Developing an Annual Training Program for the Mixed Martial Arts Athlete

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ABSTRACT

Mixed martial arts (MMA) is a multidimensional combat sport combining various forms of grappling and striking methodologies. The sport challenges the strength and conditioning professional because of the conflicting metabolic demands, high degree of variability, and a lack of a fixed competitive schedule. The existing literature identifies the need for highly developed neuromuscular qualities and high aerobic and anaerobic capacities. Although previous research has identified the physiological profile of a high-level MMA athlete, there is limited peer-reviewed research identifying the most optimal periodization strategy to improve performance. Furthermore, there seems to be no existing literature investigating the implementation of velocity-based training (VBT). This training methodology uses movement velocity to assign training loads to mitigate fatigue and improve strength and power adaptations. Existing literature on VBT suggests that it is a superior method of assigning training load compared with traditional percentage-based training. Therefore, this article serves to identify the physiological profile of the MMA athlete, outline VBT, and provide a guideline for designing an MMA strength and conditioning program to optimize performance using VBT.

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PHYSIOLOGICAL PROFILE OF THE MIXED MARTIAL ARTS ATHLETE

ENERGY SYSTEMS

To understand the metabolic requirements of MMA, one must first identify the parameters under which competition occurs. An MMA bout in the Ultimate Fighting Championship (UFC), the largest MMA organization in the world, is scheduled for 3–5 five-minute rounds with 1-minute rest between the rounds (7). A UFC bout's average fight time has steadily increased from 8:06 in 2002 to 10:43 in 2017. Also, worth noting is the near linear relationship of fight time between weight classes, with the longest bouts occurring in women's strawweight (52.2 kg [115 lbs.]) and the shortest bouts occurring in men's heavyweight (120.2 kg [265 lbs.]). A fighter's weight class is also an important consideration when identifying methods of victory because heavier weight bouts typically end in a knockout. By contrast, lighter-weight class bouts usually end with the judge's decision (29). However, when analyzing the sport holistically, 77% of MMA bouts are won through high-intensity actions that last about 8–12 seconds (23).

These high-intensity actions that win fights are anaerobic by nature; however, the average fight duration is aerobic. Therefore, it is recommended that the MMA athlete develop a high aerobic capacity that supports short bursts of anaerobic activity (23). The literature suggests that the work-to-rest ratio of an MMA bout ranges from 1:2 to 1:4 (7,10). Striking dominant athletes possess superior short-term anaerobic qualities characterized by short work-to-rest ratios, whereas grappling dominant athletes have superior long-term anaerobic qualities characterized by prolonged work-to-rest ratios (14). Furthermore, a grappling dominant profile more often defines a successful MMA athlete, as twice as many fights end during high-intensity actions on the ground than during intense striking combinations (14). Lactate levels recorded by the end of a bout can range from 10.2 to 20.7 $mmol \cdot L^{-1}$ (4,8). These data offer valuable insight to the strength and conditioning professional when managing training intensity.

At the beginning of a bout, glycolysis is the predominant metabolic pathway, but as the fight progresses, the oxidative system becomes the primary contributor to energy metabolism. The 1-minute rest period between rounds allows for the fighter's heart rate and oxygen consumption to decrease. However, lactate levels remain at or above anaerobic threshold, not allowing full recovery, significantly impacting performance (7). Therefore, the MMA athlete should train in a manner

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that develops a high aerobic capacity but still emphasizes the ability to work at high intensities (23).

STRENGTH AND POWER REQUIREMENTS

A high-level MMA athlete must possess upper-limb and lower-limb strength to rapidly transfer force through the sagittal, frontal, and transverse planes through open and closed kinetic chains. Force transfer through the transverse plane is particularly important for striking (28). In addition to dynamic strength, isometric strength also plays a significant role in success in the octagon, particularly in grappling. Grip strength is vital to control the opposing fighter and is expressed through the isometric strength of the hand and forearm (14). Speed is also a crucial factor in developing the MMA athlete because an increase in striking velocity increases the kinetic energy of the strike and, therefore, knockout power (7).

Furthermore, speed and accuracy of foot placement (agility) also play an important role in positioning defensively and offensively (28). It is also well known that the more powerful fighter has a competitive advantage, particularly when expressed through the hip, trunk, and shoulder. In addition, the ability to express power repeatedly throughout a bout is crucial for success in later rounds (7,14,17). Bounty et al. (7) recommended loads of 40–70% 1 repetition maximum (1RM) for upper-extremity power-based movements and 40–80% 1RM for lower-extremity power-based movements. The application of accommodating resistance and lighter loads has also been found to improve movement velocity, an important factor for success in MMA (7).

In addition, core stability allows for greater force transfer and power when striking, particularly through the transverse plane. A well-developed core contributes to neuromuscular control and provides the athlete a base for efficient movement (28). Isometric core strength also improves a fighter's ability to absorb strikes to the body and protect the spine from injury. During grappling sequences, a strong core gives a fighter greater control over the opponent on the ground and puts the fighter in a dominant position (7).

INJURY PREVENTION STRATEGIES

The violent nature of MMA creates a relatively high risk of injury. Seventy-seven percent of musculoskeletal injuries typically occur during competition (29) to the defending fighter (28). The mechanism of injury most commonly involves striking an area of the body inflicting injury or, less typically, the limb used to strike is injured (28). In addition, asymmetries within the body as small as 10% have been reported to increase injury risk by an astounding 70–90% (29). The most injured area of the body is the head and face making up 77.8% of all fight-related injuries. Other common sites of fight-related injuries include the wrist and hand, knee, foot, shoulder, lower leg, and elbow contributing anywhere from 5 to 20% of injuries (29).

Functional movement screening. Before starting a training program, the strength and conditioning professional should conduct a Functional Movement Screening (FMS) to identify muscular imbalances and movement deficiencies that may predispose the MMA athlete to injury. Findings by Kiesel et al. (16) identified a relationship between Functional Movement Screen test scores and relative injury risk in American football players. MMA athletes typically overdevelop the anterior musculature and underdevelop the posterior musculature because of the push-heavy nature of striking, creating a muscular imbalance (3). Bodden et al. (6) found that an FMS assessment successfully identified movement dysfunction and asymmetries, and the subsequent intervention program successfully improved the FMS score. Based on the risk of injury because of body asymmetries by the UFC Performance Institute (29), Bodden et al. (6) suggested that an FMS assessment may decrease the risk of injury for the MMA athlete, by highlighting any dysfunctional movement patterns that can then be retrained with corrective exercises. Furthermore, injury prevention strategies are imperative in a comprehensive training plan and directly affect athlete safety (28).

Tack (28) recommended a prerehabilitation program emphasizing flexibility and neuromuscular control. Developing joint strength, tensile strength of connective tissue, and bilateral muscular balance is also important (28). In addition, focus on neck musculature strengthening will reduce the risk of injury to the cervical spine and help absorb strikes to the head. Strong neck musculature also aids a fighter in resisting head grabs and pulls during grappling and clinching situations (7). Furthermore, valgus knee collapse with an extended knee increases the risk of anterior crucial ligament injury; proper limb alignment should be emphasized during training (15). Single-limb stance exercises have been known to increase neuromuscular control and reduce the risk of a valgus knee injury (28). Tai chi has been found to improve muscular strength in the stabilizing muscles of the knee and ankle and improve neuromuscular control of the extremities (20). Peacock et al. (20) found that implementing tai chi as a cooldown modality after strength and conditioning sessions improved balance on the balance error scoring system by 9% and sit and reach flexibility by 8% in professional MMA athletes.

PERIODIZATION STRATEGY

When working with MMA athletes, the strength and conditioning professional faces several challenges unique to the sport of MMA. Unlike most sports that feature a preseason, in-season competitive period, and an off-season, MMA does not have predetermined seasonal fixtures (23). However, an active MMA athlete can expect to compete 2–3 times per year. A fight camp (preseason) can be as short as 2–6 weeks or as long as 4 months, depending on when a fighter receives notice that they will be competing. A typical training camp, however, is about 1–3 months long (23). Such variability necessitates that the MMA athlete stays prepared to compete on short notice. Another factor the strength and conditioning professional needs to be aware of is the risk of overtraining. Because of the demanding nature of the sport and high volumes accumulated between strength and conditioning training and technical training, the MMA athlete is susceptible to overtraining if the training volume is not appropriately managed (7). This condition can present as chronic fatigue, muscle and joint pain, decreased performance, increased resting heart rate, depression, insomnia, and irritability (7). Finally, because of the sport's conflicting aerobic and anaerobic demands, concurrent training practices are adopted, requiring carefully executed periodization strategies to realize the desired physiological adaptations (15).

PREPARATORY PHASE

The preparatory phase for the MMA athlete can be considered the off-season. During this time, the MMA athlete is not preparing for a specific bout and focuses primarily on injury prevention, dynamic flexibility, core stability, building a base for strength and power, and developing their aerobic capacity. This phase typically adopts a linear periodization model to optimize overload (28). Ruddock et al. (23) recommend dividing the preparatory phase into 2 subphases: general preparation and special preparation. The general preparatory period is defined by low sport specificity, predominantly aerobic conditioning, and a low neuromuscular demand. The special preparatory period shifts to increased sport specificity, neuromuscular demand, and greater frequency of anaerobic conditioning (23). In addition to general physical preparation, the MMA athlete can also use the preparatory phase to develop weak points in their performance that they may not have an opportunity to develop in later phases because of specificity of a fight camp to their opponent.

During the preparatory phase, there is a greater emphasis on long-slow distance (LSD) and low-intensity interval training (LIIT) paired with higher-volume resistance training (15). Caution is advised (15) because LSD and LIIT lack specificity and negatively impact strength and power development. Therefore, it is used to build an aerobic base to support the shift to anaerobic conditioning closer to competition. Caution is also advised with high-volume resistance training because an increase in mass may affect the ability to "make weight" before competition (15). The preparatory phase typically begins 9–16 weeks before the competitive period begins (29). The UFC Performance Institute (29) implements 4 microcycles during the preparatory phase: an introductory block, accumulation block, peaking block, and deload block leading into fight camp (competitive phase).

COMPETITIVE PHASE

During the competitive phase, there is a shift from a linear periodization model to an undulating one (29). An undulating model allows the strength and conditioning professional to better manage training stress because of increased technical training sessions and better optimize overload to the neuromuscular system (28). During this phase, there is a transition to MMA-specific movements and the introduction of complex training. A 2–5% weekly increase in volume of strength and power-based movements is recommended (28). High-intensity interval training (HIIT) becomes the primary method of metabolic conditioning to improve oxidative capacity and increase maximal oxygen consumption. Strength and power movements should be paired with HIIT because the peripheral adaptations from HIIT complement the neural adaptations of strength and power (15).

Early fight camp. During the early fight camp, metabolic conditioning is primarily achieved through technical training such as high-intensity grappling. The number of technical training sessions and implementing sport-specific movements should also increase (23). There is also a continuous rightward shift on the force velocity curve toward maximum velocity in loaded exercises (29). The distribution between striking and grappling conditioning and technical training largely depends on the fight strategy (23). As the fight camp progresses, the HIIT intervals become shorter, and the movements become more MMA specific (18).

Late fight camp. The late fight camp features the greatest volume of sport specificity and focus on fight strategy. The increase in HIIT training during this phase improves mitochondrial volume and capillarization (23). HIIT also helps improve body composition, making it easier to "make weight" before the fight. Ruddock et al. (23) recommended separating HIIT sessions by 36 hours to optimize recovery. The late fight camp ends with a tapering period where training frequency remains the same but volume decreases by 60–85% (18). James et al. (15) recommended that the tapering should take place over an 8- to 14-day period. Reduced training stress during the tapering period dissipates fatigue and improves athlete readiness to perform (15). In addition, during the fight camp, the athlete is typically training in a caloric deficit to make the required weight to be eligible to compete in their weight class (29). Cutting weight can be a grueling and tedious process. A registered dietician sports nutritionist should be consulted for nutritional advice and guidelines based on dietary analysis to complement the training program of the strength and conditioning coach during the early fight camp and late fight camp training.

FURTHER TRAINING CONSIDERATIONS

Recovery from training is paramount for optimal performance and reducing risk of injury. The training team and athlete should consider several recovery modalities such as contrast water immersion, optimally timed nutrition, and massage therapy (4,7). A recovery modality worth noting is active recovery using concentric-only movements because it elicits less muscle damage than eccentric movements and has been shown to increase blood flow (7). Dynamic flexibility routines should also be included in an MMA strength and conditioning program focusing primarily on sport-specific exercises and movements, particularly targeting the hip flexor and adductor muscles (28). In addition, 2 minutes of foam rolling has been shown to increase range of motion to the same degree as static stretching without the associated loss in force production and should be applied at the beginning of a training session (28). Finally, it is important to remember that the MMA athlete competes with a mouthpiece and barefoot (7,28). Therefore, training with a mouthpiece or introducing swimming protocols to assimilate the athlete to restricted airflow can improve an athlete's comfort during a fight (7). Swimming has been shown to improve lung volumes because of the mechanical loading of hydrostatic pressure on the chest walls and larger inspirations (17). Controlled frequency breathing during swimming has been shown to further improve respiratory adaptations because of even greater inspiration and inducing hypercapnia (17). The MMA athlete should consider using controlled frequency breathing during swimming in their training to improve their lung volume (17) and increase respiratory muscle endurance (8). Finally, a progressive nostril breathing protocol is included at the end of every training session to decrease sympathetic activity and kick start the recovery process (13,26). The MMA athlete should also be encouraged to perform controlled nostril breathing during recovery intervals during training to maximize recovery (13). The fighter who can recover quicker between rounds will have an advantage.

VELOCITY-BASED TRAINING

To effectively apply VBT, several adaptations to resistance training (anaerobic training) should be considered. Of particular interest in VBT are neural adaptations expressed through training that emphasizes muscular speed and power to develop optimal neural recruitment, also known as neural drive (12). Neural drive is the sum of the stimulus sent to the motor neuron and the muscle fibers it innervates (10). Neural adaptations are critical for improving athletic performance because an increased neural drive augments the expression of muscular strength and power (12). An MMA athlete's ability to produce power is vital to success in the octagon (7). Improved neuromuscular function begins at the motor cortex, the area of the brain responsible for voluntary movement (9). Motor cortex activity is increased to produce maximal force or when new movements are being learned (9). This increase in motor cortex activity results in significant neural adaptations that promote greater force expression and recruitment of fast twitch (type II) motor units (21). In an untrained individual who lacks the neural adaptations of anaerobic training, only 71% of muscle fibers are activated during maximal effort (2). Furthermore, adaptations also occur at the motor unit level, particularly by increasing firing rates, allowing for greater ability to produce force because of the summation of overlapping action potentials (12).

The strength and conditioning coach should also be familiar with the size principle, which states that motor units are recruited in ascending order relative to their firing rates and respective thresholds for activation (19,24). As the force requirements increase, motor units are recruited from lower thresholds to higher thresholds (24). However, neuromotor adaptations allow advanced athletes to recruit motor units in a nonsequential order, recruiting larger motor units first, allowing for greater and more rapid expression of force (12). This phenomenon is known as selective recruitment and aids athletes with change of direction, acceleration, and deceleration, all of which are key components to elite athletic performance (19). In MMA, the ability to produce force rapidly increases the force by which the athlete can strike their opponent, inflicting greater damage, thereby improving chances of success (7).

In addition, anaerobic training has been shown to bring about morphological changes that improve capacity for neural transmission at the neuromuscular junction (12). Finally, the strength and conditioning coach should be familiar with the myotatic reflex, a stretch reflex response generated by the neuromuscular system that increases the scale and rate of force production without supplementary energy requirements (12). This reflex is a direct result of anaerobic training and takes advantage of the elastic components of muscle and connective tissue (tendons) and enhances athletic performance (1).

APPLICATION OF VELOCITY-BASED TRAINING

There are several methods by which the strength and conditioning professional can implement VBT. First, it is important to understand that there is nearly a perfect linear relationship between velocity and intensity (load) (30) as seen in Figure 1. As the external load increases, lifting velocity decreases. However, variables, such as sex, lifting technique, type of exercise, and measurement device, influence the velocity at a given load (30). Previous research has identified minimum velocity thresholds (velocity at 100% 1RM) and load-velocity relationships of the back and front squat (SQ) (27), barbell deadlift (5), and barbell bench press (11). Because of the near-perfect linear relationship, applying a trendline, and using the slope intercept formula, the specific movement velocity can be identified at a respective external load. However, it is recommended that individual load velocity profiles be created using the 5-point method (30). This is done by measuring the mean velocity at 20, 40, 60, 80, and 90% of an athlete's 1RM, plotting the mean velocity against relative load and then applying a trendline (30). This information allows the strength and conditioning professional to identify the target movement velocity at any given load.

Using bar velocity to assign relative load. With the understanding of the linear relationship between load and velocity, the strength and conditioning professional can assign a desired bar velocity based on its associated relative load as seen in the Table. This is known as the average set velocity method. The average mean velocity of the set must be within 0.06 $m \cdot s^{-1}$ of the prescribed velocity or the load will be adjusted accordingly. Sánchez-Medina et al. (25) identified the relationship between relative load (percent 1RM) and movement velocity in the barbell back SQ. Sánchez–Medina et al. (25) and similar findings allow the strength and conditioning professional to assign the athlete a movement velocity corresponding to a relative load associated with the desired physiological adaption. This method allows the strength and conditioning professional to adjust the load based on the athlete's neuromuscular readiness during that given session, preventing excess fatigue and ensuring that the prescribed load accurately represents the athlete's given effort and intent (25).

Appropriate velocity loss. One of the many advantages of VBT is the ability to analyze athlete fatigue to prevent overtraining. Therefore, it is crucial for the strength and conditioning professional to understand the appropriate velocity loss (VL) during a given set to prevent unnecessary fatigue and maximize the desired training adaptations. The set average velocity + VL thresholds method assigns a training load and movement velocity from the athlete's load velocity profile. The set is terminated when the movement velocity drops below the desired threshold (30).

A 2020 study by Rodríguez-Rosell et al. (22) investigated the effects of VL10% and VL30% during a given set on neuromuscular and hormonal response. Both the VL10% group and VL30% group followed an 8-week VBT program consisting of 2 training sessions per week using only a full SQ at 75–85% 1RM. The groups were tested in a 20-m sprint, countermovement jump (CMJ), 1RM SQ, muscular endurance, electromyography (during the SQ exercise), and resting hormonal concentrations pre and post intervention (22).

The VL30% group performed a significantly greater number of repetitions (228.0 ± 76.6) throughout the training intervention than the VL10% (109.6 ± 2.0) (22). In addition, while performing fewer repetitions, the VL10% group experienced greater improvements in CMJ (9.2%) and sprint performance time (−1.5%) compared with the VL30% group. The VL30% group had only a 5.4% improvement in CMJ and a slight decrease in sprint time (0.4%) (22). Hormonal comparison showed greater TnT (Troponin T–an indicator of chronic muscle damage) plasma levels in the VL30% group than in the VL10% group. Both groups showed similar improvements in muscular strength and fatigue (22). These results indicate that although the VL10% performed fewer repetitions, they experienced greater improvements in performance. These findings suggest that the strength and conditioning coach should use a velocity loss of 10% rather than 30% to elicit the greater training adaptations at lower fatigue levels (22). However, the training program may

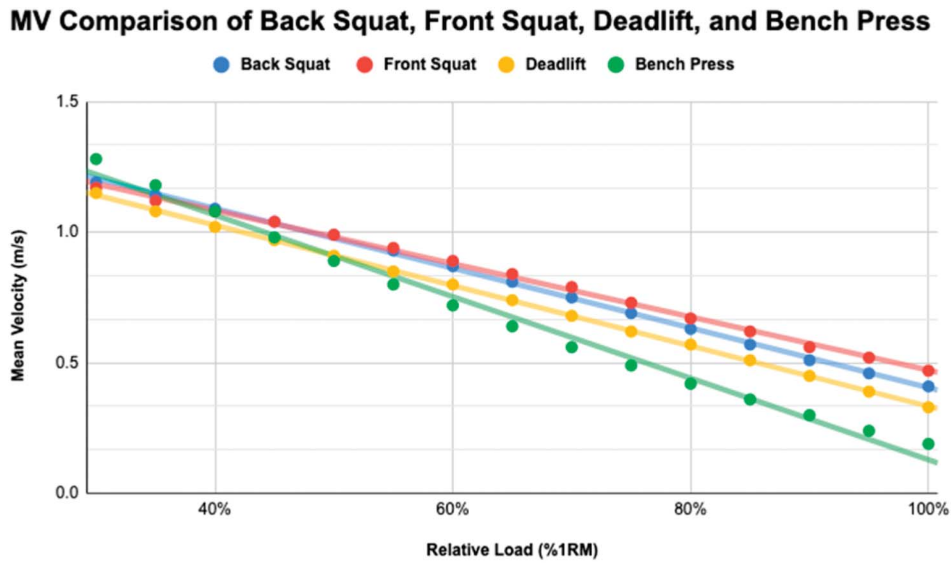


Figure 1. This is a representation of the linearity of the load-velocity relationship described. The mean velocity (MV) of the barbell back squat, front squat, deadlift, and bench press on the *y*-axis is plotted against the associated relative load (%1RM) on the *x*-axis. The data for this figure can be found in the Table. 1RM = 1 repetition maximum.

Table
General load-velocity relationship

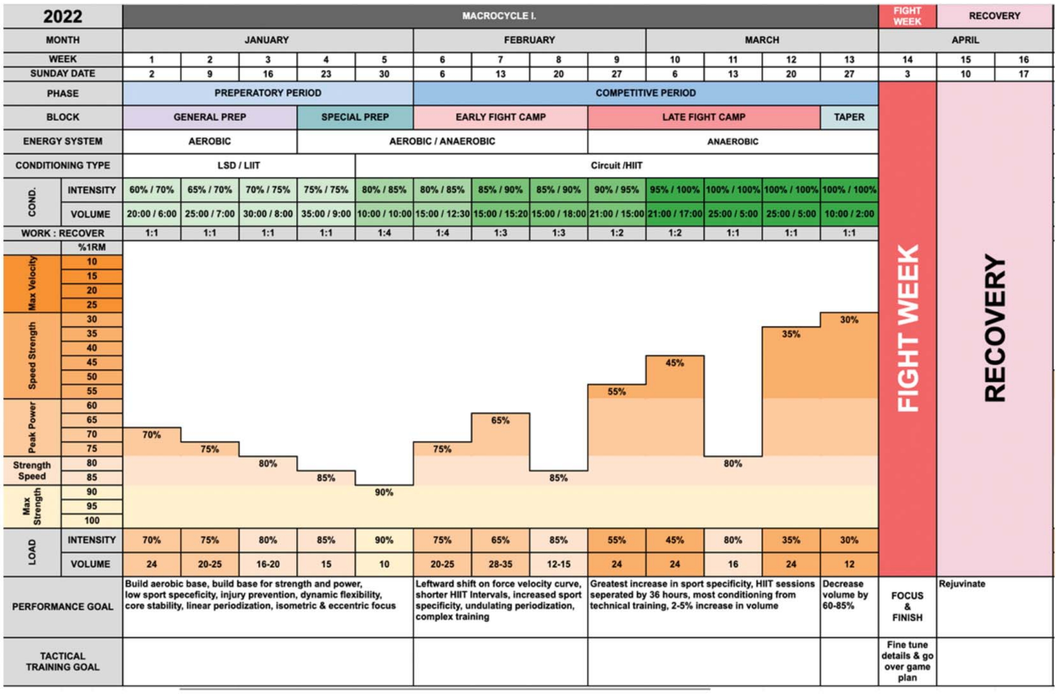
Relative load (%1RM)	Back squat velocity (m·s^{-1}) (27)	Front squat velocity (m·s^{-1}) (27)	Barbell deadlift velocity (m·s^{-1}) (5)	Barbell bench press velocity (11)
	$y = (-1.14 \times x) + 1.55$	$y = (-1.02 \times x) + 1.49$	$y = (-1.16 \times x) + 1.49$	$y = (-1.56 \times x) + 1.69$
100	0.41[a]	0.47[a]	0.33 ± 0.04	0.19 ± 0.04
95	0.47[a]	0.52[a]	0.39 ± 0.04	0.24 ± 0.05
90	0.51 ± 0.04	0.56 ± 0.03	0.45 ± 0.04	0.30 ± 0.06
85	0.58[a]	0.62[a]	0.51 ± 0.05	0.36 ± 0.07
80	0.64[a]	0.67[a]	0.57 ± 0.05	0.42 ± 0.08
75	0.70[a]	0.73[a]	0.62 ± 0.05	0.49 ± 0.09
70	0.75 ± 0.02	0.79 ± 0.02	0.68 ± 0.06	0.56 ± 0.10
65	0.81[a]	0.83[a]	0.74 ± 0.06	0.64 ± 0.11
60	0.87[a]	0.88[a]	0.80 ± 0.07	0.72 ± 0.11
55	0.92[a]	0.93[a]	0.85 ± 0.07	0.80 ± 0.12
50	0.99 ± 0.02	0.99 ± 0.02	0.91 ± 0.08	0.89 ± 0.12
45	1.04[a]	1.03[a]	0.97 ± 0.09	0.98 ± 0.13
40	1.09[a]	1.08[a]	1.02 ± 0.09	1.08 ± 0.13
35	1.15[a]	1.13[a]	1.08[a]	1.18 ± 0.13
30	1.19 ± 0.03	1.17 ± 0.02	1.14[a]	1.28 ± 0.13

The mean velocities (m·s^{-1}) at their respective relative loads (%1RM) for the barbell back squat, front squat, deadlift, and bench press are listed.

[a]Estimated by plotting the known values and then using a spreadsheet to apply a trend line and find the respective linear regression equation ($y = mx + b$) where y = velocity and x = relative load as a percent of the 1RM expressed as a decimal.

1RM = 1 repetition maximum.

A



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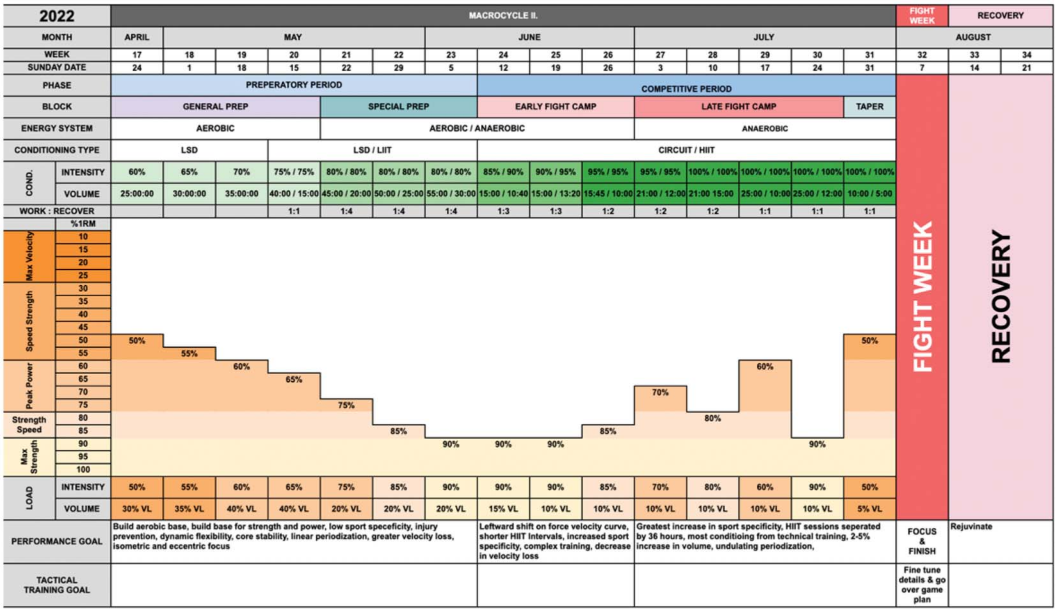

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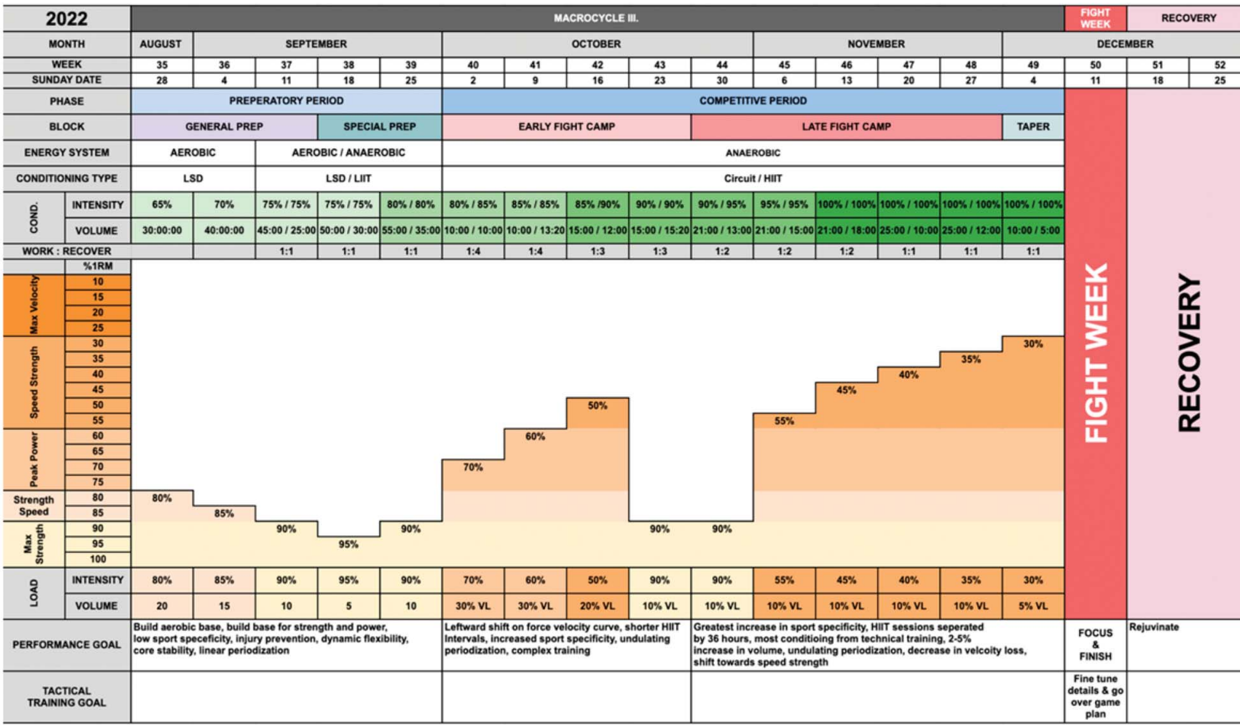

C

Figure 2. (A) The annual training calendar begins with a linear periodization model during the preparatory phase before switching to a triweekly undulating model. The preparatory phase serves to develop foundational strength before a leftward shift on the force velocity curve during the competitive period. Metabolic conditioning intensities linearly increase during the entire macrocycle implementing MMA-specific work-to-rest ratios (1:1–1:4). Macrocycle I uses the set average velocity method. (B) The preparatory period begins with moderate loads and allows for significant velocity loss (VL) to develop an aerobic base before moving to heavier loads with minimal VL. The late fight camp features an undulating periodization model maintaining lower volumes at heavier loads. Macrocycle II serves as the primary strength block of the year and uses the set average velocity + VL thresholds method. (C) The preparatory period begins a strength emphasis using the set average velocity method. The competitive period features a linear increase in velocity and adopts the average set velocity + velocity threshold method. Seven weeks out from the fight, there is a 2-week strength emphasis to maintain the strength adaptions before training at high velocities for the rest of the camp. The goal of macrocycle III is to elicit the highest performance peak at the end of the year by expressing newly realized strength adaptations at high velocities at the end of the year. MMA = mixed martial arts.

consider implementing greater velocity loss (up to 40%) in the early training phases to accumulate lactate to build resistance to fatigue. The later phases of training allow significantly less velocity loss to mitigate the accumulation of fatigue leading up to the fight.

CONCLUSIONS AND PRACTICAL APPLICATIONS

MMA is a complex, physiologically demanding sport. The noncyclical competitive season and conflicting metabolic demands of the sport create a programming challenge for the strength and conditioning professional. The existing literature on MMA periodization recommends a linearly periodized preparatory period emphasizing aerobic conditioning and higher volumes of resistance training. Once the MMA athlete moves into fight camp, there is a shift to an undulating periodization model with a greater emphasis on anaerobic conditioning, higher intensity, and lower-volume, sport-specific resistance training. With an understanding of VBT, the strength and conditioning professional can strategically manipulate fatigue and optimize force production throughout the yearly macrocycle. Greater velocity loss should be implemented during the preparatory period to support the aerobically orientated goals of this phase. During the competitive period, lower velocity loss should be prescribed to emphasize the anaerobic goals of the period and maximize force production while mitigating fatigue. Implementing VBT also allows the strength and conditioning professional to assess athlete readiness and assign training loads that correspond with the current state of the athlete's nervous system. Figure 2A–C present a comprehensive, theoretical annual MMA training program for enhancing the fight performance by developing high-capacity neuromuscular qualities and high aerobic and anaerobic capacities.

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