Psychoneuroendocrinology 87 (2018) 141–146

Contents lists available at ScienceDirect

Psychoneuroendocrinology

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

The socially evaluated handgrip test: Introduction of a novel, time-efficient stress protocol

Johannes B. Finke[a,*], Grit I. Kalinowski[b], Mauro F. Larra[a], Hartmut Schächinger[a]

[a] Institute of Psychobiology, Department of Clinical Psychophysiology, University of Trier, Germany
[b] Sankt-Franziska-Stift, Hospital for Psychosomatic Medicine, Bad Kreuznach, Germany

ARTICLE INFO

Keywords:
Stress
Handgrip
Social evaluation
Cortisol
Autonomic nervous system

ABSTRACT

Most widely-used stress-induction procedures (such as the TSST and the Cold Pressor Test) require considerable effort and overhead in terms of preparation, logistics, and staff recruitment. Moreover, while known to reliably induce HPA axis activation, especially when combined with social self-threat, most conventional laboratory stressors cannot be flexibly adapted to elicit either a mainly autonomic or an additional endocrine stress response. Being a promising alternative approach, a new version of the isometric handgrip test enriched by a social-evaluative component was evaluated in the present study.

On two consecutive sessions, forty participants (20 women) performed a handgrip task at both 45% (stress) and 10% (control) of maximum voluntary isometric contraction lasting for 3 min. During the stress test, continuous visual feedback on performance was given. Participants in the social-evaluative condition (50%) were observed and evaluated by a previously unknown person of the opposite sex, whereas in the standard condition feedback was provided via a computer monitor. Cardiovascular measures (heart rate, blood pressure) as well as additional indices of autonomic reactivity (skin conductance, heart-rate variability) were registered before, during, and after stress induction. Moreover, changes in salivary cortisol and in subjective well-being were assessed.

Relative to control, significant increases in cardiovascular and sympathetic activity were found, irrespective of experimental group. Importantly, however, additional social evaluation resulted in elevated cortisol levels. Furthermore, evidence for reduced vagal tone during sustained socially evaluated handgrip emerged. In conclusion, the socially evaluated handgrip test represents a versatile, time-efficient method to induce stress in small laboratory settings.

1. Introduction

Intense physical effort is known to cause rapid activation of the sympathetic nervous system, matching energy supply to increased metabolic demands. However, neuroendocrine responses to transient physical challenges may depend on internal and external psychological determinants, such as (perceived) social-evaluative threat, thought to be among the most powerful modulators of cortisol reactivity during potentially stressful events (Dickerson and Kemeny, 2004). This might be the main reason why previous research has associated static grip strength exercises with substantially heightened cardiovascular activity (Ewing et al., 1974; Krzemiński et al., 2012; Mitchell and Wildenthal, 1974), yet mostly failed to show corresponding increases in cortisol levels, indexing stress-induced activation of the hypothalamus-pituitary-adrenal (HPA) axis. Clinically, handgrip strength is an established index of overall physical health, especially in elders, positively related to bone density (Sinaki et al., 1989), muscle mass (Kallman et al., 1990), nutritional status (Hunt et al., 1985), and even healthy development of body composition during childhood (Sartorio et al., 2002). In turn, negative prospective associations with morbidity and aging (such as decline in manual performance; Hughes et al., 1997; and physical disability; Rantanen et al., 1999) as well as mortality risk (Laukkanen et al., 1995) have been found. However, while sympathetic activation due to sustained handgrip is well-documented, and some prior investigations have also reported elevated cortisol levels in response to static manual strength exercises (Few et al., 1975), others showed null results regarding ACTH and cortisol (despite significant rises in blood pressure and heart rate, as well as vasopressin; Nazar et al., 1989) or did not assess endocrine parameters related to the HPA axis in the first place, even though implementing the handgrip task as a means for stress induction (e.g., Jones et al., 1996; Nielsen and Mather, 2015). Another recent study reported elevated salivary cortisol in high-anxious

* Corresponding author at: University of Trier, Institute of Psychobiology, Johanniterufer 15, 54290 Trier, Germany.
E-mail address: finke@uni-trier.de (J.B. Finke).

http://dx.doi.org/10.1016/j.psyneuen.2017.10.013
Received 23 June 2017; Received in revised form 5 October 2017; Accepted 12 October 2017

women (yet only during the follicular phase) after a combination of mental stress (i.e., Stroop task) and a handgrip exercise (Hlavacova et al., 2008). Overall, the evidence regarding a putative modulation of neuroendocrine reactivity is inconclusive, since prior studies assessing hormonal changes suffered from major methodological shortcomings, including severely restricted sample sizes, insufficiently balanced study designs, and use of non-standard procedures.

Progress in stress research relies on the availability of versatile, feasible, and time-efficient laboratory stressors. Since previous research indicated that by enriching physical stress induction protocols, such as the Cold Pressor Test (CPT; Hines and Brown, 1932; Lovallo, 1975), with a social-evaluative component substantial increases in cortisol reactivity can be achieved (Schwabe et al., 2008), the present study aimed at validating a new version of the isometric handgrip test performed either with or without social evaluation. Technically, the handgrip test offers several methodological advantages over most widely-used stress induction procedures which usually require considerable effort and overhead in terms of preparation, logistics, and staff recruitment. For example, apart from issues of timing and hygiene, proper implementation of the CPT (which consists in having participants immerse their hands or feet in ice water for several minutes) demands monitoring of participants by medical staff and availability of emergency support (in view of potentially serious complications such as vasovagal syncope). Another well-known stress protocol, the Trier Social Stress Test (TSST; Kirschbaum et al., 1993), takes considerable time to conduct and requires extensive training and preparation of confederates. In contrast, the handgrip test adapted for the present study (following medical standards as recommended by DeQuattro and Lee, 1989) is minimally invasive, can be performed in almost any lab environment and easily combined with other experimental procedures, and it requires virtually no time-consuming preparation on the part of the experimenter. Moreover, the method proposed here allows to vary physical strain on a parametric basis, controlling for interindividual differences in responsivity by reference to individual maximum strength. In addition, while conventional laboratory stressors (such as the TSST) have been shown to reliably induce HPA axis activation in most participants, they cannot be easily adjusted to elicit either a mainly autonomic or an additional endocrine stress response. The (socially evaluated) handgrip test, however, might be a promising approach to overcome this limitation. Based on initial evidence, as outlined above, we expected cardiovascular and autonomic indices to reflect mainly effects of physical effort and fatigue, whereas changes in cortisol might show greater sensitivity to exposure to social-evaluative threat during stress induction.

2. Materials and methods

2.1. Participants

Forty students (20 women; mean age: 24.6 years, $SD = 2.9$) from the University of Trier and the University of Applied Sciences Trier participated in the present study, receiving partial course credit or a small monetary reward (25€). Participation was limited to healthy nonsmokers (< 5 cigarettes per day) without confirmed psychiatric or chronic somatic disorders. To control for female hormonal status, only women taking oral contraceptives were included. Further criteria for exclusion were regular intake of medication (except contraceptives) or illegal drugs, excessive exercise exceeding a workload of 8 h/week or regular night shifts. Mean BMI of the sample was 22.0 kg/m^2 ($SD = 2.4$). Participants had to refrain from drinking alcoholic or caffeinated beverages as well as from exercising within 3 h prior to the experiment. Blood pressure data of one participant were lost due to technical failure of the blood pressure monitor. Also, data of pneumatic pressure from another participant were corrupted, probably due to computer error while saving. All procedures employed in the present study were IRB approved.

2.2. Design and procedure

To limit the influence of diurnal fluctuations in cortisol, experimental sessions were scheduled in the afternoon (between 12 p.m. and 6 p.m.). On two consecutive sessions within one week (spaced at least two days apart), all participants underwent the handgrip test both at 45% (stress) and 10% (control) of maximum voluntary contraction (MVC). Half of the participants ($n = 20$; 10 women) were randomly assigned to the condition involving social evaluation. Participants in the social evaluation group were monitored by a confederate of the experimenter during stress induction (or control), whereas the other group received feedback via a computer display only. Order of testing (stress vs. control) was counterbalanced for sex and condition. At the end of the first session, a low-arousing (passive) experiment related to another study was conducted (which will be reported elsewhere).

Upon arrival at the laboratory, participants were first informed about the general methods used in the experiment, however, without any reference to social evaluation or stress. Moreover, in order to counteract specific anticipatory effects, participants in both treatment groups remained ignorant of the exact duration and procedure of the test. After written consent was obtained, the experimenter conducted a short diagnostic interview including questions about general personal and health-related information. Subsequently, the participant was familiarized with the routine of providing saliva samples. After attaching electrodes and giving initial instructions the experimenter asked the participant to relax for a while and left the room. Following a short resting phase of 5 min duration (aimed at acclimatization to the lab environment), the experimenter re-entered the room and explained how to use the grip-ball. Maximum voluntary contraction was then measured in two 10-s trials (with a break of 30 s in-between). The highest scoring out of both trials served as the reference for calculating individual maximum strength. After another 5-min resting phase (during which physiological baseline measurements were performed), the continuous handgrip test took place, lasting for a total duration of 3 min. Afterwards, participants stayed again alone in the room while post-treatment measurements were recorded.

During both pre-test and stress induction (or control) participants exerted force with their dominant hand to a pneumatic rubber ball linked to a customized dynamometer (readout by an A/D interface linked to the controlling computer). Permissable range in the stress condition was 42–48% MVC (control: 7–13% MVC). During the handgrip test, participants in the non-social evaluative condition were given continuous visual feedback on their performance by means of a life-sized hand symbol with an extended index finger shown on a computer screen at a viewing distance of approximately 100 cm. By pointing either upwards (indicating insufficient pressure), downwards (too much pressure), or to the left (optimal pressure), the symbol signaled participants how to adjust the pressure (according to both the experimental condition and their individual pre-measured strength level). E-Prime 2.0 (PST Software, Inc.) was used for the presentation of instructions and visual stimuli. In the social evaluative condition, equivalent gestural feedback was instead provided by a real person of the opposite sex (previously unknown to the participant) standing in front of him/her (also at a distance of roughly 100 cm). The confederate was trained to adapt his/her responses quickly and accurately, receiving real-time information about both the target range and the actual pressure applied by the participant (via a display visible to him/her, but not to the participant).

2.3. Data acquisition, reduction and analysis

2.3.1. Cardiovascular measures

Systolic and diastolic blood pressure was measured intermittently using a Dinamap blood pressure monitor (Dinamap 1846-SX, Critikon, Inc.) with a cuff attached to the participant's non-dominant arm. All other peripheral physiological data were recorded continuously by