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Universal Training Precautions: A Review of Evidence and Recommendations for Prevention of Exercise-Related Injury, Illness, and Death in Warfighters and Athletes

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Facing pressure to train for victory, warfighters and athletes encounter numerous health risks that are directly related to their regular physical training. The concept of universal training precautions (UTPs) signifies universal processes designed to prevent unnecessary bodily harm, including injury, illness, and death, during physical training programs. Although no formal guidelines exist for collectively implementing a defined set of UTPs to address a broad scope of exercise-related health risks, recommendations and guidelines have been published relating to preventing sudden death during high school sports and collegiate conditioning sessions. A long list of critical topics must be considered as UTPs, including physical fitness factors, transition-period accommodation, hydration, environmental factors and acclimatization, appropriate recovery, use of medications and dietary supplements, and importantly, leadership. In this article, we outline in detail, with corresponding Strength of Recommendation Taxonomy ratings, what should be considered universal recommendations to minimize the risk of warfighters and athletes coming to harm when participating in group physical activities.

Key Words: load management, acclimatization, hydration, exertional injury, injury prevention

Key Points

- Preventing the diverse array of injuries and harms that may befall warfighters and athletes during exercise requires a comprehensive approach, both in scope (injury types) and application (all warfighters and athletes).
- A proposed set of universal training precautions includes proper exercise prescription and load progression, recovery, sleep, work-rest cycles, transition-period accommodation, hydration, environmental acclimatization, and organizational leadership and culture.
- Medical professionals must prudently tailor universal training precautions to each unique population and setting, noting that many of the pertinent factors exist on a continuum (eg, physical fitness levels, climate, altitude), yet all must be carefully considered.

Achieving victory on the playing field or battlefield depends pivotally on physical training and conditioning. However, the risks of physical training may at times be overshadowed by a win-at-all-costs mentality, which could in turn tragically result in exertional sudden death. Some military commanders confront an especially challenging task of preparing for the threats of the battlefield, where the stakes are much higher than in sporting competition. Facing pressure to train for victory, warfighters and athletes encounter numerous health risks directly related to physical training, including exertional injuries (rhabdomyolysis, heat illness, hyponatremia, exertional collapse associated with sickle cell trait [ECAST]), musculoskeletal injuries, concussion and traumatic brain injury, and death. Although an immense amount of research has been conducted to define the most effective strategies to prevent training-related health risks,[1–13] many gaps remain, and hence, many strategies continue to be largely based on expert opinion. By reviewing and highlighting the clinical relevance of each recommendation and its supporting evidence base (whether scant or robust), we aim to assist health care providers on the sidelines and at training facilities integrate the diverse scope of training precautions, instead of focusing on one or a few preventive measures while neglecting other vulnerabilities. Finally, in this review, we hope to facilitate further research to fill existing gaps.

The concept of universal training precautions (UTPs) signifies universal processes that are designed to prevent unnecessary bodily harm, including injury, illness, and death, during physical training programs. Kark and Ward[14] introduced this term in the 1990s after several people with sickle cell trait experienced what we now call ECAST.[1]

Table 1. Strength of Recommendation Taxonomy for Precautions Related to Physical Fitness and Exercise Design That Should Be Universally Applied During Physical Training

Recommendation	Strength of Recommendation Taxonomy[a]
Training intensity and duration should be individualized to the fitness level of each athlete.[18–21]	C
A progressive, dynamic neuromuscular warmup should be employed to improve performance and reduce the risk for lower extremity injury.[22–25]	A
Exercise programs must account for medical conditions in the athlete, including the possibility of a previously unknown or newly manifesting medical condition.[26]	C
Strength-training programs should include balanced work on bilateral upper and lower extremities, beginning at lower resistance and higher repetitions for novices, and should include at least 2 rest days per week.[20,27–30]	B
Endurance training should be progressed slowly over weeks to months, building on the individual's current baseline.[29–34]	B
High-intensity interval training should be done in a gradually progressive manner, beginning at a level consistent with an individual's current fitness level.[35,36]	B
Individuals with sickle cell trait should be counseled on the risks of high-intensity training before undertaking a fitness regimen.[13]	B
A cooldown period should be incorporated after training sessions to allow a graded return to resting heart rate and to enable staff to observe and ensure that athletes sufficiently recover after strenuous events.[37–39]	B
Transition periods, such as returning after an illness or injury or summer break, are vulnerable periods for an athlete. Transition-period accommodation should be incorporated into a training program for these athletes by expecting and allowing some level of performance decrement and a gradual return to previous levels of fitness.[40–42]	B

[a] Ebell MH, Siwek J, Weiss BD, et al. Strength of Recommendation Taxonomy (SORT): a patient-centered approach to grading evidence in the medical literature. *Am Fam Physician.* 2004;69(3):548–556.

Those in leadership believed some of these events were associated with dehydration and exercise in the heat, and the result was a series of recommendations to mitigate adverse events during military training.

When we consider the term *universal precautions*, the processes for preventing transmission of bloodborne infections immediately come to mind.[15] However, the term is also associated with health literacy when a universal-precautions approach is taken by assuming that all patients—regardless of their health literacy level—may experience difficulty understanding and using health information.[16] Thus, all health information developed is supposed to be easy for patients to understand and help them navigate the health care system.[16] Yet to date, no set of UTPs for sports, exercise, and physical training has been proposed or defined. No formal guidelines exist for collective implementation of a defined set of precautionary strategies to address a broad scope of exercise-related health risks. Interassociation task force (IATF) recommendations related to preventing sudden death during high school sports and collegiate conditioning sessions,[2,6] as well as specific IATF guidelines for preseason heat acclimatization (HA) in high school athletics,[17] have been published. Although it is reasonable to infer that these guidelines may help prevent many types of exercise-related harm, the concept of UTPs must be more inclusive. Ideally, UTPs would apply to all warfighters and athletes and should reduce the risk of all exertion-related events. If we consider the spectrum of precautions that might be taken to protect any warfighter or athlete from exertion-related health risks, a long list will emerge. The most common considerations are presented in Table 1. The goal of our review was to provide a detailed outline of what should be considered a universal recommendation to minimize the risk for warfighters and athletes coming to harm when participating in group physical activities.

METHODS AND DEFINITIONS

Each of these recommendations and the supporting medical literature were reviewed in detail during 1 or more formal roundtable discussions among top subject matter experts:

(1) ECAST Summit, October 2019[13];
(2) Marine Corps Marathon Medical Algorithm annual review panels, 2005 to present[43];
(3) Expert panel for best practices for prevention of sudden death in US Air Force Basic Military Training, November 2014[3];
(4) Military injury-prevention roundtable discussions[18,44]; and
(5) American College of Sports Medicine expert consensus panel on exertional heat illness, 2021.[45]

After reviewing each conference or discussion, we again studied the literature pertaining to each topic and cited relevant articles in preparing this manuscript. The MEDLINE database was searched via PubMed using the following terms: *sudden cardiac death athletes*, *prevention sudden cardiac death*, *exercise collapse sickle cell trait*, *exertional heat stroke*, *exertional heat illness prevention*, *concussion prevention*, *hydration athletes*, *high altitude illness*, *altitude sickness prevention*, *exercise prescription*, *musculoskeletal injury prevention*, *resistance training progression*, *aerobic training progression*, *exercise warm-up*, *post-exercise recovery*, *sleep injury risk athlete*, *sleep athletes*, *caffeine heat illness*, *herbal dietary supplement safety*, *dietary supplement safety*, *medication heat stroke*, *emergency action plan athlete*, *emergency action plan cardiac*, and *emergency action plan leadership*. Emphasis was placed on the most recent interassociation consensus statements, organization position statements, expert summits, systematic reviews, and controlled trials from the primary research. We searched bibliographies of key articles for additional resources, and similar articles recommended by PubMed were also searched. Finally, Strength of Recommendation Taxonomy (SORT)[46] tables were created to summarize the recommendations in each section. These SORT tables were first drafted by the lead author (N.S.N.). All recommendations were then reviewed and scored independently by all coauthors. When scores were discordant, additional review of the literature was conducted to clarify the level of evidence supporting the recommendation until a consensus among all authors was reached. The recommendations presented in this article are intended to pertain to athletes and physically active people in both civilian and military settings unless otherwise specified. Hereafter, the term *athletes* will be used in reference to both civilian and military athletes. The term *warfighter* signifies any member of the armed forces. It is important to recognize that all military servicemembers are required to maintain physical fitness standards; however, some training pipelines and career fields such as special operations entail much higher physical demands than others.

PHYSICAL FITNESS STATUS, EXERCISE PRESCRIPTION, AND EXERCISE PROGRESSION

Physical conditioning levels and proper training-load progressions are extremely important for mitigating exertion-related events.[19] The appropriate exercise modality, intensity, duration, and progression should guide anaerobic and aerobic fitness training to improve performance and lower the risk of injury.[20,21,47] Current exercise guidelines are briefly reviewed here and include individualization, accounting for acute and chronic medical conditions, a proper warmup, strength training, endurance training, high-intensity interval training, stretching, cooldown, and transition-period accommodation. Additional details can be found in current position stands from the National Strength and Conditioning Association[28,48] and the American College of Sports Medicine.[27] Recommendations are summarized in Table 1.

Although its importance is paramount, individualizing training is difficult when working with large groups, and consequently, individuals with lower fitness levels who are attempting to keep up with the group are at greatest risk. An athlete with a maximal oxygen consumption ($\dot{V}O_2max$) of 40 $mL \cdot kg^{-1} \cdot min^{-1}$ cannot safely keep pace for more than a few minutes during an aerobic workout with an athlete whose $\dot{V}O_2max$ is 55 $mL \cdot kg^{-1} \cdot min^{-1}$. The Rating of Perceived Exertion scale is a validated way to measure exercise intensity and should be used when individualizing a training program.[49] Whenever available, exercise guidance should be sought from certified athletic trainers, certified strength and conditioning specialists, exercise physiologists, or a combination of these experts.[50]

Exercise precautions must account for not only healthy individuals but also those with chronic medical conditions, such as diabetes, cardiovascular disease, and hypertension. This is relevant to both civilian athletes and warfighters. Although warfighters are screened for medical conditions before accession, they often develop chronic medical conditions during their military careers and, in many cases, continue to serve productively. Individuals with chronic medical conditions should plan their exercise under the guidance of their primary and specialty care providers. For the vast majority, the benefits of a reasonable exercise plan far outweigh any risks.[26] Whenever possible, medical staff supervising a training event should be aware of the baseline health of their athletes (eg, through a preparticipation physical examination) and must always consider the possibility of a new or undisclosed medical condition presenting during exercise.

An adequate warmup should be used as a UTP. Moreover, warmups have been shown to improve performance and prevent lower extremity injury.[22,23] A warmup generally lasts 5 to 15 minutes and is intended to increase core temperature and heart rate, promote increased blood flow to the working musculature, and increase muscle and tendon elasticity. It should be similar to the actions that will be performed in the upcoming workout. A reasonable warmup begins with dynamic stretching and progresses to light- and then moderate-intensity exercise.[24,25] The warmup is complete when the athlete has progressed to the sport- or exercise-specific movements for that day of training and is ready for higher-intensity movements.

Strength-training programs vary widely depending on each athlete's experience level, goals, interests, and available resources. Although a comprehensive discussion of proper strength-training principles is outside the scope of this review, several key principles deserve mention as UTPs. First, novices should include a variety of resistance exercises in a balanced program that involves all major muscle groups. These exercises should include concentric, eccentric, and isometric muscle actions and involve bilateral upper and lower extremities. As a starting point, athletes should use lower resistance and a repetition range that corresponds to an 8- to 12-repetition maximum (RM); athletes with more strength-training experience may consider progressing to heavier loads with fewer repetitions (1–6 RM). Generally, 3 to 4 sets of a single exercise are sufficient, and the recommended training frequency for 1 muscle group is 2 to 3 d/wk for novice training, progressing to 4 to 5 d/wk for advanced strength training based on the individual's goals and physical capacity.[27,28] At least 2 d/wk of rest (consecutive or nonconsecutive) should be encouraged with even the most advanced strength training.[29,30]

The key UTP specific to endurance training is a slow training-load progression. This can be difficult to measure and enforce in many situations. Endurance training should be progressed slowly over weeks to months, building on the individual's current baseline. This allows the cardiovascular and musculoskeletal systems to adapt congruently with increased distance and training volume.[31] Various means of workload monitoring, such as the acute-to-chronic workload ratio, have shown promise for injury prevention.[32,33] The types of metrics used in workload monitoring and means of gathering and analyzing these data vary widely by sport, and further research is needed. Tissue underloading may also increase the injury risk; therefore, training less is not always safer.[34,51]

High-intensity interval training involves repetitive bouts of training at maximal or supramaximal aerobic speeds, thereby engaging anaerobic metabolism, and has been shown to improve $\dot{V}O_2max$.[35,36] Before athletes perform high-intensity interval training, their baseline fitness should be assessed, and then athletes may be progressed according to their current fitness levels. Importantly, athletes who carry the sickle cell trait should be educated on the benefits and dangers of high-intensity training, and emergency action plans (EAPs) must be in place. Two similar IATFs provided a valuable set of precautions that should be used with high-intensity training.[2,6] They include acclimatizing exercise progressively, never using exercise as punishment, ensuring proper education and credentialing of exercise instructors, confirming that staff are up to date in cardiopulmonary resuscitation training, developing and practicing EAPs, and ensuring that staff members are aware of athletes' medical conditions.[2,6]

Cooldown periods are widely used as part of a safe and effective exercise program; however, evidence for their effectiveness in preventing harm is scant. Nonetheless, we recommend this practice as a UTP based on rational experience and expert opinion.[37,38] Cooldown periods consist of degressive lower-intensity exercise for 5 to 10 minutes, often incorporating static or dynamic stretching and foam rolling. This cooldown period allows a graded return to the resting heart rate and helps mitigate the ventilation-perfusion disparity and hyperventilation from intense exercise.[39] Importantly, it also enables staff to observe and ensure that athletes recover sufficiently after strenuous events.

An emerging area of interest related to exercise progression and exertional injury prevention is the concept of transition-period accommodation or transitioning. Examples of transitioning include an athlete returning after an illness or injury, beginning a new program supervised by individuals who are uncertain of the athlete's physical fitness and capabilities, and returning to duty or play after a vacation or an extended break from training. These can be vulnerable periods for an athlete, especially if the detraining was due to illness or injury. In several studies[40–42,52] examining physiological changes during transitioning after illness or injury, researchers found negative changes in body composition and decrements in speed, muscle power, and aerobic capacity. Some performance decrements should be expected after a period of detraining or deconditioning, and each athlete needs to be considered individually and intentionally as training advances to prevent a new or recurrent injury.[41,42,52]

HYDRATION

Hydration is a well-accepted precaution against multiple exertion-related illnesses, and guidelines for both warfighters and athletes have been put forward.[9,12,53] Importantly, hydration guidelines must consider the effects of work intensity, specific environments, clothing, and personal protective equipment (PPE).[54] When individuals are exposed to heat stress, legislative bodies such as the US Occupational Safety and Health Administration and the American Conference of Governmental Industrial Hygienists recommend replacing fluids frequently, such as consuming 1 cup (250 mL) every 15 to 20 minutes when working in warm environments.[54]

Given that self-perception of sweat loss is not an accurate reflection of fluid losses,[55] objective measures such as urine studies or body mass changes can better guide hydration strategies. Brake and Bates[56] reported that urine specific gravity is a good indicator of hydration status and an effective way to improve workforce awareness of hydration and reduce rates of dehydration. In addition to urine specific gravity, other approaches for measuring or predicting the onset of dehydration are of great interest. For example, wearable sensors for measuring real-time sweat sodium, pH, and other metabolites are emerging.[57] Similarly, saliva and tears are being studied for markers of dehydration, but intraindividual and interindividual variability data are needed before these can be used.[58]

The composition of the fluid ingested is also important, especially in hot and humid conditions and when meals are inadequate. Electrolyte replacement beverages are recommended during high-intensity exercise in hot weather.[45,54] However, because they frequently have a high content of simple carbohydrates, sodium, or both, special consideration may be necessary for athletes with diabetes or hypertension, respectively, warranting individualized hydration strategies. A wide variety of products such as oral rehydration solutions[59] and amylose starch–containing sports drinks[60] have been studied. Nonetheless, small sample sizes and potential bias from sports drink industry sponsorship make interpreting the data challenging.

Hydration-monitoring and fluid-replacement strategies must be practical and easy for athletes to implement. Biochemical markers are not feasible in many sports, military, and occupational settings, and the authors[61,62] of recent reviews have raised doubts about the accuracy of urine specific gravity or urine osmolality for estimating hydration status. Hypovolemia and increased plasma osmolality result in a consistent internal thirst response in both hot and cold climates. During exercise to which they are accustomed, drinking to thirst is an effective and practical strategy for most athletes to maintain hydration while avoiding hyponatremia. Planned drinking strategies may be optimal for prolonged exercise (>90 minutes), especially in the heat.[53,63,64] Alternatively, athletes can be educated on sweat-rate calculations to estimate the amount of fluid losses that will need to be replaced during training or performance.[9] The National Athletic Trainers' Association (NATA) encourages the development of individualized hydration strategies that consider the environment, type of sport, duration of activity, and available resources with the goal of maintaining euhydration.[9] A summary of current preventive recommendations regarding hydration is given in Table 2.

ENVIRONMENTAL CONDITIONS

Heat, humidity, and altitude have tremendous influences on the risk for exertional injury and must be accounted for as UTPs. Evidence shows these factors each impose a physiological burden, and the burden is greater when physical fitness is low. Exercising without proper environmental acclimatization can contribute to exertion-related events such as ECAST and exertional heat illness (EHI).[45,65–70] Athletic trainers, strength and conditioning coaches, and others involved in training should be aware of the risks and be able to provide guidance on how to sufficiently acclimatize to confer protection.[71–73]

In 2009, the NATA, along with an IATF, published guidelines for preventing EHI in high school sports, including a specific 14-day HA protocol.[17] In a subsequent study, Kerr et al[74] found that rates of EHI decreased in states mandating adherence to these guidelines. Like the

Table 2. Strength of Recommendation Taxonomy for Precautions Related to Hydration That Should Be Universally Applied During Physical Training

Recommendation	Strength of Recommendation Taxonomy
Hydration guidelines may help prevent dehydration and must consider the effects of work intensity, specific environments, clothing, and personal protective equipment.[9,12,45,53,54,56]	B
Urine specific gravity is a good indicator of hydration status and can be an effective way to improve workforce awareness of hydration and reduce rates of dehydration.[54,58]	B
Electrolyte replacement beverages are recommended during hot- or humid-weather physical activities, especially when meals are inadequate or exercise is prolonged.[9,45,53,54]	B
Oral rehydration solutions and amylose starch–containing sports drinks are safe and likely effective for rehydration; however, the data are limited and the potential for bias is high.[59,60]	C
Drinking to thirst is an effective and practical strategy for most athletes to maintain hydration while avoiding hyponatremia.[9,53,63,64]	B

NATA guidelines, the US Army recommends HA consisting of 2 weeks of daily heat exposure for about 2 h/d (that can be broken into two 1-hour exposures) combined with physical exercise (marching or jogging).[12] Since the publication of the US Army Guidelines in 2003,[12] subsequent systematic reviews and consensus guidelines have recommended approximately 1 to 2 weeks for HA, with heat exposure durations ranging from 60 to 120 min/d.[45,71,72]

Regardless of the duration of HA, regular exercise in the heat is required to maintain acclimatization effects. For every day without heat exposure, an estimated decay of 2.5% of the physiological adaptations occurs to heart rate and sweat rate.[71] Additionally, aerobic training in the heat confers greater thermoregulatory adaptations for exercise during conditions of uncompensable heat stress than can be attributed simply to an individual's $\dot{V}O_2max$.[75] Given that many training scenarios occur under conditions of uncompensable heat stress, aerobic training in the heat is critical and should be considered for any warfighter or athletic training program. Although often limited by resources, individualized HA plans that incorporate physiological status monitoring (eg, heart rate, skin and core temperature) may be beneficial because people acclimatize at different rates (5 to 14 days).[71] Other general HA strategic tips are presented in Table 3. Regardless of the HA method chosen, continual study is needed to determine the effect of implementation across various settings and guide policy decisions.[74]

As for HA, a variety of guidelines exist for acclimatizing to altitude. The risk for high-altitude illness increases when the ascent is rapid and exertion is strenuous. No association has been demonstrated between age and the risk of developing acute mountain sickness.[76] In a recent meta-analysis, researchers[77] concluded that women may be at a slightly higher risk than men for developing acute mountain sickness (relative risk = 1.24; 95% CI = 1.09, 1.41). The amount of time required for a person to become acclimatized to altitude is a function of individual physiology (eg, aerobic fitness, hydration, concurrent medications) and the magnitude of the hypoxic challenge from the altitude attained. Currently, recommended schedules differ for low, moderate, and high altitudes. Because of the number of variables needed to develop individualized plans for acclimatization, an effective UTP would aid in minimizing high-altitude illness across all exertional activities at higher altitudes.

The US Army's published guideline, TB MED 505,[78] provided excellent information for acclimatizing at altitude. The Wilderness Medical Society[79] recommended gradual ascent (≤500 m/d at altitudes >3000 m) and a slow increase in sleeping elevation to prevent high-altitude illness. Currently, substantial efforts are focused on identifying biomarkers capable of measuring acclimatization, susceptibility, or both to high-altitude illness,[80] which may assist

Table 3. Strategic Tips for Ensuring Appropriate Heat Acclimatization[a]

Recommendation	Tip
Ensure adequate heat stress	Invoke sweating.
	Use exercise and rest to modify heat strain.
	Try to achieve ≥100 min of daily heat exposure.
	Try to achieve 4–14 d of heat exposure.
Methods	Climate-controlled rooms, hot weather, or overdress for indoor exercise.
	Start slowly.
	Acclimatize in the heat of the day.
	Train in the coolest part of the day.
	Maintain aerobic fitness and integrate heat acclimatization into training.
	Use work-rest cycles and build toward continuous work.
	Increase heat and training volume as tolerance permits.
Other	Be especially observant of salt needs during the first week of acclimatization.
	Remember that heat acclimatization increases fluid needs.
	High fitness facilitates heat acclimatization.
	If heat exposure is discontinued, benefits are retained for about 1 wk and lost within 1 mo.

[a] Adapted.[12]

Table 4. Strength of Recommendation Taxonomy for Precautions Related to Environmental Conditions That Should Be Universally Applied During Physical Training

Recommendation	Strength of Recommendation Taxonomy
Proper environmental acclimatization (heat, humidity, altitude) must be incorporated to help prevent exertion-related events such as exertional heat illness.[3,12,17,45,65–67,70,72]	A
At least 1 to 2 wk of heat exposure while exercising for 60–120 min/d is adequate for most individuals to acclimatize to the environment.[5,45,71]	B
All secondary school athletes should be given at least 14 consecutive days to acclimatize in the preseason before beginning full-length, full-intensity training.[5,17,70,74]	B
Though often limited by resources, individualized heat-acclimatization plans that incorporate physiological status monitoring (eg, heart rate, skin and core temperature) may be beneficial because individuals acclimatize at different rates (5–14 d).[71]	C
For proper acclimatization to altitude, a gradual ascent ($\leq$500 m/d at altitudes $>$3000 m) and a slow increase in sleeping elevation may be effective for preventing high-altitude illness.[76–78]	B

with individualizing acclimatization decisions in the future. Some investigators are also now focusing on exposure to simulated altitude by using intermittent normobaric hypoxia (15%) for acclimatization before altitude exposure. Ghaleb et al[81] exposed 10 men to intermittent normobaric hypoxia (15%) and found that 12 days were sufficient for acclimatization based on their cardiorespiratory responses (ie, heart rate, respiratory frequency, minute ventilation). Again, the duration and length of exposures will vary, depending on the anticipated final altitude where the mission or competition will take place. A summary of recommendations is provided in Table 4.

RECOVERY, SLEEP, AND WORK-REST CYCLES

Acute and chronic cumulative stress, whether due to heat, exercise, insufficient sleep, or other factors, lowers the threshold for exertion-related injury. Adequate periods for recovery after strenuous exercise are critical as a UTP. The concept of work-rest cycles has been considered for many years in the military and by occupational safety specialists because of its influence on aerobic and anaerobic systems, overall health, and recovery. Work-rest cycles must be based on multiple factors, including exercise intensity, environmental conditions, PPE, clothing worn, and although frequently forgotten, sleep sufficiency.[82] Military missions often require continuous operations in remote or austere environments in combination with insufficient or changing sleep patterns.[83] Thus, guidelines for recovery from the stresses of physical training in diverse environmental conditions, including work-rest cycles and sleep, are recommended as UTPs.

Many websites offer specific instructions for the appropriate duration of work relative to the requisite rest period, which is typically determined based on temperature, humidity, and clothing or PPE (Table 5). In general, the instructions are to shorten or adjust work periods and increase rest periods in accordance with the following:

- High temperature,
- Sun strength or radiation,
- Wearing protective clothing or gear,
- High humidity,
- Limited to no air movement, and
- High work or exercise intensities.

Importantly, new and unacclimatized athletes and workers should be assigned to lighter activity with longer rest periods and close monitoring until they are fully acclimatized. The Figure presents the current hydration or fluid replacement and work-rest cycle recommendations used throughout the military.

Sleep is often overlooked as a factor for health, performance, and injury prevention. It serves a vital role in the repair and growth of tissue and in brain function. Negative performance effects stemming from sleep loss and increased time awake include decreased reaction time, accuracy, vigor, strength, endurance, and ability to move and track objects with the eyes.[53,84] Inadequate sleep also impairs cognition and increases the risks for EHI and musculoskeletal injury.[85] Authors[85] of systematic reviews have suggested that individuals sleeping <8 hours per night or having frequent nighttime awakenings are more likely to sustain musculoskeletal injury. Sleep loss is associated with increased activity of the sympathetic nervous system and hypothalamus, leading to proinflammatory responses and increased stress responsivity, pain, emotional distress, mood disorders, and cognitive and memory deficits.[86] In light of these data, sleep must be considered as a UTP alongside work-rest cycles and recovery factors. At least 8

Table 5. Selected Website Resources for Acclimatization and Other Universal Training Precautions

Organization	Online Resources
National Institute for Occupational Safety & Health	https://blogs.cdc.gov/niosh-science-blog/2011/08/12/heat-2/ https://www.cdc.gov/niosh/mining/UserFiles/works/pdfs/2017-127.pdf https://www.cdc.gov/niosh/mining/UserFiles/works/pdfs/2017-124.pdf https://www.cdc.gov/niosh/topics/heatstress/acclima.html
US Army Research Institute of Environmental Medicine	https://www.usariem.army.mil/assets/docs/partnering/HeatAcclimatizationGuide.pdf (published 2003)
National Athletic Trainers' Association	https://www.nata.org/practice-patient-care/health-issues/sickle-cell
American Society of Hematology	https://www.hematology.org/education/patients/anemia/sickle-cell-trait
Occupational Safety & Health Administration	https://www.osha.gov/heat-exposure/hazards

Heat Category	Wet-Bulb Globe Temperature Index, °F (°C)	Easy Work: Work/Rest, min[a]	Easy Work: Water Intake, qt/h (L/h)[b]	Moderate Work: Work/Rest, min[a]	Moderate Work: Water Intake, qt/h (L/h)[b]	Heavy Work: Work/Rest, min[a]	Heavy Work: Water Intake, qt/h (L/h)[b]	Very Heavy Work: Work/Rest, min[a]	Very Heavy Work: Water Intake, qt/h (L/h)[b]
1	78–81.9 (25.56–27.72)	NL	0.50 (0.47)	NL	0.75 (0.71)	50/10	0.75 (0.71)	25/35	1.00 (0.95)
2 (Green)	82–84.9 (27.78–29.39)	NL	0.50 (0.47)	NL	0.75 (0.71)	40/20	1.00 (0.95)	20/40	1.00 (0.95)
3 (Yellow)	85-87.9 (29.44–31.06)	NL	0.75 (0.71)	NL	0.75 (0.71)	35/25	1.00 (0.95)	20/40	1.00 (0.95)
4 (Red)	88-89.9 (31.11–32.17)	NL	0.75 (0.71)	50/10	0.75 (0.71)	25/35	1.00 (0.95)	15/45	1.00 (0.95)
5 (Black)	>90 (>32.22)	NL	1.00 (0.95)	35/25	1.00 (0.95)	20/40	1.00 (0.95)	10/50	1.00 (0.95)

Description and Examples

Easy Work	Moderate Work	Heavy Work	Very Heavy Work
250 W; ~3.5 kcal/min	425 W; ~6.1 kcal/min	600 W; ~8.4 kcal/min	800 W; ~11.2 kcal/min
Maintaining weapon, drills and ceremonies, walking a dog, yoga, raking, washing clothes, golfing	Patrolling with 25-lb (11.3-kg) load, stair climbers, rowing 5 km/h, cutting wood, bicycling 15 km/h, hiking, low and high crawl, tennis	Walking and climbing briskly up hills, patrolling with 45-lb (20.4-kg) load, 4-person litter carry, jogging 9 km/h, cycling 25 km/h, cross-country skiing 7 km/h	Obstacle course, 2-person litter carry (150 lb [68.0 kg]), basketball game, jogging 11 km/h, judo, skipping rope 100 steps/min, swimming 3.5 km/h

Figure. Fluid replacement and work-rest cycle guidelines for training in warm and hot environments. [a] Rest indicates minimal activity and in shade, if possible. [b] Hourly fluid intake should not exceed 1.5 qt (1.4 L), and daily fluid intake should not exceed 12 qt (11.4 L). Abbreviation: NL, no limit to work time per hour (up to 4 h). Adapted.[12]

hours of sleep per night is considered optimal for most individuals. However, high-level athletes may require additional sleep for full recovery. Finally, accrued sleep is counted as the actual time spent sleeping and must not include time spent in bed trying to fall asleep.[87] A summary of sleep recommendations per age group is shown in Table 6. Ratings from SORT for precautions related to sleep, recovery, and work-rest cycles are supplied in Table 7.

MEDICATIONS AND DIETARY SUPPLEMENTS

Given that many drugs and dietary supplements increase the risk for exertion-related injuries, proper limitation or avoidance of these substances must be observed as a UTP. Of particular concern are stimulants and other ingredients that affect the cardiovascular system.[88–90] Many energy drinks, preworkout supplements, sexual enhancers, and weight-loss supplements contain various sympathomimetics, caffeine, herbal compounds, or other ingredients or drugs that can mediate vasoconstriction and increase heart rate and metabolic heat load, raising the risk for exertion-related injuries.[91] All prescription drugs and dietary supplements should be carefully reviewed and cleared, and any product containing >300 mg per serving of caffeine should be prohibited. Medical teams are encouraged to consider educating athletes regarding the risks of taking weight-loss, preworkout, and other drugs or dietary supplements containing ≥1 stimulant and discourage athletes from taking these (Table 8).[93]

Table 6. Sleep Duration Recommendations as Universal Training Precaution Guidelines

Age Group (y)	Sleep Recommendation, h[a]
Teenagers (14–17)	8–10
Young adults (18–25)	7–9
Adults (26–64)	7–9
Older adults (≥ 65)	7–9

[a] High-performance athletes may require additional sleep.

LEADERSHIP, CULTURE, AND PREPAREDNESS

Intangible factors such as motivation,[92,94–96] peer pressure,[97,98] and leadership[99] may powerfully influence the risk of injury or harm during physical training. In the military and athletic environments, competition is expected and can be highly beneficial when managed correctly. Similarly, encouragement among teammates is common and generally agreed to be beneficial. However, historically, when motivational techniques or the culture of an organization has become overbearing, toxic, or excessively punitive, individuals or teams have been detrimentally affected.[100,101] Recommended precautions related to leadership, culture, and preparedness are summarized in Table 9.

As a UTP, teams and military units should adhere to principles of leadership, motivation, and organizational culture that clearly value the well-being of team members and avoid misuse or abuse of motivational techniques. When motivation starts to move beyond producing positive adaptations and instead creates negative ones, including possible health risks, then the technique has been carried too far. The goal is to create a positive milieu throughout practices to ensure readiness for the mission or competition. Because peer pressure can be a powerful motivator and lead

Table 7. Strength of Recommendation Taxonomy for Precautions Related to Recovery, Sleep, and Work-Rest Cycles That Should Be Universally Applied During Physical Training

Recommendation	Strength of Recommendation Taxonomy
Work-rest cycles should be based on multiple factors, including exercise intensity, environmental conditions, personal protective equipment, clothing worn, and (though often forgotten) sleep sufficiency.[12,82]	C
New and unacclimatized athletes or workers should be assigned to lighter activity with longer rest periods and close monitoring until they are fully acclimatized.[12]	C
Athletes should sleep $\geq$8 h per night, in light of evidence that sleeping $<$8 h per night increases the risk for illness and musculoskeletal injury. Competitive and high-level athletes may require $>$8 h.[82,83,85–87]	A

to impaired judgment, measures such as education on signs of distress, using buddy systems, and destigmatizing the seeking of medical attention should be considered as UTPs. During sports and military training, adolescents and young adults spend abundant time around their peers. Researchers[97] have suggested that peer-related stimuli may excite the reward system to respond to the values of risky behavior. Peer pressure, whether overt or merely internally perceived by young athletes, may influence them to ignore the signs and symptoms of physiological distress during exercise. Moreover, some persons are powerfully internally motivated to perform at any cost and may not pay attention to their internal cues. The primed reward system of making the group proud and pushing through self-warning symptoms might favor short-term benefits over long-term safe alternatives. Therefore, as a UTP, coaches and leaders must destigmatize seeking help or taking a time out for health or safety checks. Buddy systems provide another means of stopping a teammate who may be showing signs of distress but internally driven to continue at all costs.

Some leadership styles may be coercive or perhaps unintentionally perceived as same. Hence, another UTP consideration may be to avoid having a high-ranking superior lead group fitness tests, as additional pressure can be exerted for athletes to finish a high-intensity workout or physical fitness test.[104] Investigators[97] have noted that adolescents exhibited stronger risk-taking behavior geared at immediate reward when they believed they were being observed. Thus, leaders and coaches have a responsibility to discuss and preempt these types of concerns and ensure that their warfighters and athletes are comfortable raising a flag or seeking medical attention.[102]

Finally, a critically important UTP under the auspice of leadership is to create and regularly practice EAPs.[103] Whereas much of the responsibility for the EAP rests with leadership, medical staff also have a duty to make recommendations to leaders and take appropriate actions to ensure an EAP is in place and regularly practiced. Properly trained medical personnel, such as certified athletic trainers and emergency medical services personnel, should be involved in EAP development. Training or coaching staff and medical personnel must be educated on the early signs of distress, when to call for onsite medical assistance, and how to activate emergency medical services. The EAP may include "go or no-go" decision criteria for individual athletes or the team based on factors such as current illness or weather conditions. As part of the EAP, leaders and medical personnel should outline relevant aspects of medical coverage, including the specific types of events requiring medical personnel onsite versus on call, the types of medical personnel required, and the equipment and supplies that must be accessible. Except in precluding circumstances, an automated external defibrillator and oxygen must be available in case of emergency.[105]

CONCLUSIONS

Given the inherent health risks of physical training, especially under pressure to achieve victory, a variety of steps must be taken universally and preemptively to minimize the risk of harm, ranging from minor musculoskeletal injuries to severe exertion-related illness or even death. Termed *UTPs*, these measures should be used with all warfighters and athletes and across all types of physical training. A collaborative approach, beginning with leadership and including all medical staff and training staff or coaches, will result in the best outcomes. Training precautions should be applied not only universally but also in a rational and systematized manner. Opportunities should be sought for continuous process improvement as changes are made and better methods are discovered. Because each UTP being recommended exists on a spectrum (eg, altitude, baseline fitness level, leadership styles), the specific method of applying each UTP must be determined by trained sports

Table 8. Strength of Recommendation Taxonomy for Precautions Related to Medications and Dietary Supplements That Should Be Universally Applied During Physical Training

Recommendation	Strength of Recommendation Taxonomy
Prescription medications and supplements containing sympathomimetics, caffeine, herbal stimulant compounds, or other ingredients or drugs can increase the metabolic heat load, thereby increasing the risk for exertion-related illness and injury.[88–92]	B
Medical staff should carefully review and clear all prescription drugs and dietary supplements being used by athletes.[90,92,93]	C
Athletes should be educated regarding the risks of taking weight-loss, preworkout, and other drugs or dietary supplements containing stimulants and discouraged from taking these.[88,92,93]	C

Table 9. Strength of Recommendation Taxonomy for Precautions Related to Leadership, Culture, and Preparedness That Should Be Universally Applied During Physical Training

Recommendation	Strength of Recommendation Taxonomy
Teams should adhere to principles of leadership, motivation, and organizational culture that clearly value the well-being of team members and avoid abuse of motivational techniques.[102]	C
Teams should incorporate athlete and coach or supervisor education on medically concerning signs or symptoms,[3,103] be cognizant of the effects of peer pressure during exercise,[97,98] and consider using buddy systems.[13,45]	C
Coaches and leaders must destigmatize seeking help, medical attention, or taking a time out for health or safety checks.[3,97,99,104]	C
Coaches and leaders must collaborate with medical staff to develop and regularly practice emergency action plans.[3,102]	C
Wherever possible, an automated external defibrillator and oxygen must be available in case of an emergency.[103]	C

and medical professionals and leaders within each setting. Further research is required to determine the effectiveness and applicability of these UTPs and guide future policy development.

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