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The Physiological Basis of Wrestling: Implications for Conditioning Programs

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summary

It is possible with proper training to improve the body's buffer system, increase isometric strength, and heighten total body strength and power capabilities in wrestlers within a fatigued environment. The suggestions included in this article provide some general guidelines from which to build a highly integrated wrestling program.

Iowa State's Cael Sanderson compiled an unblemished record (159 wins and 0 losses) during his collegiate wrestling career, culminating with his fourth consecutive National Collegiate Athletic Association title at the 2002 National Championships. Although this type of success may never be witnessed again, the pursuit of excellence in the most physiologically demanding sport should be strongly rooted in effective strength and conditioning programs that complement and enhance the technical skills of wrestling. Besides genetically gifted wrestlers, winning and losing in wrestling has several essential elements that typically occur under conditions of fatigue, including high levels of dynamic and isometric strength, anaerobic and aerobic conditioning, quickness, flexibility, and power. The complexities of demands suggest the need for a highly integrated and individualized strength and conditioning program. The purpose of this article is to examine some of the underlying physiological mechanisms of wrestling and offer some suggestions for the general design of a resistance-training program for wrestlers.

Impact of a Single Match

As a combative sport, wrestling imposes unique stresses on the body (8, 9). From a metabolic perspective, the acid-base balance is severely disrupted. For example, a college or freestyle match lasts between 6 and 8 minutes (including overtime) and can elevate blood lactate concentrations in excess of 15 mmol/L and sometimes reach nearly 20 mmol/L (5, 6)(Figure 1). In comparison, maximal treadmill tests may raise lactate levels to around 10 mmol/L (1). Lactate will directly affect the muscles' contractile mechanisms by interfering with the actin-myosin cross-bridge interactions. Therefore, wrestlers must be able to buffer the high-acidic muscle and blood concentrations in order to demonstrate optimal strength and power during training and competition.

The ability to tolerate this acid-base disruption with the body's inherent intracellular (bicarbonate) and intercellular (phosphate) buffering systems is a trainable phenomenon. This requires performing resistance training with short rest intervals or traditional cardiovascular interval training (1, 7). Adaptation will typically take about 8 weeks to achieve, which demonstrates the need for preseason conditioning programs that begin during the summer months. It is also vital that the upper body is trained in this manner to increase the capability of upper-body musculature to directly adapt to the dramatic acid-base shifts that occur with wrestling.

In a training program, the inclusion of a resistance-training protocol with a circuit format with rest periods reduced to 1 minute between sets and exercises and ending with a total body exercise (e.g., hang cleans) is one way to help improve acid-base status (7). One should allow a 4- to 6-week time frame

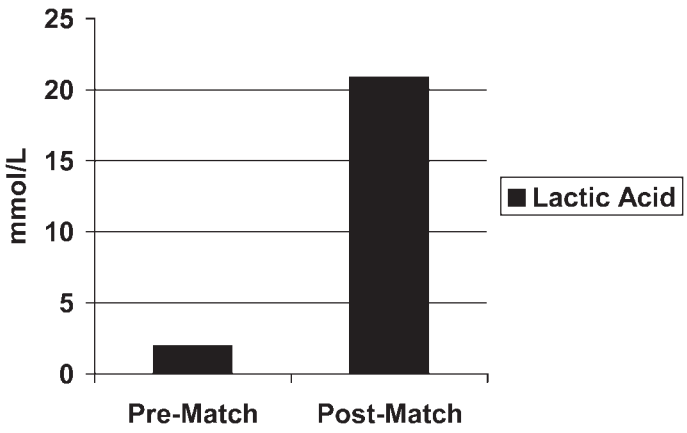

Figure 1. Blood concentrations of lactic acid pre– to post–5-minute freestyle match in collegiate wrestlers (n = 10). Adapted from data from Kraemer et al. (6). Post-match lactic-acid concentrations were significantly ($p < 0.05$) elevated over rest.

to make the gradual reductions in rest periods. Once a rest time of 60 seconds is reached, 6 to 8 weeks will be needed to optimize buffering capacity. The principle of "prioritization" will have a significant impact on program design from this point forward for wrestlers. For example, circuit training will not increase muscular power; however, it will provide enhanced buffering capacity against resistance, which is very similar to what the wrestler will experience during competition. With that said, absolute strength and power in a nonfatigued state should not be neglected during the preseason or in-season training programs. Recall that strength is a major component of power, so carefully manipulating strength development with power-endurance development is a priority for wrestling success. Depending on the schedule of competition, these different prescriptions can be mixed within a daily or weekly schedule to prevent a significant decline in performance during the course of a season.

Total work performed (volume) can be increased by including additional circuits, or sets, in a sequential manner upon toleration of the prior circuit. In other words, once a wrestler can perform 2 complete circuits with relative ease, a third circuit may be added. An alternative may be to increase the volume of certain core lifts. By performing the circuit in a set fashion (i.e., completing all sets for the first exercise before moving to the second exercise), one will be able to monitor improvements by observing a greater number of completed repetitions or sets as the body more successfully buffers the acid that is produced.

Because close matches are usually won or lost during the final seconds in a flurry of several explosive offensive and defensive maneuvers, one should also consider performing whole-body power movements at the end of a training session, which can enhance the ability to perform under conditions of fatigue. It must be noted, however, that this type of training should not be used for beginners or individuals who are not technically sound in performing Olympic-style and explosive movements. Furthermore, the intensity (resistance lifted) should be reduced compared with what would be used in a nonfatigued state. Thus, this approach of altered exercise order is used with a specific purpose to promote strength and power after creating acid-base disruption to be used with more advanced individuals.

Remember, these training methods may be extreme for some individuals; therefore, any signs of nausea or dizziness and the protocol should be stopped. The athlete should be rested and allowed to fully recover. These symptoms represent an inappropriate overshoot in the training progression, and the athlete should revert to slightly longer rest periods between sets.

Impact of a Tournament

Wrestling performance and recoverability from multi-day tournaments has received little attention from the scientific community. A wrestler who reaches the finals or consolation finals may compete in 3 to 6 matches within a 48-hour period. A unique study with a group of elite collegiate wrestlers (in a top-3 nationally ranked team) demonstrated for the first time that tournament demands are very different from a single-match response and that stress can accumulate during the course of a tournament (6). Even with the rebound in body mass caused by food and fluid intakes after weigh-ins, isometric strength and physiological status (e.g., testosterone concentrations were reduced to adolescent levels) degraded over the 2-day tournament. In fact, it was apparent that by the time of the championship match on the evening of the second day, each wrestler was in a reduced and compromised physiological state. Compounding the issue may be the food- and fluid-restriction behaviors still used in lower–weight-class wrestling (2, 3). Adopting different weight-loss strategies that stabilize muscle mass and body mass to prepare for a match appears to be the best way to eliminate physiological breakdown and allow the wrestler to perform at a higher level of physiological readiness. Nevertheless, training strategies that might be used to offset such effects remain speculative.

Strength and Power

Wrestling success requires high levels of both strength and power; however, each wrestler has a distinct style and various strategies, which will affect the design of an individual's training regimen. For example, some wrestlers may perform many offensive actions in a short burst of time, whereas others may be more defensive and slow the action of the match. Nevertheless, threshold levels of whole-

body strength and power are important factors that must be used to give each wrestler a foundation of conditioning. A lack of power and strength can be observed when a wrestler fails at an attempt to bring his opponent back to the mat after an attempted escape or is unable to finish a takedown because of a lack of explosive hip action. During these common circumstances, a wrestler needs to exhibit structural power to get the hips under his opponent and explosively lift them off the mat. Therefore, Olympic-style lifts and core strength lifts must be included in the program at maximal and submaximal loads.

The following is an example of core exercises in a strength and power protocol:

- Squat.
- Split squats.
- Side squats.
- Lunges.
- Squat jumps.
- Power cleans.
- Hang cleans from the knees.
- Hang cleans from the thighs.
- One-handed dumbbell cleans.
- One-legged dumbbell cleans.

Loading for such exercises should follow a periodization model (1). It is important that the strength base is at least maintained when power training is used with lighter loads, which approach maximal mechanical power outputs (i.e., 30–45% of 1 repetition maximum [1RM]). Another important factor that must be considered for a wrestling-specific program is the determination of how much associated hypertrophy and muscle growth is desired; however, muscle gains that are related to normal growth and development should be accepted. Athletes in their freshman and sophomore years of high school may adversely affect their growth patterns at a time when puberty is just beginning, especially if restricted caloric intake is used in combination with progressive resistance training, whereby muscle breakdown occurs at a greater rate compared with muscle synthesis. Thus, the performance team (i.e., head coach, sports-medicine professional, strength and conditioning coach) must carefully determine the ideal weight class each year for the young athlete rather than suggest that a wrestler participate at the lowest possible weight class. Many states now implement weight-certification programs in an attempt to reduce this problem on the scholastic level.

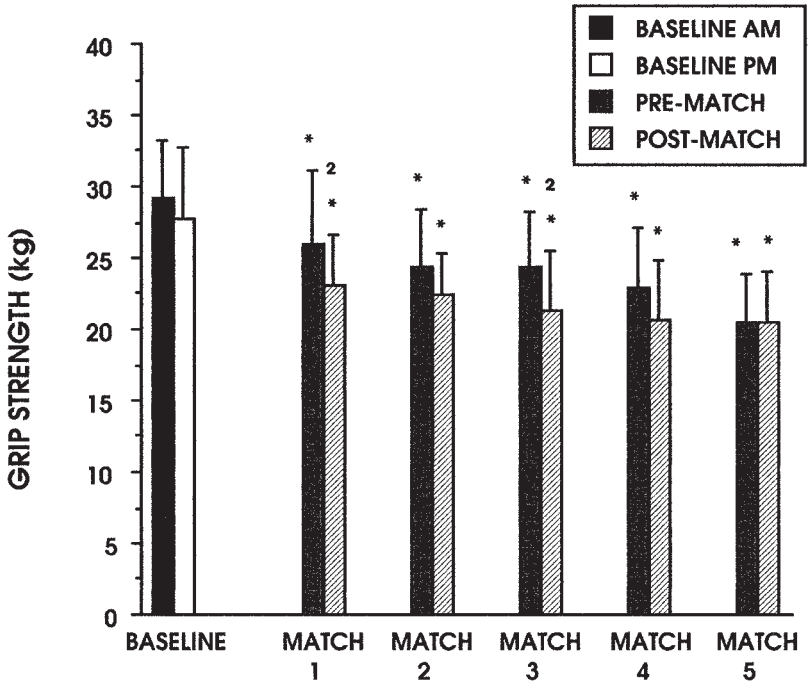

Figure 2. Demonstrates the loss of grip strength over a freestyle tournament with 3 matches on day 1 and 2 matches on day 2. Adapted from data from Kraemer et al. (6). Each match showed decreased grip strength that continued to decline, leading up to the championship match on day 2, match 5, where no changes in the grip strength pre- to postmatch were observed.

Recent research has shown that one has the choice between "quality" power training and "endurance" power conditioning. Sets should contain no more than 6 repetitions, and our unpublished data suggest that 3 may be optimal. In fact, only 1 or 2 repetitions within a set of 6 may be performed at or above 90% of peak power. When falling below 90%, the endurance component is targeted at submaximal levels of neuromuscular excitement, which may be a consequence of the inability to accelerate the mass being lifted. This concept requires more research, especially in the context of what might be considered successful repetitions in a fatigued state. So, when designing a quality power-training session, communication with the coaching staff is important to ensure the athletes are well rested; otherwise, one will not effectively train the peak power capabilities of the wrestlers. On the other hand, if power endurance is the focus for a particular training session, one must appropriately determine target training loads and repetitions (e.g., 8–10RM for 2–3 repetitions) to use within a fatigued state.

The Need for Isometric Strength

Previous work has shown that isometric strength is compromised with a wrestling match and over the course of a tournament (6) (Figure 2). This was seen in the grip strength and a bear-hug strength test, which are important com-

ponents to several wrestling holds. Isometric force is much higher than concentric force production and therefore cannot be trained specifically with a typical weight-training protocol (i.e., eccentric and concentric actions, Olympic movements), albeit some transfer occurs with resistance training alone because of gripping (1, 4). Therefore, specific isometric actions that will enhance handgrip strength as well as upper-body isometric strength of the torso and arms need to be included in a wrestler's training program.

It is generally supported that maximal voluntary muscle actions (MVMA) are superior to submaximal voluntary isometric muscle actions in increasing strength (for review, see Fleck and Kraemer [1]). The majority of sports scientists and practitioners now use 100% MVMA lasting 3 to 10 seconds for training purposes. The duration of the muscle action and the number of training-muscle actions per day individually show weaker correlations to increases in strength than do muscle-action duration and the number of muscle actions combined, which indicates that the length of time a muscle is activated is directly related to increased strength. This also indicates that optimal gains in strength are the result of either a small number of long-duration muscle actions or a high number of short-duration muscle actions. Joint-angle specificity must also be considered when designing an isometric training program. Strength will be developed only at the specific joint angle that the exercise is performed. Although not every joint angle can be trained (it would require too much time), carefully selecting key positions will ensure proper development.

Collectively, this information provides some practical guidelines if an increase in strength and power is desired throughout the entire range of motion. First, the training should be performed at joint-angle increments of approximately 10 to 20 degrees. Second, the total duration (duration of each muscle action x number of muscle actions) of the isometric training per training session should be long (3- to 10-second actions and 15–20 actions per day). Third, if isometric actions cannot be performed throughout the entire range of motion, it is best to perform them with the muscle in a lengthened position as opposed to a shortened position. To increase maximal isometric strength, the optimal program should consist of MVMA performed on a regular basis. Examples of isometric exercises include the following:

- Straight-arm grip, 15–20 repetitions at 100% of effort.
- Bear hug, 15–20 repetitions at 100% of effort.
- Grip-strength style grips of effort (finger cups and wrist grips), 15–20 repetitions at 100% of effort.

Program Considerations

The wrestling program is separated into a number of different periods over the annual cycle (i.e., active rest, off-season, preseason, and in-season). A periodized strength and conditioning plan (linear or undulating) is vital for recovery and optimal timing of peak performance. Several unique features exist that make program design challenging for the sport of wrestling, some of which include a long in-season (4–5 months), frequent competitions (2–3/wk), and optimization of competition body mass over several months. Nevertheless, there are several types of program variables that can be manipulated to suit the specific needs of each wrestler depending on time within the annual cycle, training age, and level of competition (e.g., high school, college, Olympic). Below are brief outlines for several types of training methods, which can be interwoven into a carefully designed training program.

Circuit Resistance Training

The main purpose for circuit resistance training is to develop a toleration of high hydrogen ion and lactic acid concentrations, which will subsequently enhance the acid-buffering mechanisms within the body. Program variables important to the design of a training circuit are rest periods and loads. Typically, rest periods between exercises can begin at 90 seconds and progress down to 60 seconds or less over a 6- to 8-week period. Resistances to create the needed physiological stress will range within a 10–15RM zone. The number of circuits performed within a given training session (i.e., 2–5) or within a particular week (i.e., 2–3) will be dictated by the phase of training as well as the training age of the individual wrestler. The ability to buffer acidic conditions is vital for successful wrestling performance, and circuit resistance training can help the wrestler prepare physiologically for such conditions that will occur during competition. An example of a circuit protocol includes the following:

- Squat or leg press.
- Bench press (incline).
- Stiff-leg deadlift.
- Dumbbell shoulder press.
- Lunges (various angles).
- Pull-down.
- Calf raises.
- Seated rows.
- Core development.
- Arm curls.
- Hang pulls and hang cleans.

Strength Training

Nowhere else in sports is the need for total body strength as evident as it is in wrestling. The ability to push, pull, and stabilize with the upper body and torso and to perform lifts with the body weight of a competitor by using the legs are movements occurring regularly during every 6-minute match. Therefore, strength development should include a variety of exercises that will improve those skills. It is also important to remember that both unilateral and bilateral exercises should be chosen for the program. Compared with circuit resistance training, the rest periods are longer (2–4

minutes) and require heavier loading (6RM and lower). Multi-joint exercises are necessary to develop the strength of the myriad movements integral to wrestling and should be performed with multi-planar actions. Not all the exercises listed below can tolerate 6RM loading and should be considered supplemental lifts to overall strength development. Example exercises would include the following:

- Chest: bench press, incline press, decline press.
- Upper back: lat pull-down, pull-ups, rows.
- Lower back: good morning exercise, deadlift, hyperextensions, thighs, squats, split squats, linear and lateral lunges.
- Hamstrings: stiff-leg deadlift, standing leg curls.
- Arms: arm curls, tricep extensions, wrist curls.

Power Training

Escapes from the bottom position or a Greco-Roman throw are just 2 examples of explosive movements integral to the sport of wrestling. Therefore, power development will also demand a significant proportion of training time. The focus still centers on multi-joint exercises; however, now the intent is to move the mass as quickly as possible. Repetitions can range from 1 to 6 (average 3–4 repetitions) with loads from 30 to 40% of 1RM for high mechanical loading to higher percentages (60–85% of 1RM) for improving power outputs at higher force levels. Rest should be adequate to ensure recovery from the previous set (3+ minutes) so that athletes are ready for maximal efforts. Fundamental exercises typically involved Olympic lifts (i.e., clean, snatches, jerks) but may also involve other nontraditional movements such as weighted squat jumps, 1-legged snatches, or 1-armed clean.

Plyometric Training

In conjunction with traditional power development using Olympic lifts, plyometric exercises can add another dimension to the improvement of dynamic movements needed in wrestling. Although the intensity of plyometric exercises is not yet clearly established in the literature, exercise progression needs to advance from less challenging (e.g., 2-legged take-off and landing in place) to highly difficult (e.g., 1-legged take-off and landing with rotation). Similar to performing Olympic lifts, plyometric drills must be performed with maximal effort. It is important to remember that increasing the number of repetitions within a set is not the most appropriate avenue to vary the training load, for the power or velocity of the movement may decrease. Therefore, it is recommended to carefully plan to use higher repetitions only when power endurance is targeted. Both upper- and lower-body plyometric exercises exist, which will benefit wrestling performance. Such exercises include the following:

- Upper body: medicine ball exercises such as the chest pass, scoop toss, and clean toss; plyometric push-ups.
- Lower body: jumps in place, bounds for distance.
- Core: over-unders, dynamic tubing pulls, hip toss.

Injury Prevention and Isometric Training

The ankles, knees, back, shoulders, and neck are typical sites for injury in wrestling. Although many of the exercises prescribed within a wrestling workout will address aspects of injury prevention, specific drills may be added to target specific weaknesses. Loading can be varied (typically moderate to light); however, care must be taken when exercising these areas of the body. Some exercise suggestions include the following:

- Rotator-cuff exercises.
- Neck exercises.
- Core stability and flexibility.
- Isometric bear hug.
- Isometric hand-grip exercises.
- Rope climb. ♦

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