Christopher Myers
CJ French *Editors*

Strength and Conditioning for the Human Weapon System

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Chapter 1
The Human Weapon System

Christopher Myers and Kevin Malahy

Introduction

The previous book, *The Human Weapon System*, introduced a new definition that characterizes tactical, law enforcement, and first responder populations. The term human weapon system (HWS) challenges human performance (HP) professionals to not characterize these populations as athletes but as weapon systems [1].

The SC community, not unlike other communities, is segregated around commonly shared values and/or beliefs. Larger communities, such as SC for baseball vs. SC for swimming, can be stratified many times over into more minor subcommunities based on education and experience level, certifying body, area of focus, training methodology, etc. As members of these communities, our affiliations, ideologies, and identities are heavily influenced by what we value and believe in SC, which becomes evident in how and what we program for our clients.

Labeling the military population as athletes implies that their physical requirements, motivation, and previous exposure to physical training would parallel, or at least resemble, those of competitive sports athletes.

This fallacy is exposed immediately in the realization that physical performance regimes for sport are largely designed in such a way to create ideal conditions in the realms of physical training, diet, and sleep/recovery to maximize physical performance; programs for military personnel often rely on the designer's ingenuity to optimize these parameters knowing that creating ideal conditions is neither

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plausible nor sustainable. The complexity that comes from the variability of expectations differing between countries, branches of service, reg force and reserve, occupational trades, and even ranks within the same trade underscores the need for flexibility in program design, making it imperative that those entrusted in the development of said programs have an intimate understanding of the populations for whom which the program is designed.

What Is a Tactical Athlete?

Since the early 2000s, tactical and first responder professionals have been called "tactical athletes (TAs)." Schofield and Koundini define a TA as "someone who requires physical preparedness (CPP) on which the technical and tactical skills requisite for the sport of competition are developed" [6]. Generally, this statement means TAs must be capable of performing a wide range of activities that require strength, speed, agility, endurance, and flexibility. They also must be prepared to respond to physically demanding situations at a moment's notice, often under high-stress conditions. This concept and definition emerged from applying collegiate and professional sports human performance (HP) training models [7]. At its core, "TA" tries to use the base term "athlete" to a population that does not function as athletes.

An athlete is "a person who is *proficient* in sports and other forms of physical exercise." When discussing the traits of an athlete, a person usually envisions a professional or high-performance athlete (Table 1.1). This image occurs because professional athletes are at the peak of their physical and genetic performance. For this reason, the military and first responder professions began to apply professional and collegiate human performance models to improve physical performance. Therefore, first responders and warfighters began to be called "tactical athletes."

The term "athlete" is often considered a misnomer when applied to tactical, first responder, and law enforcement populations due to the inherent limitations of the word's definition. The term is too narrow if HP professionals use "athlete" to describe the competencies required during high-stress, physically demanding tasks—akin to moments of competition. "Athlete" fails to encompass these professionals' diverse and multifaceted roles. For example, a soldier who is also an engineer is expected to perform engineering tasks regardless of their deployment status or location. Similarly, a police officer remains an officer while completing hours of paperwork after a shift. These duties, which are crucial to their roles, extend beyond the physical and tactical skills typically associated with athletes.

On the other hand, defining "athlete" too broadly to include these professions undermines their work's unique significance and context. The physical demands faced by tactical law enforcement (LOE) and first responder personnel in critical situations are just a fraction of their responsibilities. The term "athlete" does not adequately capture the complexity or the gravity of the "games" they play—games that often involve life-and-death decisions, intricate technical knowledge, and prolonged periods of mental endurance. Thus, the term "athlete" falls short of capturing

Table 1.1 High-performance athlete occupational requirements or traits

High-performance athlete occupational requirements or traits
Win the competition
Season has scheduled "in-season" and "out of season" time periods
Rehabilitation is based on optimal recovery time
Cognitive ability in competition or stressful situations
Innovative
Adaptable
Proficient in designated sport specfic tasks and abilities
Exceeds minimum physical standards for sport
Works well with a team
High self-confidence
Unwaivering determination
High level of intrinsic motivation
Type A personality
Accepts criticism to be better
High levels of resiliency to manage setbacks
Ability to manage stress and anxiety while under pressure

Please note that this table is not an exhaustive list

the scope of their everyday duties and the critical nature of their high-stakes moments.

Athletic competitions exist in the realm of known-knowns. In known-known scenarios, the participants accurately predict the outcomes and the variables influencing them. Amidst athletic competition, many known/fixed variables include when and where the competition will occur, who their opposition will be, approximately how long the competition will last, the specific role they will play, and, most importantly, that the interaction will be officiated using an established set of rules including the ability to stop the event at any point to regroup, rest, review, or provide aid to a fellow player that has been injured even on a minor scale. Even weather conditions are managed as many indoor or outdoor sports can be delayed or postponed if required. The only apparent unknown quality of athletic competition is the sequence of strategies and tactics used by their opposition to increase their probability of success. A lack of preparation considering the abovementioned variables may result in defeat or disqualification, but rarely a threat to the loss of life or limb of the athlete, other athletes, or even those in attendance.

In contrast, tactical populations "competition" functions in the realm of unknown-unknowns. In unknown-unknown scenarios, the participants cannot predict the outcomes nor have sufficient evidence to predict the influencing variables. In many instances, tactical professionals do not have foresight as to when and where they will be needed, whether they will face opposition, the event duration, whether they will be expected to take on additional roles, act alone or in tandem, etc. Most importantly, will the opposition "play" by similar standard operating procedures, rules of engagement, or law of war? There are no blood time-outs or structured time to rest, regroup, or review the tape, and even if injured, you may still be in the fight. Furthermore, ill-preparedness *may result in loss of life or limb* for the professional, their teammates, those with whom they interact, or other people in proximity.

Labeling the tactical, LOE, and first responder populations as athletes implies that the physical requirements, motivation, and previous exposure to physical training would be parallel, or at a minimum resemble, that of a competitive sports athlete. This fallacy is exposed immediately in the realization that physical performance regimes for sports are primarily designed in such a way to create ideal conditions in the realms of physical training, diet, and sleep/recovery to maximize physical performance; programs for military personnel often rely on the designer's ingenuity to optimize these parameters knowing that creating ideal conditions is neither plausible nor sustainable. The complexity that comes from the variability of expectations differing between countries, branches of service, regular and reserve forces, occupational trades, and even ranks within the same trade makes it imperative that those entrusted in the development of said programs have an intimate understanding of the populations for whom which the program is designed.

At the time, the application of athletic performance principles was good; however, HP programs have evolved to encompass a focus on more aspects of well-being (i.e., True North and POTFF programs) and access to medical care (i.e., Integrated Occupational Specialty (IOS) teams). Even though these human performance programs are becoming more holistic, many are still viewed through the prism of the tactical athlete lens. This view limits the ability of these HP programs to fully assist the tactical, police, and first responder populations.

As will be discussed throughout this book, human performance and human performance optimization for the first responder and tactical populations are very different from that of athletes. Due to these differences, the term TA must be updated to fully define the key characteristics and traits of the tactical, police, and first responder professions.

What Is the Human Weapon System (HWS)?

Sports and tactical populations are fundamentally different. Most training certifications and materials for tactical and first responders emphasize strength and conditioning, adopting training theories and practices designed for athletes. In 2005, the National Strength and Conditioning Association (NSCA) introduced the Tactical

Strength and Conditioning Facilitator (TSAC-F) certification, setting a standard for training tactical groups. Governed by the textbook *NSCA's Essentials in Tactical Strength and Conditioning*, the TSAC-F program aims to provide a standardized credential to ensure professional competence in executing scientific training TAs [2]. However, this term predominantly focuses on physical attributes, overlooking other critical aspects of human performance. Recognizing this limitation, the concept of the human weapon system was introduced to encompass the multifaceted nature of these populations.

The human weapon system (HWS) integrates various elements to comprehensively define tactical, first responder, and law enforcement personnel. This term comprises three key components: the human, the weapon, and the system. Acknowledging individuals as complex organisms underscores the need for a holistic approach beyond mere athleticism [1]. Redefining "weapon" broadens its scope beyond destruction to encompass constructive, destructive, and healing capabilities [1]. Lastly, viewing the human being as a system of subsystems emphasizes the interconnectedness of physiological, cognitive, and emotional systems [1]. Putting these elements together, the HWS is defined as:

> A human being comprised of a complex set of physiological, cognitive, and emotional systems that create a cohesively functioning tool of which is professionally trained, maintained, and optimized; capable of learning and adapting; and using various equipment and knowledge for constructive, destructive, and healing purposes, always bounded by societal moral, ethical, and legal standards [1].

So, what does this mean? Whether tactical or athletic, most HP/HPO programs have domains specific to athletic performance. These domains typically are performance, recovery, nutrition, sleep, and cognitive or some version of these domains. The domains meet the performance needs of athletes but not the holistic needs of HWS populations.

The Differences Between HWS and TA

Highlighting the nuanced disparities between athletes and the human weapon system is crucial for designing tailored HPO programs. These differences encompass cognitive agility, adaptability, resilience, decision-making under pressure, and exposure to physical and psychological stressors unique to tactical environments. While athletes focus on competition-driven decisions, human weapon systems navigate life-and-death scenarios with moral and ethical implications. However, athletes and HWS professionals have similar occupational and character traits (Table 1.2).

Athletes and tactical professionals, such as military personnel or law enforcement officers, share core traits essential for their respective fields, all pivoting around innovation, adaptability, physical conditioning, high levels of motivation, and cognitive prowess (Table 1.2). Innovation is crucial for both groups, allowing athletes to continuously refine their techniques and tactical professionals to develop

Table 1.2 Shared human weapon system (HWS) and high-performing athlete occupation requirements or traits [1]

Shared HWS & TA occupational requirments or character traits
Cognitive agility in austere environments and adverse conditions
Innovative
Adaptable
Proficient in multiple "sport specific" tasks and abilities
Exceed minimum physical standards
Self-reliant
Works well with a team
High self-confidence
Unwaivering determination
High level of intrinsic motivation
Type A personality
Accepts criticism to be better

new strategies to handle complex situations. Adaptability plays an essential role, as athletes often adjust their approach based on their opponent's tactics and game conditions, like how tactical professionals must quickly adapt to dynamic environments, unforeseen challenges, and limited resources. High levels of physical conditioning are universally requisite in both careers; athletes must maintain peak physical shape to perform at their best, paralleling tactical professionals who require endurance and strength to carry out physically demanding tasks under stress and in unforgiving environments. Cognitive focus is another parallel, with athletes needing to maintain concentration during critical moments in competition, mirroring tactical professionals who must keep a sharp focus during operations to make precise decisions. Cognitive flexibility enhances this focus, enabling athletes and tactical professionals to switch tactics and strategies efficiently when faced with new information or evolving scenarios. This mental agility supports innovation and adaptability, fostering a cycle of continuous improvement and situational responsiveness. For instance, an athlete might innovate a new, untested strategy that becomes crucial in a championship game, just as a tactical officer might devise an unconventional plan that neutralizes a threat during a critical point in the mission. Both sets of professionals also share the need for ongoing training and learning, which maintains their physical capabilities and sharpens their cognitive faculties, ensuring they can respond to high-pressure situations with a blend of instinct, strategy, and adaptability. Therefore, the intersection of these traits not only defines their professional effectiveness but also underscores the parallels between sports and tactical vocations, highlighting how each domain can inform and enrich the practices of the other.

Even though athletes and HWS have similar occupational and character traits that span multiple HP domains, HWS professionals' fundamental mission creates trait differences. Tactical, LOE, and first responder professionals often find themselves in life-or-death situations and must develop specific character and occupational traits to survive and thrive [1]. Some of the most essential HWS occupational and character traits not seen in athletes are as follows:

1. High-stress tolerance is the ability to remain calm and effective under extreme pressure. HWS professionals often face life-threatening situations that require clarity and precision [3–5].
2. Situational awareness: HWS must constantly be aware of their surroundings and swiftly assess environmental and situational factors. This enables them to make informed decisions rapidly [6–8].
3. Adaptability and flexibility: The ability to adjust strategies and approaches to ever-adapting asymmetrical environments. Conditions can change rapidly, and HWS professionals must be able to pivot and adapt without hesitation [9–11].
4. Discipline and specialized professional competencies: Rigorous adherence to rules, protocols, and a code of conduct. Discipline is essential for maintaining order and ensuring operations are carried out effectively and safely. Specialized professional competencies are vital for tactical populations, including military and emergency response teams, enabling them to handle high-stress scenarios with advanced skills and strategic decision-making. Continuous training and development in physical, cognitive, and technological areas are crucial to maintaining operational effectiveness and safety [12].
5. Decision-making skills: Proficiency in making decisions, often quickly and under pressure, with significant consequences. This also includes effectively balancing risk and tactical advantage [13–16].
6. Leadership and teamwork: Strong leadership skills to guide teams through challenging situations, along with the ability to work effectively as part of a team. Cohesion and mutual support are vital [17–21].
7. Communication skills: Clear and effective communication is crucial within teams and while interfacing with the public or other agencies. This includes verbal and nonverbal communication, as well as the use of specialized communication equipment [16, 19, 20, 22].
8. Technical proficiency: Depending on the specific role, this may include expertise in handling advanced weaponry, surveillance technology, emergency medical procedures, or other specialized equipment [19–21, 23, 24].
9. Problem-solving skills: Ability to approach complex scenarios and quickly devise effective solutions. HWS professionals often deal with unpredictable scenarios that require innovative problem-solving [19–21].
10. Mental resilience: Maintaining mental strength in adversity, trauma, and prolonged stress. This trait is essential for coping with the emotional and psychological demands of the job [25–28].
11. Attention to detail: Precision and attention to detail can be crucial, especially in complex logistics, multifaceted socioeconomic environments, or tactical operations [18, 20, 21].

These trait differences are what differentiate tactical populations from athletes.

Viewing Holistic Human Performance Through the HWS Lens

Redefining tactical, first responder, and LOE populations as a human weapon system enables HP and medical practitioners to view this population through a new lens encompassing specific occupational and character traits. Furthermore, by classifying these populations as a "weapon system," a new, more encompassing holistic approach to human performance is possible than what is typically seen in four or five athletic performance models [1].

When new equipment or weapon systems are fielded, they are part of a program of record (POR). A POR is an officially sanctioned and established government program in defense acquisition and government contracting [2]. These PORs have dedicated funding [29]. In the context of defense acquisition, the funding and POR encompass several vital elements that formalize and structure its implementation and oversight [29]. Some of the domains are as follows:

1. Authorization and funding
2. Requirements definition
3. Acquisition strategy
4. Management structure
5. Schedule and milestones
6. Performance metrics
7. Risk management
8. Reporting and accountability
9. Lifecycle management

Why is this important? The most essential weapon systems are those used by tactical personnel, first responders, and law enforcement personnel.

Classifying tactical, first responder, and law enforcement populations as "weapon systems" provides a more holistic approach to human performance. However, the adage does not stop here. The HWS definition states that a *human* weapon system is "A human being comprised of a complex set of physiological, cognitive, and emotional systems [1]." The physiological, cognitive, and emotional systems are complex. The five-domain athlete model does not fully address these human systems; more is needed. The HWS lens allows for more domains to address this complexity. Some of the possible domains are as follows:

1. Education domain
2. Learning domain
3. Spiritual domain
4. Doctrine and policy domain
5. Medical domain
6. Psychological domain

A human performance program becomes more holistic by combining the athlete HP model, POR elements, and human systems under the HWS definition (Fig. 1.1).

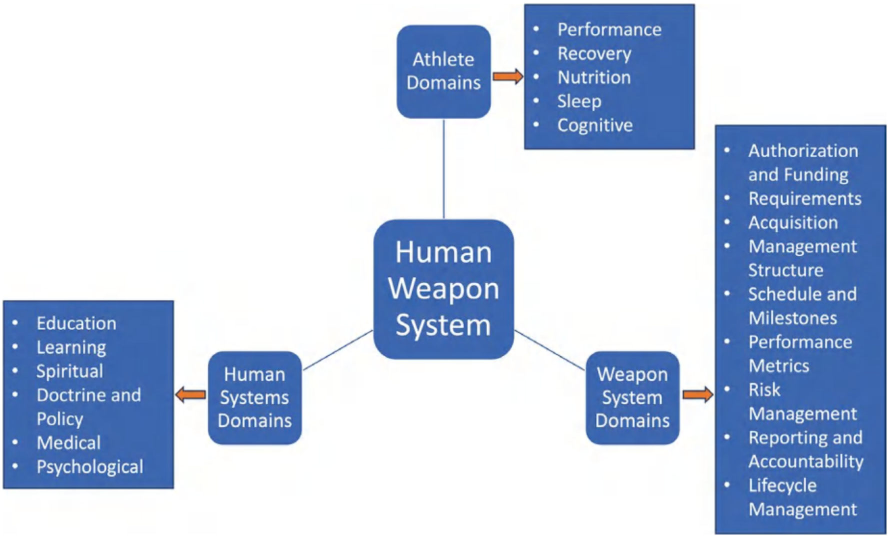

Fig. 1.1 The human performance (HP) domains of the human weapon system (HWS). The HWS domains consist of domains from the athlete HP model, weapon system POR, and human systems [1]

Conclusion

The TA paradigm was the initial concept to create human performance models for tactical, LOE, and first responder populations. However, this term limits the description of its target populations. Athletes focus on competitions with finite and predictable variables. HWS professionals face more stress, unpredictable situations, and specialized competencies, just to name a few. Updating the HP paradigm to the HWS paradigm includes more holistic domains and themes than just the performance domains seen under the TA paradigm.

The HWS paradigm is a new HP concept. From its first conception in the book *The Human Weapon System*, the identified domains have expanded. The goal is to continue to challenge the knowledge base to improve HP for the HWS populations.

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Chapter 2
Physiology of the Human Weapon System

Brian K. Leary

Basics of Bioenergetics

The human weapon system (HWS) requires energy to sustain essential physiological functions, which come from converting food into chemical energy. Energy is created through metabolism, the sum of all chemical reactions that break down food to obtain chemical energy (catabolism) and take the energy produced from catabolism to form larger molecules (anabolism). Catabolic reactions are essential during exercise as they generate the energy needed to support muscle activity. Food molecules (carbohydrates, fats, and proteins) can all be used as a fuel source to create the body's chemical energy adenosine triphosphate (ATP). This chapter will discuss how the human weapon system needs a continuous supply of ATP and how various bioenergetic pathways are used to break down and generate ATP.

Adenosine Triphosphate (ATP)

The energy currency within cells is adenosine triphosphate and can be used immediately to power molecular mechanisms that support cell, tissue, and organ functions. Potential energy from food is conserved within the phosphate bonds of ATP, and breaking these bonds generates the energy needed to power molecular mechanisms. Structurally, ATP comprises an adenine + ribose backbone with three phosphate groups (Fig. 2.1).

The three phosphate groups are linked by a chemical bond, with the link between the second and third phosphate groups considered a "high-energy bond," which is

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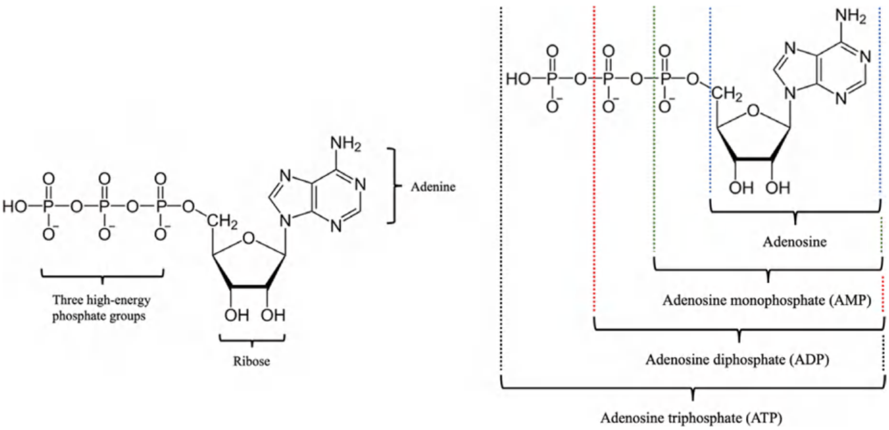
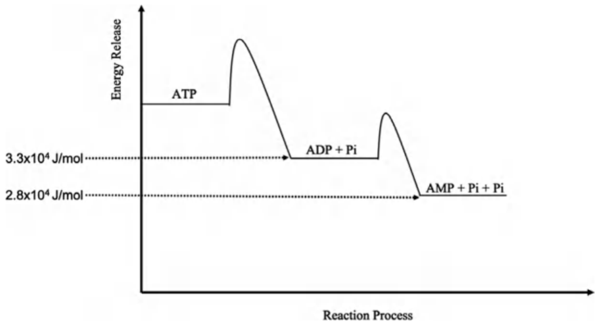


Fig. 2.1 The structure of ATP. This figure depicts the chemical structure of ATP. (**b**) This figure represents the different chemical structures of the ATP molecule as the inorganic phosphates are hydrolyzed

Fig. 2.2 ATP energy levels. This figure depicts the decrease in energy released with each inorganic phosphate hydrolyzed from the ATP molecule



the most significant energy source within a cell. Removal of phosphate results in energy release and the remaining compound adenosine diphosphate (ADP) + an inorganic phosphate (Pi) (Fig. 2.2).

There is limited storage potential for ATP; the body continuously resynthesizes ATP to overcome this. The resynthesis of ATP from ADP occurs through phosphorylation, whereby ADP gains back 1-phosphate, which requires energy. There are three primary mechanisms by which ADP can resynthesize ATP:

1. Interaction of ADP with creatine phosphate (CP)
2. “Anaerobic” respiration within the cell cytoplasm
3. “Aerobic” respiration within the cell mitochondria (Fig. 2.3)

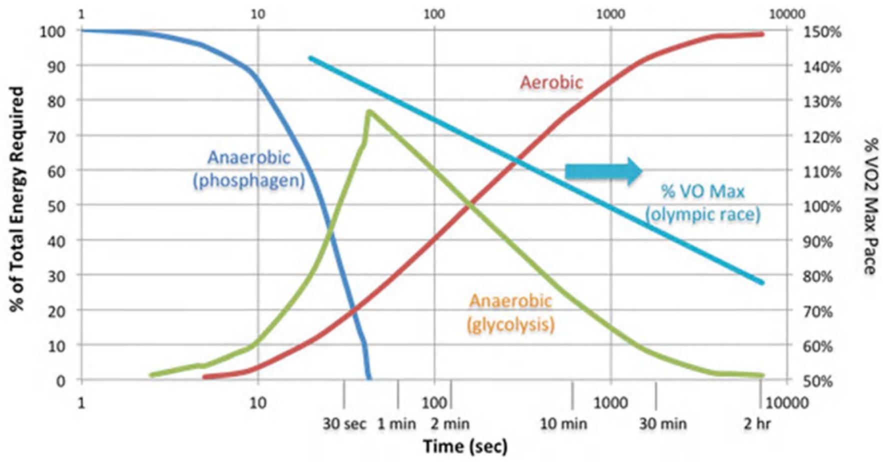


Fig. 2.3 Timing of energy production pathways. The variables of exercise intensity and duration determine the energy production pathway. These variables are inverses of each other. The higher the intensity, the shorter the duration. This figure depicts the periods when an energy system is the primary pathway to produce ATP. At the 2 min mark during steady-state exercise, the oxidative phosphorylation (aerobic) system is the primary pathway for ATP production. (This figure is used with permission)

$$\text{PCr} + \text{ADP} \xrightarrow{\text{Creatine Kinase}} \text{ATP} + \text{Cr}$$

Fig. 2.4 The chemical reaction of phosphocreatine and ADP to ATP

ATP-Phosphocreatine (ATP-PCr) System (Immediate Energy)

Phosphocreatine (PCr), sometimes called creatine phosphate (CP), is a high-energy phosphate compound that serves as a reservoir for high-energy phosphate bonds. Creatine kinase facilitates the transfer of a phosphate group from PCr to ADP, thus forming ATP and creatine. ATP-PCr system allows for the resynthesis of ATP from ADP during high-intensity short-duration activities (~ < 10 s), which coincides with the time of maximal ATP yield. Therefore, this system is used extensively in the human weapon system during activities (sprinting, jumping, weightlifting, etc.). For continual ATP resynthesis for activities that extend past ~10 s, other mechanisms (catabolism of stored macronutrients) are necessary (Fig. 2.4).

Glycolytic System (Energy Released from Carbohydrates)

The breakdown of glucose molecules (i.e., carbohydrates) into pyruvate, which generates ATP and NADH, is called glycolysis. Glycolysis serves as a primary source of ATP during short-duration, high-intensity, and longer-duration moderate-intensity exercise. Two forms of glycolysis (fast and slow) differ in end-product (i.e., lactate or pyruvate). Fast glycolysis (i.e., anaerobic respiration) is favored during short bursts of maximal efforts, lasting up to ~30 s (e.g., breaching, rapid tactical maneuvers, and close-quarter combat scenarios). Slow glycolysis (i.e., oxidative phosphorylation and aerobic respiration) is prominent during low- to moderate-intensity exercises lasting several minutes to hours (e.g., rucking and military patrol) in situations where sustained energy production is essential to mission success.

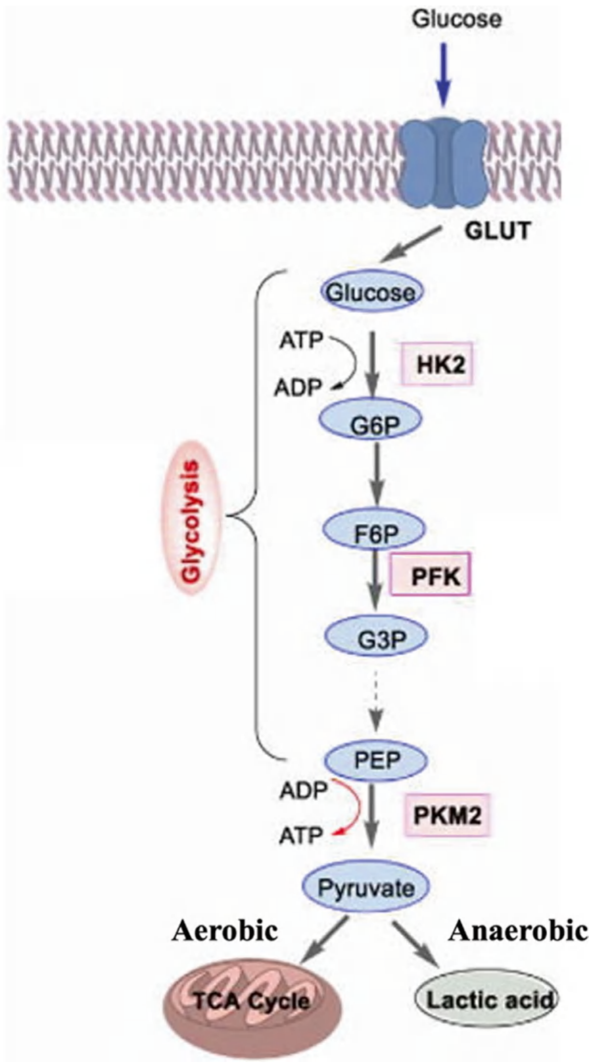
Fast glycolysis takes place in the cell's cytosol and uses the energy contained in glucose to form ATP. Initially, a series of enzymes breaks down glucose, and the body gains two ATP for muscular contraction, two molecules of pyruvate, and NADH. If the rate of glycolysis exceeds the mitochondria's oxidative capacity for pyruvate (see TCA cycle below), the excess pyruvate will be reduced to lactate by NADH and lactate dehydrogenase. During slow glycolysis, the NADH and pyruvate are shuttled to the mitochondria, which are drivers of mitochondrial respiration (see TCA cycle below). The net production of lactate or pyruvate depends on the glycolysis rate and the mitochondria's oxidative capacity. In situations where the rate of glycolysis is high, fast glycolysis will be preferred as it generates ATP more rapidly; however, when the rate of glycolysis is lower, slow glycolysis is preferred as it generates more total ATP (Fig. 2.5).

Tricarboxylic Acid (TCA) Cycle

The pyruvate produced from glycolysis substitutes for further energy extraction within the mitochondria. Pyruvate enters the mitochondria and is converted into energy-rich molecules through the tricarboxylic acid (TCA) cycle (also sometimes referred to as the Krebs cycle), the central metabolic pathway inside the mitochondria. Once entering the mitochondria, pyruvate is converted to acetyl CoA, which is the starting compound of the TCA cycle. Therefore, the primary function of the TCA cycle is to break down acetyl-CoA into intermediary products that generate high-energy molecules and facilitate electron transport.

The TCA cycle is initiated when acetyl-CoA combines with oxaloacetate to form citrate. From there, citrate undergoes a series of transformations, resulting in the generation of nine additional intermediates, the final of which is oxaloacetate regeneration, which allows the TCA cycle to restart again. Each time through the TCA cycle, only one ATP molecule is generated; however, hydrogen atoms are freed from intermediates. The freed hydrogen ions can then combine with NAD^+ and FAD to form NADH and $FADH_2$, respectively. NADH and $FADH_2$ (and the freed hydrogen ions) are shuttled to the inner mitochondrial membrane, where they enter the electron transport chain.

Fig. 2.5 ATP production via anaerobic and aerobic pathways



Electron Transport Chain (ETC)

The hydrogen ions freed during the TCA cycle serve as electron donors to progressively more electronegative acceptors within the inner mitochondria membrane. Oxygen, the final and most electronegative acceptor, binds with hydrogen to produce water. Electron transport creates an electrochemical gradient between the inner and outer mitochondria membranes, serving a pool of stored potential energy. The energy necessary for ATP synthesis is generated by the electrochemical gradient of the ETC. ATP synthase within the inner mitochondrial membrane harnesses this energy to flow hydrogen ions back across the membrane, driving its components' rotation. In turn, this rotation converts ADP and inorganic phosphate into ATP.

Energy Released from Fat

Stored fat cells serve as a large reservoir pool of potential energy for human cells. Most of this fat is stored as triacylglycerols in fat cells (adipocytes). Fats serve as a significant fuel source during rest and low-intensity activities. To use fat as a fuel source, triacylglycerols must be broken by an enzyme hormone-sensitive lipase into glycerol and fatty acids. Once broken down, fatty acids and glycerol enter the bloodstream, where they can travel to the mitochondria. Glycerol is converted to pyruvate through the glycolytic pathway; from there, pyruvate can go through the TCA cycle for energy production. During low glycogen availability, glycerol can resynthesize glucose (Cori cycle), providing an alternative substrate for energy production. Fatty acids entering the skeletal muscle are transported into the mitochondria via the carnitine shuttle. Once in the mitochondria, fatty acids go through beta-oxidation, converted into acetyl-CoA molecules, and subsequently used within the TCA cycle.

Basics of Neuromuscular Physiology

The HWS consistently engages in purposeful human movement supported by skeletal muscle and motor unit recruitment. This section reviews the properties of skeletal muscle fibers and how skeletal muscle functions in coordination with the nervous system for muscle contraction. The human nervous system comprises two major components: the central nervous system and the peripheral nervous system (PNS).

Central Nervous System

The central nervous system consists of two primary components: the brain and the spinal cord. Within the spinal cord, the core primarily comprises gray matter from which limbs extend outward. These limbs include ventral (anterior) and dorsal (posterior) horns, which are made up of three types of nerves: interneurons, sensory neurons, and motoneurons (motor neurons). Motor neurons, categorized as efferent neurons, carry impulses outward from the brain and spinal cord to supply skeletal muscle fibers. On the other hand, sensory or afferent neurons enter the spinal cord via the dorsal root, transmitting sensory information from peripheral receptors to the brain. This intricate network within the spinal cord plays a crucial role in sensory perception and motor function, serving as a vital conduit for communication between the brain and the rest of the body.

Peripheral Nervous System

The peripheral nervous system is comprised of both spinal and cranial nerves. The PNS includes afferent nerves that provide sensory information from muscles, joints, and bones to the brain. Additionally, efferent nerves transmit information away from the brain and spinal cord to the muscles. The somatic and autonomic nervous system comprises *efferent* nerves (Fig. 2.6). The somatic nervous system innervates skeletal muscle and excites muscle activation. The autonomic nervous system can either excite or inhibit muscle activation. The autonomic nervous system maintains internal consistency and is divided into the sympathetic and parasympathetic nervous systems.

Sympathetic Nervous System

The sympathetic nervous system regulates various bodily functions, supplying critical organs and tissues such as the heart, smooth muscle, sweat glands, and viscera. Upon activation, it releases norepinephrine, initiating a cascade of physiological responses. This system is mainly involved in the fight-or-flight response (Fig. 2.6), triggering excitation throughout the body. As a result, there is a widespread increase in physiological arousal, including elevated heart rate, increased breathing rate, and

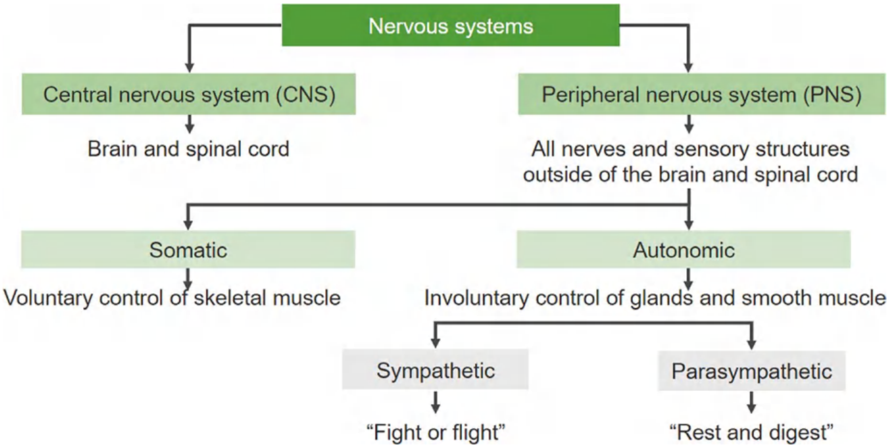


Fig. 2.6 Human nervous system hierarchy

enhanced blood flow to prepare the body for physical activity. These orchestrated responses ensure the body is primed for action during stress or danger, facilitating adaptive responses to challenging situations.

Parasympathetic Nervous System

Cholinergic fibers play a significant role in the parasympathetic nervous system, releasing acetylcholine neurotransmitters. In contrast to the sympathetic nervous system, which triggers the body's fight-or-flight response, the parasympathetic system promotes rest and digestion (Fig. 2.6). Activation of the parasympathetic nervous system, mainly through vagus nerve stimulation, decreases heart rate. Notably, the body receives input from both the sympathetic and parasympathetic systems, similar to a dimmer switch adjusting the activity level based on the body's needs. This modulation allows for a fine-tuned response to various stimuli and demands, ensuring that physiological processes are appropriately regulated. Unlike a simple on-off switch, this system operates on a continuum, dynamically adjusting the balance between sympathetic and parasympathetic activity to maintain homeostasis.

Motor Unit Anatomy

A motor unit describes the skeletal muscle fibers (covered later in the chapter) and the motoneurons innervating them. The whole muscle contains many motor units, each containing a single motoneuron and its corresponding muscle fibers. A motoneuron includes the cell body, axon, and dendrites. The motoneuron's design allows electrochemical signal transmission from the spinal cord to the muscle. The cell body is housed within the spinal cord and is the control center. The axon extends from the spinal cord and transmits signals to the muscle fibers. Dendrites are short neural branches that receive impulses and conduct them toward the cell body. Nerve cells only conduct impulses in one direction (from the stimulation point down the axon). Close to the muscle, the axon will split into branches, with each terminal branch innervating a single muscle fiber. Therefore, a whole muscle fiber will contain numerous motor units, each with a single motoneuron and its associated muscle fibers.

Neuromuscular Junction (NMJ)

The site where the motoneuron and muscle fiber meet is called the neuromuscular junction (NMJ) (Fig. 2.7). Each fiber is innervated by a motoneuron at the NMJ. The NMJ is responsible for the excitation of the muscle fibers (see excitation-contraction coupling later in the chapter). An action potential will travel along the axon until reaching the NMJ; from there, acetylcholine (ACh), a neurotransmitter, will be

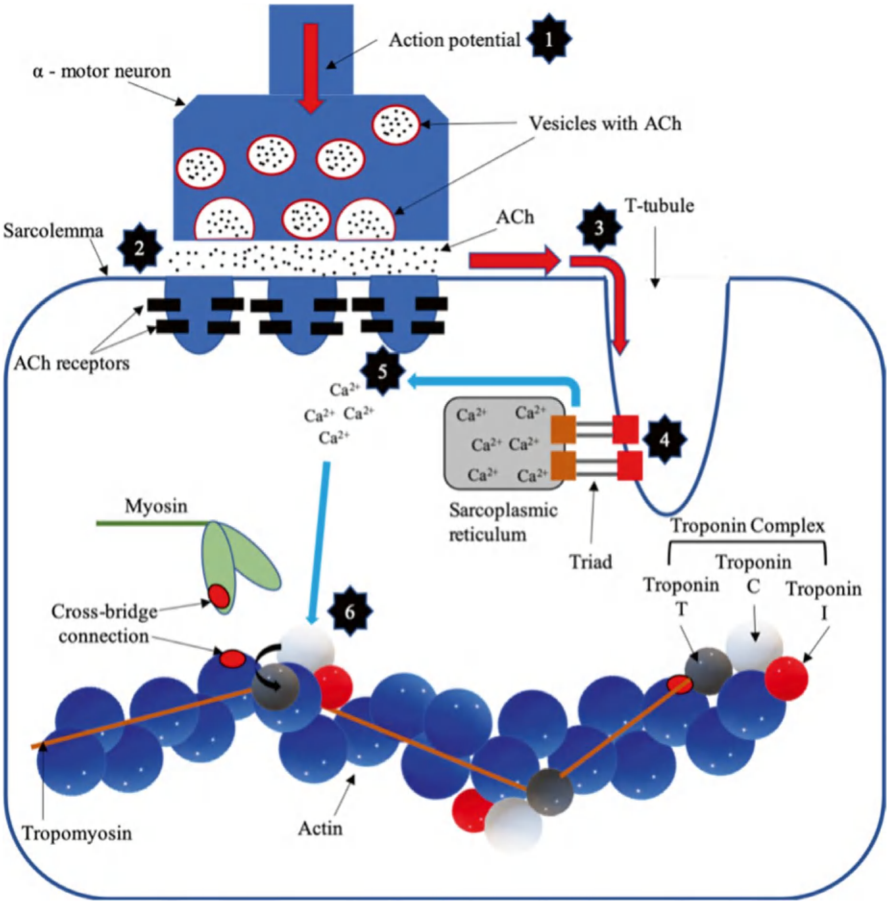


Fig. 2.7 The neuromuscular junction and excitation coupling of human skeletal muscle. This figure depicts the E-C theory in six steps

1. An action potential (AP) reaches an α-motor neuron and travels down its axon

2. The AP triggers Ca^{2+} channels in the axon to open, releasing acetylcholine (ACh) into the synaptic cleft

3. ACh binds to receptors on the motor endplate, opening cation channels and triggering an AP on the muscle fiber membrane

4. The AP propagates through the muscle fiber's transverse tubules (T-tubules), causing depolarization

5. Depolarization activates the triad, releasing Ca^{2+} from the sarcoplasmic reticulum into the cytosol

6. Ca^{2+} binds to troponin C, causing a conformational change that moves tropomyosin and exposes myosin-binding sites on actin, allowing muscle contraction

released from the NMJ. ACh will diffuse from the NMJ into the synaptic cleft (space between NMJ and a motor-end plate of sarcolemma). Once ACh binds to the motor-end plate, the sarcolemma membrane will depolarize, and a wave of depolarization will travel across the surface of the sarcolemma of the muscle fibers. Following depolarization, the membrane will repolarize. ACh in the synaptic cleft is degraded by acetylcholinesterase (AChE), preventing ACh from binding to a receptor and resulting in muscle relaxation.

Motor Unit Characteristics

Motor units are classified based on their physiological and mechanical properties, which include twitch characteristics, tension characteristics, and fatigability. Each motor unit innervates one specific muscle fiber type (type I or II; see "Functional Anatomy of Skeletal Muscle"). There are three primary types of motor units:

1. Slow-twitch, low-force, and fatigue-resistant (type I)
2. Fast-twitch, high force, and fast fatigue (type IIx)
3. Fast-twitch, high-force, and fatigue-resistant (type IIa)

Type 1 slow-twitch motor units have lower peak twitch force and a longer time to peak force to a single electrical stimulus; however, type II fast-twitch motor units generate more significant peak twitch force in shorter time frames. The slower contracting units (slow-twitch) have better fatigue resistance than fast-twitch units. Fast-twitch units are divided based on their fatigue resistance, with type IIa having better fatigue resistance than type IIx. However, fast-twitch fibers can become fatigue-resistant as slow-twitch fibers with sufficient aerobic endurance training.

Functional Anatomy of Skeletal Muscle

Hierarchical Organization

A hierarchical approach is used to examine skeletal muscle structure. Epimysium encloses the skeletal muscle, which provides a protective sheath and forms tendons at its distal and proximal ends (Fig. 2.8). Within this framework, muscle fascicles consist of muscle fibers surrounded by perimysium connective tissue. Each muscle fiber is a multinucleated cell encased in endomysium, separating it from neighboring fibers. The sarcolemma, a thin elastic membrane, encapsulates the contents of each fiber (Fig. 2.8). Within the fiber, the sarcoplasm contains essential enzymes, substrates, and organelles, including mitochondria. The sarcoplasmic reticulum, an interconnected network of tubules, facilitates muscle contraction by allowing depolarization through the T-tubule system, ensuring coordinated muscle function (Fig. 2.8).

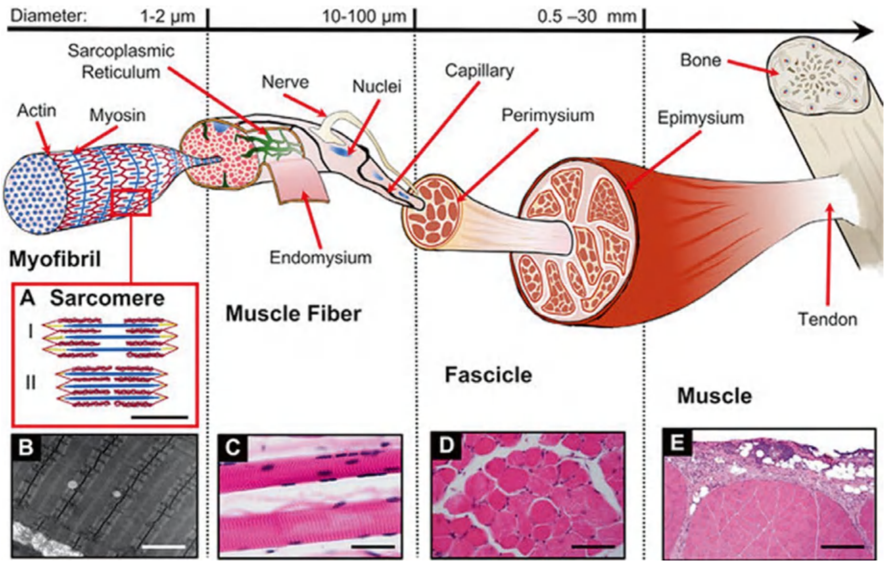


Fig. 2.8 The hierarchical structure and ultrastructure of skeletal muscle. (Used with permission [1])

Ultrastructure of Skeletal Muscle

Each muscle fiber comprises smaller functional units that align parallel to the fiber's long axis. These functional units, known as myofibrils, are approximately 1 micron in diameter and contain smaller subunits called myofilaments (Fig. 2.8). Myofilaments primarily consist of actin and myosin, the contractile filaments responsible for muscle contraction. They are arranged in an overlapping fashion, enabling filaments to slide, a concept known as the sliding-filament theory (Fig. 2.9). Within this arrangement, cross-bridges spiral around the myosin filament at regular intervals, allowing myosin heads to extend and latch onto actin (Fig. 2.9).

Additionally, regulatory proteins such as tropomyosin and troponin play crucial roles in managing the interaction between actin and myosin. Tropomyosin inhibits their interaction by preventing binding, while troponin is responsible for moving tropomyosin aside, revealing actin's active sites for muscle contraction. The sarcomere, the fundamental unit of muscle cells, is observable under a light microscope as alternating light and dark bands appear striated. It comprises actin and myosin overlap and is ultimately responsible for generating force and facilitating muscle contraction.

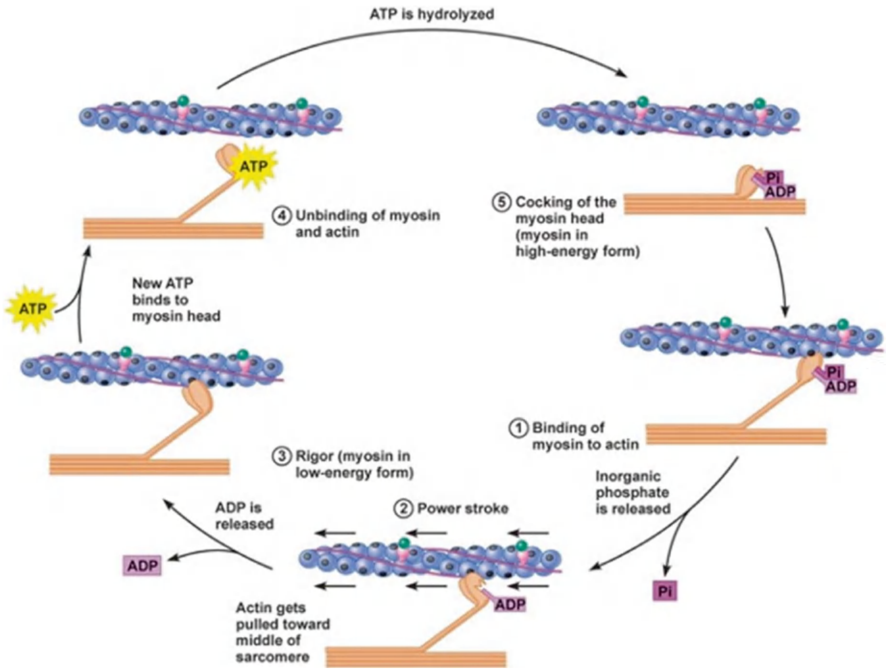


Fig. 2.9 Contraction cycle of human skeletal muscle. The steps of muscle contraction are as follows:
1. Cross-bridge formation: The myosin head, energized by ATP hydrolysis, attaches to an actin filament, forming a cross-bridge
2. Power stroke: The release of inorganic phosphate (Pi) from the myosin head triggers the power stroke. The myosin head pivots, pulling the actin filament toward the center of the sarcomere. This action releases ADP from the myosin head
3. Cross-bridge detachment: A new molecule of ATP binds to the myosin head, causing it to detach from the actin filament
4. Reactivation of myosin head: The myosin ATPase enzyme hydrolyzes the ATP, converting it into ADP and Pi. This hydrolysis reenergizes the myosin head, returning it to its original position, ready to form another cross-bridge
5. Repeat cycle: This cycle repeats as long as calcium ions and ATP are available in the cytosol, leading to muscle contraction

Basics of Muscle Contraction

In the resting state, myosin heads are in a low-energy position and bound to ATP with actin-binding sites covered by tropomyosin (Fig. 2.7). When a muscle is stimulated to contract, the calcium ions are released from the sarcoplasmic reticulum. The calcium released then binds to troponin, causing a conformational change, which causes tropomyosin to move away from actin-myosin binding sites. Therefore, the binding sites on actin are exposed, allowing the myosin head to bind to form cross-bridges.

The myosin head hydrolyzes the ATP once bound to actin, releasing energy that causes the myosin head to change its orientation, effectively pulling the actin filaments toward the center of the sarcomere (sliding-filament theory). This process continues so long as calcium ions are present and ATP is available. Once stimulation stops, calcium ions are actively pumped back into the sarcoplasmic reticulum, and tropomyosin returns to its original position and covers the actin-binding sites for myosin.

Excitation-Contraction Coupling

The initiation of calcium release is a vital step in the sliding-filament theory of muscle contraction (see above), and its release is initiated by neural impulses that stimulate a muscle fiber to contract (Figs. 2.7 and 2.9). Excitation-contraction coupling, therefore, refers to the process in which a nerve impulse is coupled with the contractile events that occur within the sarcomere. E-C coupling begins when an action potential (step 1 in Fig. 2.7), generated at the neuromuscular junction, travels along the sarcolemma (step 2 in Fig. 2.7), the muscle cell membrane, and into the T-tubules (step 3 in Fig. 2.7). This action potential triggers the opening of voltage-gated calcium channels in the sarcoplasmic reticulum (step 4 in Fig. 2.7). Calcium ions enter the cytoplasm from the sarcoplasmic reticulum, initiating the events leading to muscle contraction (steps 5–6 in Fig. 2.7).

The entire sequence of events of E-C coupling is as follows:

1. *Action potential*: This action potential occurs at the neuromuscular junction, where a motor neuron meets a muscle fiber. It travels along the sarcolemma and into the T-tubules (steps 1–3 in Fig. 2.7).
2. *Calcium release*: An action potential triggers the opening of voltage-gated calcium channels in the sarcoplasmic reticulum, and calcium ions enter the cytoplasm of the muscle fiber (steps 4–5 in Fig. 2.7).
3. *Troponin-tropomyosin complex*: Calcium ions bind to the protein complex troponin, which is bound to tropomyosin. This binding causes a conformational change in the troponin-tropomyosin complex, exposing active sites on the actin filaments (steps 5–6 in Fig. 2.7).
4. *Cross-bridge formation*: With the active sites exposed, myosin heads from the thick filaments can bind to actin, forming cross-bridges (step 1 in Fig. 2.9).
5. *Power stroke*: ATP is hydrolyzed, and the myosin heads undergo a conformational change, pulling the actin filaments toward the center of the sarcomere (step 2 in Fig. 2.9). This action causes muscular contraction.
6. *Relaxation*: When the action potential ceases, calcium pumps transport calcium ions back into the SR, reducing the cytoplasmic calcium concentration. Without calcium, the troponin-tropomyosin complex covers the active sites on actin, preventing further cross-bridge formation and allowing the muscle to relax (steps 3–4 in Fig. 2.9).

7. *Reset*: An ATP is hydrolyzed to the myosin head, preparing to repeat the cycle (step 5 in Fig. 2.9).

Muscle Fiber Type

Muscle fibers are not homogenous in terms of metabolic or contractile properties. Instead, their force production, metabolic pathway preference, and fatigue resistance vary. The human body has two primary types of fibers (fast-twitch (type II) and slow-twitch (type I)) and are classified based on:

1. Primary mechanisms in which they use and produce ATP
2. Type of motor neuron innervation
3. Type of myosin heavy chain isoform expressed

Fast-Twitch Type II Fibers

Fast-twitch muscle fibers can contract quickly and forcefully, making them well-suited for activities requiring high-power outputs (sprinting, lifting heavy weights, etc.). Although fast-twitch fibers can contract quickly and forcefully, they fatigue very rapidly and are limited in how long they can sustain high levels of muscle contraction (Table 2.1). However, these fibers can vary in their capacity for energy transfer from aerobic (high level of aerobic enzyme activity) and anaerobic (high level of anaerobic enzyme activity) sources (Table 2.1). Fast-oxidative-glycolytic (FOG) fibers are a subset of fast-twitch fibers with a developed capacity for aerobic and anaerobic sources (Table 2.1). Fast-glycolytic (FG) fibers possess the most significant anaerobic potential.

Table 2.1 General characteristics of fast-twitch type II fibers

Property	Description
Speed of contraction	Rapid
Force production	High force per unit of cross-sectional area
Metabolic pathways	Primarily anaerobic (glycolytic) metabolism
Mitochondrial density	Lower compared to type I fibers
Fatigue rate	Relatively quick due to reliance on anaerobic pathways
Myosin heavy chain isoforms	Express various isoforms such as MyHC IIa, IIx, and IIb
Size	Larger cross-sectional area and shorter length
Recruitment	Primarily during high-intensity, short-duration activities, or rapid force production tasks
Motor unit size	Often consist of fewer muscle fibers per motor neuron compared to type I fibers

Table 2.2 General characteristics of slow-twitch type I fibers

Property	Description
Speed of contraction	Slow
Force production	Lower force per unit of cross-sectional area
Metabolic pathways	Primarily aerobic (oxidative) metabolism
Mitochondrial density	Higher compared to type II fibers
Fatigue rate	Highly resistant to fatigue due to reliance on aerobic metabolism
Myosin heavy chain isoforms	Predominantly MyHC I isoforms
Size	Smaller cross-sectional area and longer length
Recruitment	Primarily during low-intensity, long-duration activities, or tasks requiring sustained contractions
Motor unit size	Often consist of more muscle fibers per motor neuron compared to type II fibers

Slow-Twitch Type I Fibers

Slow-twitch fibers contract more slowly and with less force than fast-twitch fibers; however, they can sustain contractions for much longer periods. These fibers have high levels of mitochondria and myoglobin, closely linked to their enhanced aerobic capabilities (Table 2.2). Therefore, they are well-suited to generate energy aerobically and sustain muscle contractions for long periods (distance running, rucking, and patrols).

Summary

Understanding the fundamentals of muscle physiology is essential for strength and conditioning for the human weapon system. The neuromuscular system, consisting of the central and peripheral nervous systems, regulates muscle contractions. Peripheral nerves control skeletal muscle activation through motor unit recruitment. In contrast, skeletal muscle comprises diverse fiber types, including fast-twitch (type II) and slow-twitch (type I) fibers, each with unique characteristics that impact their function. Understanding these principles is foundational in comprehending strength and power dynamics in the human weapon system.

Physiology of Conditioning

The HWS professionals frequently experience engagements lasting anywhere from 30 s to several days [2–5]. During these efforts, aerobic conditioning is vital to mission success. Conditioning can be viewed as the time needed to complete a task (e.g., 2-mile run time) or before fatigue/exhaustion sets in (e.g., time to exhaustion/

fatigue). This section focuses on the former and discusses the performance model of conditioning/endurance while examining the physiological underpinnings and adaptations to training.

The Performance Model

The performance model of endurance was initially put forth to contextually represent the various performance markers and how they interact to determine endurance performance. The velocity or power output during an endurance event dictates the time necessary to complete the task, with faster athletes achieving the highest velocities and power outputs. Therefore, strength and conditioning coaches help athletes achieve the highest velocities/power outputs for their given tasks. Although the HWS does not have a fixed competition event (e.g., 400 m or 800 m run) and often completes complex tasks in ever-changing environments, the underlying physiology of the performance model will still apply. To achieve those high velocities and power outputs, one of two underlying physiological processes must be met: [1] high-performance oxygen consumption and [2] high movement economy/efficiency.

Performance Oxygen Consumption

Performance oxygen consumption is the highest steady-steady oxygen consumption that can be maintained for the duration of the task/event and is determined by [1] maximal oxygen consumption and [2] lactate threshold. Maximal oxygen consumption sets the upper limit to performance oxygen consumption and is the highest rate of oxygen one can consume per minute. The lactate threshold determines the percentage of one's maximal oxygen consumption at which performance oxygen consumption occurs. The lactate threshold is when lactate production exceeds lactate clearance within the muscle and the increases.

Maximal Oxygen Consumption ($\dot{V}$ O$_{2\,\text{Max}}$)

Maximal oxygen consumption ($\dot{V}O_{2\,Max}$) sets the upper limit for the level of aerobic metabolism that can be sustained during a task. Very high $\dot{V}O_{2\,Max}$ values have been a marker of endurance performance since the 1930s, with elite athletes typically having $\dot{V}O_{2\,Max}$ values of 70–85 mL/kg/min. In athletes with heterogenous $\dot{V}O_{2\,Max}$ values, a strong negative correlation exists between $\dot{V}O_{2\,Max}$ and race times. However, when $\dot{V}O_{2\,Max}$ is restricted (as typically happens at elite levels of the sport or with athletes on similar training histories), $\dot{V}O_{2\,Max}$ is less predicted of endurance performance. In these situations (restricted range of $\dot{V}O_{2\,Max}$), endurance performance is best predicted by the fractional utilization of $\dot{V}O_{2\,Max}$ (i.e., % $\dot{V}O_{2\,Max}$) that can be maintained. Therefore, a high $\dot{V}O_{2\,Max}$ is likely a prerequisite for high levels of endurance performance (i.e., sets upper limit), while other factors (i.e., lactate threshold) play a more critical role in determining performance at the individual athlete level.

Lactate Threshold

The lactate threshold, the point of the initial rise in blood lactate (i.e., [La] >1mmoL baseline values), is related to endurance performance and represents the fraction of $\dot{V}O_{2\,Max}$ used during events (i.e., performance oxygen consumption). For events >10–15 min athletes, $\dot{V}O_{2\,Max}$ is not evoked, and only a fraction of $\dot{V}O_{2\,Max}$ is used during events; therefore, lactate threshold plays a vital role in determining success. Strong correlations exist between athletes' lactate threshold, marathon pace, and cycling power output. Occupationally, there are strong links between lactate threshold and heavy occupational work, firefighter job task performance, and rucking ability. In untrained individuals, blood lactate levels will only rise with increases in exercise intensity once ~60% of $\dot{V}O_{2\,Max}$. However, in trained individuals, rises in blood lactate concentration do not occur until ~75–90% of $\dot{V}O_{2\,Max}$. Therefore, one of the primary objectives of the training is to "shift" the lactate curve to the right (Fig. 2.10), allowing athletes to exercise at higher relative oxygen consumption before a substantial rise in blood lactate concentration occurs.

Movement Economy/Efficiency

The section above outlined how $\dot{V}O_{2\,Max}$ and lactate threshold work together to determine performance oxygen consumption. The concepts of "economy" or "efficiency" also work to set the velocity or power at which the performance oxygen consumption is attained. Efficiency refers to the relationship between work done and energy expended. It is typically calculated on a cycle ergometer, where the mechanical work is measured alongside the energy expended during the activity.

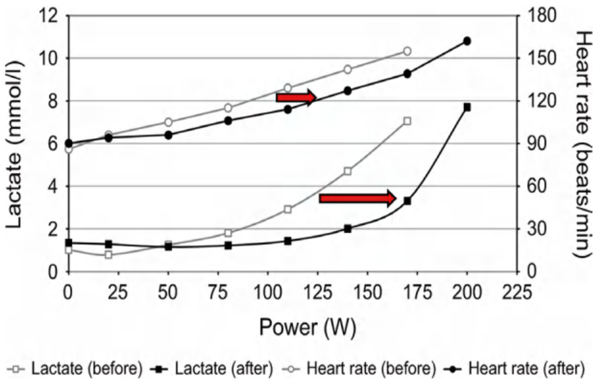


Fig. 2.10 Lactate and heart rate curve shifts. This figure depicts the rightward shift of the lactate performance curve in an athlete after undergoing endurance training. The specific aerobic training shows several improvements in lactate generation at higher efforts

While running, the velocity represents only a portion of the work being performed by the body; therefore, "efficient" or "efficiency" should not be used to relate the energy demands of running to velocity. The HWS should, thus, be interested in the movement economy. Economy is simply the oxygen cost of endurance running (mL/kg/min) at a given velocity and can vary by 30–40% among individuals. Individuals with a better economy (less oxygen for a given velocity) reach higher velocities at $\dot{V}\ O_{2\,Max}$ and perform oxygen consumption.

Physiological Underpinnings of the Performance Model

$\dot{V}$ $\mathbf{O_{2\,Max}}$

In well-trained endurance athletes, $\dot{V}\ O_{2\,Max}$ values are 50–100% higher than healthy young subjects [6, 7]. During whole-body exercise, working skeletal muscle has the capacity for increasing blood flow and oxygen consumption beyond the capacity of the heart (i.e., cardiac output), suggesting $\dot{V}\ O_{2\,Max}$ is limited by the ability to deliver oxygen to the working muscle rather than the ability of the mitochondria to consume oxygen. Differences in $\dot{V}\ O_{2\,Max}$ between untrained and trained states is primarily due to differences in maximal cardiac output. Higher cardiac outputs in the trained states are attained due to variations in stroke volume rather than changes to maximal heart rate. Additionally, oxygen extraction by active skeletal muscle (arterial-venous O_2 difference) only significantly increases $\dot{V}\ O_{2\,Max}$.

Aerobic training can increase $\dot{V}\ O_{2\,Max}$ by up to 45%, depending on training status and adequate training volume and intensity. Anywhere between 2–5 days/week and 15–45 min per session appears to be effective at raising $\dot{V}\ O_{2\,Max}$, with untrained athletes needing lower frequency (~2–3 days/week) and session volume (15–30 min/session) than trained athletes (4–5 days/week and 45 min+/session). In untrained individuals, training intensities of 40–50% of $\dot{V}\ O_{2\,Max}$ can substantially increase $\dot{V}\ O_{2\,Max}$. However, the more trained an athlete is, the higher the exercise intensity is needed to see improvements (70–100% of $\dot{V}\ O_{2\,Max}$). Little evidence strength training should be primary training mode to increase $\dot{V}\ O_{2\,Max}$ and only a trivial effect of concurrent training and $\dot{V}\ O_{2\,Max}$ compared to endurance training alone. However, in untrained individuals or individuals with relatively low $\dot{V}\ O_{2\,Max}$ at the start of training, initial improvements in $\dot{V}\ O_{2\,Max}$ can come from resistance training.

Lactate Threshold

Determinants of lactate threshold can be highly complex; however, the primary factor is the oxidative capacity of the skeletal muscle. Increased exercise intensity increases muscle glycogenolysis and lactate production rate due to lowering the ATP: ADP ratio. Lowering the ATP: ADP ratio stimulates mitochondrial respiration to increase ATP production from oxidative methods within the mitochondria. When untrained (relatively low mitochondria activity in muscle), each mitochondria must be stimulated at high rates to meet the ATP requirements. However, this increase in ADP will also promote muscle glycogenolysis and lactate production. Therefore, one of the primary purposes of endurance training is to stimulate significant increases in mitochondrial activity, allowing more mitochondria to share in the metabolic work, raise the ATP: ADP ratio for a given workload, and subsequently shift the lactate curve to the right.

Muscle oxidative capacity and mitochondrial content adapt readily to aerobic training and detraining. Mitochondrial content can increase up to twofold following high-volume and high-intensity training protocols due to increases in both size and number of mitochondria. Both high-volume low-intensity training and low-volume high-intensity training can increase mitochondrial content; however, there are differences at the individual fiber level (type I vs. type II) in how they respond to changes in volume and intensity. Training volume is an essential determinant of training-induced changes in the mitochondrial content of type I oxidative fibers. Type II fibers increase their mitochondrial content in response to higher-intensity training, presumably because type II fibers are recruited at higher exercise intensities. In fact, after a period of training, type II fibers can become as oxidative as type I fibers. However, suppose training volume/intensity is manageable. In that case, mitochondrial adaptation is likely to plateau or even reverse, with complete cessation of training resulting in mitochondria returning to untrained levels within 6–8 weeks in individuals who have only been training for 8–12 weeks. Despite the potential benefits of incorporating strength training into aerobic endurance programs, evidence supporting its efficacy in improving lactate threshold remains inconclusive. While improvements in the lactate threshold could theoretically occur through various mechanisms, including enhanced oxygen consumption or velocity/power at the lactate threshold, research findings regarding the impact of strength training on the lactate threshold are inconsistent, with some studies reporting benefits. In contrast, others still need to find none. Nevertheless, it is worth mentioning that resistance training does not detrimentally affect the lactate threshold in endurance athletes.

Movement Economy

Running is a complicated movement with periods of concentric and eccentric muscle actions with elastic/stretch components that have the potential to capture mechanical energy in the elastic components of the tissue. Researchers have attempted to explain the 30–40% variation in running economy through physiological, biomechanical, and anatomical research. However, many variables have yet to be identified to explain the variation. Physiologically, researchers have examined the relationship between type I fiber type percentage and running economy, as elite runners typically have more type I fibers than nonelite counterparts. However, running economy has not been correlated with type I fibers. Biomechanical attempts at predicting running economy have also fallen short, including examinations into stride length and stride frequency. Additionally, some research has shown anatomical explanations for determining running economy, including foot length, segmental mass distribution, and Achilles tendon moment arm length. Lastly, underlying neuromuscular characteristics may help explain some variations in the running economy, such as muscle power, leg stiffness, stretch-shortening cycle, and elastic energy storage, all related to the running economy.

Running economy can be improved over consecutive years of training in elite endurance athletes, with up to a 14% improvement in running economy for current marathon world record holder over 5 years. Strength and plyometric training improve running economy when performed concurrently with endurance training. Around 8–14 weeks of heavy strength training combined with endurance training improves running economy. Around 6–12 weeks of explosive training improves running economy. Minimum strength training of two to three sessions per week seems practical to improve running economy, as one session per week is ineffective. The improvements in running economy following resistance training are likely due to changes in neuromuscular properties (power, stiffness, stretch-shortening cycle, etc.).

Conclusion

The HWS professionals' skeletal muscle physiology is a critical aspect underpinning their performance and effectiveness. These professionals require exceptional muscular strength, endurance, and resilience to handle the physical demands of their engagements, ranging from brief, intense encounters to prolonged operations lasting several days. Understanding the nuances of muscle fiber composition, energy metabolism, and recovery processes is essential for optimizing training and performance. Advanced training regimens and nutritional strategies aimed at enhancing muscle function and delaying fatigue can significantly improve the operational capabilities of these professionals. In later chapters of this book, deeper insights are provided into maximizing the potential of the HWS through tailored physiological interventions through strength and conditioningStrength and conditioning (SC).

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Chapter 3
Needs Analysis

Kevin Malahy, Kosta Telegadas, and CJ French

Needs Analysis Application and Systematic Approach #1

Relevance and Effectiveness

Conducting a needs analysis ensures the efficacy of SC programs. It serves several functions, including creating proprioceptive awareness for the client, identifying and prioritizing critical enablers, providing objective justification for including relevant support resources, and serving as the basis for programming development and implementation. Without conducting a needs analysis, SC professionals often rely on subjective reasoning, such as gossip regarding the physical expectations imposed on the client, personal bias favoring certain ideologies or methodologies, or erroneous assumptions about everyday circumstances encountered by personnel. Additionally, the physical preparation of personnel would then be effectively based on guesswork, which in a profession where lack of preparedness can have

Dr. Chris Myers explains his needs analysis process in Chapter 9 of the preceding book, *The Human Weapon System*. This chapter presents two other methodologies for conducting a needs analysis. Approach #1 is written from the point of view of Kevin Malahy, and approach #2 is written from the points of view of Kosta Telegadas and CJ French.

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life-altering consequences is risky and irresponsible. Conducting a comprehensive needs analysis involves the following steps.

Step 1: Cast the vision and define the mission.

In numerous encounters, individuals involved in program development often struggle to answer the fundamental questions: "What is the vision?" and "What is the mission?" Although seemingly intuitive, this step proves challenging. The vision signifies one's future direction or goal(s). The mission delineates the actions required to navigate toward that envisioned future and should be highly specific. Clear vision and mission statements guide subsequent program development decisions like the proverbial northern star (Fig. 3.1). A simple exercise: instruct participants to imagine themselves in the same room in the future, reading a situation report outlining the program's results. Their reading shows they feel confident that all their goals have been successfully achieved. What does that report state?

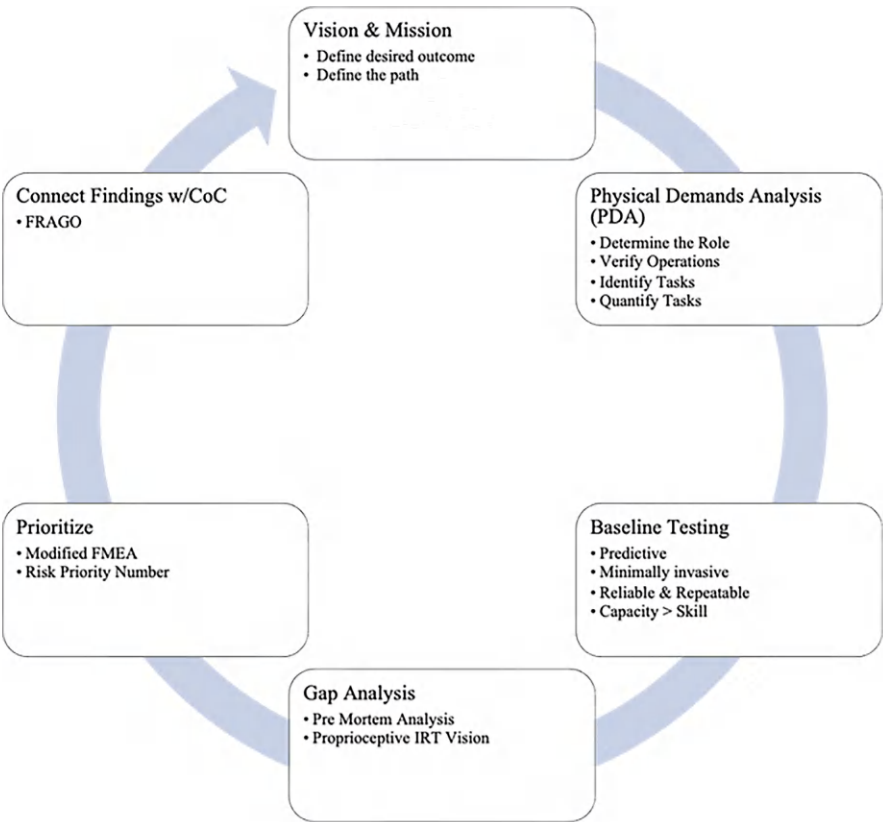

Fig. 3.1 Systematic approach #1 for conducting the needs analysis

Additionally, consolidating previous mission reports, which could include points of failure and success, can help guide the program's direction. Historical data gathering can prove helpful as a starting point.

Step 2: Conduct a physical demands analysis (PDA).

A PDA is a systematic procedure to quantify and evaluate the physical and environmental demand components of a job's essential and nonessential tasks (Fig. 3.1). PDAs consist of four steps:

2.1: Determine the Role

One should examine the service's general messaging, directives, and standing orders. Job descriptions typically include occupational task statements that elaborate on the physical expectations for the various roles within the organization and the policies governing them. For example, in the Canadian Armed Forces, all this information is outlined in documents such as The Canadian Defense Strategy (CDS), The BALANCE Strategy, Defense Administrative Orders and Directives (DAOD) 5023-1, several Canadian Forces General messages (CANFORGENS), and the Canadian Armed Forces Medical Standards (CFP 154) Annex D Military Occupational Structure Identification Code (MOS ID) task statements. These task statements outline physical tasks required by each respective MOS ID within the CAF, stratified by rank. Although comprehensive, the task statements are far from exhaustive, hence the need for a supplementary needs analysis.

2.2: Verification of operations

This involves verifying the accuracy of the physical requirements and duties outlined in the documents above and what is occurring. This can be achieved through observation and qualitative feedback via interviews or surveys.

2.3: Identifying operational tasks

In this step, one must identify all physically demanding tasks and then stratify them into categories of essential or nonessential. Essential tasks are those directly related to the job description, while nonessential tasks encompass additional requirements such as field-daying (cleaning) or other miscellaneous working parties. It is crucial to consider the workflow and the occurrence of each task. Noting the frequency, time per shift, repetition, and rest between tasks within a given timeframe is also essential.

2.4: Quantifying the physical demands of operational tasks

In this step, one must quantify the physical demands using objective measures to identify each operational task's kinetic and kinematic structures. These measures may involve traditional weight scales, luggage scales, force plates, tape measures, stopwatches, video recording, or any other accessible tool suitable for the environment. After collecting this data, they categorize it into groups such as lifting, pushing, pulling, and carrying, including frequency, intensity, and duration details.

Step 3: Establish and conduct a baseline testing protocol.

With the vision and mission of the chain of command and an understanding and appreciation of the daily physical demands of personnel roles in mind, one must next establish a testing protocol (Fig. 3.1). The testing protocol aims to predict desired outcomes or directly measure them. Ideally, these protocols are minimally invasive, repeatable, and reliable, and they require minimal coaching to perform and assess physiological capacity more than skill. It is crucial to exercise prudence in crafting the baseline testing protocol; as the adage suggests, "what gets measured gets managed."

Step 4: Conduct a gap analysis.

A gap analysis is a proactive assessment tool that evaluates personnel's current status and envisions future state. Like a mall map pinpointing "you are here," it identifies the necessary steps to reach the destination. The analysis highlights existing physical limitations that must be addressed, paving the way for subsequent program development (Fig. 3.1).

4.1: Premortem analysis

Including a postmortem analysis as a subheading is optional, depending on the circumstances. A postmortem analysis involves stakeholders imagining themselves in the future and reflecting on a failed program or project to identify potential problems and mitigate them before they arise. Akin to the goal planning exercise, instruct participants to imagine themselves in the same room in the future, reading a situation report outlining the program's results. In this scenario, they feel that one or all of their goals have yet to be successfully achieved. Why did this occur?

Step 5: Prioritize needs.

In step 5, accumulating all data mentioned above necessitates prioritization to determine optimal training methods for the population to achieve the desired goal (Fig. 3.1). Establishing an objective mechanism to organize and prioritize essential physical competencies reduces subjective bias among SC professionals and participants in the development process. Additionally, such a tool justifies adopting unconventional or less favored methods that might need more support when necessary. In this context, a modified failure mode effects analysis (mFMEA) is an organizational and prioritization tool. Unlike a traditional FMEA, which quantifies potential problems by severity during product or process development, an mFMEA identifies job-related tasks (failure mode) identified during the gap analysis and mechanical or physiological deficiencies (cause) identified during baseline testing. Each failure mode receives a numerical rating from 1 to 10 based on severity and occurrence determined from data collected in steps 2.3 and 2.4 of the PDA, as seen in Table 3.1. These scores are multiplied to establish a task-specific risk priority number, as seen in Table 3.2. Tasks with higher priority numbers indicate a greater need for improvement in their mechanical or physiological deficiencies compared to other tasks.

Step 6: Connect findings with the chain of command (CoC).

Table 3.1 Example mFMEA scoring tool for severity and occurrence

Rating scale			
Severity (S)		Occurrence (O)	
Category	Score	Category	Score
Catastrophic	9–10	Very often	9–10
High	7–8	Often	7–8
Moderate	4–6	Occasional	4–6
Low	1–3	Infrequent	1–3

Table 3.2 Example of an mFMEA for Canadian Army Vehicle Technician MOSID 00129

MOSID 00129—Vehicle Technician (VEH TECH)						
Job-related task evaluated	Deficiency cause	Effect on operations	S	O	RPN = S × O	Actions
30× lift, turn, press with 35 kg weight	Postural strength	Increased probability of lumbar injury	9	7	63	Lumbar strength
	Lateral stability					Antilateral flexion/extension core strength
	Horizontal rotational mobility					Lumbar and thoracic mobility
Modified YMCA press (overhead empty barbell)	Shoulder endurance	Limited ability to work with hands overhead for prolonged periods Increase probability for shoulder/neck injury	6	8	48	Scapular mobility
	Overhead mobility					Shoulder strength endurance
	Core strength/ endurance					Antilumbar extension/strength development

In the final step, the professional defines the path to achieve the envisioned end state outlined in step 1. They compile all information gathered from steps 2 to 5 into a comprehensive report, incorporating a cover page resembling a fragmentary order (FRAGO) (Fig. 3.1). FRAGOs across services vary, but they typically contain the following elements: situation (why), mission (what), execution (how and when), service support (who), and command and signals (communication information). A Google search for FRAGO templates is straightforward if the SC professional lacks service-specific formats. Summarizing information in this format will benefit service personnel who are familiar with its structure. While this format may seem daunting to new SC professionals, synthesizing comprehensive report information into a coherent action plan that addresses the above elements achieves the FRAGO's purpose.

Conclusion

For various reasons, fundamental movement patterns such as squats, hinges, and presses inevitably feature in most SC programs. However, assuming all personnel derive equal benefits from identical training methods should not be one. Unlike sports athletes, tactical professionals do not have the luxury of taking a loss, regrouping, and refining in training. Whether it is their first day on the job or their thousandth, every deployment, traffic stop, structure fire, and so forth can be their last, especially if they need to be adequately prepared. Therefore, prescriptions should always be based on relevant and objective data. The six-step needs analysis equips SC professionals with ample evidence to quantitatively prioritize and justify incorporating their prescribed interventions (Fig. 3.2).

Needs Analysis Application and Systematic Approach #2

In tactical strength and conditioning, the concept of a needs analysis is paramount for developing effective training programs. A needs analysis is a systematic process that identifies the specific requirements of an HWS or a group of HWS professionals based on the physical demands of their unit. This analysis guides strength and conditioning professionals in designing tailored training regimens that enhance performance, prevent injuries, and address the HWS's unique physical and physiological needs. This chapter explores the fundamental aspects of a needs analysis, its importance, and how it is applied in strength and conditioning. The needs analysis is meant to act as a starting point for the strength and conditioning coach to determine a road map to the units' or individual's desired outcomes.

Fig. 3.2 Balancing the HWS demands and needs versus the vision

What Is a Needs Analysis?

A needs analysis is a comprehensive evaluation process that examines various factors related to an HWS's performance and the specific demands of its environment. This process typically involves three main components: the tactical analysis, the HWS analysis, and the assessment of performance goals.

1. *Tactical analysis*: This component involves analyzing the physiological and biomechanical demands of the mission set. It includes examining the primary energy systems used, the types of movements performed, the intensity and duration of activities, and the injury risks associated with the tactical environment. For example, the needs of a marathon runner will differ significantly from those of a sprinter or a weightlifter, or in the tactical space, the needs of personnel will vary from the needs of the military. However, both will require a higher baseline commensurate with basic warfighting capabilities.
2. *HWS analysis*: This step focuses on the individual HWS's characteristics, including their current fitness level, strengths, weaknesses, injury history, and previous training experiences. It often involves physical assessments such as strength tests, flexibility measurements, cardiovascular fitness evaluations, and body composition analysis.
3. *Performance goals*: It is crucial to understand the HWS's short-term and long-term goals. These goals could range from improving overall strength to increasing speed to enhancing endurance to rehabilitating from an injury. Aligning the training program with these goals ensures that the HWS remains motivated and focused.
4. *Training space*: This step requires assessing the training space the HWS will be training in, what tools they will have access to, and what the battle rhythm of the unit is to ensure he can work within the constraints of the training calendar.

The Importance of a Needs Analysis

A needs analysis of strength and conditioning must be considered. Here are several key reasons why it is essential:

1. *Personalization of training programs*: Tactical personnel vary significantly regarding their physical capabilities, experience levels, and performance objectives. A needs analysis allows strength and conditioning professionals to create personalized training programs that cater to the specific needs of each HWS, ensuring optimal results and minimizing the risk of overtraining or injury. For example, training a 40-year old 5 could focus heavily on a more defined movement preparation, maintaining power, building strength, and strength maintenance. In contrast, a 20-year-old firefighter in an academy training pipeline

might focus on more performance-based metrics such as power, max strength, and improving conditioning in the anaerobic and aerobic energy systems.

2. *Enhancing performance*: By understanding the specific demands of the tactical HWS and the individual's needs, strength and conditioning coaches can design training regimens targeting the most relevant performance aspects. This targeted approach improves the individual's strength, speed, endurance, and overall performance more effectively than generic training programs.
3. *Injury prevention*: Identifying potential weaknesses and imbalances through a needs analysis enables coaches to incorporate corrective exercises and preventive measures into the training program. This proactive approach significantly reduces the risk of injuries, ensuring HWS professionals can train consistently and perform at their best.
4. *Efficient use of training time*: A well-conducted needs analysis helps prioritize training activities that significantly impact performance. This efficiency ensures that the HWS focuses on exercises and drills that will yield the best results, making the most of their training time. This will eliminate any "guessing" that the coaches and HP staff must do to ensure an efficient use of unit funds.
5. *Motivation and accountability*: When HWS professionals see that their training program is tailored to their specific needs and goals, they are more likely to stay motivated and committed. Additionally, regular assessments and updates to the needs analysis provide a clear picture of progress, holding the HWS accountable and keeping them engaged in their training.

How to Perform a Needs Analysis

Conducting a needs analysis involves several steps, each critical for gathering comprehensive information about the HWS and their training environments. Here is a closer look at the process.

Step 1: Gather background information

The initial step involves collecting detailed background information about the tactical HWS professionals. This includes their training history, injury history, medical conditions, nutritional habits, and lifestyle factors. Coaches must understand these aspects to provide a foundation for the following steps of the needs analysis. Additional information could be helpful in conversations regarding their least and most motivated days, historical trends of compliance, and historical trends of noncompliance.

Step 2: Conduct tactical analysis

Next, the coach should conduct a thorough analysis of the HWS. This involves studying the profession's physical, technical, and tactical demands and the stresses placed on the individual or group. Coaches look at the typical movements involved, the energy systems predominantly used, the frequency and duration of competitive events, and common injury patterns. For instance, in the airborne, a needs analysis would examine energy transference to include sprinting, agility, endurance, strength, and the high incidence of the lumbar spine, shoulder, and lower limb injuries associated with training accidents.

Step 3: Conduct physical assessments

Physical assessments are conducted to evaluate the HWS's current fitness levels and identify areas for improvement. These assessments can include but are not limited to the following:

- *Strength tests*: Evaluating maximal strength in various lifts (e.g., squat, deadlift, and bench press).
- *Endurance tests*: Assessing aerobic capacity through tests like the VO2 max test or maximal aerobic speed (MAS) test.
- *Speed and agility tests*: Measuring sprinting speed and agility through drills such as the 40-yard dash, 5-10-5 pro agility test, or T-test.
- *Mobility tests*: Assess the range of motion in critical joints, such as hip, t-spine, and ankle mobility.
- *Body composition analysis*: Measuring body fat percentage, muscle mass, and overall body composition through tests such as the in-body BIE test or DEXA scan.
- Step 4: Identify goals

Understanding the HWS's performance goals is critical. Goals should be specific, measurable, achievable, relevant, and time-bound (SMART). Coaches work with the tactical personnel or leadership to set realistic short-term and long-term goals, ensuring that the training program aligns with the benchmarks and objectives that the units need/want to obtain.

Step 5: Develop the training program

Based on the information gathered from the previous steps, the coach designs a tailored training program. This program should address the identified needs, improve weaknesses, and enhance strengths. It typically includes a combination of strength training, conditioning, skill development, and recovery strategies while considering compliance in a high operational tempo occupation.

Step 6: Monitor and adjust

A needs analysis is not a one-time process; it requires continuous monitoring and adjustments. Regular assessments and feedback help track progress and modify the training program. This dynamic approach ensures the program remains relevant and effective as the HWS's needs evolve. Examples of feedback could include follow-up consultations, RPE, percentage-based training, velocity-based training, GPS tracking, heart rate variability tracking, or unit-wide readiness surveys (Chaps. 5 and 11).

Conclusion

The systematic application of a needs analysis in tactical strength and conditioning is essential for developing effective and efficient training programs tailored to the unique demands of each HWS or unit. By thoroughly understanding the tactical and individual requirements, strength and conditioning professionals can design personalized training regimens that optimize performance, prevent injuries, and ensure that the training time is used effectively.

The needs analysis process involves several critical steps: tactical analysis, HWS analysis, and performance goal assessment. Each step contributes to a comprehensive understanding of the physical and physiological demands placed on the HWS. This systematic approach allows coaches to create targeted training programs that address specific strengths and weaknesses, enhancing performance and reducing injury risk.

The importance of a needs analysis cannot be overstated, as it ensures the personalization of training programs enhances overall performance, aids in injury prevention, and maximizes the efficient use of training time. Additionally, it fosters motivation and accountability among HWSs by aligning their training with their individual goals and regularly assessing their progress. Conducting a needs analysis involves gathering background information, performing physical assessments, setting performance goals, developing tailored training programs, and continuously monitoring and adjusting these programs. This dynamic and ongoing process ensures that the training remains relevant and effective as the needs of the HWS evolve.

Ultimately, a well-executed needs analysis is the foundation for achieving optimal performance outcomes in tactical strength and conditioning. By following *a systematic needs analysis approach*, strength and conditioning professionals can support HWS in reaching their full potential, ensuring they are prepared for the physical demands of their tactical roles.

Chapter 4
The Methodology of Periodization

Cory Gilday and Christopher Myers

Introduction

Periodization, the systematic planning of athletic or physical training, is a crucial tool for the human weapon system (HWS). This process involves the progressive cycling of various aspects of a training program during a specific period. For the HWS, the process is not just about enhancing performance and managing fatigue but also about preparing tactical personnel for the unpredictable physical demands they face in the austere environments in which they operate.

Components of a Training Plan

A well-designed training plan implements a periodization model by systematically varying the training load to optimize performance and recovery. Each training plan element (Table 4.1) is goal driven. The goals identified during the needs analysis process (Chap. 3) emphasize the HWS's strengths and limitations. These strengths and limitations encompass a range of factors, including biomechanical abilities, muscular strength, muscular endurance, cognitive ability and agility, cardiovascular endurance, work capacity, learning capabilities, and stress management. Each training element goal is nested to support each higher echelon goal (Fig. 4.1).

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Table 4.1 Elements of a training plan

Component	Duration	Description
Macrocycle	> = 1 year	The macrocycle is the overall training plan that encompasses the overall goals and training needs of the HWS. Traditionally, a macrocycle lasts one (1) calendar year, but it can last multiple years based on the HWS needs and mission (i.e., the US Army's ARFORGEN cycling during the Middle East conflicts
Mesocycle	4–6 weeks	The mesocycle is also known as a block. This subcomponent of the macrocycle consists of microcycles that focus on the HWS strengths and needs based on the periodization methodology employed. Each mesocycle is goal driven. The mesocycle goals break the macrocycle components into smaller, organized goals to focus on the block of training
Microcycle	<1 week	The microcycle consists of 5–7 training days. Each day can consist of one or multiple training sessions. Each microcycle works to achieve a set of goals that are nested underneath the mesocycle goals. These microcycle goals break down the mesocycle goals into trainable components to help the HWS achieve improved performance
Training session	From one (1) to several hours, up to several days	A training session is a single learning session that works a small number of biomotor, cognitive, physiological goals/skills that work toward achieving the microcycle goals. In athletics, an athlete can have 1–3 individual training sessions a day, which would last a few hours. For the HWS, the same is true, but a training session can last longer than 24 h

Note: Most training plans follow the Julian calendar format. However, this approach does not work for some HWS populations due to their unconventional schedules. The HWS work schedule is a planning component when creating training. The above components can be and should be modified to match the HWS scheduling needs

A well-structured training plan is essential for achieving specific physical performance goals. It involves various elements that ensure systematic progress and recovery, and it should consider nonphysical aspects such as sleep, sense of self, mental readiness, and performance nutrition. The overarching framework, called the macrocycle, typically spans an entire year and encompasses all training phases leading up to the main competition or peak performance period (Table 4.1). Within the macrocycle, several mesocycles exist, typically lasting 4–6 weeks. These mesocycles focus on training objectives, such as building endurance, increasing strength, or honing technical or other soft skills.

Further breaking down the mesocycles are microcycles, which usually last 1 week and include a detailed schedule of daily workouts (training sessions) and rest days. Each microcycle balances training load and recovery, ensuring steady progression without overtraining. Individual training sessions are the building blocks of microcycles (Fig. 4.1). These sessions are carefully planned to target specific performance goals, such as cardiovascular endurance, muscular strength, flexibility, or skill development.

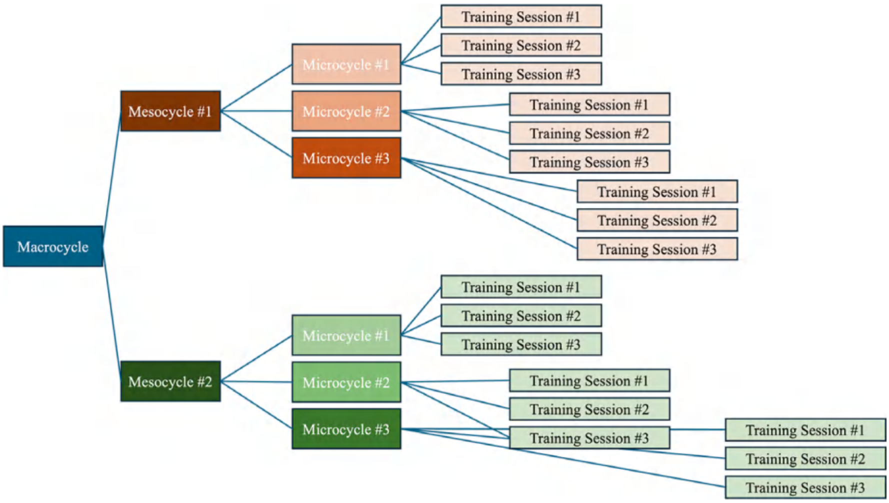

Fig. 4.1 Training plan goal hierarchy. Each element of a training plan is goal driven. Each goal nests into a higher echelon and builds upon each other. As they make, the color intensifies. The macrocycle goals (blue) provide the overarching direction and long-term vision and directly inform and shape the mesocycle goals. The mesocycle goals (dark orange and dark green) act as building blocks toward the macrocycle goals. They provide more detailed and intermediate targets to ensure progressive development and influence and are influenced by the microcycle goals. The microcycle goals (lighter shades of orange and green) provide short-term, week-by-week objectives, allowing flexibility and adjustments based on immediate feedback and performance. These goals directly shape the training session goals. Training session goals (very light orange and green) are the most detailed and specific level. They directly contribute to achieving microcycle goals and provide immediate targets and tasks for each training session

Training plan elements typically follow the Julian calendar format (12 months per year, 4 weeks per month, 7 days a week). However, some HWS professionals' work schedules do not follow this format. For example, firefighters work 24-h shifts with 72–96 h off. Even more, many HWS professionals work shifts. These work schedules may not fit nicely into the Julian calendar format. As an SC professional, do not shy away from not adhering to the Julian format. Following the training element duration guidelines in Table 4.1 and properly nesting the training element goals in Fig. 4.1 can create a training plan to fit the HWS's needs.

Another consideration is the training session length. SC literature states a training session can last several hours [1–4]. Yet, the needs analysis may show that the duration of this training session may not meet the needs of the HWS. For example, infantry maneuvers can last several days, or reconnaissance professionals may need to observe a target for several days without sleep. These types of training sessions break the typical training session model. For this reason, the training session duration explanation (Table 4.1) is different than what is typically defined [1–4].

Types of Periodization Methodologies and Loading Patterns

Periodization in training is a systematic approach to planning and varying workouts to achieve peak performance and prevent overtraining. Four primary methodologies of periodization exist [1, 5]. The methods are as follows:

1. *Linear*: This form of periodization is described as a training plan that gradually increases intensity and decreases volume throughout multiple mesocycles in a macrocycle. This model and block periodization are typically used for stock training plans.
2. *Block*: A series of highly focused mesocycles only on a few target abilities during training cycles so that instead of training concurrently, abilities are trained consecutively [5–8]. Block periodization is a significant benefit to coaching teams because it allows for the specificity of specific skills at critical times in the season [5–8].
3. *Flexible/nonlinear*: This form of periodization consists of varying patterns of training protocols involving exercise selection, volume, and intensity that are driven by an HWS's performance data [9]. Flexible periodization is most used with one-on-one coaching.
4. *Accumulation-transmutation-realization (A.T.R.)*: A.T.R. is a periodization model designed for achieving multiple peaks, featuring very short phases (general preparation, specific preparation, competition) repeated numerous times throughout the year. This approach, albeit used by professional athletes, does not fully optimize one's potential.

Daily undulating periodization (DUP) is passed off in nonpeer-reviewed literature as a periodization methodology. Undulating refers to changing the daily training stress (varying the variables of time and intensity) the HWS experiences during training sessions. Changing the training stress load is loading methodology, which is how periodization is applied [1].

Periodization is sometimes confused with loading patterns (such as DUP) (Figs. 4.2 and 4.3) [1]. However, periodization is nothing more than a way to plan blocks (mesocycles) of training in a nested goal (Fig. 4.1) in a multimodal manner [1]. The titles of the periodization methodologies refer to the loading patterns utilized in their execution [1]. The linear, ascending, descending, and flat loading patterns are traditionally used to modulate training load (Fig. 4.2).

The accumulated training load shows an undulating pattern over multiple mesocycles (Fig. 4.3). This is due to the weekly training load differences. Typically, the accumulated training load begins to take shape or can be quantified after the completion of two consecutive mesocycles.

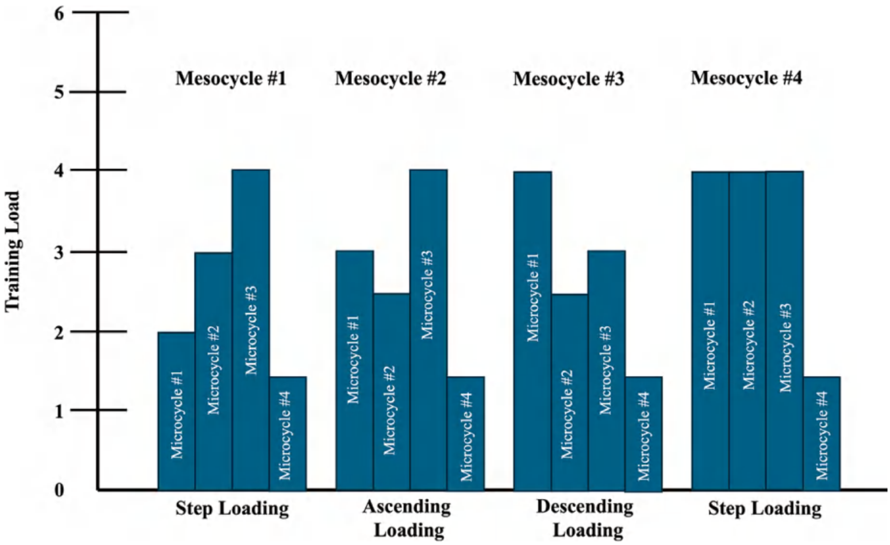

Fig. 4.2 Loading patterns. This figure depicts the four loading patterns used to implement periodization. The training load numbers on the *y*-axis are arbitrary numbers to demonstrate the increases in training load. (Adapted from Bompa & Buzzichelli, *Periodization* [1])

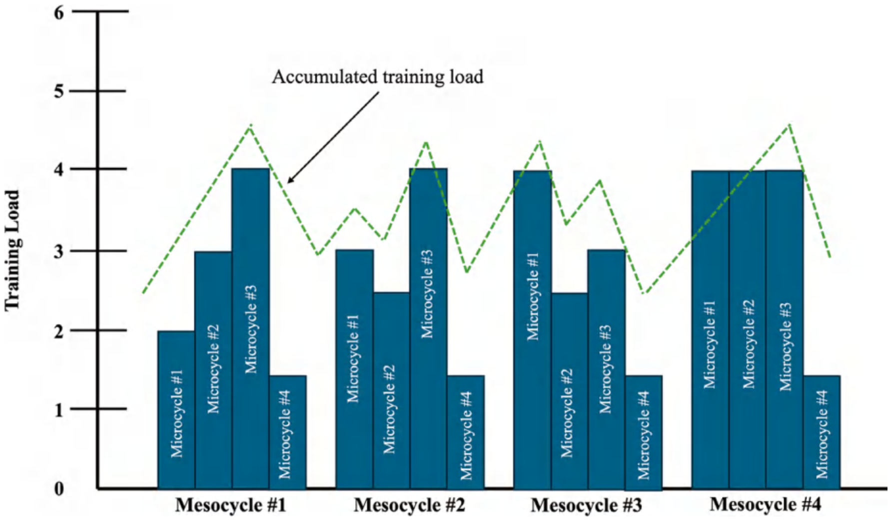

Fig. 4.3 Undulation due to loading patterns. The change in the microcycle training loads creates the undulation of the accumulated training load (green line). The types of loading patterns used create the undulation seen in training loads over a more extended period. (Partially adapted from Bompa & Buzzichelli, *Periodization* [1])

Periodization Limitation with HWS Populations

SC professionals will need support with using periodization methodologies with HWS populations. The root cause is work schedules. As stated earlier in this chapter, many HWS professionals do not work regular schedules; sometimes, their schedules could be more consistent and consistent. This type of work schedule will make consistency an issue when achieving performance goals. As shown in Figs. 4.1, 4.2, and 4.3, training sessions build upon each other to increase the training load. The consistent work in achieving the training session goals improves HWS performance. Most periodization methodologies cannot be used when training inconsistency occurs. So, how does the SC professional effectively program training? The answer is data!

Chapter 5 discusses data and metrics in greater detail. The SC can program accordingly by analyzing data (i.e., quantifying the current HWS strengths and limiters) and knowing the current operational needs determined through the needs analysis. The SC professional may have to use a mixture of all four periodization methodologies and loading methods (Chap. 10) to meet the HWS needs. The SC coach executes the periodization methodology through the structure of the loading patterns.

Training Stress Loading Patterns

Training-induced stress (also termed training stress) is the base component that induces physiological and other systematic adaptations caused by a training program. Training-induced stress is the accumulation of all the physiological, mental, cognitive, emotional, and spiritual stressors incited by both favorable and unfavorable internal and external factors [1–3, 10–13]. The intensity, duration, and frequency variables determine the training stress level [1, 4]. By manipulating these variables, an SC professional can create many loading patterns to achieve the desired performance outcome(s), which are discussed in further detail in Chap. 10.

Concentrated and Conjugated Loading Patterns

Concentrated and conjugated loading patterns are highly effective with HWS populations [14]. Concentrated loading is a block of training, typically focusing on a single skill, that achieves overreaching through a high volume of training stress followed by a recovery period [1]. Additionally, other primary skills training are maintained [1]. This loading approach occurs across an entire mesocycle [15, 16]. The loading pattern will look similar to a flat or descending loading pattern. Concentrated loading can last one to three mesocycles as long as the appropriate amount of recovery is provided (Fig. 4.4).

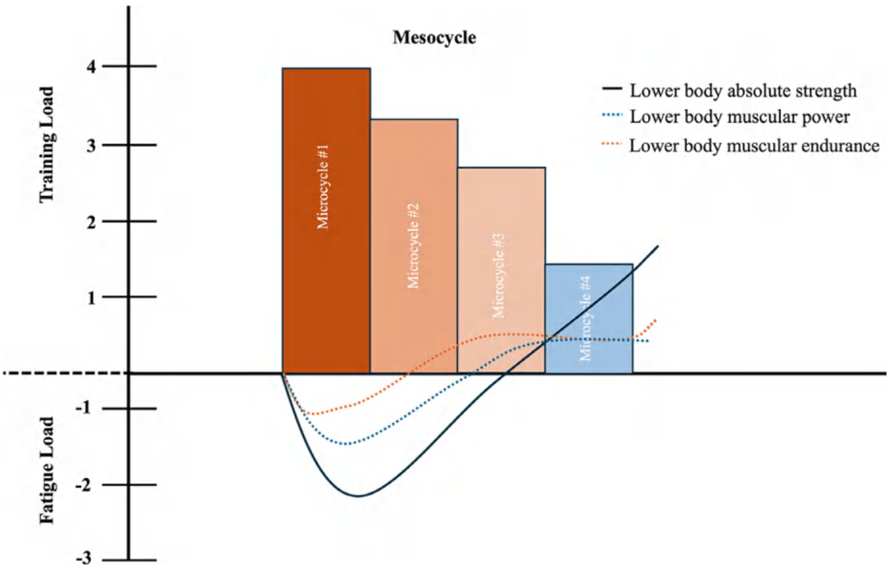

Fig. 4.4 Physiological adaptations to concentrated loading. In this figure, color intensity depicts the intensity of the microcycle. Microcycle #1 is a highly concentrated microcycle (the highest training load of the mesocycle) focused on lower body absolute strength. Microcycles #2 and #3 are normal training load microcycles following a descending loading pattern. The increased fatigue induced in microcycle #1 for lower body absolute strength carries over into microcycles #2 and #3. The normal training load during microcycles #2 and #3 helps push the lower body's absolute strength characteristics under the increased fatigue. During the recovery phase (microcycle #4), the supra-compensation is realized in lower body absolute strength while lower body power and muscular endurance are maintained

The other method, conjugated sequence loading structure, is a variant of concentrated loading [1, 16]. This method involves varying training cycles, incorporating phases of intense training (accumulation or intentional overreaching) followed by recovery periods to exploit supernormal responses. This loading structure is done through "concentrated blocks," lasting 2–4 weeks [16]. For example, in the first block, the HWS focuses on high-volume training in one area (e.g., strength/power) while maintaining minimal volumes in other areas. This approach aims to overload the system with one type of stress for 2–3 weeks, during which temporary performance declines may occur due to residual fatigue. The focus shifts in the following recovery block: strength training volume is significantly reduced while the volume for another quality (e.g., speed/technique) is moderately increased. The SC professional must ensure that the skills trained during the recovery mesocycle utilize characteristics different from those of the accumulation mesocycle. The skills must complement each other, such as power and speed. If executed correctly, the conjugated method allows the HWS performance to rebound due to a delayed training effect, improving movement speed and technical skills. The HWS can then move on to the next set of blocks with progressively stronger stimuli [16].

The SC professional can utilize the concentration and conjugated sequence loading structures to maximize the limited training time and inconsistencies within HWS populations. These strategies can help focus a training program to target and maximize the potential of the primary HWS strengths and limiters identified during the needs analysis.

Evaluating and Adjusting the Program

Considerations

- *Scalability*: Adapt the workouts according to individual skill level and fitness. The goal is to challenge yourself while maintaining proper form.
- *Recovery*: Incorporate active recovery days for physical and mental recuperation, reducing the risk of overtraining and injury.
- *Nutrition and hydration*: Emphasize a diet rich in lean proteins, vegetables, healthy fats, and complex carbohydrates. Stay hydrated to support recovery and performance.
- *Community*: Whenever possible, perform these workouts with a partner or group to simulate operational teamwork dynamics and build camaraderie.

The dynamic operational environment of the HWS necessitates ongoing evaluation and adjustment of the SC program. Regular performance assessments, feedback from HWSs, and analysis of injury data are essential for refining program design. This iterative process ensures that the SC program remains aligned with the evolving needs of the HWS, fostering continual improvement in tactical performance. How does an SC professional evaluate the program?

Establishing a thorough testing process in any training program is paramount. Testing within the program confirms its effectiveness and acts as an essential feedback tool for ongoing refinement and enhancement. It provides critical insights into the understanding and skill development of HWSs, highlighting areas that need improvement to make the program more effective. Additionally, benchmarking offers measurable data to assess the program's success. Hence, a detailed and carefully planned testing approach is vital for realizing the full potential of any SC program.

Program Testing

Testing a training program is essential for ensuring its success. This process evaluates whether the program effectively delivers the intended knowledge or skills, acting as a mirror that reflects how well the program aligns with its mission and objectives. Additionally, testing provides valuable feedback that facilitates continuous improvement. Since no training program is perfect from the start, testing identifies areas needing refinement (Fig. 4.5). Through this process, the SC and other HP

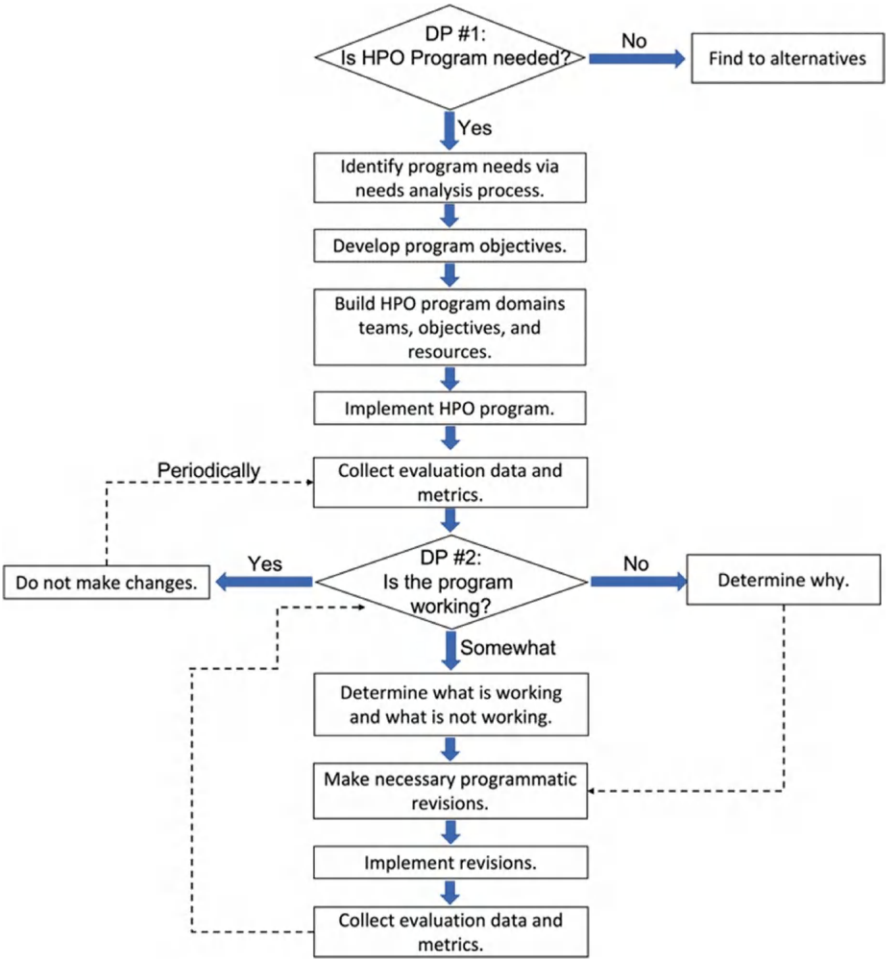

Fig. 4.5 Flowchart on how to test the viability of an SC program. (Adapted from Jenson et al. [20])

professionals can determine what aspects work well and which do not [1], ultimately enhancing the program's quality. Program evaluation is an ongoing process, as the needs of the HWS and the organization constantly evolve, requiring the program to adapt alongside its clients.

Program evaluations play a crucial role in identifying gaps, such as areas where the program may need to fully meet the needs of the HWS or require additional resources. Uncovering these gaps is vital for creating a more learner-centered program that better suits the learners' needs and improves their experience. Evaluating content relevance, effectiveness, and client satisfaction is critical to testing a training program. Since the HWS professions are constantly changing, what is relevant today may differ tomorrow, making it essential to keep the training content up-to-date and aligned with industry trends.

The Process: How to Get from Decision Point (DP) #1 to #2

Figure 4.5 details the evaluation flow or OODA (observe, orient, decide, act) loop [17–19]. The first step involves decision point (DP) #1, and that is for an organization to determine if an SC program is needed. If the answer is yes, the program is established. Once the program is established, the SC coach and team must conduct a needs analysis (Chap. 3). The needs analysis helps the team determine and build the SC personnel needs, program focus, and resources. The program should only be implemented after the program gathers the necessary resources, personnel, and funding. Once the program is functional over a certain period, the SC team needs to determine if the program is working. This action is conducted through data collection and analysis.

Data collection is pivotal in measurement and reporting [3, 4, 14, 20]. The program must collect accurate and relevant data that illustrates the program's overall success and failures. This process is the only way to understand the program's efficacy (Chap. 5). In Fig. 4.5, program metrics and data are collected and analyzed at several points in the testing process. During decision point (DP) #2, data and benchmarks provide the crucial information to answer the question, "Is the program working?" The SC team should establish these metrics during the needs analysis (Chap. 3) and address the key questions that must be answered (Chap. 5). The testing, analysis, and program revision is a feedback look process. It never ends. Testing is a requirement for compliance. This aspect may be due to state law or certification agencies.

Benchmarks: What Are They and How to Use Them to Answer DP #2

Many performance programs utilize benchmarks to determine whether a program is working. Benchmarks are standards or points of reference against which things may be compared or assessed. In human performance, benchmarks are invaluable tools to gauge progress, identify areas of improvement relevant to the career field, and facilitate goal setting. Whether in athletics, academia, professional settings, or personal development, effective benchmarking can significantly enhance one's trajectory and outcomes.

Benchmarks are determined either through research or observations of a particular population. For example, the NSCA has created several strength and power benchmarks to gauge an athlete's ability to compete with other athletes in that sport. Many of these benchmarks can be found in the NSCA's *Essentials of Strength and Conditioning, fourth ed*.

Figure 4.6 shows the benchmarks for 1RMs for the bench press, back squat, and power clean for basketball, softball, volleyball, and swimming. The benchmarks are based on the sample set of NCAA Division women participating in these sports.

% rank	1RM bench press		1RM squat		1RM power clean		1RM bench press		1RM squat	
	lb	kg	lb	kg	lb	kg	lb	kg	lb	kg
	BASKETBALL						SWIMMING			
90	124	56	178	81	130	59	116	53	145	66
80	119	54	160	73	124	56	109	50	135	61
70	115	52	147	67	117	53	106	48	129	59
60	112	51	135	61	112	51	101	46	120	55
50	106	48	129	59	110	50	97	44	116	53
40	102	46	115	52	103	47	94	43	112	51
30	96	44	112	51	96	44	93	42	104	47
20	88	40	101	46	88	40	88	40	101	46
10	82	37	81	37	77	35	78	35	97	44
Mean	105	48	130	59	106	48	98	45	118	54
SD	18	8	42	19	20	9	15	7	19	9
n	120		86		85		42		35	
	SOFTBALL						VOLLEYBALL			
90	117	53	184	84	122	55	113	51	185	84
80	108	49	170	77	115	52	108	49	171	78
70	104	47	148	67	106	48	104	47	165	75
60	99	45	139	63	100	45	100	45	153	70
50	95	43	126	57	94	43	98	45	143	65
40	90	41	120	55	93	42	96	44	136	62
30	85	39	112	51	88	40	90	41	126	57
20	80	36	94	43	80	36	85	39	112	51
10	69	31	76	35	71	32	79	36	98	45
Mean	94	43	130	59	97	44	97	44	144	65
SD	18	8	42	19	20	9	14	6	33	15
n	105		97		80		67		62	

lb = pounds, SD = standard deviation, *n* = sample size
Adapted, by permission, from Hoffman, 2006 (47).

Fig. 4.6 This figure depicts the benchmark values for NCAA Division 1 women's sports of basketball, softball, volleyball, and swimming [4]

Furthermore, these lifts correlate with how well an athlete performs within their sport. This data type allows a coach or an athlete to see how she measures up to others in the sport. For example, swimming athlete A posts the following 1RMs for the lifts above:

1. Bench press = 108 lbs.
2. Back squat = 116 lbs.

Based on these results, athlete A placed in the top 70% for bench press and 50% for back squat for NCAA Division 1 Women Swimmers. This athlete needs to focus on lower leg strength and power, which could help improve her overall swimming performance.

As demonstrated in Fig. 4.6 and the above example, benchmarks provide an objective yardstick against measuring performance, eliminating ambiguity and ensuring clarity in evaluation. Benchmarks offer clear and tangible targets individuals can aspire to achieve, which helps with goal setting. Tracking progress against established benchmarks can be a significant source of motivation. Finally, regular benchmarking can highlight areas of weakness or where additional effort is required.

The difficulty for HWS SC programs is that benchmarks may not exist. The SC team may need to create benchmarks relevant to their HWS population and program. In Fig. 4.6, the NSCA had to develop these tangible competitive benchmarks by collecting the data from a sampling of NCAA Division 1 women athletes. For an HWS SC program, key benchmarks may be more complex. The SC team must ask themselves, "What benchmarks are relevant to ensure the program works?" The SC team will have benchmarks based on data collected from *their specific population*. Once the benchmarks are set and evaluated, the SC coach will have a way forward to answer DP #2 (Fig. 4.5).

Three main types of benchmarks exist. The first is industry standards. These benchmarks are common performance metrics widely accepted and recognized within professional and academic settings. The second is personal bests. These benchmarks the individual athlete's personal best performances. These types of benchmarks are essential for tracking personal development in sports. The third type is competitive benchmarking. As shown in Fig. 4.6, this benchmark compares one's performance, typically personal bests, against others within that field or sport.

The HWS SC program can establish benchmarks through research (Chap. 5). This process involves understanding professional and academic standards, consultation, and population assessments. The SC coach can research and understand the professional and acceptable standards within the muscular domain and specific HWS population. Speaking with coaches, mentors, or industry leaders can provide insights into other valuable benchmarks that may not exist through research. The final option in creating benchmarks is through population assessments. Evaluating past performances of a particular HWS population can provide insights into what types of benchmarks are relevant and meaningful.

Making Benchmarks Meaningful Through Evaluation

Benchmarks are gathered using technology and performance records; however, these benchmarks are only helpful if meaningful. By making benchmarks meaningful, can they help the SC program answer DP#2, "Is the program working?" The SC team can consistently evaluate the benchmarks and determine whether and why the program works (Fig. 4.5). Accurate interpretation of results is essential. Many interpretations exist, but a simple, practical starting point is to look at the following three trends:

- Positive deviation: If one exceeds the standard benchmarks, this deviation is an excellent indicator of progress. However, the SC team must ensure the positive change is sustainable and not a one-off (i.e., a single personal best).
- Negative deviation: Falling short of a benchmark can indicate areas needing improvement. These negative changes require reflection on potential causes and the possibility of adjusting strategies.
- Consistency: While peaks and troughs are typical, consistent performance near the benchmark indicates stability and mastery.

What Comes After DP #2

The evaluation process is a never-ending OODA (observe, orient, decide, act) loop [17–19]. An SC program should always try to improve itself. After evaluating the benchmarks, the SC coach and team should be able to determine if the program is working, somewhat working, or not. If the program works, the team should not change its current practices. However, if the program is working somewhat or not, the SC team must determine what is not working. Programmatic changes should be made and implemented. The implemented changes need to be evaluated after a certain period. As shown in Fig. 4.5, no matter if changes are implemented or not, the program is constantly evaluating itself through benchmarks to answer DP #2. Constant evaluation helps the program adapt to the ever-changing needs of the HWS.

Conclusion

The design and periodization of an SC program for the human weapon system are critical for developing a robust, versatile, and resilient HWS. By integrating methodologies such as Triphasic Training, Concurrent Training, Hybrid Athlete, CrossFit, and Complete Sport Conditioning, tactical SC professionals can create comprehensive training programs that meet the unique demands of tactical operations. Tailoring these methodologies to the specific needs of the HWS, along with regular program evaluation, is critical to ensuring operational readiness and peak performance.

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Chapter 5
Performance Metrics

Alicia Racicot

What gets measured gets managed.

Introduction

Data Drives Decision-Making Whether on Wall Street, in health sciences, pharmaceuticals, or human performance, collecting and analyzing information of interest enables individuals to answer critical questions and make better-informed decisions. A consistent mistake many SC professionals must correct is properly selecting or using data and metrics. This chapter will distinguish between data, metrics, and key performance indicators (KPI) and explain how to determine which metric(s) best answer the question to be answered.

What Are Data, Metrics, and Key Performance Indicators

Fundamentally, data is the collection of facts or statistics together for reference or analysis [1]. Metrics are defined as pieces of collected data utilized to measure against a stated goal or outcome (citation). An example of a metric tracked within human performance might be an individual's resting heart rate in beats per minute (BPM). KPIs, within the human performance, are defined as a collection of metrics determined to be significant to the outcome or performance of the individual athlete or team. The objective of KPIs is to effectively choose which tests and measurables are relative to the human performance of the HWS. These indicators help trainers

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and coaches monitor progress, set goals, and adjust training protocols to maximize efficiency and results [2]. Traditionally, they seek to measure critical components within the company (strategic, operational, and functional) and examine them against a set of desired outcomes or objectives.

How Do KPIs Relate to Data and Metrics?

KPIs fit into the hierarchy of metrics and data within organizations or specific projects by serving as crucial benchmarks for performance evaluation and strategic management. Here is how KPIs are typically structured within the broader context of metrics and data:

1. Data. Data is the raw, unprocessed facts and figures collected from various sources, and it is at the base of the hierarchy. This data is fundamental as it provides the input needed for more complex analysis. In strength and conditioning, this could include everything from workout logs and dietary records to physiological measurements taken during training sessions.
2. Metrics. Metrics are derived from this data; they are quantifiable measures used to track and assess the status of specific processes. While all KPIs are metrics, not all metrics are KPIs. Strength and conditioning measurements might include total weekly training hours, average calorie intake, or average resting heart rate.
3. Key performance indicators (KPIs). KPIs are a subset of metrics identified as critical to the success of an organization, project, or specific goal. They are strategically selected to align with overarching goals and objectives. In the context of strength and conditioning, KPIs might focus on particular targets that indicate the success of a training program, such as improvements in 1RM and VO2 max or reductions in body fat percentage.
4. Critical success factors (CSFs). Critical success factors are the essential areas of activity that must be performed well to achieve the organization's or project's mission, objectives, or goals. KPIs are often directly tied to these factors, providing measurable outcomes that reflect success or failure in these critical areas.
5. Objectives and goals. Objectives and goals are at the top of the hierarchy. These overarching aspirations guide what the organization or individual aims to achieve. Objectives are broader and more long-term, while goals are often more specific and short-term. KPIs are instrumental in measuring the progress toward these goals and making strategic decisions based on quantifiable metrics.
6. Strategic alignment. KPIs are essential because they link everyday activities to the broader strategic objectives of an organization or project. By monitoring KPIs, managers and coaches can assess performance, make informed decisions, and steer their teams or clients toward achieving predefined targets. This hierarchy ensures that all levels of data and metrics are aligned with the ultimate goals, providing a clear pathway from raw data to strategic outcomes.

How Do You Decide What KPI to Use?

These days, with technology, HP professionals can measure just about anything. But is the measurement meaningful and necessary? The best way to decide is through a systematic approach. Having a systematic approach allows the S&C professional to ensure the KPI meets the needs of the HWS and SC program. The following six-step process is one of many approaches an S&C professional can use (Fig. 5.1).

Step 1: Initiate the process of setting a human performance metric.
Step 2: Define the performance objective.

– Clarify the desired outcome.
– Align with organizational goals.

DP #1: Does a KPI(s) exist for the question to be answered?
Step 3: Use KPI(s).
Step 4: Establish a performance baseline.

– Assess current performance levels.
– Benchmark against best practices.

Step 5: Set performance standards.

– Define clear performance targets.
– Incorporate flexibility.

Step 6: Implement and monitor performance metrics.

– Communicate expectations.
– Monitor progress continuously.

DP #2: Does the KPI(s) answer the performance question?

A systematic approach to determining KPIs in the human performance profession is essential because it ensures alignment with an organization's or individual's broader goals and objectives, ensuring that the metrics chosen are genuinely relevant. This approach fosters consistency and objectivity, reducing the influence of biases and ensuring that decisions are based on data and evidence. By thoroughly analyzing all pertinent aspects of performance, a systematic process helps to identify comprehensive KPIs that provide a complete picture of what *needs* to be measured and ensures that these indicators are measurable, comparable, and tangible, often through benchmarking, which enhances their effectiveness in driving performance improvements. Moreover, this approach allows for efficient resource allocation by focusing efforts on the most impactful areas. It also supports continuous improvement, as KPIs can be regularly reviewed and adjusted to remain relevant. Additionally, systematically chosen KPIs are more straightforward to communicate with and gain stakeholder acceptance, leading to better engagement and commitment. Finally, this approach aids in risk management by anticipating potential

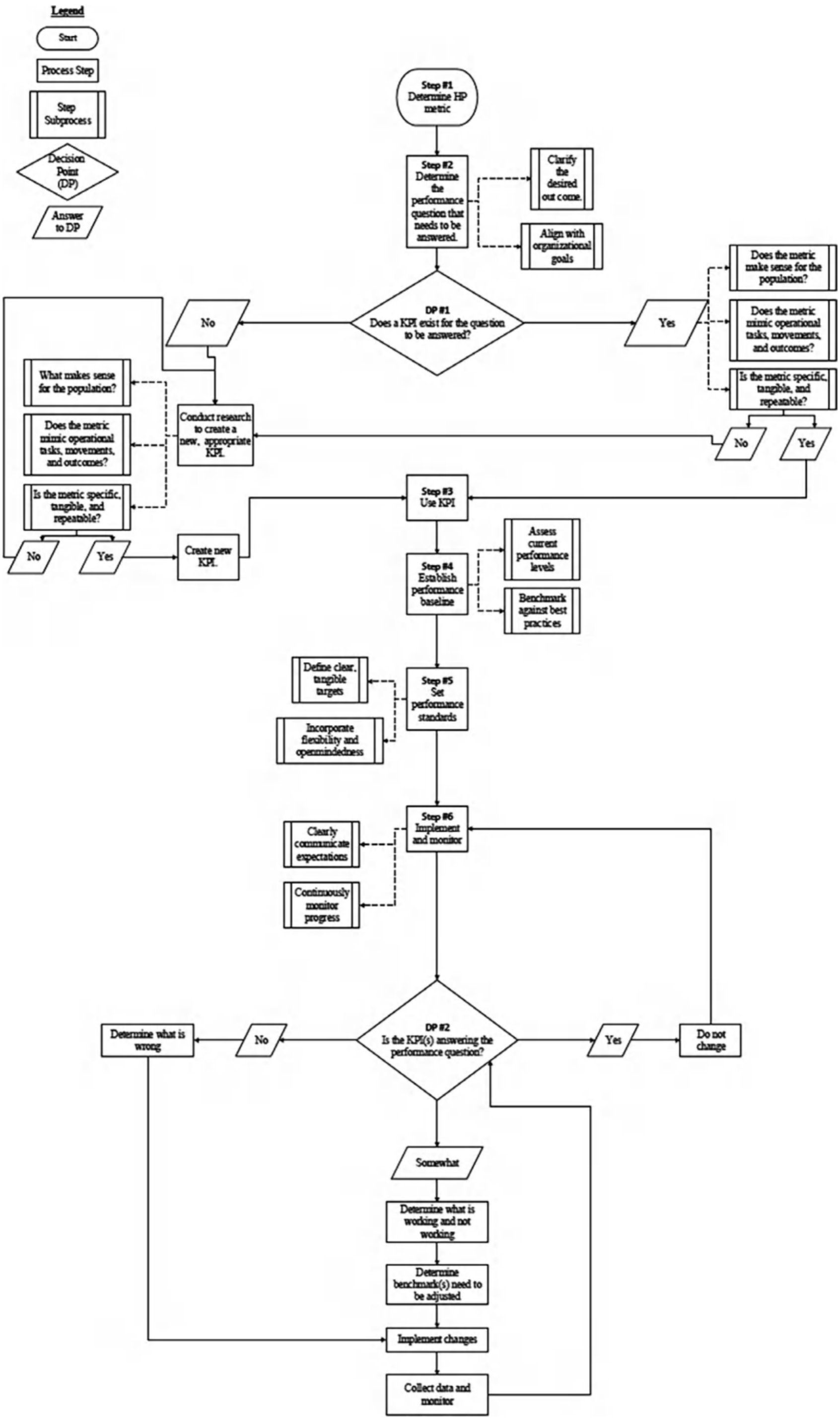

Fig. 5.1 Performance metric decision flowchart. This figure depicts a six-step decision process to determine performance metrics for an S&C program. In the chart, DP = decision point and KPI = key performance indicator

performance-related risks and selecting KPIs to monitor and address them, ultimately increasing stakeholder buy-in and ensuring meaningful improvements in human performance.

The flowchart in Fig. 5.1 outlines a few questions the S&C professional should consider; however, they are not the only questions. The following are some other questions the S&C professional should consider in the KPI decision-making process:

1. What are the physiological requirements to be a successful HWS?
2. What energy systems are most stressed or utilized in a working environment?
3. Is there a minimum strength requirement? How does kit/equipment play a role in load carriage?
4. Does the athlete need to be mobile? If so, what joints are most impacted?

For the HWS, the following provides a list and description of sample KPIs that might be measured to assess physical performance:

Here are definitions for each of the terms:

1. *Absolute strength*. Absolute strength is an individual's maximum force, regardless of body size or weight. This metric is typically measured by the maximum weight lifted in exercises like the bench press, squat, or deadlift [1–4].
2. *Relative strength*. Relative strength is the amount of strength an individual has in relation to their body weight. This metric is calculated by dividing the absolute strength by the individual's body weight, providing a measure of strength that accounts for body size [1–4].
3. *Muscular endurance*. Muscular endurance is the ability of a muscle or group of muscles to sustain repeated contractions or maintain a static contraction over an extended period without becoming fatigued [1–4].
4. *Power*. Power is the ability to exert maximum force via explosive movements quickly. This movement combines strength and speed [1–4].
5. *Aerobic capacity (VO2 max)*. Aerobic capacity, or cardiovascular endurance, is the maximum amount of oxygen the body can utilize during prolonged, sustained physical activity. It reflects the efficiency of the heart, lungs, and muscles in using oxygen during endurance activities like long-distance running or swimming [1–4].
6. *Anaerobic capacity*. Anaerobic capacity refers to the body's ability to perform high-intensity activities for short durations where the energy demand exceeds the oxygen supply. This capacity is essential in activities such as sprinting or weightlifting, where energy is derived primarily from anaerobic metabolism [1–4].
7. *Flexibility*. Flexibility is the range of motion available at a joint or group of joints. This quality depends on the extensibility of muscles, ligaments, and tendons and is essential for movement efficiency and injury prevention [1–4].
8. *Mobility*. Mobility is the ability to actively move a joint or series of joints through a full range of motion. This metric combines flexibility with strength,

control, and coordination and is essential for performing dynamic movements effectively and safely [1–4].

9. *Training stress*. Training stress is the cumulative physical and psychological strain placed on the body during exercise, influenced by factors like intensity, volume, and frequency of workouts. It determines how the body adapts, with potential outcomes ranging from improved fitness to overtraining if not adequately managed.
10. *Stress*. Stress is the body's response to any demand or challenge, whether physical, mental, or emotional, that disrupts its equilibrium. It can trigger physiological and psychological reactions, impacting overall well-being and performance.
11. *Sleep*. Sleep is a natural, recurring state of rest in which the body and mind undergo vital processes for recovery, memory consolidation, and overall health. It is characterized by reduced consciousness, muscle activity, and sensory response, essential for physical and mental well-being.

Determining which KPI is a crucial step in improving human performance. A systematic approach to choosing a KPI is essential for ensuring that the selected metrics accurately reflect progress toward desired outcomes. This methodical selection process allows for aligning KPIs with strategic objectives, ensuring they are relevant and actionable. In the context of HWS performance, this approach is particularly crucial as it ensures that the chosen KPIs not only measure technical and physical outputs but also consider the holistic well-being of individuals.

The next section of this chapter discusses stress, its effects on HWS performance, and how KPIs can be used to monitor stress. Stress metrics often need to be understood and utilized for HWS populations. Properly selected KPIs can highlight areas where stress management interventions are required, as excessive stress negatively impacts human performance.

What Is Stress?

In the 1930s, Hans Selye first coined the term "stress," or "the nonspecific response of the body to any demand" [5]. For the HWS, stress is anything that might disrupt their "normal" environment, including but not limited to occupational, relationships, financial, psychological, or physiological stressors in the short-term (acute) or longer-term (chronic). The brain [1] decides what stimuli threaten the individual; [2] regulates physiological, behavioral, cognitive, and emotional responses that an individual will utilize to manage said stressors; and [3] adjusts its plasticity as a response to mitigating stressful events [6]. The brain constantly receives and processes external stimuli from the environment and internal stimuli from the body. The brain seeks to maintain a homeostatic (i.e., balance) environment. As the body receives said inputs, it constantly modifies and adjusts physiological and psychological outputs to meet the challenges imposed upon it. Stress can be characterized

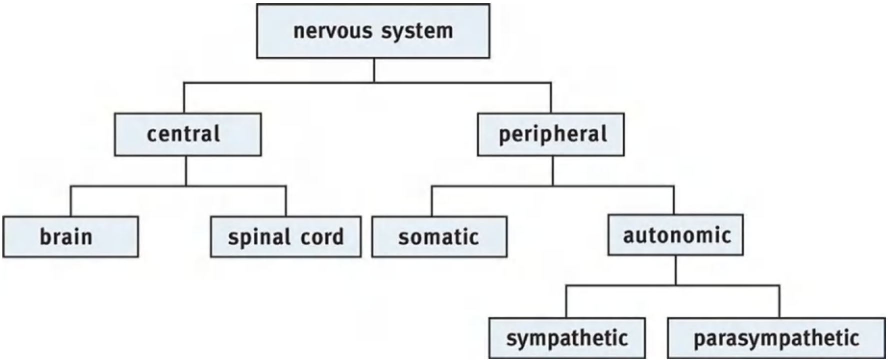

Fig. 5.2 The nervous system organization

as "good stress" or "bad stress," depending on the individual's perception of the stressor itself. A positive perception of stress and the ability to meet the demands of the stressor can promote growth and adaptation over time; conversely, negative perceptions of the stressful experience can lead to neural, physiological, behavioral, cognitive, and emotional deviations, increasing the risk of adverse health implications [6, 7].

When an HWS enters a combat zone, the body might reallocate its resources toward cardiac output and peripheral vascular resistance to support large muscle groups required for immediate action (i.e., being shot at) [6]. McEwen and Gianaros (2011) reference the following biological systems involved in the stress adaptation response: the hypothalamic-pituitary-adrenal (HPA) axis, the autonomic nervous system (ANS), the metabolic system, the gut, the kidneys, and the immune system. Our autonomic nervous system (ANS) functions subconsciously and involuntarily, such as keeping our heart pumping and lungs working and digesting food without us needing to complete these consciously, therefore playing a significant role in regulating our homeostatic environment. The ANS can be divided into two branches: the sympathetic nervous system (SNS) and the parasympathetic nervous system (PNS), as shown in Fig. 5.2. Both systems are always working; however, one system is always more "active" than the other, depending on how the body perceives its environment. Due to this, the tissue activity is either enhanced or inhibited [7], albeit each system becomes more dominant in certain situations.

Stress and Our Autonomic Nervous System

HWS professionals must operate under highly stressful conditions at various points in their careers. The nature of the HWS's career dictates that they perform duties under high physiological arousal and psychological stress [3]. For reference, deployments and the unpredictability of direct action can elicit a high-stress environment

[3]. Stress poses significant physiological implications to the body, with studies demonstrating that chronic, low-grade inflammation can lead to severe health consequences later in life [4]. For a HWS, understanding stress, the implications of one's physiology, how to measure it, and how to reduce stress is imperative to improving health and wellness in the short and long term.

The sympathetic nervous system, or the "fight or flight" system, predominates in any type of high-stress situation, such as combat or intense physical exercise. The parasympathetic nervous system predominates in quiet, nonstressful situations, such as sitting and relaxing. The parasympathetic nervous system's main objective is to conserve energy and the body's resources when the individual needs to transition to a sympathetic state. Figure 5.3 highlights the physiological responses of both the parasympathetic and sympathetic states.

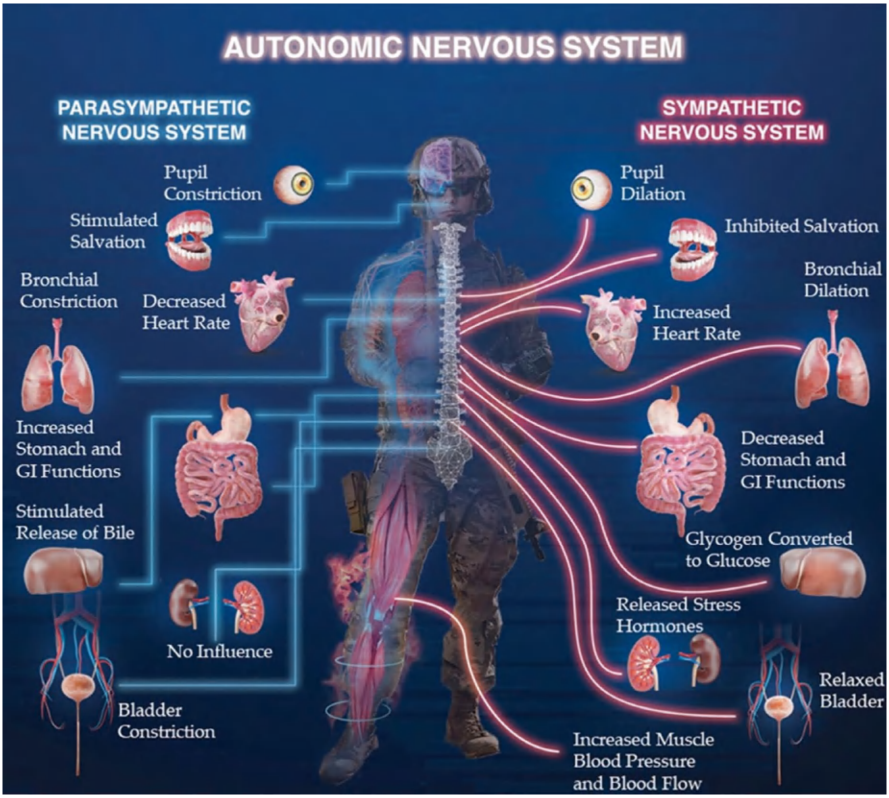

Fig. 5.3 Effects of the autonomic nervous system on the organs of the human body. This figure is initially published at https://www.ncbi.nlm.nih.gov/pmc/articles/PMC8834678/ [5]

Acute vs. Chronic Stress

Stress can be acute or chronic, affecting short-term and long-term health. Acute stress is mediated predominantly by the sympathetic nervous system, eliciting spikes in blood glucose, blood pressure, heart rate, and a spike in inflammatory cytokines, all activated to increase the individual's chance of survival. Keep in mind that stress is stress. At the core, the human body cannot distinguish between being in a combat zone, fighting with your significant other, or suffering through strenuous exercise. There are several physiological responses to acute stress: increased HPA axis activity, cortisol increases, and sympathetic nervous system activation (Fig. 5.4).

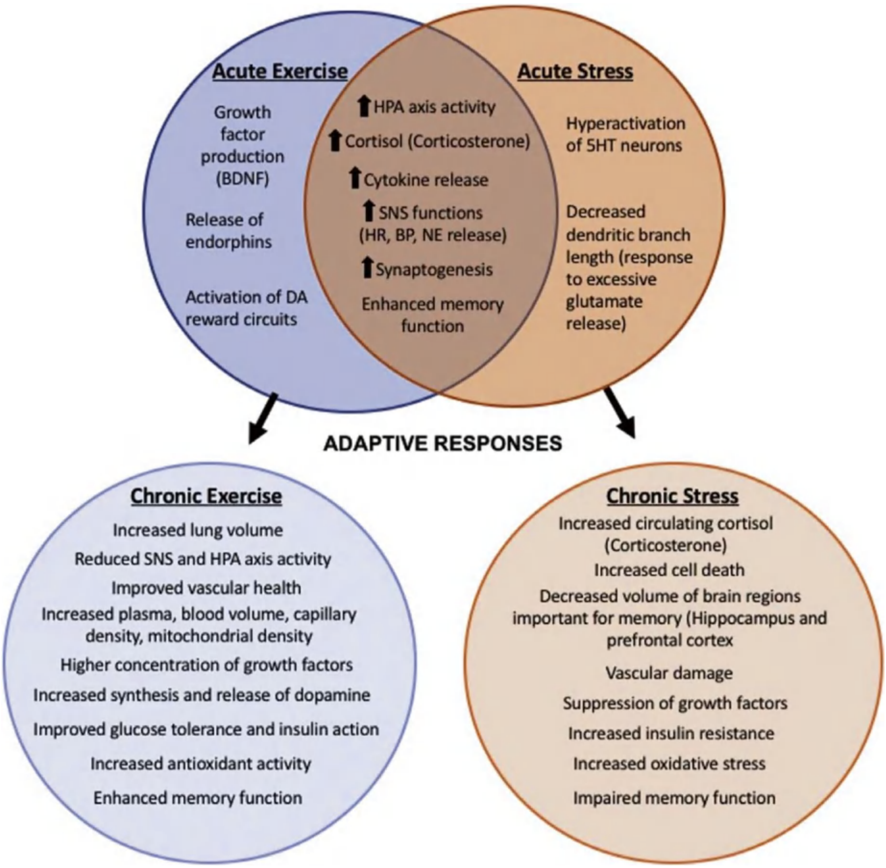

Fig. 5.4 The different effects of acute versus chronic stress. This figure is initially published at https://www.researchgate.net/profile/Justin-Lawson-2/publication/323363076/figure/fig2/AS:634546768859138@1528299147861/Acute-and-Chronic-Effects-of-Stress-and-Exercise-Acute-effects-of-exercise-and-stress.png [6]

Chronic stress, characterized as stress over several days, weeks, and months, is associated with a plethora of diseases, such as cardiovascular disease, insulin resistance, and cancer [7–9]. Bustamante-Sanchez et al. (2020) articulate the following regarding stress:

> The general definition of 'stress' focuses on acute intense situations, such as the fight or flight response presented in the military population during combat and combat situations. However, the brain, as the central organ managing stress, since it perceives what is threatening, as well as the behavioral and physiological responses to the stressor, leads to adaptations (i.e., allostasis) but also contributes to pathophysiology ('allostatic load/overload') when overused and dysregulated. Thus, the stress response becomes chronic when the stressor keeps affecting the psychophysiological response over time. [10]

As HWS professionals endure acute stressor after acute stressor throughout their careers, if they are not able to properly regulate their responses, their autonomic nervous system becomes dysregulated, leading to a disruption of their homeostatic environment and potentially further pathological issues [2]. This aspect is referred to as allostasis and allostatic load.

Allostasis and Allostatic Load

Allostasis and allostatic load are critical components when one examines stress and stress regulation. Allostasis, or the ability of the organism to maintain its homeostatic environment through change, refers to acute and momentary fluctuations in response to stressors [11–13]. Allostatic load, however, refers to the cumulative changes occurring over a determined period. It occurs

> in situations of either energy insufficiency, in which energy demand exceeds supply, and focus must be diverted wholly to survival and the maintenance of positive energy balance, or in situations with energy abundance, but social conflict or disruption…it disrupts cardiovascular autonomic balance, and are associated with the development of chronic diseases, such as excessive inflammation, chronic pain, diabetes, and more. [11]

Per McEwen and Gianaros (2011) stated that maladaptive adjustments can lead to increased wear and tear on the body, increasing the risk of stress-related mental and physical health conditions. Furthermore, lifestyle habits common with these professions, such as smoking, alcohol consumption, poor sleep, dietary habits, and lack of physical activity, all influence the HWS's ability to respond accordingly to stressors imposed upon them [14].

> The ability to self-regulate under stressful conditions is vital to those in armed tactical occupations, such as military or law enforcement, whose reliability depends on performance and sound judgment when executing their duties. [12, 13]

Metrics That Help to Measure Stress

Heart Rate Variability

An individual's resting heart rate, measured in beats per minute, indicates their overall fitness and health. A lower resting heart rate means a healthier individual and one at decreased risk of cardiovascular disease. In contrast, individuals with higher resting heart rates are generally more predisposed to risk of cardiovascular disease. Arpit et al. [14] determined that the "highest cardiorespiratory fitness (CRF) with lower mortality rate was found in individuals with a resting heart rate (RHR),<60 beats per minute (bpm), participants with a higher RHR, >80 bpm, were at a greater risk of both CVD and all-cause mortality when compared with RHR <60 bpm" (citation). The results from their study stipulated that "individuals with hypertension (HTN) and higher resting heart rates were 1.38 times greater risk for all-cause mortality compared to those with HTN and lower RHR (<60bpm)" (citation). "Individuals with higher RHRs had a 1.52 times greater risk for cardiovascular mortality compared to those with lower RHRs" (citation). Furthermore, low resting heart rate is shown to be correlated to an increased survival rate and lower susceptibility to chronic diseases [14]. The bottom line is that the fitter the individual is, the typically lower the resting heart rate and, therefore, the lowest mortality risk. So why does this matter and relate to stress, the autonomic nervous system, and performance metrics?

As mentioned above, the autonomic nervous system comprises two branches: the parasympathetic nervous system (rest or digest) and the sympathetic nervous system (fight or flight). Where the parasympathetic nervous system looks to preserve the body's resources and regulate most of the organism's involuntary processes, such as heart rate, the sympathetic nervous system is activated in situations requiring immediate action to ensure survival, such as increased blood flow and increased heart rate. While heart rate can be measured in beats per minute, the time between beats constantly varies. This aspect is referred to as heart rate variability (HRV). It exhibits the joint activity of the parasympathetic and sympathetic tone on heart rate and serves as an indicator of cardiovascular status [2]. The sympathetic nervous system decreases the time between heartbeats, whereas the parasympathetic nervous system increases the amount between heartbeats. When the sympathetic nervous system predominates, the organism's heart contracts more forcefully and faster due in part to the release of catecholamines secreted by the adrenal gland [[11], 15]. The parasympathetic nervous system is regulated through the vagus nerve, and when it predominates the organism, it slows the heart rate down.

How It Works

Heart rate variability (HRV) refers to the variation in time intervals between consecutive heartbeats, a reflection of the autonomic nervous system's regulation of the heart. A higher HRV indicates greater adaptability and a healthy balance between the autonomic nervous system's sympathetic (fight or flight) and parasympathetic (rest and digest) branches. Conversely, lower HRV is often associated with stress, fatigue, or underlying health conditions, suggesting a dominance of the sympathetic nervous system—various factors, including age, fitness level, stress, and overall health, influence HRV. Individuals and health professionals commonly use this metric in health and fitness monitoring to assess recovery, stress levels, and cardiovascular health. Regular monitoring of HRV can provide valuable insights into an individual's physiological state and help guide lifestyle or training adjustments to improve well-being. Understanding HRV allows for a more nuanced approach to managing stress, enhancing performance, and promoting long-term health.

Sleep and Sleep Hygiene

Sleep is far and away the most crucial recovery tool the HWS has within its arsenal. For any individual, sleep is a biological necessity for organismal survival. Proper brain functioning is critical; furthermore, disturbances in sleep significantly increase the risk of infectious diseases, cardiovascular diseases, cancer, and struggles with anxiety or depression [16].

Literature establishes that HWSs have constantly varying schedules in garrison and while deployed. Additionally, service members must complete multiday or multiweekly training events in the garrison. Frequently, this results in long days and lack of sleep. As noted by Good et al. [17], "a single night of > 24-hour sleep deprivation and chronic sleep restriction (<7 days) have yielded immediate, short-term compromises in physiological and brain health at levels of neural connectivity, endocrine and molecular signaling cascades, and psychological/behavioral outcomes…..single night of > 24-hour sleep deprivation rapidly increased…signatures of brain inflammation and risk for Alzheimer's disease-that did not fully return to baseline levels after recovery sleep" [17, 18]. Two primary systems are influenced by sleep: the hypothalamus-pituitary-adrenal (HPA) axis and the sympathetic nervous system. Cortisol levels, epinephrine, and norepinephrine drop [19], while growth hormone, prolactin, and melatonin levels increase. Conversely, as noted by [20], chronic sleep disturbances can lead to activation of HPA and SNS pathways, eliciting increased inflammation within the organism.

This intersection presents a significant challenge in establishing a sound circadian rhythm and enabling the HWS to obtain restorative and restful sleep. Good et al. [17] noted that "significant mental and physical derangements caused by degraded metabolic, cardiovascular, skeletomuscular, and cognitive health often result from insufficient sleep or circadian misalignment. Insufficient sleep and fatigue compromise personal safety, mission success, and national security." Therefore, understanding sleep and how the HWS can utilize wearable metrics to promote excellent sleep hygiene becomes imperative.

What Is Sleep?

Sleep is a state of unconsciousness in which the brain becomes more reactive to internal stimuli than external ones (citation). There are two main stages of sleep: rapid eye movement (REM) and nonrapid eye movement (NREM) sleep. The sleep cycle has four stages, three of which are NREM sleep and the last REM (Fig. 5.5). Most sleep occurs in NREM; additionally (Fig. 5.5), the first half of the night is

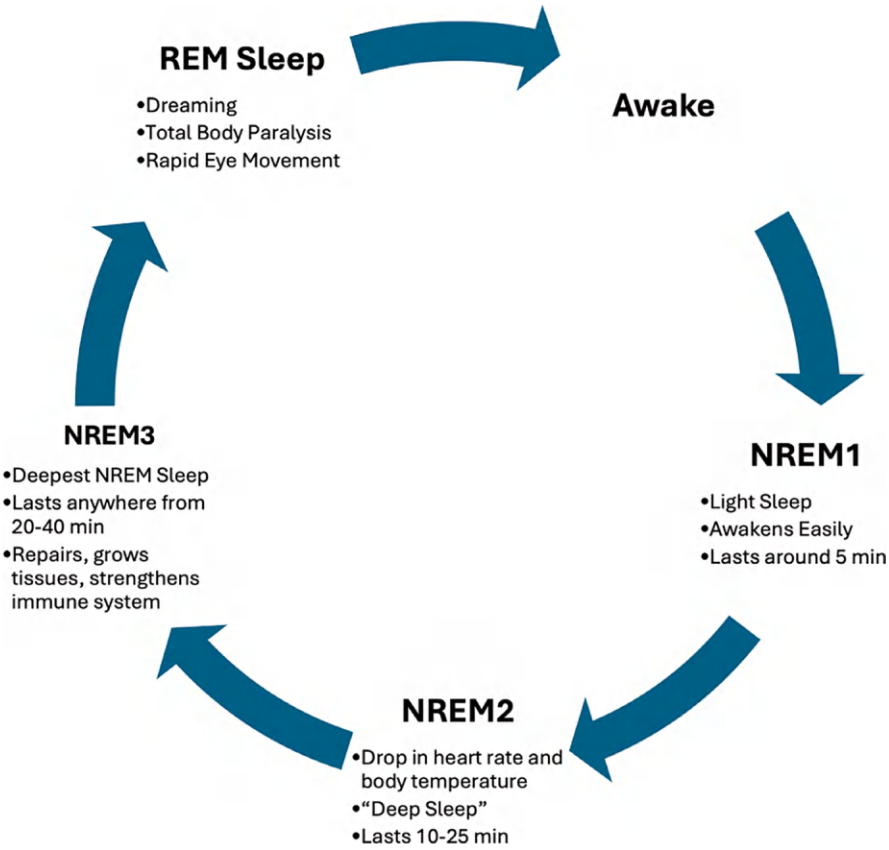

Fig. 5.5 The stages of sleep

spent in most of NREM, whereas the back half is spent in REM. See below for a synopsis of each stage within the sleep cycle:

NREM1, known as light sleep, lasts around 5 min. The individual is still easily woken up, and more than half of the alpha waves are replaced with low-amplitude mixed-frequency (LAMF) activity. This accounts for roughly 5% of total sleep. NREM2, known as deeper sleep, is characterized by a drop in heart rate and body temperature. This stage lasts 10–25 min in the initial sleep cycle but typically consumes 50% of total sleep later in the night. NREM3 is characterized as the deepest NREM sleep, shown as delta waves on the EEG, and lasts anywhere from 20 to 40 min. This stage is when the body repairs and regrows tissues, builds bone and muscle, and strengthens the immune system. The last quarter of sleep is known as REM sleep and is responsible for dreaming.

Additionally, REM is also characterized by total body voluntary muscle paralysis. Patel et al. note the following regarding the REM sleep stage: "associated with dreaming, irregular muscle movements as well as the rapid movement of the eyes, loss of motor tone, increased O_2 use, increased and variable pulse, and blood pressure, increased levels of ACh, and increased brain metabolism." Each sleep cycle takes approximately 80–110 min to complete.

The American Academy of Sleep Medicine (AASM) and the Sleep Research Society (SRS) established recommendations for the requisite amount of sleep required for optimal health in adults: Sleeping <7 h per night is associated with adverse health outcomes, such as weight gain, obesity, stroke, depression, inflammation and impaired immune function, impaired performance, and greater risk of accidents. Conversely, individuals sleeping >9 h per night may benefit those recovering from illness or sleep debt. Sixty-three percent of Americans slept 7–8 h per night, with 28% sleeping six or fewer hours a night. Conversely, around 70% of service members slept six or fewer hours per night, with under 30% sleeping the recommended 7–8 h [17].

Training Stress

Measuring training stress is crucial for optimizing athletic performance and preventing overtraining. By quantifying the physical and physiological demands placed on the body during exercise, HWS and HP professionals can better understand the balance between training intensity and recovery. This allows for more informed decisions on adjusting workout loads to enhance performance while minimizing the risk of injury and burnout. Monitoring training stress also provides insights into how well the body adapts to training, helping to fine-tune programs for sustainable progress and long-term success.

Biowearables measure and quantify training stress by continuously monitoring physiological metrics that reflect the body's response to physical activity. These devices use sensors to track heart rate, HRV, respiration rate, skin temperature, and sometimes even blood oxygen levels and sweat composition. For instance, heart rate and HRV data provide insights into cardiovascular stress and autonomic nervous system balance, with lower HRV during or after exercise indicating higher training stress. Similarly, respiration rate and oxygen saturation levels can reveal how well the body meets its oxygen demands during intense workouts. At the same time, skin temperature and sweat composition offer additional indicators of physical exertion and stress.

The data these sensors collect is processed by algorithms that quantify training stress in terms of load or strain, considering factors like exercise intensity and duration. Advanced biowearables may also analyze sleep quality and recovery, integrating these findings into a "readiness score" or similar metrics that help users adjust their training intensity accordingly. This comprehensive analysis enables athletes and fitness enthusiasts to tailor their training programs for optimal performance, reducing the risk of overtraining and injury while ensuring adequate recovery.

Interventions to Stress

Human performance professionals can effectively use stress metrics as a critical intervention tool for human weapon system professionals, such as military personnel, to enhance their resilience and overall performance. By monitoring physiological indicators like heart rate variability, cortisol levels, and sleep patterns, these professionals can gain insights into an individual's stress load and recovery status. Understanding these metrics allows for identifying early signs of chronic stress or overtraining, which could compromise physical and cognitive performance in high-stakes environments. With this data, interventions can be personalized, including adjustments in training load, targeted recovery strategies, and mental resilience training to optimize stress adaptation.

Furthermore, real-time data from these metrics can guide stress management techniques such as mindfulness, controlled breathing exercises, and tailored rest protocols. Regular assessment of stress levels ensures that interventions are timely, preventing the escalation of stress-related issues that could impair decision-making, focus, and physical readiness. In a broader sense, these practices contribute to a holistic approach to performance enhancement, ensuring that HWS professionals maintain peak readiness while minimizing the risks associated with stress accumulation. This proactive approach not only safeguards the well-being of these individuals but also maximizes their operational effectiveness and longevity in their demanding roles.

Conclusion

Selecting the correct key performance indicators (KPIs) for human performance monitoring is paramount for human weapon system professionals. These individuals operate in environments where their physical and cognitive abilities are constantly tested, often under extreme conditions. Therefore, the KPIs chosen must be directly aligned with the specific demands of their roles, accurately reflecting their readiness, resilience, and overall well-being.

Effective KPIs provide actionable insights into various aspects of performance, from physical fitness and endurance to mental acuity and stress management. By focusing on the right metrics, human performance professionals can tailor training programs, recovery protocols, and stress interventions to the unique needs of these professionals, ensuring they remain at peak performance levels.

Moreover, appropriate KPIs facilitate early detection of potential issues, such as overtraining, fatigue, or cognitive decline, allowing for timely and targeted interventions. This proactive approach enhances the operational effectiveness of human weapon system professionals and contributes to their long-term health and career sustainability. In essence, carefully selecting and continuously evaluating KPIs are critical for optimizing human performance in these high-stakes environments, ensuring that these professionals are fully equipped to meet the challenges of their demanding roles.

Remember, *data drives decision-making!*

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Chapter 6
Foundations of Strength Training

Patrick McHenry and Christopher Myers

Principles of Strength Training

Weight training is the "application" of scientific "theories" and has evolved over hundreds of years. Strength or weight training involves moving various objects (e.g., metal plates, dumbbells, medicine balls, and implements) to produce the desired result [1]. The ultimate goal is to achieve a particular aspect of fitness [2]. Unlike general physical activity, which might focus on cardiovascular health or flexibility, strength training emphasizes increasing the ability of muscles to produce force. Seven guiding principles are used to create an effective strength training program, providing a foundation for strength training methods and helping to ensure progress toward specific goals [2, 3].

1. Specificity
   - (a) Subprinciple: training modality compatibility [3]
   - (b) Subprinciple: directed adaptation [3]
2. Overload
3. Fatigue management
4. Stimulus-recovery-adaptation (SRA) [3]
5. Variation
6. Phase potentiation [3]
   - (a) Subprinciple: adaptive decay [3]

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7. Individual difference [3]

These principles are used in any training method to induce muscular adaptation to the training stress. These principles are implemented through programming (Chap. 4) and equipment. The proper equipment and facilities help facilitate the execution of the programmed training.

Facilities and Equipment

Successfully running a strength and conditioning program at the organizational level, particularly for human weapon system (HWS) professionals, requires strategic planning for facilities and equipment to meet specific needs identified during the needs analysis (Chap. 3). Budget, space, and needs of the HWS will dictate facilities and equipment. Keeping the equipment basic allows multiple exercises without requiring specialized equipment. The National Strength and Conditioning Association (NSCA), National Council of Strength and Fitness (NCSF), and American College of Sports Medicine (ACSM) provide comprehensive guidelines to consider when developing or revamping a training facility [1, 4–6]. This section discusses the fundamental considerations in creating a well-equipped strength and conditioning environment that fosters progress, safety, and efficiency.

Facility Design and Layout

The facility's layout is critical to the success of a strength and conditioning program. The design should accommodate all necessary equipment, a smooth flow from station to station, a line of sight for the coach to each station, and safety. Some key elements to consider are as follows:

1. Facility space: The number of participants and type of SC training determine the space needed. Considering these aspects prevents overcrowding and reduces accident risk. Strength and conditioning programs require areas for both lifting and functional movement drills, so open spaces free of obstructions are essential.

   An HWS SC training facility may or may not resemble a high-performance facility or a local gym. The training space is often created within the walls of the current HWS facility. The SC coach may be limited to a single room within the firehouse or in a tent in Germany. The following is a real-world example from when a new facility was created.

   Figure 6.1 depicts the initial schematics for an expeditionary performance training facility. The factor that made this facility "expeditionary" is that the facility is not made of brick and mortar. The walls were 40-foot connexes with a reinforced tent ceiling. The length and width of the facility is 140' x 38'. The center of the facility has a turf area just over 20' in length.

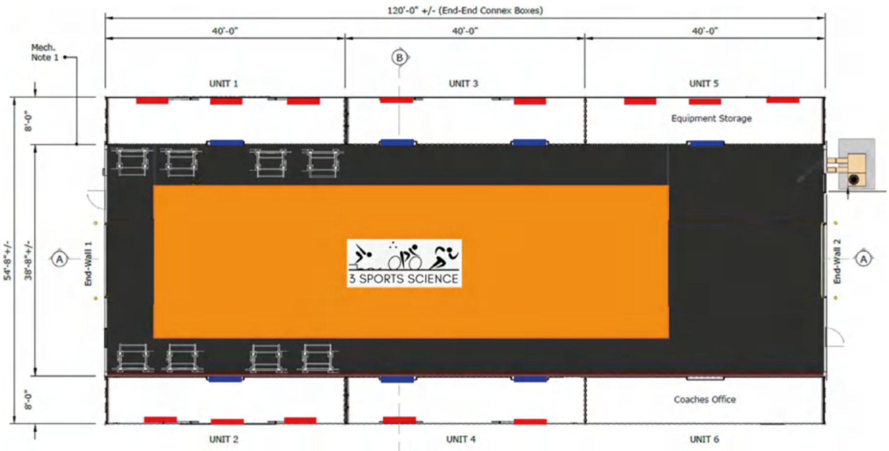

Fig. 6.1 Example of initial facility design

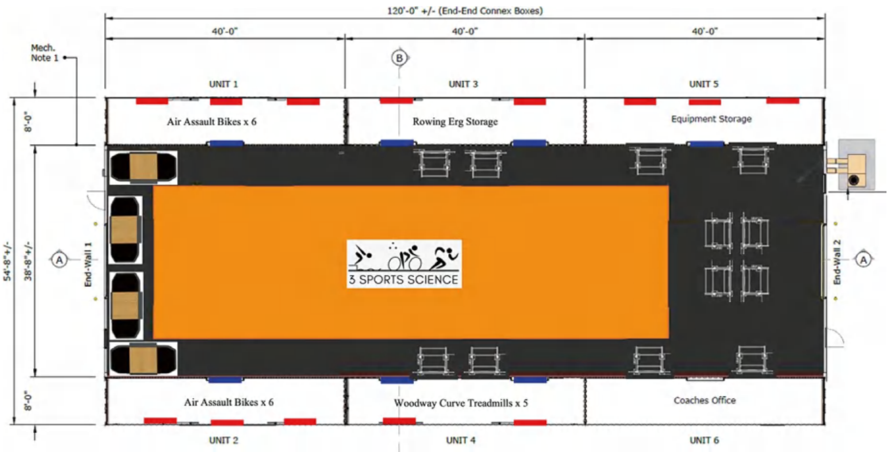

Fig. 6.2 Example of updated facility design

2. Segmentation of workout zones: Specialized training areas must be organized and identified. As shown in Fig. 6.2, the facility is broken into critical areas for weightlifting, Olympic lifting, cardio, flexibility, and recovery. This segmentation maximizes efficiency and safety. Additionally, this type of layout allows the SC professional to have clear lines of sight at every station.
3. Safety zones: Segmentation allows for safety. However, safety is a stand-alone principle. The training space needs to have enough space for safety. An example of this is allowing for enough space around racks and platforms. Participants need to have room to lift and move without risking injury.
4. Ventilation and lighting: This aspect is usually overlooked. Appropriate airflow and ample lighting are essential for maintaining a safe and comfortable workout

environment. A well-ventilated area helps regulate temperature and reduce humidity, but ventilation controls carbon dioxide levels. Furthermore, good lighting enhances visibility and safety.

Resistance Training Equipment Essentials

The equipment available for an SC program determines the types of training possible. At its core, SC programs train muscular strength, muscular endurance, and power. The program needs to have the appropriate equipment to train these muscular characteristics. The following is an essential list of equipment an HWS SC program should consider acquiring.

1. Free weights: Free weights are foundational for building functional strength and improving biomotor patterns. Fundamental items include:
   (a) Barbells: Olympic bars (45 lbs./20 kg) with varying weight plates are used for squats, deadlifts, presses, and other Olympic lifting movements.
   (b) Dumbbells: Dumbbells, ranging from light (5 lbs) to heavy (over 100 kg), allow for unilaterally training and target specific muscle groups.
   (c) Kettlebells: Kettlebells are used to develop power and functional strength, mainly through ballistic movements like swings, cleans, and snatches.
2. Power racks and squat racks: A sufficient number of racks should be available for squats, presses, and pull-ups.
3. Benches: Adjustable benches provide flexibility for various exercises, including bench presses, seated presses, and rows. Flat, incline, and decline options are ideal for a versatile strength program.
4. Deadlift platforms: For athletes focusing on powerlifting or Olympic lifting, platforms provide a sturdy and safe surface for deadlifts, cleans, and snatches. These platforms also help protect the facility floor.

Conditioning Equipment

Conditioning programs must include cardiovascular and metabolic conditioning to improve endurance, speed, and overall fitness (Chap. 7). The following equipment listing supports conditioning and circuit-based training programs:

1. Treadmills: High-quality treadmills allow interval running, sprints, or steady-state cardio work. Additionally, a solid treadmill enables the HWS to train while wearing mission-specific equipment.

2. Rowing machines: Rowing provides a full-body, low-impact workout that improves both aerobic fitness and muscular endurance.
3. Bikes: Stationary bikes, particularly air resistance models (i.e., air assault bikes), offer excellent options for high-intensity interval training (HIIT) or longer endurance work.
4. Sleds: Pushing or pulling sleds can build both strength and conditioning. This tool emphasizes functional movement patterns like acceleration and force application and can be used to mimic real-world biomotor patterns.
5. Battle ropes: Ropes are effective for increasing heart rate and building upper body endurance and power.

Movement Training Tools

Movement training equipment is essential for improving basic biomotor patterns and injury prevention. These tools are simple but effective. They focus on core stability, mobility, and balance.

1. Medicine balls: Available in various weights, medicine balls are excellent for explosive power exercises, such as slams, throws, and rotational drills.
2. Resistance bands: Resistance bands can be used for various purposes, including warm-ups, rehabilitation, mobility work, and assistance with bodyweight exercises like pull-ups.
3. Plyometric boxes: Boxes of different heights are essential for plyometric training, which develops explosive power and coordination.
4. Foam rollers and recovery tools: Foam rollers, massage balls, and mobility sticks are helpful for self-myofascial release and improving flexibility.

Safety and Maintenance

Safety is paramount in any performance or fitness program. The facility should adhere to the following safety standards:

1. First aid and automated external defibrillator (AED): Every facility must have easy access to first aid kits and AED devices in emergencies.
2. Rubber flooring: High-quality rubber flooring protects the underlying structure and reduces the impact on the HWS joints, particularly during high-intensity activities like jumping or lifting.
3. Storage racks: Proper equipment storage keeps the facility organized and reduces the risk of accidents caused by equipment left on the floor.

Technology Integration and Monitoring Tools

Modern strength and conditioning programs are beginning to integrate technology to track performance, modulate training stress, quantify progress, and prevent injury. Some may argue that technology is a nicety; however, the listed devices help to individualize organization-level SC programs.

1. Smartwatches and heart rate monitors: These devices allow coaches to track HWS's exertion levels and distance to enable individualized target heart rate zones.
2. Velocity-based training systems (VBT): VBT devices measure bar speed during lifts, providing real-time feedback on power output. These systems are very useful in monitoring fatigue.
3. Force plates: Force plates measure ground reaction forces and offer valuable data on lower limb power, balance, and asymmetries.
4. Video analysis systems: Video feedback is invaluable for correcting form (i.e., complex lifts like Olympic or multijoint exercises), gait analysis, and ROM/flexibility. SC professionals can provide HWS professionals to make real-time corrections, minimizing the risk of injury (Table 6.1).

Table 6.1 Example SC equipment list for a battalion-size element

Equipment list	# of pieces
Power racks	4–6
Adjustable benches	4–6
Olympic metal plates 5–45 lbs	4–6
Bumper plates 10–55	4–6
Dumbbells 5–120 (2.5 incr.)	2
Adjustable cable columns	4
Olympic bars	12
Collars	16 pair
Double dumbbell racks	2
Kettlebells 10–45 lbs	4 sets
Glut ham roller	12
Medicine balls 5–45 lbs	4 sets
Heavy med balls 60–120	2 sets
41 inch bands ¼–2 inch	15 sets
4 inch bands various sizes	10 sets
Push sleds	10
Bikes	15
Foam rollers	15
Sandbags 60 lbs[1]	45
Sandbags 100–50	2 sets
Revers hypers/glut ham	6
Plyo boxes	12

Fig. 6.3 The BeaverFit Performance Locker. This commercially available item through BeaverFit USA is an example of a mobile SC facility with equipment

Garrison Facilities Versus Deployed Facilities

An HWS organization's SC program usually resides in a semipermanent or permanent facility. However, in some cases, the SC facility must be expeditionary (i.e., deployable). A mobile SC facility allows an HWS organization to access the SC facility when not in the home station (Fig. 6.3). The SC facilities and equipment can often fit into a Conex box. Several companies make Conex boxes with racks attached to store the equipment inside the box. These containers range in size and available equipment. Many companies will work with the HWS organization to create a system that meets the organization's needs and budget.

Developing a Strength Training Program

Chapter 4 discussed periodization methodologies. The primary purpose of periodization is to properly regulate training stress to achieve a particular physiological outcome at a predetermined time. Training stress is the total of intensity, duration, and frequency variables.

Duration

Duration is the time for an exercise or training session [1]. Typically, a program should last between 1 h and 1:30, including the warm-up and cooldown. Research has shown that a training session should last approximately an hour. The hormone levels start to drop significantly after an hour, and the athlete will not benefit from the more extended session [4]. If the program lasts longer, several factors need to be examined: the number of exercises being performed in the workout, the number of athletes working at one time, the amount of equipment available, or the intensity of the athletes' workout. If the athlete is working at the correct pace (i.e., not talking or playing between sets) and working for more than an hour, the coach should see which exercises can be changed, modified, or eliminated from the workout. If the workout is for other reasons, the coach will have to work on the configuration of the schedule.

Intensity

Intensity is defined as the impact of the work performed on the target muscular and energy systems. The load determines the intensity, number of repetitions, sets, and recovery times in strength training determine the intensity [1, 4, 7, 8]. Load is the weight (pounds or kilograms) moved during a repetition. A *repetition (rep)* refers to the number of times one performs a movement in a single set. If a program calls for ten reps of a bench press, the HWS will perform ten reps or move the bar from the eyes to the chest ten times before putting the bar back on the rack. *Sets* refer to the number of times the exercise is performed. If the program calls for three sets of ten reps (also written as 3 × 10), then perform ten reps, rack the weight, recover for a determined period, perform ten reps, rack the weight, and then perform ten reps and rack the weight. Following these sets is performing three sets of ten reps on the bench press.

Recovery time significantly influences training intensity, particularly in high-intensity interval training (HIIT). Research suggests that longer recovery durations during HIIT sessions allow for higher external training loads, such as increased running speeds or power outputs, while maintaining similar internal physiological strain. For instance, a study on trained runners found that more extended recovery periods (3 min) enabled faster running velocities without increasing perceived exertion or physiological strain, indicating more effective training adaptations [7]. Similarly, investigations into sprint and cycling protocols revealed that shorter recovery periods lead to reduced mean power output and increased perceived exertion (RPE) ratings, making the sessions feel harder despite lower total work accomplished [8, 9]. This indicates that recovery time is essential for sustaining training intensity and performance over multiple intervals. Shorter recoveries, while increasing metabolic stress, may lead to more significant fatigue accumulation, reducing training efficiency [10]. Thus, adjusting recovery times can optimize training intensity and improve specific training outcomes.

Several standard methods are used to determine resistance training load, each with advantages depending on the specific training goals and individual needs. One of the most widely used methods is percentage-based training, which involves determining the load as a percentage of an individual's one-repetition maximum (1RM) or three-repetition maximum (3RM). This method sets the intensity relative to the 1RM, the maximum weight an individual can lift in a single repetition (Fig. 6.4). Another popular method is velocity-based training, where the load is adjusted according to the lifting speed, using tools like linear transducers to monitor bar speed (Fig. 6.5). This method allows for real-time adjustments based on fatigue levels. It ensures the load matches the athlete's current readiness, with studies supporting its effectiveness in improving strength and power with less training volume [11, 12]. Another approach involves load prediction using scientific tables or algorithms based on an individual's sport or physiological data, as demonstrated in specific student-athlete research [13]. Each method offers different advantages, with velocity-based training providing real-time adjustment while percentage-based training is more traditional and widely accessible.

Fig. 6.4 The load predictions are based on maximum repetition. This image can be found in the *Essentials of Strength and Condition,* 4th Edition [1]

Training goal	Load (%1RM)	Goal repetitions
Strength*	≥85	≤6
Power:**		
Single-effort event	80-90	1-2
Multiple-effort event	75-85	3-5
Hypertrophy	67-85	6-12
Muscular endurance	≤67	≥12

*These RM loading assignments for muscular strength training apply only to core exercises; assistance exercises should be limited to loads not heavier than an 8RM (2).

**Based on weightlifting-derived movements (clean, snatch, and so on). The load and repetition assignments shown for power in this table are *not consistent* with the %1RM–repetition relationship. In nonexplosive movements, loads equaling about 80% of the 1RM apply to the two- to five-repetition range. Refer to the discussion of assigning percentages of the 1RM for power training for further explanation.

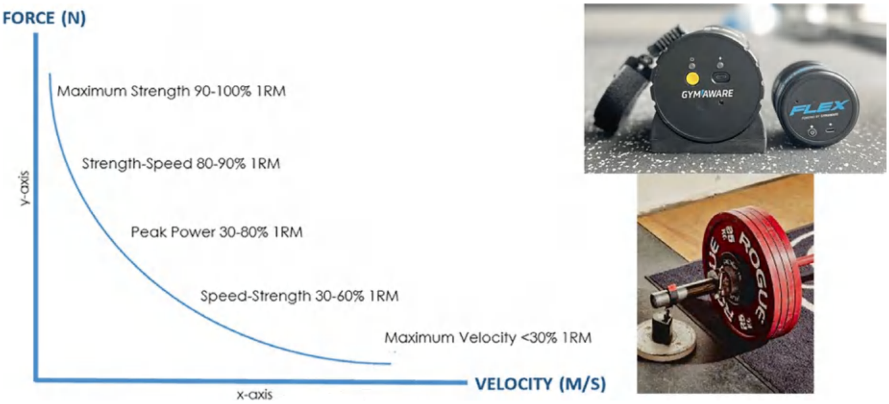

Fig. 6.5 Training zone force-velocity curve and examples of barbell velocity sensors

Strength

Strength is "the ability of a given muscle or group of muscles to generate muscular force under specific conditions" [14]. It can be measured by the amount of weight lifted. Type II fibers are used in this type of training. An example of sports that use this muscle fiber type would be football, basketball, soccer, lacrosse, baseball, or field events on track.

There are different types of strength, such as maximal, explosive (also known as power), or training maximum [14]. Maximal strength is demonstrated when a person moves as much weight as possible, regardless of speed. A powerlifter[1] performing a 1RM in competition demonstrates this. The weight moves at a slow speed. An example of an explosive lift is an Olympic lifter[2] because they must move as much weight as possible as fast as possible. This is more sport-specific because it replicates sports movements. Training maximum "is the heaviest load one can lift without substantial emotional excitement" [15]. In elite-level athletes, this could be as much as 12% of their competition maximum.

[1] Powerlifting is a sport where the lifter gets three attempts to lift as much as possible. Each attempt is for one rep only. The lifts are the bench, squat, and deadlift. Strict rules on form must be followed for the lift to be allowed.

[2] Olympic lifting is a sport where the lifter gets three attempts to lift as much as possible. Like powerlifting, each attempt is for 1RM. The lifts are the clean, jerk, and snatch.

Endurance

Muscular endurance is “submaximal contractions extended over a large number of repetitions with little recovery allowed between each set” [1, 4]. Type I muscle fibers are used in this type of training [1, 4, 10]. Examples of sports that use this muscle fiber type are cross-country running, bike races lasting longer than 5 min, swimming events lasting longer than 5 min, or running races covering more than one mile. In resistance training, muscular endurance is trained by performing higher repetitions and lower weights (Fig. 6.4) [1, 4].

Exercise Order

An essential aspect of a resistance training program is exercise order. Exercise order is vital for maintaining muscle balance. When lifting, muscles in the front /back and upper/lower need to be worked equally to prevent an imbalance. The program should alternate front exercise, back or upper body, and then lower body. This allows for proper rest between workouts so that the correct muscle fiber type is worked. An alternative term to opposing muscles is antagonist and agonist. The agonist is the primary muscle involved in a movement (i.e., in a bicep curl, the biceps brachia would be the agonist). The antagonist is the opposing muscle that would be a decelerator in a movement (i.e., in a bicep curl, the triceps brachii is the antagonist). The agonist/antagonist role switches as the movement changes (i.e., in a triceps push, the triceps brachii is the agonist, and the biceps brachii is the antagonist).

Frequency

Training frequency refers to the number of times the athlete works out, which includes both lifting and speed/agility workouts and can be expressed daily, weekly, or monthly. Without proper training frequency, training may be unproductive and possibly dangerous [4]. Many ways exist to structure the training frequency of a program. Some programs are 4 days a week, with Monday/Thursday being upper body days and Tuesday/Friday lower body days. Another example is to go 3 days a week with Monday/Wednesday/Friday lifting days and Tuesday/Thursday speed or agility days. These methods are just a few possibilities to put together the workouts. Whichever format is chosen, the program should allow for rest between muscle groups and incorporate a heavy, medium, and light day. The heavy day stresses the muscle, which breaks the actin/myosin down. The medium or light day allows the actin/myosin to rebuild so it can grow and be ready for the next heavy session.

Going heavy all the time on the same lifts causes the actin/myosin to break down, which does not let it rebuild. After several weeks of continuously going heavy, the athlete will reach a plateau, which causes overtraining. Overtraining leads to injuries and a decrease in performance.

Periodization

Periodization (Chap. 4) organizes training into specific phases to achieve the most significant training effect from the workouts. The most common ways to break up the training are preparatory, hypertrophy, fundamental strength, power, and competition (preseason/in-season/postseason/off-season) [1, 4]. The idea of breaking training into different phases or parts goes back to the Romans, Greeks, and Chinese, who used it with their military. Koto, Olympic Sport, 1917 wrote Siff, "One of the earliest texts on this subject, who considered it appropriate to divide the training into general, preparatory, and specific stages." Over the years, the Russians, who were at the forefront regarding Periodization, have been regarded as innovators in program design.

Specificity

Specificity is training[3] that enhances sports performance [4, 16]. "It is not only the exercise which modifies the body, or more specifically, neuromuscular system, but how the exercise is performed" [17]. The exercise should mirror the joint angles/range of motion, speed of movement, type of muscle contraction, and energy system.

Simulation is not the same as specificity. A simulation involves adding weight or implements while performing the movement. An example is adding weight to a bat when taking warm-up swings, throwing a heavier ball or shot in practice, or running with a sled or chute. It can positively affect performance; however, if done incorrectly, it will have a negative effect. Only 5–10% should be added to the implementation when performing simulation training.

When an athlete is trying to improve their vertical jump, run faster, or have better agility, they are training for *sport specificity*. This means the athlete is trying to develop the qualities needed to become the best athlete possible. Research has shown that cleans are effective for improving jumping and running because they have the same movement patterns. The muscles being used, the speed of movement, the range of movement, and the application of force are all the same. Thus, improving clean technique will improve running and jumping.

[3] Training can include weight training, plyometrics, or speed/agility drills.

Developing a Strength Training Program

Program design, training system, or periodization is putting all the program components together, including the order of lifts, load, number of sets/reps (volume), rest periods, and progression. Other factors like speed/agility workouts, plyometrics, and sport-specific conditioning should also be factored into the overall program [18].

"One mistake is to assume that the system used by a champion bodybuilder, powerlifter, or Olympic lifter is the best for a novice" [19]. Using a program because your competition or another team has had success with it can lead to disaster. Research has shown that there "is no scientific data on the relationship between a team's weight training program and their win-loss record" [20]. Each team, like an individual, has a unique makeup; therefore, the strength program must meet the entire team's needs. This is not to say that winning teams do not have the same lifts or program design components. There are aspects based on sound scientific principles that a quality program should have. Knowing how to assemble the elements is the "art and science" of program design. It is trying to copy another program exactly that will lead to problems.

Another misconception is going into the weight room and lifting without a plan. If novice athletes work out enough, they will get stronger with this "shotgun" approach. "Virtually any method of strength training enhances the strength of a novice during the first few months" [21]. As the athlete progresses and develops, this approach is less effective and can lead to a plateau, decreased performance, or even an injury. "A training record is invaluable for determining which training system works best for each individual" [19].

Periodization is like a puzzle where each component must fit together correctly to make a complete picture (Chap. 4). If not, the athlete and coach are wasting their time. *There is NO ONE CORRECT way to design a program, yet there can be many wrong ways*. If the coach/athlete does not consider all the components or variables when creating a program, they can quickly overtrain the athlete.

> Note: One crucial variable that many coaches/athletes need to consider is other activities that the athlete may be doing. For example, a high school volleyball player may be on a club team, playing high school volleyball, and in a lifting class. Depending on where they are in each season, this athlete could be working out three times a day. Without proper rest and communication among the coaches, this athlete could become overtrained in a matter of weeks.

To start designing a program, the coach/athlete performs a needs analysis (Chap. 3). Is this program for a beginner just learning the lifts, is it for an athlete trying to get better for their sport, or is it a program for someone who wants to lift? Once that question has been answered, the coach breaks it into three factors: the sport, the athlete, and the environment.

Conclusion

Understanding the basic elements of strength training is important to help a HWS professional achieve specific physiological goals. The interplay of these elements determine how skeletal is trained and will adapt. The coach and the HWS must work together to create a training program that will benefit the HWS professional.

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Chapter 7
The Science of Conditioning

Anthony Acevedo and Zachary Zeigler

Introduction

The conditioning practice has roots that stretch back to the dawn of time. The Greeks and Romans performed physical conditioning to prepare themselves for battle. The modern concept of physical conditioning began to take shape in the nineteenth and twentieth centuries with the emergence of organized sports and military training programs emphasizing fitness. Researchers have rapidly expanded their understanding of exercise physiology, sports science, and training methodologies in recent decades, developing various conditioning techniques.

Physical conditioning systematically applies various exercise and training protocols to enhance an individual's physical fitness, performance capabilities, and resilience. Conditioning holds multiple meanings for athletes and tactical populations, including the military, first responders, and law enforcement. Through various modalities and the utilization of systematic design and targeted exercises, conditioning can improve physical fitness and body composition or achieve the desired tactical outcomes of the human weapons system (HWS). The HWS operates in a dynamic and unpredictable environment, requiring a unique blend of conditioning techniques. Unlike traditional athletes specializing in a single sport or discipline, the HWS must be prepared for various physical challenges, from long-distance marches to high-intensity combat situations. Therefore, conditioning programs for HWSs must be comprehensive and adaptable, addressing the specific demands of their roles and missions.

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The Difference Between Conditioning and Aerobic Training

These terms are generally used interchangeably, and as they have similar interpretations and crossovers in outcomes, conditioning has distinct characteristics. Aerobic training involves structured and sustained physical activities that primarily engage the cardiovascular and respiratory systems to improve the body's efficiency in utilizing oxygen. Although aerobic training forms a fundamental aspect of a fitness regimen, it is crucial to distinguish between aerobic exercise and conditioning. While both aim to improve cardiovascular health and enhance physical fitness, they differ in focus and methodology. Table 7.1 summarizes the differences between conditioning and aerobic training.

Aerobic exercise plays a vital role in conditioning programs and is beneficial across multiple areas, from endurance and tactical environments to clinical environments like managing heart failure. Aerobic exercise is a critical tool in enhancing aerobic fitness and is crucial for maintaining extended periods of physical activity [1]. Regular participation in aerobic activities helps HWS professionals sustain prolonged exertion and can improve overall cardiovascular health. Additionally, it aids in recovery during intermittent high-intensity efforts, making it invaluable for HWS professionals who engage in scenarios requiring bursts of speed followed by rest periods [1–4]. This form of exercise supports physical endurance and contributes to better heart health by assisting in managing conditions such as heart failure. By integrating aerobic exercise into training routines, individuals can experience marked improvements in their fitness levels and athletic performance, demonstrating the comprehensive benefits of this exercise modality [1–4].

The cardiovascular system is responsible for transporting blood through the body, delivering oxygen and nutrients to the working muscles. Aerobic training, called cardio, can be categorized as movements that increase heart rate, breathing, and core temperature. It typically involves running, cycling, swimming, and brisk walking, performed at low to moderate intensity for extended durations. Aerobic

Table 7.1 Summary of differences between aerobic and conditioning training

Aspect	Aerobic training	Conditioning
Focus	Primarily cardiovascular and respiratory systems	Broader range, including strength, power, agility, coordination, and endurance
Activities	Running, cycling, swimming, brisk walking	Incorporates aerobic exercises plus resistance training, flexibility exercises, plyometrics, functional movements
Intensity	Low to moderate	Varies (can include high intensity)
Duration	Extended periods	Varies
Primary energy source	Fat	Varies depending on the exercise type
Main goals	Improves cardiovascular health, increases VO2 max	Enhance overall physical readiness, prepare for specific job-related tasks
Application to HWS	Foundational component	More directly applicable to job-specific demands

training can reduce the risk of cardiovascular disease, which has the highest death rate in the world [5], and increase maximal aerobic capacity (VO2 max), which is the body's ability to utilize oxygen and is a cause of mortality [6].

Conditioning encompasses a broader range of exercises and training modalities beyond aerobic activity. This systematic approach to training aims to enhance physical performance by improving various physiological and functional attributes [7]. It involves a comprehensive program that targets strength, endurance, agility, flexibility, and balance, tailored to the specific HWS needs [7]. This process prepares the body for the physical demands of exercise and aids in injury prevention and recovery. The following section explores the key components and benefits of conditioning in exercise. While aerobic exercise is a component of conditioning programs, they also incorporate resistance training, flexibility exercises, plyometrics, and functional movements designed to enhance strength, power, agility, coordination, and endurance. While aerobic training focuses primarily on cardiovascular fitness through sustained, rhythmic activities, an adequately designed conditioning program provides human performance (HP) programs to prepare the HWS for tasks related to their duties.

In conclusion, while aerobic training forms a foundational fitness component for the HWS, it is essential to recognize the distinction between traditional aerobic training and conditioning explicitly tailored for the military, law enforcement, and first responders. Tactical conditioning goes beyond cardiovascular endurance, incorporating a holistic approach that addresses the multifaceted demands of real-world scenarios. By integrating various training methods and prioritizing functional fitness, HWS can enhance their physical readiness, mental resilience, and operational effectiveness.

Fundamentals of Conditioning

The fundamentals of conditioning involve a series of structured workouts designed to enhance various aspects of physical performance, such as strength, endurance, flexibility, and agility. The HWS requires a unique approach that addresses the physical demands and challenges they face in their respective professions. A strength and conditioning (SC) coach must tailor the conditioning program to HWS's needs and goals, considering factors such as fitness level, age, health status, and desired outcomes.

Firstly, the absence of an off-season for the HWS must be recognized. The constant demand increases the risk of injury due to overreaching or overtraining. Effective conditioning for the HWS necessitates a multifaceted approach that integrates knowledge of energy systems, periodization principles, and job-specific training modalities. By understanding the physiological demands of their roles and implementing evidence-based training strategies, practitioners can optimize performance, enhance resilience, and ensure the readiness of military, law enforcement, and first responder personnel in dynamic and challenging situations.

Bioenergetic Foundations

Effective conditioning programs for HWS professionals necessitate a robust understanding of bioenergetics, the study of energy flow through living systems. The high-intensity demands of tactical operations necessitate a balanced approach incorporating training to enhance all three energy systems. For instance, sprinting and explosive power drills will predominantly train the phosphagen system, while interval training and moderate-duration high-intensity exercises will target the glycolytic system. Endurance training, such as long-distance marches and sustained low-intensity activities, will predominantly condition the oxidative system. The techniques elaborated upon in subsequent sections of this chapter will draw upon one or more of the body's energy systems, necessitating a detailed comprehension of their roles and interactions.

- *Phosphagen system:* The body's immediate phosphagen system predominantly utilizes creatine phosphate (CP) to rapidly regenerate adenosine triphosphate (ATP), the cell's primary energy currency. This system is characterized by its capacity for short-duration, high-intensity activities, typically lasting around 10 s. Creatine, stored primarily in skeletal muscles, is crucial for activities requiring sudden bursts of energy, such as sprinting, lifting heavy objects, and explosive movements commonly performed by HWSs [8].
- *Glycolytic system:* The glycolytic system becomes the primary source of ATP production for activities extending beyond the immediate phase, lasting approximately 10–90 s. This anaerobic pathway metabolizes glucose derived from blood and stored glycogen in muscles and the liver. The glycolytic system provides a rapid energy supply during moderate to high-intensity activities, such as combat situations, obstacle courses, and various physical testing batteries. The anaerobic glycolysis pathway, though less efficient in ATP yield compared to oxidative phosphorylation, offers a swift response to the high energy demands of these activities [9].
- *Oxidative system*: The oxidative or aerobic system, in contrast, operates at a significantly slower rate but produces a substantially higher yield of ATP through the oxidation of fats, carbohydrates, and, to a lesser extent, proteins. This system is paramount for prolonged, low- to moderate-intensity activities, supporting sustained energy production. The HWS's oxidative system is crucial during long-distance rucking, sustained patrols, and endurance events. The efficiency of this system in ATP production ensures that the athlete can maintain activity over extended periods, which is essential for the demands of prolonged tactical operations [10] (Table 7.2).

Table 7.2 Summary of energy systems

Energy system	Duration	Intensity	Examples of exercises for HWS
Phosphagen system	0–10 s	Very high	Explosive push-ups box jumps Olympic lifts short sprints (10–20 m) medicine ball throws Plyometric jumps
Glycolytic system	10–90 s	High to moderate	200–400 m sprints high-intensity interval training (HIIT) obstacle course runs kettlebell swings (for time) burpees Battle rope exercises
Oxidative system	> 90 s	Low to moderate	Long-distance rucking sustained patrols endurance runs (5 k+) swimming cycling row machine workouts

How to Build an Effective Conditioning Program

Conditioning plays a pivotal role in the performance of the HWS. Whether in military operations, law enforcement, or emergency response teams, the ability to endure physically demanding tasks is essential for success and survival. A well-designed conditioning program enhances physical capabilities, mitigates the risk of injury, and promotes overall health and resilience. This section will delve into the basic principles and methodologies of building an effective conditioning program, each tailored specifically for the HWS.

- *Client questionnaire*: A Physical Activity Readiness Questionnaire (PAR-Q) can help identify any underlying health conditions or injuries that might affect training. Review any previous injuries to tailor the program to avoid aggravating existing issues and promote recovery and strengthening.
- *Needs analysis*: Understand the specific physical demands of the athletes' tactical roles, such as endurance, strength, agility, and mobility required for their tasks. Include individual goals, strengths, weaknesses, and past experiences (see Chap. 3).
- *Physical assessments*: Conduct thorough physical assessments to determine the current fitness levels of the athletes (see Chap. 5). Use the needs analysis to design which assessments are necessary. This may include tests for cardiovascular endurance (VO2 max and YMCA step test), muscular strength (one-repetition maximum and grip strength), muscular endurance (maximal push-up test), flexibility (sit and reach), mobility (Y Balance Test, functional movement screen, and anaerobic capacity (Wingate), and body composition (DEXA, BodPod, and skin calipers).
- *Progress tracking/adjustments*: Regularly monitor and evaluate the athletes' progress using objective metrics and performance tests (Chap. 5). Be prepared to adjust the program based on feedback, progress, and emerging needs or challenges.
- *Operational environment*: Consider the environments where the athletes operate, including terrain, climate, and potential hazards. Incorporate additional risks and preventive measures for altitude or extreme cold and hot training procedures.

- *Psychological training*: Integrate mental resilience and stress management techniques to prepare athletes for the psychological demands of their roles. The training program fosters a culture of motivation, discipline, and teamwork.
- *Periodization*: Plan the program with phases of training that include varying intensity and volume to avoid plateaus and overtraining. The HWS does not have an off-season, making incorporating recovery or offloading phases imperative. If the HWS prepares for a deployment or an assessment test, the practitioner will use the end date and design the program working back.
- *Specificity*: Training should incorporate mimicking the demands of the task at hand. For the HWS, this means integrating exercises and drills that simulate the physical requirements of their duties, such as carrying heavy loads, sprinting over varied terrain, and performing functional movements in full gear. The training is tailored to replicate the demands of tactical scenarios and incorporates a combination of aerobic and anaerobic energy system development.
- *Progression*: Conditioning programs should gradually increase in intensity and volume to facilitate continuous improvement while minimizing the risk of overtraining or injury. Progression can be achieved through adjustments to workload, duration, frequency, and exercise complexity.
- *Individualization*: Factors such as age, fitness level, injury history, and job responsibilities must be considered when designing a conditioning program. Customization allows for optimal adaptation and performance gains while reducing the likelihood of setbacks.
- *Recovery*: Adequate rest and recovery are essential for optimizing performance and preventing burnout. Balancing training stress with sufficient recovery time ensures that the HWS can maintain high performance levels over the long term.

Program Example

In preparation for writing a program, the practitioner will start by ensuring the HWS is cleared for physical fitness and check for any limitations. Next, the needs analysis is examined as a tool to give the program direction. The design will start with the event, and the program will be designed backward. For example, if the HWS was set for deployment, the practitioner will use that date and periodize the program backward to ensure the HWS is in peak condition before deploying. Individualize the programs based on the needs and limitations of the HWS. This chapter includes examples of combined and individual modality programs. If the HWS has limitations in a specific modality, one will incorporate more into the program or add a particular block dedicated to enhancing that conditioning aspect (Table 7.3).

Table 7.3 Example of combined periodized program

Weeks	Objective	Activities
Preparation phase (4–6 weeks)		
Weeks 1–2	Build a foundation of general fitness	Running (30 min at a moderate pace), full-body resistance training (light weights, 15–20 repetitions), daily flexibility routines
Weeks 3–4	Build a foundation of general fitness.	Swimming (30 min), circuit training (moderate weights, 12–15 repetitions), daily mobility exercises
Base building phase (6–8 weeks)		
Weeks 1–4	Increase endurance, strength, and overall fitness	Interval running (3–5 min high intensity, 2–3 min rest), strength training (moderate weights, 8–12 repetitions), plyometrics (jump squats, box jumps)
Weeks 5–8	Increase endurance, strength, and overall fitness	Cycling (45 min with varied intensity), heavy resistance training (8–10 repetitions), agility drills (ladder drills, cone drills)
Peak phase (4–6 weeks)		
Weeks 1–3	Maximize performance capabilities	HIIT (sprints, circuit training), maximum strength training (heavy weights, 3–5 repetitions), advanced plyometrics
Weeks 4–6	Maximize performance capabilities	Mixed modality training (running, rowing, cycling), strength and power combination training (heavy weights followed by plyometric exercises), tactical drills (obstacle courses, simulated missions)
Recovery phase (2–4 weeks)		
Weeks 1–2	Allow the body to recover and adapt	Light jogging or swimming (30 min at an easy pace), light resistance training (bodyweight or light weights, 15–20 repetitions), daily yoga, or stretching sessions
Weeks 3–4	Allow the body to recover and adapt	Gradually reintroduce moderate-intensity exercises, maintaining a focus on recovery and mobility

Conditioning Techniques

Strength Training

Strength training uses progressive resistance exercise methods to increase muscular force [11]; many of these techniques are discussed in Chap. 10. It is a fundamental physical training component, enhancing performance in daily activities and athletic pursuits. Extensive research has highlighted the crucial role of strength training in developing musculoskeletal strength, fitness, health, and injury prevention [12]. Despite its well-documented benefits, previous studies have revealed a low prevalence of strength training among US adults despite its potential to prevent muscle loss and functional decline [13]. The demands of tactical tasks, such as carrying heavy loads, navigating rugged terrain, and engaging in combat operations, necessitate high conditioning levels. The HWS must include training to develop a high level of muscular strength, power, and endurance [14]. Therefore, to ensure the effectiveness of strength training in the HWS, appropriate assessment methods, such as handgrip, isokinetic, or 1RM tests, are needed [15] (Chap. 5).

Benefits of Strength Training

Strength training is crucial for the HWS as it enhances physical performance and reduces injury risk, explicitly noting that lower body strength is associated with a reduced risk of stress fractures [14, 16, 17]. Strength training has numerous benefits for the HWS, including improved physical fitness, musculoskeletal health, and mental well-being. It can enhance muscle strength, mass, bone density, and physical fitness [18–20]. Strength training has also been linked to reductions in anxiety, chronic pain, and depression, as well as improvements in cognition, sleep quality, and self-esteem [21]. The benefits are significant for the HWS as they face physically demanding and often stressful work environments. Furthermore, strength training can help prevent work-related injuries and deterioration of workability [22]. Therefore, incorporating strength training to enhance conditioning into fitness programs of the military, law enforcement officers, and first responders can be highly beneficial.

Strength Training Programming

Research suggests that high-intensity and high-volume resistance training can improve muscle strength and size, with high-intensity training being more beneficial for trained adults [23]. However, for untrained individuals, a higher training frequency, mainly three sessions per week, is vital for improving muscle strength while minimizing fatigue [23]. Manipulating resistance training program variables, such as training intensity and volume, is crucial for optimizing maximum strength development [24]. Additionally, while high-volume resistance training enhances muscle hypertrophy in trained individuals, it may not necessarily lead to strength gains [25]. To optimize training adaptations and performance, a combined approach incorporating endurance and strength training, along with periodization and individualized programming, is recommended [26]. Below is an example of what a strength training program could look like (Table 7.4).

Cardiovascular Endurance Training

Cardiovascular endurance, also known as aerobic endurance, refers to the body's ability to perform prolonged, dynamic, large-muscle group activities like running, cycling, or swimming at a moderate intensity. It relies on the cardiovascular system's capacity to deliver oxygen to working muscles [27].

Table 7.4 Summary of strength training program

Phase	Duration	Focus	Frequency	Intensity (% 1RM)	Volume (sets × repetitions)
Base	4–6 weeks	Muscular endurance	3×/week	50–65%	3–4 × 12–25
Hypertrophy	4–6 weeks	Muscle growth	3–4×/ week	65–75%	3–4 × 8–12
Strength	4–6 weeks	Maximal strength	3–4×/ week	80–90%	4–5 × 3–6
Power	2–4 weeks	Explosive strength	2–3×/ week	60–80%	3–4 × 3–5
Active recovery	1–2 weeks	Deload	2–3×/ week	40–50%	2–3 × 10–12

Benefits of Cardiovascular Endurance Training

Aerobic endurance training enhances overall physical readiness and performance in general and specialized tactical tasks. It is significant for military personnel, law enforcement officers, and first responders, particularly those over 40, to maintain cardiorespiratory fitness and reduce cardiovascular disease risk [28]. However, a balanced approach incorporating strength training is necessary, as some data suggest that excessive aerobic training can hinder strength development and increase injury rates [29].

Cardiovascular Endurance Programming

A gradual progression in aerobic training is recommended to avoid overuse-related injuries. Activities like swimming, cycling, rowing, and hiking and other low to moderate impact activities can supplement running. Interval training, fartlek runs, and terrain runs also help develop aerobic capacity. Regular dynamic resistance training has also increased aerobic performance in soldiers. Incorporating aerobic activities like shuttle runs, obstacle courses, and plyometrics into training can improve mission-specific fitness [30].

Muscular Endurance Training

Muscular endurance refers to a muscle group's ability to repeatedly contract against resistance over an extended period [31]. It is typically assessed using isokinetic dynamometry and field tests like timed push-ups or sit-ups. Muscular endurance is specific to the muscle groups, contraction type, and movement velocity.

Benefits of Muscular Endurance Training

High levels of muscular endurance are crucial for the HWS, as they directly impact their ability to perform in extreme conditions and combat situations over extended periods. Muscular endurance is also critical in reducing musculoskeletal injury risk, as individuals with greater muscular endurance are less susceptible to injuries [31]. Furthermore, maintaining muscular endurance is vital for preserving physical capability as individuals age.

Muscular Endurance Programming

Circuit training with higher repetitions and shorter rest periods is practical for developing muscular endurance. Resistance exercises like push-ups, sit-ups, squats, and lunges with higher volume (e.g., 3–4 sets of 15–25 repetitions) can be incorporated. Field exercises like obstacle courses, ruck marching, and load carriage drills also build muscular endurance. A periodized program integrating different endurance training methods with strength training is ideal for military personnel to optimize cardiovascular and muscular endurance adaptations. Table 7.5 highlights various aspects of muscular endurance training.

Plyometrics

Plyometrics, also known as "jump training" or "plyos," involves rapid and explosive movements designed to increase power, speed, and strength. This methodology focuses on the stretch-shortening cycle of muscles, which is the process where muscles rapidly lengthen (eccentric phase) and then shorten (concentric phase). Plyometric exercises are characterized by their dynamic and high-intensity nature, involving jumping, hopping, and bounding [32]. Lower body plyometrics can consist of box jumps, depth jumps, and lateral jumps, which can be body weight or

Table 7.5 Summary of cardiovascular and muscular endurance training program

Training type	Examples	Program guidelines
Muscular endurance	Circuit training, push-ups, sit-ups, squats, lunges	3–4 sets of 15–25 repetitions, shorter rest periods
Field exercises	Obstacle courses, ruck marching, load carriage drills	Incorporate regularly into training routines
Aerobic training	Running, swimming, cycling, rowing, hiking	At least 20–25 min, 3 times per week
Interval training	Fartlek runs, terrain runs	Incorporate to develop aerobic capacity
Mission specific	Shuttle runs, obstacle courses, plyometrics	Include to improve mission-specific fitness

loaded and are accounted for by counting ground contacts. Upper body plyometrics are push-up variations; medicine ball throws and repetitions account for burpees.

Benefits of Plyometric Training

The ability to exert maximum force in the shortest time is crucial in tactical operations. Plyometric training has improved athletes' speed and agility, enhancing their ability to react swiftly to dynamic situations [33]. The HWS often involves repetitive, high-intensity activities that demand sustained physical effort. Plyometric training improves muscle stamina, the ability to transfer kinetic energy quickly and efficiently, and the ability to perform high-intensity actions over extended periods, contributing to better performance during long missions. When designed correctly, plyometrics can build muscle power, enhancing overall functional strength and endurance.

Plyometric Programming

Plyometrics should be incorporated into the weekly training session and integrated with other training modalities. The HWS should begin with foundational exercises and progressively increase the intensity and complexity. The initial program should focus on building essential strength and coordination, advancing the program to develop explosive power. A meta-analysis showed that two to three weekly sessions for 4–16 weeks improved jump height, sprint, and agility performance [33]. Saez de Villarreal et al. [34] showed that incorporating plyometric work for 15 sessions over 10 weeks with 40 ground contacts each session will significantly improve performance. It is suggested that bilateral plyometric drills are more effective than unilateral drills [35]. A well-structured plyometric program can also prevent injury by strengthening muscles, tendons, and ligaments and improving joint stability. The suggested plyometric conditioning program can be incorporated into the current fitness routine. Adjust intensity and rest as needed (Table 7.6).

Agility Training

Agility training refers to drills that improve an athlete's ability to move quickly while changing direction with precision and control. This training enhances coordination, balance, speed, reflexes, and overall movement efficiency. It involves training strength, power, and neuromuscular control to achieve rapid and effective movements while adjusting to dynamic stimuli [36].

Table 7.6 Summary of plyometric program

Week	Phase	Exercise	Sets	Repetitions
1–2	Foundation phase	Jump squats	3	10
		Lateral bounds	3	8/each
		Box jumps (12″)	3	6
		Skater jumps	3	10/each
		Burpees	3	10
3–4	Progression phase	Depth jumps	3	8
		Tuck jumps	3	10
		Bounding (over 20 meters)	3	10
		Plyometric push-ups	3	10
		Split squat jumps	3	8/each
5–6	Advanced phase	Single-leg box jumps (12″)	3	6/each
		Clap push-ups	3	10
		Broad jumps	3	8
		Lateral box jumps (24″)	3	8/each
		Explosive medicine ball throws	3	10
7–8	Peak phase	Depth jumps with rebound	3	8
		Single-leg tuck jumps	3	6/each
		Overhead medicine ball slams	3	10
		Lateral bounds with hold	3	10/each
		Burpee box jumps (24″)	3	10

Benefits of Agility Training

In demanding tactical settings, moving swiftly and precisely in response to randomized external stimuli is essential to survival and injury prevention. The HWS undergoes dynamic challenges in both the physical and cognitive systems. Agility training incorporates high-intensity functional movements that improve physical performance and mental preparedness [37]. Training that combines speed, strength, power, endurance, and technical skills with the ability to accelerate, decelerate, change directions, and react to stimuli is essential to success in tactical scenarios [38]. Furthermore, agility training has been shown to assist in preventing lower limb injuries [39]. The implementation of an effective agility training program will not only enhance essential aspects of physical performance but also emphasize optimal cognitive function.

Agility Programming

Designing an agility training program for the HWS requires understanding operational demands and a tailored approach to those needs. Initial testing and assessment help determine an athlete's current condition to set measurable goals in alignment with operational performance needs. Dynamic warm-ups increase blood flow to muscles and prepare the joints for high-intensity dynamic effort. Specific exercises designed to mimic tactical scenarios may include cone drills (change of direction and acceleration), ladder drills (foot speed, coordination, and balance), reactions drills (quick responses to signals or commands), and shuttle runs (acceleration, deceleration, and directional change). Strength and power exercises targeting controlled explosive movements should be incorporated as well. These include plyometrics (mentioned above) and weightlifting to build upper and lower body strength. Functional movement training designed to replicate tactical tasks would consist of sandbag drag, climbing, crawling, and lifting from the ground. Agility should be trained in each plane of motion, and proper work-to-rest ratios must be incorporated to ensure efficient recovery and cooldown [40, 41] (Table 7.7).

Speed Training

Speed training focuses on developing maximum speed potential to move the body in one direction as fast as possible. Accelerating from a stationary position and reaching maximum speed in the shortest duration of time involves high force generation (laws of inertia and acceleration). Training under external resistance for strength and power will enhance the HWS's ability to produce force effectively and rapidly. Learning to apply this force in the correct direction is essential. The central nervous system regulates the motor units and muscle fiber types being recruited, and repetition of speed training improves these processes [42].

Table 7.7 Summary of agility program

Week	Phase	Exercise	Work-to-rest ratio
1–2	Linear speed and agility	Ladder drills (in and out)	1:2 to 1:3
		Cone drills (T-drill and pro agility)	1:3 to 1:5
		Decelerations (forward)	1:12
3–4	Lateral speed and quickness	Lateral ladder drills (icky shuffle)	1:2 to 1:3
		Hurdle drills (lateral jumps and hops)	1:3 to 1:5
		Cone drills (box drill, Z-drill)	1:3 to 1:5
		Resistance band shuffles	1:12 to 1:20
5–6	Multidirectional agility	Y-reactive agility drill	1:3
		Cone drills (star and hexagon)	1:3 to 1:5
		Agility circuit (sprint, lateral, back, shuffle)	1:12 to 1:20

Benefits of Speed Training

The HWS faces rapidly changing environments requiring swift movements to ensure personnel success and safety. Speed training can improve decision-making and tactical positioning, out-maneuver opponents, and respond rapidly to unpredictable stimuli [43]. Enhancing speed in the HWS leads to overall improved physical readiness and operational capabilities.

Speed Programming

A tactical speed training program will involve a structured approach specific to operational demands. Initial assessment and testing are critical to set athlete baselines and appropriate goals based on performance requirements. Dynamic warm-ups prepare the body for high-intensity training and involve movements such as high knees, butt kicks, leg swings, and dynamic stretching. Acceleration drills should be included to target the initial and rapid force production of setting a resting body in motion. This will include but is not limited to hill sprints, resisted sprints, and start drills. Maximal speed drills aimed at top-speed potential include flying sprints and interval sprints. Speed endurance improves the speed duration and utilizes tempo runs and fartlek training. Strength and power training are essential to build muscle force production. Technique-specific drills refine running mechanics and optimize efficiency (A skips, B skips, and gate analysis). Cooldown and recovery incorporates light jogging, static stretching, foam rolling, and following proper nutrition/hydration to enhance performance. Regular monitoring and assessment are crucial to progression. Speed training can be incorporated into an already-designed program but must be harmonized with other modalities for the appropriate training effect (Table 7.8).

Table 7.8 Summary of the speed program

Week	Activity	Details
1 and 2	Sprint mechanics and acceleration	High knees, butt kicks, A skips, B skips (2 × 20 m each) (rest 1.5 min); sprint drills: Dribbling, straight-leg bounds (3 × 20 m each) (rest 1.5 min); accelerations (5 × 20 m at 80% effort) (rest 2 min); incline sprints (4 × 20 m at 80% effort)
3 and 4	Long acceleration speed endurance	Push-up starts (4 × 15 m) (rest 2 min); incline sprints (3 × 30 m at 70% effort) (rest 3 min); interval sprints (6 × 100 m at 70–80% effort) (rest 2 min)
5 and 6	Maximum speed development	Acceleration from crouch stance (2 × 45 m) (rest 2.5 min); sprint work: Flying sprints (6 × 15 m with 20 m build-up and full recovery)

High-Intensity Interval Training (HIIT)

HIIT is a form of exercise that alternates short bursts of high-intensity work with periods of lower-intensity active recovery or rest—repeated bouts of vigorous anaerobic exercise close to maximum capacity, interspersed with lighter aerobic recovery intervals. The high-intensity efforts are typically performed at intensities above the lactate threshold, around 80–95% of maximum heart rate or (VO2 max). The recovery periods allow partial restoration before the next high-intensity interval [44]. HIIT can be applied to various exercise modalities, such as running, cycling, rowing, or resistance training, with different work-to-rest ratios and intensities tailored to the individual's goals and fitness level.

Benefits of HIIT

HIIT offers several benefits that make it well-suited for the HWS. HIIT allows for more significant training volumes and intensities in a shorter duration than traditional steady-state training. It can improve VO2 max, anaerobic power, agility, and physical fitness [37, 45]. Research shows it helps reduce body fat percentage and waist circumference while maintaining or increasing lean muscle mass [37]. HIIT can be easily implemented in various settings with minimal equipment requirements, making it suitable for the HWS. However, it is important to note that the benefits of HIIT, especially for high-intensity tasks with external loads (HITL), might be more pronounced in well-trained individuals. Lesser-trained or untrained personnel may be at a higher risk of injury if not correctly prepared [46].

HIIT Programming

When implementing HIIT for the HWS, it is important to gradually increase the intensity, duration, and frequency of HIIT sessions based on the individual's fitness level and training goals. Typical work intervals range from 10 s to 4 min (phosphagen through aerobic energy systems), with rest periods of equal or longer duration to allow partial recovery. Choose exercises that mimic job-specific movements or tasks, such as sprints, battle rope drills, sled pushes/drags, and bodyweight exercises. Ensure proper supervision and monitoring of training intensities, heart rates, and perceived exertion to reduce the risk of overtraining or injury. HIIT should be incorporated into a well-rounded training program that includes strength training, muscular endurance, and recovery protocols. Following proper programming and periodization, HIIT can be an effective and efficient training method for improving the HWS's physical readiness and performance. Below is an example of a HIIT training program (Table 7.9).

Table 7.9 Summary of the HIIT program

Week	Work interval	Rest interval	Rounds	Exercises	Frequency
1–2	20 s	40 s	6	Bodyweight squats, push-ups, mountain climbers	2×/week
3–4	30 s	30 s	8	Sprint in place, burpees, plank jacks, jump lunges	2–3×/week
5–6	40 s	20 s	8	Battle rope waves, kettlebell swings, box jumps, medicine ball slams	3×/week
7–8	45 s	15 s	10	Sled push/pull, plyometric push-ups, sandbag clean and press, sprints with direction changes	3–4×/week

High-Intensity Power Training (HIPT)

High-intensity power training (HIPT) is a form of training that combines elements of high-intensity interval training (HIIT) and traditional resistance training (TRT) (i.e., CrossFit). It involves performing multijoint resistance exercises at a high intensity with minimal rest periods between sets [47]. When implementing HIPT for the HWS, it is crucial to consider factors such as fitness levels, injury risk, and specific operational demands. A well-designed program integrating HIPT with other training modalities, such as strength training, endurance training, skill-specific drills, and recovery, can help optimize physical readiness and performance.

Benefits of HIPT

Research has shown that HIPT can significantly improve explosive power, speed, agility, and anaerobic capacity [47]. Specific variations like high-powered plyometrics have been enhanced [48]. However, some research has suggested that the benefits of HIPT, particularly for lower limb explosive power, may be limited to untrained or lesser-trained individuals [46]. Proper progression and periodization may be necessary to maximize the benefits and minimize the risk of injury.

HIPT Programming

HIPT includes compound exercises like squats, deadlifts, cleans, and presses that engage multiple major muscle groups. Exercises are performed at intensities close to maximal effort, usually above 80% of 1RM. Rest intervals between sets are kept short to induce metabolic stress, typically 30 s to 1 min. HIPT blends traditional resistance training with high-intensity cardiorespiratory conditioning. High-intensity functional training (HIFT), a form of HIPT, has led to superior aerobic fitness and strength improvements compared to traditional military, law enforcement, and first responder physical training [49]. Researchers emphasized the importance of strength and power for high-intensity combat tasks, particularly under heavy load carriage conditions, which HIPT can potentially address [50]. Similarly to HIIT, HIPT can be an efficient training method for the HWS, as it combines multiple training components into a single session.

Circuit Training

Circuit training is a form of exercise that combines resistance training and aerobic exercises into a single, continuous workout. The circuit consists of a series of resistance exercises targeting different muscle groups, with minimal rest between each exercise. Once all exercises in the circuit have been completed, a brief rest period is taken before repeating the entire circuit for the desired number of rounds [51].

Benefits of Circuit Training

Circuit training offers several benefits that make it well-suited for HWS training. Circuit training simultaneously develops muscular strength, endurance, power, agility, and cardiovascular fitness—critical components of HWS readiness [52]. It is efficient by combining multiple training components into a single session, which is advantageous for the HWS with time constraints. Circuits can be designed to mimic HWS-specific movements and tasks, improving functional fitness and occupational performance [52]. The varied nature of circuit training can increase motivation and engagement among the HWS, promoting adherence to training programs [53].

Circuit Programming

Circuits typically include resistance exercises (e.g., squats, push-ups, and lunges) and aerobic/cardio drills (e.g., jumping jacks, high knees, and burpees). The transitions between exercises are rapid, with minimal rest (e.g., 30 s or less) to maintain an elevated heart rate and metabolic demand. The intensity can be adjusted by varying the exercises, resistance loads, number of repetitions, work/rest intervals, and overall circuit duration. By incorporating well-designed circuit training sessions, the HWS can efficiently develop the physical capabilities necessary for optimal operational readiness and performance. Below is an example of a circuit training exercise routine (Table 7.10).

Table 7.10 Summary of the circuit training program

Station	Exercise	Duration/repetitions	Rest
1	Bodyweight squats	20 repetitions	15 s
2	Push-ups	15 repetitions	15 s
3	High knees	30 s	15 s
4	Dumbbell rows	12 repetitions each arm	15 s
5	Burpees	10 repetitions	15 s
6	Lunges with a twist	10 repetitions each leg	15 s
7	Mountain climbers	30 s	15 s
8	Plank hold	30 s	15 s

Tactical-Specific Drills

Tactical-specific drills focus on movements that mimic the diverse real-life activities the HWS may encounter. This type of training enhances overall physical preparedness for unpredictable situations by tailoring conditioning protocols to the specific requirements of the mission or role. To improve overall readiness for tactical missions, integration of scenario-based training, including simulations of high-stress situations, enhances task-specific skills alongside physical conditioning geared toward optimizing HWS performance.

Benefits of Tactical-Specific Drills

Providing a realistic and practical training environment for HWSs is critical to enhancing their performance in the field. Task-specific drills simulating real-world operational scenarios improve HWS performance in repeated simulated military task courses [54]. These drills are specific to marksmanship, hand-to-hand combat, tactical movements, and equipment handling. Regular exposure to high-stress situations has improved [55]. Team-based drills incorporate working with others through communication, coordination, and teamwork, often utilized in military operations. Physical conditioning, as well as mental toughness, is critical to HWS performance under demanding conditions. Practicing real-life scenarios in controlled settings allows the athletes to learn practical techniques in a safe environment and reduces the risk of injury during operational missions.

Tactical-Specific Drills Programming

An initial assessment of current skills is essential to create a plan specific to a HWS's operational needs. Dynamic warm-ups and light cardiovascular work raise core temperature and prepare the HWS for tactical-specific training. Scenario-based drills replicating real-life scenarios include room clearing, active shooter response, and vehicle operations. Marksmanship drills to enhance weapon accuracy and handling include target acquisition, shooting under stress, and transition drills. Hand-to-hand combat and defensive drills include grappling and striking for close-quarters combat and defensive maneuvers for responding to attacks. HWS will be required to carry heavy loads while performing functional movements in the field; incorporating obstacle courses and load-bearing exercises effectively trains these skills. Compound exercises, such as squats, lunges, and functional lifts, also assist in the overall strength required for these functions. Cooldown and recovery techniques are essential; regular monitoring ensures progression and the ability to address specific areas of weakness.

Metabolic Conditioning

Metabolic conditioning, also known as Metcon, is a specialized form of training that targets the body's metabolic pathways to enhance energy production. It involves high-intensity, multijoint exercises performed quickly with minimal rest intervals and challenging aerobic and anaerobic energy systems. The mechanisms underlying metabolic conditioning are multifaceted and involve several physiological adaptations that improve the utilization of energy, muscular endurance, and lactate threshold.

Benefits of Metabolic Conditioning

Metabolic conditioning workouts stress the body's energy systems, leading to adaptations that optimize energy production and utilization. This includes increased mitochondrial density, enhanced enzyme activity in energy metabolism, and improved glycogen storage and utilization [56]. It stimulates the body's metabolism, resulting in a prolonged elevation in metabolic rate postexercise. This phenomenon, known as excess postexercise oxygen consumption (EPOC), facilitates more significant calorie expenditure and fat oxidation [57]. Metabolic conditioning workouts challenge muscular endurance by subjecting muscles to repetitive, high-intensity efforts over a relatively short duration. Some adaptations include increased capillarization, improved muscle fiber recruitment, and enhanced buffering capacity, allowing muscles to sustain activity for extended periods without fatigue [58]. It can raise the lactate threshold, the point at which the body switches from aerobic to anaerobic metabolism during intense exercise. By training at or near this threshold, individuals can improve their tolerance to lactate accumulation and delay the onset of fatigue during high-intensity efforts [58].

Metabolic Conditioning Programming

Metabolic conditioning combines various exercise styles, including HIIT, HIPT, circuit training, and functional training. A Metcon program is meant to be a high-effort, time-efficient, short-duration workout. Gradually increasing the workouts' intensity, volume, or complexity will ensure progress. Varying the rest intervals will manipulate the intensity and challenge the body's energy systems. Incorporate functional exercises to mimic real-life movements that the HWS will encounter (Table 7.11).

Zone 2 Training

Zone 2 training, also known as aerobic base training, is moderate intensity that falls between the first and second ventilatory or lactate thresholds. This intensity zone is typically described as 60–70% of maximum heart rate or 55–75% of VO2 max [59].

Benefits of Zone 2 Training

Zone 2 training has an exercise intensity high enough to stress the cardiovascular system but low enough to allow for prolonged efforts without accumulating excessive fatigue. At this intensity, the body primarily relies on aerobic metabolism and the oxidation of fats and carbohydrates to produce energy. This type of training is known to enhance VO2 max, aerobic endurance, muscular endurance, and fat oxidation capabilities [60]. Zone 2 training can be incorporated into active recovery sessions or complement higher-intensity training, promoting recovery and adaptation.

Table 7.11 Summary of metabolic conditioning program

Exercise	Repetitions/ duration	Details
Sled push	40 s work, 20 s rest	Load the sled with an appropriate amount of weight and push the sled with arms fully extended, but not locked out. Lean forward slightly, back straight, and hips slightly higher than your shoulders
Burpees	40 s work, 20 s rest	Perform a squat, kick back into a plank, return to squat, and jump up
Kettlebell swing	40 s work, 20 s rest	Swing kettlebell from between legs to overhead
Farmers walk	40 s work, 20 s rest	Choose the appropriate weight and walk upright with your shoulders back and chest up
Jump squats	40 s work, 20 s rest	Squat down and jump explosively upward
Mountain climbers	40 s work, 20 s rest	In the high plank position, alternate bringing knees to chest quickly

By including zone 2 training as part of a well-rounded fitness program, military personnel can improve their aerobic endurance, muscular endurance, and overall physical readiness while developing essential life skills for operational success.

Zone 2 Programming

The gold standard in establishing zone 2 parameters includes conducting a VO2 max examining ventilatory thresholds and incorporating lactate threshold testing, which requires advanced equipment [61]. To calculate zone 2 without equipment, the practitioner can calculate the HWS maximal heart rate (MHR) using the Karvonen formula (MHR = 220—age) [62]. The HWS will measure their resting heart rate (RHR) by counting the beats per minute in the morning before leaving the bed. Heart rate reserve (HRR) (HRR = MHR—RHR) will be used, and the zone 2 lower end (RHR + 0.6(HRR) and upper end (RHR + 0.7(HRR) will be calculated. A simplified way to use zone 2 training is the talk test, which consists of comfortably talking but not singing [62]. Heart rate monitors are the most effective way of monitoring heart rate during a conditioning program. Still, rate of perceived exertion (RPE) can be used, which will typically feel like a 2 or 3 out of 10, with 10 being maximal effort [62].

Core Stability Training

Core stability training is a specialized exercise that focuses on strengthening the muscles surrounding the spine and pelvis to enhance stability and support for the body during various movements and activities. This type of training aims to improve the ability to maintain a neutral spine position, which is crucial for overall spinal health and proper body mechanics [63]. Core stability exercises typically target the multifidus, rectus abdominis, and pelvic floor muscles to stabilize the lumbar region and enhance overall core strength [64]. Core stability training focuses on improving these muscles' strength, endurance, and coordination to ensure optimal performance during various physical activities. There are three main types of core stability exercises. Static exercises such as planks and side bridges involve maintaining a stable position for a prolonged period. Dynamic exercises involve movement while maintaining core stability, such as leg lifts and medicine ball throws. Functional exercises incorporate core stability into complex, full-body movements that mimic real-life activities, such as squats and deadlifts.

Benefits of Core Stability

Core stability training is crucial for the HWS as they encounter environments requiring one to carry heavy loads, engage in combat, and perform rescue missions. It significantly enhances performance by improving force production in the upper and lower extremities, thus enhancing athletic abilities [65]. Moreover, core stability training is essential for injury prevention as it focuses on muscle activation, neuromuscular control, static stabilization, and dynamic stability, all crucial for maintaining physical health and preventing injuries [66]. Research has shown that core stability training directly impacts athletic performance by enhancing trunk and hip control and improving balance [67, 68]. Additionally, core stability exercises have been shown to activate deep muscles in the abdomen and back effectively, aiding in pelvic and trunk stabilization training and reducing the incidence of back pain [69].

Core Stability Programing

To effectively program core stability training for the HWS, it is essential to assess core strength first. This can be done by isokinetic testing, handheld dynamometry, and pressure biofeedback [70, 71]. A plank has been widely used to test core endurance, and the duration set by the Army Combat Fitness Test can be referenced. When designing a core stability training program, it is crucial to focus on exercises that target the core muscles, including the back and abdominal muscles, to improve stability and neuromuscular control [72]. Additionally, incorporating isolated and integrated core stability exercises can improve athletic performance, such as flexor endurance [68]. There is currently no ideal program to enhance core stability, but a core stability program should include a combination of static, dynamic, and functional core exercises. It is suggested that this program be completed two times a week before, intra-, or postworkout (Table 7.12).

Table 7.12 Summary of the core conditioning program

Exercise	Repetitions/ duration	Details
Plank	60 s	Maintain a straight line from head to heels, engage the core
Side plank	30 s/each	Stack feet and lift hips, keep the body in a straight line
Bird dog	15 repetitions/ each	Start on hands and knees, extend the opposite arm and leg, and then return to the starting position
Russian twists	20 repetitions/ each	Sit on the floor with knees bent, lean back slightly, and twist your torso side to side, touching the floor beside the hips
Dead bug	15 repetitions/ each	Lie on your back with arms and legs in the air, and lower the opposite arm and leg toward the floor while keeping the back flat
Leg raises	15 repetitions	Lie on your back with legs extended, lift your legs to a 90-degree angle, and slowly lower them back down

Mental Conditioning

Mental conditioning involves training and preparing the mind to optimize cognitive and emotional functioning, enhance performance, and improve overall mental well-being [73]. It encompasses various techniques and strategies to develop mental skills such as focus, concentration, resilience, and self-regulation to achieve peak performance in different domains. Mental conditioning is a cornerstone of comprehensive HWS training, integrating seamlessly with physical conditioning to prepare tactical personnel for the multifaceted demands of combat and operational environments. Mental conditioning encompasses a range of practices aimed at fortifying the mind. This includes stress inoculation training, cognitive behavioral techniques, mindfulness practices, visualization and mental rehearsal, and resilience training. These methods collectively aim to build mental toughness, reduce the adverse effects of stress, and enhance overall cognitive function.

Benefits of Mental Conditioning

The duties of the HWS generally occur under extreme stress, and effective mental conditioning enables them to maintain cognitive function, make sound decisions, and execute tasks efficiently. Research has shown that mental fatigue affects physical performance by increasing the perception of effort, affecting cardiorespiratory fitness and exercise tolerance [74]. Tashman et al. [75] showed that skilled law enforcement officers can anticipate future events and make predictive inferences, suggesting that cognitive conditioning can enhance their performance. It is demonstrated that Marines who received mental skill training that included goal setting, arousal control, visualization, positive self-talk, and concentration training enhanced performance and cognitive function during times of heightened stress [76]. Similarly, it was found that stress management and mindfulness training enhanced resilience in military and law enforcement personnel, allowing them to self-regulate and maintain focus [77].

Mental Conditioning Programming

Effective mental conditioning programs should begin with a thorough assessment of individual and unit needs. This includes evaluating stress levels, cognitive functions, emotional health, and existing coping mechanisms. Customized training plans can then be developed to address specific needs. Physical fitness is the best mental conditioning tool, with research supporting it can improve mood and decrease somatization, anxiety, depression, and hostility [78]. Jensen et al. [76] implemented mindfulness-based mind fitness training and general mental skills training during training sessions for 12 weeks. This was performed in a group setting, and the goal was to educate people on incorporating these practices into the training regimen. Notably, a study on law enforcement officers used many mindfulness training tools and suggested that mindfulness training is a promising approach [79]. When designing a specific program for your population, it is recommended that you utilize technology and build a culture that values and supports mental conditioning. Mental conditioning is not a one-time event and must be established as an ongoing process. Incorporating mental conditioning into a physical training program can encourage a positive connection between mind and body through habitual training.

Flexibility Training

Flexibility refers to the ability of a joint or series of joints to move through an unrestricted, pain-free range of motion. This attribute is critical for maintaining the overall functional movement of the body. Flexibility encompasses various components, including muscle length, joint integrity, and the health of soft tissues such as ligaments, tendons, and fascia. It is influenced by age, gender, physical activity level, and the specific demands on the body [80]. There are four main stretching types, each with their application to the HWS. Static stretching involves holding a stretch for an extended period, usually 15–60 s, to lengthen the muscle. Dynamic stretching is active movements that stretch the muscles to their full range of motion, often used as part of a warm-up. Proprioceptive neuromuscular facilitation (PNF) stretching involves stretching and contracting the targeted muscle group, frequently performed with a partner. The least used form of creating flexibility is ballistic stretching, which consists of bouncing movements to push the muscles beyond their usual range of motion; however, this method should be used with caution due to the higher risk of injury.

Benefits of Flexibility

Flexibility training is essential in HWS due to its demanding and often unpredictable operations. Tactical personnel are frequently required to perform physically demanding tasks, such as lifting heavy equipment, traversing uneven terrain, and executing rapid movements in combat situations. Flexibility training can help reduce injury, enhance performance, improve muscle recovery, and improve rehabilitation by maintaining the elasticity and resilience of muscles and connective tissues [81]. A well-conditioned body with adequate flexibility is less likely to suffer from overuse injuries, common in the repetitive and rigorous activities associated with training the HWS.

Flexibility Programming

Flexibility programs should be tailored to the individual needs of the HWS. Factors such as age, physical condition, job role, and specific physical demands should be considered. Customizing the program ensures that everyone can safely and effectively improve their flexibility. The science is conflicting on the ideal program to help with injury prevention, improve performance, and reduce muscle soreness [82]. A current consensus in the field shows that a dynamic warm-up should be conducted with task-specific methods included [83]. Marek et al. [84] showed that incorporating static stretching and PNF before exercise created small deficits in strength, power output, and muscle activation. The ACSM recommends that passive or active stretching be done two to three times per week at 10–30 s, suggesting daily is better. It was found that after 12 weeks of either daily stretching for 180 s or 3 days a week for 15, 30, or 45 s, it was found that all modalities increased hip flexion range of motion [34].

Recovery Techniques

The HWS undergoes extensive training to prepare them for their enduring job. Beyond the training, the HWS will perform their duties at a high level, requiring them to recover. Recovery comes in many modalities and can involve the mind and body.

Benefits of Recovery Techniques

Recovery from exercise is essential for restoring physiological homeostasis, repairing damaged muscle tissue, and replenishing energy stores and fluids lost during physical activity [85]. It is particularly crucial for military personnel, who often endure high training loads and physical demands. Adequate recovery allows them to cope with these demands, avoid residual fatigue, and maintain vitality and enthusiasm for training and operations. Proper nutrition, particularly carbohydrate intake, is vital in aiding recovery by facilitating the resynthesis of glycogen stores and rehydration [86]. Rapid recovery is significant for personnel who engage in frequent, high-intensity training or operations.

Recovery Programming

Various postexercise recovery techniques have been studied and found to be somewhat effective, including sleep extension and quality sleep, cold water immersion or cryotherapy, massage therapy, compression garments, nutritional interventions (e.g., protein, carbohydrates, and supplements), and active recovery (low-intensity exercise). However, the evidence for the effectiveness of some of these methods still needs to be improved, and ongoing research efforts are exploring their optimal use and combinations [87, 88]. Passive recovery techniques like compression garments, cold water immersion, cryotherapy, hyperbaric oxygen, and vibratory therapies have shown promise in improving athlete recovery [88]. The most efficient method for muscle recovery after exercise remains a topic of debate, with studies comparing the effects of massage, stretching, cold, and needling therapies [89]. Many recovery methods are effective for military personnel following exercise and physical demands [90]. Regular monitoring of muscle damage biomarkers, anabolic hormones, strength, and power levels can help determine the level of acute stress following military-specific activities, allowing for appropriate recovery periods to be implemented [91]. Sleep extension has been found to improve performance, pain sensitivity, and anabolic responses, potentially accelerating recovery from muscle injuries in military personnel [92]. Implementing a comprehensive recovery strategy that combines various techniques, such as nutrition, sleep, cold therapies, and active recovery, can be beneficial for optimizing recovery and reducing injury risk in military personnel subjected to high physical demands.

Conclusion

Building an effective conditioning program for the HWS requires careful consideration of their unique physical, mental, and environmental demands. By adhering to the principles of specificity, progression, individualization, and recovery and incorporating the key components of strength, endurance, speed, agility, flexibility, mobility, and mental conditioning, the HWS can enhance their performance, resilience, and readiness for the challenges ahead. HWSs can optimize their conditioning program through diligent planning, implementation, and evaluation to achieve peak performance and mission success.

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Chapter 8
Functional and Mobility Training

Patrick McHenry and Christopher Myers

Introduction

In the demanding world of tactical and first responder operations, the human weapon system's (HWS) physical and mental preparedness is paramount. HWS populations face unique and rigorous challenges requiring high functional fitness and mobility. Unlike conventional fitness regimens, the training for these groups must encompass a wide array of physical capabilities, from strength and endurance to agility and flexibility.

Implementing function and mobility training into existing HWS fitness programs requires a comprehensive and strategic approach. These methodologies involve assessing the role's specific demands, understanding common injury patterns identified during the needs analysis (Chap. 3), and designing targeted training protocols. Collaboration between fitness professionals, physical therapists, and tactical athletic trainers is essential to creating effective and sustainable programs. This chapter will explore various methodologies and best practices for integrating function and mobility training, providing practical insights and examples from the field.

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The Importance of Functional Fitness and Mobility

Functional Fitness

Functional fitness is crucial for HWS populations as it directly enhances their ability to perform job-specific tasks efficiently and safely. Functional fitness is the interaction between the various responses to the neuromuscular, muscular, and central nervous systems, which allows the body to excel in movements across multiple planes and tasks under arduous conditions. Functional fitness is a type of exercise regimen that focuses on training the body to perform everyday activities efficiently and safely [1–4].

Functional fitness training is all about practicality and focuses on exercises that mimic real-world movements, thereby improving strength, endurance, agility, and flexibility in ways that traditional fitness routines may not address. This training methodology fosters comprehensive physical readiness, helping these professionals navigate unpredictable environments, handle heavy equipment, and execute complex maneuvers with reduced risk of injury and improved combat regeneration (also termed force readiness). Unlike traditional fitness routines that may isolate specific muscle groups, functional fitness emphasizes whole-body movements that mimic real-life tasks and enhance the coordination between various muscle groups. This approach aims to improve overall strength, flexibility, endurance, and balance, ensuring the body can handle the physical demands of daily life or specific occupational tasks.

Functional fitness components include exercises involving multiple joints and muscles working together, such as squats, lunges, push-ups, and kettlebell swings. These movements enhance the body's ability to perform everyday HWS activities, such as lifting, bending, pushing, pulling, and twisting. By focusing on practical, everyday motions, functional fitness helps individuals develop the strength and stability needed to reduce the risk of injuries, improve posture, and enhance overall physical performance.

The remainder of this chapter will focus on mobility and its applications. However, functional fitness is inherently linked to mobility due to the demand for the full range of motion (ROM) of the joints involved with certain movements. Several resources exist that describe specific exercises that focus on functional fitness. Chapter 10 discusses several advanced resistance training methodologies that incorporate functional fitness.

Mobility

Mobility is essential to ensure HWS professionals can move efficiently and effectively in dynamic and often hazardous environments. Mobility is the "ability to move freely and easily" [5], which ensures a full range of motion in joints and muscles and improves balance, coordination, and overall physical performance. Freedom of movement is essential for successful field operations. For example, when firefighters pull up to a fire, they do not get off the truck, line up, perform a dynamic warm-up, and then put out the fire, nor does a police officer leave his car, stretch, and then chase the bad guy. In all these situations, the HWS must move immediately without the benefits of stretching or a proper warm-up. Therefore, teaching and evaluating mobility is critical to the strength program.

HWS organizations have attempted to develop tests that measure and assess human movement for injury prevention, developing athleticism, or improving performance [6, 7]. However, these organizations have yet to empirically quantify the flexibility and mobility of HWS professionals. The primary issue that has limited research is the "gear" worn during work (i.e., tactical vest or LBV, body armor, weapons, and boots) [8, 9]. A moderately loaded rucksack significantly alters the HWS's movement patterns [10]. Firefighters' movement patterns are significantly altered by the weight and design of their gear, mainly the self-contained breathing apparatus (SCBA), leading to increased strain on joints and more conservative gait patterns to reduce injury risk [11–13]. Furthermore, this equipment changes fighting postures, gaits, perception, stress impacts, etc. [13–18]. All these factors, and many more, will affect the HWS's movement ability. These factors vary highly depending on terrain, environment, and the physical condition of the HWS.

Adaptation Versus Response

In HWS populations, mobility is influenced by immediate responses and long-term adaptations to the physical demands of their roles. Response refers to the immediate physiological and biomechanical reactions to stressors encountered during missions, such as changes in gait or posture when carrying heavy loads or maneuvering in challenging environments. These acute responses are designed to preserve performance and reduce injury risk in the short term. Still, they can lead to fatigue and overuse injuries if repeated frequently [19, 20].

On the other hand, adaptation involves long-term physiological changes resulting from repeated exposure to these stressors. Over time, tactical personnel develop enhanced strength, endurance, and joint stability, allowing them to handle their equipment's and tasks' demands better. For instance, repeated load bearing can lead to musculoskeletal adaptations that improve overall stability and reduce the risk of injury. However, it can also lead to chronic issues if not properly managed [19, 20]. The balance between immediate response and long-term adaptation is crucial for maintaining these populations' mobility and overall physical health.

In essence, while responses are short-term and situation-specific, adaptations are long-term changes that enhance resilience and performance in tactical environments. Taking the HWS through a series of mobility patterns will impact their immediate mobility or a "response." In the next day, mobility will return to its original limitation. Like any other physiological response, mobility must be worked continuously to gain neuromuscular patterning adaptation.

To obtain the chronic mobility adaptions, many strength and conditioning (SC) and HP professionals want their HWS professionalsto have a deeper understanding of the interplay between flexibility, ROM, and mobility. These terms are interrelated but have very distinct definitions. SC and HP professionals need to understand the nuanced differences between these three elements to appropriately program mobility training.

Understanding the Interplay Between Flexibility, Range of Motion, and Mobility

Flexibility, range of motion (ROM), and mobility are fundamental concepts in physical fitness and rehabilitation. While they are often discussed together, each represents a unique aspect of bodily movement, contributing to the body's ability to perform efficiently and effectively.

Flexibility: The Foundation of Movement

Flexibility refers to the capacity of muscles and other soft tissues—such as tendons and ligaments—to stretch and lengthen [5, 21, 22]. The property allows these tissues to extend to their full length, permitting movement at a joint without restriction [23]. Flexibility is often considered the foundation of movement, as it directly influences a joint's potential range of motion (ROM). When muscles are sufficiently flexible, they enable joints to move freely, reducing the likelihood of injury and enhancing movement efficiency [24]. For example, touching one's toes during a forward bend is a practical demonstration of hamstring flexibility, showcasing how muscle extensibility supports movement.

Range of Motion: The Extent of Movement

Range of motion (ROM) measures the movement around a specific joint or body part, usually expressed in degrees. It represents the potential capacity of a joint to move through its anatomical limits [25]. ROM is influenced not only by flexibility but also by the structural characteristics of the joint, such as bone configuration, cartilage integrity, and ligament elasticity [25]. For instance, the shoulder joint's ROM includes its ability to flex, extend, abduct, and rotate—movements essential for daily tasks to athletic performance [26, 27]. ROM provides a quantifiable measure of joint function, but it alone does not guarantee effective movement.

Mobility: The Integration of Flexibility and ROM

Mobility is the ability to actively move a joint or series of joints through their full range of motion, integrating flexibility, ROM, strength, coordination, and stability [28]. It represents the practical application of these components in dynamic, functional movement. Good mobility requires a joint to move through its full ROM, and the surrounding muscles can support and control this movement effectively [5, 21, 22]. For example, performing a deep squat with proper form necessitates adequate hip, knee, and ankle ROM, the flexibility of the surrounding muscles, and the strength to execute the movement smoothly and safely [29].

The Interrelationship Between Flexibility, ROM, and Mobility

Flexibility, ROM, and mobility are interconnected so that each influences the others, creating a comprehensive framework for understanding movement. Flexibility is a critical component of ROM; without sufficient muscle extensibility, joints cannot achieve their full range of motion [23]. However, while ROM is necessary for mobility, more is needed. Mobility requires that individuals use their full ROM in a controlled, coordinated manner, which involves adequate muscle strength and motor control [28]. Consequently, flexibility supports mobility by allowing for unrestricted joint movement, but mobility itself is a broader concept that encompasses the active, functional use of this range [24, 25, 29].

While flexibility and ROM are foundational elements that provide the potential for movement, mobility represents the practical execution of movement in real-life activities. Understanding the nuanced relationships between these concepts is essential for anyone looking to improve physical performance, prevent injuries, or enhance overall movement quality.

Mobility Workouts and Their Benefits

Many methods exist to improve mobility, including Yoga, Pilates, dynamic warm-up, gymnastics, or martial arts. No one "best method" exists. The results depend on the target population and how it is programmed. Due to time limitations, needs, and implementation ability, coaches must focus on a method that can be incorporated into the dynamic warm-up, used as a workout, or done independently.

Before starting any mobility program, the SC professional must conduct a needs analysis. This process will lay the foundation for understanding the limiters constraining the HWS's mobility.

Mobility Screening and Evaluation

Coaches need to teach movement patterns, not individual muscles. Movement development is different from muscular development. Training muscles is different from movement training. To be successful, training must be "effective and efficient" [7]. Coaches who are too focused on the hardware (i.e., body) and not the software (motor programs) can develop "…movement mistakes in which the body compensates and uses suboptimal joint alignment, muscle coordination, and posture" which leads to energy leaks that "can cause unnecessary movement in another part of the body placing greater stress on muscles & tendons which leads to sprains/strains" [30]. To teach these movements, a coach needs to evaluate mobility. The following are effective mobility screening methodologies coaches can use in the field.

Functional Movement Screening (FMS)

The functional movement screen (FMS) is a widely used assessment tool designed to evaluate fundamental movement patterns and identify limitations or asymmetries that could lead to injury. Developed by Gray Cook and colleagues, the FMS consists of seven movement tests that require a balance of mobility and stability. Each test is scored on a scale from 0 to 3, with a maximum score of 21, as shown in Fig. 8.1 [28].

The seven tests in the FMS include the deep squat, hurdle step, in-line lunge, shoulder mobility, active straight leg raise, trunk stability push-up, and rotary stability. Each movement is evaluated based on specific criteria, allowing practitioners to identify dysfunctional movement patterns. A score of 3 indicates that the movement was performed without compensation, 2 indicates some degree of compensation, 1

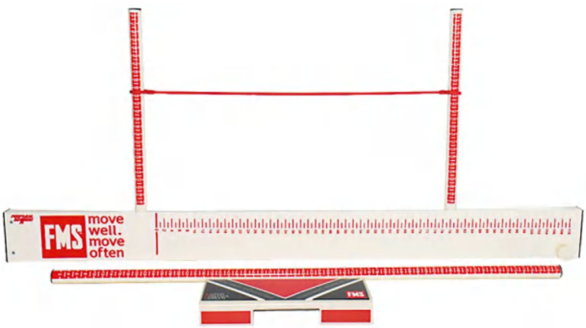

Fig. 8.1 The FMS testing kit

reflects an inability to perform the movement, and 0 is given if the participant experiences pain during the movement [28].

The FMS is a versatile tool for identifying potential injury risk factors and monitoring recovery progress. Research has shown that individuals with an FMS score below 14 are more likely to sustain injuries, particularly in athletic populations [31]. By detecting movement dysfunctions early, the FMS enables practitioners to design targeted interventions that enhance movement patterns and reduce injury risk. Furthermore, the FMS is an asset for tracking rehabilitation and fitness progress. By reassessing individuals after interventions, practitioners can evaluate the effectiveness of their strategies and make necessary adjustments to optimize movement outcomes [32].

The functional movement screen (FMS) is a valuable tool for assessing movement quality and identifying potential injury risks. However, like any assessment tool, it has its strengths and weaknesses.

FMS Strengths

1. Simplicity and standardization: The FMS is easy to administer and requires minimal equipment, making it accessible in various settings, from clinical environments to sports facilities. Its standardized scoring system allows for consistent assessments across different practitioners, contributing to its reliability [28].
2. Injury risk identification: One of the FMS's most significant strengths is its ability to identify movement dysfunctions that may increase the risk of injury, particularly in athletic populations. Studies have shown that lower FMS scores are associated with a higher likelihood of injury, which allows for early intervention and injury prevention strategies [31, 33, 34].
3. Versatility: The FMS can be used across various populations, including athletes, military personnel, and the public [28, 32–35]. It serves as a screening tool in preseason evaluations and ongoing fitness programs, helping monitor changes and improvements in movement patterns over time.
4. Guides training and rehabilitation: The FMS provides actionable insights that can be used to design targeted training and rehabilitation programs. By identifying specific movement deficiencies, practitioners can tailor interventions to address those areas, ultimately improving overall functional movement [28].

FMS Weaknesses

1. Limited predictive validity: While the FMS has been shown to identify movement dysfunctions, its ability to predict specific injuries is limited. Some studies suggest that the FMS should not be used as a sole predictor of injury risk, as

many factors contribute to injuries, including fatigue, training load, and external conditions [36].
2. Subjectivity in scoring: Although the FMS has a standardized scoring system, some scoring elements can be subjective, depending on the practitioner's experience and interpretation of movement quality. This subjectivity can lead to score variability across different assessors [37].
3. Focus on movement quality, not performance: The FMS is designed to assess basic movement patterns, but it does not account for an individual's physical performance or strength. High-performing athletes might score poorly on the FMS but still perform well in their sports, suggesting that the FMS may need to capture the complexities of athletic performance fully [9].
4. Population-specific considerations: The FMS is often applied broadly, but its relevance may vary depending on the population being tested. For example, the same movement patterns may have different implications for different age groups or for those with preexisting conditions, which can limit its generalizability [38].

The FMS is a powerful tool for assessing movement quality and identifying potential injury risks. Its strengths lie in its simplicity, ability to guide interventions, and versatility across populations. However, practitioners should be aware of its limitations, including the potential for subjective scoring and its limited predictive validity for injuries. To maximize its effectiveness, the FMS should be used with other assessments and within the broader context of the HWS's overall physical condition and goals.

Y-Balance Test (YBT)

The Y-Balance Test (YBT) is a dynamic balance assessment tool designed to evaluate an individual's stability and postural control, mainly focusing on lower extremity function [39]. It is widely used in sports medicine, rehabilitation, and injury prevention settings to assess an athlete's risk of injury, monitor rehabilitation progress, and improve performance [39, 40]. The YBT involves the participant balancing on one leg while reaching in three directions: anterior, posteromedial, and posterolateral. These reach directions form a "Y" shape, hence the test's name (Fig. 8.2). The test is performed on both legs, measuring the distances reached in each direction. The composite score is calculated as the sum of the maximum reach distances in each direction, normalized to the limb length of the participant, providing a comparative analysis between limbs.

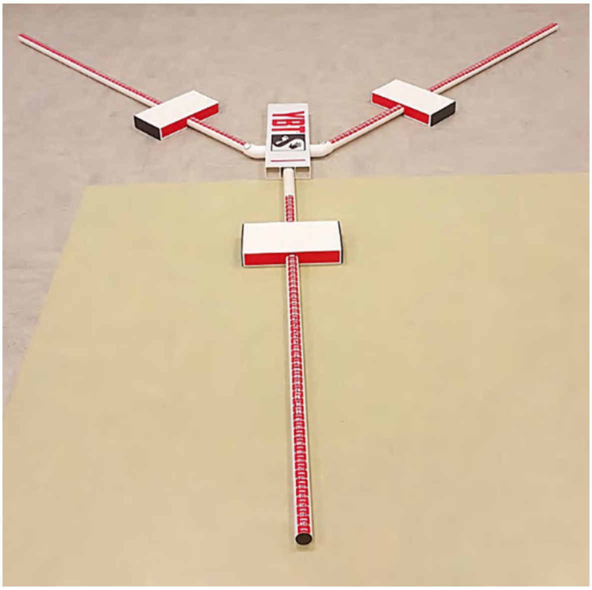

Fig. 8.2 The Y-Balance Test [39]

YBT Strengths

The Y-Balance Test's strengths lie in its simplicity, cost-effectiveness, and ability to provide quantitative data on dynamic balance and functional symmetry [39, 41]. One of the key advantages is its ease of administration; the test requires minimal equipment—just a grid or a marked surface—and can be performed almost anywhere [39]. This makes it accessible for clinicians, coaches, and trainers across various settings. The YBT also offers a standardized method to assess balance and identify asymmetries between limbs, which are often associated with a higher risk of injury, especially in HWS professionals [42, 43]. Furthermore, it is reliable and valid for different populations, including healthy individuals, those with lower extremity injuries, and older adults, thus broadening its applicability [41–43].

YBT Limitations

Despite its advantages, the YBT has notable limitations. One primary concern is that it predominantly evaluates lower extremity balance, neglecting the upper body and trunk stability, which are crucial for overall balance and athletic performance [39, 40]. Moreover, while the test effectively identifies balance deficits, it needs to provide insight into the underlying causes of these deficits, such as muscular strength imbalances, proprioceptive deficits, or joint range of motion limitations [39]. Additionally, the YBT's normative data are primarily based on athletic populations, which might limit its applicability to HWS populations [42, 43]. Another limitation is the potential learning effect and interrater variability; repeated testing might improve tester and participant performance, not necessarily due to enhanced balance but increased familiarity with the test procedure [41, 44]. This aspect could potentially skew results and mask actual balance deficiencies.

While a valuable tool in assessing dynamic balance and functional symmetry, the YBT should be used in conjunction with other assessments to comprehensively evaluate an individual's balance and injury risk comprehensively. Integrating YBT results with other clinical evaluations, such as strength testing, proprioceptive assessments, and functional movement screenings, can offer a more holistic view of an individual's functional status. Furthermore, future research should focus on expanding normative data to include a more diverse population and exploring the relationship between YBT scores and specific injury mechanisms or rehabilitation outcomes.

Range of Motion and Flexibility Tests

The YBT and FMS mobility tests focus only on mobility. Other tests exist that measure ROM and flexibility. As stated earlier in this chapter, ROM measures the movement around a specific joint or body part, usually expressed in degrees. Flexibility is the capacity of muscles and other soft tissues—such as tendons and ligaments—to stretch and lengthen [5, 21, 22]. Flexibility, ROM, and mobility are interconnected so that each influences the others, creating a comprehensive framework for understanding movement. Other tests focus only on flexibility and ROM but not mobility.

Many joint range of motion assessments use tools like goniometers, the Thomas test for hip flexor flexibility, and the overhead squat assessment for evaluating the mobility and stability of hips, knees, ankles, and the spine. The ankle dorsiflexion test, crucial for sports requiring extensive footwork, evaluates ankle ROM. The total body rotation tests for thoracic spine and trunk ROM. The 90/90 Shoulder Test measures shoulder flexibility, and the Sit-and-Reach Test measures lower back and hamstring flexibility.

These ROM and flexibility tests are great post hoc tests after conducting a mobility test. The FMS and YBT are valuable tools in identifying imbalances but not the root cause. Adding a ROM or flexibility test to the identified mobility imbalance will help the HP professional identify the root cause.

How to Improve Mobility

Mobility improvement methods for physical fitness encompass a variety of exercises and techniques designed to enhance the range of motion, flexibility, and overall functional movement of the body. Key methods include dynamic stretching, which involves active movements that stretch muscles through their full range of motion, often used as a warm-up to improve blood flow and reduce injury risk [45–47]. Foam rolling, or self-myofascial release, helps release tight muscles and break up adhesions in the fascia, leading to improved muscle elasticity and joint range of motion [48, 49]. Yoga and Pilates are also highly effective, focusing on stretching, strengthening, and stabilizing muscles while enhancing balance and core strength. Joint mobility drills, which involve controlled circular movements of the joints, help maintain or restore the natural movement capacity of the joints [50, 51]. Additionally, proprioceptive neuromuscular facilitation (PNF) stretching, which combines static stretching and isometric contractions, can significantly enhance flexibility [21]. Incorporating these methods into a regular fitness routine can lead to improved athletic performance, reduced injury risk, and greater ease in performing daily activities.

This section will not explore each of these methods but rather discuss how an SC professional can better incorporate them into an organizational-level program.

Incorporating Mobility Improvement into an Organizational HP Program

Mobility can be incorporated into any workout as part of any training session. The methods stated earlier can be added to the warm-up, main set, or cooldown of a training session or as a recovery workout. The main goal is to create a rock-solid mobility program that elicits the chronic adaptations necessary to improve the HWS's mobility [52].

The SC professional should incorporate dynamic exercises focusing on structural, postural, flexibility, mobility, or stability for a training session's warm-up and cooldown sections. This strategy accomplishes two goals for the warm-up. First, the coach can detect any issues limiting training [53]. Second, these dynamic warm-ups are controlled movements that activate muscles and tendons before the workout begins. As for the cool down, dynamic exercises along with static stretching are designed to prepare the body for recovery and prepare for the next training session.

Incorporating mobility work as a recovery session significantly improves the HWS's ability to recover from previous high-intensity training sessions [54–57]. Active recovery training sessions greatly benefit HWS populations, facilitating faster recovery while maintaining operational readiness. These sessions typically involve low-intensity activities that promote blood circulation, reduce muscle soreness, and enhance flexibility without adding stress to the body [55]. By accelerating the removal of metabolic waste products and decreasing inflammation, active recovery helps muscle repair and reduces overall recovery time. Additionally, it enables tactical professionals to maintain a high level of physical fitness and performance, even during rest periods, which is crucial for their demanding roles.

The most challenging element for a strength and conditioning (SC) professional involves integrating mobility, range of motion (ROM), and flexibility enhancement strategies at an organizational level, particularly within large groups. During the warm-up phase, it is imperative that the SC professional meticulously observes the human work system's (HWS) movement patterns, as these are foundational to practical training. This necessitates an individualized focus on each participant's movements.

A practical approach for observing multiple participants swiftly involves arranging the HWS in approximately five to six lines (the SC professional is only limited by the space size available). The SC professional should first analyze and correct the movement patterns of the initial groups across a distance of 5 to 10 yards. Subsequent groups continue the exercise for an additional 10 yards, allowing for a seamless transition and continuous observation. During this process, the SC professional should circulate among the participants, which provides varied observational perspectives of the exercises being performed.

To develop a warm-up regimen, it is advisable to select two or three mobility-specific exercises that complement other movement drills. If the primary focus of the workout targets the upper body, it is beneficial to integrate mobility drills that involve the shoulders, arms, and back (Table 8.1). Conversely, if the emphasis is on lower-body training, exercises should enhance mobility in the hips, legs, and ankles (Table 8.2).

The cooldown is structured similarly to the warm-up. The mobility exercises utilized should promote recovery from the biomotor patterns training during the current session while simultaneously promoting recovery. After completing the main set, the cooldown session can be run as a group or individual session. SC professionals must find the best strategy for training sessions and the HWS population.

In alignment with standard warm-up protocols, this example of a mobility recovery session commences with the HWS's organized into five to six lines. Initially, participants execute the first nine movements across 20 yards, with each group initiating the sequence at intervals ranging from 5 to 10 yards. Subsequently, the HWSs are instructed to maintain formation in six lines, each separated by a distance of five yards, as depicted in Fig. 8.1.

The session progresses with the additional movements performed statically, facilitating seamless transitions between each exercise (Table 8.3). During this phase, a physical therapist, athletic trainer, or strength coach must diligently

Table 8.1 Possible mobility drills involving the shoulders and upper back to prepare for an upper-body workout

Swimmers
Y/T/W
Reverse incline

Table 8.2 Possible mobility drills involving the hips, lumbar, and legs to prepare for a lower-body workout

Lunge forward
Backward lunge down/straight lg touch ground/knee to chest
Elbow to ankle rotation/ drop knee torso up/squeeze glut
Grab same hand/same foot
Overhead squat
Spiderman, front leaning rest/arch/ frog/step

traverse the rows. This allows the professional to closely monitor each participant's movement patterns, identifying and addressing any suboptimal mechanics that may result in "energy leaks," muscle tightness, or compensatory movements that can diminish the effectiveness of the exercise regimen.

Dynamic stretching sequence (10 yards downfield)—layout like that depicted in Fig. 8.3

1. Lunge forward
2. Backward lunge down/straight lunge touch ground/knee to chest
3. Elbow to ankle rotation/drop knee torso up/squeeze glut
4. Grab the same hand/same foot
5. Frankenstein (opposite toe to hand)
6. Step over hurdle forward
7. Overhead squat
8. Straight leg hip hinge
9. Spiderman, front leaning rest/arch/frog/step

Conclusion

In conclusion, this chapter comprehensively explores functional and mobility training within the context of HWS, mainly focusing on tactical and first responder groups. Mobility methodologies are crucial in tailored fitness regimes to ensure operational efficacy and injury prevention in these high-stress professions. Through the strategic incorporation of mobility, flexibility, and ROM elements into existing training programs, this chapter highlights the importance of a multidisciplinary approach involving collaboration among fitness professionals, physical therapists, and tactical trainers. By integrating a thorough understanding of the specific demands and potential injury risks associated with HWS roles, the methodologies discussed here aim to foster greater resilience and adaptability. The insights provided not only enhance our understanding of the physical demands placed on tactical personnel but also underscore the potential for these training protocols to significantly improve job performance and reduce the risk of injury, thereby promoting a healthier, more effective workforce.

Table 8.3 A series of mobility exercises can be performed for a recovery training session

Online, every 5 yards
Feet hip to shoulder length apart/back parallel to the ground
1. Y/T/W/X × 10 each
2. Sit for bottom squats with 3 s isohold (ISO) × 5 (hold toes)
3. Front lean rest × 10 s
4. Plank × 30 s
5. Plank side to side × 10 each way
6. Streamline with 3 s ISO, hold hands over head × 5
7. Swimmers × 10
8. W × 10
9. Plank reach out × 5 each
10. Plank lift leg × 5 each
11. Plank lift opposite leg/opposite arm × 5
12. Plank up to the front, leaning rest × 5
13. Front lean rest to pike position × 5
14. Inchworm in place × 5 times
15. Pike holds touch opposite hand/shoulder × 5
16. Pike to bottom squat × 5
17. Bottom squat × 30 s
18. Crab/tabletop × 5
19. Tabletop (knee/hip/shoulder/ear in-line) × 30 s
Transition via walk back to the bottom squat
Transition via a walkout to bear crawl
Transition via dropping to pigeon pose
20. Pigeon left leg/pigeon right leg × 30 s each
21. Sit through to 90/90 × 5 each
Transition by moving to quadruped pose
22. Puppy fire hydrant kicks × 20 each
23. Hip circles forward/backward × 10
24. Scap retraction × 20 each
25. Donkey kick (opposite arm down) × 20
26. Hand on the neck elbow to open T-spine × 10 each
27. Thread the needle (arm down the line) × 10 each
28. Front leaning rest windshield wiper × 10 each
29. Side plank + top leg lift (gluteus medius) × 20 each
Transition by walking back into the squat
30. Left arm up/right arm up stand up

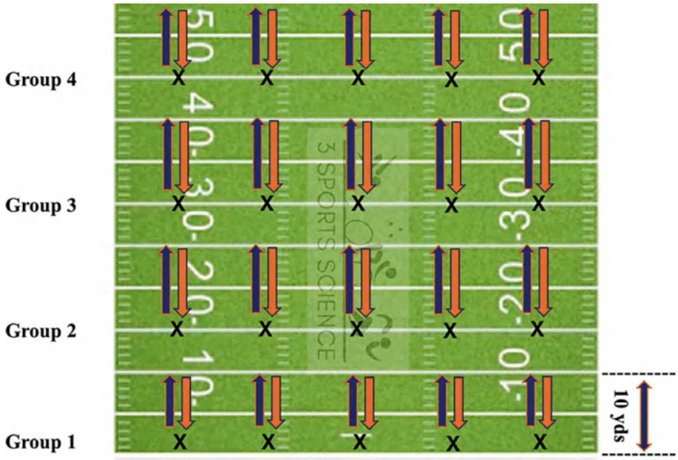

Fig. 8.3 Group mobility session layout. This figure depicts the possible layout for conducting a group session of 25 HWS professionals

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Chapter 9
Specialized Training Techniques for the Human Weapon System

Cory Gilday

This chapter explores advanced training methodologies crucial for developing the human weapon system (HWS) within the human weapon system (HWS). Drawing upon seminal works like Yuri Verkhoshansky's *Supertraining* and insights from Jimmy Radcliffe, we delve into specialized techniques such as plyometrics, Olympic weightlifting, kettlebell training, and unconventional training methods [1]. These techniques are tailored to enhance the physical capabilities of HWSs, focusing on explosive power, strength, and operational readiness.

Plyometrics for Explosive Power: Shock Method, High-Performance Plyometrics, and Injury Prevention

Verkhoshansky's Shock Method and the Stretch-Shortening Cycle

Yuri Verkhoshansky's groundbreaking work on the stretch-shortening cycle (SSC) and his development of the shock method have fundamentally shaped the understanding and application of plyometric training. Verkhoshansky identified the SSC as a natural, elastic response of the muscles and tendons that involves a rapid stretch of a muscle (eccentric action) followed by a short transition time or amortization phase and then an explosive shortening (concentric action) of that same muscle [1]. The shock method, widely recognized as true plyometrics, capitalizes on this mechanism by subjecting the muscles to high-intensity, explosive movements like depth jumps [1]. This method is designed to enhance the neuromuscular system's

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efficiency in producing powerful movements by improving the reactivity of the neuromuscular system and increasing the muscle's ability to generate force quickly.

Jimmy Radcliffe's High-Performance Plyometrics

Building on the foundational concepts of plyometrics, Coach Jimmy Radcliffe has made significant contributions through his work on *High-Performance Plyometrics*, which focuses on applying plyometric principles to enhance athletic performance across a range of sports [2]. Radcliffe emphasizes the versatility of plyometric training, advocating for its use not just for improving explosive power but also for enhancing agility, balance, and overall athletic ability. By carefully structuring plyometric programs, Radcliffe demonstrates how athletes can achieve significant gains in performance while also focusing on technique and safety to minimize the risk of injury [2].

Injury Prevention and Force Absorption in HWSs

The injury prevention component of plyometric training is particularly crucial for HWSs, who often face scenarios requiring rapid absorption and reabsorption of force. Activities such as helo casting (jumping from a helicopter into water), repelling, or military free fall involve significant impact forces that the body must be able to absorb and manage safely. Plyometric training emphasizes the development of the SSC and prepares the athlete's body for these high-impact situations by enhancing the efficiency of the force absorption and reabsorption mechanisms.

Properly implemented plyometric training can significantly reduce the risk of injury in HWSs by:

- *Improving muscular tendon stiffness*: This enhances the body's ability to absorb shock upon landing, reducing the strain on joints and connective tissues.
- *Enhancing proprioception and neuromuscular control*: Plyometrics improve the body's awareness and control during dynamic movements, allowing for safer landings and transitions.
- *Increasing joint stability*: By strengthening the muscles around critical joints, plyometrics contribute to joint stability, further mitigating injury risk during high-impact activities.

Conclusion

The work of Verkhoshansky in developing the shock method and Jimmy Radcliffe's contributions to plyometric training underscores the value of these techniques in enhancing athletic performance and preventing injuries [1, 2]. For HWS populations, the ability to safely absorb and reabsorb force is a performance enhancer and a critical component of operational readiness and longevity in their demanding physical roles. By integrating plyometric training into their conditioning programs, HWS can significantly improve their explosive power, agility, and resilience, equipping them to handle the physical challenges of their duties safely and effectively.

Olympic Weightlifting Techniques: Insights from Jimmy Radcliffe and Coach Leo Totten

As Jimmy Radcliffe and Coach Leo Totten analyzed and taught, Olympic weightlifting techniques are crucial for developing explosive power, speed, and coordination in HWS populations [2]. These techniques, focusing on the snatch, clean, and jerk, are foundational for enhancing the physical capabilities required in demanding operational environments [2].

Insights from Jimmy Radcliffe

Jimmy Radcliffe, renowned for his expertise in strength and conditioning, emphasizes the significance of Olympic weightlifting movements in improving neuromuscular efficiency and power output [2]. Radcliffe advocates for including these techniques as a core component of athletic development, highlighting their role in enhancing kinetic chain efficiency and force production. Under Radcliffe's guidance, the integration of weightlifting exercises is tailored to improve the athlete's explosive strength, a critical attribute for rapid movements and actions under load, frequently encountered in tactical situations.

- *Practical application*: Radcliffe recommends starting with foundational movements and drills to ensure proper technique and form. Progression to more complex lifts is contingent upon mastery of these basics, focusing on power development through efficient force transfer.

Contributions from Coach Leo Totten

Coach Leo Totten, a respected figure in Olympic weightlifting in the United States, brings knowledge and experience to athletes' training. Totten's approach is detailed and organized, emphasizing the technical precision required in Olympic lifting. His work includes a comprehensive breakdown of the snatch, clean, and jerk, offering HWSs and coaches a clear pathway to integrating these lifts into their training regimens.

- *Implementation strategy*: Totten stresses the importance of a systematic approach to learning and teaching Olympic weightlifting. This includes using auxiliary exercises to build the strength, flexibility, and technique for effective lifting. Totten's methods also focus on periodizing training to peak athletes for optimal performance in their operational roles.

Integration into HWS Development

The methodologies Jimmy Radcliffe and Coach Leo Totten advocated offer HWSs a structured approach to incorporating Olympic weightlifting techniques into their training [2]. The emphasis on technical mastery, combined with explosive power and strength development, aligns well with the physical demands of tactical personnel. By following the principles laid out by these experts, HWSs can significantly enhance their operational readiness and physical resilience.

Kettlebell Training for the HWS: Insights from Pavel Tsatsouline, StrongFirst, and the Russian Kettlebell Club

Kettlebell training, rooted in Russian exercise science, has been popularized in the West, largely thanks to Pavel Tsatsouline, the founder of StrongFirst and a major proponent of Russian kettlebell methods [3]. Pavel, StrongFirst, and the Russian Kettlebell Club emphasize strength, endurance, flexibility, and mental toughness—which are essential for the HWS. This section expands on how kettlebells can be used effectively in developing the HWS, drawing upon the principles set forth by these authorities [3].

Pavel Tsatsouline's Kettlebell Principles

Pavel Tsatsouline, a former physical training instructor for the Soviet Special Forces, introduced kettlebell training to the United States [4]. His approach focuses on building functional strength and conditioning through minimalist and high-efficiency workouts [4]. Pavel's methodology, characterized by its emphasis on safety, technique, and gradual progression, highlights several essential exercises:

- *The kettlebell swing*: The cornerstone of kettlebell training is that the swing develops power in the hips and legs while improving endurance.
- *The Turkish get-up*: A complex movement that increases mobility and stability across multiple joints, enhancing functional strength and resilience.
- *The kettlebell snatch: It builds explosive power and shoulder strength, which is* vital for the pressing and pulling movements required in tactical operations.

StrongFirst: A School of Strength

StrongFirst is a global organization that teaches strength training with kettlebells, barbells, and bodyweight exercises [4]. StrongFirst's philosophy revolves around the idea that strength has a greater purpose, serving as the foundation for physical and mental toughness. The organization offers comprehensive training protocols that include:

- *Progressive overload*: Gradually increasing the weight or complexity of exercises to challenge the athlete continuously.
- *Grease the groove*: Performing submaximal repetitions of an exercise throughout the day to improve neuromuscular efficiency and strength.
- *Simple and sinister program*: A minimalist routine focusing on kettlebell swings and Turkish get-ups designed to build strength, mobility, and endurance.

Russian Kettlebell Club (RKC) Techniques

The Russian Kettlebell Club, another initiative spearheaded by Pavel, emphasizes the traditional Russian kettlebell training techniques [4]. RKC promotes a holistic approach to kettlebell training, integrating strength, cardiovascular conditioning, and flexibility into a unified regimen. Key principles include:

- *Breathing techniques*: Proper breathing patterns to enhance performance and ensure safety during lifts
- *Tension and relaxation*: Mastering the art of creating muscle tension to lift heavier weights, combined with relaxation to conserve energy and improve endurance

- *Complexes and chains*: Sequences of different kettlebell exercises performed back-to-back without setting the kettlebell down, effectively combining strength and cardiovascular training

Application in Tactical Training

Incorporating kettlebell training into HWSs' regimens can significantly enhance their operational effectiveness. Additionally, the equipment is easily attainable and portable. The versatility of kettlebells allows for developing explosive power, strength endurance, and functional mobility—attributes crucial in the austere environments where tactical personnel often operate. By applying the methodologies of Pavel Tsatsouline, StrongFirst, and the Russian Kettlebell Club, HWSs can achieve a high level of physical preparedness, ensuring they are ready to meet the demands of their profession with resilience and strength [3, 4].

Conclusion

Kettlebell training offers a comprehensive approach to building the physical capabilities required by HWSs. The principles and exercises these experts advocate are instrumental in developing a well-rounded, highly capable human weapon system that can perform optimally in any situation.

Unconventional Training Tools and Methods

Unconventional training methods have enhanced functional strength, endurance, and overall physical resilience, especially in environments where traditional gym equipment may not be accessible, such as forward operating bases or certain deployment areas. Coaches Jimmy Radcliffe and Michael Boyle and renowned trainer Joe DeFranco have contributed significantly to developing and advocating these training methodologies, underscoring their relevance for HWSs and the broader athletic community [5].

Embracing Unconventional Tools

Unconventional training tools—such as sandbags, tires, sleds, battle ropes, and resistance bands—offer versatile and dynamic approaches to strength and conditioning. These tools effectively build physical capabilities and mimic the unpredictable nature of operational tasks and environments HWSs face while working with familiar equipment [5, 6].

- *Sandbags*: Michael Boyle emphasizes that sandbag training enhances grip strength, core stability, and functional movement patterns. Sandbags can be used for various exercises, including carries, squats, and throws, closely simulating the demands of lifting and moving irregular loads in operational settings.
- *Sleds*: Joe DeFranco highlights sled pushes and pulls for developing lower body strength, power, and endurance without the eccentric loading that often leads to muscle soreness. This makes sled work particularly valuable for maintaining training intensity without compromising recovery.
- *Battle ropes*: This equipment offers a unique modality for building upper body endurance, power, and core stability. Jimmy Radcliffe points out that battle rope exercises can improve cardiovascular fitness, making them a multifaceted tool in the HWS's regimen.

Adaptability in Training

The adaptability of unconventional training tools is particularly relevant for HWSs operating in environments where traditional gym facilities are unavailable. Coach Jimmy Radcliffe emphasizes the importance of adaptability in training, advocating for using natural and readily available materials to maintain physical readiness. This adaptability ensures that HWSs can keep their conditioning and readiness, regardless of location.

Training for the Unpredictable

The core philosophy behind incorporating unconventional training tools and methods, as shared by coaches like Radcliffe, Boyle, and DeFranco, is to prepare athletes for the unpredictable. The varied nature of these tools challenges the athlete physically and mentally, fostering a readiness mindset for any challenge. This is particularly crucial for the HWS, whose operational environment is inherently unpredictable and demanding.

Expansion on Unconventional Training Tools: Portability and Tactical Environments

One of the most significant advantages of unconventional training tools is their portability. This makes them exceptionally well-suited for austere tactical environments where traditional gym equipment is unavailable or impractical. This section further explores how the portability of these tools benefits HWSs, especially when deployed or operating in remote areas.

Sandbags: The Ultimate Portable Gym

Sandbags are a prime example of a versatile and portable training tool. Their weight can be easily adjusted by adding or removing sand, making them adaptable for various exercises targeting strength, endurance, and stability. Michael Boyle, a proponent of functional training, emphasizes that sandbags can be deployed quickly for training sessions anywhere, from a forward operating base to remote field locations, providing a full-body workout that mimics operational lifting and carrying tasks.

Sleds: Compact and Field-Ready

While sleds might seem less portable than other tools, compact and collapsible models can be easily transported and used on various terrains. Joe DeFranco has highlighted the effectiveness of sled training for building lower body power and endurance without significant muscle soreness, allowing for consistent training intensity. The adaptability of sleds to different surfaces makes them ideal for use in diverse operational environments, from desert landscapes to forested areas [5].

Battle Ropes: Lightweight and Versatile

Battle ropes are lightweight and can be rolled up for easy transport. They offer a high-intensity cardiovascular and strength training option to set up anywhere a secure anchor point is available. Jimmy Radcliffe points out the benefits of battle rope exercises for improving upper body endurance, power, and core stability. The simplicity and ease of transport of battle ropes make them an excellent option for maintaining physical fitness in any setting [5].

Kettlebells: Compact Strength Training

Kettlebells are compact and relatively easy to transport, providing a powerful tool for strength, power, endurance, and flexibility training. Their unique design allows various dynamic movements that engage the entire body, closely simulating the functional movements required in tactical operations. Their portability ensures that HWSs can maintain a high level of physical readiness, even in confined spaces or when on the move [6, 7].

The Advantage in Austere Environments

The portability of these unconventional training tools offers a strategic advantage in austere tactical environments. HWSs often operate in conditions where traditional training facilities are not accessible. The ability to carry and utilize training equipment like sandbags, compact sleds, battle ropes, and kettlebells allows for the continuation of a comprehensive strength and conditioning program, ensuring that HWSs always remain operationally ready.

Integrating Portability into Training Programs

Coaches and strength and conditioning professionals working with tactical populations should integrate these portable training tools into their programming, emphasizing their utility and versatility. Training programs should include instructions on adapting workouts based on the available equipment and space, ensuring that HWSs can maintain their fitness levels, irrespective of their operational environment.

The portability and adaptability of unconventional training tools provide practical solutions for maintaining physical readiness in any setting and prepare HWSs for their unpredictable and challenging responsibilities. By incorporating these tools, HWSs can ensure they are physically prepared to meet the demands of their profession, regardless of location.

Conclusion

Specialized training techniques play a critical role in preparing HWSs for the rigors of their duties. Drawing on the foundational principles of Verkhoshansky's *Supertraining* and Radcliffe's expertise, this chapter provides a comprehensive guide to elevating the physical capabilities of the human weapon system through specialized training.

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Chapter 10
Advanced Strength Training Techniques

Kosta Telegadas, Christopher Myers, and Cory Gilday

Introduction

Knowing different resistance training methodologies will make you a better strength and conditioning (SC) professional. Each human weapon system (HWS) professional reacts differently to various training stimuli. Human performance training is not a "one size fits all" type of system. The more training methodologies an SC professional can implement, the more adaptable the SC professional can make the SC programming.

This book introduces and discusses strength and conditioning theory for HWS professionals. This chapter explores applying many resistance-loading techniques and methods, which can be used to achieve the periodization methodologies discussed in Chap. 4. The ultimate goal is to provide SC professionals with a baseline but comprehensive guide to the existing resistance-loading techniques and methodologies.

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Resistance-Loading Techniques

Pyramids

Pyramid training involves starting with lighter weights and higher repetitions, then progressively increasing the weight while decreasing the number of repetitions for subsequent sets. This type of training targets different muscle fibers, improves endurance and strength, and helps prevent overtraining.

Ascending pyramid: Start light and increase the weight with each set while decreasing reps (e.g., 12 reps at a lighter weight, 10 reps with a heavier weight, and 8 reps with an even heavier weight).

Descending pyramid (reverse pyramid): Start with the heaviest and lowest reps and then decrease weight while increasing the number of reps for each set.

Rest-Pause Training

In rest-pause training, one performs a set to failure or near failure, rest for a short period (typically 10–20 s), and continue doing more repetitions with the same weight. This cycle can be repeated multiple times. The benefits of this technique are increased time under tension, the force of the muscles to continue working after a brief recovery, and the improvement of strength and endurance.

Example: One lifts a weight for eight reps, rests for 15 s, and then performs another two to three reps with the same weight.

Supersets and Compound Sets

These two techniques are similar but uniquely different. A superset is a technique where two different exercises are performed together with little to no recovery and train *opposing* muscle groups. A compound set is a technique where two different exercises are performed together with little to no recovery and train *the same* muscle groups. This technique increases intensity, shortens workout time, and can improve hypertrophy and muscular endurance.

Superset example: Barbell bench press followed by barbell rows (chest and back)
Compound set example: Barbell bench press followed by dumbbell flys (chest)

Giant Sets

Giant sets are similar to compound sets but involve performing three to four exercises for the same muscle group in succession, with little to no rest in between. This technique is highly effective for muscle hypertrophy and endurance, as it targets one muscle group with multiple angles and intensifies the workout.

Example: A giant leg set might include squats, lunges, leg presses, and leg extensions.

Cluster Sets

Cluster sets involve breaking down a single set into smaller "mini sets" with short rest periods in between. The total number of reps is the same as a regular set but spread over multiple attempts. This technique lets one do more reps at a given weight, thus increasing volume to improve hypertrophy and strength.

Example: Instead of doing 12 reps, one can do four sets of 3 reps with 15–20 s of rest between each set.

Lift-Phase-Specific Techniques

Lift phase techniques are load-variation techniques that focus on the three phases of a lifting movement, the eccentric, isometric, and concentric phases, and the timing of these phases. Each of these techniques brings a different training component to improve muscular strength, power, and muscular endurance.

Eccentrics (Negative Reps)

Eccentrics focus on the lengthening phase of a movement, such as lowering a weight slowly in a bench press or squat. The eccentric phase of a lift tends to produce more muscle damage (a key factor for growth), and lifters are typically more vital during this phase [1–3]. This makes eccentrics highly effective for building both strength and muscle mass. By lowering weights under control, one overloads muscles differently than in the concentric (lifting) phase.

Example: At 60–72% of one-rep max (1RM) of a barbell back squat, one takes 5–6 s to lower (eccentric movement) the load into the base of the squat position and pushes up (concentric phase) at a normal velocity.

Isometrics

Isometrics involve holding a muscle contraction in a static position without changing the joint angle or muscle length. In strength training, isometric exercises help build strength at specific joint angles. By stabilizing muscles and repairing tendons and ligaments, isometrics can improve strength endurance and benefit injury recovery.

Example: A plank is an isometric exercise for the core muscles. Another example is pausing at the bottom of the barbell back squat for 2–3 s.

Concentrics

This technique is the most commonly trained. The concentric phase of a movement is when “muscle tension rises to meet the resistance then remains stable as the muscle shortens” [1]. When the muscle shortens or contracts, it produces force to move the load. A prime example is the bicep curl. As the elbow flexes to lift the load, the bicep, the agonist muscle group, shortens to produce force to lift the load. The benefit of this technique, if performed correctly, can improve hypertrophy and power output.

Example: Performing an explosive upward (concentric) movement of the trap bar deadlift at 60–72% of 1RM to train a higher rate of muscular contraction velocity to improve power output

Time Under Tension (TUT)/Tempo Training

Time under tension refers to the total time one’s muscles are under strain during a set. In TUT training, the user controls the tempo of each repetition to increase the time the muscles work. Usually, a novice lifter will perform all movements of an exercise at a single speed. However, varying the speed of the three-movement phases increased the training stress by increasing the time under tension. Using this technique improves muscular strength and hypertrophy.

Example: This technique is written using a four-digit alphanumeric code. The four digits depict a particular phase of the movement. The numbers determine the length of time in seconds. The only letter used, “X,” means to move as fast as possible. For example, a tempo code for the bench press is 31X2. The first digit, “3,” defines the first eccentric movement. The eccentric movement is to be 3 s in length. The “1” states the lifter should pause for 1 s at the bottom of the lift (the transition point between the eccentric and concentric phases). The “X” means the lifter should push the weight as fast as possible through the concentric phase. Finally, the “2” states the lifter should hold the weight for 2 s at the top of the lift before beginning the sequence again.

Not all exercise movements start with an eccentric movement. The trap bar deadlift begins with a concentric movement. For this exercise, the lifter was given a tempo code of 2362 for one set of five repetitions. The lifter will perform the upward movement (concentric phase) for 2 s. Then, at the top of the movement, the lifter will hold the weight for 3 s. The lifter will lower the weight (eccentric phase) for 6 s and hold the weight for 2 s before repeating this pattern for the rest of the set.

Forced Repetitions

Forced repetitions involve having a training partner assist one in completing additional repetitions after reaching muscle failure. The partner helps lift just enough load to keep the movement going. This technique extends the set beyond failure, increasing muscle fatigue and promoting hypertrophy.

Example: In performing the barbell bench press, a partner helps one lift the bar just enough to complete two to three more reps after failure is reached.

Pin Presses

A pin press is a variation of pressing exercises (such as the bench press) in which the bar is pressed from a set of safety pins placed at a specific height in a power rack. The safety pins are generally placed in two positions: near the top of the concentric and near the bottom of the eccentric movements. The pins limit the range of motion, often starting from the "sticking point" or the most challenging part of the lift. This method isolates certain portions of the lift, helping to break through strength plateaus and build power where the lifter is weakest.

Example: One struggles to lift a specific load at the transition phase at the bottom of the barbell bench press's eccentric phase (downward motion). The safety pins are placed at this position, so the barbell touches at this exact position. This forces one to move the bar from a complete stop.

Resisted Pin Presses

Resisted pin presses are a specific variation of a pressing movement, typically performed in a power rack. The barbell is pressed from a static position against immovable safety pins, usually set at a fixed height. The pins provide a solid surface to resist against, allowing the lifter to target specific portions of the lift by limiting the range of motion. This technique is commonly used to build strength in a lift portion. This technique improves a "sticking point" where the lifter is weakest.

Example: For the pin bench press, which focuses on the sticking point at the transition phase between the eccentric (downward) and concentric (upward) movements, the safety pins are set a few inches above chest height. The bar is held underneath the safety pins, creating a maximal isometric contraction at the sticking point. The lifter presses from that point, focusing on strength and overcoming mid-range sticking points.

Partial Repetitions and Oscillations

Partial repetitions and oscillations are techniques used in resistance training to increase muscle activation, but they differ in their range of motion, intent, and application. The following discusses their differences and benefits.

Partial Repetitions

Partial reps are repetitions where the range of motion is deliberately shortened, often focusing on just a portion of the lift (either the top, bottom, or middle portion). This technique strengthens weak points in lifts and increases time under tension, particularly at specific joint angles. These overload the muscles at specific points in the lift where the body is more robust.

Example: A lifter might perform partial squats to handle more weight than they could at full depth, which can help strengthen the quads and improve overall squat performance.

Oscillations

Oscillations are defined as small, controlled movements or fluctuations within a limited range of motion during an exercise, typically at the top or bottom of the movements. These oscillations normally involve a repeated, rapid shift between contracting and relaxing the muscles within a small range rather than moving through the full range of the exercise. This technique improves muscular contraction speed to improve power and sticking points.

Example: In the seated cable back row, using 60–70% of the one-rep max (1RM), start by performing ten fast rowing repetitions, moving from full extension to about a quarter of the way through the eccentric phase. The movement should be at most the halfway point. Immediately after, without taking a break, perform ten partial reps, starting from the fully contracted position and moving up to a quarter of the way out. Once finished, complete one entire rowing movement and then rack the weight.

Variable Force Production Techniques

Four variable force production techniques discussed are [1] accommodating resistance, [2] drop sets, [3] post-activation potentiation (PAP), and [4] back-down sets.

Accommodating Resistance

This technique involves using equipment like resistance bands or chains to adjust the resistance of an exercise based on the lifter's strength curve. As the lifter moves through the range of motion, the resistance increases or decreases to match the strength curve.

Example: For the banded barbell back squat, the lifter lifts 50–60% of 1RM with bands. The bands are looped around the barbell on the outside portion of the weights and anchored to a point just below the lowest portion of the squat movement. The resistance increases at the top (where the lifter is more robust) and decreases at the bottom (where they are weaker), allowing for a more efficient workout.

Drop Sets

Drop sets are a technique where the weight is immediately reduced by 10–30% after reaching failure with a given weight, and additional reps are performed without resting. This method allows for extended time under tension, stimulating muscle hypertrophy by pushing past the point of initial fatigue. This technique is often used in bodybuilding to maximize muscle growth.

Example: A lifter performs a drop set for the barbell bench press. The lifter lifts 200 lbs. (91 kg) for ten repetitions. After the last repetition, the lifter immediately decreases the weight by 15% (30 lbs./13.6 kg) and performs three more repetitions.

Post-activation Potentiation (PAP)

Post-activation potentiation (PAP) is a performance-enhancing effect in which muscles temporarily become stronger and more explosive after a high-intensity or heavy resistance exercise. This feeling occurs because the prior heavy effort is "primed" by the neuromuscular system. This sequence improves force production in subsequent movements, such as jumping, bounding, or sprinting. PAP is commonly used in SC programs via contrast exercises, where an explosive movement follows a heavy lift. Timing and balance between potentiation and fatigue are crucial to maximizing its benefits.

Example: Barbell back squats paired with bodyweight squat jumps are an example. The lifter performs a set of five repetitions of barbell back squats at 80% of 1RM. Immediately after completing the back squat, the lifter performs two to three squat jumps.

Back-Down Sets

Back-down sets are lighter sets performed after lifters complete their main working sets, typically at a reduced weight and sometimes with higher reps. The goal is to accumulate more volume without the high intensity of the leading sets, allowing the lifter to focus on technique, hypertrophy, or conditioning.

Example: A lifter is performing the barbell deadlift. The lifter performs five repetitions at 82% of 1RM, then reduces the weight by 10%, and performs two sets of eight to ten repetitions.

Burns or Burnouts

This technique is similar but different to back-down sets. It is performed at the end of a session and uses a single functional movement exercise at a very lightweight (10–30% of 1RM) and very high repetition range (15+ repetitions) or until muscular fatigue is reached. Burnouts help with improving muscular endurance and hypertrophy.

Example: On the barbell bench press, the lifter performs two sets of 30 repetitions at 30% of 1RM with a 3-min rest interval at the end of an upper body-focused training session.

Bilateral and Unilateral Training

Bilateral Training

Bilateral training involves using both limbs (arms or legs) simultaneously to perform an exercise, such as squats, deadlifts, or bench presses. Since both sides of the body are working together, bilateral exercises allow for heavier loads. This type of training is effective for building overall strength, stability, and muscle mass. However, it may mask strength imbalances between sides, as the more vital limb may compensate for the weaker one. It is a staple in strength training for developing maximal power and hypertrophy.

Example: A lifter performs the standard barbell back squat.

Unilateral Training

Unilateral training involves using one limb at a time to perform an exercise, such as lunges, single-leg deadlifts, or one-arm dumbbell presses. Unilateral exercises emphasize balance, coordination, and correcting muscular imbalances between the limbs. One can identify and strengthen weaker muscles by isolating one side at a time. This training improves unilateral lifting performance typically seen in HWS professions, injury prevention, and functional movement patterns. Also, this technique places a greater demand on stabilizing muscles, increasing the challenge on the core and smaller supporting muscles.

Example: A lifter performs a set of rear foot elevated barbell split squats.

Deficits

Deficit training involves performing exercises from a position where the range of motion is increased by standing on an elevated surface or adjusting body position. This method increases mobility, improves strength at the start of a lift, improves acceleration through the lift, and can help break through sticking points when plateaus occur.

Example: In a deficit deadlift, the lifter stands on a platform, increasing the range of motion and making the lift more difficult.

Wave Methodology

The wave methodology is a technique where the exercise's intensity (weight) and volume (sets/reps) are alternated in a series of waves to maximize strength or power gains. This variation helps prevent overtraining, enhances neural adaptation, and stimulates progressive overload while allowing recovery within the session. It is often used in advanced strength training programs to maximize power output at a certain period within a training cycle.

Example: In this method, the lifter performs multiple waves where the intensity increases across sets, followed by a slight reduction, and then ramped back up in subsequent waves. For example, a wave might look like: set 1 at 70%, set 2 at 73%, and set 3 at 76%, then repeating another wave at higher percentages. The second wave would look something like this for reference: set 1 at 73%, set 2 at 76%, and set 3 at 78%.

Contrast Training

Contrast training pairs a heavy-strength exercise with a lighter, explosive movement (plyometrics) that mimics the same pattern. This technique is different from PAP because PAP refers to the enhancement of muscle function following high-force activity. The contrast between the heavy load and the lighter, fast movement helps improve neuromuscular coordination and power output. This technique is used to improve speed and explosive strength.

Example: A lifter pairs heavy trap bar deadlift with box jumps. The lifter performs one set of 10 repetitions at 77% of 1RM. Immediately upon completing the deadlift, the lifter performs ten box jumps.

Resistance-Loading Methodologies

This section discusses the different loading methodologies utilized in the field. These methods are used to implement periodization theory with HWS organizations and professionals as best as possible.

Weight and Repetition Variations

Weight and repetition variation resistance training refers to different methods of adjusting the load (weight) and the number of repetitions performed in a set to achieve specific fitness goals. This is the standard methodology used in periodization techniques to achieve a particular fitness goal. The two standard weight and repetition variation techniques used in resistance training are weight and velocity goal–based training.

Weight Goal–Based Training

Weight goal–based training is a widely used methodology focused on achieving a specific objective, such as increasing muscular power, endurance, or hypertrophy. This approach involves adjusting the number of repetitions and the amount of weight lifted to align with the desired goal. Generally, the relationship between weight and repetitions is inverse: as the weight increases, the number of repetitions decreases [4–8]. For example, lifting heavier weights usually means performing fewer repetitions. The weight lifted is typically based on a percentage of an individual's one-rep max (1RM) or three-rep max (3RM), which refers to the maximum

Fig. 10.1 Load and repetition requirements for goal-based training. (Adapted from Haff, G.G, & Triplett, N.T., *Essentials of Strength Training and Conditioning* [4])

Training goal	Load (% 1RM)	Goal reps
Muscular Endurance	< 65 %	> 12
Hypertrophy	65 – 85 %	6-12
Muscular Strength	> 85 %	< 6
Muscular Power		
Maximal	80 – 90%	1-2
Endurance	75 – 85 %	3-5

weight they can lift for one or three repetitions [4–8]. The generally accepted load and repetition requirements for goal-based training are detailed in Fig. 10.1 [4–8].

Velocity Goal–Based Training

Velocity goal–based, or barbell velocity training, is a resistance training method that emphasizes the speed at which a barbell moves during an exercise. Rather than solely focusing on the amount of weight lifted or the number of repetitions performed, this approach tracks and prioritizes the velocity or speed of each lift. How fast the barbell moves (typically measured in meters per second via an accelerometer attached to the barbell) can provide valuable information about strength, power, and fatigue levels during a workout (Fig. 10.2).

Similarly to weight goal–based training, velocity-based training zones are utilized based on the goal. Figure 10.3 depicts the velocity training zones used to achieve particular training goals.

Critical Aspects of Barbell Velocity Training

1. *Measurement of velocity*: Barbell velocity is often measured using specialized devices such as velocity-based trackers (VBT devices) or accelerometers, which are attached to the barbell and track how fast the bar moves during each repetition (Fig. 10.2). These devices allow for real-time feedback on performance, helping HWS professionals adjust their training load based on speed rather than just effort.
2. *Focus on power output*: Barbell velocity training efficiently improves power, combining strength and speed of muscular contraction, the two skeletal muscle characteristics that create power. This methodology significantly emphasizes the concentric motion of the functional movement. By training with moderate to heavy loads, while focusing on moving the barbell as quickly as possible, the HWS can enhance their power output, which is critical in explosive movements like sprinting, jumping, or lifting.

Fig. 10.2 GymAware accelerometer. The GymAware accelerometer is an example of a sensor system used for velocity goal–based training

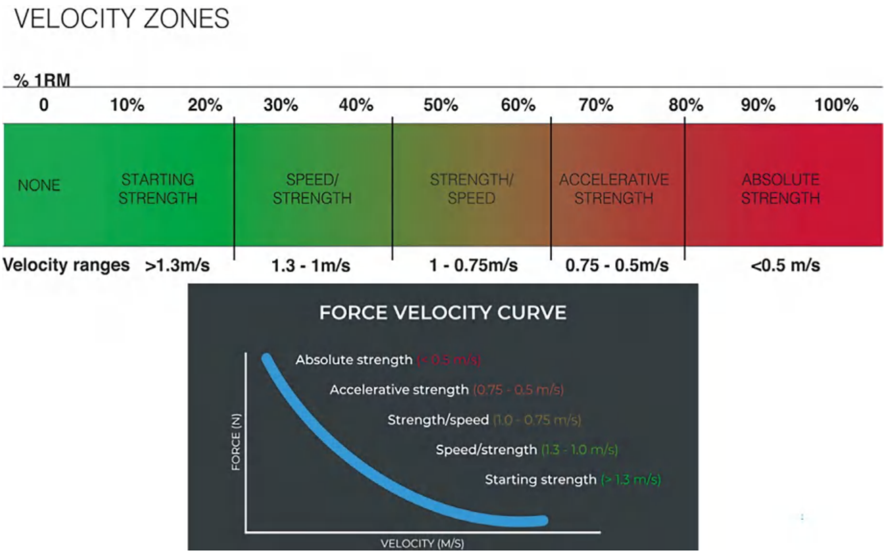

Fig. 10.3 Velocity goal–based training zones. (Adapted from Gymware.com)

3. *Autoregulation*: One of the most significant benefits of velocity-based training is that it allows for autoregulation, which means adjusting the training load based on how the HWS feels that day. If the barbell moves slower than usual at a certain weight, it could indicate that the HWS is tired or not fully recovered, signaling the need to reduce or adjust the workout intensity. Conversely, if the barbell moves faster, it might be a sign that the HWS can handle more weight that day.
4. *Targeted velocity zones*: Barbell velocity training typically uses different velocity zones depending on the HWS's goals (Fig. 10.3). These zones correspond to specific training adaptations:

   (a) Strength (0.15–0.5 m/s): Heavier loads with slower movement speeds to build maximal strength

   (b) Power (0.75–1.0 m/s): Moderate loads moved faster to develop explosive power
   (c) Speed strength (1.0–1.5 m/s): Lighter loads moved at high velocity to enhance speed with some strength component
   (d) Speed (above 1.5 m/s): Very light loads or unloaded movements to focus purely on speed

5. *Fatigue management and real-time feedback*: Many VBT devices provide immediate feedback on how fast the bar moves, which can be a source of motivation. This feedback encourages the user to move the bar quickly, promoting higher intensity and better performance during each set. Also, by tracking velocity, HWS and SC professionals can identify early signs of fatigue during a workout. When bar speed drops below a certain threshold, the action signals that the HWS may reach their limit, allowing them to stop the set or reduce the weight before becoming overly tired. This helps to prevent overtraining and maintain training quality.

Benefits of Barbell Velocity Training

Barbell velocity training offers several key benefits for athletes. One of the primary advantages is improved power development, as velocity plays a critical role in generating power (power = force × velocity). This makes the method especially effective for HWS, which aims to enhance its explosive power. Additionally, velocity-based training provides objective feedback, allowing HWS and SC professionals to make real-time adjustments based on the speed of the barbell, which helps them regulate training intensity more effectively [9–15].

Another benefit is the ability to customize training. Instead of following a rigid prescription of sets and reps, barbell velocity training allows for more personalized sessions that align with the HWS's current performance while having an organizational-level program [9–15]. This adaptability also ties into fatigue monitoring, as a decrease in bar speed can indicate fatigue, helping to reduce the risk of injury and overtraining. Lastly, the real-time feedback from velocity tracking boosts motivation, often increasing engagement and competitiveness, which can drive HWS to push themselves toward better performance.

How Barbell Velocity Training Is Applied

Coaches may establish an individual's load-velocity profile, which shows how different loads affect the speed at which the athlete can move the bar. This profile then selects appropriate weights and velocity targets for various exercises. Another avenue is dynamic effort training. Barbell velocity training is often incorporated into

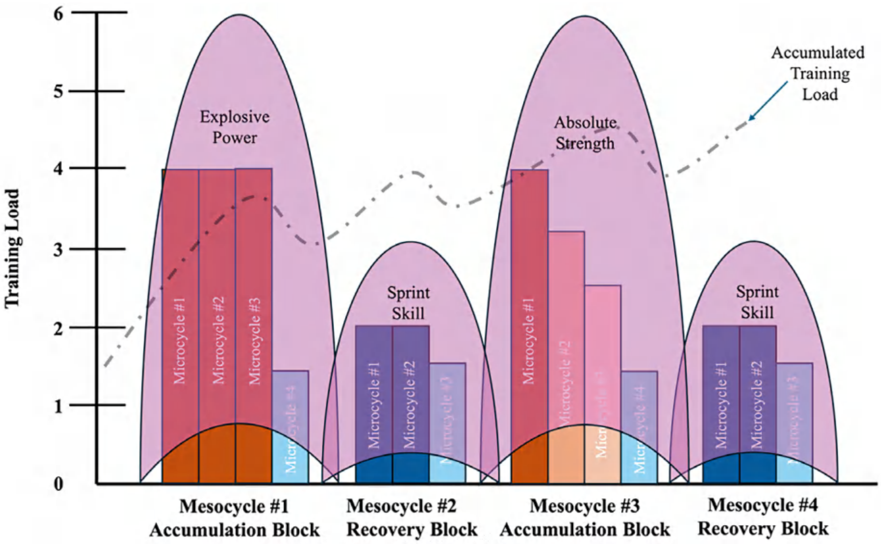

Fig. 10.4 The training load effect of conjugated sequence loading structure. (Adapted from Plisk, *Periodization Strategies* [16])

dynamic effort days in powerlifting and strength sports. HWS uses submaximal loads but focuses on moving the bar as fast as possible to develop speed and power (Fig. 10.4).

Triphasic Training Methodology

Triphasic training focuses on the three phases of muscle action: eccentric, isometric, and concentric. This methodology, developed by Cal Dietz and Ben Peterson, enhances strength, power, and speed through specialized training blocks that isolate each movement phase [17–19]. The eccentric phase aims to improve the muscle's ability to absorb force, the isometric phase stabilizes and strengthens the muscle in a static position, and the concentric phase enhances the muscle's ability to produce force. This approach mainly benefits the HWS, optimizing performance across various tasks.

Below is a sample workout plan based on triphasic training for an HWS, which involves focusing on the three main muscle action phases: eccentric (lowering phase), isometric (pause phase), and concentric (lifting phase) [17, 18]. This approach is designed to improve the athlete's ability to absorb and generate force, crucial for enhancing overall performance and resilience in tactical operations. The plan outlined below spans 6 weeks, with each 2-week block dedicated to one of the phases, culminating in a comprehensive approach to strength and conditioning.

Eccentric (ECC) Phase Example

Day 1: ECC phase primary block + traditional rep effort (volume focus)	Day 1: ECC phase primary block + EMOM	Day 1: ECC phase primary block + AMRAP
A1. Eccentric barbell back squat 3 × 5 (6 s down) 80–85% A2. Eccentric pull-ups 3 × 5 (6 s down) A3. 6 part squat drill 3 × 5	A1. Eccentric barbell back squat 3 × 5 (6 s down) 80–85% A2. Eccentric pull-ups 3 × 5 (6 s down) A3. 6 part squat drill 3 × 5	A1. Eccentric barbell back squat 3 × 5 (6 s down) 80–85% A2. Eccentric lat pulldown 3 × 6 (6 s up) A3. 6 part squat drill 3 × 5
B1. Single-leg curl machine 3 × 8 each B2. Single-arm DB OH press 3 × 8 each	**EMOM 25 min** B1. Slider leg curl ×10 B2. Single-arm DB rows × 8 each B3. Body saw ab plank × 30 sec B4. Assault bike ×12 cal B5. Tire flips × 5	**AMRAP 25 min** B1. MB slams × 5 B2. Slider leg curl ×8 B3. Single-arm DB rows × 8 each B4. Body saw ab plank × 30 sec B5. Assault bike ×12 cal
C1. Monster walks (four-way) 3 × 25 feet each C2. SA cable rows 3 × 8 each		
D1. Sled backward drag 20 s on/20 s off ×6 rounds		

Isometric (ISO) Phase Example

Day 1: ISO phase primary block + traditional rep effort (hypertrophy/ strength focus)	Day 1: ISO phase primary block + EMOM	Day 1: ISO phase primary block + AMRAP
A1. Isometric barbell squat 4 × 3 (4-s iso) 82–86% A2. Isometric DB high row 4 × 5 (4-s iso each) A3. Weighted plank hold 3 × 30 sec	A1. Isometric barbell squat 4 × 3 (4-s iso) 82–86% A2. Isometric DB high row 4 × 5 (4-s iso each) A3. Weighted plank hold 3 × 30 s	A1. Isometric barbell squat 4 × 3 (4-s iso) 82–86% A2. Isometric DB high row 4 × 5 (4-s iso each) A3. Weighted plank hold 3 × 30
B1. DB SL RDL 4 × 6–8 each B2. DB incline bench press 4 × 8	EMOM 25 B1. DB incline bench ×8–10 B2. DB RDL × 6–8 B3. Farmer carry × down/ back B4. Assault bike ×12 cal B5. Chin ups or lat pulldowns ×8	AMRAP 25 B1. DB incline press × 6–8 B2. Sled push × down/ back B3. Farmer carry × down/ back B4. Ropes ×15 reps each B5. Assault bike ×12 cal
C1. WTD barbell glute bridges 3 × 8 C2. Weighted chin ups 3 × max		
D1. Sled push 20 s on/10 s off × 8 rounds		

Concentric (CON) Phase Example

Each workout should begin with a thorough warm-up focusing on dynamic movement and mobility exercises and end with a cooldown incorporating static stretching to aid recovery. Additionally, incorporating core and stability work throughout the program will enhance performance and injury prevention. HWS professionals should also focus on recovery strategies, including adequate nutrition, hydration, and sleep, to maximize the benefits of this triphasic training methodology (Table 10.1).

Concurrent Training

Concurrent training integrates strength and endurance training within the same program period [4]. This methodology works to simultaneously develop multiple fitness components, which is necessary for HWSs requiring strength and endurance. Concurrent training addresses the challenge of the interference effect, where improvements in one domain (e.g., endurance) may hinder gains in another (e.g., strength) [4]. For the HWS, programming must carefully balance these components

Table 10.1 Triphasic example workouts

Day 1: CON phase primary block + traditional rep effort (strength/power)	Day 1: CON phase primary block + EMOM	Day 1: CON phase primary block + AMRAP
A1. Barbell back squat 5 × 3 85–88%A2. Box jumps 4 × 3	A1. Barbell back squat 5 × 3 85–88% A2. Box jumps 3 × 5	A1. Barbell back squat 5 × 3 85–88% A2. Box jumps 3 × 5
B1. Bent over DB rows 4 × 5–8 B2. Lateral step ups 4 × 6–8 each	EMOM 15 B1. Sled backward drag × down/back B2. DB bench press ×5 B3. TB carry × down/back B4. Plank with shoulder taps × 5 each B5. Chest supported DB rows ×12	RFT × 5 rounds B1. Sled backwarddrag × down and back B2. Plank + pull through × 5 each B3. DB thrusters × 8 B4. Side planks ×20 s each B5. KB swings ×8
C1. DB bench press 4 × 6 C2. DB RDL 4 × 5	C1. KB swings EMOM 10 s on/50 s off × 6 rounds	C1. Rower EMOM 7 s on/53 s off Record max watts × 6 rounds
D1. Assault bike 7 s on/53 s off Record max watts × 6 rounds		

These tables were used with permission from the author, Kosta Telegadas [19]
KB kettlebell, *DB* dumbbell, *EMOM* every minute on the minute, *RFT* rounds for time, *AMRAP* as many rounds as possible

to ensure holistic physical development without compromising overall performance. This system is one of the most ideal forms of tactical programming because of the total development of the physiological engine. The flexibility of the programming allows the HWS to adjust volume and intensity according to operational tempo while not sacrificing any physical attribute.

This sample 4-week workout plan demonstrates balancing these components to enhance tactical performance. The plan cycles through different focuses across the week, ensuring comprehensive development without overtraining any single aspect [4].

Week 1–4 Overview

- Day 1: Strength and power
- Day 2: Endurance (steady-state cardio)
- Day 3: Active recovery and mobility
- Day 4: Hypertrophy and muscular endurance
- Day 5: Speed and agility
- Day 6: Long duration, steady-state endurance
- Day 7: Rest

Training Session Breakdown

Day 1: Strength and power

- Warm-up: 10 min of dynamic movement and light cardio
- Squat (strength): Five sets of five reps at 75–85% 1RM
- Deadlift (strength): Five sets of five reps at 75–85% 1RM
- Power cleans (power): Four sets of four reps, focusing on explosive movement

Daily Breakdown

Day 1: Strength + power

- *Warm-up*: 10 min of dynamic movement and light cardio
- *Squat (strength)*: Five sets of five reps at 75–85% 1RM
- *Deadlift (strength)*: Five sets of five reps at 75–85% 1RM
- *Power clean (power)*: Four sets of four reps, focusing on explosive movement
- *Box jumps (power)*: Four sets of six reps, focusing on maximal height

Day 2: Endurance (cardio)

- *Warm-up*: 5 min of dynamic movement
- *Interval running*: 30-s sprint followed by 1 min of light jogging, repeat for 20 min
- *Cycling or rowing*: 20 min at a moderate pace, focusing on maintaining a consistent effort

Day 3: Active recovery/mobility

- *Yoga or Pilates*: 45 min, focusing on flexibility and core strength
- *Foam rolling*: 15 min, targeting major muscle groups
- *Light walk or swim*: 30 min for low-impact cardiovascular activity

Day 4: Hypertrophy + muscular endurance

- *Warm-up*: 10 min of dynamic movement and light cardio
- *Bench press (hypertrophy)*: Four sets of 8–12 reps
- *Pull-ups (muscular endurance)*: Four sets of as many reps as possible
- *Dumbbell lunges (hypertrophy):* Four sets of 8–12 reps per leg
- *Plank (core endurance):* Four sets, hold for 1 min

Day 5: Speed + agility

- *Warm-up*: 10 min, including dynamic movement and agility ladder drills
- *Sprint drills*: 10 × 50 meters, focusing on maximal effort with complete recovery
- *Agility cone drills*: Various patterns focusing on quick directional changes
- *Plyometric drills*: Including lateral bounds and depth jumps for lower body reactivity

Day 6: Long duration endurance (cardio)

- *Warm-up*: 5 min of dynamic movement
- *Long run, ruck, or bike ride*: 60–90 min at a steady, manageable pace, focusing on sustaining effort over time

Day 7: Rest

- *Active rest*: Engage in light activities like walking, stretching, or leisurely cycling to promote recovery without exerting stress on the body.

Hybrid Athlete Training

Not to be confused with the hybrid athlete defined by Shogan [21], hybrid athlete training blends various fitness disciplines—such as weightlifting, endurance activities, and gymnastics—into a single program [20, 21]. This approach develops a versatile HWS capable of high performance across diverse physical challenges. By incorporating elements from different training methodologies, hybrid athlete training ensures that HWSs are strong, powerful, agile, flexible, and enduring [20, 21].

This comprehensiveness is vital for the HWS, where operational demands are varied and complex.

The following sample workout plan is designed to be executed over a week. It incorporates these varied elements to improve fitness, resilience, and operational readiness.

Weekly Overview

- *Day 1*: Strength + power
- *Day 2*: Endurance + recovery
- *Day 3*: Agility + speed
- *Day 4*: Rest or active recovery
- *Day 5*: Mixed modal endurance
- *Day 6*: High-intensity interval training (HIIT)
- *Day 7*: Rest

Daily Breakdown

Day 1: Strength + power

- *Warm-up*: 10-min dynamic movement focusing on mobility for all major joints, followed by a light jog
- *Squats*: Five sets of five reps at 75% of 1RM to build leg strength
- *Bench press*: Four sets of six reps at 70% of 1RM, focusing on upper body strength
- *Deadlifts*: Four sets of five reps at 75% of 1RM to improve posterior chain strength
- *Power cleans*: Three sets of three reps at 65% of 1RM, emphasizing explosive power
- *Box jumps*: Three sets of eight reps, focusing on lower body explosiveness

Day 2: Endurance + recovery

- *Long-distance run*: 45–60 min at a moderate pace, focusing on cardiovascular endurance
- *Cool down*: 15 min of stretching, focusing on flexibility and muscle recovery
- *Yoga*: Optional 30-min session to enhance mobility and relaxation

Day 3: Agility + speed

- *Warm-up*: 10-min dynamic movement and agility ladder drills
- *Cone drills*: For agility, set up cones in various patterns for drills lasting 15 min

- *Sprints*: 8 × 100 meters with full recovery between sets, focusing on maximal speed
- *Shuttle runs*: Four sets of five reps, focusing on change of direction and acceleration

Day 4: Rest or active recovery

- *Option 1*: Complete rest, focusing on hydration and nutrition
- *Option 2*: Active recovery, including light jogging, swimming, or cycling for 20–30 min, followed by extensive stretching or foam rolling

Day 5: Mixed modal endurance

- *Circuit training*: Create a circuit including rowing for 500 meters, 20 kettlebell swings, 15 pull-ups, and 20 push-ups. Repeat the circuit three to five times, resting as needed between rounds.
- *Cool down*: Stretching session focusing on full-body flexibility.

Day 6: High-intensity interval training (HIIT)

- *Warm-up*: 10-min dynamic movement and light cardio.
- *HIIT session*: 20 s of high-intensity exercise (e.g., burpees, sprinting, and jump squats) followed by 40 s of rest or light activity. Repeat for 20 min.
- *Core training*: Three sets of planks (60 s), side planks (30 s on each side), and 15 Russian twists.

Day 7: Rest

- *Full rest day*: Focus on recovery strategies such as hydration, nutrition, sleep, and some light stretching or mobility work if needed.

CrossFit Methodologies

CrossFit, an extreme conditioning program, is known for its high-intensity, constantly varied, functional movements. It covers broad modal domains, preparing individuals for any physical contingency. This system has been controversial in the tactical strength and conditioning community for being too broad and not addressing the specific needs of HWSs. According to TSAC report 32 (tsac_report_32_nsca.pdf (menlosecurity.com)), this type of programming has the "greatest concerns for injury, and it does not appear ECPs offer training benefits that cannot be acquired through more traditional training programs, such as resistance/cardiovascular/HIIT training." For the HWS, CrossFit's emphasis on functional fitness aligns with the unpredictable nature of tactical operations. However, it is crucial to tailor extreme conditioning programs to address HWSs' specific needs and injury risks, focusing on scalable workouts and emphasizing proper technique and recovery.

The following sample 4-week program incorporates CrossFit principles. It ensures that workouts are short, intense, and diverse, targeting all significant aspects of fitness to enhance operational readiness.

Weekly Structure

- *Day 1*: Strength + MetCon (metabolic conditioning)
- *Day 2*: Gymnastics + endurance
- *Day 3*: Rest or active recovery
- *Day 4*: Power + HIIT
- *Day 5*: Long duration cardio
- *Day 6*: Mixed modal workout
- *Day 7*: Rest

Daily Workouts

Day 1: Strength + MetCon

- *Strength*: Back squat 5 × 5 at 75% of 1RM
- *MetCon*: AMRAP (as many rounds as possible) in 12 min
  - 10 pull-ups
  - 15 push-ups
  - 20 air squats

Day 2: Gymnastics + endurance

- *Gymnastics*: Four rounds for quality
  - Five handstand push-ups or wall walks
  - 10 ring dips
  - 15 toes-to-bar
- *Endurance*: 5 K run at a steady pace

Day 3: Rest or active recovery

- *Active recovery*: 30-min light jog or swim, focusing on staying loose and mobile. Follow up with stretching or yoga.

Day 4: Power + HIIT

- *Power*: Clean and jerk 5 × 3, working up to a heavy triple.
- *High-intensity interval training (HIIT)*: Four rounds for time.
  - 250 m row

  - 20 kettlebell swings (1.5 pood/1 pood)
  - 15 burpees

Day 5: Long duration cardio

- *Endurance event*: Ruck march for 60–90 min with a 35-pound pack, focusing on maintaining a consistent pace

Day 6: Mixed modal workout

- *Chipper*: For time
  - 50 box jumps (24″/20″)
  - 40 wall balls (20 lbs./14 lbs. to 10′/9′)
  - 30 deadlifts (135 lbs./95 lbs)
  - 20 power cleans (135 lbs./95 lbs)
  - 10 muscle-ups or bar muscle-ups
  - 800 m run

Day 7: Rest

- *Complete rest*: Focus on hydration, nutrition, and mental recovery. Prepare for the upcoming week of training.

Complete Sport Conditioning (CHC)

Complete Sports Training, developed by Michael Boyle, emphasizes developing all athletic performance aspects: strength, power, speed, agility, and endurance [22]. This comprehensive approach suits the HWS by preparing these professionals for the diverse physical demands. Boyle's methodology prioritizes functional strength, operational power development, agility for combat readiness, endurance for sustained operations, and a strong focus on injury prevention through tailored exercises and mobility work.

The following is a sample 4-week plan inspired by Complete Sports Training, designed to build upon each aspect of physical fitness essential for the demands faced by tactical personnel [22].

Weekly Overview

- *Day 1*: Strength + power
- *Day 2*: Endurance + mobility
- *Day 3*: Agility + speed
- *Day 4*: Rest or active recovery
- *Day 5*: Functional strength + core stability

- *Day 6*: High-intensity interval training (HIIT) + injury prevention
- *Day 7*: Rest

Daily Breakdown

Day 1: Strength + power

- *Warm-up*: 10 min of dynamic stretching focusing on mobility
- *Barbell squats*: Four sets of five reps at 80% 1RM to build lower body strength
- *Deadlifts*: Four sets of five reps at 80% 1RM to enhance posterior chain strength
- *Push press*: Four sets of five reps for upper body power
- *Box jumps*: Three sets of eight reps for explosive lower body power

Day 2: Endurance + mobility

- *Cardiovascular endurance*: 45-min run at a moderate pace, focusing on sustaining effort
- *Mobility session*: 30 min of yoga or dynamic stretching, emphasizing full-body mobility and flexibility

Day 3: Agility + speed

- *Warm-up*: Agility ladder drills for 10 min
- *Cone drills*: Various patterns focusing on quick direction changes for 20 min
- *Sprints*: 6 × 100 meters with full recovery, focusing on maximal speed
- *Plyometric drills*: Including skater hops and tuck jumps to improve reactivity and agility

Day 4: Rest or active recovery

- *Option 1*: Complete rest
- *Option 2*: Active recovery, such as a light swim or bike ride, followed by a thorough stretching session

Day 5: Functional strength + core stability

- *Warm-up*: Dynamic stretching and mobility work for 10 min
- *Kettlebell swings*: Four sets of 12 reps for hip power and endurance
- *Single-arm dumbbell snatches*: Four sets of eight reps per arm to improve unilateral power
- *Farmer's walk*: Three sets of 40 meters to enhance grip strength and core stability
- *Planks*: Three sets, holding for 1 min to strengthen the core

Day 6: High-intensity interval training (HIIT) + injury prevention

- *HIIT session*: 20 s of high-intensity exercise (e.g., burpees and mountain climbers) followed by 40 s of rest; repeat for 20 min

- *Injury prevention circuit*: Including exercises such as Nordic hamstring curls, lateral band walks, and shoulder "YTWL" exercises; three sets of 10–15 reps for each exercise

  Day 7: Rest

- *Full rest day*: Emphasize recovery strategies like nutrition, hydration, and sleep.

Key Considerations

- *Flexibility in programming*: This plan should be adapted based on individual needs, operational duties, and recovery abilities. Athletes should listen to their bodies and adjust intensity, volume, and rest.
- *Nutrition and hydration*: Essential components of the program, focusing on supporting intensive training and recovery processes.
- *Progressive overload*: Gradually increase the intensity, volume, or complexity of the exercises to continue making gains throughout the training program.

This sample plan, inspired by Michael Boyle's Complete Sports Training, is structured to enhance an HWS's comprehensive fitness profile. It prepares them for the physical demands of their role while emphasizing injury prevention and operational longevity.

Pillar Training Methodology

Exos created the pillar training methodology, which is defined as the blend of mobility and stability through the pillar, which includes the hips, torso, and shoulders [23]. The emphasis on these areas enhances overall movement efficiency, reduces the risk of injury, and improves performance in athletic and everyday activities. This methodology has a few key components [23–25].

1. *Pillar*: The "pillar" refers to the functional connection between the shoulders, hips, and core. These areas work together to provide stability and support for movements in all planes of motion, acting as a foundation for the body. Improving these areas can significantly improve posture for better power transference and enhanced biomechanics.
2. *Core stability and strength*: The core links the upper and lower body during movement. A strong core ensures more efficient and safer movement patterns. Common core exercises in this methodology focus on antirotation, antiextension, and antilateral flexion.
3. *Hip mobility and strength*: The hips are critical for lower body power and mobility. The Exos pillar methodology training emphasizes hip mobility to ensure proper alignment and reduce stress on the knees and lower back. Strength exer-

cises targeting the hips, such as glute activation and hip stabilization drills, are crucial in supporting HWS movements like running, jumping, and lifting.

4. *Shoulder stability and mobility*: Shoulder health and stability are essential for transferring force and ensuring functional movement patterns, particularly for upper body strength and performance. This methodology incorporates exercises that enhance shoulder mobility and strength, reducing the risk of injury and improving movement efficiency.

This methodology is efficient for addressing the critical musculoskeletal injuries seen in many HWS populations. The Exos approach uses goal-based lifting methodologies to target load and repetition prescription while prioritizing exercises and movements focusing on pillar strength and mobility. This approach offers critical benefits to HWS professionals by developing the strength, stability, and mobility of the core, hips, and shoulders—essential areas for efficient movement and injury prevention. Focusing on these areas improves posture, enhances force transfer, and optimizes movement patterns, making the body more resilient and robust. This method helps prevent injuries common in tactical and high-intensity environments while increasing functional strength and agility, enabling better performance in dynamic, physically demanding tasks essential for mission readiness.

Conclusion

This chapter offers many different loading techniques to an SC professional. The techniques and methods provided are not exhaustive; however, this chapter is designed to give you a baseline. The more tools you have, the more adaptive you can be. The needs of HWS professionals are in a state of constant flux. Being adaptive allows you to provide the HWS professionals with the best services possible.

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Chapter 11
Building Mental Resilience

Iasia Norton-Gardner, Whitney Tramel, and Lina Ochoa

Introduction to Mental Resilience

In life, the inevitable roadblocks and obstacles occur along the way. Navigating these challenges requires resilience. Resilience is the ability to progress and overcome difficulties, regardless of what comes your way. The mental aspect is fundamental to resilience since an individual's self-concept/self-esteem and cognition abilities can play a significant role. Mental resilience involves adapting to adversity, trauma, and stressors to maintain psychological well-being. Resilience is a trait that is developed and consistently nurtured to be effective.

Building mental resilience is crucial for enhancing the psychological well-being of tactical professionals. However, what makes mental resilience essential for tactical personnel such as military, law enforcement, and emergency responders? Tactical personnel face unique stressors and circumstances in their careers, as described in Chap. 1. Due to the distinctive challenges, tactical personnel require a tailored approach to building resilience. The aim is to use various principles to strengthen the mental resilience of the human weapon system (HWS). Aspects involve devising programs and interventions to address adaptability, high-stress environments, separation, physical/mental demands, and work/life balance. Ultimately, the goal is to optimize military readiness and success by improving the overall well-being of service members.

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Unique Challenges Faced by Tactical Personnel

Understanding the importance of mental resilience for tactical personnel involves delving into their unique challenges. One primary challenge is the need for constant adaptability/flexibility. A common saying in the military is "being comfortable with the uncomfortable." This phrase exemplifies the reality that circumstances can quickly change or be entirely altered, even when individuals think they are proficient and excelling at a professional or leadership level. Military members can deploy with minimal notice, performing unfamiliar tasks or expecting to take over a unit without prior experience.In comparison to athletes and other occupations, who are typically acquainted with and trained for specific demands of their profession and are rarely surprised by unexpected requirements.

On the other hand, tactical professionals face daily demands that can vary significantly from their training and usual focus areas. HWS personnel must adapt to any situation and circumstance, maintaining composure in uncomfortable settings. A flexible and adaptable mindset fosters continuous growth in cognitive abilities and withstanding obstacles and uncertainty. Emphasizing these aspects underscores mental resilience's essential role in overcoming challenges.

Moreover, high-stress environments are another unique aspect for tactical personnel. These settings can involve combative and dangerous elements such as battle areas, hostage scenarios, emergency responses, and disaster response efforts. In these circumstances, individuals make life-or-death split-second decisions with high stakes and pressures. These stressful situations can lead to trauma and possible mental dysfunctions. Turliuc and Balcan research has highlighted a significant connection between elevated levels of work-related stress and increased occurrences of mental disorders among military personnel [34]. The implication aligns with that prolonged sympathetic nervous system (SNS) activation in the "fight or flight" response can lead to long-term physiological and psychological implications.

Furthermore, maintaining and building mental resilience allows individuals to process and cope with these long-term stressors. It helps them stay composed in the face of adversity, reducing the likelihood of errors that could have severe consequences. Tactical personnel's ability to manage stress and perform effectively in these critical situations is essential for psychological resiliency. Exposure to challenging stressors and stress management allows for maintaining clarity of thought and accomplishing the mission or duties.

Tactical personnel, often experience prolonged separation from family and friends due to the nature of their duties. This separation can lead to depression, anxiety, feelings of loneliness, sadness, and homesickness. The lack of a social support system is a critical factor that can lead to adverse effects. Therefore, cultivating an organizational culture centered on mutual support and promoting effective coping strategies is essential. Implementing unit cohesion can significantly improve well-being , especially with the challenges of the roles. This approach aligns with the need for belongingness outlined in Maslow's hierarchy of needs, ensuring that individuals feel valued and supported within their unit or organization[38].

Furthermore, the physical and mental demands of the job are unique stressors. The circumstances where moral and ethical decisions have gray areas often present complex challenges that can lead to significant mental distress for individuals, especially in high-stakes environments such as military or tactical operations. Mental resilience allows sound decisions in the face of conflicting values. In combat missions, quick choices may have to be made that do not align with an individual's moral compass. Additionally, physically draining tasks such as specialized training, combat, rucking, running, and maintaining physical standards are essential to exert physical demands. Enduring these demands requires mental resilience, enabling individuals to persevere and maintain a positive self-concept. A critical aspect is the determination to commit to and accomplish physical and mental challenges in perspective roles.

Lastly, it is essential to recognize the importance of work/life balance for tactical personnel. Individuals can become captivated only by the rigorous tasks of their employment. A well-rounded focus on work and personal life can affect mental resilience. A critical point is reintegration back into society after active involvement in battlefield scenarios or high-stress environments, as PTSD can be prominent. Individuals must experience and make decisions not typically encountered outside their professional roles. In these environments, moral dilemmas arise or align with organizational demands. The disconnection of the human weapon system (HWS) mindset in personnel life can affect an individual's self-concept. This phenomenon can refer to how the mindset in tactical settings cannot easily translate into day-to-day life. Leading individuals to view themselves differently in professional versus personal contexts can lead to internal conflict. The discrepancy influences mental health support to meet the integration demands and maintain identities.

Strategies for Building Mental Resilience

HWS personnel should effectively align a strategy for building mental resilience with proper training and preparation. As previously expanded on, it is crucial to implement regular mental resilience training tailored to the specific needs of HWS personnel and their unique challenges. These approaches target metacognition, self-concept, stress management, alleviating stigma, and improving unit cohesion.

Changing mindset through metacognitioncan be trained, yet it must have a personal application. Metacognition is awareness of your thought processing and the aspects that influence it. The application allows one to be more in sync with one's emotions and behaviors. To this extent, individuals need to know themself and be aware of their thoughts and feelings.Metacognition learning is applied through monitoring and control [37].In addition, the concept that metacognition enhances neuroplasticity. Neuroplasticity highlights that the brain is reconstructing new neural connections formed in the past and reorganizing and replacing them with new connections. The actions of neuroplasticity are essential to promote and create resilience traits and behaviors. It is beneficial for individuals to use self-awareness in the face of stressors and adversity. It is necessary to consider that change and improvement can only be made if the challenges or weaknesses are specifically recognized. Applying metacognition and reshaping cognitive patterns assists with adaptive behavior and coping strategies for mental resilience.

Nevertheless, understanding self-concept and its influences on tactical personnel's lives is essential. Perception can shape reality and holds great significance. One's self-concept reflects one's perception, which influences reality. Individuals can shape how they experience and interpret the world around them. In addition, self-concept is a sufficient component of an individual's belief and trust in their abilities. Believing in oneself is a critical factor in building mental resilience as it impacts the perceived value in themselves. An individual with a high self-concept is crucial to build mental resilience and withstand unique stressors. Highlight self-concept's positive influence on self-esteem and identity clarity to address the work/life balance and overcome other challenges effectively.

Some standard favorable management techniques include mindfulness, meditation, and breathing exercises. Research, such as that by Bonura and Fountain (2020), has explored the effectiveness of Tai Chi yoga, led by qualified instructors, in supporting military members' stress management [35]. This approach incorporates deep breathing and techniques to release muscle tension, relieving suppressed stress. By fostering mindfulness, individuals become more present in the moment and gain a deeper understanding of their behaviors and the emotions influencing them. Stress management techniques can be readily integrated into units and organizations to help build mental resilience, especially for preparing personnel for high-stress environments where complex decision-making is demanding, impacting psychological and physiological aspects.

Furthermore, it is crucial to recognize the need for professional support, improve access to mental health resources, address mental health stigma, and regular mental health assessments. Highlighting the importance of coordination and providing easier access to counseling and mental health resources is essential. Especially for those who are struggling to meet the mission or organization demands, the lack of resilience can stem from underlying mental health issues. Mental health stigma persists across various spectrums and needs to be actively addressed and reduced. Specifically, mental health stigma is very prevalent in the military, though it has become increasingly present at the forefront over the years. The recognition that military members often face unique demands due to their service is a challenge that applies to all tactical personnel. Incorporating regular mental health check-ins/assessments can help identify early indicators and provide timely interventions for mental health-related issues. By addressing these aspects, organizations can better support the mental resilience and overall mental health of personnel.

Lastly, strengthening a solid community and support system among peers through unit cohesion can directly impact a member's mental health. According to Bekesience and Smaliukiene (2022), their study demonstrates that strong unit cohesion facilitates personal growth by diminishing the negative impact of stress on individuals[36]. A vital perspective is underscoring the importance of unit cohesion. Unit cohesion is critical in bolstering and maintaining resilience at individual and organizational levels, especially in contexts where separation from family and friends. Reliable support can be detrimental for those who lack emotional support from home and are seeking to find that support among coworkers. Simple actions can be significant, like having someone to talk to or debrief after a stressful day or mission. Given tactical members' unique challenges, having colleagues who understand their experiences can provide valuable emotional support. Personal development through unit cohesion allows individuals to feel supported and connected, facilitating the effective functioning of the HWS. The unit cohesion must be a cornerstone that provides essential social and emotional support. This cohesion is crucial for helping individuals cope with their roles' numerous stressors and demands, emphasizing the unit/organization's acceptance to advocate for maintaining mental health. Creating a personalized approach by understanding the stressors and difficulties affecting each unit/organization can be achieved through various means, such as conducting yearly surveys or facilitating in-person feedback sessions, allowing leaders to tailor strategies based on the specific needs and preferences of the unit members.Integrating the concept, of how can someone provide meaningful support to their personnel without genuinely knowing them or understanding their individual needs?

Benefits of Mental Resilience

Strengthening mental resilience leads to improved performance and decision-making under pressure. The enhanced ability to cope with and recover from traumatic events applies to better overall mental health and well-being while increasing job satisfaction and motivation. Fostering mental resilience among tactical personnel enhances individual capabilities and strengthens team effectiveness and the operational human weapon system. Practice makes perfect, as the saying goes. Repetition creates stronger synaptic connections, making thoughts that influence behaviors flow more naturally. Building mental resilience means deliberate, conscious awareness of thoughts and behaviors. Consistent practice and purposeful application are essential to avoid undesirable outcomes and risk of mental illness.

Conclusion

Building mental resilience is desirable and essential for all tactical professionals, such as the military, law enforcement, and emergency responders. These professionals face unique stressors and challenges that must prevail to complete missions and perform required duties. It is crucial to address the psychological and physiological implications of strategies that assist with the strengthening and continuous improvement of mental resilience, especially in the human weapon system (HWS). All components are valuable to the operation, as a machine cannot operate correctly without the required pieces and their proper functioning. For most population groups, the primary focus is on mental resilience through a personal approach. However, the aspect that makes tactical personnel distinctly different is the importance of the collective approach that shapes the organization's success and the complex and demanding environment. The team mindset strongly influences success and optimizes readiness. Elaboration on the phrase, "If one falls, we all fall together." Ultimately, investment in building mental well-being is essential for units and organizations for tactical personnel.

Stress Management Techniques

Stress is generally considered an event or scenario with a high physical and cognitive demand, acutely or chronically—a feeling that begins to wear you down over time. At times, this feeling may even be debilitating. Before diving into what stress is and how to manage it, consider the two different scenarios:

1. Sergeant (SGT) Hill works in an intelligence role with a high cognitive demand. His role requires precision, focus, and attention to detail. SGT Hill also recently had a family member pass away, and his home life could have been better.
2. SGT Taylor works primarily physically, requiring extended time away from home for training exercises and deployments. This tends to cause problems at home with his spouse. SGT Taylor also has a shoulder injury that has been progressively getting more painful, but due to being gone so often, he tries to ignore it and hope it simply goes away.

Which of these individuals is the *most* stressed? The correct answer would be BOTH.

HWS professionals are exposed to a variety of stressors throughout their careers. The environments in which these professionals work and train are both physically and mentally demanding; these scenarios often cause decrements in performance on the job that could potentially be life-threatening [1–3]. Traversing unpredictable terrain, prolonged periods of heavy load carriage, evading human threats, combat simulations, and field training that are sometimes five or more days in length [4–7] are just a few physical stressors these personnel are exposed to. Additionally, the nature of these roles includes other, less physical stressors that can be equally detrimental. This includes excessive workloads, lack of support or control, pressure from the top down, tasks that include high cognitive demand, and struggling to find a work/life/home balance.

Stress is a shock to the system, and [8] implies that there has been a disruption to an otherwise ordinary environment (acutely) or there is an existing imbalance (chronically) [8, 9]. Hans Selye coined the general adaptation syndrome (GAS) theory [10]. This theory states that when an individual is exposed to a stressor for the first time, known as the alarm phase, their normally functioning physiological system will be disrupted. The disruption initiates a cascade of hormonal and neural responses—in the sympathetic nervous system (SNS) and the

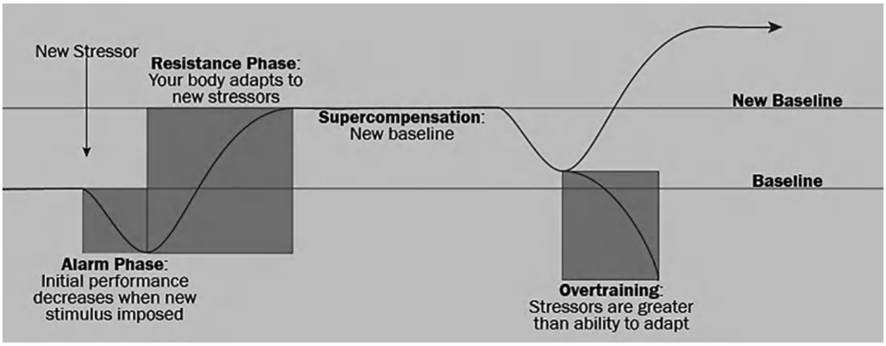

Fig. 11.1 General adaptation syndrome [16]

hypothalamic-pituitary-adrenal (HPA) axis [8, 11]. The response that results leads to reduced cognitive processing and cortical arousal and increased metabolic, cardiovascular, and muscular responses [12–15]. The body will quickly return to its resting state or baseline in acute exposure. When stress is applied appropriately, systems will supercompensate and create a new baseline. In environments where the demands of the stressor exceed regulatory mechanisms, the body's ability to adapt or return to homeostasis goes down significantly [8, 11] (Fig. 11.1).

Brief Figure Description

Of important note, stress is relative to the individual's perception of what "stress" really is. One person may find an event highly stressful, while another may find the same event relatively easy and stress-free. Stressors can be broken down into eustress vs. distress [17]. Eustress is defined as "good" stress and elicits a positive response in the body and brain. This might look like feelings of excitement, satisfaction, or fulfillment [17]. Distress, typically associated with stressors, is "bad" and elicits a negative response in the body and brain [17]. When individuals start to feel overwhelmed or broken down because they perceive that the physical, mental, or emotional resources they currently possess are inadequate to meet the demands of what they are currently facing, they are experiencing distress. This chapter will focus on distress and ways to manage the stress experienced at the job and at home.

Managing stress is of utmost importance for personnel to tolerate the job demands for long periods and maintain high levels of on-the-job performance. A few ways we can manage the stress we experience include:

1. *Mindset*. One's mindset around stress is one of the most critical factors in managing the stress experience. Kelly McGonigal writes in *The Upside of Stress* [18], "There is always stress, so the only point is to make sure it is useful to yourself and others." When someone embraces the stress experience instead of

feeling like a victim, this significantly changes the stress response. Remember, stress is relative to one's perception of it. When we think of it more positively and remind ourselves that we can become more resilient [19], we are more likely to cope positively and, in turn, experience a less harmful physiological response. Stress **IS** good for us.

2. *Breathwork*. This technique is often used to help reduce the impact of stress and the resulting physiological responses [20]. "Box breathing"—or as some may call it, "tactical breathing"—has been used as a technique to help tactical personnel control their body's physiological response in high-stress scenarios [21]. This breathing technique consists of slow and controlled inhales through the nose, breath holds at the end of an inhale, slow exhales through the mouth, and breath holds again at the end of the exhale. A more commonly used method of box breathing is the 4 × 4 method. This includes a 4-s inhale, a 4-s breath hold at the top of the inhale, and a 4-s exhale, followed by a 4-s breath hold at the end of the exhale before repeating the same cycle. Attempting to control our breathing will lead to a synchronization with our heart rate [22]. Thus, when individuals consciously slow their breathing, they can slow the heart rate and the resulting stress response.
3. *Physical activity*. While physical activity and exercise are stressors in and of itself, they can still play a significant role in stress management. The research shows that prior exposure to physical, emotional, or environmental stress leads to increased performance and reduced anxiety [15]. Think back to the GAS theory discussed earlier. Exposure to a controlled and systematic stressor will create adaptations that help manage the response to that stressor over time [8, 11]. In this case, physical activity will be the focus: When following a controlled periodized training program that exposes personnel to training stimulus correctly over time, the result is an adaptation that exceeds previous baseline levels [16]. Furthermore, exercise and training can be complex and challenging. Doing hard things over time creates a mental adaptation where we can become more resilient to other stressors outside of training.

   A. *Physical activity and management of emotional stress*. Research on physical activity and stress associated with mental health has shown that being physically active can play an essential role in managing the stress experience. Mindfulness-based practices, such as yoga, have been shown to decrease the physiological symptoms of stress, such as reductions in cortisol levels, blood pressure, heart rate, and blood glucose levels [23]. Running has been seen to have a positive overall effect on anxiety. In a study comparing "running therapy" to antidepressants, running had a more significant positive impact on anxiety and increased health measures associated with increased physical activity [24]. The running therapy consisted of running outdoors two to three times a week at intensities of 50–80% of their heart rate reserve. Lastly, strength and resistance training two to three times a week at moderate to vigorous intensities has been shown to reduce symptoms of depression, anxiety, and PTSD—all issues associated with stress [25–27].

4. *Social support*. Another factor in helping manage stress is having a solid support system. Feeling a sense of support and connectedness has led to individuals reporting more significant feelings of happiness and reduced stress [28]. Also, relationships that foster support can make one feel less lonely [29]. Loneliness is a top contributing factor to depression and anxiety—both symptoms of stress. This support may come from family members, romantic partners, friends, or coworkers. Along with feeling less stressed, a solid social group can increase our motivation and likelihood to stick to a challenging task or goal [29]—such as working out—which, as seen above, will also aid in reducing stress. Having the support to work through hard things, whether in life, at work, or in training, allows individuals to come out more confident and better able to take on challenges or stressors.
5. *Spiritual resiliency*. When people feel a sense of meaning and purpose in life, they are more likely to pursue things that make them happy, reducing the stress they experience [30]. Additionally, when individuals have a robust value system and live a value-driven life, they are more aware of what matters most, begin to pay better attention to their health, and are more persistent toward goals and outcomes in life [31]. This further aids in reducing stress simply by taking better care of the self and being relentless in living a balanced, healthier lifestyle. Self-efficacy (the belief that we are capable) also begins to increase, and small, minor stressors no longer seem as daunting because of the belief system built to know minor stressors can be handled [32].

"Stress management" can also be known as "stress optimization." As mentioned in the mindset section, stress IS good for the HWS professional. Take into consideration the Yerkes-Dodson principle. This states that performance can continue to increase with optimal stress or arousal [33]. After an optimal point, performance begins to decline. Remember that the amount of stress needed for a specific event may vary. The stress required to go hand-to-hand in combat differs from the stress needed to give a presentation to leadership. How, then, can the HWS professional use the listed techniques to optimize the stress they are experiencing, use it to their advantage, and increase their performance on the job? Optimizing the stress experience might look like being intentional with physical training goals, finding and committing to something meaningful and worthwhile outside of work, spending more time with loved ones, incorporating breathwork as a means to simply slow-down from time to time, and changing one's mindset to believe stress builds resiliency.

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Chapter 12
Lessons from the Field

CJ French, Kevin Malahy, and Chris Myers

Understanding and Assimilating into Military Culture

Assimilation into the military culture will help you understand the strength and conditioning (SC) coaches' role within the human performance team (HPT), the unit, and their clientele. Once you learn and understand the military culture, conveying your ideas and intentions using appropriate customs and courtesies will be much easier. The following are a few outlined steps that will help you learn how to navigate the tactical space.

Doctrine

All military branches and other HWS organizations use doctrine to provide a common location for expectations. Within the doctrine, you will find the organizational structure, rank structure, dress and appearance, how to write correspondences, and customs and courtesies. These will help you learn how to recognize and speak to the different levels of ranks found within the unit. With this foundational knowledge,

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you can avoid saying something improperly or insultingly. As with any culture, learning to behave within the environment can help ensure team cohesiveness. Most doctrine is available online; ensure you read the most up-to-date version.

The Importance of Relationships

In the complex, high-stakes environment of the military, relationships are not just beneficial—they are essential to the overall effectiveness of the force. As an SC professional, you will not be effective unless you build good relationships with your HWS professionals. Regarding the human weapon system (HWS) concept, which views military, law enforcement, and first responder personnel as the central asset, relationships play an even more critical role in maintaining physical and psychological readiness.

Trust and Cohesion: The Core of Element of Effectiveness

HWS organizations function under extreme stress, often facing life-threatening situations that demand rapid, coordinated responses. Trust is at the heart of these responses—the belief that one's fellow service members will perform their duties effectively and reliably. Trust is cultivated through interpersonal relationships built over time, often forged during training, joint missions, and shared hardships. This trust translates into cohesion, where individuals within a unit function seamlessly as a team, compensating for each other's weaknesses and amplifying strengths.

As the HP professional, your understanding of the HWS mission and requirements is crucial. This understanding is not passive; it is gained through active participation in their training. Do not just sit behind the desk or stay in the gym; get out where the training occurs! When possible, be part of their training or, at a bare minimum, observe. This active engagement is the first step in building relationships and gaining trust.

Psychological Resilience and Stress

The HWS environment is inherently stressful, and HWS professionals are frequently exposed to situations that can have significant psychological impacts. Whether deployed in combat zones, undergoing intense training, or dealing with the isolation of long-term assignments, these stressors can wear down mental resilience. Solid personal relationships within HWS organizations help individuals cope with the psychological toll of these conditions.

HP professionals usually find themselves in unique positions. You can build a bond when working with the same clientele day in and day out. You may become an informal social support for them. Listen and care.

The importance of relationships cannot be overstated. Fostering trust and cohesion within units is fundamental to the functioning of the human weapon system. As HWS organizations continue to evolve and face new challenges, the bonds formed between the professionals and their HP staff will remain critical to the ongoing strength and success.

Mentorship and Internship

Collaborating with existing resources is essential to help create more touchpoints with the coaching staff. Each branch has personnel who are trained to execute a physical training session. Work with these personnel to be their reach back capability and further mentor them so you can have a more significant impact by increasing your reach through using existing capabilities. Additionally, with the growth of the strength and conditioning field in the tactical space, universities and colleges are taking advantage of internship opportunities that students and graduates can apply for. These internship opportunities allow for a behind-the-scenes look into what a day in the life of a tactical strength and conditioning coach may look like. Remember, it may vary from branch to branch and unit to unit. Since the right fit is essential to ensure both the SCC and the unit work well together, signing up for internship or mentorship programs allows you to experience it firsthand and assists in building your network, which will be helpful while navigating the tactical space.

Differences Between Units

Each HWS organization's primary focus is on its own mission. The branches refer to these differently, but ultimately, knowing the primary focus of the team and each person on the team will help you perform the needs assessment. Additionally, each unit can be categorized as either training or operational. In training units, high output and efficiency are valued. Getting to know the client is usually tricky because the pipelines can be vigorous and on a condensed timeline, so throughput becomes a focus. On the contrary, operational units work toward a team dynamic and foster getting to know one another to help build cohesiveness. This becomes an important dynamic to be aware of as you consider your personality and coaching style, and you will want to choose a unit that best aligns with yourself (Fig. 12.1).

Variations between units

Training

- High volume
- Limited time
- Go/No-go benchmarks
- Washback reintegration considerations
- Graduation expectations

Operational

- Harder to gain buy-in
- More time with personnel/need creative programming
- Varying schedules
- Deployment
- No-notice departure
- Mission-ready focus
- Reintegration considerations

Fig. 12.1 Differences between training and operations in HWS organizations

Budget

Each unit will have a point of contact responsible for managing the budget. This is important as you must continually replenish and/or upgrade your facility's equipment. Your budget may not be what you expect as a tactical budget, and its processes are much more convoluted. You may need to project 6 months to a year in advance for the purchases you need to make and start the approval process to ensure you receive your items when required/expected. Budgeting may need to be projected much further for overseas locations, also known as Outside the Continental United States (OCONUS). Money is often allocated through different avenues, and learning how to write unfunded requests (UFR) may be essential to help build and sustain a training space, especially when dedicated lines of funding do not exist.

Growth as a SCC in the Military Setting

In the civilian sector, growth as an SCC means honing your skills to be more sport-specific. For example, coaches may be baseball experts. The career path may be interning with a collegiate team, hoping to eventually work their way up the ladder to work in Division I baseball. In military culture, this is not necessarily the case. Honing your skills as a tactical SCC usually means being able to adapt to different Mission Essential Task Lists (METL)/Military Occupational Specialty (MOS)/Air Force Specialty Code (AFSC), or essentially the military member's physical demands. With each branch, the physical readiness test differs. Different jobs require different skills/abilities. Each team has a different skill set they must be able to perform for each mission. Becoming an adaptable coach means getting exposure to as much of the military culture as possible through different branches, specialty codes, or units.

Measuring the Coach's Worth

One term often heard in the tactical space is return on investments (ROIs). These ROIs keep the funding available for HPTs, making leaders see the value of investing in the human weapon system. Each military branch determines ROIs, but there may be different ROIs that the Commander deems necessary to track. Often, it is up to the coach to determine their responsibility to track, research, and procure their method for tracking. I highly encourage each coach to take a data analysis course to help understand this portion of the job well. Data analysts are now prevalent in human performance in the military sector, so do not be afraid to ask questions and learn from them.

Get a Look at the Long-Range Training Calendar

Each unit has a long-range training calendar and a point person responsible for building and updating it. This is crucial to assist you in periodizing your training blocks. For example, half of the team may be preparing to deploy to a hot/humid location for an exercise. This gives you visibility and allows you to titrate appropriate doses of heat acclimation into the training plan. This also benefits considerations with exercises and operations at altitude, cold weather, and other austere locations. Not only does this assist you in planning your training, but it makes human performance visible on the long-range training calendar and can hold leaders accountable for how their teams prepare.

Learn to Straddle Legacy and Exercise Science

If you are an exercise science major, you learned the laboratory way to do things. Unfortunately, the laboratory way is not always feasible or applicable. It is equivalent to field medicine. Although being treated for an injury in a medical facility is preferred, it may not always be possible. The next best option is field medicine to get the person stable and treated in a medical facility. Coaches in the tactical space should know many legacy and heritage considerations with each branch that will not be negotiated. For example, excessive rucking over time can cause damage to the body; however, rucking is always expected in the Army. A good coach will straddle legacy and heritage, and although they cannot change the fact that their military members will ruck, they can help them better prepare for and recover from it. This could include giving warm-up exercises, teaching soft tissue techniques, ensuring the ruck is packed correctly, and building up tissue tolerance to support the demands of the ruck. Instead of focusing on what you cannot change, focus on what you can.

There are many more ways to get started, but these few are easy to obtain in a short amount of time. The culture of human performance within the military is changing but is still behind the sports sector. It is crucial to keep in mind that your professionalism, attitude, and persistence are a few things that will help represent the field of tactical strength and conditioning and assist in the effort to help drive the culture change within the military forward.

Expectation Management

Before transitioning to the tactical sector, you must ask your potential supervisor questions. These questions could include but are not limited to the following:

1. What is the HPT's budget?
2. Do you receive a continuing education credit (CEC) allotment? If so, how much?
3. Describe a day in the life of a SCC on the team.
4. How and when will the coach receive performance feedback?
5. Are relocation expenses covered?
6. What in-processing timelines will be granted?

Many more questions could arise based on the conversation, but creating an environment where there is truth in lending to help manage expectations is essential. Reach out to coaches you may know in the tactical space who could help build out any further questions to help formulate a clearer picture of the job.

Operationalizing SC for the HWS

"Many people think they lack motivation when they lack clarity" (James Clear).

It Is Knowing Where to Start

Modified Failure Mode and Effect Analysis (FMEA): List physical/physiological competencies and capacities identified through needs analysis and supporting doctrine to be developed > Create 2–5 columns representing CoC, the consensus from the participants, your analysis, etc. > Number the competencies 1–10* (*whatever rating scale makes sense for the size of the list) based on the importance/priority of each competency respective to each of the stakeholders represented in the columns > total the ratings across each of the columns for a total > use this total to assign priority in the programming prescription.

Benefits: An objective approach to organizing training helps remove personal bias. It considers all stakeholders and provides a clear justification for the methods. The list can be reused and reordered based on the outcomes of preexisting programs, operational tempo, and unit activity/assignments.

When to Develop the Program

1. Ease of use: Manage your word count. If the explanation of an exercise does not fit into a tweet, it is too long. Also, consider document formatting, use of color coding, etc.
2. Time management: Particularly in programming formation PT, time for set up and tear down, in addition to explaining the workout, should not absorb half of the allocated time to train.
3. Low-hanging fruit: Most military populations will benefit significantly from consistently doing priority one (fundamental) compound movements. Do not complicate for the sake of complicating.

If you are still unsure if the program may be too complicated, have a friend, relative, or spouse (not a colleague) read it without your assistance and observe whether they can explain it as intended.

Increase Adherence to the Program: Personnel Buy-In Is Critical

1. Majority rules: Utilize methods that do not have overly strict prescriptions around frequency or occurrence of training. When operational requirements are high, PT is almost always the first to be cut. If the program is not resilient to interruptions, you are likely setting up your personnel for failure.
2. Nonlinear: Using RPE, daily maxes, etc. may better accommodate the highly variable ops tempos, lack of sleep, and other factors that may inhibit a member's ability to meet the prescribed intensity of ongoing percentage-based prescriptions.
3. Minimal effective dose: Few things will guarantee the loss of confidence in your programming faster than a program that results in personnel being so tired or sore they struggle to perform their daily, job-related tasks. Given the many other stressors in their daily regime, recovery will likely be suboptimal. Therefore, it is best to induce the least stress required to drive the desired adaptation.

Additional Factors to Consider

1. Optimize, not maximize: Physical performance programs for tactical populations must be designed to optimize performance despite lacking ideal conditions of training (FITT), diet, and sleep/recovery provided in collegiate or professional athletics. These are implemented to give a perfect balance and maximize performance.
2. Be solution-oriented: Do not let a lack of creativity limit your programming when programming formation or large-scale PT. I have overheard many instances where SC professionals "cannot" support formation PT strength training for reasons such as "we do not have enough weight to support a large group," "the space provided is too small to use barbells," or "there isn't enough time to…."
3. Keep multiple training tools in your coaching toolbox. Most strength-biased programs can be fundamentally split between two camps: powerlifting and Olympic weightlifting centric. Yet, ironically, few in either camp will argue that strength can be developed and displayed with seemingly endless variability. As a tactical SC coach, you should be versed in strengthening a person regardless of the tools available.

Excuses like the ones above will not be well received or serve as valid justification to a chain of command convinced (likely by you) that their personnel's most significant physical deficit is strength-related. No, large formation PT is not ideal for barbell-based strength training, but just as is expected of a young lieutenant, the chain of command will expect you to adapt and meet the mission using the resources available.

Operationalizing SC for the HWS

This text has defined the HWS and elaborated on how to assess the needs of these personnel, apply methods of fitness, etc., but this would all be in vain if we did not also discuss how to take all of the pieces and assemble them into a clear picture of how this looks when applied in an operational setting. Pretend with me for a moment that at the stage, we are having this discussion; you have already established a relationship with the senior command by way of strategic planning discussions with this command team, and your needs analysis defined goal(s), timelines, resources, and prioritized the deficiencies that you intend to improve upon. You have written an eloquent program worth publishing; the facility space has been locked in, and you have access to state-of-the-art equipment; life is good. With confidence in your step and a coffee in your hand, you stroll into your designated space (15 minutes early) for the first morning PT session for a platoon of 30 soldiers. You begin writing up the session for the day on a whiteboard. Ten minutes until class, no one is there. You pull out a few pieces of equipment you intend to use to demo your warm-up. Five minutes until class, and still, no one is there. In a minor state of panic, you confirm that you have the correct time and location; you check your messages and voicemail, and nothing indicates the foreseen absence of your group. Five minutes after the scheduled start, no one was there. You have waited until a quarter after, and you begin to put away the few pieces of equipment you staged for your demo and erase the board before heading back to your desk. About an hour later, the company commander contacted you to let you know that the platoon you had planned to work with earlier that morning had been sent at the last minute to support a task assigned by the brigade. The good news is that the company commander has also informed you that he has spoken with the platoon commander that you are scheduled to meet tomorrow morning, and they have no problem letting today's group join them for their PT time. Your group has now doubled in size; you have no more equipment, time, or space; and you have less than five business hours to figure out how to achieve the program's aim.

Scenarios like the one above are pretty standard for military PT yet unique elsewhere in the realm of SC, making operationalizing SC in tactical settings as much an art as it is a science. This art form of crafting programs with mechanisms making them as resilient as they are both efficient and effective requires consideration of (1) usability, (2) adherence, and (3) adaptability.

Usability

To preface, the concept of usability, as it will be discussed, assumes that you are delegating these programs to the personnel to execute on their own or even to a subordinate or associate SC professional. You can skim to the next adherence section if this is not your situation.

Usability starts by managing your word count. As tempting as it may be to write dissertation-like explanations detailing the immense benefit of the prescribed exercises, justifications for why they are organized in such a way to provide the optimal balance of stimuli across respective domains, etc., the likelihood is that nine out of the ten personnel you have distributed programs like this did not read the explanations. It is like searching for a recipe online to find the world's best casserole, and when you click the link, you are forced to scroll through someone's 15-page blog post about how this recipe reminds them of their childhood. I am sure the sentiment is heartwarming, but I always click "Take me to the recipe." If you intend to educate these personnel about the benefits of exercise or even specific components, the preface to a program you have provided is not the appropriate platform. If the explanation of an exercise does not fit into a tweet, it is too long.

When including curing in your programs, again assuming you are not coaching in-person, do not include common mistakes, and it is performed incorrectly. You have forced the reader to visualize and focus on what you are trying to avoid by providing examples of what not to do. By focusing on the wrong thing as a means to prevent it, they now struggle to focus on what they should be doing, which leads to an apprehension referred to as "analysis paralysis," causing them to hesitate during the execution of movement. Be as precise as possible with curing, exclusively focusing on what to do, leaving additional corrections to be conducted based on need. I recommend that for more technical exercises or ones performed at a higher intensity (something that requires their undivided attention), curing be simplified to three single-word cues to be recited cyclically in order of occurrence leading up to the execution of the exercise. A bonus tip for curing: do not fixate on your personnel adopting your specific cues. Have them pick one to three single-word cues that resonate specifically with them, allowing the execution of the task regardless of whether it resonates with you. For example, if you are using an individual to be more deliberate in how they brace through their midsection, words such as breath, brace, tight, flex, belly, and squeeze are all common ways I have heard people cue the task. So long as it accomplishes what is needed, the word does not matter.

Here are a few additional considerations for usability:

- Series/sets/reps/rest scheme formatting: Despite the comments above regarding word count, it is better to write out formats in plain language (i.e., three sets of eight reps with 2-minute rests between sets) than for your format to look like an algebraic equation.
- Color schemes/color coding: It is boring, but black and white is ideal 99% of the time. The use of color coding for things like identifying an endurance vs. a strength day or to signify high-, moderate-, or low-intensity relative exertions is all valid, but be mindful that certain colors are correlated to specific actions (e.g., green means go) and mental or emotional status (e.g., red is tied to extreme effort and/or anger, respectively) and that there are very few colors that in combination are easy on the eyes when printed in the 12-pt font on a piece of paper or a PowerPoint presentation. The unit you work with colors may be royal blue and gold, but if you put bright yellow letters on a royal blue background, everyone who reads your program will be complaining of unexplained headaches at the end of your sessions.
- Training software: The use of software apps can be a fantastic asset, mainly when you work with personnel outside your geographical location and/or if you need to log the training of your personnel to collect the data for any number of reasons. However, many of these programs require the user to have access to Wi-Fi or even access to their device. Many locations on most bases/wings are secured or have inferior infrastructure to wireless capabilities. Be mindful of your specific personnel's access limitations if you intend to use these platforms.

Adherence

Early in my career as an SC professional, another coach explained that the best program for your clients would be the one they could adhere to the easiest. I took this advice with a grain of salt and thought the comment was absurd. The best program is backed by peer-reviewed research and empirical evidence. Although my original thought is valid, as I matured in my career, I quickly learned that the most well researched and well written has no value if no one is willing to do it. Here are a few of the lessons I have learned by observation and experience that may increase the probability of your personnel performing and adhering to your programs:

- Time management: This is particularly crucial in the formation of PT. Looking back at usability, time to set up and tear down the training session, including the explanation, should not absorb half of the allocated time to train. The group's frustration is palpable when they have been standing around for 10 minutes watching the coach write up a workout and have yet to start moving or when receiving a long explanation before getting any equipment out to receive it again after everything is set up.
- Low-hanging fruit: Most military populations will benefit significantly from consistently doing priority (fundamental) compound movements. Do not complicate for the sake of complicating. Be obsessed with simplifying your programs.
- Minimal effective dose: Few things will guarantee the loss of confidence in your programming faster than the program that results in personnel being so tired or sore they struggle to perform their daily, job-related tasks. Back to the needs analysis in Chap. 3, a general aim of your program should be supporting, not compounding, the existing physical stressors these personnel face.

Adaptability

Let us revisit our example of the platoon that missed their PT session. What separates a tremendous tactical SC program from a good one is whether the program can be exposed to these types of interruptions and yet remain effective. The quality of adaptability in these situations is likely equal to the mindset and the experience/knowledge of the SC professional. All considered you can equally increase your chance to still deliver a practical PT session amidst the chaos that is operational tempos and tasks by predicting that, in all likelihood, these will occur, thus including one or more of the following fail-safe mechanisms to your programs:

1. Majority rules: Either some PT is better than no PT, or it is not. When operational requirements are high, PT is almost always the first task to be cut. Make an effort to design programs confined by days of the week or times of day. If sessions are designed with the flexibility to miss and/or make up sessions without derailing the program, this increases usability and adherence.
2. Nonlinear schemes, such as using RPE, daily maxes, and velocity-based targets (provided you have this technology available), may better accommodate inconsistent schedules, fatigue/lack of sleep, and other factors that may inhibit a member's ability to meet the prescribed intensity or ongoing percentage-based prescriptions.
3. Be solution- oriented: If COVID-19 restrictions exposed anything in the SC community, it would be the industry's heavy codependence/reliance on conven-

tional strength and power training methods. Do not let a fixed mindset toward your preferred methods limit your programming for these personnel. Although exercises like barbell squats and presses are great strength developers, they are just another means to achieve a desired outcome. Go back to your foundational biomechanics classes, break down the kinetic and kinematic structures of the movement, extract specific qualities you wish to develop, and apply the overload principle.

Operationalizing SC for the HWS is an art as much as a science. Physical performance programs for tactical populations must be designed to optimize performance despite lacking ideal conditions of training (FITT), diet, and sleep/recovery provided in collegiate or professional athletics that are implemented in such a way as to give a perfect balance and maximize performance. You must be capable and confident in making these personnel stronger, regardless of the tools that will be expected of you.

Conclusion

The items discussed in this section are just a few lessons learned from the field. However, these essential lessons identified can help make your initial tenure as an HWS SC/HP professional more successful. Do not be afraid to make mistakes; learn from them. You will be successful if you build those relationships, listen, and learn.

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