Psychoneuroendocrinology (2009) 34, 190—198

available at www.sciencedirect.com

ScienceDirect

journal homepage: www.elsevier.com/locate/psyneuen

The level of physical activity affects adrenal and cardiovascular reactivity to psychosocial stress

Ulrike Rimmele [a,*], Roland Seiler [b], Bernard Marti [c], Petra H. Wirtz [d], Ulrike Ehlert [d], Markus Heinrichs [a,*]

[a] *Department of Psychology, Clinical Psychology and Psychobiology, University of Zürich, Binzmühlestrasse 14/Box 8, CH-8050 Zürich, Switzerland*
[b] *Institute of Sport Science, University of Bern, Bremgartenstrasse 145, CH-3012 Bern, Switzerland*
[c] *Swiss Federal Office of Sports, CH-2532 Magglingen, Switzerland*
[d] *Department of Psychology, Clinical Psychology and Psychotherapy, University of Zürich, Binzmühlestrasse 14/Box 26, CH-8050 Zürich, Switzerland*

Received 9 February 2008; received in revised form 28 August 2008; accepted 29 August 2008

KEYWORDS
Physical activity;
Sports;
Exercise;
Psychosocial stress;
Cortisol;
Heart rate

Summary Physical activity plays a key role in the control of neuroendocrine, autonomic, and behavioral responses to physical and psychosocial stress. However, little is known about how the level of physical activity modulates stress responsiveness. Here, we test whether different levels of physical activity are associated with different adrenal, cardiovascular, and psychological responses to psychosocial stress. In addition, competitiveness is assessed as a personality trait that possibly modulates the relationship between physical activity and stress reactivity. Eighteen elite sportsmen, 50 amateur sportsmen, and 24 untrained men were exposed to a standardized psychosocial laboratory stressor (Trier Social Stress Test). Repeated measures of salivary free cortisol, heart rate, and psychological responses to psychosocial stress were compared among the 3 study groups. Elite sportsmen exhibited significantly lower cortisol, heart rate, and state anxiety responses compared with untrained subjects. Amateur sportsmen showed a dissociation between sympathetic and hypothalamic—pituitary—adrenal responsiveness to stress, with significantly reduced heart rate responses but no difference in cortisol responses compared with untrained men. Different levels of competitiveness among groups did not mediate stress reactivity. Our results are in line with previous studies indicating reduced reactivity of the autonomic nervous system to psychosocial stress in trained individuals. More importantly, these findings imply a differential effect of the level of physical activity on different stress-related neurophysiological systems in response to psychosocial stress.

1. Introduction

Psychosocial stress increases the risk of developing cardiovascular and mental diseases, such as hypertension or

* Corresponding authors. Tel.: +41 44 635 7363; fax: +41 44 635 7159.
E-mail address: m.heinrichs@psychologie.uzh.ch (M. Heinrichs).

0306-4530/$ — see front matter © 2008 Elsevier Ltd. All rights reserved.
doi:10.1016/j.psyneuen.2008.08.023

depression (Gold et al., 1988a,b; McEwen, 2000, 2002; Vanitallie, 2002). Physical activity is commonly regarded as beneficial to both physical and psychological health, and is seen as an effective preventive measure and treatment for stress-related diseases (Perkins et al., 1986; Ross and Hayes, 1988; Steptoe et al., 1993; Blumenthal et al., 1999; Babyak et al., 2000; Talbot et al., 2002; Ketelhut et al., 2004; Barlow et al., 2006; Nabkasorn et al., 2006). Physically active people show reduced reactivity to physical stressors as well as reduced susceptibility to the adverse influences of life stress (Tucker et al., 1986; Luger et al., 1987; Deuster et al., 1989; Steptoe et al., 1989; Dishman, 1997; Throne et al., 2000; Dishman et al., 2006; Rimmele et al., 2007). Moreover, it has been proposed that physical activity influences stress reactivity more generally, with protective effects also on non-physical stress, such as mental stressors (Claytor, 1991; Cox, 1991; Sothmann et al., 1991, 1996). Although findings are not uniform (de Geus and van Doornen, 1993; Moyna et al., 1999; Jackson and Dishman, 2006), there is substantial evidence showing that physical activity is associated with lower reactivity of the sympathetic nervous system and the hypothalamic–pituitary–adrenal (HPA) axis to psychological stress protocols. Specifically, physically active subjects showed lower cortisol increase (Rimmele et al., 2007), lower cardiovascular reactivity (Crews and Landers, 1987; Spalding et al., 2004; Rimmele et al., 2007), and more rapid cardiovascular recovery (Jackson and Dishman, 2006) to psychological laboratory stressors in comparison with less active controls. Interestingly, stress reactivity differs not only between extreme groups of physically active and inactive controls, but also between groups with less distinct differences in activity levels. For example, heart rate reactivity to a mental stressor is lower and heart rate recovery is faster in elite sportsmen compared with amateur sportsmen (Moya-Albiol et al., 2001). Thus, the level of physical activity might differentially affect stress reactivity, which could also explain some inconsistent results of previous studies.

Personality traits may be important modulators of the relationship between physical activity and stress reactivity. Compared with untrained controls, sportsmen typically show higher levels of self-efficacy (Netz et al., 2005; Rimmele et al., 2007) and competitiveness (Frederick, 2000), with elite sportsmen scoring significantly higher on competitiveness in comparison to amateur sportsmen (Houston et al., 1997). Notably, self-efficacy has been associated with lower anxiety and physiological stress reactivity (Schwarzer, 1992; Bandura, 1997; Butki et al., 2001), and competitiveness has been related to higher cardiovascular reactivity to competition (Harrison et al., 2001). However, studies relating to the modulating influence of self-efficacy and competitiveness on stress reactivity in sportsmen are scarce. In a recent study from our laboratory, higher levels of self-efficacy in elite sportsmen were found to be unrelated to lower physiological and subjective stress responses compared with untrained men (Rimmele et al., 2007). Sportsmen with higher levels of competitiveness exhibit lower anxiety before a competition (Jones and Swain, 1992). However, whether or not competitiveness likewise accounts for differences in reactivity to a psychosocial stressor is unclear.

The aim of the present study was twofold. First, we examined the effect of different levels of physical activity on psychosocial stress reactivity by including three study groups that clearly differ in their level of physical activity (elite sportsmen, amateur sportsmen, and untrained men). Second, we investigated possible modulating effects of competitiveness on stress responsiveness. Physical fitness was characterized by reported training regimens and by a lactate test. Psychological and physiological responses to a psychosocial laboratory stressor were assessed by repeated measurement of state anxiety, mood and calmness, heart rate, and salivary free cortisol levels.

2. Methods

2.1. Participants

The final study sample comprised 18 elite sportsmen, 50 amateur sportsmen, and 24 untrained men. All participants were recruited by the Swiss Federal Office of Sports, local sports clubs, and through advertisements in newspapers and at the local universities in Zürich. Based on the physical activity levels and endurance capacity of trained subjects assessed by a physical fitness test and a self-report questionnaire (see Section 2.2), subjects were classified into groups of elite sportsmen, amateur sportsmen, and untrained

Table 1 Description of the study groups

	Elite sportsmen (n = 18)	Amateur sportsmen (n = 50)	Untrained men (n = 24)
Age (years)	24.17 ± 0.89	24.82 ± 0.43	23.65 ± 0.61
Body mass index (kg/m^2)	22.27 ± 0.54	21.8 ± 0.25	21.46 ± 0.42
Perceived stress (PSS)	19.79 ± 1.36	21.64 ± 0.94	22.91 ± 1.30
Training (h/week)**	11.61 ± 1.07	5.44 ± 0.34	0.37 ± 0.12
Running (h/week)**	4.67 ± 1.01	2.43 ± 0.21	–
Running distance (km/week)**	42.95 ± 8.34	21.43 ± 1.72	–
V 4 mmol/l (km/h)**	15.38 ± 0.51	13.16 ± 0.25	–
Maximum velocity (km/h)*	18.84 ± 0.38	17.35 ± 0.32	–
Perceived exertion (BORG rating scale)	18.33 ± 0.27	18.67 ± 0.19	–

Data are expressed as mean ± S.E.M.
V 4 mmol/l—velocity at 4 mmol/l blood lactate concentration; PSS—perceived stress scale.
* $p < 0.05$.
** $p < 0.01$.