



Stress reactivity and personality in extreme sport athletes: The psychobiology of BASE jumpers

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HIGHLIGHTS

- BASE jumpers are usually resilient but vary widely in stress reactivity.
- Stress reactivity depended on profiles of personality and experience.
- Cortisol reactivity was dissociated from sympathetic arousal.
- Emotional style predicted cortisol reactivity, but not sympathetic arousal.
- Experience and tenacity predicted alpha-amylase, but not cortisol, reactivity.

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ABSTRACT

This is the first report of the psychobiology of stress in BASE jumpers, one of the most dangerous forms of extreme sport. We tested the hypotheses that indicators of emotional style (temperament) predict salivary cortisol reactivity, whereas indicators of intentional goal-setting (persistence and character) predict salivary alpha-amylase reactivity during BASE jumping. Ninety-eight subjects completed the Temperament and Character Inventory (TCI) the day before the jump, and 77 also gave salivary samples at baseline, pre-jump on the bridge over the New River Gorge, and post-jump upon landing. Overall BASE jumpers are highly resilient individuals who are highly self-directed, persistent, and risk-taking, but they are heterogeneous in their motives and stress reactivity in the Hypothalamic-Pituitary-Adrenal (HPA) stress system (cortisol reactivity) and the sympathetic arousal system (alpha-amylase reactivity). Three classes of jumpers were identified using latent class analysis based on their personality profiles, prior jumping experience, and levels of cortisol and alpha-amylase at all three time points. "Masterful" jumpers (class 1) had a strong sense of self-directedness and mastery, extensive prior experience, and had little alpha-amylase reactivity and average cortisol reactivity. "Trustful" jumpers (class 2) were highly cooperative and trustful individuals who had little cortisol reactivity coincident with the social support they experienced prior to jumping. "Courageous" jumpers (class 3) were determined despite anxiety and inexperience, and they had high sympathetic reactivity but average cortisol activation. We conclude that trusting social attachment (Reward Dependence) and not jumping experience predicted low cortisol reactivity, whereas persistence (determination) and not jumping experience predicted high alpha-amylase reactivity.

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1. Introduction

Little is known about stress reactivity in athletes in extreme sports despite their increasing popularity [1]. "Extreme sports" include high-

risk sports such as mountaineering, rock climbing, downhill mountain biking, and BASE jumping. BASE jumping developed out of skydiving and uses specially adapted parachutes to jump from fixed objects. "BASE" is an acronym for the four categories of fixed objects from which one can jump: a Building, Antenna, Span, and Earth. BASE jumpers rely on a single canopy with no reserve parachute. Estimates of injury rate are 0.2–0.4% per jump [2,3] and fatality rates of 0.04% per jump or 1.7% per participant per year [3,4], suggesting that this is one of the most dangerous sporting activities. BASE jumping is 20 to 40 times

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more dangerous than skydiving, so it is legally prohibited in many areas. The New River Gorge Bridge Day in West Virginia, the site of the current study, is the main legal BASE jump meet in the USA.

Monasterio and colleagues examined high-performance mountaineers and BASE jumpers with the Temperament and Character Inventory (TCI) to assess their personalities [5,6]. The TCI provides a comprehensive account of personality traits, measuring seven dimensions of personality (see Table 1) that are moderately heritable and associated with distinct brain networks and psychological characteristics [7,8]. The model measures four dimensions of temperament, which involve basic emotional drives modulated by the hypothalamus and related limbic structures [9], and three character dimensions, which involve self-regulation of emotions in order to achieve intentional goals and values regulated mainly in the neocortex [6,8]. In temperament, BASE jumpers were often adventurous risk-takers, as measured in the TCI by lower Harm Avoidance (HA), higher Novelty Seeking (NS), and lower Reward Dependence (RD) compared to low-risk sports participants and people in the general population. In character, they were highly self-controlled and well-organized, as characterized in the TCI by higher Self-directedness, higher Cooperativeness, and lower Self-Transcendence [1,10].

There is no consistent temperament and character profile that characterizes all extreme sports athletes because the choice of such activities is influenced by diverse personal, social and geographic variables. As a result, extreme sports athletes provide an unusual opportunity to understand the effects of variable combinations of traits and situations that may influence their decision-making and stress reactivity.

Table 1
Descriptors of people with high or low scores on TCI personality scales and subscales.

TCI scales	TCI subscales	High scorers	Low scorers
Novelty seeking	NS1 excitability	Exploratory	Reserved
	NS2 impulsivity	Impulsive	Rigid
	NS2 extravagance	Extravagant	Thrifty
	NS4 disorderly	Rule-breaking	Orderly
Harm avoidance	HA1 pessimism	Pessimistic	Optimistic
	HA2 fearfulness	Fearful	Risk-taking
	HA3 shyness	Shy	Outgoing
	HA4 fatigability	Fatigable	Vigorous
Reward Dependence	RD1 sentimentality	Sentimental	Objective
	RD2 sociability	Open	Secretive
	RD3 attachment	Friendly	Detached
	RD4 dependence	Approval-seeking	Independent
Persistence	PS1 eagerness	Enthusiastic	Hesitant
	PS2 hard-working	Determined	Easily discouraged
	PS3 ambition	Ambitious	Lazy
	PS4 perfectionism	Perfectionistic	Underachieving
Self-directedness	SD1 responsibility	Responsible	Blaming
	SD2 purposefulness	Purposeful	Aimless
	SD3 resourcefulness	Resourceful	Helpless
	SD4 self-acceptance	Hopeful	Hopeless
	SD5 self-actualizing	Self-actualizing	Unfulfilled
Cooperativeness	CO1 social tolerance	Tolerant	Prejudiced
	CO2 empathy	Empathetic	Self-centered
	CO3 helpfulness	Considerate	Hostile
	CO4 compassion	Forgiving	Revengeful
	CO5 conscience	Principled	Opportunistic
Self-transcendence	ST1 self-forgetfulness	Acquiescent	Controlling
	ST2 transpersonal identification	Altruistic	Individualistic
	ST3 spiritual acceptance	Spiritual	Skeptical

Stress activates two major neurobiological systems: (i) the endocrine response involves activation of the HPA axis and results in increased cortisol levels, whereas (ii) the autonomic nervous system response involves activation of the sympathetic-adrenal medullary (SAM) axis and results in release of norepinephrine from sympathetic nerve terminals [11]. Salivary cortisol provides a non-intrusive index of activation of the HPA axis, whereas salivary alpha-amylase provides an index of arousal of the SAM axis [12].

Prior literature led us to hypothesize that temperament profiles of Novelty Seeking, Harm Avoidance, and Reward Dependence predict stress reactivity of the HPA axis whereas the effortful struggle to control events measured by persistence and character profiles predict reactivity in the SAM axis. Specifically, lower cortisol reactivity has been observed in healthy individuals who are high in Novelty Seeking and/or low in Harm Avoidance compared to others [13,14]. In addition, individuals who are high in Reward Dependence (i.e., warmly sociable and trusting) have larger oxytocinergic regions in their hypothalamus and higher circulating levels of oxytocin [15,16], which reduces activation of the amygdala, insular salience network, and cortisol release in dangerous situations [17–19]. Accordingly, individuals who are highly sociable have reduced cortisol responses to stress in socially supportive situations [18,20]. In contrast, cortisol release by activation of the HPA axis is usually blunted in individuals who are high in neuroticism (i.e., high Harm Avoidance and/or low self-directedness) [21–23] or who experience chronic adversity or repeated stress beyond their control and/or without adequate social support [20,24].

Little objective information about alpha-amylase or cortisol reactivity is available in extreme sports enthusiasts. Heterogeneity in cortisol reactivity has been documented in parachute jumpers [25]. Skydiving has been shown to stimulate a rise in salivary cortisol compared to the level before the jump and at recovery in both novice and experienced skydivers [26]. Novices reported greater anxiety than did experienced skydivers, but there were no significant differences in their salivary cortisol levels.

We hypothesized that personality measures of emotional style (temperament) predict salivary cortisol reactivity, whereas personality measures of intentional goal-seeking (persistence and character) predict salivary alpha-amylase reactivity during BASE jumping. We also hypothesized that resilient individuals (measured by high Persistence combined with low Harm Avoidance and high Self-directedness) would show “The Right Stuff” [27], accomplishing their dangerous mission without substantial arousal of either stress system.

2. Methods

2.1. Study site

Data for the study was collected from the 2014 New River Gorge Bridge Day BASE jumping event. This is an annual event in October in Fayetteville, West Virginia USA where participants jump from a bridge 876 ft above the New River. Participants freefall for 2 to 6 s and then release a parachute prior to landing at a site adjacent to the New River that flows through the gorge, as shown in videos posted (<https://www.youtube.com>) about the event (New River Gorge Bridge Day 2014). The videos show the cheerful camaraderie among participants and spectators at the event. Although injuries and fatalities have occurred at this event, the supervision of jump conditions was collegial but well-disciplined.

2.2. Literature review

In order to generate testable hypotheses, a systematic literature review was conducted in PubMed using all possible combinations of three groups of search terms: (1) extreme sports, BASE jumping, (2) personality, temperament, character, motivation, and (3) stress reactivity, cortisol, alpha-amylase, norepinephrine. References were

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