throughout the season, while all but 3 players in the END group decreased power. The decrease in power in the END group represented a 2% drop in power with the SPT group increasing an average of 15% (Table 2).

Discussion

The data collected and analyzed in the present investigation demonstrate that lower body power is compromised by the inclusion of moderate- to high-intense cardiovascular endurance training during a collegiate baseball season. The game of baseball involves repeated power tasks such as sprinting, throwing, and jumping. Performance on such tasks is highly dependent on a players speed and power. Anything that decreases power can have a detrimental impact on performance and should be avoided.

Previous research examining the issue of exercise training compatibility has focused almost exclusively on strength and cardiovascular endurance. To our knowledge, this study is the first to demonstrate an actual decline in power with concurrent moderate- to high-intensity cardiovascular and high-intensity muscular power training. As presented in Table 1, standard deviation values for the change in power during the study are large for both groups. While the change in power between groups was determined to differ significantly ($P < .05$), and carry extensive professional significance in favor of the SPT group, the large variation between individuals presents a particular challenge. It is apparent that there was a great deal of individual response to the different training protocols. A deeper examination of the individual data demonstrates that all but 3 members of the END group decreased in power ranging from −17 to −299 watts. The other 3 subjects increased 4, 56, and 137 watts respectively. All individuals of the SPT group increased power ranging from 5 to 535 watts. These individual differences, and individual factors, determining whether concurrent training interferes with power development require further research to delineate.

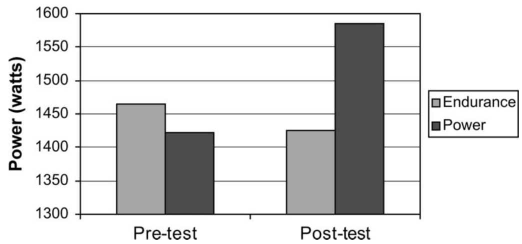
A continuum of fitness components exists (Table 3), ranging from muscular power to cardiovascular endurance. The separate ends of this continuum are marked by dramatic physiological differences resulting in different expressions of muscular performance (13). Nader (15) presented a more detailed continuum and described numerous physiological differences between adaptations to strength or endurance training. Of these, activation of AMP-activated protein kinase (AMPK) and the inhibition of eEF2 kinase (eEF2K) brought about by endurance exercise could impair the responses to resistance training by altering the anabolic response to resistance training. While this proposed physiological

Table 1. Descriptive Data.

Group(n)	Pretest (w)	Posttest	Change	% Change
END(8)	1465.13 ± 175.86	1425.63 ± 179.28	−39.50 ± 128.03*	−2.6%*
SPT(8)	1374.75 ± 346.18	1585.38 ± 419.70	+210.63 ± 168.96*	+15.3%*

Note: w = watts, * = Significant difference between groups ($P \leq 0.05$).

TABLE 2. Differences in Power between Groups.



Note: The Power training group significantly ($P < .05$) increased power during the training program with no significant change in the Endurance group.

rationale for noncompatibility of training is specific to strength development, a similar role might be expected with regards to muscular power. Neurological adaptations, such as muscle fiber recruitment and synchronization, which play a vital role in the development of power may also be hampered by the performance of cardiovascular endurance training (8).

Components such as muscular strength and muscular endurance differ in physiological and performance characteristics; however, these differences are not as dramatic. Previous investigations (5,11,17,18) have demonstrated that the inclusion of training for multiple muscular fitness adaptations may not have a negative impact on adaptations in either fitness component. However, in these investigations components being trained were closer to each other along the fitness continuum than in the current investigation (i.e., strength and muscular endurance, strength and cardiovascular endurance, power and strength). It may be speculated that the further the components are apart along this continuum, the less compatible training for such components will be.

An additional issue in this regard was eloquently addressed by Docherty and Sporer (6). After reviewing research on concurrent strength and aerobic conditioning, they suggested that training intensity could be a principle factor in determining the interference of training adaptations. It was suggested that low intensity strength training and high intensity aerobic training would result in conflicting peripheral adaptations. While the proposed model may adequately address some issues regarding the development of muscular strength, in our study participants followed a high intensity resistance training protocol with moderate to high intense aerobic training. Such training demonstrated an interference of training adaptations in power.

TABLE 3. Fitness Continuum.

Neuromuscular Power	Muscular Strength	Muscular Endurance	Cardiovascular Endurance

Continued research on the compatibility of muscular power and aerobic training is suggested to develop more specific information including the extent to which training volume and intensity in different fitness components affects compatibility. Additionally, strategies for minimizing the negative effect of concurrent training, when such training is needed for job or sport performance, would represent significant contributions to the literature.

PRACTICAL APPLICATIONS

This research demonstrates that power training and intense, lengthy cardiovascular endurance training are not compatible with the aerobic training resulting in decreased power among college baseball players. Such a decrease in lower body power during the length of a baseball season is a negative outcome that must be avoided to maintain performance in both pitchers and position players. It is suggested that conventional metabolic conditioning for baseball players, which generally includes extension aerobic endurance exercise be altered to include interval-type training or repeated sprint conditioning. By keeping all conditioning on the power end of the muscular fitness spectrum, power can be maintained or even increased throughout a baseball season.

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