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Reduced emotional stress reactivity to a real-life academic examination stressor in students participating in a 20-week aerobic exercise training: A randomised controlled trial using Ambulatory Assessment

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ABSTRACT

Objectives: To examine if a preventive 20-week aerobic exercise intervention (AET) can improve emotional stress reactivity during real-life stress.
Design: Randomised controlled trial; within-subject design.
Method: Sixty-one inactive students were randomly assigned to a waiting control and an AET group. To capture the situation-specific, intra-individual data in real life, electronic diaries were used. Participants reported their moods and perceived stress (PS) repeatedly over two days during their daily routines pre- and post-intervention. The pre-intervention baseline assessment was scheduled at the beginning of the semester, and the post-intervention assessment was scheduled at a real-life stressful episode, an academic examination. For the aerobic fitness assessment, both groups completed a cardiopulmonary exercise test on the treadmill before and after the intervention. Multilevel models (MLMs) were conducted to compare within- and between-subject associations.
Results: Significant emotional stress reactivity was evident in both groups during all assessment periods. However, participants in the AET group showed lower emotional stress reactivity compared with their control counterparts after the 20-week training programme during the real-life stress episode (the academic examination).
Conclusions: AET conferred beneficial effects on emotional stress reactivity during an academic examination, which is likely an extremely stressful real-life situation for students.
AET appears to be a promising strategy against the negative health effects of accumulated emotional stress reactivity.

Introduction

Research in psychology has found that reactivity to daily life stress is not only determined by a physiological response but also can be defined as a covariation of stress and affect (Sliwinski, Almeida, Smyth, & Stawski, 2009). Perceived daily life stressors, such as excessive demands at work, have an immediate effect on physical and emotional functioning (Van Eck, Nicolson, & Berkhof, 1998; Zautra, Affleck, Tennen, Reich, & Davis, 2005). For example, the risk of depression and cardiovascular disease increases through the accumulated effects of daily stress (Cacioppo et al., 1998; Carels, Blumenthal, & Sherwood, 2000; Van Eck, Berkhof, Nicolson, & Sulon, 1996). Enhanced emotional reactivity to real-life stress reflected by Negative Affect (NA) predicts physiological (Salovey, Rothman, Detweiler, & Steward, 2000; Van Eck et al., 1996, 1998) diseases and higher vulnerability to psychotic disorders (Collip et al., 2013; Myin-Germeys, van Os, Schwartz, Stone, & Delespaul, 2001). Patients with psychosis showed increased emotional sensitivity to smaller disturbances in daily life (Myin-Germeys, Krabbendam, Delespaul, & van Os, 2003). In addition, the

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emotional component of stress reactivity plays an important role in future stress appraisals (Lazarus & Folkman, 1984).

Physical activity and exercise offer the potential to reduce the risk of stress-induced mental and physical diseases (Warburton, Katzmarzyk, Rhodes, & Shephard, 2007). Until now, the existing link between the health-enhancing effects of physical exercise and the phenomenon of stress has been mostly explained by the so-called 'stress-buffer hypothesis' (Gerber & Pühse, 2009; Hamer, 2012; Sothmann, 2006; Tsatsoulis & Fountoulakis, 2006), which is based on the assumption that the positive health effects of physical activity and fitness serve as a moderator in the relationship between stress and health. In terms of stress reactivity, researchers have mainly examined the physiological parameters (heart rate variability, heart rate, cortisol) of fit versus unfit individuals at baseline and during mental stress tasks in laboratories (De Geus & Stubbe, 2007; Forcier et al., 2006; Gerber, 2008; Jackson & Dishman, 2006; Sothmann, Hart, & Horn, 1991). Because psychology research indicates that emotional and physiological stress reactivity may differ (Campbell & Ehlert, 2012), it is also important to assess emotional stress reactivity. However, existing research that considers the association between exercise and emotional stress reactivity has a number of limitations.

First, most studies have used laboratory-induced stress tasks, and the results of both cross-sectional studies (Klaperski, von Dawans, Heinrichs, & Fuchs, 2013; Rimmele et al., 2007, 2009) and randomised controlled trials are inconsistent (Anshel, 1996; Calvo, Szabo, & Capafons, 1996; Goldin, Ziv, Jazaieri, Hahn, & Gross, 2013; Julian, Beard, Schmidt, Powers, & Smits, 2012; Throne, Bartholomew, Craig, & Farrar, 2000; Zanstra & Johnston, 2011). In a recent cross-sectional study that used the Trier Social Stress Tests (TSST), a laboratory stress test that is more related to naturalistic stressors, Klaperski et al. (2013) found greater decreases in mood in young women who exercised compared with women who did not exercise in response to the TSST. Using a similar study protocol, Rimmele et al. (2009) reported contradictory findings, namely, higher anxiety and lower mood levels in untrained compared with trained men. Puterman et al. (2011) found that activity levels moderated the relationship between rumination and cortisol levels in response to acute stressors, suggesting that active people may be protected against stress-induced rumination. Although laboratory studies deliver important insights under controlled conditions, they often do not result in the same outcomes as those from naturalistic settings (Gauvin, Rejeski, & Norris, 1996; Wilhelm, Grossman, & Müller, 2012).

Second, previous randomised controlled trials used single retrospective pre/post self-report measures of NA and global measures of PS (Baghurst & Kelley, 2014; De Geus, van Doornen, & Orlebeke, 1993; Norris, Carroll, & Cochrane, 1992). However, psychological variables such as stress and affect are fluctuating constructs that change over the course of time (Stone, Smyth, Pickering, & Schwartz, 1996). Moreover, the patterns of responses to daily stressors may vary (Bolger & Schilling, 1991). Thus, repeated real-time assessments of PS and affective states during different situations across contexts represent the dynamic nature of the subjective stress experience more accurately than single pre/post assessments (Lazarus, 2000; Poole et al., 2011; Schlotz et al., 2008).

Finally, the few conducted field studies are cross-sectional and focus on the associations between acute exercise and emotional stress reactivity in daily life (Giacobbi, Hausenblas, & Frye, 2005; Giacobbi, Tuccitto, & Frye, 2007; Steptoe, Kimbell, & Basford, 1998). For example, Giacobbi et al. (2007) asked university students about their daily exercise, conducted threat appraisals in response to stressful events and assessed positive/negative affect via an internet platform during an examination period. During the most stressful days, exercise was significantly related to increased positive affect (PA). In addition, exercise led to decreased NA when events were appraised as being threatening; however, NA increased with accompanied exercise when events were appraised at higher threat levels. In another study, Giacobbi et al. (2005) showed that exercise and daily life events were both independently associated with PA. Increased levels of exercise led to increases in PA on days with more positive and more negative events. Steptoe et al. (1998) found fewer perceived stressful events on exercise days compared with non-exercise days among regular exercisers with low trait anxiety and higher PA on exercise days compared with non-exercise days. Another daily life study showed that walking time during the evening was inversely correlated with perceived stress (PS) ratings before going to sleep, and walking time during the afternoon was inversely correlated with negatively evaluated high activation during the evening (Hallman & Lyskov, 2012). None of the studies addressed the effects of regular exercise on emotional stress reactivity during real life.

To date, there has been a need for inexpensive strategies that are easy to use and effective at preventing the development of mental disorders, such as depression. The potential of exercise as a strategy to reduce the negative effects of repeated enhanced emotional reactivity to real-life stress is still unclear. To overcome the shortcomings of previous studies, we conducted a randomised controlled trial using Ambulatory Assessment. The term "Ambulatory Assessment" encompasses a wide range of methods used to study people in their natural environments, including momentary self-reports, ecological momentary assessments, and observational and physiological methods (Trull & Ebner-Priemer, 2013).

To investigate if a preventive 20-week aerobic exercise intervention could lower emotional stress reactivity during real life, we compared the emotional stress reactivity of students who were participating in aerobic exercise training with a control group (CG) pre- and post-intervention. To maximise within-subject differences in stress reactivity and to demonstrate the treatment effect, we chose the following two real-life assessment periods: We set the pre-intervention baseline assessment to the beginning of the semester because we assumed that students had low stress at this time. The post-intervention assessment was set to the end of the semester (the examination period) and was used as the real-life stressful episode given that academic examinations are a real-life demand that induces noticeable stress in students (Hazlett, Falkin, Lawhorn, Friedman, & Haynes, 1997; Nguyen-Michel, Unger, Hamilton, & Spruijt-Metz, 2006).

Methods

Participants

Sixty-one inactive ($\leq 1\times$ moderately active for 60 min/week) male electrical engineering students ($M_{age} = 21.4$, $SD = 1.6$) were recruited during the semester's first week of lectures. The sample came from two phases (each with 30 participants) that lasted for one winter semester (October 2011 to March 2012 and October 2012 to March 2013). After the study, participants attended a lecture on the potential of exercise to reduce stress. We addressed only subjects in their 3rd or 5th semesters of university studies because they sat for similar exams. Thus, we achieved similar conditions during academic examinations for all participants. To recruit participants, we informed the students about the study during lectures in the first week of the semester. Interested students signed up to be contacted via email to receive an invitation to the study kick-off meeting. Every student received information about the study, and eligible participants who wanted to participate gave written informed consent. Students did not receive financial compensation,