Weightlifting to Improve Volleyball Performance

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ABSTRACT

VOLLEYBALL IS AN EXPLOSIVE SPORT IN WHICH A SUCCESSFUL PERFORMANCE IS LARGELY DETERMINED BY THE CAPACITY TO DEMONSTRATE REPEATED BOUTS OF MAXIMAL OR NEAR-MAXIMAL POWER. GIVEN THE RELATIVELY HIGH LEVELS OF FORCE BEING GENERATED AND ABSORBED, THE RISK FOR INJURY EXISTS WHEN PLAYING. THIS ARTICLE FOCUSES ON WEIGHT-LIFTING AS THE PRIMARY MEANS WITH WHICH TO ADDRESS THOSE ATTRIBUTES THAT UNDERLIE PERFORMANCE AND REDUCE THE CHANCE FOR INJURY.

INTRODUCTION

Volleyball is an explosive sport in which the objective is to pass a ball over a net in such a way that the opponent is unable to successfully return the ball back over the net. Rallies, which commonly include powerful actions such as spiking, blocking, diving, and serving, are followed by relatively long recovery periods (12,22,35,52). The average work to rest ratio is 1:2.4 (7 seconds of work to 16 seconds of rest) (52). A successful performance is largely determined by the capacity to demonstrate repeated bouts of maximal or near-maximal power (22,35). Because individuals generate and absorb relatively high levels of force when playing, the risk for injury exists (35). Meeting these demands requires a well-designed training program that addresses those attributes that lead to maximum performance and reduce the chance for injury.

The application of specificity and overload is required to best improve sport performance. Specificity refers to the training regimen, namely, does it mimic the movements that are most important to performance. Overload refers to the manipulation of the training stimulus (weight, speed, and duration), so as to enable a greater than normal effort (35). Although some would contend that exercises cannot replicate sport movements, it is commonly accepted that exercises selected based on their similarity to sport movements, particularly in the strength/power training program of athletes, are beneficial (36).

Looking closer, specificity might not refer to a particular exercise but instead to the outcome of the exercise. Put another way, specificity refers to the objective of the exercise and its potential benefit to sport performance, that is, the exercise produces an outcome that likely enhances performance in a given sport, task, or context (57). Under this perspective, exercises that facilitate increases in power output, which in turn develop the abilities to jump, accelerate, dive, and change direction quickly, might be most critical to a high-level performance in volleyball (22,35,48,50,52).

PERFORMANCE CONSIDERATIONS

Strength is defined as the maximal amount of force a muscle or muscle group can produce in a specified movement pattern and velocity (4). Alternatively, power is the ability to exert as much force as possible in a limited amount of time (20). It is argued that nothing is more critical to athletic success than the capacity to display a high rate of force development (22,52). As in most sports, developing a volleyball player's power output is considered an essential component to a successful performance (35).

Weightlifting, often referred to as Olympic-style lifting, is one of the most accepted methods to enhance power output among athletes. Because the exercises involve rapid acceleration against resistance throughout the movement, power outputs are quite high (35,36,40,66). Indeed, the snatch and clean and jerk afford the highest power outputs recorded in sport (23,25) (Figures 1–6). Given the intent to move the load as quickly as possible, weightlifting exercises stimulate greater motor unit synchronization and therefore improve the ability to generate power (30,36,60). The high levels of force development as well as improved muscle action speed associated with weightlifting can enhance performance in sports that require explosive dynamic movements, including volleyball (23,25,33,35,36,48,60).

WEIGHTLIFTING AND IMPROVING SPORT SKILLS

Vertical jumping is integral to the sport of volleyball (50). Skills that involve jumping, including the jump set along with the jump serve, blocking, and spiking, are generally dependent on the development of vertical power (35,50). Although these skills are fundamental to the sport, the spike is the

KEY WORDS:
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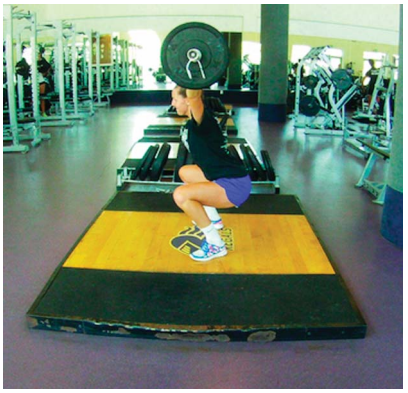

Figure 1. Snatch: side.

Figure 3. Clean (first pull): side.

Figure 5. Clean: side.

action that generates most of the points during a game. A successful spike typically depends on the height of contact, ball direction, and ball speed (52). The ability to jump and reach the ball at its highest point is commonly reliant on vertical jump performance (52). Thus, considerable training time should be allocated to improve this component of performance (35).

Studies have demonstrated a correlation between weightlifting and sport movements, particularly the vertical jump (11,13,34,59–61). Vertical jump performance is largely dependent on the force produced at the hip, knee, and ankle joints (34,35). In accord, the musculature involved when performing weightlifting exercises is the extensors of the hip and knee along with the plantar flexors of the ankle (11,27,38). Forceful extension of these joints, particularly in the second pull, mimics the requirement to push aggressively against the ground when performing a vertical jump (13,17,36,47). Indeed, the kinetics and kinematics of the second pull and the drive phase of the jerk display comparable acceleration patterns to the vertical jump (38,40).

Of importance, studies have indicated that weightlifting exercises can improve vertical jump performance (11,13,14,32,61). Stone et al. (61), for example, found that weightlifting exercises improved vertical jump results. Similar results were observed by Carlock et al. (13), who reported a strong relationship between weightlifting performance and a countermovement jump. When comparing the hang power snatch with the noncountermovement jump, Canavan et al. (11) observed similarities in maximal power, relative power, maximal force, and time to maximal force. Ground reaction forces in the snatch were also comparable to that of the countermovement jump.

WEIGHTLIFTING VERSUS POWERLIFTING

The sports of weightlifting and powerlifting are commonly confused (36,40,51). Although the exercises along with the performance attributes are different, the goal is similar, namely, to amass the most weight lifted. Powerlifters perform 3 exercises: deadlift, back squat, and bench press. Given the relatively high loads and the biomechanics of the movements, maximum force production at slow velocities is typically observed after the initiation of powerlifting exercises (26). In contrast, weightlifting exercises require maximum force

Figure 2. Snatch: behind.

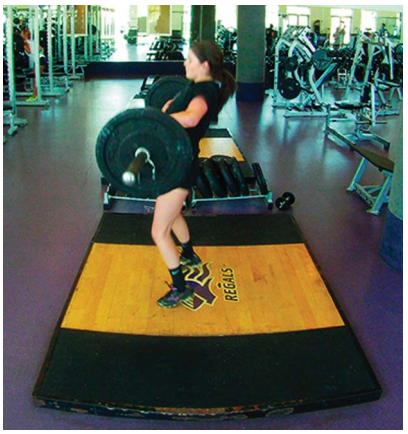

Figure 4. Clean (second pull): side view.

Figure 6. Split jerk: side.

production at high velocities across a load spectrum (15,21).

In a review of studies examining power outputs among male lifters, Garhammer (26) noted that approximately 12 W/kg of body weight is produced in the back squat compared with 52 W/kg during the second pull of the snatch and clean. This article also noted a decrease in power output in both weightlifting and powerlifting exercises as the weight increased (26). However, the effect was more pronounced in the powerlifting exercises because of the increased time it takes to complete the exercises. In powerlifting exercises, for example, a 1 repetition maximum (1RM) lift can decrease power output by as much as 2 times in comparison to a 90% effort (26).

To illustrate the differences in power output between weightlifting and powerlifting, O'Shea (51) compared the values for world record lifts made by 2 former world champions. While executing a 405-kg deadlift, Doyle Kenady produced 5.57 W/kg of body weight. In comparison, Alex Pisarenko generated 21.64 W/kg of body weight during a 265-kg clean. The deadlift, which traveled 0.40 m off the floor, took approximately 2 seconds to complete compared with 0.90 seconds for the clean. The observations suggest that powerlifting might be a misnomer and that if the objective of training is to increase total body power output, then weightlifting exercises are warranted (36,51,66).

A study by McBride et al. (43) compared differences in power output as assessed through weighted jumping among elite weightlifters and powerlifters. Jumps from a 90° knee angle were performed at 0, 20, and 40 kg and at 30, 60, and 90% of their 1RM squat. Notwithstanding the load, results showed that weightlifters generated the higher power outputs. Peak power in the unloaded vertical jump was also significantly higher among weightlifters compared with powerlifters. The findings were supported by Stone (60) who observed significantly higher power outputs among weightlifters compared with powerlifters when performing a parallel squat at any percentage of individuals' 1RM. Taken together, the results indicate that weightlifters produced significantly greater peak velocities, power outputs, and jump heights than powerlifters (40,43,64).

COMPARING WEIGHTLIFTING WITH ALTERNATIVE METHODS OF IMPROVING POWER FOR VOLLEYBALL PERFORMANCE

A training program that combines high force and high velocity training to enhance power is reasonable. Addressing the 2 components separately can improve power (37). However, there are disagreements regarding the optimal loading parameters, movement velocities, power outputs, rest intervals, and exercises used to develop maximal power (6,29,40,41,58,70). In contrast, several studies have found that the ability to generate maximum power is improved with high force, high velocity training (as occurs in weightlifting) (11,13,32,61).

Granted, weightlifting is not the only training means with which to enhance power output. Plyometric movements, such as jumping, hopping, and bounding along with loaded jump exercises, can be effective (4,20). Combined methods, including combination training, compound training, complex training, and contrast training, can also be useful (40). According to Hoffman et al. (37), training programs that combine high force and high velocity training are more effective than training programs that emphasize high force or high velocity training. However, combined methods may have limitations compared with weightlifting.

According to Hori et al. (38), plyometric exercises can improve reactive strength, that is, the ability to quickly transition from an eccentric to a concentric muscle action by using the stretch-shortening cycle. Because the exercises typically do not require individuals to decelerate the load, the characteristics are similar to weightlifting (38). However, plyometric exercises are typically performed with the individuals' body weight or a relatively light implement. As noted, power is the product of force and velocity (56,63). Thus, the load might not be adequate to improve maximal power, particularly the force component of the equation. Notwithstanding the load, the successful completion of weightlifting exercises is velocity dependent (66). Therefore, it is logical to assume that training at high power outputs will facilitate increases in maximal power (26).

Loaded jump exercises have been shown to increase the ability to develop force rapidly (7,70). In comparison to plyometric exercises, these movements can increase the slope of the early portion of the force-time curve (47). Similar to plyometric movements, the exercises do not require individuals to decelerate the load. Loaded jump exercises, such as barbell countermovement jump squats, are typically performed with 30–60% of individuals' 1RM (38). Relatively lighter loads, for example, might enhance the velocity component of the force-velocity equation in accordance with plyometric exercises (38,47). Conversely, relatively heavier loads, which can cause injury to the lower leg, knee, back, and neck because of the high impact at landing, will primarily improve force production (38,44). In comparison, the outcome of the snatch and clean is largely dependent on movement speed, particularly in the second pull, regardless of the load (10,49,66).

Combined training methods typically use powerlifting and power exercises, such as plyometric and loaded jump movements, during the same session or training cycle to develop power (40). Combination training, for example, commonly involves performing plyometric exercises before squatting movements. In accordance, compound training uses powerlifting and power exercises on different days to allow for recovery. Both methods have been found to improve power in the short term in novice athletes with lower levels of strength (16,71). Research examining the long-term effects on power in experienced individuals is lacking (16,40,71).

In comparison, complex training involves performing an exercise such as the back squat with loads approaching individuals' 1RM followed by a plyometric exercise (16). Commonly confused with complex training, contrast training involves alternating powerlifting exercises with power movements from set to set (40). Complex and contrast training have been shown to improve power in experienced individuals (6,16,47,71). However, in each case, there is a need to examine the long-term effects on maximal power as well as to identify optimal rest intervals between exercises (6,58).

Notwithstanding individuals' level of weightlifting experience, research supports the use of high force high velocity training for the long-term development of power (11,13,32,61,67). Noteworthy, Tricoli et al. (67) compared training programs that used weightlifting exercises with those that used powerlifting and plyometric movements (contrast training). Although the contrast training method group outperformed their counterparts in the 1RM half-squat test, the weightlifting group, which improved significantly in all 3 areas, scored higher in the countermovement vertical jump and 10-m sprint tests (67).

BENEFITS OF WEIGHTLIFTING FOR VOLLEYBALL

Besides the development of power, benefits of weightlifting include positive changes in fiber adaptation, aerobic and anaerobic metabolism, balance, flexibility, kinesthetic awareness, and lean body mass (36,67). Although genetic factors contribute primarily to fiber-type characteristics, the extreme power production of weightlifting can provide a distinct physical stimulus (21). Because weightlifters typically spend a considerable amount of time using loads upward of 80% of their 1RM, particularly during pulling movements, the conversion and hypertrophy of muscle fiber types is common (21,66). A shift from type IIx to type IIa fibers, along with increases in the cross-sectional area of type IIa fibers, has been observed among individuals who participated in a weightlifting program. The outcome is typically

Table 1
Training block 1: 3 weeks

Monday (PM)	(Weight/reps)sets	Tuesday (AM)	(Weight/reps)sets	Wednesday (PM)	(Weight/reps)sets	Friday (PM)	(Weight/reps)sets
Front squat (Figure 7)	(X/3)3	Power snatch	(X/2)3	Front squat (Figure 7)	(X/3)3	Snatch	(HS/1)X
Clean and split jerk	(X/1 + 1)3	Power clean and power jerk	(X/2 + 1)3	High hang snatch	(X/2)3	Clean and split jerk	(HS/1 + 1)X
High hang clean pull	(X/3)3	Glute-ham raise	(X/6)3	Split jerk (from rack)	(X/2)3	Front squat (Figure 7)	(HS/1)X
Back squat (Figure 8)	(X/5)3	Rotator cuff strengthening	(X/6)3	High hang snatch pull	(X/3)3	Rotator cuff strengthening	(X/6)3
Core	—	Core	—	Core	—	Core	—

Training loads should be below maximum effort and based on the ongoing evaluation of technique. Weightlifting variations can be included to improve technical skill. Exercises can be added or manipulated to develop identified individual deficiencies. The recommended sets and reps can be varied depending on players' physical preparedness. Core exercises may include a variety of movements that target abdominal, oblique, gluteus, and low back musculature.

HS = heavy single; Reps = repetitions.

Figure 7. Front squat: front.

an increase in the muscles' capacity to produce force.

Because weightlifting involves brief high-intensity efforts, it mimics the energy demands in volleyball. Similar to weightlifting, the source of energy substrates for volleyball is primarily the phosphagen system (15,35,54). It has been argued that the intensity and duration of training activities, along with the length of recovery periods, should be manipulated so that the fast glycolytic system followed by oxidative metabolism can restore high-energy phosphates (35,54).

Repeated bouts of high-intensity exercise, without sufficient recovery time, can lead to increased blood lactate levels, which in turn can inhibit maximal power output (35,36,54). Notwithstanding time-outs and player substitutions, the average break between points is 16 seconds (52). Thus, the capacity to recover in a relatively short period is paramount to the sport of volleyball. Of interest, trained weightlifters are able to perform more mechanical work and reach greater blood lactate levels

Figure 8. Back squat: behind.

than untrained individuals (65). Furthermore, weightlifters demonstrate lower blood lactate and ratings of perceived exertion at the same intensity of exercise.

Additional benefits, including improvements in balance, flexibility, and kinesthetic awareness as well as increases in lean body mass from weightlifting training, have been observed (18,21,67). According to Fry et al. (21), increases in lean muscle mass and decreases in body fat enable individuals to produce more force while remaining at the same weight. Taken together, these outcomes can have a positive effect on volleyball performance.

INJURY PREVENTION

Volleyball players are frequently reacting, starting, stopping, changing direction, and jumping in response to situational factors. As such, the capacity to absorb and rapidly generate force throughout the lower extremity joints is crucial to performance and the prevention of injury. Arguments suggest that weightlifting, if taught and supervised by a qualified instructor, likely reduces the chance for injury (36,38,53).

Several studies observed that ankle, knee, and back injuries were the most common among volleyball players (1,3,5,69). Augustsson et al. (3) observed overuse injuries to be as common as acute injuries in volleyball. Overuse injuries to the knee were the most frequently reported (1,3,5,69). According to Vaneckova et al. (68), knee injuries because of overuse might be successfully treated with resistance training. The authors posited that acute knee and ankle injuries could be prevented with training that developed balance, coordination, and kinesthetic awareness. Given the relatively high forces acting on the knees, ankles, and lower back in volleyball, weightlifting programs that improve neuromuscular coordination as well as strengthen the connective tissues of the lower extremities and enhance spinal stability can minimize the likelihood of injury (55).

Increases in bone density from weightlifting have been observed (15). Because weightlifting exercises have been shown to stimulate bone remodeling and enhance bone tensile strength, they might be useful to the prevention of lower extremity injuries, particularly among players who frequently generate and absorb high levels of force when jumping and landing (15,35,62).

Along with the knee, ankle, and back, injuries to the shoulder are the most prevalent in volleyball (1,3,69). Ferretti et al. (19) estimated that 15–20% of high-level volleyball players experience shoulder pain during their careers. As a consequence of overuse, injuries to the shoulder can be common, particularly among front line players (1–3,5,19,42). Kugler et al. (42) estimated that a highly skilled volleyball player attacks about 40,000 times a year. As such, he or she might be at a higher risk for developing conditions such as shoulder impingement, bicipital tendinitis, irritation of the rotator cuff muscles, and subscapular neuropathy (19). According to Ferretti et al. (19), shoulder injuries in volleyball can result in atrophy as well as a loss of strength that can frequently diminish players' performance.

In their study, *Muscular Imbalances and Shoulder Pain in Volleyball Attackers*, Kugler et al. (42) observed a significant difference in muscular and joint capsular patterns at the dominant shoulder compared with the nondominant shoulder. The scapula of the dominant shoulder, for example, was significantly depressed and lateralized, suggesting a lengthening of the trapezius and rhomboid muscles. These differences were more pronounced in players with shoulder pain than in players without shoulder pain. The authors stated that this imbalance can lead to a disturbance of the gliding and rolling motion of the humeral head during overhead movements, thereby causing pain (42).

In addition to improving the spiking and serving technique of attackers, players can improve the muscular function of the shoulder joint and therefore reduce the chance for injury by strengthening the muscles that

Table 2
Training block 2: 3 weeks

Monday (PM)	(Weight/reps)sets	Tuesday (AM)	(Weight/reps)sets	Wednesday (PM)	(Weight/reps)sets	Friday (PM)	(Weight/reps)sets
Front squat (Figure 7)	(X/3)3	Power snatch	(X/3)4	Front squat (Figure 7)	(X/3)5	Snatch	(X/1)4
Clean and split jerk	(X/1 + 1)5	Power clean and power jerk	(X/1 + 1)5	High hang snatch	(X/2)4	Clean and split jerk	(X/1 + 1)5
High hang clean pull	(X/3)4	Glute-ham raise	(X/4)4	Split jerk (from rack)	(X/1)4	Front squat (Figure 7)	(X/1)4
Back squat (Figure 8)	(X/5)5	Rotator cuff strengthening	(X/6)3	Snatch pull	(X/3)4	Rotator cuff strengthening	(X/6)3
Core	—	Core	—	Core	—	Core	—

With an increase in volume, training loads should be similar to that used in the previous training block. The ongoing evaluation of individual's technical deficiencies should guide the use of weightlifting variations. The recommended sets and reps can be varied depending on players' physical preparedness. Core exercises may include a variety of movements that target abdominal, oblique, gluteus, and low back musculature.

Reps = repetitions.

stabilize the scapula, including the rhomboid major, rhomboid minor, upper and lower trapezius, and latissimus dorsi (42). The likelihood of shoulder injuries among players who are not experiencing pain might be minimized by performing weightlifting exercises that include overhead movements, which strengthen the scapular retractors as well as the rotator cuff and deltoid muscles (36).

The first pull of weightlifting exercises requires individuals to lift the barbell from a static position off the ground to above the knees (15). Because the angle of the torso relative to the ground is more horizontal than vertical, the spinal extensors, scapular retractors, and shoulder extensors are involved (9). In this position, the spinal extensors produce shearing forces, which, along with the compressional forces generated, increase spinal stability (15,45). During the initial pull, the scapular retractors and shoulder extensors keep the barbell close to the body, thereby strengthening these muscles (15). Using this technique, individuals can apply large forces (9). Thus, pulling from the ground can improve the ability to rapidly generate high forces from the onset of muscle activation, which is related to the initial defensive position as well as help to prevent shoulder and lower back injuries (15).

PROGRAM DESIGN

Essentially, there are 5 variables to consider when designing a resistance training workout: exercises, loads, repetitions (reps), sets, and rest periods (38). Manipulating these variables to develop those characteristics that underlie performance is critical. In volleyball, a successful performance is largely determined by the capacity to demonstrate repeated bouts of maximal or near-maximal power (22,35). Thus, the use of weightlifting exercises with relatively large loads is reasonable (36,66).

Although the majority of time spent training should involve the snatch and clean and jerk, the benefits of weightlifting might be best attained

Table 3
Training block 3: 3 weeks

Monday (PM)	(Weight/reps)sets	Tuesday (AM)	(Weight/reps)sets	Wednesday (PM)	(Weight/reps)sets	Friday (PM)	(Wt/reps)sets
Clean and split jerk	(X/1 + 1)5	Power snatch	(X/2)4	High hang snatch	(X/2)4	Snatch	(HS/1)X
High hang clean pull	(X/2)4	High hang clean and power jerk	(X/2 + 1)4	Snatch pull	(X/3)3	Clean and split jerk	(HS/1 + 1)X
Back squat (Figure 8)	(X/3)5	Weighted glute-ham raise	(X/6)3	Power clean and power jerk	(X/2 + 1)3	Rotator cuff strengthening	(X/6)3
Core	—	Rotator cuff strengthening	(X/6)3	Front squat (Figure 7)	(X/2)4	Core	—
—	—	Core	—	Core	—	—	—

With a decrease in volume, training loads can be increased based on the ongoing evaluation of technique. The recommended sets and reps can be varied depending on players' physical preparedness. Core exercises may include a variety of movements that target abdominal, oblique, gluteus, and low back musculature.

HS = heavy single; Reps = repetitions.

by strategically using a variety of weightlifting exercises (15,36). Depending on the needs of the player, variations can be used to develop certain physical qualities required to improve technique in the snatch and clean and jerk as well as to enhance desired performance capabilities. Because the second pull mimics the requirement to push aggressively against the ground when performing a vertical jump, a greater emphasis might be placed on developing a proper pull to improve volleyball performance (13,36,39,47). However, when prescribing pulling movements, coaches should be aware of the factors that can affect power output, such as the applied force pattern, bar movement velocity, range of motion of the involved joints, and the power output of the movement related to the intended outcome of the exercise, all of which might be changed depending on the weight of the barbell (28).

Depending on the load prescribed for each set, variations of weightlifting exercises can also be used to vary intensity for the purpose of recovery or unloading. The snatch and clean, if performed in their entirety (with squat catches), can allow for greater loading, whereas power-style variants that typically use lighter loads can be used to improve technique, to avoid stagnation, and to help avoid overtraining symptoms caused by movement pattern monotony (28,36,40).

To improve performance, experienced players should use loads that maximize power output (40). Given the inverse relationship between force and velocity, the use of relatively heavy loads will elicit high force outputs at low velocities and vice versa (56,63). Garhammer (24) reported that as the weight of the barbell increases the height to which it is lifted, maximal vertical bar velocity, peak applied vertical force, and power output decrease. To counteract these effects, studies have suggested loading 75–80% of players' 1RM during weightlifting exercises to maximize power output (31,46,66).

Although research (31,46,66) indicates that power outputs during weightlifting exercises are maximized at 75–80% of individuals' 1RM, loading parameters are commonly determined by individual needs. For those players who are not yet familiar with weightlifting exercises, the focus should be on learning proper technique using loads that can be lifted safely (38). Once technically proficient, training loads might be assigned based on individual weaknesses. For example, players who need to be faster might emphasize low-intensity lifts (70–85%), whereas players who need to improve strength might emphasize high-intensity lifts (85% and above) (28).

Because power output is considered an essential component of volleyball performance, and given power output is largely the result of efficient neuromuscular processes, the quality of repetitions should not be negatively impacted by fatigue. Thus, repetitions will typically be between 1 and 3 reps with rest intervals of at least 3 minutes (8,38,40,66). Volume (the total weight lifted, i.e., sets multiplied by repetitions) should also be reduced in favor of intensity (the number of lifts completed at or near an experienced player's 1RM), so that fatigue can be effectively managed while power output is maintained or improved.

The 12-week program shown in Tables 1–4 used 4 weightlifting sessions per week and was developed based on the concepts put forward. Each phase of training is sequential and progressive and intended to foster a high level of performance. It should be noted that the intensities used in the exercises is temporal. That is, it is determined by the training conditions of the session (28). The author concedes that this approach might leave the coach to select the appropriate means by which to determine the 100% weight. However, adjustments during the course of training are common. In this way, programming might be more frequently a reactive endeavor (28).

Table 4
Training block 4: 3 weeks

Monday (PM)	(Weight/reps)sets	Tuesday (AM)	(Weight/reps)sets	Wednesday (PM)	(Weight/reps)sets	Friday (PM)	(Weight/reps)sets
Clean and split jerk	(X/1 + 1)5	Power snatch	(X/3)5	High hang snatch	(X/2)4	Snatch	(HS/1)X
High hang clean pull	(X/2)3	Power clean	(X/2)5	Snatch pull	(X/2)4	Clean and split jerk	(HS/1 + 1)X
Back squat (Figure 8)	(X/2)4	Split jerk (from rack)	(X/1)3	Power clean and power jerk	(X/2 + 1)3	Front squat (Figure 7)	(HS/1)/X
Core	—	Weighted glute-ham raise	(X/4)4	Core	—	Rotator cuff strengthening	(X/6)3
—	—	Rotator cuff strengthening	(X/6)3	—	—	—	—

Training loads can be increased based on the ongoing evaluation of technique. The recommended sets and reps can be varied depending on players' physical preparedness. Core exercises may include a variety of movements that target abdominal, oblique, gluteus, and low back musculature.

HS = heavy single; Reps = repetitions.

CONCLUSIONS

Volleyball is an explosive sport in which a successful performance is largely determined by the capacity to demonstrate repeated bouts of maximal or near-maximal power (22,35). Given the relatively high levels of force being generated and absorbed, the risk for injury exists when playing (35). Arguments posit that weightlifting exercises can help to address those attributes that underlie performance and reduce the chance for injury (18,21,35,36,67).

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