Psychological Adaptation To Heat Stress

This excellent work by Vernacchia and Veit-Hartley was presented at the Coaching Education Level III in December, 1998. It not only shows the quality of the authors' research and writing, but also the what one might find at a Level III seminar. Both authors are to be commended for presenting in-depth material on heat stress from the psychological aspect, and then concluding with some very practical pointers for the coach. Contact USATF for further information on Coaching Education, and the various Levels, including Level III.

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Heat exposure is a threat to performance, as well as to the health of athletes who are competing in hot weather. Coaches and athletes need to be aware of the physiological and, equally importantly, psychological preparations needed to produce optimal performances in high-temperature environments.

There is extensive literature developed on the physiological effects of heat stress on the body and the body's mechanisms of achieving heat balance. However, the literature regarding the *psychological* aspects of heat stress and athletic performance is sparse. This article addresses the psychological aspects of heat stress on athletes.

First, an overview of the effects of heat stress on the body will be discussed. Then the psychological aspects (emotions, arousal, anxiety, attention, and decision making) of heat stress will be explained. Lastly, this article will discuss the importance of heat adaptation or heat acclimation and will provide recommendations on how to prepare mentally for competition in the heat.

HEAT STRESS DEFINED

Heat stress is composed of two components: 1) heat load which rises from metabolism, heat exchange, radiation, and convection with the environment; and 2) heat dissipation which is release of the heat load through sweat evaporation. According to Brotherhood (1987), heat stress is any factor (e.g., high temperatures) or any combination of factors (e.g., high temperature and high humidity) that overloads the thermoregulatory system thereby raising the body temperature, as well as affecting the ability of the thermoregulatory system to disperse heat from the body into the environment.

Brotherhood (1987) states that the principle source of heat stress comes from the metabolic heat production arising from physical activities such as in sports. Other factors that contribute to heat stress are improper clothing and the thermal environment (air temperature, air movement, and radiant temperature). All these factors affect the heat exchange between the body and the environment which takes place at the skin surface (Brotherhood, 1987).

Brotherhood further explains the role of heat stress in sports. Physical training and competition inherently produce extremely high metabolic heat loads. In hot conditions, sweat increases, as do deep body (core)

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temperature and skin temperature. Also, the heart rate and cardiac output increases. According to Doust, Carter, and James (1997), high temperatures cause an increase in blood flow to the surface tissue, causing the heart to pump more blood to the muscles and to the skin resulting in a higher heart rate.

Skin temperature also plays a major role in the ability to tolerate heat (Brotherhood, 1987). In order to maintain optimal performance, the athlete's skin temperature should be lower than 30 degrees Celsius.

Another important characteristic of athletic performance, in regard to heat stress, is the high relative air movement over the body when performing the physical movements. By utilizing convective exchange and evaporative capacity, the body is able to move more freely (Brotherhood, 1987).

In conclusion, Brotherhood's study of heat stress states that an increase in environmental temperature may result in greater stress than the combined capacities of thermoregulation and heat dissipation can handle. This condition will cause a dangerous increase in the athlete's body temperature and skin temperature, affecting his/her performance, as well as his/her health and safety.

BEHAVIORAL RESPONSE TO HEAT STRESS—PLEASURE VS. DISPLEASURE

From another perspective, Cabanac (1987) believes that heat exchange between the body and the environment is behavioral. He states that behavioral control is the main response to heat stress physiologically and psychologically. The motivation for behavior is seeking pleasure which originates through the skin via deep body temperature (Cabanac, 1987).

Pleasure is a tri-dimensional sensation from the stimuli: 1) qualitative, the nature of stimuli; 2) quantitative, the intensity of stimuli; and 3) affective, the amount of pleasure and displeasure aroused by stimuli (Cabanac, 1987). This last dimension of sensation is a continuum between pleasure and displeasure which is extreme negative affectivity (distress) at one end and extreme positive affectivity (delight) at the other end. The relationship, therefore, is between the affective part of sensation and the behavior which is determined by the strength of motivation for or against the stimuli as a function of pleasure or displeasure (Cabanac, 1987).

Cabanac continues to state that in thermal stimuli pleasure or displeasure is aroused by the body's temperature. For example, *pleasure is obtained when the stimuli aids the body to its normal state.* Once the body has reached its normal state, the thermal stimuli looses strength in the pleasure component. Therefore, sensory pleasure and displeasure aroused by stimuli is a motivation for thermoregulatory behavior which depends on the internal state of the individual (i.e., deep body temperature, set-point, and skin temperature) (Cabanac, 1987).

Furthermore, Cabanac explains the thermoregulatory behavior with muscular exercise. He states that when the body is in conflict with biological motivations such as fatigue and heat stress, individuals tend to increase or maximize sensory pleasures to enhance physiological functions to solve the conflict. For example, fatigue is known to be a discriminative perception in distance running. In this situation fatigue is used against the motivation to win or to perform well and against thermal stress/discomfort. Fatigue is eliminated when the individual adjusts the body temperature and the intensity of muscular activity (reducing muscle heat) by maximizing sensory pleasure through thermoregulatory behavior.

Cabanac's study concludes that seeking pleasure and avoiding displeasure leads to positive behaviors and motivation. Thus, individuals are able to maximize psychological pleasure at the cost of physiological displeasure.

THE PSYCHOLOGICAL ASPECTS OF HEAT STRESS

The stress of environmental temperature that accentuates physiological responses to performance also has an impact upon the psychological domain (Ekkekakis, et al., 1997). To understand the concept of stress it is important to define it. According to Keller and Schilling (1997) stress is a "relationship between the person and the environment that is appraised by the person as relevant to his or her well-being and in which the person's resources are taxed or exceeded" (p.354).

HEAT STRESS AND PERCEPTION—THREAT VS. CHALLENGE

Stress is perceived in two ways: threat and challenge. Threat is considered to be a potential of loss with negative emotions and challenge is the potential of growth with positive emotions. Therefore, threat contributes to poor performance and challenge to better performance in stressful situations (Keller & Schilling, 1997).

The study conducted by Keller and Schilling illustrates this concept of stress in relation to threat and challenge. They selected subjects who were taking an athletic examination for admission in the Physical Education Department. The subjects were asked to describe personal best performance and to evaluate actual performance capability, their intended performance, and their feelings (threat or challenge) on 14 emotions.

The negative emotions in the study were sadness, anxiety, disgust, anger, and shame. The positive emotions were affection, happiness, joy, and pride. The ambivalent emotions were confidence, excitement, determination, eagerness, and hope.

The results of the study showed that threat was related to negative emotions and to the ambivalent emotion of excitement, whereas, challenge was related to positive emotions and the ambivalent emotions of determination and hope. Therefore, Keller and Schilling concluded that the more insufficient an athlete feels in relation to actual performance, the more the athlete is threatened, lowering performance. Threat, therefore, is associated with negative emotions, as well as with poor performance.

PSYCHOLOGICAL "HARDINESS" AND HEAT STRESS

Crews (1992) examined the influence of psychological states on performance, particularly on running economy. Psychological state refers to a particular cognitive and emotional condition of the mind which can influence the physiological and behavioral responses to performance. In her review she critiques studies that use categories of affect, perception, and cognition as an influence of performance.

According to Crews, affect is an emotion or feeling (e.g., sadness, happiness, anger, anxiety, etc.) related to an idea or object. She has found through studies that psychological state of affect (negative and positive emotions) alters physiological responses to performance.

Perception, on the other hand, involves the use of senses, awareness, and comprehension to understand objects and the environment. Crews concludes from various studies that attempting to alter perception (e.g., hypnosis) in order to influence the physiological response is not as effective as personality characteristics. For example, the personality characteristic of "hardiness" seems to have a positive effect on psychological state and physiological responses to performance. This characteristic, according to Crews, is composed of commitment, control, and challenge where an athlete tends to be curious, expects change, views obstacles as challenges versus threats, and perceives that he/she has control over his/her environment (e.g., hot conditions).

Lastly, cognition is the integration of memory, judgment, and perception; the process of knowing (Crews, 1992). Cognition in Crews' review is composed of mental strategies (associative and dissociative techniques), coping strategies (relaxation and stress management techniques), and biofeedback (the control of physiological responses). These categories of cognition appear through several studies to be an important factor in influencing physiological responses to performance by reducing tension or anxiety and improving efficiency (Crews, 1992).

At this point, it is known that performance under stress, such as competing in the heat, is definitely affected by psychological states. In response to heat stress, acute exercising such as competing in a race is emotionally aversive, affecting cognitive coping skills (relaxation, affective responses, etc.) and perception of physiological responses (heart rate, dehydration, etc.) (Ekkekakis, et al., 1997). Therefore, training or competing in heat reduces positivity of affect and increases perception of effort or physical exertion. According to Ekkekakis, et al., studies have shown that an increase in the body core temperature which can be caused by exposure to high temperature from the environment, or heat production of working muscles, leads to negative affective responses (psychological state of emotions).

AROUSAL AND PERFORMANCE

Performance effects caused by heat are also interpreted in relation to arousal and the inverted U-relationship theory between arousal and performance (Razmjou, 1996). Arousal is viewed as an energizing function that is responsible for physiological responses to a stimulus. An individual's state of arousal is seen on a continuum ranging from deep sleep to extreme excitement. According to Razmjou, it is proposed that in heat the arousal level increases with an increase in skin temperature which has an effect on performance.

When arousal levels become too high, an athlete may experience unpleasant emotional reactions associated with the physiological responses. In this situation the athlete is in a state of anxiety (stress) which results in ineffective performance, faulty decision making, and inappropriate perception (Landers & Boutcher, 1993). Petruzzello, Landers, and Salazar (1993) also proposed that an increase in temperature will increase anxiety. In their study 20 male subjects ran for 30 minutes at 75% VO_2max in three different temperatures: normal temperature associated with exercise; cooler condition in which normal rise in temperature was attenuated; and warmer condition in which normal rise of temperature was accentuated. The results demonstrated a positive relationship between change in temperature and affective response. As temperature increased, anxiety also increased; but a decrease in temperature was associated with a decrease in anxiety (Petruzzello, et al., 1993).

STRESS AND ANXIETY

Furthermore, Koltyn, Shake, and Morgan (1993) investigated the anxiety response, as well as body awareness to temperature, by having divers exercise in warm and cold water with and without a wet suit for 30 minutes at 35% underwater VO_2max. The results revealed that anxiety increased significantly for cold condition without a suit and warm condition with a suit. However, body awareness data revealed different results in which the cold condition without a suit and the warm condition with a suit indicated an increase in body awareness (i.e. somatic anxiety). Therefore, Koltyn, et

al., (1993) concluded that individuals with high trait anxiety will be more likely to experience panic behaviors in stressful situations (i.e., in relation to the study, diving accidents with scuba divers, or in relation to heat stress, poor competitive results).

STRESS, ATTENTION AND DECISION MAKING

Another important psychological aspect that is affected by heat is the information processing system or the decision making process. According to Razmjou (1996), the information processing system (IPS) is limited because the capacity of the channel line in the nervous system is limited; it is considered to have a fixed limited transmission capacity. This capacity is viewed as a limited energy input to IPS components and is associated with attention and effort.

In response to heat, decision making becomes more complex and the task demand (mental structures such as perceptual, response-selection, and response-execution used during performance of a task) increases which causes longer reaction time and higher workload (Razmjou, 1996). Therefore, an increase in workload demand (e.g., heat stress) will pose an increase in mental workload, causing the IPS order process such as strategies, decision making, and attention to be delayed and to negatively affect performance.

The concept of mental workload and physical workload is further explored by Gonzalez (1997). He investigated physical fatigue and attentional demands by using dual-task techniques. Gonzalez used 17 male students from the PE department as subjects and had them exercise under five fatigue conditions (intensity level of 0, 25, 50, 75, and 100% of maximal work capacity) on a bicycle ergometer.

The results indicated that the five fatigue conditions demanded different degrees of attentional resources. Therefore, he concluded that the higher the physical workload, the more attention demand is needed to perform the task, causing fatigue difficulties in task performance. This fatigue stage leads to a delay of information processing and a decrease in attention, thereby decreasing performance.

HEAT ACCLIMATION AND PRACTICAL RECOMMENDATIONS FOR COACHES AND ATHLETES

Heat acclimation through the natural or artificial environment leads to improvement in exercise tolerance under hot conditions. It increases blood volume and sweat production and decreases thermal discomfort, as well as lowering the ratings of perceived exertion (Aoyagi, McLellan, & Shephard, 1997). It also lowers the thermoregulatory set point and reduces energy cost for a given task.

The optimal method of preparing for hot environment is to spend several weeks in that environment (Aoyagi, et al., 1997). The correct acclimation depends on: initial acclimatization and fitness level, the severity of the heat stress presented during the acclimation session, inclusion of exercise during acclimation sessions, and the length of individual sessions. According to Aoyagi, et al., each exposure to heat must be sufficient enough to raise the body core temperature and to produce sweat. In addition, repeated periods of maximum effort in the heat are required to improve performance further.

Overall, heat acclimation is successful in increasing blood volume, decreasing heart rate, redirecting cardiac output to the skin and active muscles, increasing sweating, and decreasing skin blood flow (Aoyagi, et al., 1997). Heat acclimation can improve an athlete's homeostatic mechanism, reducing physiological and psychological strains that are imposed by training and competing in the heat.

DEVELOPING PSYCHOLOGICAL "HARDINESS"

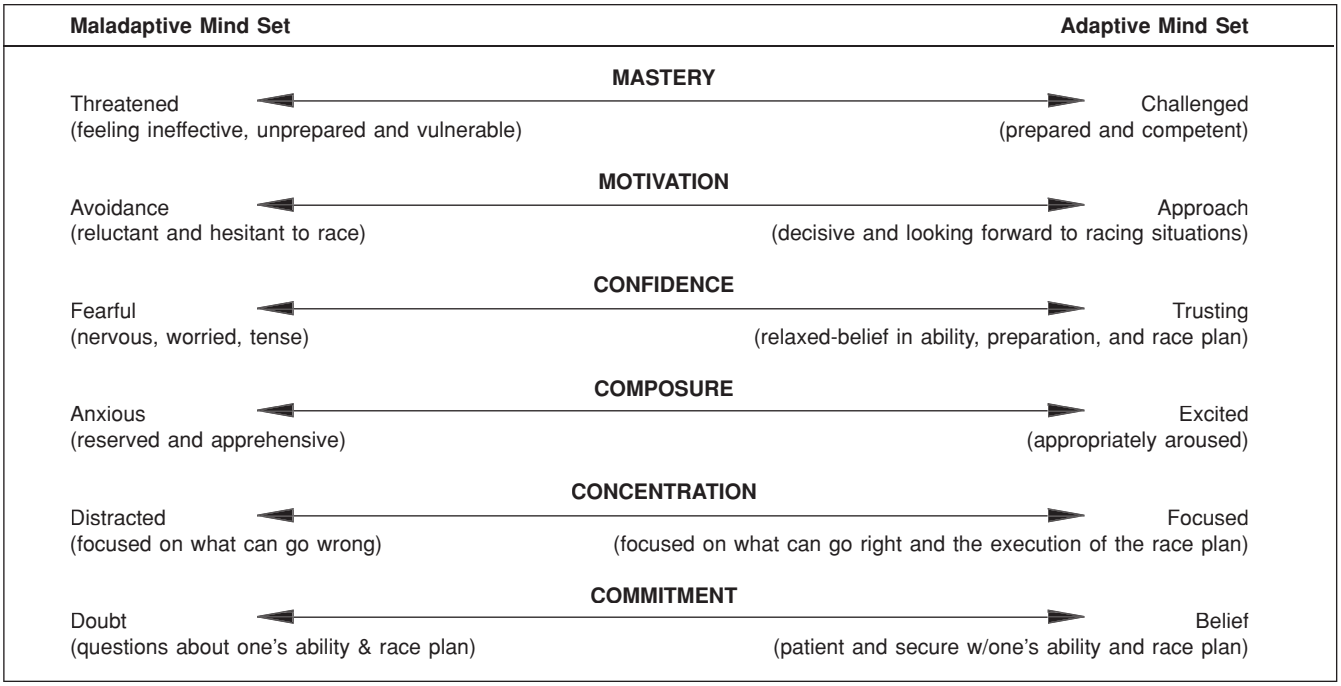
As the literature suggests, coaches who desire to prepare their athletes to effectively train and race in heat related environments would be best served to develop a mind-set in their athletes that would help them cope with and adapt to heat stress. The development of psychological "hardiness" through mental skills training focuses on developing an athlete's sense of commitment and control when faced with a challenging situation (Crews, 1992). Dimensions of psychological "hardiness" outlined in Figure 1, include mastery, motivation, confidence, composure, concentration, and commitment.

Ideally we would like an athlete to adapt to environmental stress by being excited and motivated toward approaching challenging training and racing situations. Such excitement is a result of their ability to trust and focus their attention, talent and physical preparation on the process and pleasure of attaining successful performance goals and outcomes. The key to mentally adapting to the physical challenges of heat stress is to engage in mental and physical preparation strategies that instill confidence, trust, and control rather than fear and anxiety

Mental skills training can be an effective compliment to physical preparation and can serve to enhance an athlete's feeling or perception of competence in stressful training and racing situations. In general, mastery of the following mental skills (Thompson, Vernacchia, & Moore, 1998; Vernacchia, McGuire, & Cook, 1996; Weinberg & Gould, 1995; Williams, 1998) are helpful in developing the mental attributes, such as concentration, confidence, composure, and commitment, which are essential in coping with the training and racing demands of heat stress:

- *Concentration* (distraction control, focusing, decision-making)

Figure 1: Dimensions of Psychological "Hardiness"



- *Confidence* (self-talk, goal setting, visualization, race plan)
- *Composure* (arousal control training, relaxation training, stress management, biofeedback)
- *Commitment* (belief in method, ability, preparation, talent, and race plan)

More specifically, it is recommended that coaches and athletes address the following mental preparation strategies prior to performing in hot weather:

1. Be in the know about the challenges you will face. Understand the psychophysical ramifications of heat stress as it applies to the duration and intensity of your event. Utilizing simulation training that helps athletes mentally and physically adapt and acclimate to environmental stress is an important first step. Review past racing results in similar climatic conditions and factor your previous physical and mental responses to heat stress into your current race plan. Select an appropriate effort and pace for your fitness and experience level and also establish a hydration and fluid replacement plan (i.e., location of aid stations, frequency of fluid consumption, type of fluid, etc.).
2. Listen to your body. Be sensitive to how you feel physically throughout your event; internally monitor your physiological responses to training and racing stress. This is the simplest form of biofeedback. Recognize when muscular tension is adversely affecting running rhythm and tempo and remain relaxed and in control by regulating your breathing rhythm and being patient. Run your race.
3. Have a performance plan. Know the environmental and physical conditions that you will face and develop a performance plan that is specific to the racing environment. Your plan must adapt your talents, skills, and abilities to the situation (pace, terrain, competition protocol, etc.). Keep your plan flexible so you can adjust and adapt to the ongoing and moment-by-moment stress of training and racing.
4. Expect the unexpected. Develop contingency plans. Anticipate and prepare responses for various situations that you may face. Anticipation and preparation are the keys to mental toughness. Mentally "walk" through various race scenarios and specifically rehearse your physical/racing response to such conditions as a fast early race pace, mid-race surges, climatic changes such as rain, missing a fluid replacement station, etc. How an athlete responds to what happens to him or her during a race is often more impacting than what actually happened to him or her. Rehearsing responses to a variety of racing scenarios allows an athlete to mentally and physically prepare effective racing strategies, reduces anxiety, and builds confidence and a feeling of control before and during races.
5. Keep your composure by regulating your arousal level. Control your arousal level (excitement) by being patient and using coping strategies (relaxation training, thought stoppage, positive self-talk, imagery, etc.) which will help you make good decisions in the "heat" of battle. As stated previously, there is a direct relationship between

increase in skin temperature and an athlete's arousal or excitement level and decision-making ability (Landers & Boutcher, 1993; Petruzzello, et al., 1993; Razmjou, 1996). Pay attention to the early stages of the race; this is where overaroused, overconfident athletes can make poor decisions about pace and strategy because they feel loose and full of racing. On the other hand, overaroused, underconfident athletes can be so worried and anxious about heat stress that they become indecisive, hesitant, and unable to trust and implement their race plan or respond appropriately to race tactics.

6. Trust in your talent, preparation and race plan. Be confident and focus on the aspects of the performance that you can control and regulate.

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