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An Ecological Dynamics Perspective of Return to Play Decision-Making for Extreme Sport Athletes

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SUMMARY

Background. Extreme sport participation occurs for many reasons. A commonality for many is the high risk of serious injury or death, particularly in association with mismanaged execution.

Methods. This review describes a conceptual return to play decision-making model for extreme sport athletes based on considerations of ecological dynamics.

Results. In guiding the extreme sport athlete through sport-specific training simulations and secondary injury prevention education, the rehabilitation clinician must develop a thorough understanding of the sport and the factors that contribute to their safe performance.

Conclusions. The interaction of multiple factors including (but not limited to) experience and skill level, personality, conditioning level, overall health and injury status and the injury risks associated with many extreme sports make return to play decision-making particularly difficult.

KEY WORDS

Return to play; adventure; sports; training; education.

INTRODUCTION

Any attempt to define extreme sports should consider emerging creativity and the trade-off between order and instability as essential elements (1). The lack of consistency with the term, extreme sport, means that those who wish to understand this field often have to develop their own criteria as a starting point (2). Both high-risk and extreme sport represent any sport that is defined as one in which the participant must accept the possibility of severe injury or death as an inherent part of the activity (3). However, some extreme sports, such as climbing, possess lower injury incidence and severity scores than traditional sports, such as sailing, basketball and soccer (4). For example, the death rate reported among climbers in the United Kingdom is significantly lower than that reported for motorcycle riding (5). Part of the difficulty in being able to define extreme sport is that they possess many other factors aside from risk that include, but are not limited to, spatial, emotional, individualistic and transgressive dimensions (6). Extreme sports are temporal emergent products of development within individual, task and environmental constraints, being open to continual evolution through creative exploratory behaviors and technical innovations (1). The most common terms considered representative of extreme sports include alternative, action, adventure, lifestyle, media-driven, and individualism (2), however, extreme sport appears to be most used and this is what we will adhere to in this concepts paper.

Common misconceptions of extreme sport athletes is that they are solely risk-taking, adrenaline and thrill-seeking or death-defying individuals. In contrast, many participants describe experiencing positive, deeply meaningful and life-enhancing events (1). Conceptualization of extreme sports participation, using more qualitatively-based phenomenological research methods, enables researchers and clinicians to better understand how extreme sport athletes experience certain phenomenon, while also helping control for biases and preconceived assumptions regarding sport-related life experiences, feelings, and responses to particular events. With this approach, the rehabilitation clinician will likewise develop a more holistic perspective as they develop strategies for treating and evaluating these athletes.

Reasons for extreme sports participation and injury risk

While many traditional sports promote teamwork, extreme sports tend to be focused on goals that challenge the individual. Cohen et al (2) operationally defined extreme sport as a predominantly competitive (by comparison to others or self-evaluation) activity within which the participant is subjected to natural or unusual physical and mental challenges that include elements of speed, height, depth, or natural forces. Orth et al (7) proposed that rather than ideation leading to creative action, in extreme sports, creative actions are more likely to emerge as the action interacts spontaneously with task-environmental constraints. A zone of meta-stability is often achieved in which a system is poised between states of order and instability (8). In direct association with this is the reality that injury or fatality is more likely to occur than in a non-extreme sport.

In recent years, extreme sport participation rates have increased faster than many traditional sports (9). Extreme sport participation may develop a profound athlete-environment relationship that can potentially enhance psychological and physical well-being and health (10). Extreme sport athletes may be searching for high risk experiences involving elevated levels of sensation, physiological arousal, and novelty (11). They have also been described as self-confident and optimistic individuals who are more likely to attribute accidents and fatalities to internal characteristics rather than to external circumstances (12), while often underestimating their personal risk of being injured (13). Risk-centric interpretations of extreme sport participants may be too superficial (1). Of considerable importance may be the development of a profound person-environment relationship that can potentially offer a variety of ways to enhance psychological and physical well-being and health (14,15). Many extreme sport athletes may also pursue higher-level motives such as goal achievement, mastery-seeking, defeating monotony, self-discovery, social motivation, natural environment connections, time for peace and reflection, feeling of pleasurable bodily sensations, and achievement of unselfconsciousness (16-17). Experiencing fear can also be a potentially meaningful and constructive event in the lives of extreme sport athletes. Having a better understanding of the implications of fear as a potentially developmental and transformative process is important when treating extreme sport athletes (14). Likewise, emotions such as anxiety, excitement and pleasure, as well as beliefs, values and motivations possess significant roles during extreme sport participation and have a strong influence on an individuals' environmental perceptions (18). Participation in extreme sport can be a way to strive for self-actualization, self-discovery and to develop new coping mechanisms (2,15). Individuals who are self-actualized possess a greater sense of self-acceptance and thrill for living for the moment, with the mind and body acting in unison (15,19). Extreme sports participation has been described as being ineffable edgework, suggestive of emerging subcultures or neotribes, existential reflection or self-actualization (14).

Robinson (20) viewed extreme sport as an activity based on both cognitive and emotional components, such as, "a variety of self-initiated activities that generally occur in natural environment settings and that, due to their always uncertain and potentially harmful nature, provide opportunity for intense cognitive and affective engagement" (**figure 1**). Similar to this is the flow concept described by Csikszentmihalyi (21), in which the conscious state becomes completely absorbed into a situation or sport. The sense of elation and peace experienced in extreme sport may be the result of the endogenous mood enhancement provided by a combined adrenalin rush and endorphin release (2). Linked with this may be the need for the extreme sport athlete to escape the mundane boredom of daily tasks or living in a risk-free comfort zone through outlets where the self and reflective thought can be rediscovered (15,22). The majority of extreme sport athletes are between 15-44 years of age (23) with an average of 30-31 years (2). Therefore, another essen-

Figure 1. Surfer-wave, athlete-environment interaction "in the flow" (21).

tial factor may be the transition from adolescence to adulthood, as a modern rite of passage, given the uncertainty of approaching adulthood and issues related to work, family and finances (2,15,24). Extreme sports may be better than traditional sports for encouraging lifelong wellness (14).

Equipment needs and individual body mechanics vary between different extreme sports, as do potential injury risks and injury mechanisms (25). For example, while the knee is the most commonly injured body region among extreme sport skiers, the wrist and ankle are more often injured among snowboarders (26). Most traumatic skate- or snow-boarding injuries involve teenage boys older than 16 years of age (27,28). More surfing injuries occur in men in their late twenties (29). Most base jumping injuries occur in single men in their thirties, with most participants having witnessed the death or serious injury of another participant (30). Whitewater paddle sportsmen who sustain serious injury tend to be of similar age and gender (31); however, commercial whitewater rafters display equal gender distribution (32). Having an unsuccessful outcome in an extreme sport is more likely to result in severe injury or even a fatality (26). It is not uncommon for a wingsuit athlete to have known someone who died suddenly from a collision while performing their sport. For purposes of ameliorating risk in sports that have a high death risk, it is important that clinicians develop a sound understanding of the actions or inactions that may have preceded the tragic event.

The expanded specific adaptations to imposed demands (SAIDS) principle

The Specific Adaptations to Imposed Demands (SAIDS) principle of training suggests that the human body adapts specifically in response to the neurophysiological and, perhaps, psychobehavioral inputs to which it is subjected (33,34). Optimal athletic performance is achieved through complex three-dimensional coordination of the muscles, connective tissues and nervous system throughout the kinetic chain. A fundamental attribute to complex dynamical systems is that they must continuously adapt and change their organizational states (35). This is characterized by emerging coordination between system components or degrees of freedom and by synergetic relations between individuals and the environment in a manner that more effectively translates integrated axial and appendicular body function (36). It is crucial that extreme sport athletes align these coordinated efforts with environmental conditions, gravitational forces and natural energy sources such as wind and water. During extreme sport performance, environmental constraints may never remain truly fixed from one moment to the next. For extreme sport athletes, the SAIDS principle of training needs to place greater emphasis on linkages between psychobehavioral, sociological, and emotional considerations with physical, mental, cognitive, and environmental factors. Rehabilitation clinicians need to better understand the ideal, likely and worst case scenarios for any given extreme sport both from the perspective of the athlete, sport partners, teammates, and support crews. As important to environment conditions and task skill is an individual athlete's personality characteristics, which not only affect the rehabilitation process, but also the predicted outcome (37-39).

Ecological dynamics

Immonen et al. (40) proposed that ecological dynamics represented a holistic, comprehensive framework for defining extreme sports participation. The ecological dynamics approach to perception, knowledge, action and skill acquisition involves a process where an existing repertoire of behavioral capabilities (or coordination repertoire) are destabilized prior to being re-organized through effective practice. When done correctly, this process can expand the athlete's affordance boundaries, enabling them to explore new environments (36). Key ecological dynamic factors include skillful behaviors that involve athlete-environmental interactions, the timely processing of perceptions that drive action strategy and tactic development, and how performance behavior modifications occur over time based on interacting constraints (1). Strategy represents the operational plan an athlete uses to achieve a particular goal or aim (climb to the summit, win, have fun). Tactics are the specific actions, means or methods the athlete uses to achieve the strategy they have selected. Having a sound understanding of these factors and how synchronously they link, given the athletes experience, skill, personality, conditioning, and injury recovery status, is essential to the rehabilitation clinician. Within this context, constraints represent the temporary boundaries that shape the emergence of each athlete's developing cognitions, actions, and decision-making processes. Constraints may include, but are not limited to, factors such as knowledge, skills and technical abilities, conditioning level, injury, surgical or medical history, capacity to tolerate pain, motivations and perceptions (41). As extreme sport athletes adapt to changing conditions or unpredictable natural and social environments, they must develop a sound understanding of their individual constraints within the context of task performance and environmental conditions (1). For a high injury risk sport such as BASE jumping, concerns exist regarding participant training level, discipline (i.e. tactical and strategic decision-making efficacy) and control (17). Adequate preparation requires participants to possess sport knowledge and understanding of the unique characteristics of the location where they plan to perform the activity, the environmental conditions and especially, themselves (17). Ecological dynamics integrate ideas from dynamical systems theory and psychology toward the achievement of better adaptive learning and behaviors in any particular environment (40). Rehabilitation clinicians should understand that in an effective therapeutic exercise environment self-organizing global system order best emerges when the patient's own system dynamics are challenged by instantaneous disorder (42) (**figure 2**). The effort to satisfy existing performance constraints gives rise to perceptual neuromotor couplings that support and optimize the extreme sport athlete's perception of action affordances or opportunities (43). By learning new ways to adapt to novel situations, the extreme sport athlete experiences movement system degeneracy prior to developing newer, more efficient functional solutions (44). This process helps extend the boundaries of what their environment affords for action (7). During guided rehabilitation, temporary task instability facilitates exploration of alternative movement solutions and hence, adaptability (45). Rehabilitation clinicians should help guide and shape extreme athlete responses by manipulating constraints and affordances so that the athlete in training learns varied task solutions without presuppositions, even when confronted with sudden perturbations or chaotic situations (38,46). Movement adaptability combines task exploration, enhanced degeneracy and discovery of new, adaptive, functional answers that support the expansion of affordance boundaries or the "comfort zone" (47). With practice, individuals can develop new, more refined adaptive movement coordination patterns.

In team sports such as soccer or basketball, constraints are directly embedded within game rules. In contrast, extreme sports are usually free of organizational rules and regulated competitive frameworks. Environmental constraints may be related to physical phenomenon such as weather, temperature, gravity, surface friction, buoyancy, vision, oxygen level, etc. and/or sociocultural factors such as values or norms that influence perception, family or peer support (43) (**figure 3**). The rehabilitation clinician experiences similarly complex decision-making situations when train-

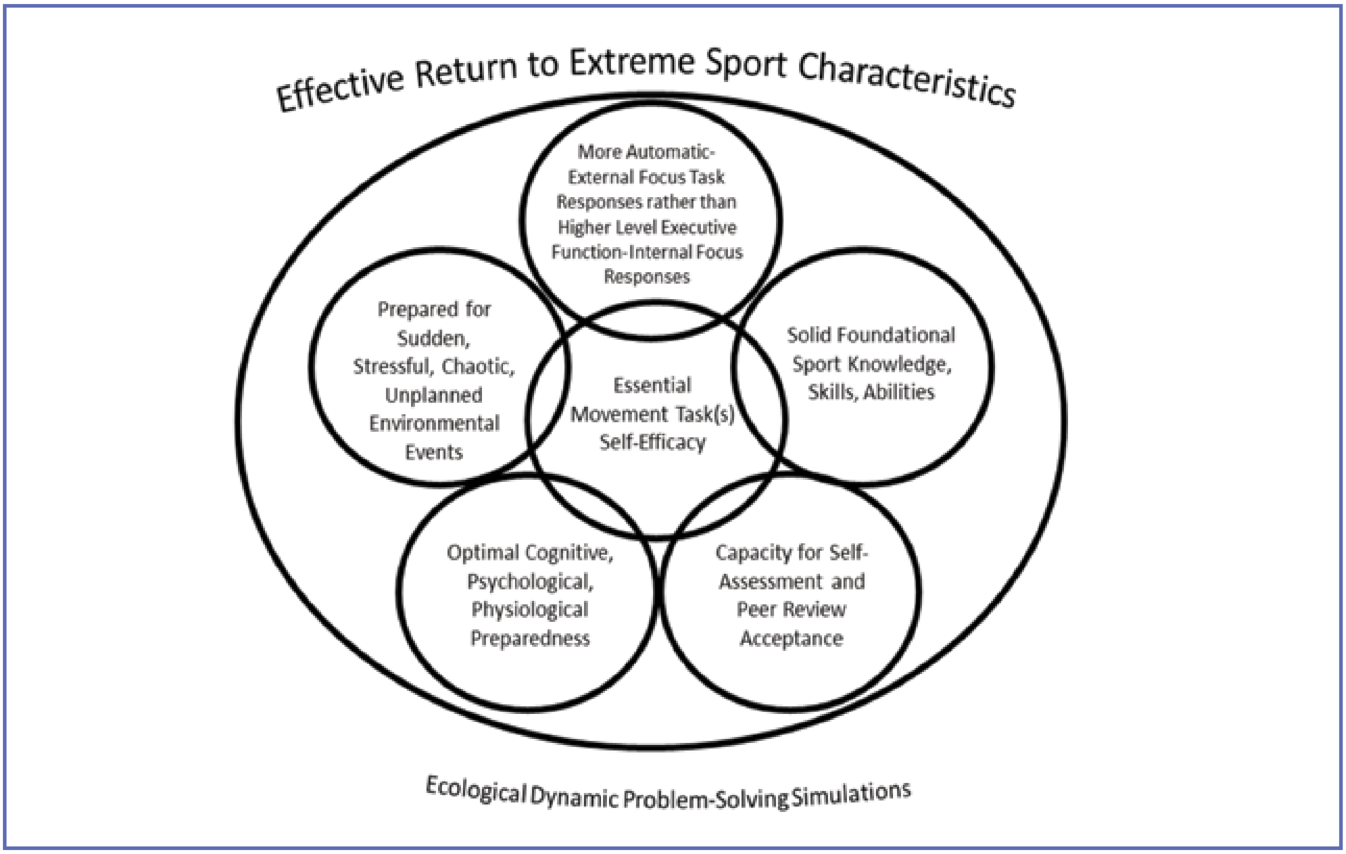


Figure 2. Improving the rehabilitating extreme sports athlete's self-organizing systems.

Figure 3. Young climber with multiple climbing wall route options, exploring to expand the comfort zone.

ing and evaluating these athletes. Given the uniqueness of each extreme sport environment, game-based virtual reality training simulations similar to those used with military jet pilots, law enforcement, or military special forces training might be integrated into strategic and tactical training to obtain objective spontaneous decision-making effectiveness measurements to better validate the needed cognitive processes. In agreement with the SAIDS Principle, rehabilitation programs should consider the specificity of loading force magnitudes, application points, velocity, variances, the impact of sudden unplanned, random or chaotic events in relationship to the time needed by the athlete to effectively react with the necessary motor plan adjustments required to restore psychophysiological homeostasis. Upon returning to extreme sport activities, it is essential that the athlete maintain a reflective journal that documents their subjective perceptions of performance, skill level or general conditioning strengths, weaknesses, training or safety needs that might require more dedicated attention during practice or training in addition to environmental factors. This self-assessment should then be integrated with information obtained through peer assessment by sport colleagues who have comparable or greater skill levels.

Training to return-to sport decision making

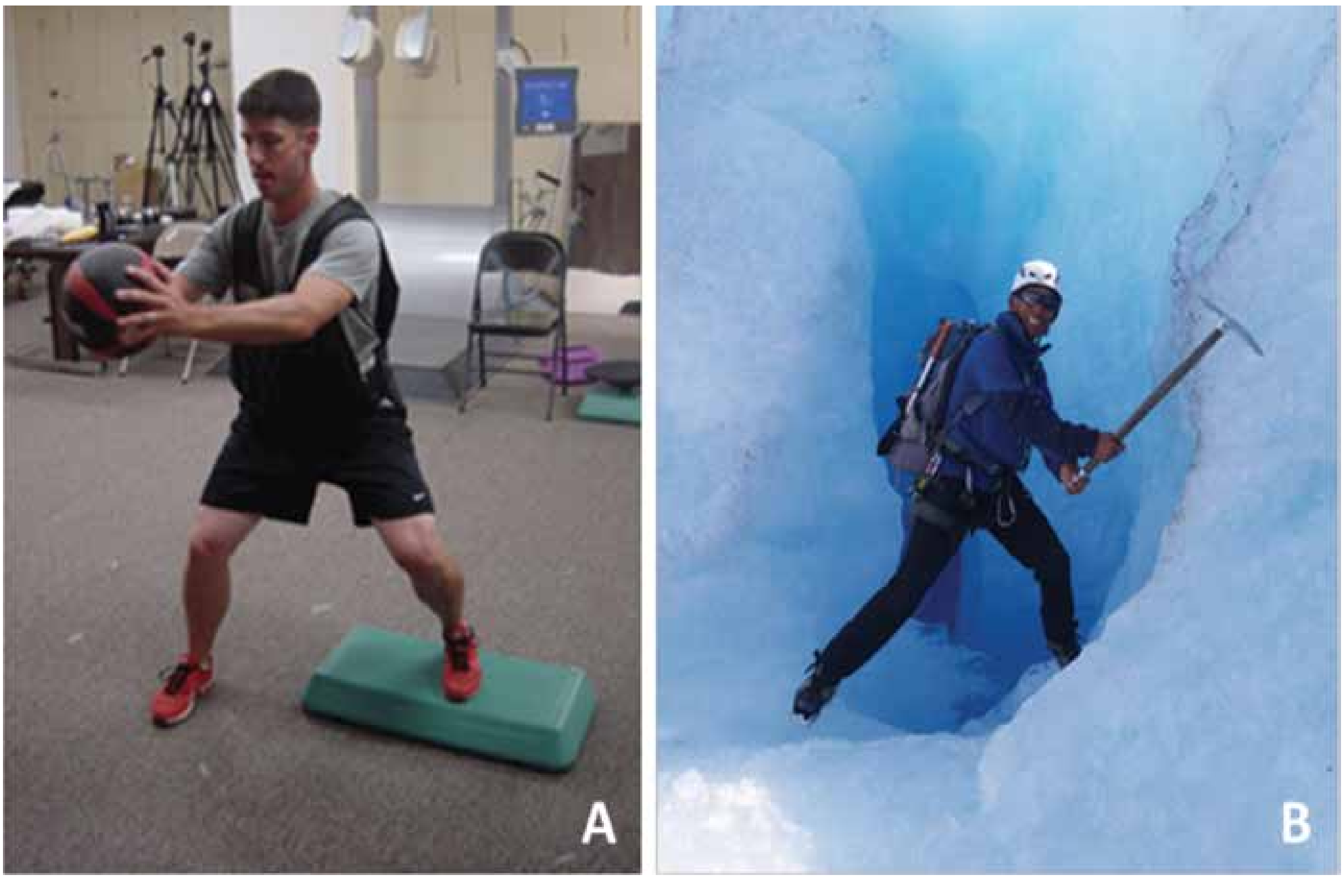
Interactive educational programs and workshops are effective in reducing injury risk, collisions, and falls in novice skiers and snowboarders, while one hour educational workshops have been shown to be beneficial to more advanced participants (48). Valid appraisal of the extreme sports athlete as possessing beginner, intermediate, advanced, or expert skills is an essential part of the return to sport decision making process. Prior to the return-to-sport decision making, it is important that the rehabilitation and medical teams evaluate performance and injury prevention readiness with consideration for the ability of the extreme sport athlete to realistically self-appraise strengths and weaknesses. This is particularly important when confronted with stressful, unexpected, challenging situations such as rapidly changing weather conditions, unstable or slippery surfaces, limited vision, or sudden perturbations.

Extreme sport performance represents the intersection between athlete-environmental coupling and complex, emergent system self-organization adaptations (49). Training of specific movement tasks under progressively more difficult, functionally relevant conditions can increase athlete self-efficacy as has been shown with other forms of musculoskeletal rehabilitation (50).

Rehabilitation clinicians should guide the extreme sports athlete toward movement creativity and adaptability by encouraging exploration. To better develop adaptive behaviors, environment manipulation may be needed to place the athlete outside of their comfort zone. This process is enhanced through added noise such as perturbations, unstable surfaces, reduced vision and use of a more external than internal task focus. In this non-linear, learner-centered approach to skill acquisition, the rehabilitation clinician serves more as a functional movement designer/architect rather than a drill sergeant-focusing on the guided exploration of opportunities or affordances of action (49). Training relevance and validity can be enhanced by manipulating the environment from both an internal and external performance perspective and changing the context within which timely decisions must be made when confronted with unplanned or chaotic events. Movement paths variability should not be considered a lack of optimization, but rather, an essential factor to developing multiple problem solutions, expanding the zone of safe functional possibilities. By holding devices or tools in the hands when training, integrated core-extremity coordination can be developed in a manner that better prepares the athlete for actual environmental conditions (51) (**figures 4A, 4B**). Extreme sports techniques and use of innovative technologies continue to evolve. For example, pioneers of extreme sports such as surfing and wingsuit flying have adapted their sports through the use of jet skis to access larger waves, and suit airfoil designs to enable better horizontal flight and glide proximity flying maneuverability (52). Extreme sports are often more directly connected to technological innovations that drive performance than traditional sports. Rehabilitation clinicians need to be equally vigilant in designing return to sport training programs and evaluation methods to accommodate extreme sport strategic and tactical plan modifications. Although primary injury prevention strategies are essential for all sports, secondary injury prevention strategies should be stringently embedded in the return to play decision-making process for most extreme sports, as a secondary injury is more likely to be associated with major trauma or sudden death to the athlete or to their partner, teammate or support team.

Developing extreme sport-specific rehabilitation key task assessment criteria

Return to extreme sports training post-injury or surgery requires that the rehabilitation clinician has a thorough understanding of the extreme sport, the index injury mechanism(s), the athlete's knowledge, experience, skill level, personality and the potential influence of environmental factors. Consolidation of factors such as these, in addition to knowing the extreme sport athlete's reason for participation (to summit, to win, to achieve better quantitative or qualitative scores, to feel self-actualized, etc.) and capacity for handling stressful, unplanned events set the stage for more prescriptive training and guidance. Use of a variety of unstable training surfaces such as wobble boards, Swiss or Bozu ball, with or without single leg or arm support, can simulate the unsteady natural surfaces associated with many land-based tasks (**figure 5**). Use of blind folds, vision blocking goggles, or dark rooms can provide the exteroceptive deficit needed to elicit optimal somatosensory system responses within the confines of a clinic or performance training area.



Figures 4A and 4B. Use of a medicine ball during whole body lunge – long axis rotational movement (A) improves athlete preparedness for tool use during extreme sport performance (B).

Figure 5. Whole body mobility (A), on an unstable surfaces (B), adding the core to isometric dumbbell work (C-E).

Specific key movement task subcomponents or unexpected events such as sudden single leg support requirements, multi-directional near falls, reverse falling and equipment failure scenarios can be integrated into task problem-solving scenarios, where both the extreme sport athlete's movement quality and ability to master functional puzzles or dilemmas in a timely, efficient manner are assessed. Within this context, the rehabilitation clinician should include a variety of situational scenarios related to key aspects of performance cognitive decision-making. Given the strength, power and endurance requirements of each sport, both central and peripheral fatigue should be included as training stimuli. Naturally undulating slopes or elevated treadmill hikes with sudden acceleration-deceleration and changing terrain intervals, in combination with weighted vest, dumbbells or resistance bands performed over repeated sessions with reduced recovery time can improve simulation validity and fatigue tolerance. It is also important to mention that the extreme sport athlete who performs with partners or teammates should be sufficiently fit, and fatigue resistant, to not just care for themselves in serious conditions, but also to develop the reserve to be able to oversee the care of partners or teammates who may have succumbed to injury or illness (**figure 6**).

Continuous performance improvement through guided practice may be more likely to occur in extreme sports athletes who do not need to dramatically modify their existing overall movement patterns, but rather, just need to refine them to more effectively achieve the desired outcome (53). Alternately, individuals who display sudden performance improvement may display greater behavioral variability during learning-suggesting that the newly learned behavior is

Figure 6. Mountaineering team ascending a Himalayan mountain slope.

initially unstable. Lastly, in situations where an extreme sport athlete does not improve through practice, the task dynamics may be too complex relative to their current skill level. In this case, a transitional, new behavior may not surface, possibly preventing them from achieving the task goal, even after extensive practice. Individuals also may not improve because they do not have sufficient physical or mental skills to explore effectively. Exploration is a necessary ingredient for learning behavior improvement to occur, uncovering the transitional information needed to support a new movement coordination mode. In climbing, because of the added elements of altitude, slope and injury risk due to falling, facilitating safe exploration is particularly important (54). Indeed, if an individual feels unsafe when climbing, they will have more restricted movements leading to ineffective task exploration. Movement restrictions following knee joint surgery are known to be problematic and should be overcome to prevent re-injury. One of the key challenges to the rehabilitation clinician is to appropriately scale task difficulty relative to the individual learner over time. Subsequently, the rehabilitation clinician should identify constraints that best influence the extreme sport athlete's stability as they search for ways to achieve fluent successful new movement patterns.

Psychological return to sport evaluation considerations

Psyche and emotion are directly related to task performance decision-making and this often contributes directly to safety and outcome success (55). For this reason, athletes that engage in high risk sports likely need more varied, novel, and complex sensorimotor experiences during rehabilitation to perceive validity and therapeutic exercise task relevance. Extreme sport athletes may also be more likely to use active coping strategies during rehabilitation (54). Return to sports decision-making for the extreme sport athlete requires an appreciation for the possibility of underlying stress perceptions, fear avoidance, health locus of control, task specific self-efficacy, and kinesiophobic characteristics. Extreme sport athletes may also be more likely to ignore medical or rehabilitation advice and continue with potentially destructive behaviors post-intervention (39). Cohen et al (37) identified a significant difference in the level of neuroticism (i.e. anxiety, worry, fear, anger, frustration, envy, jealousy, guilt, depressed mood, and loneliness) with regards to athlete skill level. Eysenck et al (56) reported that neuroticism was lower in professional athletes compared to amateurs and Cohen et al (36) confirmed this claim with professional drag racers and professional archers scoring lower in neuroticism than amateur athletes.

SUMMARY

Rehabilitation clinicians need to consider multiple factors during post-injury or surgery return to sport decision-making to effectively treat extreme sport athletes. Factors such as experience and skill level, personality, conditioning level, overall health and injury status and the injury risks associated with many extreme sports makes this process particularly difficult. Through sport movement-specific affordance and constraint manipulation, the rehabilitation clinician can guide and shape the learning needs and fatigue tolerance of extreme sport athletes to develop variable movement solutions to better adapt to environmental challenges. Return to sport decisions should represent a team effort between the athlete, medical and rehabilitation team. Research is needed to develop the best holistic approach to capturing the essential physiological, psychological and perceptual information needed to guide this process and to develop specific criteria for differing sports.

CONFLICT OF INTERESTS

The authors declare that they have no conflict of interests (57).

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