

## CHAPTER 3

# EXTREME CONDITIONS IN ENDURANCE SPORT

*“I believe that most of us have an astonishing natural strength that includes the ability to walk and run considerable distances every day, and we also have the capacity to survive in conditions that are scarcely imaginable”. – Mike Stroud*

### 3.1 INTRODUCTION

The aim of this chapter is twofold. Firstly, to give a broad overview of extreme conditions in general and extreme conditions in endurance sport. This will be done to give the reader a clear understanding of what extreme conditions in endurance sport are as well as the differences between “normal” endurance conditions and extreme endurance conditions. In this chapter both concepts will be defined as well as the conditions that constitute extreme conditions. The second aim of this chapter is to discuss the extreme conditions of the specific group that participated in this study as well as the psychological effect that these specific environmental factors have on this specific group. This is done to give the reader a clear and specific understanding of the factors that constitute extreme conditions for this specific group. Furthermore, the psychological influence of these environmental conditions will be discussed to highlight the important influence on performance that these environmental factors have.

### 3.2 DEFINING KEY CONCEPTS

Since the first marathon in ancient Greece, people seem to have the urge to prove their physical and mental abilities by pushing themselves to go faster, further and higher. In fact, this is a condition seen not only in sport, but also in most facets of human civilization. If humans did not have this capacity, we, if we survived, would probably still be living in caves. Fortunately, people are created and programmed with the capacity to adapt to and overcome obstacles and challenges. However, it is only in the last 150 years that people have been starting to participate in endurance events just for the enjoyment of the event itself. It is only in the last 40 years that endurance events such as marathon running, cycling, to name a few, have become commonplace events accessible to the general population (Stroud, 1998). The

growth of extreme/endurance sports such as triathlons, cycling and adventure racing, may highlight the need to take risks and to fulfill an internal need to overcome enormous physical and mental challenges some people seem to have. Endurance sport, as opposed to non-endurance events, has differences not only in the technical aspects of the sport but also in the type of challenges that are involved. In non-endurance sport such as athletics, rugby and soccer the events usually take place in front of crowds or spectators. Apart from the stress induced by the athlete on himself, this is a factor that increases the level of stress experienced by the athlete(s). Due to the length and nature of endurance sport and especially extreme endurance sport, it is seldom that the athletes compete in front of spectators. Logically, this should decrease their levels of stress. However, this stress can also help to motivate athletes of non-endurance events (Jones & Hardy, 1990). Athletes in endurance sport therefore have to employ more self-motivating strategies for longer periods to perform well.

One factor that increases endurance athletes' levels of stress is the environment within which they participate. Owing to factors such as extreme heat, cold, the distance involved, these environments may be and usually are very harsh. The influence of these factors on endurance athletes has been studied extensively from a physiological perspective. This can be seen in the numerous examples of studies conducted such as Creagh, Reilly and Nevill (1998) on female "off road" runners, Laursen and Rhodes (2001) on factors affecting performance in an ultra endurance triathlon and Ainslie, Campbell, Frayn, Humphreys, McLaren, Reilly and Westerterp (2002) on energy balance, metabolism, hydration and performance during strenuous hill walking. Although some studies have been conducted to identify the psychological stress environmental factors create in endurance events (Bolmont, Thullier & Abraini, 2000; Lane, Terry, Stevens, Barney & Dinsdale, 2004), this has been studied less extensively than the physiological stresses. The motivational and coping strategies used by endurance athletes specifically in endurance events under extreme conditions have also not been studied to a great extent (Campen & Roberts, 2001; Weinberg & Gould, 2003).

The aim of this study is therefore to determine what type of influence environmental conditions or stressors have on non-elite athletes' performance as well as the motivational-and-coping strategies used to control this. It is therefore important to know what stress is as well as the influence of stress in sport on performance with the emphasis on its effects on performance and arousal. The remainder of this

chapter will focus on the conceptualisation of endurance sport, what the environmental conditions present in endurance events are and how it influences performance.

### 3.2.1 STRESS IN SPORT

Stress is a term that is widely used in everyday conversations as well as academic circles. In psychology and sport psychology this term is widely used and researched. However, due to the fact that stress is often used interchangeably with terms such as resilience, anxiety and arousal, some confusion exists about the meaning of the term as these terms distinguish between related factors that are closely linked but are not the same. According to Jones and Hardy (1990), Cox (2002), O' Neil (2002) Potgieter (2003) and Weinberg and Gould (2003), a distinction should be made between the terms stress, fear, anxiety and arousal. To fully understand the relationships it is necessary to clarify any confusion between the terms and give clearly defined distinctions between the terms fear, anxiety, stress and arousal.

Fear can be defined as the emotional and physiological reaction to immediate, tangible and realistic danger (Reber, 1995; *Gale Encyclopaedia of Science*, 2001). Fear may be provoked by exposure to traumatic situations, observations of other people exhibiting fear or when receiving frightening information. Anxiety can be defined as the physical and psychological response to a perceived threat or danger. This perception can be triggered by a combination of biochemical changes in the body, individual history and memory and the social situation (Reber, 1995; *Gale Encyclopaedia of Science*, 2001). Lazarus (2000) concurs and stresses that anxiety like all emotions such as anger or happiness has a powerful influence on performance. These emotions occur as a response to an environmental event following an appraisal of the impact of the environmental event on the individual. If the athlete perceives an environmental event to be threatening he would experience anxiety. Anxiety is related to fear and has the same physiological and psychological symptoms, but it is not the same thing. The difference is that fear is the direct response to a specific, objectively observable danger or threat that the individual is consciously aware of. Anxiety on the other hand, is often unfocused, vague, hard to pin down to a specific event and can be a very subjective observation (Reber, 1995; *Gale Encyclopaedia of Science*, 2001). The cause of anxiety might not be the same for another individual. Anxiety experienced in the present might stem from an event or person that caused pain or fear in the past. In this situation, the individual might

not even be consciously aware of the cause of the anxiety (Reber, 1995; *Gale Encyclopaedia of Science*, 2001).

Stress, according to Kellmann (2002), from a system point of view, can be described as a destabilisation or deviation from the norm in a biological or psychological system. Deviations in a psychological system are the result of demands that are too high or too low. Reber (1995) distinguishes between stress as a *cause* and stress as an *effect*. Stress as a cause is seen as any force that when applied to a system (individual/group) will cause some significant change or adaptation to that system. These forces that cause stress are called stressors. Stress as an effect is the psychological tension that is the result of forces that are applied to any system that cause significant changes or adaptations. Stress is both a psychological and physical response that occurs when an individual has to adapt to changing conditions, whether those conditions are real or perceived, positive or negative. In this point of view, stress can be differentiated in Eustress (positive) or Distress (negative) (Cox, 2002).

Weinberg and Gould (2003) define stress in terms of balance between the demands (physical and/or psychological) of a situation and the ability of the individual to respond successfully to these demands. This usually takes place in a situation where the individual's inability to successfully meet the demands of the situation has important consequences for the individual. According to the *Israel Centre For the Treatment of Psycho Trauma*, stress is the feeling of discomfort that individuals experience when they perceive that they are in a threatening situation. Following the same point of view, O'Neil (2002) defines stress as the physical and psychological process of reacting to and coping with events or situations that place extraordinary pressure upon a human being. Stress is a normal reaction to an abnormal situation and serves primarily the function of self-preservation in a threatening situation enabling one to focus full attention on a particular threat, thereby mobilizing maximum physical and psychological energy to respond to a particular threat.

All individuals experience stress in daily life that may produce tension, frustration and anger. However, an individual's reaction is largely determined by that individual's physical and psychological strength (coping capacity) or weakness at that specific time. Thus, each individual's capacity to handle stress will differ and even for the same individual the ability to cope with stress will vary (O'Neil, 2002). Stress consumes physical, cognitive and emotional energy and although some stress can

be beneficial to the individual, it should not be allowed to accumulate to the point where it cannot be controlled. This leads to cumulative stress, a situation where the individual is not able to cope anymore (O'Neil, 2002). Cumulative stress (Grossman, 2000; Ford-Martin, 2001) is the result of stress that occurs too often (frequency), lasts too long (duration) and is too severe (intensity). In these circumstances stress leads to exhaustion and other manifestations that undermines an individual's ability to cope.

From these definitions about stress, the following deductions can be made:

- o Various factors or stressors that destabilize the individual's physiological and psychological equilibrium or balance can cause stress.
- o Stressors usually cause a change in the present (or future) situation. These changes in the situation cause internal tension to the individual to rectify the equilibrium or situation. This forces the individual to adapt to the situation by means of psychological, behavioural and physiological responses.
- o The stressors may be difficulties and challenges, real physical danger (fear) or it may be perceived to be dangerous (anxiety) by the individual or it may be when the individual perceives that he/she will not be able to cope with the demands (stressors) of the situation.
- o It is important to notice that threats, challenges, difficulties or danger do not necessarily have to be physical danger to the individual's life (although it can be). It can include failure or any threat to the individual's short- or long-term goals, self-esteem or ego.
- o Stress can be positive (Eustress) or negative (Distress). Eustress can energize the individual to perform well, while distress can lead to a stress overload where the individual is unable to perform or performs poorly. The experience of stress (emotional state) as positive or negative depends on the individual's perception of the situation and perceived capacity to cope with the demands (stressors) of the situation.

- o The methods whereby the individual adapts to changes in the situation are called coping strategies or stress management techniques. These strategies may be physiological or psychological or a combination of both.

For the purpose of this study, stress will be defined as the internal psychological tension caused by internal and external stressors that changes or are perceived to change the nature of the present and/or future situation to such an extent that it forces the individual to adapt by means of physiological and psychological responses.

A process that is related and linked to stress is arousal. Arousal, according to Jones and Hardy (1990) and Potgieter (2003), can be defined as the energizing of the body and mind leading to a level of alertness. Reber (1995) defines arousal as a dimension of activity or readiness for activity based on the level of sensory excitability, glandular and hormonal levels and muscular readiness. Various authors (Jones & Hardy, 1990; Robert *et al.*, 1996; Grossman, 2000; Ford-Martin, 2001; Cox, 2002; Potgieter, 2003; Weinberg & Gould, 2003) identified three types of arousal namely; cognitive, autonomic and behavioural.

**Cognitive arousal** refers to the sensory and emotional processes that are involved to prepare an individual for action. These processes involve the sensory awareness (perception) of a change in a situation. It also involves the cognitive evaluation of the situation, stressors involved and the individual's ability to cope. This evaluation leads to an emotional state such as fear or anxiety that determines the level of autonomic and behavioural response. The intensity of the emotional state would be determined by the perceived threat to the individual that the stressor holds. Thus the higher the threat level – the more intense the emotional state.

**Autonomic arousal** refers to the degree of physiological activity primarily controlled by the autonomic nervous system to prepare an individual's body for action. Indicators of this are palmar sweating, increased skin conductance, increased rapid respiration, increased heart-rate, higher blood pressure, tensed muscles, dryness of mouth, numbness and tingling of limbs, metabolic rate decreases and dilated eyes.

**Behavioural arousal** refers to the overt or visible activity of the individual. This includes actions such as frequent urination, nausea, vomiting or diarrhoea, pacing,

trembling, restlessness, hand wringing, pressured speech, withdrawal, confusion, inability to concentrate, emotional outbursts or aggressive behaviour.

Cognitive, autonomic and behavioural arousal are closely linked and interact to prepare the individual for action. This action will be the response to a stressor or stressors that the individual identified and the consequent coping strategy(s) that are necessary to adapt to these stressors.

The relationship between stress, anxiety, fear and arousal can be summarised in the following manner: stress is the internal tension of the individual caused by changes in the situation or future situation. These changes or perceived changes cause an emotional state of either fear or anxiety, depending on the stressor. This forces (motivates) the individual to take certain physiological and psychological actions to adapt to these changes. The process whereby the individual is prepared physiologically and psychologically for the adaptive actions is called arousal and takes place before the individual starts to take adaptive action. The level of arousal will depend on the level of stress that the individual experiences as well as the intensity of the emotional state experienced by the individual. The intensity of the emotional state experienced would depend on the stressor or perceived stressor as well as the individual's perceived capacity to cope with the stressor or perceived stressor. Therefore, stress will be the factor that motivates the individual to adapt to changes in the situation. This is accompanied by an emotional state that will determine the level of arousal that the individual experience. The arousal level will determine the individual's physiological and psychological readiness to respond to changes or stressors and the physiological and psychological coping strategies will determine how the individual will respond to stressors. As seen previously in this chapter, stress can have positive and negative effects on the individual and his or her performance. The effect of stress would depend on the individual's capacity and perceived capacity to cope with the stressors as well as the level of physiological and psychological readiness to do so. However, therein lie the two important factors that determine the effect of stress on individual performance. Firstly, if the individual does not have the capacity or perceived capacity to cope with the demands or stressors of the situation or chooses incorrect strategies – the individual's performance will suffer or he will be overwhelmed completely. (Coping strategies will be discussed in chapter 4). Secondly, if the individual's level of readiness is too low or too high, performance will also suffer or fail completely. The effect of arousal on performance will be briefly discussed in the following section.

### 3.2.2 AROUSAL AND SPORT PERFORMANCE

One of the major concerns of many athletes is to attain a psychological state (arousal level) that will facilitate increased performance (Jones & Hardy, 1990). In sport there are many factors that can have a negative influence on the athletes' psychological state and thereby alter it from the optimum required for a particular sport. (As seen in the previous section, these factors are called stressors). According to Jones and Hardy (1990) and Potgieter (2003) one of the causes of deterioration in performance is that athletes cannot control the effect of over-arousal. In other words, they are unable to cope with the effects of over-arousal and consequently perform poorly. However, if the athlete were able to control his arousal level his performance would probably increase. This is similar to Csikszentmihalyi's (1990) theory of flow and the influence of inner disorder or psychic entropy where he states that information that disrupts consciousness by threatening an individual's goals leading to a disorganisation of the self and impaired effectiveness. Flow is the state of inner calmness where the individual is able to focus on his goals without disruption thereby increasing effectiveness.

There are several theoretical approaches and perspectives on the complex relationship between arousal and performance in sport. However, the main focus of this study is not what the relationship between arousal and performance is. Therefore, in this section only the main similarities and differences between the theories will be briefly discussed. The theories that will be compared in this section are the drive theory, inverted-u theory, zones of optimal functioning, flow approach and catastrophe model. According to various authors (Csikszentmihalyi, 1990; Jones & Hardy, 1990; Horn, 1992; Reber, 1995; Woods, 1998; Gill, 2000; Cox, 2002; Potgieter, 2003; Weinberg & Gould, 2003), arousal has the following effects on performance:

According to the drive theory there is a positive linear relationship between arousal and performance. The higher the level of arousal, the better the performance if the task is well learned or a skill is mastered. If the task is not well learned or a skill not mastered or complex, an increase in arousal will negatively affect performance. Social facilitation suggests that the presence of other people will increase arousal. If the task is simple and well learned – increased arousal will lead to increased performance. If the task is not well learned or a skill not mastered or complex, the

presence of others will negatively affect performance. Subsequent research has shown that it is not the mere presence of others that affects performance but the evaluative capacity or perceived evaluative capacity of these people that influences arousal levels.

According to the inverted-u theory the relationship between arousal and performance follows an inverted-u curve with optimal levels that differ according to each individual and each individual task. As the complexity of a task increases, so the level of arousal required for performance decreases. Arousal levels above and below the optimal level are associated with lower performance. According to this theory optimal arousal level depends on the nature of the task. According to this theory a slightly above average level of arousal will enhance performance on all motor tasks. Moderately high arousal levels would enhance gross motor activities involving speed, strength or endurance but would interfere with complex skills, concentration or fine motor activities. Optimal arousal would depend on the ability and personality of the athlete. For a highly skilled and experienced athlete complex skills might not be the same for the beginner athlete. Athletes with a personality tendency of high trait anxiety would experience more arousal more quickly than an athlete with lower trait anxiety. It is therefore difficult to determine what each individual's optimal level of arousal would be. According to this theory there are always some kind of pressure or stressors on athletes. This pressure or stressors do not in themselves cause stress. It is the individual's perception of the situation and response that is the relevant factor. The athlete will experience stress when he perceives himself unable to cope with the demands of the situation. High trait anxiety athletes are more susceptible to this perception than athletes with lower trait anxiety.

According to Jones and Hardy (1990), the problem with the inverted-u theory is that it is simple and intuitive appeal leads to unquestioning acceptance by sport psychologists. Furthermore, they state that the theory is too simplistic and does not take into account the advances made by research in cognitive psychology. According to Jones and Hardy (1990), the relationship between arousal and performance is much more complex than the inverted-u theory postulates. As previously mentioned, one of the problems with the inverted-u theory is that it is difficult to measure. Secondly, all athletes seem to have the same optimal level of arousal and therefore, the theory does not take individual differences into account.

The zones of optimal functioning (ZOF) attempt to overcome these shortcomings by proposing individual zones of optimal functioning. Each athlete would have a zone within which his performance would be optimal. This theory is based on the anxiety level that the individual experiences. As seen in section 3.2.1, anxiety is an emotional state that determines the level of arousal. Therefore, when the athlete's anxiety level falls outside the optimal zone (too high or too low), his performance would also deteriorate. The difference between the ZOF and inverted-u theory is that an athlete's optimal level of arousal and therefore performance is not necessarily at midpoint, but can differ according to individual differences.

Another theory that follows a similar approach as the inverted-u theory and the ZOF is the flow approach. According to this theory athletes perform at their best when they are in a state of flow. This state is reached when the athlete is completely absorbed by the activity that he/she is busy with. This state is achieved when there is a balance between the ability of the athlete and the demands of the situation. If the demands are too little the athlete will become bored and if the demands are too high he will experience anxiety (Csikszentmihalyi, 1990). Another factor that influences this state is the level of perceived capacity to cope. When the individual perceives his coping capacity to be enough, he/she will feel in control of the situation and will be able to cope. However, any uncertainty or loss of confidence will induce anxiety. Anxiety will also influence concentration (Csikszentmihalyi, 1990; Cox, 2002; Weinberg & Gould, 2003). The athlete must be able to concentrate on the task at hand. In a state of flow any stimulus that are irrelevant to the task at hand are disregarded. The deduction that is made by the researcher is that anxiety will produce an increase in arousal levels. This will ensure a drop in performance, as the athlete would be outside his/her flow state or zone of optimal arousal.

Most of the previous theories make the assumption that less than optimal arousal would lead to a gradual decline in performance. In other words, if the athlete's level of arousal were too low or too high, the decline in performance would be slight or extreme depending on the degree of deviation. Furthermore, any deviation from the optimal level would result in gradual decline in performance and that the correct intervention(s) will be able to rectify this decline. The catastrophe model does not support this symmetrical relationship between arousal and performance. Performance depends on the interaction between arousal and cognitive anxiety (Cox, 2002; Potgieter, 2003; Weinberg & Gould, 2003).

Under normal circumstances the relationship between arousal and performance follows an inverted-u curve. However, when cognitive anxiety is extremely high, arousal levels also become extremely high (higher than the optimal level) and performance drops dramatically rather than gradually. This catastrophic pattern is usually associated with high cognitive anxiety but is further increased when coupled with high levels of physiological arousal. Once this catastrophic pattern starts it is very difficult to recover even to moderate levels of performance. This model suggests that optimal arousal is important but that extreme levels of anxiety and arousal should be controlled in order to prevent the catastrophe pattern.

According to Jones and Hardy (1990) and Weinberg and Gould (2003), the main critique against the theories previously discussed is that they are simplistic and do not take into account the complex nature of the arousal-performance relationship. They ignore the fact that people actively attempt to cope with any harmful demands in a sporting environment.

Therefore, several two-dimensional theories were developed to accommodate the complex nature of the arousal-performance relationship as well as individual coping responses. These theories by Broadbent, Eysenck, Hockey and Hamilton proposed a two-dimensional arousal system where the first system is a passive, undifferentiated physiological arousal state that influences performance according to the processing demands of a particular task (Jones & Hardy, 1990). A second, cognitive control, system monitors and rectifies any adverse effects of the passive arousal system on performance. In other words, when performance is negatively influenced by under- or over-arousal in the first (physiological) system, the second (cognitive) system compensates for this by increasing or decreasing arousal levels.

According to these theories high performance levels are obtained through two different methods: through optimal or near-optimal arousal in the first system with minimal involvement of the second system, or through compensatory action by the secondary system. Therefore, according to this approach, performance is not always impaired through under or over physiological arousal levels since the equilibrium is maintained by efficient action of the second (cognitive) control system. According to this approach, a distinction should be made between performance effectiveness and processing efficiency. Performance effectiveness relates to the quality of performance, in other words how well or poorly the athlete performs. Processing efficiency refers to the relationship between performance effectiveness and the effort

required for this performance. This relationship can be expressed by the following formula:

**Processing efficiency = Performance effectiveness/effort**

In other words, when performance is good and the effort required to do so is low, processing efficiency would be high. When effort is high and performance is low or mediocre, processing efficiency would be lower. Processing efficiency would therefore be the total effectiveness of the individual's coping strategies. Compensatory action by the second arousal system would reduce the effects of under- or over-arousal on performance effectiveness. Thus, should the arousal level be lower or higher than what is needed for optimal performance, the secondary control system would compensate for this by increasing or decreasing physiological arousal. However, the effort needed would increase as additional cognitive activation or cognitive coping strategies are needed to compensate for the arousal deficiencies. Therefore, arousal would influence the processing efficiency more than performance effectiveness.

According to these theories, different stressors such as noise, incentives, and extreme environments create qualitatively different cognitive activation states that then influence performance through different cognitive processes. The focus of these theories is the different performance patterns that emerge under different environmental conditions. The underlying assumption is that different stressors influence performance in different ways.

To summarize, arousal therefore has a definite influence on performance. From the theories it seems as if performance is dependant on an optimal level of physiological and cognitive arousal. As each individual is different with regards to skills, experience, motivation and personality traits, the perception of stressors as well as coping strategies and optimal arousal level will differ. When an individual's arousal level is under or above the optimal level, his/her performance will deteriorate. Arousal is influenced by the cognitive perception of a stressor and different stressors would require different cognitive activation states or coping strategies. Arousal, as such, is not the focus of this study. However, it is one of the factors or stressors that endurance athletes have to cope with during endurance events.

In the next section, the concepts endurance sport as well as the environmental stressors present in endurance sport will be discussed.

### 3.2.3 ENDURANCE SPORT

To give a comprehensive definition of endurance sport is almost as difficult as defining personality. Most people would know what an endurance event is and would probably be able to make the distinction between an endurance event and a non-endurance event. However, to give a scientific definition based on literature that would satisfy most people is difficult.

There are various ways and methods to classify endurance events and to make a distinction between endurance events and non-endurance events. Four basic methods are identified in the literature, distance, time needed to complete the event, comparison with other events, and the amount of aerobic and anaerobic fitness or intensity required.

- *Distance* (Jarver, 1989; Kellmann, 2002). In the Olympic Games, all track events longer than 800m are considered endurance events.
- *Time needed to complete the event* (Brook, 1987; Jarver, 1989; Kellmann, 2002). Some events such as the 800m track event can take anything from 3 minutes and more. Events such as a marathon would need 2½ hours for elite athletes, while ultra-marathons and expedition adventure races may take several days of non-stop racing.
- *Comparison with other events* is the third method that is used to classify an endurance event (Brook, 1987; Jarver, 1989). Compared to ultra-marathons and adventure races, the 800m might seem to be a walk in the park. However, when the 3 minutes of the 800m is compared to the 10 seconds of the 100m sprints, it definitely is an endurance event. The time and distance as well as the aerobic and anaerobic requirements of a specific event are compared with other events. The higher the requirements for a specific event, the more endurance is required.
- *The intensity of energy required* used during an event will determine the level aerobic or anaerobic fitness required (Brook, 1987; Jarver, 1989; Seiler,

1996; Mann & Schaad, 2001; Rawling, 2003). For short high intensity events such as the 100m sprint or power lifting, the athlete would require high levels of anaerobic energy. This would also lead to a quick build-up of lactic acid in the muscles that would limit the endurance of the athlete. For longer events such as marathon running, adventure racing or rock-climbing, the intensity of the event is much lower and the athlete would require high levels of aerobic energy. As the intensity of the event is lower, the build-up of lactic acid is slower and the endurance of the athlete would be more. However, due to the duration (several hours or days) the energy requirements would increase with very little or no opportunity to replace used energy that will counter the build-up of lactic acid in muscles. Therefore, endurance can be seen as a product of the athlete's aerobic energy capacity.

It is clear that these definitions cannot necessarily be used on their own, but that the combination of these definitions can be best used to differentiate between endurance events and non-endurance events. When combining all four definitions, endurance events can be classified as *those sport events where the distance, time and the level of aerobic fitness/intensity requirements for successful completion are considerably higher than when compared to other sport events.*

To achieve the aim of this study a combination of these four definitions will be used to determine the events that can be seen as endurance events. This will then be used to select the participants that will participate in this study. The criteria for inclusion are that an event should take at least one hour to complete and should involve one or more disciplines that involve one or more aerobic/anaerobic exercises such as running, walking, cycling, swimming or rowing. An operational definition of an experienced non-elite endurance athlete is a person who has participated in at least four endurance events (marathons – 10 km+, cycling – 30km+, mountain biking – 20km+, canoeing/kayaking – 30km+, backpacking – 30km+, adventure racing – 25km+, Iron Man etc.), of which two must have been in the past year without being a professional athlete (non-paid).

### **3.2.4 EXTREME CONDITIONS IN ENDURANCE SPORT**

According to the literature (Sisson, 1983; Dettweiler, 1991; Anthony, 1996; Powers & Dodd, 1996; Stroud, 1998; Mann & Schaad, 2001) extreme conditions in sport can be defined as those environmental conditions or characteristics of the specific sport that

place extreme physical and mental pressures on the athlete. These pressures or stressors, when not correctly managed, can have psychological, cognitive and physical effects ranging from perceptual distortions to lower performance and extreme physical injuries or death. Stressors refer to factors such as heat, cold, altitude; sleep deprivation, hunger, thirst, terrain that disturb the homeostatic balance of the body.

According to the literature (Sisson, 1983; Dettweiler, 1991; Bloomfield, Fricker & Fitch, 1992; Anthony, 1996; Powers & Dodd, 1996; Stroud, 1998; Mann & Schaad, 2001) the environmental conditions that have an influence on athletes during endurance events can be seen in table 3.1.

**TABLE 3.1: ENVIRONMENTAL CONDITIONS DURING ENDURANCE EVENTS**

<b>PHYSICAL</b>	
<b>Heat</b>	<b>Lack of Nutrition</b>
<b>Cold</b>	<b>Lack of Hydration</b>
<b>Altitude</b>	<b>Terrain</b>
<b>Distance</b>	<b>Sleep deprivation</b>
<b>Rain</b>	<b>Wind</b>
<b>Equipment</b>	

The human body consists of materials and elements that, on their own, are extremely unstable. Only a few minutes of oxygen deprivation can damage brain cells irreparably or a rise in body temperature by a few degrees before proteins start to break apart at the molecular level. In comparison to the external environment, one's body is extremely vulnerable and fragile (Armstrong, 2000). However, due to various physiological responses and biochemical reactions that maintain stability within the body's cells, the human body is more robust and adaptable than what most people think. Humans can disregard the external environment because of the cell consistency and are therefore independent of the external world (Armstrong, 2000). This explains why people can live, work and exercise in a variety of potentially dangerous environments such as extreme heat, cold or altitude. The nineteenth century scientist Claude Bernard, who is acknowledged as the first author to recognize the relative independence from the external environment by the human body, puts it in the following manner (Bernard in Armstrong, 2000: 25):

*"The organism is...constructed in such a fashion that, on the one hand, there is full communication between the external environment and the internal environment of cells, and on the other, that there are protective functions...holding living materials in reserve and maintaining (temperature, fluids) and other conditions indispensable to vital activity. Sickness and death are only a dislocation or perturbation of (these processes)".*

The physiologist, Walter Cannon, described the actions of cells that respond to perturbing stimuli in terms of a dynamic relationship of equilibrium and variability, rather than absolute intracellular constancy. Cannon coined the term homeostasis to indicate similarity with some variability, rather than sameness. Homeostasis refers to the body's tendency to maintain a steady state despite external changes or stressors. Adaptive responses or adaptations (physiological changes that minimize bodily strain) are attempts by the body to neutralise stressors and to re-establish the homeostatic balance of the body (Bloomfield *et al.*, 1992; Armstrong, 2000). Adaptations may be short-term (accommodation), intermediate (acclimatization) or long-term (genetic adaptation). Accommodation refers to the reaction of cells and tissue to changes in the external environment. An example of this would be shivering when cold. Acclimatization involves a complex set of adaptive responses to changes in the external environment. An example of this would be the metabolism of body fat when all carbohydrate stores have been depleted to provide the body with energy. Genetic adaptation refers to semi-permanent physiological, morphological or other changes that occur over thousands of years within one species to ensure survival due to changes in the external environment. Each of the stressors or extreme environments requires a unique set of adaptive responses. Adequate acclimatization to virtually all extreme environments requires approximately 8–14 days of exposure and the loss of acclimatization to these stressors occurs in 14–28 days (Bloomfield *et al.*, 1992; Armstrong, 2000).

Each of the stressors or extreme environments, their effect on the individual as well as physiological adaptations will be discussed in the following section.

### 3.2.4.1 HEAT

According to the literature (Bloomfield *et al.*, 1992; Powers & Dodd, 1996; Stroud, 1998; Armstrong, 2000) humans are homeotherms, which means that body

temperature, is regulated around a set point to keep this temperature around 37°C. To maintain this body temperature, the body is constantly adapting to changes in air temperature, humidity, air movement, solar radiant, barometric pressure, and clothing insulation. Variations in body temperature can result in serious bodily injury. In fact, heat illness can occur when body temperature increases by as little (relatively speaking) as 4°C. Therefore, to avoid life-threatening situations, the body has to maintain strict control over temperature (Bloomfield *et al.*, 1992; Powers & Dodd, 1996; Stroud, 1998; Armstrong, 2000). During exercise, heat is produced as a by-product of muscular contractions. High-intensity exercise using large muscle groups generates more heat than low-intensity exercise using small muscle groups. Therefore, exercise using large muscle groups such as running, walking, rowing, cycling and so forth generates a large amount of heat that the body has to get rid of to prevent a dangerous rise in temperature.

Short-term exposure (30 – 60 minutes) to an extremely hot environment causes sufficient heat stress to lead to heat illness in some people (Bloomfield *et al.*, 1992; Powers & Dodd, 1996; Stroud, 1998; Armstrong, 2000). Even people who are physically fit and used to heat are at risk when exercising in hot environments. The duration of most endurance events is 2 – 3 hours or longer and therefore the risk increases considerably for heat stress and other heat-related illnesses. Heat stress is not only a function of air temperature but also of heat and humidity. The higher the humidity, the higher is the level of “effective temperature”. According to Powers and Dodd (1996) the effective temperature can be defined as the temperature that the body senses. At high levels of humidity, evaporation is retarded and as this defence mechanism is less effective, the body cannot get rid of excess heat through evaporative processes. This then causes the body temperature to increase to levels higher than what it would have been on a less humid day at the same ambient temperature. Thus, high humidity causes a moderately high ambient temperature to be sensed by the body as extremely hot.

### **3.2.4.2 COLD**

According to Stroud (1998), the human body is genetically better adapted to hot environments than colder environments. When faced with extreme cold, humans have to use behavioural means such as clothing or lighting fires to be able to survive and function. When exercising in effective temperatures below 27°C your ability to lose heat increases and greatly reduces the opportunity for heat illness. However,

when exercising in temperatures below 16°C a combination of heat production due to muscle contraction as well as protective clothing is needed to prevent excessive heat loss. If muscle contractions and protective clothing are not properly combined in extremely cold conditions the chances for a major decrease in body temperature (hypothermia) increase. This could be life threatening.

Exercise in extremely cold conditions for prolonged periods (1 – 4 hours) without adequate protection or swimming in cold water may overpower the body's ability to generate enough heat, resulting in an increase in heat loss and hypothermia (Bloomfield *et al.*, 1992; Powers & Dodd, 1996; Stroud, 1998; Armstrong, 2000). One factor that has a large impact on heat loss is water. Water is 25 times or more heat conductive than air at the same temperature (Powers & Dodd, 1996; Stroud, 1998; Armstrong, 2000). Therefore, a person who is immersed in water at a temperature of between 0°C - 13°C for between 1 – 6 hours will probably die from hypothermia. However, this depends on the physical activity, fitness, body mass, clothing insulation, position in the water, psychological factors such as will to live and subcutaneous fat (Stroud, 1998; Armstrong, 2000). A second factor that influences the loss of body heat is the speed of wind, also called wind chill factor (Armstrong, 2000). Any air movement over the body will accelerate body cooling in three ways:

- a. Removing still warm air layers trapped in insulative clothing;
- b. Increasing evaporative cooling directly from sweat-soaked skin and;
- c. Increasing evaporative cooling when the insulative clothing is wet.

Therefore, the higher the wind speed, the faster this cooling process takes place and the colder it feels. This effect may account for up to 80% of body heat loss during cold conditions. However, at wind speeds above 64 km/h, very little additional heat loss takes place due to convection. Wind chill can have a serious influence on the body cooling of a person exercising or performing tasks in extreme cold conditions. On a calm day with very little wind but an air temperature of -30°C convective heat loss becomes dangerous. At a wind speed of 10 km/h the effective temperature drops to -58°C and at a wind speed of 20 km/h the effective temperature drops to -81°C. An effective temperature this low falls into the great danger category due to convective heat loss. Even a temperature as relatively high as 15°C can become dangerous at wind speeds of 64 km/h at which level the effective temperature would be -29°C. In conditions such as this, exposed skin and flesh can freeze in one minute or less.

### 3.2.4.3 ALTITUDE

According to the literature (Bloomfield *et al.*, 1992; Powers & Dodd, 1996; Stroud, 1998; Armstrong, 2000), the main concern with exercise at high altitude (altitudes of >1500m) is that the low barometric pressure puts limits on the amount of oxygen transported in arterial blood. This leads to a reduction in the transportation of oxygen to exercising muscles and therefore, reduces both exercise tolerance and VO<sub>2</sub> max. The reduction in oxygen transportation increases as a function of the altitude. In other words, the higher the altitude, the greater the reduction in exercise tolerance and VO<sub>2</sub> max. At altitudes from sea level up to 1500m there is very little difference in the exercise tolerance or VO<sub>2</sub> max performance. However, there is a marked drop in performance at altitudes above 1500m. Where the VO<sub>2</sub> max performance at sea level is 100%, this percentage drops to approximately 82% at 3000m, 69% at 5000m and 55% at 6000m. According to Armstrong (2000: 174), this can be illustrated by the following experience of a climber near the summit of Mount Everest:

*"After every few steps, we huddle over our ice axes, mouths agape, struggling for sufficient breath to keep our muscles going. I have the feeling I am about to burst apart. As we get higher, it becomes necessary to lie down to recover our breath".*

To cope with this reduction in oxygen delivery to exercising muscles, the body makes several physiological adjustments. In an attempt to maximize oxygen transfer from the lungs to the blood, breathing becomes faster and deeper. To increase blood flow and oxygen delivery to exercising muscles the heart rate rises. To lower the target heart rate, the individual has to lower the intensity of the exercise at high altitude. In general, there is little need to alter the duration or frequency of training during a brief stay at high altitude. However, at very high altitudes the air is very dry, which results in increased water loss with breathing. In addition, the body decreases its water content as a way of coping with the stress of altitude exposure.

### 3.2.4.4 NUTRITION

Substances contained in food that are necessary for good health are called nutrients. Nutrients can be divided into two categories called macronutrients and micronutrients. According to Mann and Schaad (2001), food performs three basic functions. Firstly, the three macronutrients; carbohydrates, proteins, and fats give us energy to move about. Secondly, protein and minerals are needed to build and repair tissue. Thirdly, nutrients are needed to regulate many mechanisms, such as

concentration. This occurs with the help of vitamins, minerals and proteins. Therefore the second nutrient category, micronutrients, such as minerals and vitamins regulate the functioning of the cells. Good nutrition means that an individual's diet supplies all of the necessary foodstuffs required to maintain a healthy body. Although many industrialized countries had a problem with dietary deficiencies in the past, the biggest problem associated with nutrition today is overeating (Bloomfield *et al.*, 1992; Mellion, 1994; Powers & Dodd, 1996; Stroud, 1998). However, very few or no endurance athletes have major problems with overeating (Stroud, 1998). Most endurance athletes have less than 20% body fat and usually fall into the range of 10% – 20% or less body fat (Powers & Dodd, 1996; Stroud, 1998, Armstrong, 2000) and tend to fall into the "Too Lean" category (see figure 3.1). According to Dettweiler (1991) various researchers report body fat percentages of 5.1% to 19.1% for elite endurance athletes depending on the sport with a mean of 12 – 14.4%.

A healthy male would have between 10% and 20% fat as a percentage of his total body weight. A healthy female would have between 15% and 25% fat as a percentage of her total body fat. Any percentage below or above 10% –20% and 15%-25% would be either "Too Fat" or "Too Lean".

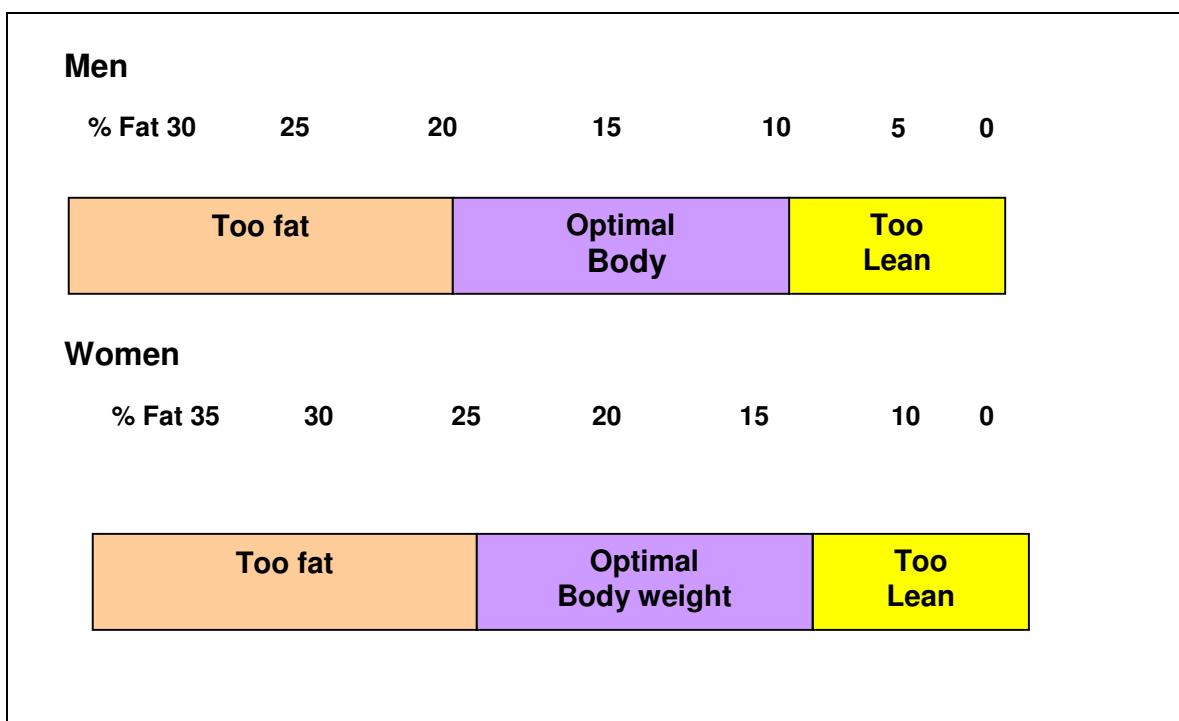


FIGURE 3.1: BODY FAT PERCENTAGES (POWERS & DODD, 1996)

Most endurance athletes would therefore fall into the lower "Optimal" body weight category with a tendency towards the *Too lean* category. The reason for this lies in the nature of endurance events and the effect that it has on the metabolism of a

human body (Dettweiler, 1991; Bloomfield *et al.*, 1992; Powers & Dodd, 1996; Stroud, 1998, Armstrong, 2000; Mann & Schaad, 2001). Endurance events such as marathon running, endurance cycling, long-distance walking, kayaking and so forth impose severe metabolic demands and provoke strenuous cardio-respiratory responses. Metabolism refers to the rate at which the body transfers fuel into energy. People cannot use food eaten directly as energy. It has to go through a series of processes in order to be converted into energy that can be used for mechanical work. That form of energy is called adenosine triphosphate or ATP. High-intensity activities demand quick metabolism of energy through the ATP system. Once immediate stores of ATP are used, broken down carbohydrates that reside in the muscles or glycogen are anabolized to create ATP through a process called glycolysis. Oxygen plays a key role in muscle glycolysis. When oxygen is abundant during aerobic activity, enormous amounts of ATP are available for aerobic or continuous energy. If oxygen is not available during anaerobic events, less ATP is produced and fatigue sets in rapidly.

Carbohydrates are the main source of energy for the body (Mellion, 1994; Mann & Schaad, 2001). Muscle contraction is dependant on the efficient breakdown of this macronutrient. Once absorbed by the small intestines it is converted to glucose and can be used as energy. When excess carbohydrates are present, it is stored in the liver and muscles as glycogen. When these stores are “full”, additional carbohydrates are stored as potential energy under the skin in the form of subcutaneous fat and also between the muscles. According to various authors (Dettweiler, 1991; Powers & Dodd, 1996; Stroud, 1998, Armstrong, 2000; Mann & Schaad, 2001), the body has a limited capacity to store glycogen and these stores are rapidly depleted during exercise. The body’s energy system works synergistically to provide a steady flow of energy to the body when working. In endurance events the body uses all energy reserves to work. Once immediate reserves in the liver and muscles have been used, body fat is converted into glucose and moved to the muscles via the blood. However, the body needs carbohydrates to effectively metabolise body fat. When sufficient carbohydrates are not available, the body mobilizes more fat than what can be metabolized. The breakdown of fatty acid (lipid metabolism) is dependant on certain levels of carbohydrates. However, when lipid metabolism is the primary source of energy, muscle power is approximately half compared to a normal situation where carbohydrate metabolism is the primary source of energy. The second drawback to lipid metabolism as sole source of energy is that the depletion of muscle glycogen

causes localized muscular fatigue during exercise. The result is that the person not only performs at a slower rate but also feels more fatigued.

When sufficient levels of carbohydrate and body fat are not available for energy – the body starts to metabolise protein for energy. This alternative is not as efficient in energy production as carbohydrate metabolism. When protein is metabolized as energy it uses lean muscle mass and therefore disturbs the body of this vital source of tissue synthesis and repair. Furthermore, sufficient carbohydrates are essential for the nervous system. When carbohydrate levels fall below normal, the normal functioning of the brain is affected. Substantial losses in carbohydrate levels can lead to deficiencies in memory, concentration and situational awareness through hallucinations and even brain damage in extreme cases of starvation. When exercising, glycogen stores are initially readily available in the muscles and additional liver and muscle glycogen provides up to 50% of energy needs. Lipids and a small percentage of protein metabolism provide the other 50%. The percentage of energy substrates is dependant on the intensity of the exercise. In high-intensity exercise carbohydrates dominate whereas lipids dominate during low and moderate intensity (Dettweiler, 1991; Powers & Dodd, 1996; Stroud, 1998, Armstrong, 2000; Mann & Schaad, 2001).

After 20 minutes of exercise, glycogen stores are reduced and blood glucose is the major supplier of energy. During prolonged exercise, lipid breakdown also contributes a great deal of energy. As blood glucose is reduced and lipid metabolism becomes the major source of energy, the body is in a carbohydrate-depleted state where performance is dramatically reduced. According to Mann and Schaad (2001), when exercising beyond the stage where liver and muscle glycogen levels are depleted is where fatigue sets in and is called “bonk” or “hitting the wall”. This is fairly common in high-intensity endurance events such as marathon running, mountain biking, cycling, backpacking and adventure racing. If exercise is continued without sufficient carbohydrate intake, performance will drop even further and changes in cognitive thinking patterns can be expected. Sufficient carbohydrate intake is essential for daily functioning. As a general rule, a person with normal daily activities should ingest 10 grams of carbohydrates for every kilogram of body weight. Therefore, a 65kg person would need a daily carbohydrate intake of 650g or 2600 calories. During intense exercise, a steady depletion of carbohydrates occurs and in order to satisfy the body's requirement for glycogen synthesis it is recommended that the diet consists of 70% carbohydrates (Dettweiler, 1991; Mellion, 1994; Powers & Dodd, 1996; Stroud,

1998, Armstrong, 2000; Mann & Schaad, 2001). In some cases of prolonged exercise (several days) even 80% may be necessary. The remaining 20% to 30% should be made up of proteins and fats (15% – 25% proteins and 5% fats). The amount of energy expended per hour during an endurance event is dependant on several factors such as size, ratio of lean mass to fat, efficiency in the discipline, intensity of the event (speed of work, weight of equipment carried and terrain), climate and metabolism (Mann & Schaad, 2001).

Mann and Schaad (2001) give the following values as estimates of energy utilisation during endurance races of progressively longer distances:

- a. Marathon: 2600 – 5000 calories.
- b. 160-km Ultra run: 10 000 calories.
- c. Eco-Challenge British Columbia (592 km; elevation gains 20 000 m; pack weight 15 – 20 kg): 60 000 calories.

Therefore, the average endurance athlete expends approximately 100+ calories per hour. In endurance events with a duration of 2 hours or more (especially non-stop events such as adventure races spanning several days) athletes will expend an enormous amount of energy, which if not replaced at regular intervals, will lead to a drop in performance levels.

The following quote by Don Mann (in Mann & Schaad, 2001: 196) illustrates this:

*"One of my favourite conversations Angelika Castaneda (team Odyssey, RAID Gauloises, 1997) was when I said to her, "Angelika, be sure you bring enough food for this race. We are going to be out there for eight to eleven days and I want to be sure that you eat enough." Her reply in a thick Austrian accent was this: "Don, you do not need to worry about me. I do not need to eat much in a race this short. My body will eat from itself. I will not die on you, I will only feel like I'm going to die".*

### **3.2.4.5 HYDRATION**

According to Mann and Schaad (2001), water is the single most important environmental factor influencing sport performance. The average adult requires at least 1.7 litres of water a day to keep essential physiological systems functioning. If the person is active, another 280ml is needed. In conditions of extreme heat and humidity performing physically demanding tasks requires even more water.

According to Mann and Schaad (2001), a multi-day adventure race in humid conditions would require at the very least 4 litres. Water allows the body's physiological systems to function smoothly. Almost all our metabolic mechanisms require water to function. When water supply is inadequate, alternate routes such as a fall in performance are created to compensate for this lack. Disturbances in body water and resultant disturbances of electrolyte balance can adversely affect cellular as well as systemic functioning, thereby reducing the ability of humans to tolerate prolonged exercise (Armstrong, 2000). Water lost during exercise-induced sweating can lead to dehydration of both intracellular and extracellular fluid compartments of the body. Even a small amount of dehydration (see table 3.2) can place strain on the cardiovascular system.

**TABLE 3.2: ADVERSE EFFECTS OF DEHYDRATION (Powers & Dodd, 1996)**

% Body weight loss	Symptoms
0.5	Thirst
2	Stronger thirst, vague discomfort, loss of appetite
3	Concentrated blood, dry mouth, reduced urine
4	Increased effort for exercise, flushed skin, apathy
5	Difficulty in concentration
6	Impaired temperature regulation, increased heart rate
8	Dizziness, laboured breathing in exercise, confusion
10	Spastic muscles, loss of balance, delirium

11	Circulatory insufficiency, decreased blood volume, kidney failure
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Although some forms of heat illness can occur prior to significant weight loss due to sweating, table 3.2 shows that weight loss due to sweating can adversely affect the human body physiologically and mentally. Prolonged, profuse sweating is the first warning indicator of impending dehydration. The negative effect of dehydration on the cardiovascular system can be seen by an increase in heart rate and a limitation in the ability of the body to transfer heat from contracting muscles to the surface skin where it can be dissipated by convection into the environment (Stroud, 1998; Armstrong, 2000). According to Powers and Dodd (1996), exercise in the heat can be extremely dangerous depending on ambient temperature, exercise intensity, relative humidity, clothing and state of hydration (water content of the body). A product of exercise is metabolic heat. Under normal circumstances the body is able to manage this heat effectively (Mann & Schaad, 2001). However, when environmental heat is added to heat metabolism, this can have the following three effects namely; overheating, chemical balance disruption and dehydration. To keep from overheating, blood flows to the skin surface to be cooled and skin pores excrete fluids that through air movement on the skin (convection) is evaporated into the environment.

The higher the intensity of the exercise, the more blood flows to the skin surface and less flows to the working muscles thereby cooling the body down. However, the more the body sweats, the more body fluids are lost and when enough fluid is lost, 6% of body weight (see table 3.2), temperature regulation becomes difficult (Stroud, 1998). When this happens, the body's core temperature increases dramatically and if body fluids are not sufficiently replaced, it can lead to serious injury or even death. In an attempt to cool down, temperature regulation prevails over muscular function, as immobility of muscles will not be as life threatening as an extreme rise in core temperature. Therefore, performance will decrease when the body is dehydrated (Powers & Dodd, 1996; Stroud, 1998; Armstrong, 2000; Mann & Schaad, 2001).

Normal biochemistry is severely threatened if the body's core temperature rises by only a few degrees. If the core temperature rises past 37°C the situation becomes life threatening. Temperatures above 37°C greatly alter the body's physiological mechanisms. If the core body temperature rises above 37°C, enormous volumes of

blood are diverted to the skin surface in an attempt to cool down the body temperature. The effect thereof is that optimal blood pressure and cardiac output are lessened, thereby depriving the muscles of oxygen and leading to muscle suffocation.

In average environmental conditions, the body stays cool by means of physiological mechanisms such as blood being carried to the surface skin and sweating (Mann & Schaad, 2001). However, as previously mentioned, when body temperature rises and sweating increases in an attempt to cool the body down – the body loses fluids that, if not sufficiently replaced can lead to dehydration and severe physiological, mental and behavioural effects.

According to Mann and Schaad (2001) a major concern in extreme endurance events is not only the amount of body fluid loss, but also the loss of electrolytes through sweating. To maintain adequate hydration, it is important to have a steady intake of water every 15 minutes, striving to drink at a minimum of 420ml per hour. It is important to drink water as often as possible and to sip from a sports drink such as *Energade* or *Powerade* every 15 to 20 minutes. The reason for the sports drink is that the body loses large amounts of sodium and to a lesser degree potassium through sweating, creating a biochemical imbalance. In endurance events lasting more than four hours, hyponatremia or a low sodium concentration in the blood can become a problem if not effectively replaced. Hyponatremia can lead to confusion, a reduction in coordination and possible seizures. To prevent this it is necessary to have an adequate intake of salt or foods and sports drinks high in sodium.

### **3.2.4.6 TERRAIN**

During “normal” field and track events the terrain where athletes compete is usually controlled, level and as flat as possible. This is done to eliminate extraneous factors that could detract from the athlete’s performance. Consequently, terrain plays a limited role in these events. However, during endurance and extreme endurance events, terrain is seldomly controllable and consequently plays a major role in the performance of endurance athletes. In some events such as adventure racing difficult terrain is purposely chosen to increase the difficulty of the event. Terrain also greatly affects the amount of energy used (Mann & Schaad, 2001). Walking in sand uses twice the amount of energy used on grass or tarmac. Snow can use up to three times as much energy as paved roads. When the terrain encompasses large gains/losses

in elevation, it will not only affect energy use, but will also use different joint- and muscle groups than level roads.

Mountainous terrain puts enormous strain on the athlete for several reasons. Going uphill requires that the athlete's cardiovascular system has to work harder (Mann & Schaad, 2001). Therefore the athlete's energy requirements increase, heat production increases as well as hydration needs. Walking downhill might seem to be easier; it is so only for the cardiovascular system (Mann & Schaad, 2001). When going downhill, it requires enormous effort for a person to keep his/her balance. This "resisting" and "breaking" with good form and a safe tempo down a steep gradient is very costly in terms of energy usage. Deceleration is actually harder on the human body, especially wearing a backpack, adding greater wear and tear over time. When the terrain is higher than 1500m above sea level, altitude starts to play a role as previously mentioned. When the mountains are very high, the likelihood of extremely cold and windy conditions increases leading to the effects of cold as mentioned. Rockslides and scree found on mountain slopes are frequently easier to cross than thick bush, but can be tricky and lead to serious injury (Mann & Schaad, 2001).

Other terrain factors such as sand, marshes, rivers, thick bushes, lack of water and snow are all types of terrain encountered during endurance events such as adventure racing, backpacking, mountain biking. Although most athletes and people participating in events and working in this terrain accept this as part of the event or working environment, it still has a great influence on the performance of the individuals (Mann & Schaad, 2001). This influence is not only physiological, but also more importantly psychological (Stroud, 1998; Mann & Schaad, 2001).

Kelly of Team A.C.A.R in *Adventure Racing*, (Senk, 2001: p 2), says the following about the psychological impact of severe terrain in adventure racing:

*"I think ultimately the competition is the race course. From all my understanding and experience, the race course is designed to hurt, bruise, maim, punish and take no prisoners...When you feel physically broken...when you really feel on edge but you think you can hang on, then something really small, really insignificant, like a flat tyre, will happen and it just screws you emotionally - and then you snap!"*

According to various authors (Stroud, 1998; Mann & Schaad, 2001), one of the most profound aspects of endurance races and especially adventure racing is the physical

and mental discomfort caused mostly by the terrain. When an athlete is busy with a race or event, the level of discomfort increases with time. Any endurance athlete will know that to succeed in an endurance race or event depends on the amount of pain and discomfort the person can tolerate (Mann & Schaad, 2001). The more time a cyclist spends on the road, the more the level of pain and discomfort increase. A canoeist on the Berg river marathon will not only endure physical fatigue and painful muscles, but also extreme discomfort due to wetness and cold. The ultra-marathon runner has to contend with muscle pain and cramps, dehydration, sweat, heat and elevation gains and losses. The level of tolerance for pain and discomfort will determine whether the endurance athlete is ultimately successful. According to the literature (Stroud, 1998; Mann & Schaad, 2001), tolerance becomes a blend of physical stamina, mental endurance and emotional stability. One of the biggest factors in endurance sport that test the athlete's tolerance is the terrain.

### **3.2.4.7 DISTANCE**

Apart from the terrain, the distance covered by endurance events is one of the main factors that distinguishes it from "normal" track and field events. As seen in the definition of endurance sports, distance is one of the factors used to define endurance events. As previously mentioned by various authors (Brook, 1987; Jarver, 1989), all track events in the Olympic Games further than 800m are considered endurance events.

Various sport disciplines also have varied distances. In adventure racing four types of races are found: sprints, shorts, classics and expeditions.

Sprints are usually events of 15 – 50km in length with duration of a few hours. Shorts consist of distances of 65 – 150km with duration of 12 – 48 hours. In classic races, the competitors cover distances of between 150 – 250km in events lasting between 48 – 96 hours. Expedition-style races cover distances of 250 – 700+ km and can take up to 10+ days to complete. These races are usually non-stop (Caldwell & Siff, 2001; Greyling, 2002; KIMM, 2002; Marais, 2002).

Cycling usually consists of events from 30 – 5000+ km and can take between 1½ hours to several days to complete. Most ultra-cycling events cover distances of 100+ km and can take between 2½ and 7½ hours to complete. An example of this in South Africa is the *Pick and Pay Cape Argus Cycle Challenge*. Ultra-ultra cycling events

such as the *Tour de France* can take several days to complete the 5000+ km. However, this is done in several stages.

A marathon, long considered the ultimate endurance race, covers a distance of 42.2km and can take between 2½ and 6 hours to complete. However, for a number of years ultra-marathons such as the *Comrades*, *Two Oceans* and *Skyrun* have covered distances of respectively 87.6km, 56km and 150km. The time needed to complete these distances varies according to the race but usually takes between 4 – 35+ hours to complete. Another example of ultra-endurance events and the distances covered would be the *Iron Man* competitions. In the standard event in South Africa, the athlete would have a time limit of 18 hours. In this time, the athlete has to swim 3.2km, cycle 180km and run 42.2km.

An obvious deduction that can be made is that the further the distance, the longer the time required to finish the endurance event. As seen previously, the longer an individual is participating in an event, the more factors such as heat, cold, altitude, terrain, hydration and nutrition can negatively affect the individual physiologically and psychologically. Not only does the person's physiological demands increase, but pain and discomfort also increase as the duration of an endurance event increases, thereby contributing to the physical and mental/emotional difficulty of the endurance event.

### **3.2.4.8 WIND AND RAIN**

Wind and rain have a dual effect on the individual's environment. Firstly, wind and rain have a marked effect on the temperature level. Secondly, wind and rain increase the level of discomfort that the individual experiences. As seen previously under 3.2.2.1 and 3.2.2.2 wind and water can have a definite influence of effective temperature in the sense that wind and sweat are major elements of the body cooling processes of evaporation and convection (Stroud, 1998; Armstrong, 2000). At the same time a lack of wind can increase temperature and if coupled to a high level of air moisture can increase humidity. This will negatively influence the body's ability to effectively cool down and increase hydration needs. Furthermore, wind can also increase extreme cold through the same processes by cooling the human body down too quickly. This is called the wind chill factor and as seen in 3.2.2.2 can have a dramatic effect on the effective temperature.

Invariably, this will also have an influence on the energy needs of the individual in the sense that the individual would need more energy. Furthermore, the individual's hydration needs would also be affected. By increasing heat, humidity and cold to extreme levels will increase the level of physical and psychological discomfort for the individual. Another factor is that heavy rain can decrease performance by reducing visibility, turning ground into mud and rivers into torrents. Although a wind from behind can be of great help to increase performance, a headwind will not only hinder performance and increase performance demands, but would also increase the energy outputs and hydration needs.

### **3.2.4.9 SLEEP DEPRIVATION**

In general it can be said that sleep has a recuperative function. It is the recuperation that individuals experience that allows a level of optimal performance (O'Neil, 2004). Although this level of performance is relative to each individual's abilities, it is certain that it would decrease as soon as recuperation through sleep is not obtained. The physiological mechanisms by which sleep restores and sustains alertness and cognitive performance are not yet known (Wesensten, Balkin & Belenky, 1999). One sleep parameter, however, clearly impacts on the recuperative value of sleep, namely sleep duration.

Most healthy adults need between 6 and 8 hours sleep per 24 hours to function effectively the following day. However, the amount of sleep per day needed differs between individuals. Regardless of the inter-individual differences of sleep duration needs, the fact remains that when an individual sleeps less than what is needed, he or she is said to be sleep deprived (O'Neil, 2004). It has been proposed by Horne (in Van Dogen, Rogers & Dinges, 2003) that a normal nocturnal sleep period is comprised of two types of sleep: core or obligatory sleep and optional or facultative sleep. The initial sleep period of the night is referred to as "core" sleep which Horne posits repairs the effects of waking wear and tear on the cerebrum. Accordingly, only the core sleep duration, especially dominated by EEG slow wave activity (SWS), is required for adequate daytime alertness and functioning to be maintained. The additional optional sleep does not contribute to this, although it is regularly cited that the loss of optional sleep resulted in daytime sleepiness (not necessarily cognitive performance degradation). However, it is proposed that this is due to the habitual sleep-wake cycle of individuals and consequently adaptation may take place, which will result in the elimination of this effect.

Horne's theory (Van Dogen *et al.*, 2003) stipulated that a lack of core sleep results in sleep debt, and thus sleep deprivation. Originally Horne's hypothesis (Belenky, Wesensten, Thorne, Thomas, Sing, Redmond, Russo & Balkin, 2003) stated that a minimum amount of nightly sleep that is equal to approximately 4,5 hours is required to satisfy the brain's physiological need for recuperation. In other words, the core sleep duration is 4-5 hours of sleep per night. However, faced with recent evidence of cumulative physiological sleepiness and neurobehavioral deficits at this level of nocturnal sleep, Horne has increased core sleep to be 6 hours of good quality, uninterrupted sleep for most adults (Van Dogen *et al.*, 2003).

According to the core sleep hypothesis, the utilization of spare cerebral capacity enables the brain to perform well with less than 8 hours sleep each night. The possibility of such spare cerebral capacity is consistent with the suggestion of Drummond (Belenky *et al.*, 2003) that the cognitive performance during sleep deprivation involves recruitment of resources from additional, non-task specific – and therefore relatively non-fatigued brain regions. However, Belenky *et al.* (2003) cited that core sleep might best be considered as a minimum amount of sleep needed by the brain to achieve a state of equilibrium in which alertness and performance are maintained at a stable but lower-than-normal level.

Results of other studies (Van Dogen *et al.*, 2003) support this hypothesis. One night of total sleep deprivation was found to produce a significant decline of neurobehavioral performance capability. Subjects whose time in bed was restricted to 4 hours of sleep per night or 6 hours of sleep per night for several nights displayed neurobehavioral performance declines as well. These decrements were less substantial than after 24 hours total sleep deprivation, but were greater after 2 days with 4 hour-restricted sleep and four days of 6 hour restricted sleep. The 6 hours sleep restriction conditions showed less neurobehavioral impairment and it was consequently concluded that a compensatory adaptive mechanism operated during slow accumulation of sleep debt. However, since neurobiological impairment did occur after 8 hours accumulated sleep debt, it was inferred that 8 hours of basal sleep is needed to satisfy optimal functioning levels. This approximate 8 hours of sleep is referred to basal sleep that implies the duration of sleep below which waking deficits begin to accumulate.

At this point, a differentiation should be made between Total Sleep Deprivation (TSD) and sleep restriction (SR or TSR for the Total Sleep Restriction over a period of time). TSD is 24 hours or more without any sleep. TSD is typically defined as the length of time since the end of the last sleep period (Bonnet & Arand, 2001) and can as such be categorized in Steenari's (2003) categorization of short- and long-term sleep deprivation. Short-term sleep deprivation is 24 - 45 hours without sleep, while long-term sleep deprivation is over 45 hours without sleep (Steenari, 2003).

Sleep restriction is what Steenari (2003) refers to as partial sleep deprivation. Sleep will be restricted when a person sleeps less than the amount required (Normally less than 7 – 9 hours of sleep per 24 hours) (Belenky *et al.*, 2003). According to Steenari (2003) partial sleep deprivation will refer to sleep restriction that allows approximately 5 out of 24 hours of sleep. Partial sleep deprivation is typically defined both by the length of the partial sleep period and the chronicity of the shortened sleep schedule (Bonnet & Arand, 2001).

According to Bonnet and Arand (2001: 289) “*the effects of partial and total sleep deprivation are qualitatively similar (a) hormonal effect; (b) pulmonary effects; (c) behavioural effects and (d) alertness effects*”.

In addition to sleep duration the sleep continuity seems also to play a role in the extent to which sleep may be recuperative (Belenky, 1997; Wesensten *et al.*, 1999). A disturbance in the continuity of sleep is also referred to as sleep fragmentation. Based on studies that have shown to affect next-day performance and alertness as impaired by sleep fragmentation procedures even when total sleep time (TST) is unaffected it is hypothesised that both the duration and continuity of sleep determine its recuperative value (Wesensten *et al.*, 1999). Brief fragmented sleep has little or no recuperative value and is similar to TSD on performance. In a review of comparative studies Bonnet and Arand (2001) concluded that the symptoms of TSD and sleep fragmentation are effectively the same.

Sleep deprivation is directly linked to a decrease in overall performance owing to impairments in the mental (cognitive), emotional and physiological functions. A meta-analysis by Pilcher and Huffcutt (Steenari, 2003) revealed that sleep deprivation affects cognitive performance more than motor performance. According to Belenky (1997) laboratory studies showed that mental work declines by 25% during each successive 24 hours of continuous wakefulness. Even though sleep

deprived individuals are able to maintain accuracy on cognitive tasks the speed declines as wakefulness is extended. According to O' Neil (2004), sleep deprivation degrades complex cognitive performance, including the ability to understand, adapt, and plan in rapidly changing circumstances. In contrast to the complex mental performance, simple psychomotor performance, physical strength and endurance are unaffected by sleep deprivation.

Sleep loss symptoms become more prevalent as sleep debt builds up. In other words, the effects of sleep deprivation become more severe the longer the individual is sleep deprived. Sleepiness is one of the first indications of sleep loss and micro sleep lapses; the eventual outcome of accumulating sleepiness is often visible after approximately 48 – 72hours TSD.

Sleepiness by sleep loss impairs human performance (Hodoba, 1999). Mild sleepiness is most apparent during passive or boring situations. With more severe sleepiness, the individual may have difficulty staying awake during more active conditions, such as during conversations or meals. Sleepiness is excessive when it occurs at inappropriate or undesirable times. Chronic or excessive sleepiness is accompanied by lapses of attention and by impaired motor and cognitive abilities. When sleepiness is chronic and severe, the individual may become less aware of sleepiness and may fall asleep without warning – these episodes are called sleep attacks or micro sleep lapses.

With prolonged sleep deprivation the body's requirement for sleep will increase so strongly that it becomes impossible to withstand sleep, and subjects will fall asleep even in the upright position (Opstadt, 1995; Caldwell & Siff, 2001; RAILRIDERS, 2001; E.S.C.A.P.E, 2002; Frontier Adventure Racing, 2002; Marais, 2002). Firstly however, this will appear during the night-time, particularly in a period with rather low physical activity, in the form of extreme tiredness followed by balance disturbance, problems with straight walking along the roads, later with pseudo – or real illusions and hallucinations.

Poor performance in sleep-deprived condition refers to below the expected average performance after no sleep loss. Poor performance of sleep-deprived individuals may be ascribed to higher error rates and errors of omission (Bonnet & Arand, 2001). Consequently below standard performance occurs. The sleep-deprived individual is also inclined to underestimate his/her performance as well as accept the below

standard performance. This can be seen in the results of a study by Engle-Friedman, Riela, Golan, Ventuneac, Davis, Jefferson and Major (2003).

According to the authors, sleep loss results in a preference for tasks demanding minimal effort. In other words, when individuals have control over the tasks they have to do, sleep deprived individuals will preferably engage in the tasks demanding minimal effort. Motivation often lacks to complete tasks that are perceived as trivial. It is because of this that in endurance events one may find that athletes fail to complete routines like drying the feet, changing socks, or filling canteens when water is available. One of the clinical symptoms of SD is poor mood, which includes increased fatigue, confusion, stress and irritability (Belenky, 1997; Bonnet & Arand, 2001). It may also include aggression or abusiveness, mood swings and in extreme cases apathy.

Mood changes, decreased motivation or willingness to work, and diminished performance go hand in hand. Sleep deprived individuals may feel less energetic, alert, and cheerful and less interested in their surroundings while at the same time, they are more irritable and increasingly negative and sleepy (Caldwell & Siff, 2001; Senk, 2001; KIMM, 2002; O' Neil, 2004). Some may even become depressed and apathetic. After long periods of sleep loss, individuals may go from being irritable and negative to dull and weary. The effect of SD on emotion is visible after only 24 hours SD. Losing more than one night's sleep does produce a noticeable increase in irritability, lethargy, and disinterest (Gale Encyclopaedia of Science, 2001). Engle-Friedman et al., (2003) found that after 24 hours of sleep deprivation subjects' levels of depression/dejection, fatigue, tension/anxiety, confusion/bewilderment and anger/hostility increased, while vigour decreased. All of these mood states differed significantly from a non-sleep deprived group, except for anger/hostility. From this one can infer that depression, fatigue, tension/anxiety and confusion/bewilderment may be a direct consequence of SD, while anger and hostility may be more situationally bound. In this same study, the total mood disturbance of sleep-deprived individuals was also significantly higher than that of non-sleep deprived individuals.

According to Hodoba (1999) the results of a meta-analysis of 19 original studies suggest that mood is more affected by SD than either cognitive or motor performance. Of course, mood, cognition and physical functioning are interlinked and may have direct or indirect influence on one another.

Mild cases of paranoia have been cited as symptom of sleep deprivation. For some paranoia may set in after only 24 hours of SD or SR (Gale Encyclopaedia of Science, 2000). This may be linked to the individual's mental state before SD/SR occurs, although the basis of this has not yet been established. Hallucinations are a very common occurrence under sleep-deprived conditions. Visual hypnagogic hallucinations occur, according to Opstadt (1995), after 72 hours SD. If these symptoms of prolonged SD start to appear, the subjects may take the hallucinations for real signs, whereas at later on stages, they will have become normal and all unexpected events will be registered as hallucinations.

In other words, the individual no longer has the ability to distinguish between reality and 'dream' (O' Neil, 2004). In endurance events such as adventure races or multi-day ultra marathons, this may be a serious impairment of an athlete's functioning owing to the loss of ability to differentiate between real and not real signs – functions such as navigation will become impossible (Brook, 1987; Caldwell & Siff, 2001; E.S.C.A.P.E, 2002; Frontier Adventure Racing, 2002; KIMM, 2002; Marais, 2002).

According to Thomas, Sing, Belenky, Holcomb, Mayberg, Dannals, Wagner, Thorne, Popp, Rowland, Welsh, Balwinski and Redmond (2001) task performance during SD are influenced by visual perception. Subjects reported that they had difficulty seeing numbers on a computer screen while busy with an addition/subtraction exercise. Their visual perception decreased significantly from 24 – 72 hours sleep deprivation. Blurred vision, fog sight and disturbed distance vision were also reported by Opstadt (1995) after 72 hours of sleep deprivation. Increases in occurrences of blurred vision and visual misperceptions were evident in the study by Thomas *et al.*, (2001).

According to the authors (Thomas *et al.*, 2001), there was a linear increase over the prolonged SD period for occurrences of blurred vision, which was significant only for the 24 hours to 48 hours, SD. By implication occurrences of blurred vision increase over the period of 72 hours, but there is a larger increase between 24 to 48 hours of SD than between 48 to 72 hours. Slurred and incoherent speech is another symptom of SD. Except for the speech deficits, communication overall seems to deteriorate. The sleep-deprived individual has difficulty formulating messages, deciding on the priority in the message content or how to communicate the message content in an understandable manner.

Many authors have cited the effect of SD on alertness. Lamberg (1999: 3) notes that sleep “*may be viewed as a drug that increases alertness*”. In other words, optimal alertness is directly linked to adequate recovery sleep. The reduced vigilance in sleep-deprived individuals may be directly linked to attention and concentration impairments. Lapses in attention and concentration are one of the clinical symptoms of SD (Bonnet & Arand, 2001). In effect a subject who is sleep deprived can be easily distracted as SD causes the attention span to shorten. The sleep-deprived person cannot sustain peak attention in monotonous circumstances (Moore-Ede, 2003).

After 24 hours, concentration seems to be adversely affected, although not seriously impaired. Concentration over 72 hours of SD seems to reduce rapidly between 48 hours and 72 hours. Thomas *et al.* (2001) cite that concentration measured over 72 hours of sleep deprivation shows a linear decrease and causes an increase in task difficulty that is significantly different at 72 hours than at 48 hours or 24 hours.

SD is known to have an effect on memory. Memory is the retention of information over time. Impaired short-term memory or working memory (memory loss for recent events) is a clinical symptom of SD (Bonnet & Arand, 2001). Working memory enables one to manage in new situations and is necessary for fundamental aspects of human behaviour including learning, reasoning and language comprehension. Working memory can further be divided into the central executive who is an attention control system and hierarchical lower slave systems that are utilized in holding and manipulating modality-specific working memory information (Steenari, 2003).

Owing to impaired working memory due to SD it is also increasingly difficult to learn new information. However, Thomas *et al.*, (2001) note that long-term memory (remembering how to do tasks) also has an influence on task performance over 72 hours of SD.

It is said that SD slows reaction speed (delayed responses) and leads to mental lapses in cognitive tests (Kim, Guilleminault, Hong, Kim, Kim, Go & Lee, 2001). According to Belenky (1997) the cognitive performance of subjects over a period of 72 hours SD, indicated that performance on serial addition/subtraction declined steadily. In other words, the degradation in performance was linear. Under sleep-deprived conditions, the overall performance typically declines, primarily as a result of a reduction in speed. Accuracy can be relatively preserved during SD. Between 0

– 24 hours of sleep deprivation, performance actually inclines, while after 24 hours a steady decline is observable. In a study of serial subtraction/addition over a period of 85 hours of SD with 30-minute naps per day, indicated that decreased the rate of performance degradation.

Decision-making is a complex cognitive process. It includes the accurate search and appraisal of information, understating the options and choosing the best option of the available alternatives. The latter includes the evaluation of possible consequences of specific actions. During the process, the individual will continue to seek new information and re-evaluate old information and when the desired level of confidence is reached a final decision is made (Bruck & Pisani, 1999).

SD has the effect of reduced decision-making abilities, impaired judgment, the persistence of ineffective solutions, fixation/inability to mentally adapt to differing situations, difficulty in processing information and reduced comprehension and perceptual abilities. As cited by Lamberg (1999: 1): "*Sleep disruption, coupled with heavy physical demands...may impair critical decision-making and other cognitive skills*".

A decrease in stimulus comprehension (i.e. not understanding incoming stimuli) has been cited in other studies as well. Thomas *et al.* (2001) cited that stimulus comprehension in an addition/subtraction task over 72 hours SD increased task difficulty and resulted in lower task performance. According to Flemming-Michael (2003), SD has serious consequences for decision-making, information processing and judgment. This is owing to the regions of the brain that best perform these actions which are most affected by SD. Degrading activity in the prefrontal cortex, parietal cortex and thalamus can cause problems during these types of cognitive tasks. These cognitive tasks are associated with higher-order thinking or executive thinking. The effects of SD on cognitive functioning have been well documented. The most effected mental processes are the more complex higher order functions such as high-level executive thinking. Although executive tasks are not clearly defined, it includes the frontal lobe functions involved in "*the ability to plan and co-ordinate willful action in the face of alternatives, to monitor and update action as necessary, and to suppress distracting material by focusing attention to the task in hand*" (Jones & Harrison, 2001: 464).

Executive tasks do not draw on automatic processes, but should include a combination of novelty, effort and working memory demands. Examples of the effect of SD on executive thinking are outlined by Jones and Harrison (2001). Short-term sleep deprivation (36 hours) has been found to decrease creative thinking, verbal fluency and working memory, and impair risk-taking strategies. Chronic partial sleep deprivation impairs mental flexibility, attention and memory. People working in emergency situations who are sleep deprived are likely to have an impaired ability to make decisions that involve the unexpected. The effects of SD become physically visible in appearance. Changes in appearance include vacant stares, bloodshot eyes, pale skin, and poor personal hygiene. Other physical signs of sleep loss include the body swaying when standing, sudden dropping of the chin when sitting occasional loss of handgrip strength and walking into obstacles and ditches.

According to Opstadt (1995) slow motion, visible balance disturbances and headaches become apparent after 72 hours SD. Physical exhaustion becomes especially apparent after 72 hours SD. The consequences of SD are affected by the time of day in which performance is measured or observed. In terms of circadian rhythms, the effects seem to occur during nighttimes or the times during which the individual will usually sleep. Also, of course, melatonin secretion does not take place during darkness, which also has an influence on the effects SD. For example, sleepiness may be increased. Since core body temperature has an effect on sleepiness, a person who is sleep-deprived may be more suspect to the effects of SD during some periods of the day when the core body temperature is at its lowest. Athletes may feel that it takes more effort to do a physical task in the morning than it takes to do the same task in the afternoon. They may feel like stopping work due to exaggerated feelings of physical exertion. This is especially true between 04h00 – 07h00. During this time the tendency to fall asleep is considerably more noticeable than at other times of the nighttime work period. The time of day should however only be a determining factor for a certain period of time. After approximately 72 hours most effects will not be enhanced by the time of day.

The individual's health and diet (water and food intake) also plays a role in the prevalence of SD (O'Neil, 2004). No studies dedicated how these aspects influence the effects of SD, were found. However, the logical inference would be that poor health and diet during SD should increase the effect thereof. Another logical inference may be that health and diet may determine when the effects set in. Logically, a healthy person following a balanced diet during SD should maintain the

body's balance for longer. Degradation in the body system should however have special needs in terms of diet. The specific dietary needs of a sleep deprived individual have however not been specified.

The amount of physical activity has a definite effect on the consequences of SD. While physical activity should lead to physical exhaustion, it should reduce sleepiness owing to the maintenance of core body temperature. As mentioned earlier, sleepiness is induced by a loss of core body temperature (Matsumoto, Mishima, Satoh, Shumizu & Hishikawa, 2002).

In light of this it makes sense that subjective sleepiness can be elevated by physical exercise as it produces a heat-production effect. However, even though subjective sleepiness may be elevated by physical exercise, objective productivity impairments remain. In other words, although an individual may not feel sleepy due to physical exercise, his performance levels will still be influenced by a lack of sleep. According to O'Neil (2004), this effect of dissociation between sleepiness and performance levels may increase the risk of human error as the decrease in subjective sleepiness may blind one of the actual deteriorating brain functions.

High motivation can help keep people going, but there is an increased risk due to impaired performance. When sleep is limited to 4-5 hours of sleep each night alertness and performance decline to the same low levels as those seen following two-days of TSD.

### **3.2.4.10 EQUIPMENT**

In endurance events such as backpacking, kayaking/canoeing, cycling, mountain biking, adventure racing, participants have some form of equipment that they need to complete the event and that increases the difficulty of the event. Marathon running and cycling are the only exceptions where athletes carry as little as possible and where refreshments are available along the route. However, even in events such as ultra-distance cycling, competitors take along hydration bags and other forms of nutrition, especially when the event is longer than 2½ -3 hours. In some ultra-distance marathons such as the *Skyrun* or the *Marathon of the Sands* in Morocco, competitors have to carry their own nutrition and hydration on their backs in packs weighing between 7 – 16kg (Stroud, 1998).

In adventure racing the compulsory equipment for a short race can weigh up to 20kg whereas unassisted expedition races can require packs of up to 25kg. This does not include the parts of the race where the competitors have to carry their mountain bikes or watercraft for long distances. Even in canoeing events such as the *Dusi* or *Berg River*, competitors have to get out of the water and carry their canoes for long distances where the water levels are too low for paddling. Backpacking involves that hikers have to cover long distances carrying all their nutrition and hydration needs on their backs – enough for 5+ days. This involves packs sometimes weighing between 25 – 35kg. Some people such as soldiers and policemen sometimes have to carry between 35 – 45+ kg packs for extended periods of time.

The effect of this is that the equipment needed for some endurance events contributes to the extreme conditions in the sense that it increases the difficulty of the event and increases the energy and hydration needs. Furthermore, the weight of the packs increases the level of pain and discomfort that the individual has to endure.

### 3.3 SUMMARY

This chapter focused on stress and arousal in sport as well as the influence thereof on performance. For the aim of this study, stress was defined as *the internal psychological tension caused by internal and external stressors that changes or are perceived to change the nature of the present and/or future situation to such an extent that it forces the individual to adapt by means of physiological and psychological responses*.

The process whereby the individual is prepared physiologically and psychologically for the adaptive actions is called arousal and takes place before the individual starts to take adaptive action. The relationship between stress, anxiety, fear and arousal is that stress is the internal tension of the individual caused by changes in the situation or future situation. These changes or perceived changes cause an emotional state (fear and anxiety) depending on the stressor. This forces (motivates) the individual to take certain physiological and psychological actions to adapt to these changes.

The level of arousal would depend on the level of stress that the individual experiences as well as the intensity of the emotional state experienced by the individual. The intensity of the emotional state experienced would depend on the stressor or perceived stressor as well as the individual's perceived capacity to cope

with the stressor or perceived stressor. Therefore, stress will be the factor that motivates the individual to adapt to changes in the situation. This is accompanied by an emotional state that will determine the level of arousal that the individual experiences. The arousal level will determine the individual's physiological and psychological readiness to respond to changes or stressors and the physiological and psychological coping strategies will determine how the individual will respond to stressors. Stress can have positive and negative effects on the individual and his or her performance. The effect of stress would depend on the individual's capacity and perceived capacity to cope with the stressors as well as the level of physiological and psychological readiness to do so. However, therein lie the two important factors that determine the effect of stress on individual performance. If the individual does not have the capacity or perceived capacity to cope with the demands or stressors of the situation or chooses incorrect strategies – the individual's performance will suffer or he will be overwhelmed completely.

Secondly, if the individual's level of readiness is too low or too high, performance will also suffer or fail completely. The effect of arousal on performance is that performance is dependant on an optimal level of physiological and cognitive arousal.

As each individual is different with regards to skills, experience, motivation and personality traits, the perception of stressors as well as coping strategies and optimal arousal level will differ. When an individual's arousal level is under or above the optimal level, his/her performance will deteriorate. Arousal is influenced by the cognitive perception of a stressor and different stressors would require different cognitive activation states or coping strategies. Arousal, as such, is not the focus of this study. However, it is one of the environmental factors or stressors that endurance athletes have to cope with during endurance events.

The second part of this chapter focused on physical environmental factors that have an influence on athletes that participate in endurance events. To do this it was necessary to define endurance sport. In this study, endurance events are defined as:

*Those sport events where the distance, time and the level of aerobic fitness/intensity requirements for successful completion are considerably higher than when compared to other sport events.*

Furthermore, it was necessary to identify the environmental factors or stressors that have an influence on the endurance athlete. The factors that were identified and discussed in this chapter were heat, cold, altitude, nutrition, hydration, wind & rain, terrain, distance, sleep deprivation and equipment. Each of these factors were discussed in terms of the negative influences that they have on the physiological and psychological functioning and performance of the endurance athlete.

In the next chapter, the psychological adaptations that people make to cope with extreme conditions in endurance events will be discussed.

## CHAPTER 4

### HUMAN PSYCHOLOGICAL ADAPTATION TO EXTREME ENVIRONMENTS

***“Where there is no pain in the fight - there is no glory in the triumph”.***

– Pierre Corneille (1606 – 1635)

#### 4.1 INTRODUCTION

In the previous chapter, extreme environments or stressors during endurance sport were discussed as well as the physiological adaptations that the human body makes to survive in these conditions. In this chapter, the focus will be on the cognitive, emotional and social adaptations or coping strategies that the individual makes in order to survive in these extreme environments. According to various authors (Stroud, 1998; Armstrong, 2000; Mann & Schaad, 2001), there are several principles that need to be considered to fully understand human ability to adapt to extreme environments. These principles are the following:

- a. Humans may lack or have insufficient hereditary physiological abilities to survive and adapt to all extreme environments.
- b. All people are different and therefore may differ in their reaction to threats, danger or challenges. For some, stressful experiences may result in temporary upsets or permanent psychological damage. For some, these stressful experiences may have positive effects and may lead to personal growth.

- c. Different individuals respond differently to the same stressor. Some may show no strain, illness or injury depending on factors such as age, developed tolerance, immune system, competence, level of physical and mental fitness and the number, intensity and outcome of previous exposure to the stressor.
- d. Stressors may have positive effects that will allow the individual to meet future physical and psychosocial challenges successfully.
- e. Extreme environments are strongly mediated by psychological factors (see table 4.1). If extreme environments are not seen as noxious or alarming, they will produce smaller or even opposite physical responses.
- f. If humans are able to prevent, control, avoid or respond to stressors, they will usually not become ill or injured and will perceive the stressor(s) and their own ability to cope more positively.
- g. Psychological strategies or coping strategies may influence or change the amount of strain that the individual experiences when exposed to a stressful environment. Strategies used can include self-assurance, self-deception, denial, religion, social support, visualization.
- h. Mediators are biological, social, cognitive and emotional modifiers that act on stressors to alter the level of physiological strain experienced. Mediators can lower or enhance the level of physiological strain experienced.
- i. Physiological and behavioural changes occur sometimes even before a stressor is experienced in anticipation of and in preparation for challenges, threats or danger. An example of this is the high arousal levels experienced by an individual before an important event.

**TABLE 4.1: FACTORS THAT INFLUENCE THE OUTCOME OF EXPOSURE TO A STRESSFUL ENVIRONMENT (ARMSTRONG, 2000)**

Personal perception of environment or situation
Emotional response to the environmental situation

Genetic characteristics  
Available resources  
Age (especially in preadolescence and old age)  
Nature and duration of previous experiences  
Control or escape possibilities  
Intelligence, education and skills  
Number of similar previous experiences

As seen in chapter 3, human beings have extensive physiological mechanisms to cope with extreme environments. However, the human body is not genetically designed to be able to withstand all extreme environments and even where it is, the physical and psychological discomfort caused by these environments can have a negative impact on performance under these conditions (Stroud, 1998; Armstrong, 2000; Mann & Schaad, 2001; Williamson, 2003). Therefore, individuals and groups that have to survive and perform under extreme conditions need to employ certain psychological strategies to cope with the extreme environment and to motivate themselves to survive and perform. To fully understand the coping strategies used by endurance athletes under extreme conditions, it is necessary to break up the concept into two parts, motivational strategies (will be discussed in Chapter 5) and coping strategies. The next section will focus briefly on the coping strategies employed by humans to survive and perform under extreme conditions.

## 4.2 COPING STRATEGIES

According to various authors (Aldwin, 1993; Lingren, 1998; Taylor, 1998; Levin, 2003; Fryenburg, 2004; Lopez-Vazquez & Marvan, 2004) coping strategies refer to the specific efforts, both behavioural and psychological, that people employ to master, tolerate, reduce, or minimize stressful events. Some authors use the term resilience to describe the same phenomena.

Weinberg and Gould (2003) define coping as the process where the individual constantly changes cognitive and behavioural efforts in order to manage specific external and/or internal demands or conflicts that are appraised as taxing or exceeding the individual's resources. Garmezy (Van Breda, 2001) uses the term resilience to describe the skills, abilities, knowledge and insight that accumulate over time by people to surmount challenges and overcome adversity. It is an ongoing fund of energy and skills that people can use to overcome current challenges. Van Breda

(2001) describes resilience as the capacity for successful adaptation, positive functioning or competence despite high-risk status, chronic stress, or following prolonged or severe stress. For this study the term coping strategies will be used to describe those behavioural and psychological means (inherent and learned) that people employ to surmount difficulties and meet challenges.

Coping strategies can primarily be defined in terms of the protective factors (personal, family, community) that enable the individual to resist life stress (Taylor, 1998; Van Breda, 2001). An important component of coping strategies is the hazardous, adverse or life-threatening circumstances that result in individual vulnerability (Taylor, 1998; Van Breda, 2001). The effectiveness of an individual's coping strategies at any moment is determined by the ratio between the presence of protective factors and the presence of hazardous circumstances. This would mean that the more protective factors or coping strategies a person has that is effective in a specific situation, the better the person will be able to overcome the challenge or stressful situation.

Four patterns or sources of coping strategies are identified by Polk (1997):

- 1) Dispositional pattern refers to the physical and ego-related psychosocial attributes that enhance the coping ability of the individual. Examples of this are positive self-concept, independence, self-resiliency, physical fitness and health.
- 2) Relational pattern refers to the roles and relationships that the individual has in the society. These roles and relationships can range from intimate and close relationships to more broader and distant relationships.
- 3) Situational pattern can be related to the link between the individual and a specific stressful situation. These can include a multitude of stressful situations and can include a person's judgment, problem-solving ability and the ability to respond to the stressful situation.
- 4) Philosophical pattern refers to the worldview or perception of life that the individual has. This pattern has a major impact on the individual's capacity to overcome challenges and adversity. A belief system that sees problems as

challenges and learning opportunities will promote the individual's coping capacity.

From these patterns, the deduction can be made that coping strategies function at different levels and have distinct applications. It would seem that athletes and especially successful athletes vary their coping strategies to cope with different situations, but that all have specific strategies that are used when needed (Weinberg & Gould, 2003). Some are very specific while others are all encompassing and is more an attitude than a specific strategy. It is also possible to identify strategies that can be linked to personality, cognition, social strategies and affective or emotional strategies. As such, coping strategies can therefore be defined as: ... *those strategies (cognitive, emotional, behavioural and social) that individuals use to successfully adapt to stressors or adversity in their present or future situations and thereby continue to function at the same or better level of functioning/performance than before the adverse or stressful situation.*

A distinction can be made between the focus of coping strategies: problem solving focused strategies and emotion-focused coping strategies. Problem-solving strategies actively try to overcome the challenge or alleviate stressful circumstances. Emotion-focused strategies are efforts to regulate the emotional consequences of stressful or potentially stressful situations (Jones & Hardy, 1990; Taylor, 1998; Cox, 2002; Weinberg & Gould, 2003). A person may use both strategies to cope with stressful situations. Predominance of either strategy is determined by personal style or the type of situation the person finds himself in (Jones & Hardy, 1990; Taylor, 1998; Cox, 2002; Weinberg & Gould, 2003).

Taylor (1998), Cox (2002) and Weinberg and Gould (2003) also identified two other styles: active and avoidant. Active coping strategies usually involve either behavioural or psychological responses that attempt to change the nature of the stressful situation or the perception of the individual about the stressor. Avoidant strategies are behavioural or psychological strategies that keep them from addressing the stressors directly. Reber (1995) supports the notion of active and avoidant coping strategies. He uses the term to refer to coping strategies and defence mechanisms.

*"Coping strategies are conscious, rational ways of dealing with the anxieties of life. The term is used for those strategies designed to deal with the source of the anxiety."*

Defense mechanisms ...are designed unconsciously to deal directly with the anxiety itself rather than with the source... Furthermore it is ...processes (or behaviours) that are unconsciously motivated, unconsciously acquired, and developed to protect the self or ego from unpleasantness of many kinds. Literally dozens of defence mechanisms have been hypothesized; some of the most commonly cited include repression, regression, rationalization and projection" (Reber, 1998: 164, 187 – 188).

Active coping strategies, where the source of the anxiety or stress is positively solved or removed are better than avoidant strategies where the anxiety itself is dealt with (Aldwin, 1993; Reber, 1995; Lingren, 1998; Taylor, 1998; Van Breda, 2001; Levin, 2003; Fryenburg, 2004; Lopez-Vazquez & Marvan, 2004).

In summary, the following deductions can be made about coping strategies:

Coping strategies are efforts or actions by an individual to minimize the negative effect of stressors. They function at different levels, including personality, cognition, social and affective or emotional levels – each with its distinct functions. Coping strategies can be described as skills, techniques, attitudes and behaviour learned in an ongoing process through life. They can be either active (conscious/rational) or avoidant (unconscious) behavioural or psychological responses. For a person to use coping strategies, the individual must perceive (consciously or unconsciously) that a threatening, dangerous or hazardous situation or condition is present. When a threatening, dangerous or hazardous situation or condition is perceived, the individual must be motivated to overcome the threatening situation or condition before active coping strategies can be used.

In this study, a distinction will be made between active coping strategies and avoidant coping strategies.

Active coping strategies are conscious, rational learned behavioural, emotional, cognitive or social responses used to minimize the effect of or the sources of stress and anxiety.

Avoidant coping strategies are learned processes (or behaviours) that are unconsciously motivated, unconsciously acquired, and developed to protect the self or ego from anxiety itself.

More specifically this study focuses on the active coping strategies that athletes use during endurance sport. Avoidant coping strategies are viewed and described as coping strategies (also it includes strategies that enable the individual to cope and protect the ego from anxiety). However, active coping strategies focus on problems related to the external environment, which is the focus of this study.

Before active coping strategies can be discussed in more depth, it is important to understand the theoretical perspectives and approaches to coping and coping strategies.

### **4.3 COPING THEORIES**

As seen in chapter 2, the theoretical approach used in this study when studying the development of coping and motivational strategies is the Salutogenic Model of Health. This model basically studies the reasons why people are able to cope with the stressors of different situations as opposed to the pathogenesis approach that focus on the reasons why people are unable to cope. This is also the basic approach of the researcher in this study.

Five theories with a similar basic approach as the Salutogenic approach will be discussed. They include, sense of coherence (SOC), thriving, hardiness, self-efficacy and locus of control (LoC).

#### **4.3.1 SENSE OF COHERENCE**

Sense of coherence (SOC) is the central contribution to Antonovsky's Salutogenic theory. Ongoing research has shown that SOC contributes substantially to people's ability to cope (Van Breda, 2001). It is not a specific coping style; method or technique but is rather a general approach to life that enables the individual to cope with challenges. A person with a strong SOC, may understand a situation, the stressors involved and will see it as a challenge that can be solved with the correct coping techniques.

Antonovsky (1979: 123) defines SOC in the following manner:

*"The sense of coherence is a global orientation that expresses the extent to which one has a pervasive, enduring, though dynamic feeling of confidence that one's*

*internal and external environments are predictable and that there is a high probability that things will work out as well as reasonably can be expected ”.*

Accordingly, SOC is in essence a life philosophy or an attitude that perceives life and problems or challenges in a positive light. It is furthermore an attitude or belief in the individual's own ability to overcome most problems by means of understanding of problems and the mobilization of the correct coping strategies.

Antonovsky identified three concepts or main components of SOC to formulate coping better (Van Breda, 2001):

- 1) Stimuli derived from the individual's internal and external environments are structured, predictable and understandable;
- 2) Resources are available to meet the demands posed by these stimuli;
- 3) These demands are challenges that are worth the individual's time and effort.

Antonovsky called these components comprehensibility, manageability and meaningfulness (Van Breda, 2001).

Comprehensibility can be described as the cognitive dimension of SOC whereby the individual makes sense of or thinks about internal and external stimuli or situations. This component is based on the belief that the current situation is comprehensible and that future situations would also be comprehensible. Although future situations might be challenging and even difficult to comprehend, the situations will still be comprehensible and still make sense.

Manageability can be described as the extent of the individual's belief that he/she not only understands the situation but is also able to control the situation to such an extent that the outcome is within the reasonable expectations of the individual. This component refers to the fact that the individual perceives that the resources needed to overcome the situation are available to the individual. Although there seems to be some similarities with the locus of control theory, Antonovsky (Van Breda, 2001) proposes that the two concepts are quite different. Locus of control refers to the resources that *an individual* controls to overcome the situation. Manageability, as proposed by Antonovsky, refers to all resources that are controlled by the individual

as well as by legitimate others – friends, colleagues, and family – on which one can depend to help overcome the challenges. Manageability refers to a realistic expectation that difficulties and challenges will occur in life, but also that the individual will be able to overcome these difficulties by the use of own resources and/or the help of legitimate others.

Meaningfulness can be described as the emotional dimension of comprehensibility. Where comprehensibility means that the individual makes cognitive sense of life and the specific challenges that confront him/her, meaningfulness means that life and the specific challenge is worth the effort to overcome it. In other words, it has a specific emotional meaning for the individual to overcome the specific challenge. In this sense meaningfulness accounts for an individual's motivation to overcome a difficult situation. When a difficult situation is perceived to be meaningful, the individual would invest emotional energy into the overcoming of the situation and would see it as a challenge and not a burden. Therefore, the resolution of the problem or the overcoming of the challenge provides the individual with rewards that makes the effort worthwhile.

Antonovsky makes the assumption that SOC is established at the age of 30 and that it remains stable thereafter. An individual that enters adulthood with a strong SOC will continue to search out life experiences that will reinforce and even enhance his/her SOC. Even extremely traumatic experiences will be overcome with SOC still intact. Antonovsky argues that people with a strong SOC will get more SOC, while individuals with a low SOC will develop a pattern of deteriorating health and weakening SOC (Van Breda, 2001).

However, Antonovsky (Van Breda, 2001) also points out that SOC is dynamic and that his position on the development of SOC is theoretical and not empirical. He proposes that due to the dynamic nature of the construct, SOC can change throughout an individual's life. He proposes that change and even significant change can take place when people frequently seek out SOC-enhancing experiences over a sustained period of time.

#### **4.3.2        THRIVING**

Thriving, a concept developed by Ickovics and Park (Van Breda, 2001), goes further than coping or resilience in the sense that stressors or challenges may enhance the

functioning of an individual. Ickovics and Park (Van Breda, 2001:237 - 238) define thriving as:

*"The effective mobilization of individual and social resources in response to risk or threat, leading to positive mental or physical outcomes and/or positive social outcomes. We suggest that thriving represents something more than a return to equilibrium following a challenge... We propose a "value-added" model, whereby an individual or community may go beyond survival and recovery from an illness or a stressor to thrive".*

Thriving is more than mere coping with stressors. It entails the mobilization of all individual and social resources (coping strategies) to not only survive a threat, but to overcome the stressor or challenge stronger than before.

As with SOC, the individual who thrives, does so by means of a cognitive attitude or belief that adversity is not a burden but something that is a challenge worthwhile (emotional dimension) to overcome by means of individual and social coping strategies. This mental or cognitive attitude can be seen in the four possible responses to adversity as proposed by Carver (in Van Breda, 2001). All of these responses assume an initial deterioration of functioning (see Figure 4.1).

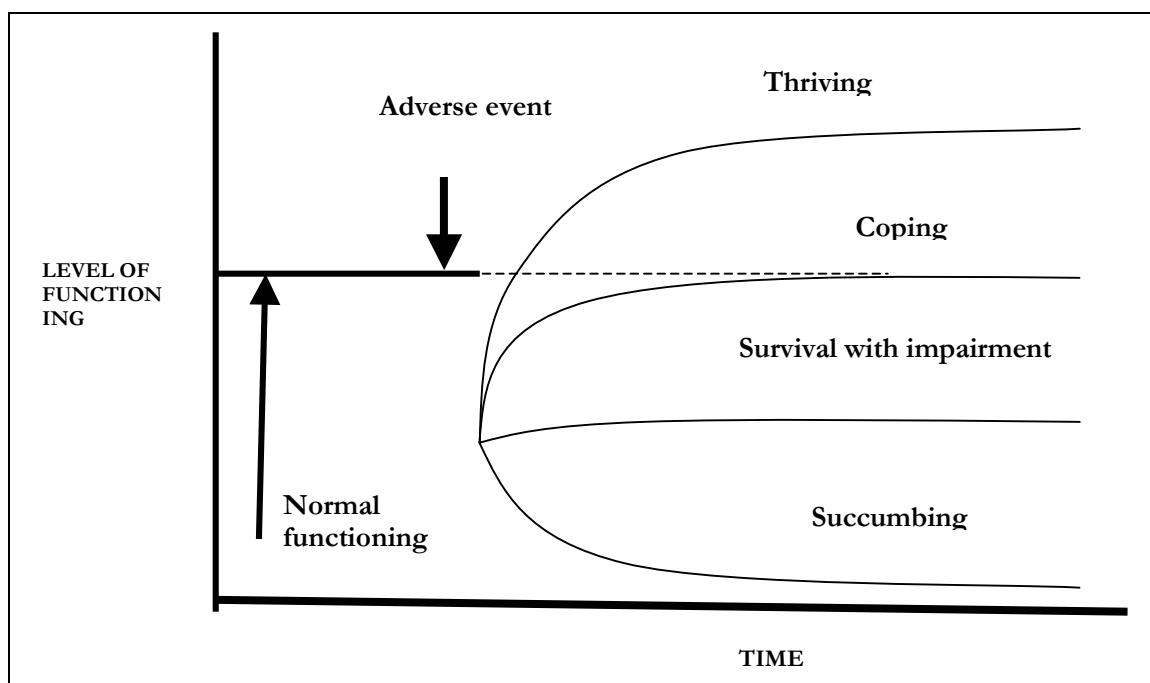


FIGURE 4.1: RESPONSES TO ADVERSITY (VAN BREDA, 2001)

Firstly, the individual's functioning may continue to fall below the initial level of deterioration induced by the crisis. In this response the individual *succumbs* to the stressors. The second response is where the individual's performance improves but is still below the level it was before the crisis. In this response the individual *survives* but his/her capacity is *diminished* or *impaired*.

The third response is where the individual's performance improves to the same level of functioning that it was before the adverse event. The individual therefore coped effectively with the demands or stressors of the event and is not impaired in any manner. This response is called *resilience* or *coping*. Lastly, the individual's performance not only returns to the level of functioning that it was before the adverse event. Here the level of functioning exceeds the normal levels. This response is called *thriving*. Whereas coping attempts to return the individual to the equilibrium or balance that existed before adversity, thriving is the acquiring of new skills and knowledge (about the self, new coping techniques), of new confidence and mastery and new interpersonal skills. Thriving is best understood by focusing on the processes whereby people recover or thrive from adversity (Van Breda, 2001). These three processes are adaptation by desensitisation, adaptation by enhanced recovery potential and adaptation by thriving.

The first process or adaptation by desensitisation the individual becomes desensitised to adverse events or stressors through continued exposure to these stressors. By continued exposure to these stressors the deterioration of performance or functioning as well as the recovery time will become less. Eventually the individual will become so inoculated against the stressors that it will have no noticeable effect. This process will not enhance performance above the baseline and is therefore a form of coping.

In the second process, the individual learns to cope more efficiently with the stressors. Although the stressors are experienced each time are just as severe and disruptive for each event, the recovery time is reduced. As with the previous process the baseline functioning does not improve. Therefore, this process is also an example of coping and not thriving.

The third process, adaptation through thriving, is where the individual's performance (after an initial deterioration) is raised to a level above the initial baseline. When the event or stressor is experienced again, the loss of performance or functioning is

equally disruptive as the first time. However, the baseline of functioning has been raised and the event or stressor can further enhance the individual's performance or functioning to an even higher level. In this process the individual's performance or functioning is continually enhanced above baseline levels. Therefore, this is not only coping with the stressors but also thriving.

Thriving not only requires challenges or adversity but also an individual with certain qualities that will be able to utilize the challenge or adversity to thrive. According to Van Breda (2001), these qualities are cognitive, emotional, personality and social resources such as accurate threat appraisal and perceived personal risk, self-efficacy, social support systems, problem-solving skills, self-motivation and the ability to integrate the meaning attached to adversity and stressors, and social processes and rituals that facilitate life-transitions.

### **4.3.3 HARDINESS**

The construct, hardiness, was developed following several studies that focused on the relationship between stress and well being that showed only moderate correlations. One of the reasons for this was the presence of subjects with high stress scores who were not getting ill. Kobasa (1979), conducted studies on middle and upper executives and found that high stress/low illness executives could be distinguished from high stress/high illness executives on a construct called hardiness. These executives had a stronger commitment to the self, an attitude of vigorousness toward the environment, a sense of meaningfulness and an internal locus of control.

Hardiness was posited as the mediating factor between stress and illness, potentially reducing the negative effects of stress. According to Van Breda (2001), hardiness comprises three subconstructs; commitment, control and challenge.

Commitment refers to the positive value that the individual places on his life and activities, himself, his relationships as well as the investment (effort) of himself in these valued dimensions. Commitment results in a self-perceived sense of purpose in the individual's life that can carry him/her through difficult times or adversity.

Control refers to the perceived sense of control that the individual has over a situation. It entails the belief and consequent actions that the individual has that the

situation is controllable and changeable through the individual's own actions and attitudes. Therefore, people with control are able to change situations by developing and implementing action plans that transform adversity and stressors into positive outcomes.

Challenge as opposed to threat is the belief that change is a normal part of life. Individuals with this attitude view stressful life events and situations as normal (they are anticipated). Nor are these stressful events or even adversity viewed with dismay as they are seen as exciting opportunities for growth and development.

According to this theory, hardy individuals have considerable curiosity and tend to find their experiences interesting and meaningful. Furthermore, they believe that they can control the outcome of situations by their words, actions or ideas. At the same time they expect change and regard it as an important stimuli for development.

These beliefs and tendencies are useful in coping with adversity and difficulties. Hardy people make optimistic cognitive appraisals; perceive changes as natural and meaningful and even interesting despite the stressfulness. This helps the individual to keep the situation within perspective. Furthermore, they take decisive action to understand changes better and to learn from previous mistakes. Thereby, they are able to incorporate these lessons in an ongoing life plan.

#### **4.3.4 SELF-EFFICACY**

This theory developed by Albert Bandura (Meyer, Moore & Viljoen, 1997), has its roots in the social-cognitive learning school. According to Bandura (1984), individual coping depends on the individual's sense of personal efficacy or ability to produce and control events or situations in his/her lives. This would mean that self-efficacy is personal evaluations by the individual to determine how well the person expects to be able to handle present or future situations.

According to Meyer *et al.* (1997), people are constantly busy with a process of self-evaluation and that the outcome of this self-evaluation would determine whether they would actively try to handle a situation or not. When an individual decides that he has the necessary abilities to cope with a situation, he would make an attempt to control the situation. If the individual perceives that he does not have the necessary abilities, he would not even try to make an attempt. According to Van Breda (2001), it is

therefore important that the individual is able to make accurate and reliable self-assessments. According to Bandura (1984), people form judgements of their own abilities based on information derived from four sources:

Enactive attainments that refer to previous experiences and successes. At the same time previous failures decrease perceived ability and increase the likelihood of future lower self-efficacy in those situations. Vicarious experiences refer to the observation of success of attempts by people of perceived same competence as the individual making the observations. When these individuals are successful it would increase their own perception of self-efficacy. Verbal persuasion refers to attempts by others to verbally persuade an individual to believe in their own ability. These attempts have limited effect but such persuasion may have the result that the individual will actually attempt or try harder, thereby increasing the chances of success. Success then enhances the individual's perception of self-efficacy.

Physiological state refers to the excess or aversive arousal that informs the individual that success or failure is imminent. Consequently self-efficacy increases or decreases, depending on how the individual evaluates the arousal state. If arousal were perceived to be positive, the individual's self-efficacy would increase. If arousal were perceived to be negative, the individual's self-efficacy would decrease.

Thus, self-efficacy perception has a strong influence not on the actions that people will take in situations but also in what type of situations they would choose to become involved in. People tend to choose situations where they believe that success is possible (Meyer *et al.*, 1997). In these situations, people with high self-efficacy are more motivated and tend to persist longer in their attempts to overcome adversity or master a situation than people with low self-efficacy. Therefore, high self-efficacy can increase the possibility of success, thereby increasing self-efficacy.

#### **4.3.5 LOCUS OF CONTROL**

Locus of control (LoC) is a construct that was developed by Rotter. It also has its roots in the social-cognitive learning school (Meyer *et al.*, 1997). This construct refers to the extent to which people believe that their lives are controlled by internal (themselves) or external factors. Rotter (Van Breda, 2001) argues that behaviour is reinforced to the degree that individuals believe that their behaviour and the

consequences of their behaviour are under their own control or under the control of external forces.

Rotter (Meyer *et al.*, 1997) made a distinction between internal LoC and external LoC. Internal LoC refers to where people believe they are to a large extent in control of their lives, that they are largely responsible for the consequences of their actions and that they can change their present and future situations by their own actions. People with an external LoC believe that they have very little control over their lives and that things that happen to them are the result of factors external to them, such as luck, coincidence, and actions of other people or fate. Research indicates that people with a strong sense of external control are more susceptible to external influences, while people with a strong sense of internal control are strongly motivated to achieve (Meyer *et al.*, 1997).

According to Rotter (Van Breda, 2001), the individual with a strong sense of internal control is likely to be more alert to clues in the environment that would prove useful for future behaviour, takes action to improve his environmental condition, is more concerned with his own skills and abilities (and place more value there) especially failures and is resistant to attempts to influence him.

In summation, these five theories propose the following about coping and people that are able to cope with adversity or stressors in situations.

It is a generalised approach/orientation, attitude or belief towards life and difficult situations experienced in life. This belief or attitude is that difficult situations should not be viewed with despair, but as challenges and problems that can be overcome or solved. These challenges or problems are a normal part of life and should be expected as learning and development opportunities. This attitude is based on a belief in the individual's own abilities, skills and experience as well as the access to resources held by legitimate other people that will enable the individual to understand the situation and/or nature of the stressors. Once understanding is reached, the individual can use personal and other resources to actively change the difficult situation.

This belief in own abilities is developed (not inherited) since early childhood. Once a person has developed (or not developed) these beliefs, they remain relatively stable but are dynamic and can be learnt or enhanced. People who believe in their own

abilities are motivated to seek out opportunities to test these abilities and to develop new skills from their failures to enhance their coping abilities. These individuals are motivated not only to survive adversity but also to cope and to thrive.

Apart from testing their abilities, this motivation stems from the individuals' belief that they as well as their lives and activities are inherently valuable and that the overcoming of adversity or challenges is worthwhile and meaningful. From these theories, it is seen that coping entails rational, conscious strategies or actions that individuals use to overcome adversity and challenges. Only when they perceive the stressors of a situation too big or their self-perceived abilities too small will they fall back to avoidant coping strategies.

In the following sections, each of these two types of coping strategies, active and avoidant, will be briefly discussed.

#### **4.4 AVOIDANT AND ACTIVE COPING STRATEGIES**

Avoidant coping strategies are learned processes (or behaviours) that are unconsciously motivated, unconsciously acquired, and developed to protect the self or ego from anxiety itself. It is important to focus on the fact that these strategies are unconsciously learned cognitive processes or behaviour. It is also important to notice that these strategies are unconsciously motivated and developed. This means that the individuals using these strategies are not consciously aware of the fact that they are using the strategies and will be unable to trace the origin of the strategy.

Some of the avoidant strategies that are used by individuals are the following; reaction formation, identification, displacement and sublimation, denial, conversion, isolation, repression, fixation and regression, rationalization and projection (Meyer *et al.*, 1997).

The term avoidant coping strategies might be misleading. Avoidant does not necessarily mean that the individual avoids coping with the stressors of the situation. By the term "avoidant" is meant that the individual would avoid coping with the cause of anxiety and focus on coping with the anxiety itself. Therefore, the individual is coping with the stressors but by using unconscious strategies.

As seen in this section, the cause of the anxiety can be varied and the individual is not always consciously aware of these causes. The anxiety is due to a threat to the individual's ego or to certain needs and desires that, if expressed or met would be socially unacceptable. However, these desires and needs as well as the conflict still remain and the individual has developed several unconscious strategies that avoid the anxiety caused by this internal conflict. To avoid threats to the ego or (perceived) social disapproval, the individual would behave in such a manner as to avoid, suppress, project, isolate or rationalize the anxiety and transform it to acceptable behaviour. This behaviour could be an avoidance of certain situations or a succumbing to stressors. This would then be an avoidance of coping. However, this behaviour could also mean that the individual exhibits behaviour where he/she copes and even thrives in adverse situations. The important fact to remember is that avoidant coping strategies are strategies and behaviour that avoid internal anxiety caused by threats to the ego or because of needs and desires that are perceived to be socially unacceptable. These threats may be triggered by external stimuli, but are not strategies or techniques designed to cope with external stressors. Avoidant coping strategies can therefore also be powerful motivators for behaviour as will be seen in section 5.5, motivational strategies.

On the other hand, active coping strategies are conscious, rational learned behavioural, emotional, cognitive or social responses used to minimize the effect of or the sources of stress and anxiety. More specifically this study focuses on the active coping strategies that athletes use during endurance sport. Avoidant coping strategies are viewed and described as coping strategies (also it is strategies that enable the individual to cope and protect the ego from anxiety). However, active coping strategies focus on problems related to the external environment, which is the focus of this study.

Various authors (US Army, 1999; Van Breda, 2001), identified three main types of coping responses that serve distinct functions:

- a. Responses that change the source of the stress or the situation out of which the strainful experience arises.
- b. Responses that change the individual's perception of the stressor or that control the meaning of the strainful experience after it happened but before the emergence of stress.

- c. Responses that control the symptoms of stress itself after they have emerged.

#### **4.4.1        RESPONSES THAT CHANGE THE SOURCE OF THE STRESS OR THE SITUATION OUT OF WHICH THE STRESSFUL EXPERIENCE ARISES**

According to Van Breda (2001), this strategy is not widely used. People must recognise the situation or factor that causes the stress before they are able to change it. However, this is not always possible or people might not know how to change the situation directly. Trying to change a situation might lead to more stressors that might inhibit further efforts.

Van Breda (2001) makes a note of the fact that most research done on resilience and coping revolved around situations such as concentration camps, terminal illness, growing up in poverty or being in a war where very little could be done to remove the source of stress.

This is one of the reasons why this study is so important. All the respondents used in this study participate in stressful, hazardous and even dangerous situations and conditions out of their own free will. They actually choose to be in these situations. The importance of this is that these people are all able to remove the source of stress – yet they do not. They are all motivated by some need or reason to expose themselves to these stressful and dangerous situations.

However, there seems to be disagreement with the statement by Van Breda (2001) that this style is not commonly used. In the literature various authors (Antonovsky, 1984, 1998; Kreitner & Kinicki, 1992; Gill, 2000; Cox, 2002; Potgieter, 2003; Weinberg and Gould, 2003) propose that stress is not only necessary for optimal functioning but developed problem-solving and stress management techniques, either individually or for teams, to control themselves and the situation or environment.

Therefore, although there is some disagreement, the majority of researchers holds the view that certain personality predispositions and attitudes, cognitive techniques

such as problem-solving and social skills such as networking or teamwork enable individuals to control the source of stress.

#### **4.4.2      RESPONSES THAT CHANGE THE INDIVIDUAL'S PERCEPTION OF THE STRESSOR OR THAT CONTROL THE MEANING OF THE STRESSFUL EXPERIENCE AFTER IT HAPPENED BUT BEFORE THE EMERGENCE OF STRESS**

According to Pearlin and Schooner (Van Breda, 2001), this is the most commonly used coping strategy. This coping style can entail paying selective attention to relevant stimuli and thereby concentrating on the less stressful aspects of the situation, positive comparisons that reduce the perceived severity of the stressful situation and to reduce the perceived importance of the stressful situation or the outcome of the situation in relation to one's overall life situation.

Many of the sport psychological interventions and Neuro Linguistic Programming (NLP) techniques, especially those relating to arousal control and attentional strategies such as dissociation, realistic expectations, simulation training, imagery, distraction, physical techniques and self-talk are examples of this style (Horn, 1992; Gill, 2000; Cox, 2002; Potgieter, 2003; Weinberg & Gould, 2003).

#### **4.4.3      RESPONSES THAT CONTROL THE SYMPTOMS OF STRESS ITSELF AFTER THEY HAVE EMERGED**

According to Van Breda (2001), this coping style does not focus on the situation itself, either directly or by changing the meaning or perception. The focus is rather on the resultant stress itself and entails basic stress management techniques.

These strategies attempt to decrease the negative effects of physiological and behavioural symptoms of stress such as palmer sweating, increased skin conductance, increased rapid respiration, increased heart-rate, higher blood pressure, tensed muscles, dryness of mouth, numbness and tingling of limbs, decreased metabolic rate, dilation of the eyes, frequent urination, nausea, vomiting or

diarrhoea, pacing, trembling, restlessness, hand wringing, pressured speech, withdrawal, confusion, inability to concentrate, emotional outbursts or aggressive behaviour.

As seen in chapter 3, stress is the internal psychological tension caused by internal and external stressors that change or are perceived to change the nature of the present and/or future situation to such an extent that it forces the individual to adapt by means of physiological and psychological responses.

Therefore, this strategy focuses not on stress itself or the sources of stress but on the behavioural and physiological symptoms of arousal. Examples of these are hypnosis, self-hypnosis, progressive muscular relaxation, biofeedback, centering, autogenic training, meditation and imagery (Horn, 1992; Woods, 1998; Cox, 2002; Potgieter, 2003; Weinberg & Gould, 2003).

Whichever type of response is used, the fact remains that individuals use learned coping strategies, responses and techniques to consciously overcome adversity or challenges as well as the psychological pressure caused by either internal or external stressors. In other words, once an individual becomes aware of some psychological pressure or stress, usually manifested as physical or behavioural symptoms. They are sometimes able to determine the source of the stress or change their perception or focus on stress symptom management or use a combination of responses and techniques to overcome these stressors.

As seen in this section, each response would have different techniques that could be categorized under that response. Under responses that focus on the source of the stressor could fall the technique of visualization, if the source of the stress is uncertainty. However, it is possible that one technique could also be categorized under more than one response. The technique of visualisation could also be used under the response that changes the perception of the stressor. If, for example, the athlete has previously failed in a task or skill and has the perception that he/she is not able to execute the skill, visualisation can be used to change that perception.

To summarize, active coping strategies are conscious, rational learned behavioural, emotional, cognitive or social responses used to minimize the effect of or the sources of stress and anxiety.

Responses used to cope with stressors can be described as responses focusing on the source of the stress, responses changing the individual's perception about the stress and/or situation or his/her ability to cope and responses that focus on the symptoms of the stress itself.

People usually use one or a combination of these responses to cope with the situation. Under each response several techniques such as problem solving, progressive muscular relaxation and visualisation are found, categorized under a response depending on the use of the technique. See figure 4.2 for a schematic representation of active coping strategies.

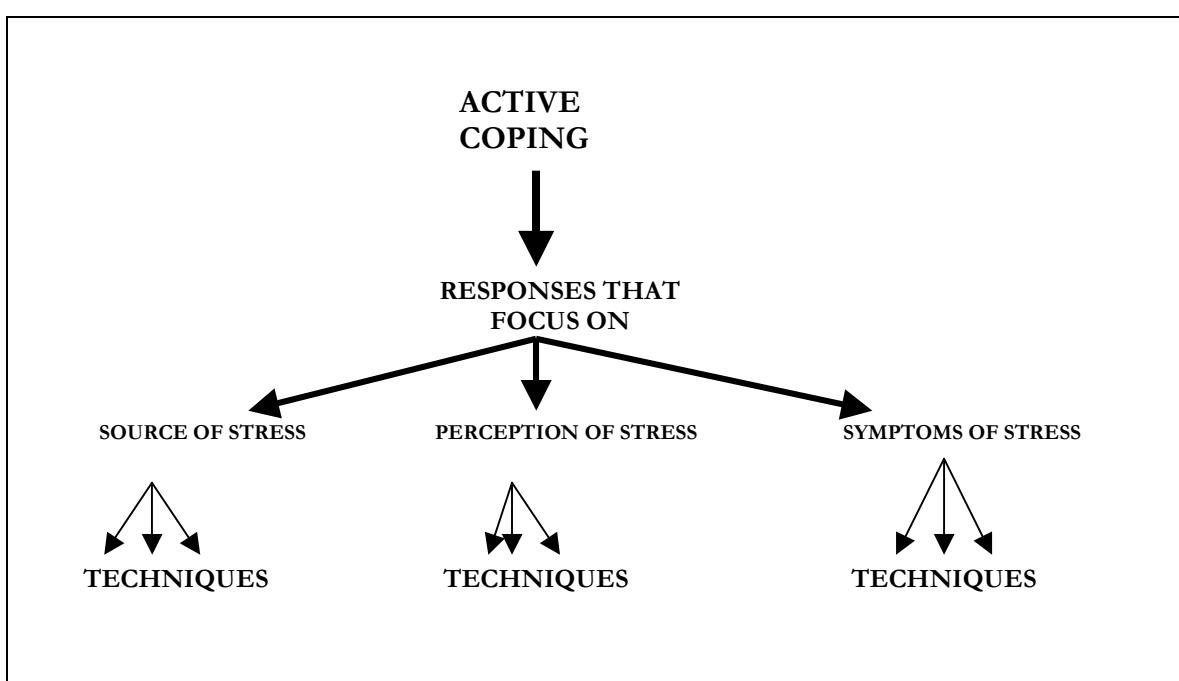


FIGURE 4.2: ACTIVE COPING STRATEGIES

## 4.5 INTERACTION OF ACTIVE AND AVOIDANT COPING STRATEGIES

A straightforward and simple explanation would be that some individuals use active coping strategies and that other individuals use avoidant coping strategies to overcome stressors and to avoid stressors. However, it is not as simple as that. Active and avoidant coping strategies focus on two different types of stressors and have two completely different but interlinked functions.

Avoidant coping strategies have the function to help the individual cope with threats to the ego or needs and desires that would be socially unacceptable should they be

met. This may be triggered by external stimuli. Depending on the nature of the internal conflict, the individual would have developed certain coping techniques such as projection, reaction formation, rationalisation, regression, isolation, conversion and sublimation. The conflict as well as the coping techniques will always be at the unconscious level.

These coping techniques would lead to behaviour that would meet individual needs in socially acceptable ways or avoid threats to the ego. This might entail the use of active coping strategies to overcome external stressors and even thrive in adverse conditions or it might lead to behaviour that avoid stressors or that the individual succumbs to the stressors.

## 4.6 SUMMARY

This chapter focused on the strategies that people use to adapt to extreme environments and the stressors found in these situations. Coping strategies were defined as the psychological strategies (cognitive, emotional, behavioural and social) that individuals use to successfully adapt to stressors or adversity in their present or future situations and thereby continue to function at the same or better level of functioning/performance than before the adverse or stressful situation.

Two types of coping strategies were identified; active coping strategies and avoidant coping strategies. Both of these strategies are interlinked but focus on different stressors and have different functions. Active coping strategies are conscious, rational learned behavioural, emotional, cognitive or social responses used to minimize the effect of or the sources of stress and anxiety. Avoidant coping strategies are learned processes (or behaviours) that are unconsciously motivated, unconsciously acquired, and developed to protect the self or ego from anxiety itself.

Before these two coping strategies were discussed, the theoretical perspectives to what coping and coping strategies are, were briefly explained. Five theories were briefly discussed: sense of coherence, thriving, self-efficacy, locus of control and hardiness.

The theoretical perspectives discussed in this chapter propose that coping is a generalised approach/orientation, attitude or belief towards life and difficult situations

experienced in life in that difficult situations should not be viewed with despair, but as challenges and problems that can be overcome or solved.

Furthermore people with this perception view challenges or problems are a normal part of life and should be expected as learning and development opportunities. This attitude is based on a belief in the individual's own abilities, skills and experience as well as the access to resources held by legitimate other people that will enable the individual to understand the situation and/or nature of the stressors. Once the individual understand the problem, he/she can use personal and other resources to actively change the difficult situation or overcome the challenge. People with this attitude or belief in own abilities developed it (not inherited) since early childhood. Once a person has developed (or not developed) these beliefs, they remain relatively stable but are dynamic and can be learnt or enhanced.

People who believe in their own abilities are motivated to seek out opportunities to test these abilities. By learning from their failures they develop new skills to enhance their coping abilities. These individuals are motivated not only to survive adversity but also to manage and to thrive. By believing that they as well as their lives and activities are inherently valuable and that the overcoming of adversity or challenges are worthwhile and meaningful are these individuals motivated to do so.

It is seen that coping entails rational, conscious strategies or actions that individuals use to overcome adversity and challenges. Only in situations where they perceive the stressors of a situation too big or their self-perceived abilities too small, will they fall back to avoidant coping strategies. Active coping strategies are conscious, rational learned behavioural, emotional, cognitive or social responses used to minimize the effect of or the sources of stress and anxiety.

Responses used to cope with stressors can be described as responses focusing on the source of the stress, responses changing the individual's perception about the stress and/or situation or his/her ability to cope and responses that focus on the symptoms of the stress itself.

People usually use one or a combination of these responses to cope with the situation. Under each response several techniques such as problem solving, progressive muscular relaxation and visualisation are found, categorized under a response depending on the use of the technique.

Lastly, avoidant coping strategies as well as the interrelationship between active and avoidant coping strategies were discussed. Avoidant coping strategies help the individual to cope with threats to the ego or needs and desires that would be socially unacceptable should they be met. Depending on the nature of the internal threat, the individual would have developed certain coping techniques such as projection, reaction formation, rationalisation, regression, isolation, conversion and sublimation. The threat as well as the coping techniques will always be on the unconscious level.

In the next chapter the focus would be on defining motivation, motivational theories as well as motivational strategies used by endurance athletes to overcome extreme environmental conditions associated with endurance events.