Concurrent Strength and Endurance Training for Strength/Power Athletes

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Strength/power sports, such as American football, throwing events in track and field, and sprinting are characterized by the demonstration of high power outputs. The principle of training specificity requires that athletes competing in these activities train using exercises which maximize power output. These exercises may include the weightlifting sport lifts and their variations, plyometrics, and medicine ball training. However, many of the strength/power sports involve maximal efforts which must be repeated after relatively short rest periods. Thus, some strength and conditioning professionals believe that the addition of aerobic endurance training may offer some benefits to strength/power athletes.

Possible Benefits of Training Concurrently for Strength/Power and Endurance

Athletes in predominately strength/power sports are frequently given training programs designed to induce positive changes in both endurance and strength/power attributes, particularly during the off-season. Strength and conditioning professionals prescribing aerobic exercise for their strength/power athletes often cite the benefit of enhanced recovery during the limited rest periods which intersperse the supramaximal work efforts. Recovery from anaerobic exercise is highly dependent upon aerobic metabolism. Thus, aerobic endurance training may help athletes recover more quickly between anaerobic work intervals, such as multiple sets in resistance training or repeated sprints.

Strength/power athletes may perform endurance exercise in order to maintain an optimal body weight or to reduce body fat levels. Aerobic endurance exercises are an effective and efficient method of reducing body fat. Another possible benefit of aerobic training for strength/power athletes is the increased tolerance for exercise in the heat and during hyperthermia in aerobically trained individuals. In extreme heat, 15 to 20% of the cardiac output may be distributed to the skin for heat dissipation (18). This limits the blood flow to the working muscles. Aerobically-trained individuals have an increased sensitivity and capacity of the sweating response so that they are better able to regulate their body temperatures (18).

Possible Negative Effects of Training Concurrently for Strength/Power and Endurance

Aerobic endurance exercise appears to have potential benefits for strength/power athletes. However, the adaptations to strength/power training and aerobic endurance training are different. For example, strength/power training increases muscle hypertrophy, while aerobic endurance training increases mitochondrial and capillary density and has little or no effect of causing muscle hypertrophy. In addition, experimental evidence indicates that aerobic conditioning may interfere with strength and/or power development. For example, one of the earliest studies examining the effects of concurrent strength and endurance training found that strength gains were negatively affected when strength and endurance training were performed concurrently (10). Subsequent research has yielded conflicting findings with regard to the effects of concurrent strength and endurance training on strength. Some studies have demonstrated an interference effect (3, 7, 9, 14), while others have not (1, 2, 12, 13, 19, 20, 23, 25). Differences between these studies may have been due to differences in the length of the studies, experience level of the subjects, and the training protocols utilized. For example, studies differed with respect to the specific exercises performed, whether strength and endurance training were performed on the same or different days per week, the sequence of training modes (strength before endurance or endurance before strength).

While experimental results regarding the effects of concurrent strength and endurance training on strength are mixed, the effects of concurrent training on power appear more predictable. Several studies have demonstrated an interference effect of endurance training on performance measures of power expression. For example, several studies examining the effects of concurrent training on vertical jump performance found that only groups training exclusively for strength and/or power increased vertical jumping ability (9, 13). This suggests that aerobic endurance training may affect the expression of power more than strength. This negative effect of endurance training on power is an especially important consideration because many sports require the application of maximal force over very short time periods. For example, a sprinter may have contact with the ground for only 0.101 – 0.108 seconds while running (21). Thus, the capability for developing maximal force over a very short time period (rate of force development) is an important characteristic in strength/power sports, and may be hindered when training simultaneously for strength/power and endurance. Indeed, vertical jump ability has been shown to increase with the cessation of training in endurance athletes (5).

Alternative Methods of Enhancing Sport Performance and Short-Term Endurance without Hindering Strength and Power

Alternative methods of enhancing short-term endurance and improving body composition are needed which do not interfere with strength and power development. Fortunately, appropriately designed strength and power training programs may be able to elicit these changes without the compromising effects of aerobic endurance training. For example, resistance training has been shown to increase muscle stores of ATP, PC, and glycogen (17), while also increasing the activity of enzymes (phosphorylase, creatine kinase, phosphofructokinase, and myokinase) associated with anaerobic exercise (6). Thus, it is not surprising that experienced weight trainers have been shown to have an increased capacity for anaerobic energy transfer during maximal work bouts (24). Strength training can also increase short-term (4 – 8 minutes) time-to-exhaustion on a cycle ergometer (11, 24). The increases in time-to-exhaustion were independent of increases in maximal oxygen consumption. With regard to body composition, resistance training can increase lean body mass and decrease body fat levels. This leads to an increased capacity for strength, power, and anaerobic performance (8). In addition to a properly designed resistance training program, high intensity interval training may also be used to enhance endurance without compromising strength and power (15, 16, 22). For example, among the adaptations that occurred after a repeated 15 to 30 s sprint interval training program were significant increases in PC, glycogen, and maximum oxygen consumption (22).

Adaptations to exercise are dependent upon the type, intensity, duration, and frequency of training. The specific biochemical adaptations to aerobic (4) and strength/power (8) modes of training have been documented. Strength and power training exercises are generally used to improve the force output ability of the nervous and muscular systems. This type of training causes little or no increase in maximal aerobic power. Endurance training is performed to increase maximal aerobic power and endurance. Endurance training does not increase the force output ability of skeletal muscle. While the specific cellular adaptations resulting from the simultaneous performance of aerobic and strength modes of exercise are largely unknown, it seems logical that these adaptations are not compatible with prolonged training. Therefore, strength and conditioning professionals should carefully consider the cost-to-benefit ratio of including aerobic exercises for their athletes, and should consider alternative methods for enhancing short-term endurance and improving body composition.

References

1. BALABINIS, C.P., C.H. PSARAKIS, M. MOUKAS, M.P. VASSILIOU, AND P.K. BEHRAKIS. Early phase changes by concurrent endurance and strength training. J Strength Cond Res. 17:393 – 401. 2003.
2. BELL, G.J., S.R. PETERSEN, J. WESSEL, K. BAGNALL, AND H.A. QUINNEY. Physiological adaptations to concurrent endurance training and low velocity resistance training. International journal of sports medicine. 12:384 – 390. 1991.
3. BELL, G.J., D. SYROTUIK, T.P. MARTIN, R. BURNHAM, AND H.A. QUINNEY. Effect of concurrent strength and endurance training on skeletal muscle properties and hormone concentrations in humans. European Journal of Applied Physiology. 81:418 – 427. 2000.
4. BROOKS, G.A., T.D. FAHEY, AND K.M. BALDWIN. Exercise physiology : human bioenergetics and its applications. 4th ed. Boston: McGraw-Hill, 2005, xxi, 876, 877, 822 p.
5. COSTILL, D.L. The relationship between selected physiological variables and distance running performance. The Journal of sports medicine and physical fitness. 7:61 – 66. 1967.
6. COSTILL, D.L., E.F. COYLE, W.F. FINK, G.R. LESMES, AND F.A. WITZMANN. Adaptations in skeletal muscle following strength training. J. Appl. Physiol. 46:96 – 99. 1979.
7. DUDLEY, G.A., AND R. DJAMIL. Incompatibility of endurance- and strength-training modes of exercise. Journal of applied physiology (Bethesda, Md. 59:1446 – 1451. 1985.
8. FLECK, S.J., AND W.J. KRAEMER. Designing resistance training programs. 3rd ed. Champaign, IL: Human Kinetics, 2004, xiii, 377.
9. HENNESSY, L.C., AND A.W. WATSON. The interference effects of training for strength and endurance simultaneously. J Strength Cond Res. 8:12 – 19. 1994.
10. HICKSON, R.C. Interference of strength development by simultaneously training for strength and endurance. European journal of applied physiology and occupational physiology. 45:255 – 263. 1980.
11. HICKSON, R.C., B.A. DVORAK, E.M. GOROSTIAGA, T.T. KUROWSKI, AND C. FOSTER. Potential for strength and endurance training to amplify endurance performance. J. Appl. Physiol. 65:2285 – 2290. 1988.
12. HIKIDA, R.S., S. VAN NOSTRAN, J.D. MURRAY, R.S. STARON, S.E. GORDON, AND W.J. KRAEMER. Myonuclear loss in atrophied soleus muscle fibers. Anat Rec. 247:350 – 354. 1997.
13. HUNTER, G., R. DEMMENT, AND D. MILLER. Development of strength and maximum oxygen uptake during simultaneous training for strength and endurance. The Journal of sports medicine and physical fitness. 27:269 – 275. 1987.
14. KRAEMER, W.J., J.F. PATTON, S.E. GORDON, E.A. HARMAN, M.R. DESCHENES, K. REYNOLDS, R.U. NEWTON, N.T. TRIPLETT, AND J.E. DZIADOS. Compatibility of high-intensity strength and endurance training on hormonal and skeletal muscle adaptations. J. Appl. Physiol. 78:976 – 989. 1995.
15. LINOSSIER, M.T., C. DENIS, D. DORMOIS, A. GEYSSANT, AND J.R. LACOUR. Ergometric and metabolic adaptation to a 5-s sprint training programme. European journal of applied physiology and occupational physiology. 67:408 – 414. 1993.

16. MACDOUGALL, J.D., A.L. HICKS, J.R. MACDONALD, R.S. MCKELVIE, H.J. GREEN, AND K.M. SMITH. Muscle performance and enzymatic adaptations to sprint interval training. J Appl Physiol. 84:2138 – 2142. 1998.

17. MACDOUGALL, J.D., G.R. WARD, D.G. SALE, AND J.R. SUTTON. Biochemical adaptation of human skeletal muscle to heavy resistance training and immobilization. J. Appl. Physiol. 43:700 – 703. 1977.

18. MCARDLE, W.D., F.I. KATCH, AND V.L. KATCH. Exercise physiology : energy, nutrition, and human performance. 5th ed. Philadelphia: Lippincott Williams & Wilkins, 2001, lxii, 1158.

19. MCCARTHY, J.P., J.C. AGRE, B.K. GRAF, M.A. POZNIAK, AND A.C. VAILAS. Compatibility of adaptive responses with combining strength and endurance training. Medicine and science in sports and exercise. 27:429 – 436. 1995.

20. MCCARTHY, J.P., M.A. POZNIAK, AND J.C. AGRE. Neuromuscular adaptations to concurrent strength and endurance training. Medicine and science in sports and exercise. 34:511 – 519. 2002.

21. MERO, A., AND P.V. KOMI. Force-, EMG-, and elasticity-velocity relationships at submaximal, maximal and supramaximal running speeds in sprinters. Eur. J. Appl. Physiol. Occup. Physiol. 55:553 – 561. 1986.

22. RODAS, G., J.L. VENTURA, J.A. CADEFAU, R. CUSSO, AND J. PARRA. A short training programme for the rapid improvement of both aerobic and anaerobic metabolism. European journal of applied physiology. 82:480 – 486. 2000.

23. SALE, D.G., J.D. MACDOUGALL, I. JACOBS, AND S. GARNER. Interaction between concurrent strength and endurance training. Journal of applied physiology (Bethesda, Md. 68:260 – 270. 1990.

24. STONE, M.H., K. PIERCE, R. GODSEN, G.D. WILSON, D. BLESSING, R. ROZENEK, AND J. CHROMIAK. Heart rate and lactate levels during weight-training exercise in trained and untrained men. Phys Sportsmed. 15:97 – 105. 1987.

25. WOOD, R.H., R. REYES, M.A. WELSCH, J. FAVALORO-SABATIER, M. SABATIER, C. MATTHEW LEE, L.G. JOHNSON, AND P.F. HOOPER. Concurrent cardiovascular and resistance training in healthy older adults. Medicine and science in sports and exercise. 33:1751 –1758. 2001.