Should All Athletes Use Explosive Lifting?

by

Harvey Newton and Simon Jenkins

Reprinted from

International Journal of
Sports Science & Coaching

Volume 8 · Number 3 · 2013

Should All Athletes Use Explosive Lifting?

Harvey Newton[1] and Simon Jenkins[2]
[1]Newton Sports, Ormond Beach, FL 32175, USA
E-mail: harveynewton@newton-sports.com
[2]Carnegie Faculty of Sport and Education,
Leeds Metropolitan University, Leeds, LS6 3QT, UK
E-mail: S.P.Jenkins@Leedsmet.ac.uk

ABSTRACT
In this stimulus article, the question is addressed of whether or not the best way to train is explosively, like a weightlifter. Arguments in favour of explosive lifting are increased strength, increased power, hypertrophy, injury prevention, improved flexibility, improved inter- and intramuscular coordination, and sharpened psychological abilities. Arguments against explosive lifting are a complexity of technique, physical capabilities, initial flexibility challenges, initial strength deficiencies, lack of availability of good coaching, and lack of proper facilities, equipment and footwear.

Key words: Clean-and-Jerk, Flexibility, Power, Resistance Training, Snatch, Strength, Weightlifting

INTRODUCTION

Nearly all sports today consider resistance training a crucial ingredient for the acquisition of optimal sporting results. Secondarily, such training, commonly referred to as "strength training," is touted as a reasonable means of preventing injuries and keeping a player on the court or field. But exactly what is the best and/or most effective resistance training remains a debate.

What about an endurance athlete, such as Tour de France cyclist Lance Armstrong? Reportedly Armstrong did little, if any, resistance training throughout his career [1]. The first author was invited (by the USA Cycling coaching staff) to advise Armstrong on the finer points of plyometric training in the early 1990s. Characteristically for an endurance cyclist, Armstrong had exhibited below average vertical jump (a common test for explosiveness, or power) results when tested with the US team in December 1991. The thinking was, perhaps some explosive training would be helpful.

But the US Olympic Committee physiologists at the time thought otherwise, and suggested Armstrong should simply focus on his strong points and not consider attempts to improve his absolute power.With his outstanding cardio-respiratory fitness, suggesting that Armstrong could have performed even better had he engaged in explosive training is at best a stretch.

But, in light of recent research [2] and media coverage of poor skeletal health in male cyclists, perhaps abbreviated explosive training has its place in endurance sports. Research repeatedly shows that ground-based, large muscle group training, such as weightlifting

exercises, squatting, and deadlifting, are beneficial in combating bone mineral density concerns [3, 4].

It is the aim of this target article to explore the oftentimes-heard advice, "The best way to weight train is to train explosively, or like a weightlifter."

TERMINOLOGY

Explosive lifting customarily refers to the specific competitive lifts, namely the snatch and the clean-and-jerk, performed by weightlifters in the Olympic Games [5]. Obviously, lifts other than Olympic-style movements may be performed explosively. *Explosive strength* is the ability to exert maximal forces in minimal time [6]. *Explosive exercises* are performed at maximum or near maximum rates of force development [7, p. 28]. *Plyometric* training, which is explosive by design, is defined as those activities that enable a muscle to reach maximal force in the shortest possible time [8, p. 414]. Since all plyometric exercise also includes a *stretch-shortening cycle* (SSC), the reader is advised that there are explosive motions that are not considered plyometric.

For example, performing an explosive medicine ball throw from the chest while in a seated position is a measure of explosive strength, or power. The often-studied squat jump involves explosively blasting upward from a squatting (thighs parallel to the ground) position. However, in neither of these static start movements is a stretch-shortening cycle involved, thus the movements cannot be considered plyometric.

Clearly, athletes in power-oriented sports are often encouraged to perform their adjunct resistance training in the same manner in which they execute their sporting skills; i.e., explosively. Among other considerations, the principle of *specificity of training* strongly supports this notion, but this does not require that activities must share identical characteristics [9, p. 171].

However clear this association between sporting performance and proper supplemental training may be, there are those who have expressed serious reservation or blatant opposition to the idea that athletes from sports (explosive or otherwise) should train with weightlifting methods [10, p. 189-191; 11]. Often this hesitation is related to the amount of time necessary to master the technical intricacies of the snatch and clean-and-jerk. This objection may also reflect the challenge of acquiring adequate coaching of the lifts. Yet others write, primarily in non-refereed publications, that weightlifting training leads unnecessarily to increased injury, thus keeping a player away from their chosen sport.

Defenders of explosive lifting reference evidence that suggests such training is, in fact, quite safe, provided adequate coaching and supervision are present [12-14]. The current Youth Resistance Training Position Statement of the National Strength and Conditioning Association (NSCA), which markets itself as the worldwide authority on resistance training, states, "With qualified instruction and a stepwise progression of the training program, researchers have reported significant gains in muscular strength without any report of injury when weightlifting movements (snatch; clean and jerk; and modified cleans, pulls, and presses) were incorporated into a youth resistance training program" [15].

The current use of explosive lifting to train athletes of many sports is probably at an all-time high. One recent survey of high-school strength coach members of the NSCA found that 97% of such coaches incorporate weightlifting movements in the training routines of their scholastic athletes [16].

Since on the one hand coaches and athletes are encouraged to train explosively, yet on the other hand they may encounter opposition to the idea, this article explores the finer points of explosive lifting and sheds light on the question of its appropriateness for all.

A BRIEF HISTORY OF RESISTANCE TRAINING

Resistance training is the umbrella term applied to the use of bodyweight and/or external loadings for any number of specific results. The notion that resistance training could create a better athlete has gained in popularity only over the past 50 or so years. Prior to this, lifting weights, like other recreational pursuits, did not attract a large audience.

It is important for the reader to realize that due mostly to differences in training intensity or volume, or the training modality used, various forms of resistance training result in different end results for the user. In other words, not everyone who lifts weights gets stronger, since in the case of light intensity efforts, actual gains in maximum strength (how strength is measured) may not be present.

Characteristic of high-intensity resistance training is the sport of *weightlifting*, which has been part of the Olympic Games since the first modern Olympic Games in 1896. It has evolved over the years into today's two-lift competition, practiced by 167 member nations of the International Weightlifting Federation. Modern competition consists of the snatch and the clean-and-jerk, both commonly known as the "quick lifts." In earlier versions of weightlifting, non-explosive lifts (such as the press) were also contested.

Competitive weightlifting remained the primary means of training for those lifting weights up until about the 1940s. John Fair has written extensively on the impact of World War II and resistance training, when such methods were used to strengthen recruits and rehabilitate wounded servicemen [17]. He references the budding success of York Barbell Company and similar groups as a result of this new-found interest in physical improvement in the post-war years.

Much of this new interest also contributed to the increased popularity of *bodybuilding*, a non-Olympic sport focused on the development of muscular hypertrophy. Later, the expanding interest in lifting weights contributed to the birth of another non-Olympic sport, *powerlifting*. In both cases, these activities have proven to be more popular than weightlifting. And, both of these relatively new forms of training have influenced strength training practices and philosophy.

The more recent and commonly used term *strength training*, in its proper use refers to lifting weights by non-weightlifters for improved performance in their specific sports. This now popular concept was quite revolutionary and controversial when it first appeared toward the end of the 1950s. The idea of strength training for athletes first became widely popular in the United States. Alvin Roy, a trainer who accompanied several US weightlifting teams to international competitions, relied on weightlifting and other movements to increase the physical qualities and performances of American football athletes. The success of his efforts launched the popular use seen today of various forms of resistance training, all too often erroneously called strength training.

Up until the 1960s, resistance training machines were non-existent. Only free weights and exercises performed with bodyweight were available to those wishing to improve strength and/or power. With the increased popularity of lifting weights came the success of product lines such as Universal and Nautilus. Due largely to successful marketing plans to promote and sell these products, resistance training machines became the norm, and lifting free weights, especially as in the sport of weightlifting, faded from popular use.

Largely as a result of the new and increased demand to create stronger, more powerful athletes in literally all sports, the development and manufacture of resistance training machines has burgeoned. Today, anyone interested in resistance training has a full palette of training concepts from which to choose, although the scientific evidence of the most effective methods of training remains unsettled.

And, for the most part, training practices have come full circle. Weightlifting, having faded from popular participation, has returned to a place of prominence, due mostly to non-weightlifters embracing this sport's many benefits. With this returns the debate over the effectiveness of explosive training for all sports.

ARGUMENTS IN FAVOUR OF EXPLOSIVE LIFTING

Weightlifting training has many advantages, which is one reason this form of training persists even as more and more machine options become available.

Both genders, including individuals of any size, can participate in this ground-based, multiple-joint form of training. Weightlifting training produces many benefits, including:

- Increased strength
- Increased power
- Hypertrophy
- Injury prevention
- Improved flexibility
- Improved inter- and intramuscular coordination
- Sharpened psychological abilities

Increased *strength* is an obvious by-product of nearly any form of resistance training, provided the intensity is appropriately high. In powerlifting (a misnomer, as power here is only a fraction of that present in weightlifting) heavier resistances are used and the lifts are performed slowly. As a result *absolute, or maximum, strength* may be greater with this sport, as measured by their competitive lifts. But weightlifters obviously must be quite strong in order to achieve their sporting success, as they move maximum weights with blinding speed.

Greater *power* is truly the most highly sought-after training attribute related to weightlifting training, thus the overwhelming endorsement by most American strength and conditioning staffs, be they scholastic, university, or professional teams focused on this type of training [16]. One can think in terms of speed-strength here, or the old adage, "How fast can you be strong?" Importantly, not all forms of resistance training produce greater power.

The *hypertrophy* benefits of weightlifting training, while more evident in those specializing in the sport of weightlifting, are not nearly as extreme as those obtained via the pursuit of bodybuilding. Few athletes training for improved sports performance seek or need extreme measures of strength or large, muscular bulk, thus the obvious improvements in strength and power, minus muscular growth, are attractive to many.

Injury prevention is a by-product of resistance training, not a goal in and of itself. All forms of resistance training contribute to injury prevention.

Flexibility is a requirement for success in weightlifting. Training for the snatch and the clean-and-jerk requires and develops outstanding flexibility, something often not present in general resistance training, bodybuilding, or machine exercises.

Weightlifting requires outstanding muscular *coordination* in order to execute the complex snatch and clean–and-jerk motions. Aside from the muscular benefits of this type of training one must also consider the neural, or nervous system, benefits of executing such lifts in the blink of an eye. Training the nervous system can have a positive carryover to other sports with similar neural characteristics.

Finally, the *psychological* requirements of weightlifting are challenging. Harnessing one's total concentration to perform an explosive lift that requires less than one second to execute calls on many psychological traits present in other sports, such as golf.

ARGUMENTS AGAINST EXPLOSIVE LIFTING

The use of weightlifting training for improved athletic performance is not a concept embraced by all. In fact, there are many detractors that suggest much simpler training (bodyweight resistance, machines, or other "toys" currently popular in the fitness profession) is sufficient to obtain the necessary benefits without the risk of more complex efforts.

Many coaches correctly note that the technique requirements of weightlifting training demand much individual attention to detail. It may be impractical in some settings (a university weightroom, for example) to properly instruct a medium or large number of novice participants in the intricacies of weightlifting technique.

Some opponents of weightlifting training argue that the mere performance of these types of lifts, especially when done explosively, may increase the odds of a weightroom injury.

Is explosive lifting the panacea for all athletes' strength training? Here are some real challenges that are present for someone wanting to engage in weightlifting training.

- A complex, technique-driven activity
- Physical capabilities
- Initial flexibility challenges
- Initial strength deficiencies
- Lack of availability of good coaching
- Lack of proper facilities, equipment, footwear

To be proficient at this form of training, one much master basic techniques of the key lifts. Proficient technique is *not* necessary to successfully elevate a barbell overhead, as this can be done in poor form, as well. But performing these lifts in anything other than proper form both shortchanges the participant in terms of benefits, and it greatly increases the chances of injury.

Most able-bodied athletes may consider performing snatch, clean-and-jerk, or derivative exercises without hesitation, provided proper technique is learned. However, physically challenged athletes need to improvise and modify existing techniques in order to still train explosively.

Just as the specific lifts generally require outstanding flexibility, there are many novices that present with less than adequate flexibility on their first day in the gym. An inability to fully extend one's arms overhead or to fail to sit comfortably in a full squat receiving position (with a neutral spine posture) are sure indicators that additional preparatory work must be done before introducing the full snatch and clean-and-jerk exercises.

In some cases actual flexibility may not be the limiting factor. In teaching a squatting action, the second author has found that many novices exhibit an action with posterior tilting of the pelvis and large knee moment with the heels off the ground. It doesn't take long to coach them into correct pelvic tilting to achieve a neutral pelvis and spine with a larger hip moment and feet flat on the floor.

Similarly, it is possible that one is simply too weak to hold correct posture in the lifts or to exhibit adequate strength as measured by a standard fitness evaluation. Such an individual is ill advised to perform explosive training without proper remedial preparation. Young lifters are sometimes seen lifting weights in excess of what they can perform in good form, suggesting further basic strengthening is necessary. In this case, more general resistance training protocols are needed in order to properly strengthen the individual prior to engaging in advanced training.

The growth in the number of "certified" weightlifting coaches in recent years, at least in

the United States, can only be described at phenomenal. As a principal in the initial stages of weightlifting coaching training in America, the first author confirms that it was initially thought that more coaches schooled in the subtleties of explosive lifting would identify budding athletic talent, and in the long run, return the nation to a position of competitiveness on the international platform.

Recent figures from USA Weightlifting (USAW) reflect more than 5,400 coaches among USAW's more than 8,700 members [Personal Communication by First Author with USAW]. Those claiming coach status appear across several strata of competency. Despite the myriad people throughout the country claiming to be weightlifting coaches and experts, the team's current international standings are worse than ever before. The success of certification programs appears to neutralize the challenge of finding a qualified coach to teach weightlifting, yet many of these individuals are hardly more than rank novices themselves when it comes to actually performing lifts.

Weightlifting, at least in the United States, exists in small pockets around the country. Although not absolutely necessary in order to practice weightlifting, the sport does encourage the use of specialty equipment. This includes revolving barbells, rubber "bumper" discs, platforms, racks, and, like most other sports, specialty footwear. Far too many individuals fail to utilize properly designed weightlifting shoes, which actually do contribute to one's ability to properly lift heavier weights more safely.

One cannot simply go into the average fitness center and expect to find the equipment or layout necessary for weightlifting training. In fact, many fitness centers in America actively discourage or forbid some of the sights or sounds that accompany serious, high-intensity weightroom efforts such as dropping weights on a weighlifting platform.

CONCLUSION

Explosive lifting provides a great number of benefits in terms of developing outstanding strength and power in most individuals. At first glance it may appear that weightlifting training is perfect for all athletes. Certainly there are some, especially those dyed-in-wool weightlifting disciples, who would argue that this is the case.

But it must again be stated that weightlifting is perhaps the most advanced form of resistance training, and as a result, one that must be approached carefully and with proper preparation and coaching.

REFERENCES

1. Spencer, J., Society of Weight-Training Injury Specialists Conference (Lecture), Toronto, Canada, September 2002.
2. Nichold, J. and Raugh, M., Longitudinal Changes in Bone Mineral Density in Male Master Cyclists, *Journal of Strength and Conditioning Research*, 2011, 25(3), 727-734.
3. Virvidakis, K., Georgiou, E., Korkotsidis, A., Ntalles, K. and Proukakis, C., Bone Mineral Content of Junior Competitive Weightlifters, *International Journal of Sports Medicine*, 1990, 11(3), 244-246.
4. Conroy, B. P., Kraemer, W. J., Maresh, C. M., Fleck, S. J., Stone, M. H., Fry, A. C., Miller, P. D. and Dalsky, G. P., Bone Mineral Density in Elite Junior Olympic Weightlifters, *Medicine and Science in Sports and Exercise*, 1993, 25(10), 1103-1109.
5. Newton, H. S., *Explosive Lifting for Sports*, Enhanced Edition, Human Kinetics, Champaign, IL, 2006.
6. Stone, M. H., Literature Review: Explosive Exercises and Training, NSCA Position Statement, *National Strength and Conditioning Association Journal,* 1993, 15(3), 7-15.
7. Zatsiorsky, V. M., *Science and Practice of Strength Training*, 2nd edn., Human Kinetics, Champaign, IL, 2006.

8. Baechle, T. R. and Earle, R. W., *Essentials of Strength Training and Conditioning*, 3rd edn., Human Kinetics, Champaign, IL, 2008.

9. Stone, M. H., Stone, M. and Sands, W. A., *Principles and Practice of Resistance Training*, Human Kinetics, Champaign, IL, 2007.

10. Gambetta, V., *Athletic Development*, Human Kinetics, Champaign, IL, 2007.

11. Jesse, J. P., Olympic Lifting Movements Endanger Adolescents, *The Physician and Sportsmedicine,* 1977, September, 61-66.

12. Hamill, B., Relative Safety of Weightlifting and Weight Training, *Strength and Conditioning Journal,* 1994, 8(1), 53-57.

13. Byrd, R., Pierce, K., Rielly, L. and and Brady, J., Young Weightlifters' Performance Across Time, *Sports Biomechanics*, 2003, 2(1), 133-140.

14. Stone M.H., Fry, A. C., Ritchie, R., Stoessel Ross, L. and Marsit, J.L., Injury Potential and Safety Aspects of Weightlifting Movements, *Strength and Conditioning*, 1994, 16(3), 15-21.

15. Faigenbaum, A. D., Kraemer, W. J., Blimkie, C. J., Jeffreys, I., Micheli, L., Nitka, M. and Rowland, T., Youth Resistance Training: Updated Position Statement Paper from the National Strength and Conditioning Association, *Journal of Strength and Conditioning Research*, 2009, 23 S60-S79.

16. Duehring, M. D., Feldmann, C. R. and Ebben, W. P., Strength and Conditioning Practices of United States High School Strength and Conditioning Coaches, *Journal of Strength and Conditioning Research*, 2009, 23(8), 2188-2203.

17. Fair, J. D., *Muscletown USA: Bob Hoffman and the Manly Culture of York Barbell*, The Pennsylvania State University Press, University Park, PA, 1999.

Should All Athletes Use Explosive Lifting?

A Commentary

Loren Z.F. Chiu
Neuromusculoskeletal Mechanics Research Program,
University of Alberta, Edmonton, AB Canada T6G 2H9
E-mail: Loren.Chiu@ualberta.ca

INTRODUCTION

Newton and Jenkins' article argues for the inclusion of explosive strength training in the preparation of athletes. Moreover, they highlight the importance for coaches to develop their knowledge of explosive strength training to maximize effectiveness in practice. While resistance training in athletic populations has grown in popularity over the last two decades, my observations as a scientist, educator and coach are that the underlying principles of explosive strength training are not well understood. An appreciation of the physiology and biomechanics of explosive strength training is required to appropriately design resistance training programs to enhance performance.

WHAT IS EXPLOSIVE STRENGTH TRAINING?

Another term for explosive strength training is ballistic training. However, ballistic has two meanings in the scientific literature. From a mechanical perspective, ballistic refers to an object that becomes a projectile at the instant of release. Examples of projectiles in sport include a discus, javelin or baseball. The human body itself may become a projectile, such as in a vertical or horizontal jump. Thus, an exercise that creates a projectile, whether the object is an implement or the athlete, is a component of ballistic training. However, physiologically, ballistic refers to a distinct type of muscle action [1]. Ballistic muscle actions involve the rapid, yet brief, firing of motor units, which is different than a typical muscle action where motor units fire at a relatively slow and constant frequency [1]. Training with ballistic muscle actions results in different adaptations than training with non-ballistic muscle actions. Most notably, ballistic muscle actions facilitate increased motor unit firing rates resulting in increased rate of force development [2].

Taken together, it is important that both mechanical and physiological characteristics of ballistic training are met. In a hierarchy, ballistic muscle actions take precedence. Higher rate of force development increases impulse generated [3], and as impulse is related to change in momentum [4], increased velocity at release. Due to the nature of motor unit behaviour, a ballistic muscle action must be brief [1, 2]. That is, longer muscle actions cannot be ballistic. This is important to consider as, while the mechanics of the exercise can be considered to be ballistic (i.e., a projectile is created), the muscle action may not be (i.e., firing rate is too low). As such, a high velocity alone does not make an exercise effective for ballistic or explosive strength training. This is an important distinction, as many coaches and researchers espouse that explosive strength training can be performed simply by performing an exercise at high velocity.

There is one further factor that must be considered in ballistic exercise – motor unit recruitment. While ballistic muscle actions reduce a motor unit's recruitment threshold, sufficient resistance must still be employed to recruit high threshold, fast twitch motor units [1]. Motor units that are not recruited will not adapt as no training stimulus is placed on them, thus it is important to utilize relatively heavy resistances in ballistic exercises. This poses a problem, however, as increases in resistance tend to increase the time required to perform the exercise.

VALUE OF WEIGHTLIFTING EXERCISES

Weightlifting exercises (snatch, clean, jerk and variations) are unique in resistance training as: 1) heavy resistance is lifted at high velocity; and 2) they have a distinct ballistic phase with brief movement time [5-7]. This uniqueness is a function of the technique that has evolved over the past century of competition. In particular, for the snatch and clean, and their variations, the double-knee bend technique is almost universally employed by elite weightlifters. This technique creates two phases of hip and knee extension. The first phase, the first pull lifts the barbell from the ground. Due to the mechanics of this phase, the first pull is relatively long – too long for a ballistic muscle action [7]. As the barbell rises to mid-thigh, the knees flex (i.e., second knee bend) in preparation for the second phase of combined hip and knee extension, known as the second pull. In the second pull, the knee extensors generate large forces over a small range of motion, thus the time required is small [5, 7]. The upright posture of the athlete, position of the barbell in relation to the body and momentum generated in the first pull are all features that allow the second pull to be a ballistic action performed against heavy resistance.

Although the double-knee bend technique in weightlifting is almost universally performed by elite weightlifters, many athletes do not utilize this technique. Stone et al. [8] reported data of US weightlifters that were uncharacteristic of the double-knee bend technique. In my own research, I have found athletes (including weightlifters), who have received coaching, whom do not use this technique. I would suggest that this is due to poor understanding of the mechanics of weightlifting. For example, it is often suggested that the dominant action in the first and second pull is hip extension, generated by the hip extensor muscles. This action has colloquially been referred to as a "hip hinge". However, Garhammer [9] has found that the ability to lift heavier weights is dependent on increasing the knee extensor torque generated during the first pull. Moreover, the second knee bend reengages the knee extensors resulting in a second peak in knee extensor torque and power during the second pull [5]. During the second pull, hip extensor torque decreases [10]. Thus, the quadriceps are responsible for elevating the barbell in the first pull and generating propulsion in the second pull. The role of the hip extensors is to maintain trunk posture during the first pull and initiate the second knee bend via the biarticular nature of the hamstrings.

CONCLUSION

In order for strength and conditioning coaches to optimally instruct exercises and design training programs, a solid theoretical background in the science of human performance is required. In considering the science, weightlifting exercises are an ideal method for developing explosive strength, which is essential to enhance performance across many sports. However, training efficacy is dependent on proper execution of exercises. The mechanics of weightlifting have been investigated extensively (see Reiman et al. [7] for a detailed review). In order to achieve coaching excellence, these mechanics should form the

basis of strength and conditioning coaching practice, rather than relying on conjecture or common (but unsupported) beliefs.

REFERENCES

1. Desmedt, J.E. and Godaux, E., Ballistic Contractions in Man: Characteristic Recruitment Pattern of Single Motor Units of the Tibialis Anterior Muscle, *Journal of Physiology,* 1977, 264, 673-693.
2. Duchateau, J. and Hainaut, K., Isometric or Dynamic Training: Differential Effects on Mechanical Properties of a Human Muscle, *Journal of Applied Physiology*, 1984, 56(2), 296-301.
3. Aagaard, P., et al., Increased Rate of Force Development and Neural Drive of Human Skeletal Muscle Following Resistance Training, *Journal of Applied Physiology*, 2002, 93(4), 1318-1326.
4. Schilling, B.K., Falvo, M.J. and Chiu, L.Z.F., Force-Velocity, Impulse-Momentum Relationships: Implications for Efficacy of Purposefully Slow Resistance Training, *Journal of Sports Science and Medicine*, 2008, 7, 299-304.
5. Enoka, R.M., Load- and Skill-Related Changes in Segmental Contributions to a Weightlifting Movement, *Medicine and Science in Sports and Exercise*, 1988, 20(2), 178-187.
6. Garhammer, J., Biomechanical Characteristics of the 1978 World Weightlifting Champions, in: Morecki, A., Fidelus, K., Kedzior, K. and Wit, A., eds., *Biomechanics VII-B*, University Park Press, Baltimore, MD, 1981, 300-304.
7. Reiman, M.P., Escamilla, R.F. and Chiu, L.Z.F., Applied Biomechanics of Common Weight Training Exercises, in: Magee, D.J. et al., eds., *Athletic and Sport Issues in Musculoskeletal Rehabilitation*, Elsevier Saunders, St. Louis, MI, 2011, 385-422.
8. Stone, M.H. et al., Analysis of Bar Paths During the Snatch in Elite Male Weightlifters, *Strength and Conditioning*, 1998, 20(4), 30-38.
9. Garhammer, J., Longitudinal Analysis of Highly Skilled Olympic weightlifters, in: Terauds, J., ed., *Science in Weightlifting*, Academic Publishers, Del Mar, CA, 1979, 79-88.
10. Baumann, W., et al., The Snatch Technique of World Class Weightlifters at the 1985 World Championships, *International Journal of Sport Biomechanics*, 1988, 4, 68-89.

Should All Athletes Use Explosive Lifting?

A Commentary

Brian K. Schilling
Department of Health and Sport Sciences, The University of Memphis, Memphis, TN 38152, USA
E-mail: bschllng@memphis.edu

INTRODUCTION

The authors have taken on a considerable task by asking if all athletes should use explosive lifting and should be admired for such. In my opinion, the heart of the debate centers around the various terminology used by sport coaches, strength and conditioning coaches, and sport scientists. Without everyone speaking the same "language", substantive debate is elusive. The diet and fitness industry is particularly susceptible to misuse of proper terminology, particularly when it comes to marketing.

EXPLOSIVE

The varying terminology seems to come from a lack of understanding of basic scientific concepts, and how they relate to the human body. For instance, the term "explosive" used in science as a noun is defined as: "a substance that decomposes rapidly under certain conditions with the production of gases, which expand by the heat of the reaction. The energy released is used in firearms, blasting, and rocket propulsion" [1]. "Rocket propulsion" is certainly a good metaphor for certain sporting movements, particularly those done from a static position with relatively light loads over a short period of time. However, it does not make for a good scientific verbiage when applied to training. Many movements that have high rates of force development may not appear at all "explosive" as used as an adjective. In fact, one can perform isometric actions with very high rates of force development, and will hardly bring to mind rocket propulsion. There are data that support the hypothesis that the intent to move a load quickly, regardless of the actual velocity, may be an indicator of velocity adaptation [2], thus the outward appearance of an exercise may not be the best indicator of its specificity to performance.

INTENSITY

Another term to consider is "intensity". This term typically describing field strength or energy transmission by radiation or sound, or as a measure of the size of an earthquake in geology. It is oft thought synonymous with load in resistance training. However, certain schools of thought prescribe the term "high-intensity" training to single-set protocols that usually use purposefully slow contractions. Since both the rate of work and the load in this case is less than maximal, "high-intensity" is a misnomer, and further muddies the water concerning terminology in weight training. When referring to light-bulb intensity, the units of measure are Watts. This is the unit of measure for power, or the rate of performing work.

PLYOMETRIC

Plyometric is a term that has been variously defined over the years as well. The term is defined in the dictionary as "a system of exercise in which the muscles are repeatedly stretched and suddenly contracted". While "suddenly" invokes a time component, there is no mention here that that time must be minimal. In fact, the time component is likely the most important part of describing various sporting motions. Most high-rate of force development (RFD) activities function in a time period that is less than that required to reach maximal force. Hence, the amount of force that can be developed in the allowed time could be a crucial component to sport success. Often for a given range-of-motion in dynamic actions, as the muscular effort becomes maximal, less time is allowed for force development (i.e., jumping). This relationship is demonstrated by the impulse-momentum relationship and the work-energy relationship [3].

CONCLUSION

Only when sport scientists and coaches are speaking the same language will productive debate on the applicability of acute training variables be possible. While there will always be an art to coaching, progress in athletic performance can likely be enhanced by promoting the science of sport and exercise, by increasing the education of coaches in the basic sciences, especially mechanics. This background in the basic sciences along with the ability to conduct, read, and interpret research will give the strength and conditioning or sport coach to argue the finer points of high RFD training.

REFERENCES

1. The Free Dictionary, *Http://www.thefreedictionary.com/explosive*
2. Behm, D.G. and Sale, D.G., Intended Rather than Actual Movement Velocity Determines Velocity-Specific Training Response, *Journal of Applied Physiology*, 1993, 74(1), 359-368.
3. Schilling, B.K., Falvo, M.J. and Chiu, L.Z.F., Force-Velocity, Impulse-Momentum Relationships: Implications for Efficacy of Purposefully Slow Resistance Training, *Journal of Sports Science and Medicine*, 2008, 7, 299-304.

Should All Athletes Use Explosive Lifiting?

A Commentary

John D. Fair
University of Texas, Austin, TX, USA
E-mail: john.fair@austin.utexas.edu

INTRODUCTION

The term "explosive lifting" is relatively new, but the concept goes back to the glory days of American weightlifting when Tommy Kono and the George brothers (Pete and Jim) reigned supreme on the international scene. Concentration and intensity were critical to awakening those fast-twitch muscle fibers essential to winning Olympic and world championship medals. Tommy still employs explosive concepts, synoptically termed "acceleration" and "mental conditioning," in his *Weightlifting Olympic Style* [1] and *Championship Weightlifting* [2], and Pete has often emphasized the importance of strong mind to muscle commands to activate as many fibers as possible for maximal performance. It was Bob Hoffman, however, who propagated the idea that the strength and skills developed in Olympic weightlifting would lead to proficiency in virtually any other sport. Bill Starr, his renegade editor at *Strength & Health*, later pooh-poohed this notion as fanciful, but the subsequent spread of resistance training and strength coaching to virtually all colleges and high schools in subsequent decades speaks for itself. It is within this historical context that this thought-provoking essay by Harvey Newton and Simon Jenkins is set.

PLYOMETRICS

Now it's plyometrics and the shortening-stretch cycle that sets the tone for modern exercise scientists who are interested in explosive techniques. Both authors recognize the potential of these concepts for weightlifting. In his *Sports Science Handbook*, the second author points out that "the greater a muscle is pre-stretched from its resting length before shortening occurs, the greater the force the muscle will be able to exert" [3, p. 308]. But the first author, in *Explosive Lifting for Sports* is quick to point out that though "plyometric training provides an excellent stimulus for increased power," its application should be carefully designed to fit "your sport and its specific requirements" [4, p. 35]. The authors also concur that not all explosive motions in sport are plyometric. But weightlifting is a sport that should provide an almost perfect match. That it has not experienced greater popularity, concludes Artie Drechsler in *The Encyclopedia of Weightlifting* owes much to "the tendency for plyometrics to lead to injuries of the muscle-tendon units … and because so much of ordinary training on the classic lifts [already] involves a plyometric component" [5, p. 135] Yet one of the trends in high school football coaching in recent decades has been the utilization of explosive movements, especially the snatch, the power clean, and jump squats—this after many more earlier decades of condemning weight training in any form.

ENDURANCE TRAINING

That resistance training is not necessarily appropriate for all sports is admitted at the outset of the essay, citing the example of Lance Armstrong who, early in his career, eschewed advice from the first author that he incorporate some plyometric movements in his exercise regimen. Although scientists have shown that male cyclists have poor skeletal health and could increase their bone density by doing more weight lifting, what works in the short run, the authors argue, is their continued focus on endurance training. What exercise physiologists have also discovered, however, is that resistance training, focused on intensity and not necessarily heavy weights, can yield aerobic benefits. It stemmed from the ground-breaking study published by Goreham et al. [6] who concluded that muscle mass produced by resistance training brought metabolic changes similar to aerobic training. A follow-up study Tang at et al. [7] determined that resistance training did not limit endurance in athletes but actually improved aerobic capacity. These results were further confirmed by Wang et al. [8]. It would appear then that anaerobic exercise, contrary to conventional wisdom, actually complements aerobic exercise. But the extent to which explosive lifting, as a form of intensity, will ever be embraced fully by endurance athletes remains to be seen.

PROS AND CONS OF EXPLOSIVE LIFTING

In more specific terms, it can be asked whether the snatch and clean & jerk, two of the fastest and most explosive movements in all of sports are applicable to other sports. This article examines some of the pros and cons to adopting the so-called "quick lifts" as a training medium. That they induce strength and power is an obvious benefit, while the possible prevention of injury is not so obvious. Perhaps the development of greater flexibility and coordination is the characteristic that sets Olympic lifting apart from its sister iron sports, powerlifting and bodybuilding, and inspires so much respect within the athletic community and general public.

As for the cons, the authors list a series of properties that sound more like challenges for athletes to overcome than deficiencies inherent to the activity itself. Olympic lifting is a complex, technique driven endeavor that requires above average flexibility, decent reflexes, and a modicum of strength, at least for beginners. But good coaching and facilities can be found. Just tap into the "Find a Club" tab on the USA Weightlifting website. It's my opinion that the greatest drawback to practicing weightlifting as a complement to another sport lies in the possibility of acquiring too great a proficiency and interest in it and not devoting enough time and effort to practicing one's primary sport. Perhaps the best example of this scenario was the great Gary Gubner who became a world class shot putter and weightlifter, but never fully realized his full potential by winning an Olympic or world championship gold medal in either sport.

CONCLUSION

However frivolous it might sound, I would argue that beauty of form and motion is a compelling argument in favor of explosive lifting. One of my most satisfying experiences as a volunteer at the 1996 Atlanta Olympics was having the opportunity to observe the speed, flexibility, and strength of the best lifters in the world. Most memorable was the explosiveness of the great Bulgarian lifters, especially Zlatan Vanev, who went on to become a world champion and record holder. He combined these qualities into charisma, despite not even looking like a weightlifter. It stirred my imagination and reminded me of one of the reasons I was attracted to weightlifting a half century ago. To some, the Olympic lifts may appear to be tedious and a form of drudgery, but to practice it and watch it can be an exhilarating and awe-inspiring experience.

REFERENCES

1. Kono, T., *Weightlifting, Olympic Style*, HKC, Honolulu, HI, 2001.
2. Kono, T., *Championship Weightlifting: Beyond Muscle Power*, HKC, Honolulu, 2010.
3. Jenkins, S., *Sports Science Handbook: The Essential Guide to Kinesiology, Sport and Exercise Science*, Vol. 2: I-Z, Multi-Science Publishing Co. Ltd., Brentwood, UK, 2005.
4. Newton, H., *Explosive Lifting for Sports, Enhanced Edition*, Human Kinetics, Champaign, IL, 2006.
5. Dreschsler, A., *The Encyclopedia of Weightlifting: A Guide to World Class Performance*, A is A Communications, Flushing, NY, 1998.
6. Goreham, C., Green, H.J., Ball-Burnett, M. and Ranney, D., High-Resistance Training and Muslce Metabolism During Prolonged Exercise, *American Journal of Physiology – Endocrinology and Metabolism*, 1999, 276(3), E489-E496.
7. Tang, J.E., Hartman, J.W. and Phillips, S.M., Increased Muscle Oxidative Potential Following Resistance Training Induced Fibre Hypertrophy in Young Men, Applied Physiology, *Nutrition, and Metabolism*, 2006, 31(5), 495-501.
8. Wang, L., Mascher, H., Psilander, N., Blomstrand, E. and Sahlin, K., Resistance Exercise Enhances the Molecular Signaling of Mitochondrial Biogenesis Induced by Endurance Exercise in Human Skeletal Muscle, *Journal of Applied Physiology*, 2011, 111(5), 1335-1344.

Should All Athletes Use Explosive Lifting?

A Commentary

N. Travis Triplett
Department of Health, Leisure, and Exercise Science
Appalachian State University, Boone, NC, 28608, USA
E-mail: triplttnt@appstate.edu

INTRODUCTION

The article by Harvey Newton and Simon Jenkins effectively presents both a background of and the importance of resistance training for sport performance. In addition, the authors address the applications and limitations of a type of resistance training known as explosive lifting and the discrepancies in the field about its use. In particular, they focus on the weightlifting movements and how they are used to develop explosive power.

ARGUMENTS IN FAVOUR OF EXPLOSIVE LIFTING

There are strong arguments for all types of athletes utilizing explosive lifting in their overall training regimens. Muscular power, a function of force (strength) and time, is a component of most every sport and is developed most effectively through explosive training [1, 2]. All sports, even endurance sports, have elements of explosiveness in certain situations during competition, some more than others. Aside from the general goal of developing power, the arguments for including explosive training range from sport specificity (to enhance carryover) to the development of physiological traits such as strength and hypertrophy [3-5]. The authors do an excellent job of pointing out that the explosive lifts (weightlifting movements and their derivations) have the added advantage of being multi-joint and multi-muscle so performing these movements with a higher load is possible, and the neural adaptations of rate of force development and inter-muscular coordination can therefore be greater than with other explosive movements [4].

ARGUMENTS AGAINST EXPLOSIVE LIFTING

The arguments in the field against the use of explosive lifting in a resistance training program for an athlete are weaker and can be addressed. The authors explain that some practitioners are hesitant to utilize explosive lifts in training because of misconceptions about their safety. There is no evidence that explosive lifts are any more dangerous than any other types of lifts [6, 7]. The real issue is related to lifting technique. Since the explosive lifts are technically complex, requiring a good base of strength to be performed effectively, the authors emphasize that proper instruction and supervision is vital to using these lifts in a resistance training program. While practitioners have valid concerns about the availability of proper instruction for the weightlifting movements, there are several other explosive lifts with weight that can be utilized while the more complex weightlifting movements are being learned. These lifts include weighted jumps (barbell or dumbbells) or leg press throws, or bench press throws for the upper body [8]. The main disadvantage to using other explosive

lifts is that they cannot be loaded to the same extent. One advantage, though, is that peak power typically occurs with lighter loads so training can focus more on the speed aspect of power [3]. Another argument against the use of explosive lifting in training is valid from a monetary perspective as explosive lifting requires specialized equipment in order to be performed properly. Some facilities may simply not be able to purchase this equipment for use. However, the other previously-mentioned explosive lifts do not require the same equipment and could be used with good results to develop power.

CONCLUSION

Explosive lifting has a definite place in the training programs of athletes. The main concepts that practitioners need to be aware of are that there are multiple types of explosive lifts and the weightlifting movements are considered to be more advanced and should be placed into a training program after the athlete has developed sufficient strength, flexibility, and technique. If these lifts are incorporated too early the athlete will not benefit and may suffer as a result. However, if these lifts are used appropriately they provide more benefits than many other lifts/equipment that is commonly utilized in training. Aside from the physical development necessary for successful sport performance, prevention of potential injuries is an added benefit to using these lifts, which is very important to sport performance as well.

REFERENCES

1. Garhammer, J. and Gregor, R., Propulsion Forces as a Function of Intensity for Weightlifting and Vertical Jumping, *Journal of Applied Sport Science Research*, 1992, 6(3), 129-134.
2. Schilling, B.K., Stone, M.H., O'Bryant, H.S., Fry, A.C., Coglianese, R.H. and Pierce, K.C., Snatch Technique of Collegiate National Weightlifters, *Journal of Strength and Conditioning Research*, 2002, 16(4), 551-555.
3. Cormie, P., McCaulley, G.O., Triplett, N.T. and McBride, J.M., Optimal Loading for Maximal Power Output During Lower-Body Resistance Exercises, *Medicine and Science in Sports and Exercise*, 2007, 39(2), 340-349.
4. Hori, N., Newton, R.U., Nosaka, K., and Stone, M.H., Weightlifting Exercises Enhance Athletic Performance that Requires High-Load Speed Strength, *Strength and Conditioning Journal*, 2005, 27(4), 50-55.
5. Tricoli, V., Lamas, L., Carnevale, R. and Ugrinowitsch, C., Short-Term Effects on Lower-Body Functional Power Development: Weightlifting vs. Vertical Jump Training Programs, *Journal of Strength and Conditioning Research*, 2005, 19(2), 433-437.
6. Hamill, B.P., Relative Safety of Weightlifting and Weight Training, *Journal of Strength and Conditioning Research*, 1994, 8(1), 53-57.
7. Stone, M.H., Fry, A.C., Ritchie, M., Stoessel-Ross, L. and Marsit, J.L., Injury Potential and Safety Aspects of Weightlifting Movements, *Strength and Conditioning*, 1994, 16(3), 15-21.
8. Newton, R.U., Cormie, P. and Kraemer, W.J., Power Training, in: Hoffman, J.R., ed., *NSCA's Guide to Program Design,* Human Kinetics, Champaign, IL, 2012, 95-117.

Should All Athletes Use Explosive Lifting?

A Commentary

Lawrence W. Judge
Ball State University
HP 360M, Muncie, IN 47306, USA
E-mail: LWJudge@bsu.edu

INTRODUCTION

As training techniques are tested and evaluated, new research recommendations based on those evaluations have also emerged [1]. The endorsement of resistance training as a means to enhance performance in all sports has become increasingly accepted by strength and conditioning professionals worldwide. Although the value of strength to sport performance appears undisputable, several authors have recommended that explosive power is actually a more important physical characteristic [2]. Numerous studies and review articles have reported evidence and logical arguments for the use of explosive exercises for athletes [3]. Olympic-style lifts (Clean, Jerk, and Snatch) and their derivatives are being used in a variety of aerobic and anaerobic based sports. Weightlifting training produces many benefits, including: injury prevention, improved flexibility, improved inter- and intramuscular coordination and sharpened psychological abilities [3].

The recommendation for athletes involved in aerobic based sports is related to increased evidence of the positive impact explosive training has on running economy (RE). Voigt et al. [4] and Verkhoshansky [5] described that efficient sprinting, the effective usage of the stretch-shortening mechanism, can recover approximately 60% of the total mechanical energy, thereby increasing RE. This should be considered fundamental due to the significant contribution a high $\dot{V}O_2$ max makes to a soccer players' game, of which RE is a fundamental component [6-8]. Paavolainen et al. [9] investigated the effects of "explosive strength training" on the performance capabilities of 18 male well-trained endurance athletes and found that concurrent explosive-strength training yielded improved neuromuscular characteristics and subsequent improvements in RE. Bastiaans et al. [10] investigated the effects of explosive strength training on endurance related factors in competitive road cyclists and found that strength training mitigated the commonly observed loss in power and sprint ability associated with long-term endurance training. These types of results can be found in wide variety of sports which has attributed to the increase in the use of explosive lifting to train athletes, currently at an all-time high. One recent survey of high school strength coach members of the National Strength and Conditioning Association (NSCA) found that 97% of such coaches incorporate weightlifting movements in the training routines utilized by their scholastic athletes [11].

Specificity is also a vital concept in training for the sport [12]. The optimal training program is based on the premise that specific physiological/performance characteristics can be developed by emphasizing specific training variables. Thus, exercises must be specifically designed for the demands of the sport. Effective program design must address energetics,

mechanics and coordination characteristics specific to the chosen sport. As with any sport for which a training program is to be implemented, the strength and conditioning professionals must first undergo a needs analysis to identify the biomechanical and physiological requirements of the sport. Only after completion of this analysis is an efficacious training program formulated.

EXPLOSIVE TRAINING FOR ENDURANCE ATHLETES

The importance of aerobic fitness to the preparedness of endurance-based sports like cycling and soccer is clearly established in the research [6, 7, 8, 10]. But some coaches take the concept of specificity of training too far and fail to prescribe a balanced approach to training by not including/emphasizing weight lifting training. According to the article by Newton and Jenkins, there are those who have expressed opposition to the idea that athletes from various sports (explosive or otherwise) should train with weightlifting methods [13, 14]. Often this reluctance may be spearheaded by former athletes (coaches) who may have been successful in their chosen sport without utilizing explosive training.

Seven-time Tour de France winner Lance Armstrong is one of the more successful endurance athletes in history. Based on his success in the sport of cycling, his outstanding cardio-respiratory fitness is undisputable. According to Newton and Jenkins, his training primarily emphasized aerobic fitness as Armstrong did little if any explosive training when he was in peak condition. Various physiological parameters of aerobic fitness have been shown to have strong correlations with performance in endurance-related sports like soccer [6-8]. As Castagna et al. [15] reported, it has been shown repeatedly, through descriptive, cross-sectional, and training studies, that aerobic fitness ($\dot{V}O_2$ max, lactate/anaerobic threshold, and RE) is positively related to soccer performance outcomes in terms of an individual's match statistics. This would include important parameters such as distance covered, time on the ball, and number of sprints during a match [6, 7, 15].

Incorrect resistance training strategies or not taking advantage of the benefits of explosive training, on the other hand, can have a negative impact on performance and impact competitive opportunities for a developing young cyclist [16]. One must be well-rounded in terms of his or her strength preparation. It is not enough to develop one biomotor quality (i.e., endurance) at the expense of all others.

STRENGTH VERSUS POWER

The benefits of explosive exercise are well established in the research literature, but are still not utilized by some coaches [17]. The application of free-weights as a means of developing physical capabilities for athletes has long been a common practice [18]. The use of other forms of resistance equipment and machines has become popular in recent years. While any variety of resistance applied against working muscles can enhance the strength of that muscle group, the use of free weights is superior to fixed position machines [18]. From a practical standpoint, the previous section begs the question of whether training should be more focused towards a balanced approach to training including the development of strength and power or just focused on sport-specific energy system fitness. This question, however, may be addressed by understanding the relationship between maximal strength and power output.

Numerous studies and review articles have reported evidence and logical arguments for the use of explosive exercises [19, 20]. Schmidtbleicher has characterized explosive exercise as having maximum or near maximum rates of force development [21]. These types of exercises are not only marked by high force development, but are high-velocity movements [20, 22]. The specific explosive exercises often chosen include global exercises that work

explosiveness in more than one muscle group all at once [18]. The snatch, clean and jerk and their derivatives have potential for power outputs higher than the so-called "power-lifting exercises" (squat, bench press, dead lift) or more appropriately termed "strength" lifts [19]. The clean and snatch are two of the exercises that offer a lot of versatility. The many derivatives of these exercises can be changed to reflect the goal of the training cycle [22]. For example, you can choose between performing a snatch from the floor, from the knee, from the thigh, with a close grip, with a wide grip, or with dumbbells.

CONCLUSION

As the knowledge base for training strategies continues to evolve, coaches must adapt their practices to ensure their athletes are being properly prepared for training and competition. Ignoring the benefits of weight lifting exercises clearly puts the athlete at a competitive disadvantage. Explosive exercises can be easily administered by a strength and conditioning professional, as required, throughout a season according to the periodized training plan.

REFERENCES

1. Craig, B.W. and Judge, L.W., The Basics of Resistance Program Design: Where Do I Start?, *Strength and Conditioning*, 2009, 31, 75-77.
2. Bakarinov, Y. and Ozerov, V., How Throwers Should Train (Review of Scientific Research), *Legkaya Atletika*, 1985, 7, 4-5.
3. Stone, M.H., Sanborn, K., O'Bryant, H.S., Hartman, M., Stone, M.E., Proulx, C., Ward, B. and Hruby, J., Maximum Strength-Power Performance Relationships in Collegiate Throwers, *Journal of Strength and Conditioning Research*, 2003, 17(4), 739-745.
4. Voigt M., Bojsen-Moller F., Simonsen, E.B. and Dyhre-Poulsen P., The Influence of Tendon Young's Modulus, Dimensions and Instantaneous Moment Arms on the Efficiency of Human Movement, *Journal of Biomechanics*, 1995, 28, 281–291.
5. Verkhoshansky, Y.U., Perspectives in the Development of Speed-Strength Preparation in the Development of Jumper, *Track and Field*, 1966, 11–12.
6. Chamari, K., Hachana, Y., Kaouech, F., Jeddi, R., Moussa-Chamari, I. and Wisløff U., Endurance Training and Testing with the Ball in Young Elite Soccer Players, *British Journal of Sports Medicine*, 2005, 39, 24–28.
7. McMillan, K., Helgerud, J., Macdonald, R. and Hoff, J., Physiological Adaptations to Soccer Specific Endurance Training in Professional Youth Soccer Players, *British Journal of Sports Medicine*, 2005, 39, 273–277.
8. Hoff, J., Training and Testing Physical Capacities for Elite Soccer Players, *Journal of Sports Science*, 2005, 23, 573–582.
9. Paavolainen, L. Hakkinen, K., Hamalainen, I., Nummela, A. and Rusko. H., Explosive-Strength Training Improves 5-km Running Time by Improving Running Economy and Muscle Power, *Journal of Applied Physiology*, 1999, 86, 1527-1533.
10. Bastiaans J.J., Van Diemen A.B., Veneberg T. and Jeukendrup A.E., The Effects of Replacing a Portion of Endurance Training by Explosive Strength Training on Performance in Trained Cyclists, *European Journal of Applied Physiology*, 2001, 86, 79-84.
11. Duehring, M. D., Feldmann, C. R. and Ebben, W. P., Strength and Conditioning Practices of United States High School Strength and Conditioning Coaches, *Journal of Strength and Conditioning Research*, 2009, 23(8), 2188-2203.
12. Stone, M. H., Stone, M. and Sands, W. A., *Principles and Practice of Resistance Training*, Human Kinetics, Champaign, IL, 2007.
13. Gambetta, V., *Athletic Development*, Human Kinetics, Champaign, IL, 2007.
14. Jesse, J. P., Olympic Lifting Movements Endanger Adolescents, *The Physician and Sportsmedicine*, 1977, September, 61-66.

15. Castagna, C, Impellizzeri, F.M., Chamari, K., Carlomagno, D. and Rampinini, E., Aerobic Cycle Training, *Strength and Conditioning*, 2008, 30, 33–38.

16. Nichold, J. and Raugh, M., Longitudinal Changes in Bone Mineral Density in Male Master Cyclists, *Journal of Strength and Conditioning Research*, 2011, 25(3), 727-734.

17. Haff, G., Potteiger, J. and Whitley, A., A Brief Review: Explosive Exercises and Sports Performance, *Strength and Conditioning*, 2001, 23(3), 13–20.

18. Garhammer, J., Free Weight Equipment for the Development of Athletic Strength and Power, *National Strength and Conditioning Journal*, 1982, 3(6), 24-26.

19. Garhammer, J., Power Production by Olympic Weightlifters, *Medicine and Science in Sports and Exercise*, 1980, 12, 54-60.

20. Stone, M.H., Explosive Exercise, *National Strength and Conditioning Association Journal*, 1993, 15(4), 7-15.

21. Schmidtbleicher, D. Training for Power Events, in: Komi, P.V., ed., *Strength and Power in Sports,* Blackwell Scientific Publications, Oxford, UK, 1992, 381-395.

22. Newton, H. S. *Explosive Lifting for Sports*, Enhanced Edition, Human Kinetics, Champaign, IL, 2006.

Should All Athletes Do Explosive Lifting?

A Commentary

Tim J. Gabbett[1, 2]
[1]School of Exercise Science, Australian Catholic University,
Brisbane, 4014, Australia
[2]School of Human Movement Studies, The University of Queensland,
Brisbane, 4072, Australia
E-mail: tim_gabbett@yahoo.com.au

INTRODUCTION

The article by Newton and Jenkins poses several important questions relating to strength training and weightlifting. The question of whether strength and power training "optimises sporting results" has received considerable attention, particularly in recent years.

STRENGTH AND POWER AND SPORTS PERFORMANCE

While some muscular strength and power qualities discriminate higher- and lesser-skilled athletes [1], others do not [2, 3]. Indeed, in a study of American football players, a wide range of muscular strength and power qualities (1-repetition maximum squat, bench press, power clean, and snatch) were measured [3]. The strongest predictor of playing ability was vertical jump performance, with strength and power measures (bench press and power clean) only moderately associated (r = -0.48 to -0.58) with playing ability, and only in defensive players.

A large number of studies have examined the relationship between muscular strength and power qualities and performance (e.g., sprinting speed, jumping ability, and tackling proficiency) [4-6]. In general, greater muscular strength and power is associated with greater performance [4-6]. However, studies demonstrating transfer effects of strength and power training to the competitive environment are less conclusive, with improvements in strength and power often observed without concurrent changes in sport-specific skills [7]. While there is sufficient evidence to support the use of strength and power training as an important component of athletic preparation, clearly further research is required in order to determine if improvements in physical qualities that are developed through strength training, transfer to the performance of sporting skills.

STRENGTH AND POWER TRAINING AND INJURY RISK

An equally important question raised by Newton and Jenkins' article, is the degree to which strength training offers a protective effect against injury. The authors correctly assert that some coaches circumvent strength training in their programs, due to an (often) unsubstantiated fear of injuring their athletes. Others avoid strength training as the fatigue and soreness that manifest in the days following training prevents athletes from performing other important "sport-specific" training (e.g., quality swimming sets). Although the decision to use strength and power training to improve athletic performance is often heavily influenced by tradition and the culture of the sport, empirical evidence demonstrating a

protective role of strength training against injury is equivocal, with studies showing increased [8], decreased [9], and unchanged [10] injury risk in the strength-trained state.

McGill et al. [10] examined the relationship between measures of strength and injury in university-level basketball players. No relationship was observed between measures of muscular strength and injury incidence. It should be recognised, however, that the degree to which high levels of muscular strength and power prevent injuries is likely dependent on the sport in question. We recently investigated the risk factors for collision injuries in professional rugby league players [9]. Players with poorly developed upper-body strength (chin-up) and power (bench throw) were at increased risk of collision injury. These findings are in contrast to the results of others [8] that have shown a significant relationship ($r = 0.82$) between strength and power training loads and non-contact field training injuries. Collectively, these findings suggest that high strength and power training loads may contribute indirectly to field injuries, but the development of muscular strength and power that occurs through this type of training is likely to prevent more commonly occurring collision injuries.

CONCLUSION

Clearly, the use of strength and power training for athletic performance depends on the physical requirements of the sport, and also balancing the potential benefits of resistance training with the negative consequences which may arise. While the evidence supporting a protective effect of strength and power training against injury is far from conclusive, there is sufficient evidence to suggest that appropriately periodised strength and power training can improve athletic performance [7, 11].

REFERENCES

1. Hansen, K., Cronin, J.B., Pickering, S.L. and Douglas, L., Do Force-Time and Power-Time Measures in a Loaded Jump Squat Differentiate Between Speed Performance and Playing Level in Elite and Elite Junior Rugby Union Players?, *Journal of Strength and Conditioning Research*, 2011, 25, 2382-2391.
2. Kuzmits, F. and Adams, A.J., The NFL Combine: Does it Predict Performance in the National Football League?, *Journal of Strength and Conditioning Research*, 2008, 22, 1721-1727.
3. Sawyer, D.T., Ostarello, J.Z., Suess, E.A. and Dempsey, M., Relationship Between Football Playing Ability and Selected Performance Measures, *Journal of Strength and Conditioning Research*, 2002, 16, 611-616.
4. Cronin, J.B. and Hansen, K.T., Strength and Power Predictors of Sports Speed, *Journal of Strength and Conditioning Research*, 2005, 19, 349-357.
5. Gabbett, T.J, Abernethy, B. and Jenkins, D.G., Correlates of Tackling Ability in High-Performance Rugby League Players, *Journal of Strength and Conditioning Research,* 2011, 25, 72-79.
6. Sheppard, J.M., Cronin, J., Gabbett, T.J., McGuigan, M.R., Etxebarria, N. and Newton, R.U., Relative Importance of Strength, Power, and Anthropometric Measures to Jump Performance of Elite Volleyball Players. *Journal of Strength and Conditioning Research,* 2008, 22, 758-765.
7. McGuigan, M.R., Wright, G.A. and Fleck, S.J., Strength Training for Athletes: Does it Really Help Sports Performance?, *International Journal of Sports Physiology and Performance*, 2012, 7, 2-5.
8. Gabbett, T.J. and Jenkins, D.G., Relationship Between Training Load and Injury in Professional Rugby League Players, *Journal of Science and Medicine in Sport*, 2011, 14, 204-209.
9. Gabbett, T.J., Ullah, S. and Finch, C.F., Identifying Risk Factors for Contact Injury in Professional Rugby League Players – Application of a Frailty Model for Recurrent Injury, *Journal of Science and Medicine in Sport*, 2012, 15(6), 496-504.
10. McGill, S.M., Andersen, J.T. and Horne, A.D., Predicting Performance and Injury Resilience from Movement Quality and Fitness Scores in a Basketball Team Over 2 Years, *Journal of Strength and Conditioning Research*, 2012, 26(7), 1731-1739.
11. Harries, S.K., Lubans, D.R. and Callister, R., Resistance Training to Improve Power and Sports Performance in Adolescent Athletes: A Systematic Review and Meta-Analysis, *Journal of Science and Medicine in Sport*, 2012, 15(6), 532-540.

Should All Athletes Use Explosive Lifting?

A Commentary

Mike Lambert
MRC/UCT Research Unit for Exercise Science and Sports Medicine, Sports Science Institute of South Africa, Boundary Road, Newlands, 7700, South Africa
E-mail: mike.lambert@uct.ac.za

INTRODUCTION

The article by Newton and Jenkins exposes the complexities in terminology of the various practices of resistance training. The paper also shows there are disparate viewpoints among practitioners about the effects of different types of training and the pros and cons of each method. What appears to be lacking in the debate is a clear definition of the desired outcome after starting a resistance training programme. Is the desired goal to become bigger, more powerful or resistant to injury? Does the enhanced strength have to be very specific for a muscle group, or general for the whole body? Does the increased power have to be demonstrated for just a few muscle contractions, or after repeated muscles contractions?

Another point which needs to be considered in a debate on the pros and cons of the different training programmes is the resistance training experience of the athletes [1, 2]. A novice will experience neurological adaptations in the early stages of training, followed by morphological changes after a few weeks. Therefore it obvious that it is difficult to reach resolution about the best training approach if the outcome and conditions are not defined clearly.

A GUIDING PRINCIPLE

I believe that by applying the concept of the long-term athlete development model [3] some of the issues described above can be resolved. The philosophy behind the long-term athlete development model is that the exposure to the different levels of resistance training should unfold in a systematic way as the athlete matures. The initial exposure to resistance training should emphasise the importance of resistance training and expose the young athletes to different types of resistance training equipment. The emphasis in these early formative years should be on correct technique and safety. The young athletes should not be encouraged to specialise too soon, and should be taught that different types of training are matched with different outcomes. It goes without saying that the resistance training programme should be prescribed to meet these objectives.

LESSONS ABOUT RESISTANCE TRAINING FROM SOUTH AFRICA

Rugby union is a popular sport in South Africa, second to football in terms of numbers of players in the country. Rugby players in South Africa start competing at a provincial level at the age of thirteen, culminating in a national under-thirteen tournament [4]. Success in rugby

at the age group level is determined to a large extent by body size. This imposes challenges to the administrators, because talented but small players may by overlooked by coaches who favour the bigger, less skilful players. This can have long-term consequences for the game, particularly because the players from a lower socioeconomic group are smaller than players from more affluent groups [5].

As result of the relationship between body size and performance in rugby, aspiring young players start training with weights at an early age. Players who do not have access to weight training equipment are clearly disadvantaged [4]. Too counter this problem, the South African Rugby Union and the Sports Science Institute have designed "mobile gyms". These are refurbished shipping containers, fully equipped with sufficient weight training equipment to enable the squad to train together. The "mobile gyms" have an Olympic lift platform that rolls out onto the field. In addition to Olympic lifts there are plyometric boxes that are used for explosive jump training. The "mobile gyms" are built in a factory and then transported to remote areas that do not have equipment (Figure 1), enabling the players to train and remain competitive (Figure 2). At present 38 "mobile gyms" have been distributed around the country by the South African Rugby Union. The Sports Science Institute has produced an instructional DVD and manual that describes the weight training exercises. The instructions include the standard resistance training exercises as well as more complex exercises such as the Power Clean, Hang Clean, One-Arm Snatch, Push Jerk and Deadlift. The training also includes various medicine ball explosive exercises (squat throws, over head toss) and various plyometric exercises (box jumps, squat jumps). The manual has programmes for three levels of players; beginners, intermediate and advanced, prescribed for different phases of the season. Personnel from the Sports Science Institute train coaches on how to do the exercises. The type of training that is prescribed is similar to the programmes that are given to the national tournament age-group players. Therefore, when the players reach senior level they can easily slot into the weight training programmes that the players from the more advantaged areas are accustomed to.

Figure 1. A Mobile Gym Being Hoisted onto a Truck at the Factory Before Being Transported to a Club

Figure 2. Mobile Gym Training Session

CONCLUSION

The success of this programme is starting to be realised. Two players, who had their formative years in rural areas with the mobile gym as their only facility for resistance training, have matured and ended up playing for the national senior team. Without their early exposure to resistance training, it is highly unlikely that they would have matured into players that became internationally competitive.

REFERENCES

1 Cannon, J. and Marino F., Early-Phase Neuromuscular Adaptations to High-and Low-Volume Resistance Training in Untrained Young and Older Women, *Journal of Sports Sciences,* 2010, 28, 1505–1514.

2 Folland, J.P. and Williams, A.G., The Adaptations to Strength Training : Morphological and Neurological Contributions to Increased Strength, *Sports Medicine,* 2007, 37, 145–168.

3 Lloyd, R. and Oliver, J., The Youth Physical Development Model: A New Approach to Long-Term Athletic Development, *Strength and Conditioning Journal,* 2012, 34, 61–72.

4 Lambert, M.I. and Durandt, J., Long-Term Player Development in Rugby – How are We Doing in South Africa?, *South African Journal of Sports Medicine,* 2011, 22, 67–68.

5 Armstrong, M., Lambert, E. and Lambert, M., Physical Fitness of South African Primary School Children, 6 to 13 Years of Age: Discovery Vitality Health of the Nation Study, *Perceptual and Motor Skills* 2011, 113, 999–1016.