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for CECS Level II Coaches

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SPECIFIC THEME: Complex Training Methods

GENERAL THEME: Complex Training Components and Physiology

Specific Theme

COMPLEX TRAINING METHODS FOR SPRINTERS, JUMPERS, AND THROWERS

1 Introduction

The term *complex training* was introduced in 1966 by Y. Verkhoshansky as describing a "complex of exercises united according to the principle that basic exercise for the development of reactive ability is fulfilled in a background of heightened excitability of the central nervous system, brought about by preliminary fulfillment of exercise requiring great power." (See Ebben/Jensen/Blackard 2000, 451) Verkhoshansky used the example of the perception of lifting a half-full can of water when you think it's full. The excitability of the central nervous system responds in such a way that the water literally flies in the air because of the force applied. This shows that if the body thinks it has to do more heavy work, it will remember what is necessary to lift the full can and will react accordingly.

By doing a light-weight exercise after a heavy-weight exercise one fools, as it were, the body into remembering the heavy weight. One, therefore, obtains high velocity of movement which will develop power.

In light of established principles of strength and conditioning, the following recommendations on designing a complex training program can be offered.

2 Recommendations for complex training

2.1 Who should do complex training?

Complex training should be used by individuals who are already trained. Training volume should be quantified and specified and should follow periodization schedules. Weight training components should include exercises commonly used by athletes in training, such as the parallel squat and the power clean.

2.2 Periodization

Complex training must be part of a periodized program. First, the athletes must develop functional base strength. Complex training should therefore be incorporated after a base strength or "preparation" training cycle of weight training (cycle 1).

Complex training should follow established periodization principles associated with plyometric training programs. For example, low-intensity plyometric drills, not in complex pairs, should be introduced in the strength-power cycle (cycle 2).

Eventually sport-specific plyometric drills can be paired with functionally similar weight training, as complex training in the competition cycle (cycle 3).

Including plyometric drills and reducing the volume of weight training allows for 'unloading' and facilitates power development. Sport-specific complexes are a form of 'functional training' and increase the generalizability of training to the actual athletic activity. Complex training is also time-efficient and offers variation of training methods during the competition cycle.

2.3 Intensity and volume

The athlete needs to work at a high intensity level for both weight and plyometric training. This means that the volume of complex training must be low enough to guard against undue fatigue so the athlete can focus on the quality of the work performed.

An example of complex pairs may include biomechanically similar exercises such as the bench press (see *Fig. 1*) and medicine ball power drop (see *Fig. 2*), or the squat (see *Fig. 3 a-b*) and squat jump (see *Fig. 4*).

2.4 Specificity and exercise choice

Recommendations for exercise choice in complex pairs are consistent with the principle of biomechanic and velocity specificity needed for power sports. Complex pairs should include a multi-joint weight training exercise followed by a biomechanically similar plyometric exercise. Total body or Olympic-style lifts may also be used, followed by plyometric exercises in a complex pair. Numerous sport-specific combinations of biomechanically similar free-weight and plyometric exercises can be paired in complex training. Furthermore, one should consider unilateral exercises such as single-arm power drops vs. two-arm power drops, since full motor unit activation may occur more readily during unilateral contractions.

2.5 Training frequency and recovery

Complex training must be undertaken 1-3 times a week with 48-96 hrs recovery between sessions in which the exercise affects the same muscle group.

Weight training and high-intensity plyometric training on alternating days for the same muscle groups violates the principle of recovery.

For an untrained individual, the initial training cycle would contain no plyometric drills, while for athletes with prerequisite functional strength it would contain limited, low-intensity

plyometric drills. Later training cycles such as the pre-competitive cycle may contain complex training 2 or 3 days a week. One or two complex training sessions a week can be used during the competitive season as a high intensity/low volume, time-efficient training method.

2.6 Exercise order

Recommendations for exercise order in complex training typically call for high-load weight training followed by functionally similar plyometrics. For example, one set of squats followed by one set of depths jumps. Another recommendation is to follow a high-load weight training exercise (e. g., squat) with sport-specific lighter exercises of 30-40% RM (e. g. jump squat), followed by plyometrics such as depth jumps, creating a 3-exercise complex.

It is generally believed that the advantages of complex training accrue from performing plyometrics *after* weight training, taking advantage of the heightened neural stimulation afforded by the weight training. In a given workout, multijoint complex pairs should be performed before other exercises to ensure that they are done at a high work intensity.

2.6 Rest between exercises, sets and comlex pairs

Recommendations for *rest between exercises in complex pairs* range from almost none to 5 minutes. However, as complex training is designed to increase short-term power output, it is necessary to allow time for the replenishing of the anaerobic energy sources if the fast velocity contractions are to be performed at a power output as high as possible. Therefore, rest periods of 3+ minutes seem to be appropriate.

As far as the *rest between the weight training set and the plyometric exercise set* is concerned, the majority opinion is to perform the plyometric exercise set relatively soon after the weight training set so as to take advantage of the possible heightened neural stimulation afforded by the weight training set.

Adequate *rest between complex pairs* is important. Recommendations are 2 to 10 min of rest after completing one complex pair (weight training + plyometric training exercise) and before beginning the next set of the same pair. Generally, strength/power training requires adequate rest between sets to allow the body to replenish the anaerobic energy sources needed for performing high-velocity contractions at high power output.

2.7 Examples of training complexes

Complex 1:

Back squats: 2 x 2-3 reps at 90% of 1 RM.

Rest periods: 3-4 min between sets, 4-6 min after both sets.

Depth jumps: 2 x 10; recommended height: 75 cm.

Rest periods: 3-4 min between sets.

This complex should be performed 2-3 times per training session with 8-10 min of rest between complexes.

Complex 2:

Back squats: 2 x 2-3 reps at 90% of 1 RM.

Rest periods: 3-4 min between sets, 4-6 min after both sets.

Sequence of 5 standing long jumps: 2 x 6 reps (5 jumps = 1 rep), sequence is: L, R, L, R, both.

Rest periods: 3-4 min between sets.

This complex should be performed 2-3 times per training session with 8-10 min of rest between complexes.

Complex 3:

Kettle bell jumps on 2 benches: 2 x 10 jumps. (Athlete stands on 2 benches shoulder-width apart, holding a kettle bell or dumbbell (10-35 pounds) – assumes a deep squat and then jumps – performs the 10 jumps in natural rhythm.)

Rest periods: 3-4 min between sets.

Sequence of 5 standing long jumps: 2 x 6 reps (performance as in *Complex 2*).

This complex should be performed 2-3 times per training session with 8-10 min of rest between complexes.

Complex 4:

Back squats: 2 x 2-3 reps at 90% of 1 RM.

Rest periods: 3-4 min between sets, 4-6 min after both sets.

Kettle bell jumps on the floor: 2-3 x 8 reps.

Rest periods: 3-4 min between sets, 4-6 min after the 2-3 sets.

This complex should be performed 2-3 times per training session with 8-10 min of rest between complexes.

Complex 5:

Back squats: 2 x 2-3 reps at 90% of 1 RM.

Rest periods: 3-4 min between sets, 4-6 min after both sets.

Back squats: 3 x 6-8 at 30% of 1 RM. (The reps must be performed explosively and the athlete should be actually jumping into the air.)

Rest periods: 3-4 min between sets.

This complex should be performed 2-3 times per training session with 8-10 min of rest between complexes.

Complex 6:

Back squats: 1 x 2-3 reps at 90% of 1 RM.

Rest periods: 4-6 min.

Back squats: 2 x 6-8 at 30% of 1 RM. (The reps must be performed explosively and the athlete should be actually jumping into the air.)

Rest periods: 3-4 min between sets, 4-6 min after both sets.

Alternate leg bounding 5 jumps off of each leg: 2 x 5 reps (5 jumps off of each leg = 1 rep).

Rest periods: 1 min rest between reps, 3-4 min rest between sets, 4-6 min rest after both sets.

Acceleration sprints: 3-4 x 50-60 m.

Rest periods: 10-15 sec between sprints.

This entire complex should be performed 2 times per training session with 6-8 min of rest between complexes. After this complex some non-intensive activity such as basketball for 5-10 min is recommended.

2.7 Summary

Complex training is consistent with the principles of periodization, variation, specificity, recovery, and individualization. Research supports the value of combining weight training and plyometric training in the same session. Researchers found superior improvements in the vertical jump, 40-yd dash, and standing long jump when compared to weight training alone. Complex training most likely will offer an enhanced training stimulus for athletes possessing functional strength and athletic development.

Figure 1: *The bench press (free weight)*

Description of the bench press: *Beginning position (lifter):* Lie face up on a bench. Position feet flat on the floor. Position head, shoulders, and buttocks flat on the bench. Eyes should be below edge of the bar shelf. Grasp bar with a closed, pronated grip. Signal spotter. Move bar off bar shelf. Position bar over chest with elbows fully extended. *Beginning position (spotter):* Stand 15 to 20 cm from the head of the bench. Grasp bar with an alternated grip. Grip should be inside lifter's hands. Keep torso erect, knees slightly flexed. At lifter's signal, assist with moving bar from bar shelf. Guide bar to position over lifter's chest. Release bar smoothly. *Downward movement phase (lifter):* Lower bar slowly and under control. Maintain body position on bench, feet on floor. Keep wrists straight. Lower bar to touch the chest near the nipples. Inhale during the downward movement phase. *Downward movement phase (spotter):* Keep hands close to the bar as it descends. Maintain torso and knee position. *Upward movement phase (lifter):* Push bar up to full elbow extension. Maintain body position on bench, feet on floor. Do not arch the lower back. Exhale during the sticking point of the upward movement phase. At the completion of the set, signal spotter. Move bar to bar shelf. Keep grip on bar until racked. *Upward movement phase (spotter):* Keep hands close to bar as it ascends. Maintain upright body position, knees flexed. At the lifter's signal at the completion of the set, grasp bar with alternated grip. Grip should be inside lifter's hands. Guide bar back into bar shelf. Keep grip on bar until racked.

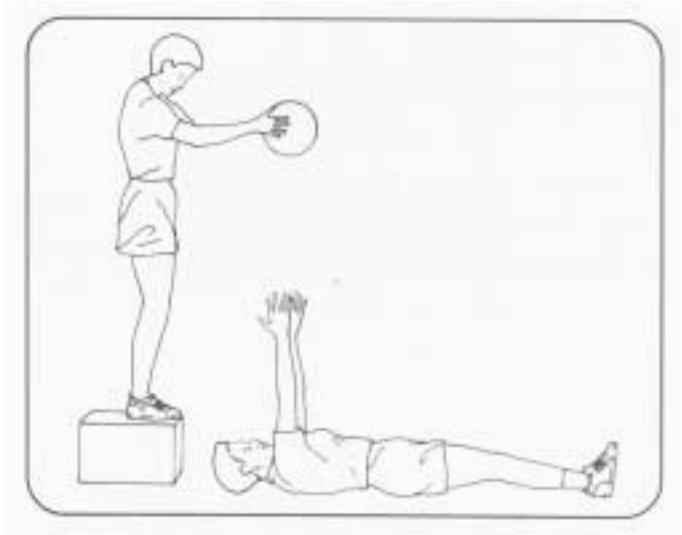

Figure 2: *The medicine ball power drop*

Description of the medicine ball power drop: *Equipment:* A box 12 to 42 inches high and a medicine ball. This drill requires a partner. *Start:* Lie supine on the ground with your arms outstretched. Your partner stands on the box holding the medicine ball at arm's length. *Action:* Your partner drops the ball, and you catch it and immediately propel it back to your partner. Repeat the action.

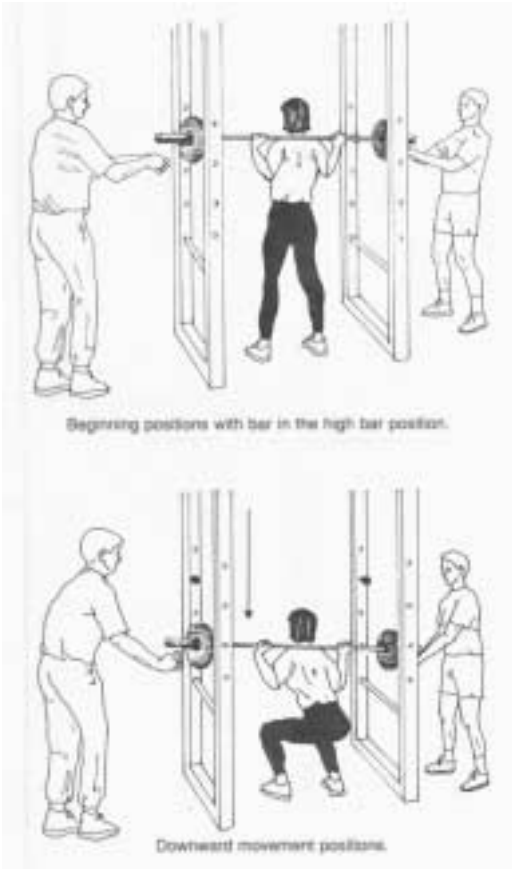

Figure 3 a: *The back squat (free weight) – beginning and downward movement positions*

Description of the back squat: *Beginning position (lifter):* Grasp bar with a closed, pronated grip (slightly wider than shoulder-width). Step under the bar, position feet parallel to each other, and move hips under bar. Position the bar on the shoulders above posterior deltoids at the base of the neck (high bar position). Lift and hold chest up and out. Pull shoulder blades toward each other and tilt head slightly up. Lift elbows up to create a 'shelf' for the bar. Straighten both legs to lift bar out of racks. Take one or two steps backward. Position feet shoulder-width apart or wider, and even with each other. Point toes slightly outward. *Beginning position (spotters):* Two spotters stand at opposite ends of the bar, feet positioned slightly wider than hip-width. Cup hands with palms facing upward. Palms begin and are maintained in a position 5-8 cm below the ends of the bar. Spotters move sideways in unison with the lifter as lifter moves backward. Once in position, feet are slightly wider than hip-width, knees slightly flexed, back flat. *Downward movement phase (lifter):* Focus eyes on wall 30 to 60 cm above eye level. Slowly lower bar by flexing at the hips and knees. Maintain erect body position. Keep weight over the middle of the foot and heels, which are kept on the floor. Slowly lower hips until tops of thighs are parallel to the floor. Inhale during the downward movement phase. Do not bounce at the bottom of the movement. *Downward movement phase (spotters):* Spotters squat down in unison with the lifter. Cup hands 5 to 8 cm below the bar and follow the bar downward. Maintain body position.

Figure 3 b: *The back squat (free weight) – upward movement positions and racking the bar*

Description of the back squat (continuation): *Upward movement phase (lifter):* Keep eyes focused on wall 30 to 60 cm above eye level. Slowly raise bar by straightening the hips and knees. Maintain body position. Keep knees aligned over the feet and do not let them move in or out. Exhale through the sticking point of the upward movement phase. Do not accelerate the bar at the top of the movement. At the completion of the set, slowly step forward into the rack. Position hips beneath the bar. Squat down until the bar is resting in the rack. *Upward movement phase (spotters):* Stand up with the lifter. Keep hands 5-8 cm below and close to the bar. Assist only if necessary. Walk the lifter back into the rack. Spotters simultaneously grab onto the bar, keeping it level, and assist lifter with placing the bar in the rack.

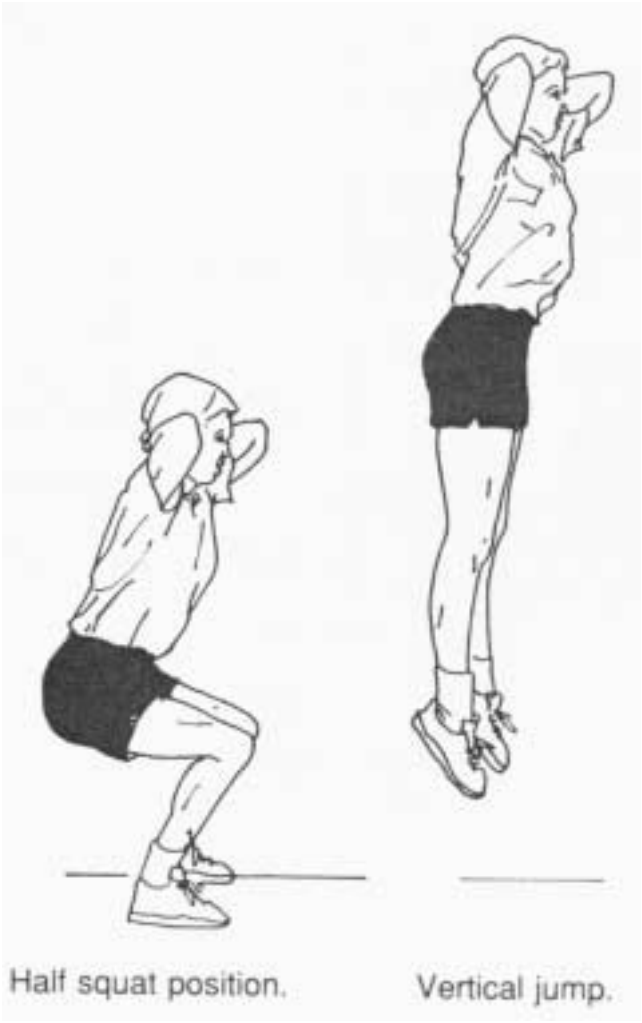

Figure 4: *The squat jump*

Description of the squat jump: *Starting position:* Half-squat position (thigh parallel with the ground) with feet shoulder-width apart. Interlock fingers and place hands behind head. *Direction of jump:* Vertical. *Arm action:* None. *Starting action:* Start movement by explosively jumping to maximum height. *Descent:* Upon landing immediately go into half-squat position and, without pause, repeat exercise.

General Theme

COMPLEX TRAINING COMPONENTS AND PHYSIOLOGY

1 Introduction

The two benefits from traditional strength training are:

(1) increased neural activity

(2) increased muscle mass (hypertrophy).

Strength work has been shown to improve sports performance particularly for sprinters, jumpers and throwers but it is not beneficial in developing rate of force, i.e. the speed with which force is achieved in a movement.

For example, it takes 400msec to develop maximum force during a squat exercise, but the foot-ground contact time in sprinting is around 90msec, so there is not enough time to produce maximum force in sprinting. Therefore, for speed-strength events like sprinting, it is the rate of force development that becomes more important than absolute strength.

The sort of exercises that improve the rate of force development are:

- speed-strength exercises, e.g. weighted squat jumps,
- plyometric exercises, e.g. bounding.

Many athletes include plyometric exercises in their training programs and are well aware of their benefits. However, it is slightly less well known that the combination of traditional strength with power and plyometric exercises together results in even greater improvements in power and rate of force development.

Athletes who require muscular power must therefore find a way to incorporate weight training and plyometric training. One method of doing this is *complex training*.

2 The nature of complex training

Complex training alternates biomechanically comparable high-load weight or resistance training and plyometric exercises in the same workout. Combining the bench press with the medicine ball power drop (see *Fig. 2*) is an example of upper body complex training. Other examples are:

- squats (see *Fig. 3*) followed by squat jumps (see *Fig. 4*),
- bench press (see *Fig. 1*) followed by plyometric press-ups.

On a rather general level, functional strength is a prerequisite for plyometrics. Weight training is also used to prepare for plyometric training to reduce the chance of injury, develop a strength base, and prepare the musculoskeletal system for high-impact forces.

From a neurophysiological point of view, the logic behind matched pairs of resistance and plyometric exercises is that high-load weight training increases motoneuron excitability and reflex potentiation, which may create optimal training conditions for subsequent plyometric exercises. Also, the fatigue associated with high-load weight training may force more motor

units to be recruited during the plyometric phase, possibly enhancing the training state.

3 Complex training physiology

As already decribed in *IAAF @-Letter* 4/2002, type I fibers (slow-twitch or ST fibers) are capable of producing submaximal force over extended periods. These are the fibers athletes involved in aerobic activities (such as distance running) want to develop.

However, type II fibers (fast-twitch or FT fibers) are capable of producing maximal force for brief periods. These are the types of fibers strength and power athletes and sprinters want to develop.

Type II fibers may be further divided into three categories based on their stained appearance, as well as their propensity for recruitment. FT IIa fibers constitute about half the FT muscle fibers, with the remainder predominantly FT IIb fibers. Only a very small number of intermediary type IIc (or IIab) fibers have been identified. The difference between the FT IIa and the FT IIb fibers is that the IIa fibers have more endurance characteristics whereas the IIb fibers have more speed characteristics. In many sports, both fiber types are used, with the type IIb fibers contracting first.

Despite the implied preference a strength and power athlete would have for predominantly type II fibers, type I and type II fibers are important to the athlete's overall development. FT fibers give the athlete the ability to move quickly and explosively. ST fibers are responsible for the stabilization and posture the athlete needs when performing any movement. In other words, ST fibers provide the stability to make the action complete.

In the context of complex training, the primary goal of a strength and power athlete is to first emphasize the type IIb fibers and get the type IIc fibers to act like type IIb fibers. The type IIa fibers, although called fast-twitch, are often not especially useful for many athletes. Power lifters and bodybuilders, for example, have highly developed type IIa fibers but cannot display their strength quickly.

When properly challenged, the human body has the capacity to make significant changes, one of which is a change in muscle fiber function. Research shows that it is possible to train a fast-twitch muscle fiber to behave like a slow-twitch fiber, and vice versa. However, both of these changes are difficult to bring about and require a great amount of work.

The difficulty in training is a result of daily life. On any given day, the activities a human being performs during the course of a normal routine (walking across the room, washing dishes, lifting a stack of books) are completed at such slow speeds that they condition the body to function slowly. Thus, everything an athlete does outside of training actually hinders the progress he or she makes in a program intended to develop faster muscles. Fortunately, the FT fibers an athlete already possesses are very resistant to change. To turn a fast muscle into a slow one, the athlete needs a constant quasi-static resistance training program. Exercise bouts would consist of fewer repetitions of heavy loads at low speeds, leaving higher

speed and explosive work completely out of the standard regimen.

The number of muscle fibers an athlete has and the types of fiber in these muscles are both important factors. However, it is the neural factors that give the body the 'jump start' that allows the training process to begin. As the conditioning process continues, the nervous system learns the necessary skills and hypertrophy takes over the limelight. Before getting to that point, the athlete needs to find a way to arouse the nervous system quickly to get the most of the workout. In other words, once the motoneurons are fired up through resistance training, it's time to teach the muscles to function at their highest possible speeds. The second half of the workout should thus be a plyometric exercise, matched to stimulate the muscles awakened during the resistance training exercise by performing a related or specific explosive movement similar to the resistance exercise.

Thus, complex training matches pairs of exercises from two sources: a resistance training pool and a plyometric pool. The resistance exercises will be of the traditional variety (e.g., squats, lunges, and various dead lifts). This broad-based group of exercises complements a large selection of plyometric exercises. Depending on the sport, the season, and which muscles need to be worked on any given day, the athlete will be able to arrange a large number of combinations. The variety will not only keep the athlete interested in the training program, but it will also make the workouts more effective: the more varied the workout, the less chance the body has to adapt to any one way of training. This is the key in building speed and thus power.

References:

Baechle, Thomas R. (1994). *Essentials of Strength Training and Conditioning*. Champaign (Ill.): Human Kinetics

Chu, Donald A. (1996). *Explosive Power and Strength. Complex Training for Maximum Results.* Champaign (Ill.): Human Kinetics

Croxdale, Kenny (2001). Building Strength and Power with Complex Training. *Powerlifting USA* (http://www.strengthcats.com/complextraining.htm)

Ebben, William P.; Phillip B. Watts (1998). A Review of Combined Weight Training and Plyometric Modes: Complex Training. *National Strength and Conditioning Association Journal, 20* (5), 18-27

Ebben, William P.; Randall L. Jensen; Douglas O. Blackard (2000). Electromyographic and Kinetic Analysis of Complex Training Variables. *Journal of Strength and Conditioning Research, 14* (4), 451-456

Fleck, Steve (1986). Complex Training. *National Strength and Conditioning Association Journal, 8* (5), 66-68