Is Olympic Lifting Relevant to Developing Athletic Power?

INTRODUCTION

Improving the ability to forcibly propel oneself against the physical constraints of the athletic environment is the task of training. One of the most exploited training principles used to achieve this goal is power development (Jarver 1991; Lyttle 1994). Over the years this form of training has been employed extensively to improve many power oriented movements in a variety of sports (Newton 1996). There are many variations on the theme of power training. Some of these training principles include plyometrics (Wilson, Elliot & Wood 1990), assisted and resisted training (Faccioni 1993a; 1993b) and speed and acceleration drills (Cinkovich 1992). A popular method used to increase athletic power is Olympic Lifting (ie power cleans, push presses, snatches, jump jerks and their variations) conducted in the weight room. This has traditionally been seen as an effective way of producing general explosive ability (Takano 1992; Stone 1993; Garhammer & Gregor 1992). However, considering motor skill and neurological aspects of movement, the logic of employing Olympic Lifts in power training becomes unclear. Therefore, the interpretation and application of Olympic Lifting to the development of power will be considered.

POWER DEFINED

Power has been defined as the optimal combination of speed and strength to produce movement (Chu 1996). More specifically, power represents the ability of the athlete to produce high levels of work through a given distance. The more power an athlete possesses the greater the level of work performed (Wilson 1992). Power is a combination of strength and speed:

POWER = STRENGTH *(force application)* x SPEED *(velocity)*

Therefore, an analysis of the components of strength and speed should help to define the fundamental mechanisms controlling the expression of power.

Strength

Physiological and neural adaptations comprise the strength component (Moritani 1992). Physiological adaptations to strength consist of an increase in muscle tissue through hypertrophy, connective tissue density and bone integrity (Tesch 1992a). Neural adaptations (Schmidtbleicher 1992) that can be produced are: (1) increased recruitment of motor units; (2) increased firing rate of motor neurones; (3) synchronised firing of motor neurones; (4) increase in intra-muscular coordination; and (5) increase in inter-muscular coordination.

Speed

Execution and delivery of movement is composed of a variety of interrelated factors (Ackland & Bloomfield 1995). These are; (1) muscle fibre type; (2) skill; (3) muscle insertion points; (4) lever length; (5) muscular posture; and (6) elastic energy use of the series elastic component.

Analysis of Power

From material presented above, concerning the components of power (strength and speed), several categories can be discerned.

1. ***Physiological*****:** encompasses all physiological adaptations of the strength component, and muscle fibre type and posture of the speed component.
2. ***Genetic*****:** includes muscle insertion points and lever length of the speed component.
3. ***Neurological*****:** includes neural adaptations of the strength component, and skill and elastic energy use of the speed component.

Genetic endowment is essentially unalterable (Simoneanu *et al.* 1986; Brzycki 1989); physiological adaptations can be enhanced through various hypertrophy and strength training regimens (Ostrowski, Wilson & Weatherby 1994; Tesch 1992b); and neurological adaptations are related to specific movement qualities (Wolpaw 1994; Young 1994; Ackland & Bloomfield 1995) and their accompanied load patterns (Pribram 1991; Sale 1992). Therefore, by using the deductive method (Teichman & Evans 1996), and neglecting the genetic component because of its fundamental role in physical development, one can logically conclude:

1. neurological processes coordinate physiological processes in strength expression.
2. neurological processes coordinate physiological processes in speed expression.
3. power is composed of strength and speed.
4. Therefore, neurological processes coordinate physiological processes of power expression.

Examining neurological mechanisms of power expression should elucidate strategies conducive for effective improvements of power transferable to the competitive environment.

NEUROLOGICAL PROCESSES OF POWER

The neurological control mechanism of movement is determined by the hierarchical structure of the central motor systems (Noth 1992). The 'motor program' (comprising an aspect of movement control) takes place in the premotor cortex, the supplementary motor area, and other cortical association areas. These areas, plus sensory input form the cerebellum and basal ganglia, converge to the primary motor area which eventually excites or inhibits the specific parts of the nervous system (Noth 1992). The motor program is the essential information processing system that controls stereotyped movement. It directs the muscles to contract in the proper order and with the proper levels of force and timing to produce predetermined movement (Enoka 1994). A motor program is the neurophysiological (neural network) processing structure reinforced by a specific pattern sequence of a learned motor skill (Schmidt 1991).

Movement Patterns and Motor Skills

Movement pattern specificity producing motor skills has been expressed as the fundamental constituent of any movement related to speed and power (Ackland & Bloomfield 1995; Sale 1992; Schmidtbleicher 1992). Many sporting skills require a very precise moment and direction of force application (Poliquin 1990). Regarding power training, Poliquin (1990) states that conventional equipment can be used to train the acting muscles in that precise range, but the neural pattern for the precise force application is acquired only by repetition of the desired skill. Thus, precise movement patterns of specific *motor skills* are needed to effectively entrain appropriate motor programs for efficient coordination of muscular contraction. Therefore, factors composing the execution of specific motor skills are also important in considering effective movement patterns.

Motor Skills and Abilities

Motor skills are made up of many abilities (Schmidt 1991). These abilities include: (1) Reaction Time (speed of reaction); (2) Response Orientation (choice reaction time); (3) Speed of Movement (appendage velocity); (4) Finger Dexterity (fine control of small objects); (5) Manual Dexterity (control of large objects); (6) Response Integration (sensory processing); and (7) Physical Proficiency Abilities (pure physiological adaptations).

Possessing a 'general motor ability' has been identified as a fallacious concept precipitated through inductive observation by coaches (Schmidt 1991). Different skills are composed of many different types of abilities. The precise selection and proportions of a number of these abilities within specific movement patterns constitutes the fundamental basis of a given skill. Even those motor skills which look similar can have different underlying abilities (Schmidt 1991).

Non Transfer of Basic Abilities

Schmidt (1991) states there is a misconception that fundamental abilities can be trained through various activities. These fundamental abilities are not transferable, and coaches have often employed various 'quickening' exercises to try to enhance their athlete's 'quickness'. There is no single quickness ability that can be trained. Thus, attempts to modify an ability with a non-specific drill is ineffective. However, transference of 'physical proficiency abilities' is possible because of the global nature of pure physiological factors effecting other movements. For example, an increase in muscle tissue effects all skills because extra muscle tissue will proportionately raise global strength levels (assuming everything else being equal).

Motor Skill learning

Schmidt (1991) suggests practical applications when learning motor skills that are important for explosive activities. These are:

1. Transfer of conceptual and strategic skill elements in early learning is great, so teach to maximise this transfer.
2. In later learning, where movement pattern is being acquired, do not expect much transfer from even similar appearing skills.
3. Later in learning, treat each class of skills (eg throwing) as a specific activity and do not encourage transfer from a somewhat related skill (eg volleyball spiking).
4. Drills and lead-up activities take considerable practice time and do not produce much transfer, so use them sparingly in later practice stages.
5. It is fruitless to try to train fundamental abilities (eg quickness), so concentrate on the fundamental skills instead.

POWER DEVELOPMENT AND OLYMPIC LIFTS

Power cleans, push presses, snatches, etc. are used by strength and conditioning coaches in an attempt to increase the athletes' general power ability, and is then assumed to transfer over to sporting activity. From the arguments presented so far;

1. fundamentally, power is governed by neurological processes;
2. neurological processes are governed by the motor cortex;
3. the motor cortex employs motor programs to control predetermined explosive muscular movement; and
4. practiced motor skills reinforce motor programs,

One can conclude that, if no general power ability exists, and the ultimate expression of power is through specific motor programs that govern explosive movement, then, Olympic Lifting used to develop power can not transfer to athletic activity. To make Olympic Lifting a plausible training principle to develop athletic power it would have to at least approximate sporting movements. From a motor skill aspect, this seems not to be possible.

For example, power cleans approximately use the same muscles, joints and range of motion as vertical jumping in volleyball (Garhammer & Gregor 1992). However, if movement patterns and direction of external loads influence the reinforcement of motor programs, and therefore power production, power cleans do not appropriately simulate vertical jumping. These discrepancies between the skills of Olympic Lifts and sporting movements can be summarised in three main categories.

1. **Velocity Curves**.

The limitation of performing Olympic Lifts is that the load generally achieves zero velocity at the end of the movement, eg proceeds from high to low velocity (Wilson *et al.* 1989). A normal sporting activity (eg jumping) involves a gradual increase in velocity of the involved limbs throughout the entire range of movement, achieving peak velocity at the end of the range of motion (Wilson 1992). Thus, the velocity curve for an Olympic Lift (because of inertial and momentum limitations of the loaded bar) is almost opposite to that of sporting activity.

2. **Velocity of Movement**.

The force-velocity curve dramatically demonstrates the relationship of the speed that an individual can produce at a given level of force production (McArdle, Katch & Katch 1991). Increasing velocity of movement decreases force production and vice versa. A small increase in load used in Olympic Lifting will therefore slow appendage velocity and effect acceleration compared to sporting activity.

3. **Changes in Biomechanics.**

Center of gravity will change relative to body alignment during Olympic Lifting compared to sporting activity because of the extra mass (the loaded bar) one must forcibly move in different directions. Altering momenta vectors will inherently change postural alignment (Hayes 1982).

When these factors (velocity curves, velocity of movement and biomechanical changes) are combined they can dramatically alter the sequencing of movement, and consequently perturb performance during explosive movements (Fukashiro & Komi 1987; Bobbert & Van Ingen Schenau 1988). Thus, Olympic Lifts are distinct and separate skills, also encompassing distinct and separate abilities from those experienced in sport. Therefore, not only are Olympic

Lifting abilities non transferable and distinct from sporting motor skills, but also the subsequent motor programs they produce.

As a general body exercise Olympic Lifts are satisfactory in incorporating large scale muscular activation. However, when current motor skill and biomechanical models are examined their purpose to facilitate power development is undermined.

Implications to Power Training

The above arguments advocate that developing a general power base using non-specific exercises is ineffective. To develop athletic power one can therefore proceed logically from the above statements:

1. Physiological attributes (muscle and connective tissue, bone integrity, posture, etc.) can be improved with conventional hypertrophy and strength training modalities (Wilson 1994a; 1994b)
2. Analyse the major power movement(s) in the particular sport to identify the dominant movement patterns. Employ training principles that increases resistance on the musculature to overload the neurological system but minimally effects the specific skill involved. This can be achieved through variations of plyometrics (Wilson, Elliot & Wood 1990), assisted and resisted training (Faccioni 1993a; 1993b) and speed and acceleration drills (Cinkovich 1992).

This approach to power training requires the innovation and imagination of the coach to create exercises which closely simulate biomechanical, physiological and psychomotor factors for efficient transfer from training to competition.

SUMMARY OF ARGUMENTS

1. Power is composed of strength and speed.
2. Neurological processes coordinate physiological processes.
3. Physiological processes can be enhanced through conventional strength training regimens.
4. Neurological processes are governed by the motor cortex.
5. The motor Cortex employs motor programs to control predetermined explosive movements.
6. Motor Programs are structurally reinforced through learned motor skills.
7. Motor skills are specific to the intended movement and constructed of abilities.
8. Abilities are non-transferable and subject to specific movement patterns for their selected use.
9. Training with non-specific activities will not elicit the same neural responses in another specific activity.
10. When athletes become advanced in specific motor skills there is little transfer with even similar skills.
11. Olympic Lifts do not simulate any sporting movement accurately.
12. Therefore, Olympic Lifts do not enhance general power.
13. Power training must be very specific to the movement involved.
14. Power training must load the athlete sufficiently but minimally effect the actual sporting movement.

CONCLUSION

The above arguments identify that power training needs to be considered as a specific motor skill and not as a general ability. Much of the research to date has centred on a reductionist perspective. This perspective concentrates on individual mechanisms (ie motor units) involved in local muscular systems and gives little attention to the complex interrelated aspects of movement (motor skills and motor programs). Olympic Lifting can be an effective way to produce large scale muscular activation in training. However, the role that they were traditionally designed to perform (developing general athletic power) is unattainable within the current scope of motor control theory.

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