# Strength and Conditioning for Grappling Sports

Nicholas A. Ratamess, PhD, CSCS*D, FNSCA
Department of Health and Exercise Science, The College of New Jersey, Ewing, New Jersey

## SUMMARY

THE GRAPPLING SPORTS OF JUDO, JIU-JITSU, AND WRESTLING REQUIRE THE ATHLETE TO BE IN PEAK PHYSICAL SHAPE. SPECIFIC TRAINING TARGETING ALL HEALTH- AND SKILL-RELATED FITNESS CONDITIONING COMPONENTS IS NEEDED TO MAXIMIZE SUCCESS IN GRAPPLING SPORTS. STRENGTH AND CONDITION PROGRAMS FOR GRAPPLERS CONSIST OF WEIGHT, PLYOMETRIC, AGILITY, FLEXIBILITY, SPEED, AND AEROBIC TRAINING ALL PROPERLY PERIODIZED AND INTEGRATED WITH SPORT PRACTICE TO MAXIMIZE PERFORMANCE AT THE APPROPRIATE TIME.

## INTRODUCTION

Judo, jiu-jitsu, and wrestling are grappling sports that require athletes to be in superb physical condition. *Judo* is a martial art/sport that requires one athlete to throw or takedown another athlete. It involves several grappling skills, including various throws, foot sweeps, clenching and off-balancing techniques, joint locks, chokeholds, and ground grappling techniques (1,33). As a sport, judo competitions are divided based on age and have 7 weight classes for male and female competitors (7). Judo matches may range from several seconds to 10 minutes (for postregulation competition) but most matches last approximately 3–4 minutes, with 20- to 30-second intermittent bursts of high-intensity activity (7). The match ends when an athlete scores an *ippon* (full point) either by way of a successful throw where the opponent lands on his/her back, holding the opponent on their back for 25 seconds, or a submission from a chokehold or joint lock.

*Jiu-jitsu* is a martial art that is similar to judo in many aspects. Although different styles are practiced, they generally involve gripping, throwing, ground grappling, chokeholds, and joint locks, as well as basic kicking, punching, and blocking skills characteristic of karate (28). Competition jiu-jitsu is technically similar to judo. However, the age classifications, weight classes, rules, and scoring are different. Match regulation times vary from 2 to 10 minutes based on the athletes' age and rank, and athletes may score 2–4 points depending on the technique used, for example, throws, takedowns, sweeps, knees on stomach, front and back mounts, and passing the guard. Similar to judo, the match may end with submission.

Wrestling is a combat sport where one athlete tries to gain and maintain superior position over his/her opponent. *Folkstyle* (or collegiate style) wrestling is commonly seen at the elementary, middle school, high school, and collegiate levels of competition in the United States. *Freestyle* wrestling and *Greco-Roman* wrestling are international styles. Greco-Roman wrestling forbids the wrestler to use or attack the opponents' legs, and freestyle wrestling allows the wrestler to use the arms and legs and attack the opponent's upper and lower body (similar to folkstyle but with different scoring rules and strategies). Although scoring is different between styles, several techniques are common. Nevertheless, several weight and age categories exist, and wrestlers will compete for 3 periods ranging from 1 to 2 minutes per period, with a 30-second break in between periods. Wrestlers score points for takedowns, escapes, reversals, near falls, riding time (college), back exposure/danger position (freestyle and Greco-Roman), and penalties and can win the match by pinning or by outscoring their opponent.

## NEEDS ANALYSIS

Strength and conditioning program design for the grappler begins with the needs analysis. A needs analysis consists of answering questions based on goals and desired outcomes, assessments, access to equipment, training frequency/duration, health, and the demands of the sport (6,18). In this section, the critical health- and skill-related fitness components, metabolic demands, and common injury sites for grapplers are discussed.

### *HEALTH-RELATED COMPONENTS OF FITNESS*

Grapplers benefit from increasing lean body mass while minimizing percent body fat to maintain a weight class.

**KEY WORDS:**
wrestling; jiu-jitsu; judo; sports training; strength training; power training

Athletes in light-to-middle weight classes benefit from having high strength-to-mass ratios and low body fat, whereas heavyweight athletes can tolerate additional body fat because making weight may not be a concern. Elite world-class and Olympic judo athletes typically have percent body fat of <10% (7), and percent body fat tends to be lower in higher- versus lower-ranked athletes (4), and judo athletes have higher total-body bone mineral density compared with swimmers and distance runners (22). Mean body fat ranges of 7–13.7% in men and 15.2–22% in women have been reported (7). Wrestlers have mean body fat percents of 3–13% during the in-season and 8–16% during the off-season (3,12). Percent fat rises on average per weight class, with heavyweights showing percent fat ranges of 15–26% (24).

Grapplers need high levels of dynamic [concentric (CON) and eccentric (ECC)] and isometric strength and endurance. Wrestlers and judo athletes have sufficient levels of dynamic muscular strength, for example, absolute strength is greater in heavier athletes, whereas relative strength is greater in smaller athletes (7,12,24). Wrestlers have high levels of strength in neck flexion, extension, lateral rotation (34), and sport-specific (bear hug) movements (16). In comparison, wrestlers have greater trunk flexion and extension strength (and larger rectus abdominis muscle size) but less oblique and quadratus lumborum muscle size than judo athletes of similar mass (13). Studies have shown a mean 1 repetition maximum (1RM) bench press of 96–160 kg and squat of 104–185 kg in male judo athletes (7). Successful wrestlers have greater isokinetic strength than less-successful wrestlers (12). Isometric strength is needed for grabbing and holding an opponent. Most often, grip strength is assessed, and wrestlers and judo athletes have high levels of grip strength (e.g., 42–83 kg) depending on weight class (7,12,24). High-intensity muscular endurance is needed at high levels due to the intermittent and intense nature of grappling, where rest is minimal. Wrestlers and judo athletes score very well on pull-up, push-up, and sit-up endurance tests (7,24). One may hypothesize that muscle endurance is the most critical component especially as match duration increases. Successful coaches of grapplers have long recognized the importance of high-intensity muscular endurance for success.

Grapplers benefit from having good flexibility. Although some studies have shown wrestlers not to be more flexible than other individuals, flexibility is site-specific and certain joints require greater flexibility (12). Wrestlers have scored well on shoulder, hip/glute/hamstring, and neck flexibility tests in many (12,24) but not all (3) studies. In fact, more successful wrestlers have scored higher on the sit-and-reach test than less successful wrestlers (32). Grapplers can land in awkward bodily positions, so flexibility can be beneficial.

A sufficient aerobic capacity allows the grappler to maintain a higher intensity of anaerobic exercise, lowers the metabolite ($H^+$, inorganic phosphate) response to intense exercise, increases phosphocreatine resynthesis, and improves recovery during intermittent exercise (36). Although grappling has a high anaerobic component, an increased $\dot{V}O_2max$ could potentially allow the athlete to endure longer and recover quicker during intermittent bouts of high-intensity exercise. Wrestlers and judo athletes have sufficient $\dot{V}O_2max$ with values ranging from 40 to 63 $mL \cdot kg^{-1} \cdot min^{-1}$, with most between 50 and 60 $mL \cdot kg^{-1} \cdot min^{-1}$ in male athletes and 40 and 50 $mL \cdot kg^{-1} \cdot min^{-1}$ in female judo athletes (3,7,12,21,35). Relative $\dot{V}O_2max$ decreases with heavier weight classes (7,24). Although maintaining a sufficient $\dot{V}O_2max$ is important for grapplers, $\dot{V}O_2max$ does not appear to be a major discriminating factor between athletes of different caliber (7,12). These data may be interpreted as increasing $\dot{V}O_2max$ to a large extent (i.e., to levels similar to endurance athletes) may not create a better grappler. However, substantial improvements in other health- and skill-related fitness components (strength, power, muscle endurance, and flexibility) may play a greater role in grappling superiority.

## SKILL-RELATED COMPONENTS OF FITNESS

Grapplers need sufficient levels of power, agility, quickness, balance, and coordination. Power is associated with explosive moves that allow the grappler to control their opponent and is a critical predictor of success. Judo athletes score well on vertical jump assessments, and vertical jump has been shown to correlate to winning percentage in judo competition (7). Judo athletes score well (>90th percentile), and elite athletes score better than nonelite athletes in upper-body anaerobic power tests (Wingate) (7). Correlations have been shown between winning percentage in judo competitions and upper-body Wingate test peak power in female judo athletes (7). Wrestlers have scored well on rope climbing power assessments (3) and Wingate anaerobic tests, yielding peak power ranges of 6.1–7.5 and 9–19.9 W/kg of body mass, respectively, for upper- and lower-body tests (12). Anaerobic power of elite wrestlers may be as much as 13% higher than nonelite wrestlers matched for age, weight, and experience (12).

## METABOLIC DEMANDS

Grappling requires contributions from both anaerobic and aerobic energy systems. The ATP-PC (adenosine triphosphate-phosphocreatine) system provides high-energy liberation for activities that last up to 10–15 seconds. Wrestling, jiu-jitsu, and judo matches are usually longer, so the ATP-PC can only meet some of the energy demands. Because of the intermittent nature of grappling, some PC recovery takes place during a match but this source is limited. Anaerobic glycolysis plays a substantial role in grappling that lasts a few to several minutes in duration (15). Studies have shown blood lactate values of 16–20 mmol/L immediately after a wrestling match (15,16,19). Blood lactate ranges of 13.3–19.7 mmol/L have been shown after mixed

martial arts training/sparring sessions, and blood lactate ranges of 10.5–20.7 mmol/L have been shown after mixed martial arts bouts of various durations (2).

### INJURY SITES

Grappling sports are very physical in nature and may result in awkward positions where large forces can be injurious, particularly during takedowns or throws (26). Common areas of injury in grapplers include the shoulder, knee, and ankle, mostly from sprains, strains, and contusions (14). Neck and trunk injuries may also occur (10). College wrestlers have shown an injury rate of 9.6 injuries per 1000 athlete exposures (14), whereas high school wrestlers have shown 6.0 injuries per 1000 athlete exposures (26). Most studies show 6.0–7.6 injuries per 1,000 athlete exposures across the board in wrestlers with the rate increasing with age, experience, and level of participation (10).

## TRAINING THE GRAPPLER

The strength and conditioning program is critical to the grappler. Although sport-specific qualities, such as technique, skill, strategic knowledge, and the ability to react to, counter, and apply movements, are critical to grappling performance, conditioning ultimately determines winners and losers. Physical conditioning can account for up to 45% of the variance observed between successful and less successful wrestlers (25). A recent study by Garcia-Pallares et al. (8) comparing amateur to elite wrestlers has shown that elite wrestlers have greater strength (7–25%), power (14–30%), jump height (8–17%), and grip strength (6–19%) than amateur wrestlers. Thus, each major health- and skill-related fitness component must be adequately trained for grapplers to attain peak performance.

### WEIGHT TRAINING

Weight training is a staple of grappler training for at least 3–4 workouts per week. Exercises should be selected from 3 broad categories: Olympic-style/power lifts, basic strength, and auxiliary exercises (Table 1). Each workout should consist of exercises from each category. The grappler can select 1–2 power exercises, 2–4 basic strength exercises, and 3–6 auxiliary exercises per workout and perform these exercises in that general sequence. Within each exercise category, sequencing guidelines include most complex to least complex for Olympic-style lifts (snatch, cleans, and variations), large before small muscle mass exercises, multiple- before single-joint exercises, and higher- before lower-intensity exercises (29). Sequencing exercises between upper- and lower-body and/or agonist/antagonist muscle groups is also effective (29). Table 1 depicts typical weight training exercises that stress all major muscle groups. The Olympic-style/power lifts and basic strength exercises can be systematically periodized in volume and intensity with each training phase. Olympic-style lifts and variations may be periodized within a 1–6 repetition range, whereas basic strength exercises may be periodized within a 1–12 repetition range. Hypertrophy training begins the off-season phase where intensity is moderate and volume is high. Subsequent phases entail increasing load (intensity) and reducing volume (repetition number) until strength and power peak before preseason or precompetition training. Auxiliary exercises are not periodized in the same way. These exercises are commonly performed for 8–12 repetitions or more. For strength training, it is recommended that novice-to-intermediate athletes train with 60–70% of 1RM for 8–12 repetitions and advanced athletes cycle training loads from 80 to 100% of 1RM using rest intervals of at least 2–3 minutes for structural exercises using heavier loads and 1–2 minutes of rest for auxiliary exercises (29). The athlete can benefit from exercise periodization or systematic rotation of exercises over 4- to 6-week training periods.

Power training requires moderate-to-heavy loads to increase maximal strength but also low-to-moderate intensities performed at explosive lifting velocities. Peak power during ballistic exercises (jump squats, ballistic bench press) is attained with light-to-moderate loading (15–60% of 1RM) but is higher for traditional exercises (40–70% of 1RM) (29). It is recommended that power training consisting of 1–3 sets per exercise using light to moderate loading (30–60% of 1RM for upper body exercises, up to 60% of 1RM for lower body exercises) for 3–6 repetitions performed at an explosive velocity be added concurrently to strength training (29).

### PLYOMETRICS

Plyometric exercises use the stretch-shortening cycle and rely greatly on minimizing the time between ECC and CON phases. Plyometric training increases strength, power, and speed (27), which is critical for improving grappling performance. Each repetition should be performed with maximal effort regardless of whether it is a low-, moderate-, or high-intensity drill. Plyometric exercises can be integrated in 3 ways: (a) they can be included in conditioning workouts or grappling-specific practices; (b) they could be integrated into a weight training workout (e.g., *complex training*); or (c) they can be performed entirely on their own in a plyometric workout.

Conditioning workouts target strength and power endurance. For example, various jumps or medicine ball (MB) throws can be included in conditioning circuits perhaps sequenced in between other drills, such as rope climbs, shadow drills, wheelbarrows, sandbag drags, partner push-up hand slaps, takedown toe-taps, sledge hammer swings, or a multitude of free weight, kettle bell, MB, stability ball (SB), elastic band, sandbag, keg, TRX Suspension Trainer (attachable and adjustable straps with grips used for body weight training), and BOSU ball (SB with a flat base) exercises. Complex training is a way to augment plyometric exercise performance using postactivation potentiation. For example, performing vertical jumps in between sets of barbell squats can augment jump performance provided that the squats do not elicit high levels of fatigue (11). Complex training

**Table 1**
**Weight training exercises for grapplers**

| Olympic-style/power lifts | Basic strength | Auxiliary exercises | | |
|---|---|---|---|---|
| Power clean | Back squat | Single-leg squat | Low pulley row | Back extension |
| Power snatch | Front squat | Thick bar deadlift | DB rotation press | Hyperextension |
| Push press | Overhead squat | Bear hug deadlift (sandbag/keg) | KB side press | Hyperextension press |
| Jump squat | Lunge/side lunge | Single-leg deadlift | Side lateral raise | Reverse hyperextensions |
| High pull | Leg press | Overhead lunge | Shrugs | Crunches/sit-ups |
| Single-leg DB/KB snatch/clean | Deadlift | SB leg curl (or TRX) | Upright row | Twisting knee ups |
| Single-arm DB/KB snatch/clean | Lat pull-down | Leg curl | Internal/external shoulder rotation | Sit-up and press |
| | Pull-up | Reverse leg curl | | Russian twist |
| | Bent-over row | Leg extension | Prone scapula circuit | Bent-over trunk rotation |
| | Bench press (flat, incline, decline) | Calf raise | Triceps extension/pushdown | Plank/side plank |
| | Dips | DB fly | Arm curls | SB rollout |
| | Shoulder press | Bench press with chains/bands | Wrist/reverse wrist curls | Leg raise |
| | | Renegade bar rotation | Wrist roller | Plyo leg raise |
| | | DB T-rotation | Plate grabs/pinch grips | TRX windshield wiper |
| | | Push-ups (many variations) | Tire flips | SB exchange |
| | | Inverted row | Quadruped | Cable rotations |
| | | Renegade row | KB swings | Squat rotation press |
| | | Towel chin-ups | 4-way neck | Turkish get-up |

DB = dumbbell; KB = kettle bell; SB = stability ball.

increases workout efficiency by making positive use of planned rest intervals. Interestingly, potentiation can augment acute power performance but does not provide any advantage over chronic training periods (23). Athletes who train using plyometric-only workouts or complex training increase power at similar rates (23). Thus, the use of complex training is a matter of personal preference by the athlete or coach but may be best served when performed by experienced athletes.

Exercise selection for plyometric-only workouts should be specific to the demands of the sport. Table 2 depicts some plyometric exercises that benefit grapplers. The sequence of exercises can vary, but the grappler benefits from performing a low- or moderate-intensity drill first as an additional warm-up but followed by high-intensity drills so they can be performed with minimal fatigue. Less complex drills can be performed in succession. Sport-specific drills can be integrated with plyometric exercises to improve skill development along with power. Gradual progression should be used, and an increase in intensity through the addition of more complex exercises and perhaps some light external loading is accomplished. Volume can be increased within reasonable limits. Although little scientific research has been conducted in this area, Chu (5) has recommended 120–200 and 150–450 foot contacts per workout, respectively, for off-season and preseason training in advanced athletes. Volume and intensity are inversely related. Low-intensity and moderate-intensity drills should be mastered before progressing to high-intensity drills. High-intensity workouts require greater recovery time. Work-to-rest ratios of 1:5 (for low- and moderate-intensity drills) to 1:10 (higher-intensity drills) are recommended (5,27). Shorter rest interval lengths minimize recovery and train power endurance rather than absolute peak power. Plyometric training is often integrated with resistance training, practice, and conditioning sessions. Thus, a frequency of 1–3 workouts per week may be used and volume must be adapted accordingly (5). Workouts stress all major muscle groups. Upper-body/core exercises can be performed in between lower-body exercises to increase training efficiency. A sample workout may look like:

Squat jumps–3 × 10
MB side throw–3 × 8 (each side)
Split squat jump with cycle–3 × 10
MB back throw–3 × 5
Single-leg push-off–3 × 6 (each leg)
Plyo push-up–3 × 10
Box jumps–3 × 8

### AEROBIC TRAINING

Grapplers benefit from aerobic training mostly by running. Although some question its application to primarily anaerobic athletes, aerobic training provides a means of increasing $\dot{V}O_2$max, muscular endurance, and weight control for the grappler. Aerobic training is not prioritized during the off-season. Off-season training is devoted to increasing strength and power, and high-intensity, high-frequency aerobic training can impede strength and power gains (especially in the lower body), with power being affected to a greater extent (9,17). If the grappler chooses to perform aerobic training during the off-season, 1–2 days per week performed at a low intensity (*road work*) for 20–30 minutes may suffice. Aerobic endurance training increases in frequency and intensity during the preseason and in-season phases. Athletes may increase aerobic training frequency to 3–5 days per week. The intensity increases, so hill training (or stair running) and interval training are preferred modes rather than distance running. For those athletes who compete all year (with no off-season), an aerobic base is maintained and prioritized 8–12 weeks before competition.

Interval training allows the athlete to train at higher intensities while improving anaerobic and aerobic capacities and is a common training method among grapplers (20,30,31). Intervals using a 1:1 ratio target aerobic capacity. For example, the athlete can run at a high

**Table 2**
**Plyometric exercises**

| Lower body | Upper body/core |
|---|---|
| Ankle hops | MB chest pass |
| Squat jumps | Overhead MB throw |
| Tuck jumps | MB back throw |
| Split squat jump | Single-arm vertical core ball throw |
| Cone hops (forward, backward, lateral, diagonal) | Overhead MB slams |
| Single-leg hops | MB side throw |
| Bounding | Plyo push-up |
| Box jumps | Depth push-up |
| Single-leg box jumps | Sandbag bear hug throws |
| Lateral push-offs | Sit-up rotation MB throw |
| Depth jumps (boxes of 20–115 cm) | |
| Depth jump to penetration shot or clench | |
| Single-leg depth jumps | |

MB = medicine ball.

intensity for 3 minutes and reduce pace to a jog for 3 minutes and repeat the sequence for 5 sets totaling a 30-minute workout. Lower-intensity bouts interspersed in between high-intensity bouts allow the athlete to train at a higher intensity than that seen with continuous aerobic training. Interval training is used to increase anaerobic capacity with longer work to relief ratios (e.g., 1:5–10 for ATP-PC system and 1:2–3 for glycolysis). For example, sprinting ten 40-yard dashes at high-intensity with 1–2 minutes rest in between targets the ATP-PC system and performing eight 100-yard dashes with 30 seconds of rest targets glycolysis.

### FLEXIBILITY

Static and dynamic flexibility enhancement has many performance benefits, including improved muscle balance, strength, posture, and ability to move, and is thought to reduce the risk of injury. Grapplers need adequate flexibility to perform several scoring maneuvers and counteract opponent attacks. Jiu-jitsu, judo, and wrestling training alone could increase joint flexibility. However, it is recommended that the grappler include dynamic (consisting of movement throughout the joint range of motion) and static (where the final position is held in a specified area of the range of motion) stretching to their training programs. Static stretching is best performed at the end of a workout or practice session and can be performed daily. The grappler should select a few major stretches and perform multiple sets (3–5) held at the point of moderate discomfort for 30–60 seconds or more to increase flexibility.

### CIRCUIT TRAINING AND CONDITIONING

Circuit training is an excellent way to improve the grappler's conditioning or anaerobic capacity/endurance. Circuits allow the athlete to perform several exercises in a short period, yielding substantial metabolic and cardiovascular responses. The continuity is a stimulus for increasing aerobic capacity as well. For example, it is common in wrestling to have athletes peak for strength and power, then subsequently begin a 2- to 4-week preseason phase comprised mostly of weight training circuits (i.e., 8–10 exercises, moderate intensity, 10–15 repetitions, <15 seconds between exercises) to improve endurance. Circuits can be developed using most modalities of exercise, including sport-specific techniques. Circuit progression can take place by increasing the load, repetitions, duration or length of drill and reducing the total time needed to complete the entire circuit (e.g., *timed circuits*). Table 3 depicts some examples of 3 different circuit workouts. The athlete can perform the entire circuit, rest approximately 1–2 minutes, and repeat the circuit for the desired number of sets. Circuits are dependent on equipment availability (including mats) and spacing and can be varied a number of ways by altering the exercise selection and number per circuit, loading, and volume.

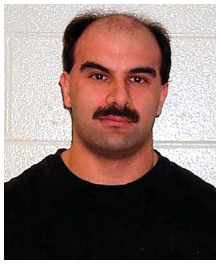
### SUMMARY

Judo, jiu-jitsu, and wrestling require athletes to be in superior physical condition. Specific training targeting muscle strength and endurance, flexibility, speed, power, agility, balance and coordination, aerobic endurance, and body fat reductions is needed to maximize success in grappling sports. Strength and conditioning programs for grapplers consist of weight, plyometric, agility, flexibility, speed, and aerobic training, all properly periodized and integrated with sport practice to maximize performance at the appropriate time.

**Table 3**
**Grappler circuits**

| Circuit 1 | Circuit 2 | Circuit 3 |
|---|---|---|
| Body weight squats 1 × 50 | Rope skipping 1 × 200 | Step-ups 1 × 1 min |
| ISOM chin-up holds 1 × 20 s | Pull-ups 1 × 15 | KB swings 1 × 20 |
| Bear crawls 1 × 20 yd | Hip heist over/under 1 × 10 | Shoulder roll/breakfall 1 × 20 yd |
| Agility ladder ins and outs 1× | ISOM squat (sumo) 1 × 30 s | Side crawls 1 × 10 yd |
| Wheelbarrow drags 1 × 20 yd | Sledge hammer slams 1 × 15 | Sled pulls 1 × 20 yd |
| Rope climbs 1× | Keg carries 1 × 20 yd | Side plank (hip abduction) 1 × 15 s |
| SB circling 1 × 30 s | ISOM half-push-up 1 × 20 s | Spiderman push-ups 1 × 10 |
| Neck bridge DB press 1 × 10 | Duck walks 1 × 20 yd | Single-leg bridge 1 × 15 s |
| Bear hug carries (sandbag) 1 × 20 yd | Army crawls 1 × 15 yd | ISOM lunge 1 × 20 s |
| Weighted vest takedowns 1 × 10 | Squat rotation press 1 × 20 | SB exchange 1 × 15 |

DB = dumbbell; ISOM = isometric; KB = kettle bell; SB = stability ball.



**Nicholas A. Ratamess** *is an associate professor at The College of New Jersey.*

## REFERENCES


1. Amtmann J and Cotton A. Strength and conditioning for judo. *Strength Cond J* 27: 26–31, 2005.
2. Amtmann JA, Amtmann KA, and Spath WK. Lactate and rate of perceived exertion responses of athletes training for and competing in a mixed martial arts event. *J Strength Cond Res* 22: 645–647, 2008.
3. Callan SD, Brunner DM, Devolve KL, Mulligan SE, Hesson J, Wilber RL, and Kearney JT. Physiological profiles of elite freestyle wrestlers. *J Strength Cond Res* 14: 162–169, 2000.
4. Callister R, Callister RJ, Staron RS, Fleck SJ, Tesch P, and Dudley GA. Physiological characteristics of elite judo athletes. *Int J Sports Med* 12: 196–203, 1991.
5. Chu DA. *Jumping Into Plyometrics* (2nd ed). Champaign, IL: Human Kinetics, 1998. pp. 1–138.
6. Fleck SJ and Kraemer WJ. *Designing Resistance Training Programs* (3rd ed). Champaign, IL: Human Kinetics, 2004. pp. 154–158.
7. Franchini E, Del Vecchio FB, Matsushigue KA, and Artioli GG. Physiological profiles of elite judo athletes. *Sports Med* 41: 147–166, 2011.
8. Garcia-Pallares J, Lopez-Gullon JM, Muriel X, Diaz A, and Izquierdo M. Physical fitness factors to predict male Olympic wrestling performance. *Eur J Appl Physiol* 111: 1747–1758, 2011.
9. Häkkinen K, Alen M, Kraemer WJ, Gorostiaga E, Izquierdo M, Rusko H, Mikkola J, Häkkinen A, Valkeinen H, Kaarakainen E, Romu S, Erola V, Ahtiainen J, and Paavolainen L. Neuromuscular adaptations during concurrent strength and endurance training versus strength training. *Eur J Appl Physiol* 89: 42–52, 2003.
10. Hewett TE, Pasque C, Heyl R, and Wroble R. Wrestling injuries. *Med Sport Sci* 48: 152–178, 2005.
11. Hoffman JR, Ratamess NA, Faigenbaum AD, Mangine GT, and Kang J. Effects of maximal squat exercise testing on vertical jump performance in American college football players. *J Sports Sci Med* 6: 149–150, 2007.
12. Horswill CA. Applied physiology of amateur wrestling. *Sports Med* 14: 114–143, 1992.
13. Iwai K, Okada T, Nakazato K, Fujimoto H, Yamamoto Y, and Nakajima H. Sport-specific characteristics of trunk muscles in collegiate wrestlers and judokas. *J Strength Cond Res* 22: 350–358, 2008.
14. Jarret JW, Orwin JF, and Dick RW. Injuries in collegiate wrestling. *Am J Sports Med* 26: 674–680, 1998.
15. Kraemer WJ. Wrestling: physiological aspects for conditioning. *Strength Cond J* 40: 66–67, 1984.
16. Kraemer WJ, Fry AC, Rubin MR, Triplett-McBride T, Gordon SE, Koziris LP, Lynch JM, Volek JS, Meuffels DE, Newton RU, and Fleck SJ. Physiological and performance responses to tournament wrestling. *Med Sci Sports Exerc* 33: 1367–1378, 2001.
17. Kraemer WJ, Patton JF, Gordon SE, Harman EA, Deschenes MR, Reynolds K, Newton RU, Triplett NT, and Dziados JE. Compati bility of high-intensity strength and endurance training on hormonal and skeletal muscle adaptations. *J Appl Physiol* 78: 976–989, 1995.
18. Kraemer WJ and Ratamess NA. Fundamentals of resistance training: Progression and exercise prescription. *Med Sci Sport Exerc* 36: 674–678, 2004.
19. Kraemer WJ, Vescovi JD, and Dixon P. The physiological basis of wrestling: Implications for conditioning programs. *Strength Cond J* 26: 10–15, 2004.
20. La Bounty P, Campbell BI, Galvan E, Cooke M, and Antonio J. Strength and conditioning considerations for mixed martial arts. *Strength Cond J* 33: 56–67, 2011.
21. Little NG. Physical performance attributes of junior and senior women, juvenile, junior, and senior men judokas. *J Sports Med Phys Fitness* 31: 510–520, 1991.
22. Matsumoto T, Nakagawa S, Nishida S, and Hirota R. Bone density and bone metabolic markers in active collegiate athletes: Findings in long-distance runners, judoists, and swimmers. *Int J Sports Med* 18: 408–412, 1997.
23. Mihalik JP, Libby JJ, Battaglini CL, and McMurray RG. Comparing short-term complex and compound training programs on vertical jump height and power output. *J Strength Cond Res* 22: 47–53, 2008.
24. Mirzaei B, Curby DG, Rahmani-Nia F, and Moghadasi M. Physiological profile of elite Iranian junior freestyle wrestlers. *J Strength Cond Res* 23: 2339–2344, 2009.
25. Nagle FJ, Morgan WP, Hellickson RO, Serfass RC, and Alexander JF. Spotting success traits in Olympic contenders. *Phys Sports Med* 3: 31–34, 1975.
26. Pasque CB and Hewett TE. A prospective study of high school wrestling injuries. *Am J Sports Med* 28: 509–515, 2000.
27. Potach DH, Chu DA. Plyometric training. In: *Essentials of Strength Training and Conditioning* (3rd ed). Baechle TR and Earle RW, eds. Champaign, IL: Human Kinetics, 2008. pp. 413–456.
28. Ratamess N. Weight training for jiu jitsu. *Strength Cond J* 20: 8–15, 1998.
29. Ratamess NA, Alvar BA, Evetovich TK, Housh TJ, Kibler WB, Kraemer WJ, and Triplett NT. American College of Sports Medicine position stand: Progression models in resistance training for healthy adults. *Med Sci Sports Exerc* 41: 687–708, 2009.
30. Rooney M. *Training for Warriors.* New York, NY: Harper Collins Publishers, 2008. pp. 71–222.
31. Sanders MS and Antonio J. Strength and conditioning for submission fighting. *Strength Cond J* 21: 42–45, 1999.
32. Stine G, Ratliff R, Shierman G, and Grana WA. Physical profile of the wrestlers at the 1977 NCAA championships. *Phys Sports Med* 7: 98–105, 1979.
33. Takahashi R. Power training for judo: Plyometric training with medicine balls. *Strength Cond J* 14: 66–71, 1992.
34. Ylinen JJ, Julin M, Rezasoltani A, Virtapohja H, Kautiainen H, Karila T, and Malkia E. Effect of training in Greco-Roman wrestling on neck strength at the elite level. *J Strength Cond Res* 17: 755–759, 2003.
35. Yoon J. Physiological profiles of elite senior wrestlers. *Sports Med* 32: 225–233, 2002.
36. Yoshida T. The rate of phosphocreatine hydrolysis and resynthesis in exercising muscle in humans using 31P-MRS. *J Physiol Anthropol* 21: 247–255, 2002.