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Maximum Power Training and Plyometrics for Cross-Country Running

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A NUMBER OF SOURCES DEscribe conditioning programs for cross-country running and endurance sports. More specifically, strength training has been recommended for the development of cross-country runners (10, 16). Several sources describe plyometric training and its practical application to anaerobic sports (3, 11, 12, 15, 18, 21). Only a limited number of sources recommend plyometric or maximum power training for endurance sports such as cross-country running (13, 14, 16). On the other hand maximum power training and plyometrics are not contraindicated for training cross-country runners.

Plyometrics have been recommended for cross-country skiing (13) and endurance athletes (16), and single and double leg hops and bounding have been recommended for runners (14). The purpose of this article is to provide a rationale for, and recommend the use of, maximum power training and plyometrics as conditioning strategies for cross-country runners.

Evaluation of Training Methods

Strength Training

Fox et al. (7) indicates that track events of 3–6 miles rely in part (5–10%) on anaerobic energy sources. Because cross-country running occurs on uneven terrain, it is likely that the anaerobic component is even greater as athletes may use these energy sources to overcome the terrain. Strength development may be particularly important because $\dot{V}O_2$ max typically does not change after 12–18 months of training. One way to improve performance is through improved running economy through improved strength and muscular power and core stability (10).

Johnston et al. (10) conducted research on the effect of strength training on running economy. Results revealed no significant differences in body mass, body fat, body circumferences, $\dot{V}O_2$ max, or blood lactate accumulation. However, upper and lower body strength improved by 24 and 34%, respectively, and improved running economy as evidenced by 4% decrease in steady-state oxygen consumption. Increased running economy means that runners should be able to run faster over the same distance. This evidence suggests that strength training is important for the development of cross-country runners. However, strength training has some limitations.

The principle of specificity suggests that training is most effective when the training activity is similar to the target activity. Strength training at relatively slow movement velocities results in adaptations that are velocity specific (8, 12, 21). One possible solution is to perform strength-training exercises at the highest possible speed of movement (17). However, increased velocity of movement during strength-training exercises may require that the resistance be decelerated toward the end of the range of motion. According to Newton and Kraemer (12), this deceleration results in a loss of motor unit activation of the agonist and most likely is a less than optimal training stimulus.

The Olympic-style lifts have a more optimal velocity profile compared to some strength exercises such as the squat, making them an effective training strategy for sports requiring explosive power (12). In addition to traditional strength-training exercises and Olympic-style lifts, a mixed methods training strategy incorporating maximum power training and plyometrics is necessary to optimally develop cross-country runners.

Maximum Power Training and Plyometrics

Thirty percent of maximum voluntary contraction (MVC) is considered optimal for increasing mechanical power (8, 12) and has been referred to as maximum power training (20). In addition to maximum power training, numerous sources recommend plyometrics as a training method for increasing muscular output and improved performance in explosive activities (3, 5, 8, 12, 15, 18, 20). Maximum power training and plyometrics offer a high-velocity training stimulus without the undesirable deceleration phase potentially associated with many strength-training exercises, as the resistance is projected into free space such as when the athlete jumps.

Table 1
Relative Force/Velocity Characteristics of Training Methods

Training method	Capacity for Force Development	Capacity for Velocity Development
Strength training	High	Relatively low
Olympic lifts	Moderate	Moderate
Maximum power training	Relatively low	Relatively high
Plyometrics	Low	High

Compared to strength training or Olympic-style weightlifting, maximum power training and plyometrics train different aspects of the force/velocity curve (Table 1). Compared to many strength-training exercises and loads, running is a relatively high velocity activity. As such, it is necessary to include high-velocity training strategies in addition to force developing strategies such as strength training. The optimal resistance for training explosive power requires the integration of training strategies to develop both the force and velocity components of power (12).

The optimal ratio of force or velocity depends on the demands of the sport. The best combination of force and velocity training strategies depends on the mass of the object to be moved in a sport. Sports that require an athlete to overcome a large external mass (i.e., effectively blocking a 300-lb defensive lineman) require training strategies favoring force development. Conversely, cross-country running requires only that the athlete overcome his or her own body mass. Furthermore, successful performance in the sport of cross-country requires relatively high movement velocity because success in the sport is largely dependent on speed of movement. The principle of sport specificity dictates that training loads and velocity should attempt to replicate the requirements of the sport. Functionally specific strength training, Olympic-style weightlifting, maximum power training, and plyometrics have varying force and velocity characteristics. Arguably, maximum power training and plyometrics include movement velocities that are more sport specific than weight training.

Biomechanic and Velocity Specificity

The movement speed and biomechanics of many plyometrics more closely approximate running compared to strength training exercises. According to Wathen (18), plyometrics are intended to increase the force that can be exerted at a high velocity of movement. In addition to the improved velocity specificity associated with maximum power training and plyometrics, these types of exercises are more biomechanically specific than strength-training exercises. Wathen (18) recommends that a portion of training time is spent performing movements mechanically similar to those movements encountered in the sport for which the athlete is training. For example, the back squat occurs primarily in the vertical plane of motion. In contrast, multiple single leg hops are more mechanically similar to running since they have a greater horizontal component.

Role in Preventing Injury

Some sources have suggested that plyometrics pose a significant risk of injury and should not be included for training athletes (1, 2, 9, 19). Undoubtedly, poorly designed plyometric training programs increase the risk of athlete injury. However, the same is true for any type of training program. Conversely, opponents of plyometrics overlook the obvious fact that ballistic activities such as running and jumping are the fundamental movements of most sports. It seems illogical to conclude that these types of activities are completely safe in competition but unsafe in a supervised controlled conditioning session. Furthermore, the hypothesis that impulsive loading is detrimental is not consistent with evidence that suggests that biomaterials such as muscle connective tissue and bone adapt to reasonable training stimulus (4, 20).

Potential benefits of impulsive loading include the development of eccentric strength, connective tissue strength, and bone remodeling (4, 20). Cornu et al. (4) investigated the influence of 7 weeks of plyometric training on the ankle joint. Research results suggest that musculoarticular structure adaptation occurred and resulted in decreased viscosity and passive stiffness. Witzke and Snow (20) report that plyometric jump training of sufficient duration may serve as an effective training stimulus to increase bone mass. Maximum power training and plyometrics exercises may be necessary to prepare the athlete for the impact forces associated with running and foot strike on uneven terrain as they offer the athlete a controlled ballistic/dynamic training stimulus that is more consistent with the biomechanics and velocity of cross-country running.

Practical Application of Maximum Power Training and Plyometrics

Prerequisite Strength

Ebben and Watts (5) described functional strength prerequisites necessary for performing plyometric exercises. These recommendations include performing a strength-training cycle prior to the incorporation of maximum power training and plyometrics and the ability to meet strength requirements.

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Periodization

Maximum power training and plyometrics should follow a periodized model with exercise volume, and intensity gradually progressed and regularly cycled. For example, Chu (3) describes a progression of intensity and volume of plyometrics. Because cross-country running is a high-volume activity, it may be necessary to be judicious about the volume (foot contacts) of plyometrics used in the program.

Biomechanic Specificity

The maximum power training and plyometric exercises used should be biomechanically specific to cross-country running. Examples include exercises with a horizontal component such as bounding, multiple cone, box and hurdle hops, and long jumps. Nonetheless, maximum power training and plyometric exercises that are performed primarily in the vertical plane are more velocity specific than strength-training exercises such as the squat, which are also performed in the vertical plane. Examples of vertical plane maximum power-training exercises include dumbbell split squat jumps and dumbbell box jumps. Examples of vertical plane plyometrics include box jumps, timed box jumps, cone hops, and a variety of single leg hops.

Unilateral Training

Single leg plyometric exercises such as the single leg hop, single leg box jump, single leg push-off, and alternating leg push-off should be included because running foot strike is a unilateral event. However, these exercises should be gradually implemented because only 1 foot/leg must accommodate the body's entire mass potentially resulting in greater impact forces.

Training Facility

Ultimately, facility type and availability may dictate the type of maximum power training and plyometric exercises that can be included in a program. For example, inclement weather may negate the use of outdoor facilities. Indoor facilities may be unavailable, limited in size, or have an inappropriate floor for plyometrics. Facilities of adequate size will allow horizontal component plyometrics.

Some coaches may not have

facilities other than the weight room or may need to incorporate maximum power training and plyometrics as part of the strength-training program. Small or congested weight rooms may constrain the athletes to perform primarily vertical component plyometrics.

■ Summary

Surprisingly, some strength and conditioning and sport coaches still follow old, anecdotal prohibitions against the incorporation of plyometric training. Others may believe maximum power training and plyometrics are only appropriate for anaerobic sports. Improved running economy is a benefit of resistance training. Velocity and biomechanic specificity suggest maximum power training and plyometrics are an essential component of a conditioning program for cross-country running. Furthermore, these modes of conditioning may reduce the likelihood of injury providing that the conditioning program is periodized and supervised. Strength and conditioning coaches are encouraged to incorporate a maximum power training and plyometrics for training their cross-country runners. ▲

■ References

1. Brzycki, M. Point: plyometrics are unsafe. *Coaching Volleyball.* 1(5):14. 1988.
2. Brzycki, M. Plyometrics: A giant step backward. *Athl. J.* 66(9): 22–23. 1986.
3. Chu, D. *Jumping Into Plyometrics.* Champaign, IL: Leisure Press, 1992.
4. Cornu, C., A. S. Silveira, and M. I. Goubel. The influence of plyometric training on the mechanical impedence of the human ankle joint. *Eur. J. Appl. Physiol.* 76(3):282–288. 1997.
5. Ebben, W. P. and P. B. Watts. A review of combined weight training and plyometric modes: complex training. *Strength Cond. J.* 20(5):18– 27. 1998.
6. Fees, M. A. Plyometrics in rehabilitation. *Athl. Ther. Today.* May: 26–27, 1996.
7. Fox, E. L., R. W. Bowers, and M. L. Foss. The physiological basis for exercise (5th ed). Madison, WI: Brown and Benchmark, 1993. pp. 200.
8. Hedrick, A. Literature review: High speed resistance training. *Strength Cond. J.* 15(6): 22–30. 1993.
9. Horrigan, J. and D. Shaw. Plyometrics: Think before you leap. *Track and Field Q Rev.* 89(4):41–43. 1989.
10. Johnston, R. E., T. J. Quinn, R. Kertzer, and N. B. Vroman. Improving running economy through strength training. *Strength Cond. J.* 17(4):7–13. 1995.
11. Lundin, P. and W. Berg. A review of plyometric training. *Strength Cond. J.* 13(6):22–30. 1991.
12. Newton, R. U. and W. J. Kraemer. Developing explosive power: Implications for a mixed methods training strategy. *Strength Cond. J.* 16(5): 20–31. 1994.
13. Renfro, G. J. Power training for cross-country skiing. *Strength Cond. J.* 20(2):28–30. 1998.
14. Othersen, M. Plyometrics. Hops, skips and jumps. *Runner's World.* 27(10):30. 1992.
15. Siff, M. C. and Y. V. Verkhoshansky. *Supertraining: Strength Training for Sports Excellence.* Johannesburg, South Africa: University of Witwatersrand, 1998.
16. Sleamaker, R. and R. Browning. *Serious Training for Endurance Athletes* (2nd ed.). Champaign, IL: Human Kinetics, 1996.
17. Stone, M. Literature review: Explosive exercise and training. *Strength Cond. J.* 15(3): 6–19. 1993.
18. Wathen, D. Literature review: Explosive/plyometric exercise. *Strength Cond. J.* 15(3): 17–19. 1993.
19. Wikgren, S. The plyometrics debate: Safe and beneficial or dangerous and unproven? *Coaching Women's Basketball.* 1(5):10–14. 1988.
20. Witzke, K. A. and C. M. Snow. Effects of plyometric jump training on bone mass in adolescent girls. *Med. Sci. Sports Ex.* 32(6):1051–1057. 2000.
21. Young, W. B. Training for speed/strength: Heavy vs. light loads. *Strength Cond. J.* 15(5):34–42. 1993.

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