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Resting cardiac function in adolescent non-suicidal self-injury: The impact of borderline personality disorder symptoms and psychosocial functioning

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ABSTRACT

Vagally mediated heart rate variability (vmHRV) is reduced in borderline personality disorder (BPD). Non-suicidal self-injury (NSSI) is associated with comorbid psychopathology, in particular BPD. We aimed to examine differences in cardiac function (vmHRV and heart rate [HR]) comparing adolescents (12–17 years) engaging in NSSI (n=30) and healthy controls (n=30). Further, we aimed to determine clinical concomitants of cardiac function in patients with NSSI. Analyses showed no significant group differences on cardiac function. Controlling for a host of confounding variables resting state HR and vmHRV in adolescents with NSSI were significantly correlated with BPD symptoms and the current level of functioning.

1. Introduction

Lower resting state vagally-mediated heart rate variability (vmHRV) is considered a transdiagnostic marker of psychopathology (Beauchaine and Thayer, 2015). In adults, reduced vmHRV is associated with a variety of psychiatric disorders (i.e., depression; (Kemp et al., 2010), schizophrenia; (Clamor et al., 2016), or borderline personality disorder (BPD, Koenig et al., 2016b)). Resting vmHRV is decreased in children and adolescents with mental health problems, e.g. conduct disorder (Beauchaine et al., 2007) and depression (Koenig et al., 2016a). Non-suicidal self-injury (NSSI; i.e., the self-directed act of harming one's own body tissue by cutting etc. without suicidal intent) is common (16–18%) in non-clinical samples of adolescents (Swannell et al., 2014). NSSI is associated with comorbid psychopathology and represents a diagnostic criterion of BPD. Further, NSSI is associated with suicidal thoughts and suicide attempts (Wilkinson et al., 2011), that themselves have recently been linked to altered vmHRV. While one study found vmHRV to be positively associated with suicidal ideation in a clinical sample (Lin et al., 2015) others have shown that resting vmHRV is negatively associated with suicide ideation in healthy adult students (Forkmann et al., 2016). To date, only one study investigated potential alterations of vmHRV in a sample of 23 parasuicidal adolescents between the ages of 14 and 17 compared to controls (Crowell et al., 2005). Results showed that parasuicidal adolescents exhibit reduced vmHRV. Here we aimed to clarify if cardiac function is altered in adolescent NSSI. It was hypothesized that adolescents engaging in NSSI show greater resting state mean heart rate (HR) and lower vmHRV compared to controls. In secondary analysis, we aimed to determine potential clinical concomitants of altered cardiac functioning.

2. Methods

Data for this secondary analysis were taken from an experimental study on pain in NSSI (Koenig et al., 2015, in press). For the present analysis only baseline data were used. The study was approved by the Ethical Committee of the Medical Faculty, Heidelberg University, Germany (Study: ID S-471/2013). Participants were females between 12 and 17 years of age. The study comprised 30 patients with NSSI recruited from a specialized outpatient unit, engaging in NSSI on at least five days within the last year according to DSM-5 criteria, and 30 age-matched healthy controls. 18 (60%) participants from the NSSI group fulfilled full diagnostic criteria for BPD.

2.1. Assessments

The *German version of the Self-Injurious Thoughts and Behavior Interview* (SITBI-G) was used to obtain detailed information on NSSI

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and suicidality (Fischer et al., 2014). Diagnosis of BPD was confirmed using the German version of the *Structured Clinical Interview for DSM-IV Personality Disorders* (SCID-II; First et al., 2002). Current and lifetime Axis-I disorders were assessed using the German version of the *Mini-International Neuropsychiatric Interview for Children and Adolescents* (M.I.N.I- KID 6.0; Sheehan et al., 2010). The German version of the *Children's Global Assessment Scale* (C.GAS; Shaffer et al., 1983) was used as measure of psychosocial functioning. Depressive symptoms were assessed with the German *Depression Inventory for Children and Adolescents* (DIKJ; Stiensmeier-Pelster et al., 2000). The *Childhood Experience of Care and Abuse Questionnaire* (CECA.Q; Kaess et al., 2011) was administered to measure adverse childhood experiences. Participants provided information on general demographics and health-related variables to control for potential confounders of physiological functioning. Weight (kg) and height (cm) were taken to calculate body mass index (BMI). Alcohol intake, drug use, smoking, oral contraceptives and medication during the past 30 days were assessed and coded as dichotomy (yes/no) for the present analysis.

2.2. Recording of heart rate variability

A Polar® RS800CXTM Heart Rate Monitor was used to record inter-beat-intervals (IBIs) between adjacent heart beats during a 5 min resting period while participants were seated and breathing spontaneously. Polar watches in general (Weippert et al., 2010) and the particular model used in this study, have shown good validity and reliability in recording HRV when compared to classic ECG (*see* Quintana et al. (2012) for a discussion). The baseline recording preceded all experimental procedures involved in the study. Details on the measurement are given elsewhere (Koenig et al., 2015, in press). IBIs were corrected for artifacts excluding IBIs above or below the 10th interquartile range. Mean HR was calculated as beats per minute (bpm) and the square root of the mean squared difference of successive NN intervals (RMSSD) measured in milliseconds (ms) was used as a time-domain measure of vmHRV, reflecting cardiac vagal activity (Task Force, 1996).

2.3. Statistical analysis

Group differences were tested using two-sided student's t-tests or Chi-Square (χ^2) or Fishers' exact F-tests. For exploratory analysis on clinical concomitants of cardiac function, first zero order Pearson correlations were calculated within the NSSI group. Second, clinical variables were added to a stepwise regression model based on a Bayesian information criterion applied on all predictors predicting HR or vmHRV, while adjusting for BMI, alcohol intake, drug use, smoking, pill intake, medication and childhood adversity. All analyses were performed using Stata/SE (Version 14.0; StataCorp LP, College Station, TX, US) with alpha set to 0.05. All tests were two-tailed. Graphs were prepared using GraphPad Prism (version 6.0, GraphPad Software Inc., USA).

3. Results

3.1. Sample characteristics

Sociodemographic and psychiatric characteristics of the study sample are provided in Table 1 of the Supplementary Material. Groups significantly differed on weight (*p=0.007*) and BMI (*p=0.001*), smoking (*p < 0.001*) and drug use (*p=0.010*). Five participants in the NSSI group (16.7%) were on current medication (*Fluoxetin:* n=1; *Valdoxan:* n=4). In the control group one participant was currently taking L-Thyroxin, and 1 participant was using anti-histamines and cortisol. Eleven (36.7%) participants in the NSSI group and 6 (19.4%) controls were continuously taking oral contraceptives

during the 30 days preceding the experiment. Groups significantly differed on the level of functioning (*p < 0.001*), depressive symptoms (*p < 0.001*) and experience of childhood adversity (*p < 0.001*). On average NSSI patients fulfilled 4.73 (SD=2.27) criteria for BPD and reported 96.1 acts of NSSI (SD=77.47) in the past 12 months. All patients reported previous suicidal thoughts - on average 132.7 episodes (SD=112.64) in the past 12 months. 20 participants engaging in NSSI reported previous suicide attempts - on average 1.7 attempts within the past 12 months (SD=1.30). The majority of participants from the NSSI group reported adverse childhood experiences (n=24, 80.0%), unlike participants in the control group (n=4, 13.3%).

3.2. Heart rate and heart rate variability

Groups did not significantly differ on HR (*p=0.213*) or vmHRV (*p=0.984*). HR ($t_{(28)}$=−1.700; *p=0.100*) and vmHRV ($t_{(28)}$=0.304; *p=0.764*) did not differ as a function of childhood adversity in NSSI. In NSSI, HR was unrelated to depressive symptoms ($r_{(28)}$=−0.015, *p=0.936*), acts of NSSI ($r_{(28)}$=−0.138, *p=0.467*), suicidal thoughts ($r_{(28)}$=0.150, *p=0.429*), suicide attempts ($r_{(18)}$=−0.062, *p=0.795*) or the current level of functioning ($r_{(28)}$=0.350, *p=0.058*). vmHRV was unrelated to depressive symptoms ($r_{(28)}$=0.047, *p=0.807*), acts of NSSI ($r_{(28)}$=0.146, *p=0.441*), suicidal thoughts ($r_{(28)}$=−0.245, *p=0.192*) or suicide attempts ($r_{(18)}$=−0.059, *p=0.806*). However, vmHRV was significantly, inversely correlated to the current level of functioning ($r_{(28)}$=−0.486, 95%CI: [−0.720;−0.153], *p=0.006*). Both, HR ($r_{(28)}$=0.479, 95%CI: [0.144;0.716], *p=0.007*) and vmHRV ($r_{(28)}$=−0.418, 95%CI: [−0.676;−0.068], *p=0.022*) showed associations with the number of BPD symptoms, as illustrated in Fig. 1. In stepwise regression, BMI, alcohol intake, drug use, smoking, oral contraceptives, medication, childhood adversity, the number of BPD-criteria, and the current level of functioning were included as potential predictors of HR and vmHRV. Only the number of BPD-criteria and the current level of functioning remained as independent predictors of HR (BPD-criteria: β=2.530, 95%CI: [0.842; 4.218], *p=0.005*; C.GAS: β=0.289, 95%CI: [0.024;0.553], *p=0.034*) and vmHRV (BPD-criteria: β=−6.751, 95%CI: [−11.691;−1.812], *p=0.009*; C.GAS: β=−1.234, 95%CI: [−2.01;−0.460], *p=0.003*). Findings are illustrated in Fig. 1. The number of BPD criteria endorsed and ratings on the current level of functioning were unrelated (r=0.006, *p=0.976*).

4. Discussion

We aimed to clarify if resting cardiac function is altered in adolescents engaging in NSSI. We found no significant differences comparing resting state HR and vmHRV in 30 adolescents engaging in NSSI and matched controls. The number of BPD criteria met and the current level of functioning were significantly associated with both resting HR and vmHRV. Findings remained even after controlling for a host of health related variables (i.e., smoking), that have previously been discussed to potentially underlie altered ANS function in BPD (Koenig et al., 2016b).

These findings highlight that decreases in resting state vmHRV and increases in HR are related to greater symptom severity of BPD. Unlike recent reports (Lin et al., 2015; Forkmann et al., 2016), we found no association of vmHRV and suicidality or NSSI frequency. Further, and in line with a recent meta-analysis (Koenig et al., 2016a), we also found no correlation of depressive symptoms and cardiac function. Finally, the non-significant difference between individuals in the NSSI group with and without childhood adversity may be a function of the disparate sample sizes. Based on these findings, we hypothesize that cardiac function in adolescents engaging in NSSI seems to be less indicative of current behavioral symptoms and affective states, but phenotypic BPD traits and the level of functioning. Interestingly, the direction of the (likewise weak) association of cardiac function and the one-item clinician rated level of functioning is counterintuitive.