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Borderline personality disorder symptoms in relation to adverse childhood experiences and balance performance

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1. Introduction

The adrenals respond to threats by pouring out major stress hormones. The hypothalamic–pituitary–adrenal (HPA) axis is the elite force of the defense cascade, and, when functioning properly, it helps individuals deal with crisis. However, the hormones ultimately return to the brain, thereby affecting the brain's functioning and with it behavior and health (Heim & Nemeroff, 2001). When unremitting stress forces the axis to tilt, depression and difficulties in emotional regulation can be among the consequences (Elbert & Rockstroh, 2003; McEwen, 2002). Problems in emotion regulation prevail in various kinds of mental disorders (Sloan et al., 2017), and have been found in victims of adverse childhood experiences (ACE; Dvir, Ford, Hill, & Frazier, 2014), in fact as well in stressed healthy samples (Shipman, Edwards, Brown, Swisher, & Jennings, 2005). Neglect of infants (NOI) entails extended periods of time in which infants are left without protection or company (McLaughlin, Sheridan, & Nelson, 2017), and is biologically programed as a threat and may alter developmental trajectories. The impact of early and sometimes prenatal life stress on mental health is mediated by epigenetic reprogramming of at least the HPA axis (Radtke et al., 2011, 2015). This has been documented for the glucocorticoid receptor (hGR) gene. Radtke et al. (2015) suggest an additive effect of early modulated hGR methylation and later ACE in predicting borderline personality disorder (BPD)-associated symptoms, suggesting that the combination of both NOI and other forms modifying DNA methylation and later ACE possibly poses a decisive risk for BPD. Early during development, the cerebellar vermis (CV) might be particularly vulnerable to these modifications (Teicher, 2000). Moreover, NOI may result in a lack of cerebellar stimulation, which would impact its development. Non-neglected babies are carried for hours every day. It is thought that the infants are soothed by vestibular stimulation, which, when combined with the subsequent inputs into the cerebellum, contributes to sensory-vestibular development (Esposito et al., 2013; Schaper, 1982). Later in life, this deprivation could manifest through abnormalities in sway. The CV regulates balance in tandem stand (Ouchi, Okada, Yoshikawa, Nobezawa, & Futatsubashi, 1999). Sensorimotor problems (Gardner, Lucas, & Cowdry, 1987) and structural deviance in the CV in BPD (Schauer & Elbert, 2019 unpublished manuscript) highlight the importance of considering cerebellar regions in understanding these symptoms. In the present hypothesis-generating pilot study, we explored a possible relation of BPD symptoms, postural sway, a behavioral measure of cerebellar processing (Morton & Bastian, 2004), and ACE.

2. Method

2.1. Study sample and Procedure

To preclude possible sex effects increasing the variance, we recruited only females. Neurological damage, physical impairment and age over 50 years were exclusion criteria. On the assumption of the dimensionality of BPD associated symptoms, we investigated subjects with little (healthy controls, $n = 29$), moderate (depressive patients, $n = 5$) or high BPD symptoms (BPD patients, $n = 9$), in in- or outpatient treatment diagnosed according to the International Statistical Classification of Diseases and Related Health Problems, 10th Revision (ICD-10, World Health Organization, 1992). Age ranged between 18 and 49 years (average 27.8; $SD = 8.5$). Education was high $n = 26$, moderate $n = 13$, and low $n = 4$ (classified by level of secondary education). Participants were medicated, with varying prescriptions (last two weeks: analgesics $n = 16$, hypnotics $n = 6$, anxiolytics $n = 2$, antidepressants $n = 12$, neuroleptics $n = 5$, phase-prophylactic agents $n = 2$, gastric drugs $n = 7$, laxatives $n = 0$, blood pressure medication $n = 0$). Subjects were informed and agreed by informed consent to the study protocol, approved by the Ethics-Committee of the University of Konstanz.

2.2. Materials and instruments

Balance aims at the minimization of sway (Jančová, 2008). Force platforms quantify sway by detecting changes in the Center of Force (CoF) to the ground (Jančová, 2008). We used the Leonardo Mechanograph Ground Reaction Force Platform and its STD software (Novotec

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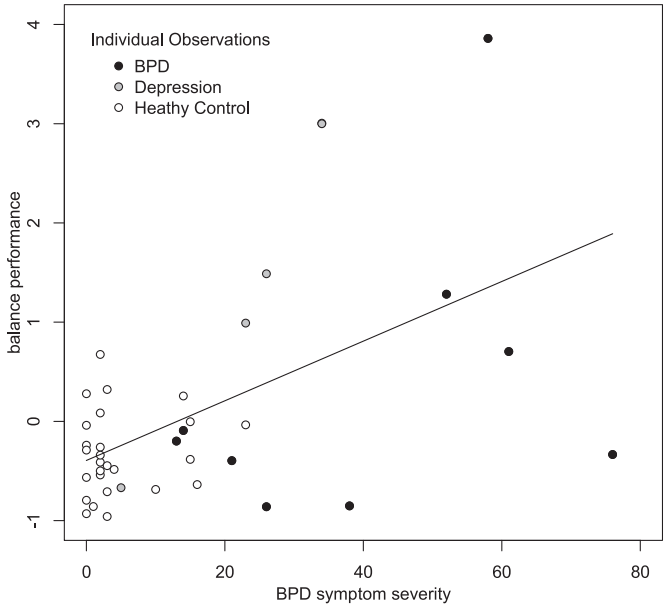

Fig. 1. Scatter plot illustrates the associations between BPD symptom severity and balance performance. Individual observations are in this plot displayed as a function of the dimensional current BPD symptom severity, in individuals with current BPD, current depression and healthy controls.

Medical GmbH Pforzheim, Germany). It calculates the CoF, variations in CoF and standard ellipses including 90% of CoF. Higher values indicate more sway. Current BPD symptom severity was measured by the *Borderline Symptom List -23* (Bohus et al., 2009; *range* = 0–92); the average sample severity was 14.87 (*SD* = 18.91; *range* = 0–76). ACE were assessed using the *KERF-I* (Isele et al., 2014, overall severity *range* = 0–100); the mean sample severity was 22.62 (*SD* = 16.53; *range* = 0–68.17). Note that such a retrospective assessment of NOI is not possible, as no explicit memory is formed before the age of 2.

2.3. Data analysis

Subjects performed single trial *tandem stand* (left foot toes to right foot heel, arms at the side of the body, head straight and not fixate, ten seconds) with *eyes open (Eo)* then *closed (Ec)*. Balance parameters were condensed by factor (principal component) analysis on one *balance performance* factor (*Kaiser–Meyer–Olkin* = 0.78; *Bartlett's test of sphericity* $X^2(6) = 115.58$, $p < .001$; *eigenvalue* = 3.17). It explained 79% of the variance. Factor loadings were high: *Eo relative path length* = 0.93; *Eo* sway *index* = 0.87; *Ec relative path length* = 0.93; *Ec sway index* = 0.83. The average sample balance performance was 0 (*SD* = 1; *range* = −0.96–3.86, $n = 40$), it correlated with education ($r_{Tau} = -0.25$; $p < .05$), not with age ($r = 0.11$, $p = .50$), body mass index ($r = 0.05$, $p = .74$), height ($r = 0.29$, $p = .07$), weight ($r = 0.10$, $p = .52$), foot length ($r = 0.25$, $p = .12$) or fitness (Runge, Rittweger, Russo, Schiessl, & Felsenberg, 2004; $r = -0.23$, $p = .15$). Pearson correlations were analyzed, $p < .05$, two-tailed testing. Missing balance data meant partial exclusions among correlations, and list-wise exclusion for factor analysis.

3. Results

Correlations indicated strong positive associations between BPD symptoms and balance performance ($r = 0.52$; $p = .001$; see Fig. 1). The overall severity of ACE was correlated with BPD symptoms ($r = 0.57$; $p < .001$), but not with balance performance ($r = 0.12$; $p = .47$).

4. Discussion

In accordance with our hypothesis, BPD symptoms were associated with sway. ACE (recalled after the age of 3) were correlated with BPD symptoms, but not with balance. Radtke et al. (2015) indicated that BPD is best predicted by the combination of ACE and the epigenetic modification of the hGR gene. The altered DNA-methylation observed by Radtke et al. (2015) is likely to result in a long-term modification of glucocorticoid regulation and with it inflammation and energy metabolism (Boeck et al., 2018a). Childhood maltreatment has been associated with altered levels of lipid peroxidation (Boeck et al., 2019) cellular damage of the genome in terms of telomere shortening (Boeck et al., 2018b) and alterations in mitochondrial bioenergetics in peripheral blood immune cells (Boeck et al., 2016) and hippocampal tissue (Nold et al., 2019 in press). The Nervus vestibulocochlearis as well as the cerebellum might also be affected by stress-induced changes in pro-inflammatory signaling and bioenergetic alterations. This might lead together with disturbances of hemoglobin-mediated oxygen supply in erythrocytes due to increased levels of oxidative stress (Chiu & Liu, 1997; Karabatsiakis et al., 2015; Koenig et al., 2018) to the worse balance performance in stressed cohorts (Iris-Tatjana Kolassa and Alexander Karabatsiakis, personal communication, May 14, 2019). Cerebellar maturation may further be impaired by insufficient early vestibular stimulation (Levinson, 1989; Schauer & Elbert, 2019 unpublished manuscript; Sklare, Konrad, Maser, & Jacob, 2001). As a retrospective retrieval of NOI is impaired by deficits in explicit memory forming (before the age of 2), a prospective assessment of NOI would be necessary to test this prediction. Patients were medicated. We tried to minimize potentially induced variance by careful evaluations. Nevertheless, an un-medicated sample would be needed to exclude the possibility of such a confound.

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Conflict of interest

The authors declare that they have no conflict of interest.

Supplementary materials

Supplementary material associated with this article can be found, in the online version, at doi:10.1016/j.mhp.2019.200167.

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