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2015-03-05

Mathewson , K J , Pyhälä , R , Hovi , P , Räikkönen , K , Van Lieshout , R J , Boyle , M H , Saigal , S , Morrison , K M , Kajantie , E & Schmidt , L A 2015 , ' Cardiovascular Responses to Psychosocial Stress Reflect Motivation State in Adults Born at Extremely Low Birth Weight ' , Global Pediatric Health , vol. 2 . https://doi.org/10.1177/2333794X15574092

http://hdl.handle.net/10138/178747
https://doi.org/10.1177/2333794X15574092

Global Pediatric Health
January-December 2015: 1–9

DOI: 10.1177/2333794X15574092
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Cardiovascular Responses to Psychosocial Stress Reflect Motivation State in Adults Born at Extremely Low Birth Weight

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Abstract

Background. Adults born extremely preterm appear to have more difficulty managing the stresses of early adulthood than their term-born peers. *Objective*. To examine the effects of being born at extremely low birth weight (ELBW; birth weight < 1000 g) versus at full term on cardiovascular responses to stress. *Method*. Cardiovascular responses were elicited during administration of a widely used laboratory stressor, the Trier Social Stress Test (TSST). *Results*. Term-born adults exhibited a larger decrease in total peripheral resistance and larger increase in cardiac output for TSST performance, reflecting greater resilience, than did ELBW adults. Furthermore, in ELBW participants but not controls, cardiovascular responses were correlated with anxiety, suggesting that their responses reflected feelings of stress. *Conclusions*. Skills-training and practice with relevant stressors may be necessary to increase the personal resources of ELBW participants for managing stress as they transition to adulthood.

Keywords

extremely low birth weight, prematurity, motivation states, cardiac output, total peripheral resistance, Trier Social Stress Test

Introduction

Achieving the typical goals of early adulthood (e.g., living independently, getting a job, finding a partner) requires motivation and purposeful action. While the majority of individuals born very preterm report good quality of life in young adulthood,[1-3] researchers have noted differences in their personality and behavior that may complicate the achievement of milestones associated with this life stage.[4-7] Young adults born at extremely low birth weight (ELBW; birth weight < 1000 g) are at elevated risk for problems related to internalizing symptoms,[8] shyness,[9] and behavioral inhibition.[10,11] Similarly, those born at very low birth weight (VLBW; birth weight < 1500 g) are likely to exhibit higher levels of cautiousness,[12,13] and lower levels of assertiveness and extraversion,[13-15] than their term-born peers. Inhibited behavior may contribute to difficulties in meeting the demands of young adulthood, a time of life where self-presentation tasks abound.

Situations often encountered during the transition to adulthood involve motivated performance, requiring an individual to act instrumentally to achieve an important goal, with no guarantee of a successful outcome. These typically involve self-presentation, for example, delivering a speech or interviewing for a job. As such, these situations may be experienced as "stressful," affecting some individuals more than others.

Psychological states during motivated performance are reliably reflected in cardiovascular responses that represent the net activation of 2 important physiological systems. The presentation of virtually any stressor will activate the sympathetic-adrenomedullary (SAM)

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system, releasing epinephrine, a fast-acting hormone that mobilizes energy reserves, increases heart rate and contractility, and dilates the vasculature to facilitate blood flow to the large muscles for an immediate response to situational demands. Quick onset and offset of the SAM system, coupled with limited activation of the hypothalamic–pituitary–adrenal (HPA) axis, signifies psychophysiological resilience,[16] and has been associated with good performance outcomes during stressful tasks.[17] In contrast, situations that are experienced as "stressful" result in activation of both the SAM system and the HPA axis. Activation of the HPA axis releases cortisol, a relatively long-lasting hormone that inhibits the release of epinephrine, offsetting the vasodilation that would otherwise be initiated by the SAM system, while heart rate and contractility remain high.[18,19] However, joint activation of the SAM system and the HPA axis is metabolically costly, increasing allostatic load[20] and influencing task performance in the short run, and affecting cardiovascular health in the long run.

When engaged in challenging or stressful situations, heart rate and ventricular contractility increase (measured as reductions in heart period [HP] and pre-ejection period [PEP], respectively). However, additional cardiovascular changes, specifically, changes in total peripheral resistance (TPR), and cardiac output (CO), may distinguish between resilience and vulnerability to stress in the following way: a resilient response to a perceived challenge is reflected in reduced TPR, and substantially increased CO, changes that have previously been associated with physiological and emotional confidence.[17] Conversely, cardiovascular reactivity reflecting vulnerability to stress is evidenced as increased TPR, with little or no increase in CO.[21-23] Varying patterns of TPR and CO changes suggest contrasting motivation states.

The Present Study

Here, we examined affective and cardiovascular responses to stress in young adults born at ELBW. We know little about these relations during the transition to adulthood in ELBW survivors. Whether young adults born at ELBW differ from young adults born at term in their approach to motivated performance situations was tested in the present study using a well-known laboratory stressor, the Trier Social Stress Test (TSST).[24] This standardized public-speaking task requires individuals to prepare and deliver an impromptu speech in a mock job interview before a small audience. The TSST reliably elicits strong affective and physiological reactions in unselected populations,[25] as this task involves both motivated performance and exposure to social-evaluative threat (the possibility of being judged negatively by others).

Since ELBW survivors tend to experience more difficulties with social situations and behavioral inhibition than their peers, we hypothesized that term-born adults would approach this task as a manageable challenge, whereas adults born extremely preterm would find the same situation stressful. Term-born controls were expected to generate a more resilient cardiovascular response to TSST performance (lower TPR and greater CO), whereas ELBW participants were expected to exhibit a more vulnerable response (higher TPR and attenuated CO increase). Furthermore, to test the validity of our interpretation of the cardiovascular responses to TSST performance, we correlated cardiovascular reactivity to the TSST with subjective assessments of affective states during TSST performance in each group.

Method

Participants and Overview

The ELBW and control participants were part of a larger study (the Helsinki Study of Very Low Birth Weight Adults), a cohort study of infants born at VLBW between 1978 and 1985 in a geographically defined area around Helsinki, Finland. All were cared for in a single neonatal intensive care unit of a regional center, the Children's Hospital at the Helsinki University Central Hospital. A control group, group-matched for sex and age, was identified from the records of all consecutive births at each of several birth hospitals. For each VLBW survivor, the next available singleton infant born at term (≥37 weeks) was selected. In 2004-2005, 166 (65.1% of those invited) VLBW and 172 (54.8%) term-born controls attended a clinical examination, described elsewhere.[26] Of these, 56 VLBW and 44 term-born randomly selected participants participated in the TSST. Seven participants (3 VLBW, 4 controls) did not complete the test due to equipment difficulties or voluntary withdrawal.

Among the remaining 53 VLBW participants, 16 participants were born at ELBW (≤1000 g), between 24.9 and 31.4 weeks' gestation, weighing between 670 and 1000 g. Due to the sample size, we chose an extreme groups approach to increase power to detect the presence of birth weight group differences in the cardiovascular indices.[27] The ELBW subgroup was intentionally selected for study because these participants were exposed to the greatest risks associated with preterm birth: survival rates of infants born at ELBW were very low during the 1970s and 1980s, for example, 45%.[28]Control participants were born between 38.0 and 42.3 weeks' gestation and weighed between 2520 and 4900 g at birth.

Group comparisons were followed by correlational analyses of cardiovascular indices with subjective ratings and behavior tendencies for each group.

Only those with complete blood pressure, TPR, and CO data from both the resting and test conditions were included in our analyses. TPR and CO data from one control participant who showed no task engagement (eg, no reduction in HP; PEP unavailable) were eliminated from all analyses. The final sample included 35/44 controls (80% of those invited) and 13/16 young adults born at ELBW (81% of those invited).

Self-Reported Affective Responses to TSST

Participants were asked to provide subjective ratings of their affective state at 8 time points before, during, and after TSST performance. Participants rated themselves on terms adapted from a diary developed by Hedges et al,[29] using a scale ranging from 1 to 6 (low level to high level) to indicate how they felt at the time of each measurement. Means of 2 representative variables were selected for associations with cardiovascular reactivity measures in each group, one denoting an unworried, relatively relaxed state ("carefree"), and one representing a more anxious state ("anxious").

Procedure

Each participant provided informed consent before procedures began. Prior to the TSST, a 5-minute baseline recording of resting cardiovascular physiology was performed for each participant (ie, alone, standing in a relaxed position). We then administered the TSST, asking participants to explain to a 2-person evaluation committee in a 5-minute speech why they should be hired for a job, followed by 5 minutes of mental arithmetic. Except for delivering instructions, the committee minimized all verbal and nonverbal communication with the participant. The test was administered in a laboratory setting between 10:45 AM and 4:10 PM.

Blood pressure and impedance measures (ZKG) were monitored using a Finometer (FMS, Amsterdam, Netherlands), a noninvasive, beat-to-beat, finger photo plethysmograph that had been validated against mercury sphygmomanometers.[30] Heart rate was recorded via 3 external electrocardiogram electrodes placed in a modified Lead II configuration. Blood pressure results have been reported previously.[31]

Autonomic parameters (HP, PEP, TPR, CO, systolic blood pressure [SBP], diastolic blood pressure [DBP]) were calculated offline for each individual from blood pressure, impedance, and cardiac data for the resting baseline ("rest") in its entirety (5 minutes total), and an average of the TSST speech and arithmetic conditions ("task"), using Biopac Acqknowledge 3.8.1 software (Santa Barbara, CA) for HP, and WinCPRS software (Absolute Aliens Oy, Turku, Finland) for PEP, TPR, CO, SBP, and DBP. Reactivity measures (change scores) were calculated by subtracting each resting measure from the appropriate averaged task-related measure, a procedure commonly used in psychophysiological studies.[32] The study protocol was approved by the Ethics Committee for Children and Adolescents' Diseases and Psychiatry at the Helsinki University Central Hospital.

Statistical Analyses

Preexisting group differences in the demographic variables, cardiovascular measures, and subjective measures were assessed in t tests or χ^2 tests. Two 2 × 2 (group by condition) ANOVAs were used to estimate task engagement, measured by change in HP and PEP between rest and TSST performance, in each group. Declines in HP and PEP (increased heart rate and ventricular contractility) between rest and task performance indicate sympathetic activation, and by implication, task engagement. Next, a mixed model multivariate analysis of covariance (MANCOVA) was conducted on the TPR and CO change scores, to assess group differences in cardiovascular responses to the TSST. TPR-reactivity and CO-reactivity scores were also combined to make one index (TPR/CO reactivity) for each participant, by subtracting standardized TPR-reactivity from standardized CO-reactivity, and analyzed by ANCOVA. Complementary to the absolute reactivity measures, the combined measure of TPR/CO reactivity allowed us to make group comparisons of cardiac activity changes relative to changes in vascular functioning.[17,19,33,34] Positive values of the combined TPR/CO reactivity measure index a greater sense of challenge, and negative values index greater stress. Subjective ratings experienced during the experimental protocol were assessed in separate 2 (group) by 8 (measurement) ANOVAs, and the group means were correlated with the cardiovascular reactivity measures. To account for violations of sphericity, Huynh-Feldt corrections were used to report significant results. Age, sex, body mass index (BMI), and parental history of hypertension were controlled statistically.

Converging evidence for the interpretation of cardiovascular markers as reflections of motivation states was obtained in analyses of 2 representative subjective ratings: "anxious," and "carefree". Anxiety was selected to reflect the degree of stress participants experienced, and ratings of relaxed, carefree feelings, the degree of challenge. Reliability for both anxiety (Cronbach's α = .93,

Table 1. Characteristics of the Sample (Unadjusted Means).

Variable	ELBW (n = 13), Mean (SD)	Controls (n = 35), Mean (SD)
Birth weight (g)***	850 (114)	3585 (512)
Gestational age (weeks)***	27.9 (2.0)	40.2 (1.2)
SGA status (SGA/AGA)***	7/6	2/33
Gender (male/female)	6/7	14/21
Mean number of fetuses	1.08 (1.0)	1.00 (0.0)
Mother's age	28.7 (4.6)	28.8 (5.7)
Parental hypertension, n(%)	4 (31)	8 (23)
Parental education*	2.5 (1.1)	3.2 (0.9)
Age in years	24.0 (2.5)	23.7 (2.0)
Height (m)	1.65 (0.1)	1.71 (0.1)
Weight (kg)	66.2 (13.1)	71.2 (15.7)
Body mass index	24.1 (3.9)	24.3 (4.8)

Abbreviations: ELBW, extremely low birth weight; SD, standard deviation; SGA, small for gestational age; AGA, average for gestational age.
***$P < .001$. *$P < .05$.

intraclass correlation coefficient = .61, $P < .001$) and carefree ratings (Cronbach's $\alpha = .88$, intraclass correlation coefficient = .47, $P < .001$) was good. The subjective ratings were then correlated with cardiovascular reactivity measures (TPR, CO, combined TPR/CO reactivity) separately for each group, to test for associations between cardiovascular reactivity and self-reported affective states. Significant associations with anxiety would support the interpretation that cardiovascular reactivity reflected stress responses during TSST performance, whereas significant associations with carefree states would suggest general resilience to TSST stress.

Results

Demographic Data

Included (n = 48) and excluded (n = 52) participants were similar with respect to all demographic variables (Ps > .07), except that included participants (mean [M] = 23.8 [2.1] years) were 1 year older than nonparticipants (M = 22.9 [1.9] years, $P < .03$), and mean birth weights (included: M = 2844 [1304]; excluded: 1575 [932] grams) and gestational ages (included: M = 36.8 [5.7]; excluded: 31.6 [4.6] weeks) were larger for those included, as a result of having a greater number of control participants than ELBW participants in the final selection. Characteristics of the final sample are presented in Table 1.

Between-Group Analyses

Measures of HP and PEP were normally distributed in both groups (Shapiro–Wilk tests, Ps > .08). Extreme data from one ELBW outlier were excluded, and complete PEP data were available for 7 ELBW participants and 29 controls due to recording issues. As expected, HP, $F(1, 45) = 75.98$, $P < .001$, $\eta_p^2 = .63$, and PEP, $F(1, 34) = 75.80$, $P < .001$, $\eta_p^2 = .69$, declined between rest and TSST performance across groups, with no interactions (Ps > .08). PEP was greater in controls than ELBW survivors, $F(1, 34) = 6.42$, $P < .02$, $\eta_p^2 = .16$, suggesting greater resting contractility in the ELBW group. However, heart rate and contractility increased for task performance similarly in both groups, suggesting that the groups were equally engaged in the task. Covariance matrices and error variances for HP (Box's M = 3.22, P > .35; Levene's tests, Ps > .20) and PEP (Box's M = 0.64, P > .90; Levene's tests, Ps > .45) did not differ between groups.

A MANCOVA of the TPR-reactivity and CO-reactivity data revealed a significant effect of group, multivariate $F(2, 41) = 3.87$, $p < .03$, $\eta_p^2 = .16$ (Pillai's trace), with age, sex, BMI, and parental history of hypertension controlled. Separate ANCOVAs for each variable revealed that group interacted with both TPR-reactivity, $F(1, 42) = 4.34$, $P < .05$, $\eta_p^2 = .09$, and CO-reactivity, $F(1, 42) = 7.84$, $P < .01$, $\eta_p^2 = .16$. Independent t tests of the TPR- and CO-reactivity scores revealed that the direction of TPR change differed by group, $t(46) = 2.05$, $P < .05$ (increased in ELBW survivors, decreased in controls), and the magnitude of the increase in CO for task performance was larger in control participants than ELBW survivors, $t(46) = 2.24$, $P < .04$.

Controlling for the same covariates as above, a one-way ANCOVA of the combined reactivity measure revealed a significant group difference, $F(1, 42) = 7.03$, $P < .02$, $\eta_p^2 = .14$. The TPR/CO reactivity index was positive in term-born participants (unadjusted M = 0.40, SD = 1.8), but negative in ELBW survivors (unadjusted M = −0.95, SD = 1.7). A post hoc power analysis indicated the likelihood of detecting a group difference of this size (d = .73) was 61% (α = .05, 2-tailed). See Figure 1 and Table 2.*

Associations Between Cardiovascular Responses to Laboratory Stress and Affective States

The results of the ANOVA on subjective anxiety experienced during the experimental protocol indicated that ELBW survivors reported nonsignificantly higher levels of anxiety than controls during TSST performance, $F(1, 36) = 2.81$, $P < .11$, $\eta_p^2 = .07$, with no other effects (Ps > .15). Analyzed similarly, carefree ratings declined across TSST performance across groups, $F(7, 252) = 2.69$, $P < .02$, $\eta_p^2 = .07$, with no interaction or other

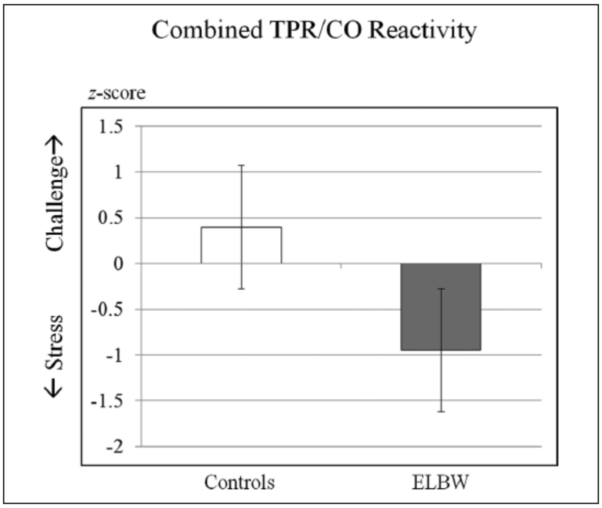

Figure 1. The combined reactivity index of change in total peripheral resistance (TPR) and cardiac output (CO), by group.
Combined TPR/CO Reactivity = CO-reactivity (z-score) − TPR-reactivity (z-score).
Positive values reflect a challenged state. Negative values reflect a stressed state.

effects (*P*s > .14), suggesting that the groups responded similarly to the demands of TSST performance.

Subjective ratings were entered in correlation analyses with TPR-reactivity, CO-reactivity, and the combined TPR/CO reactivity measure. Results are presented in Table 3. In ELBW survivors, CO-reactivity and the combined measure were inversely associated with anxiety (*P*s < .04), suggesting that in this group, anxiety declined in proportion to the increase in CO for TSST performance (greater CO-reactivity being an index of relative resilience). Controls showed no associations between anxiety and the cardiovascular reactivity measures (*P*s > .35). Group differences in the strengths of these correlations were significant, according to Fisher's r to z transformation (CO-reactivity: $z = 2.26$, $P < .03$; combined reactivity: $z = 2.27$, $P < .03$, 2-tailed). In the control group, carefree ratings increased with all 3 indications of resilience: lower TPR reactivity ($P < .04$), greater CO reactivity ($P < .06$), and a positive combined reactivity measure ($P < .03$). ELBW participants showed no similar associations (*P*s > .75). Group differences in the strengths of the carefree correlations could not be confirmed using Fisher tests (*P*s > .30), but the associations in the control group were consistent with our predictions.

Together, the pattern of findings supported the notion that cardiovascular responses to TSST stress reflected ELBW anxiety, consistent with greater vulnerability to TSST stress, and suggested that cardiovascular responses to TSST performance in controls reflected a relatively untroubled state, consistent with greater resilience to TSST stress.*

Discussion

We found that young adults born at ELBW and their term-born peers exhibited comparable engagement in a widely used public speaking task, but exhibited significantly different responses to the task in terms of TPR and CO. Cardiovascular responses to the laboratory stressor suggested that ELBW survivors were more stressed than term-born controls in this relatively common situation: explaining in an interview why one should be hired. Whereas term-born young adults responded to the TSST stressor as a challenge for which they had adequate resources, those born at ELBW exhibited significant vulnerability to stress in the same situation.

What Do Cardiovascular Differences to Stress Reflect in ELBW Survivors? Blascovich's Biopsychosocial Model of Motivation

Psychological states are reliably reflected in cardiovascular responses when people engage in motivated performance situations. In these instances (eg, applying for a job), a successful outcome is not guaranteed, even though achieving an important goal depends on the individual's actions. A biopsychosocial model of motivation states offers a theoretical approach for understanding psychological states during motivated performance situations.[18] Perception of a situation as stressful or not follows from an immediate evaluation of personal resources vis-à-vis situational demands. When engaging an important, personally relevant stressor, individuals typically weigh the degree of uncertainty, potential loss, or effort required against their personal resources for meeting these demands (eg, their skills, the availability of external support). A situation is appraised as challenging but manageable when personal resources are perceived as relatively high and the demands of the situation are

*The ELBW group had a relatively high proportion of adults born at SGA (41%; cf. Saigal et al,[28]: 24%). It was possible that intrauterine growth restriction, rather than extremely preterm birth, was responsible for the group differences in the motivation states reported above. Therefore, we repeated the main analyses with SGA status added to the covariates. The findings did not differ greatly from those of the original analyses. The ANCOVA for TPR/CO reactivity still indicated a significant group difference, $F(1, 41) = 5.36$, $P < .03$, $\eta_p^2 = .12$, but SGA status was not significant ($P > .75$). These results suggested that cardiovascular responses to TSST performance were more likely influenced by preterm birth than SGA status.

Table 2. Mean (SD) Cardiovascular, Behavioral, and Subjective Indices by Group, With Unadjusted Mean Differences Between Term-Born Controls and ELBW Participants.

Variable	ELBW (n = 13), Mean (SD)	Controls(n=35), Mean (SD)	Mean Difference (95% CI)
Resting TPR (dynes-s/cm^{-5})	1296 (246)	1325 (325)	−29 (−230 to 171)
TPR reactivity (dynes-s/cm^{-5})†	65 (200)	−64 (190)	129 (2 to 255)
Resting CO (L/min)	5.90 (0.9)	5.68 (1.5)	0.21 (−0.69 to 1.11)
CO reactivity (L/min)*	0.92 (1.1)	1.84 (1.3)	−0.91 (−1.74 to −0.09)
TPR/CO reactivity*	−0.95 (1.7)	0.40 (1.8)	−1.35 (−2.51 to −0.19)
Anxious (mean rating)*,[a]	4.80 (0.4)	4.41 (0.7)	0.39 (0.01 to 0.78)
Carefree (mean rating)[a]	2.58 (0.9)	2.56 (0.8)	0.02 (−0.64 to 0.68)

Abbreviations: ELBW, extremely low birth weight; SD, standard deviation; CI, confidence interval; TPR, total peripheral resistance; CO, cardiac output.
[a]Analyses were conducted with available subjective ratings.
*P < .05. $^{\dagger}P$ < .06

Table 3. Pearson (r) Correlations Between Cardiovascular Predictors and Mean Subjective Ratings (Anxious, Carefree) for Each Group.

	ELBW		Controls	
	Anxious (n = 10)	Carefree (n = 9)	Anxious (n = 28)	Carefree (n = 29)
TPR-reactivity	.55	−.12	−.09	−.40*
CO-reactivity	−.66*	−.06	.17	.36 †
TPR/CO reactivity	−.68*	−.01	.14	.41*

Abbreviations: ELBW, extremely low birth weight; TPR, total peripheral resistance; CO, cardiac output.
*P < .05. $^{\dagger}P$ < .06.

relatively low. Typically, when a situation is deemed to be challenging, TPR declines and CO increases, reflecting lower peripheral resistance and increased cardiac output. When these conditions are reversed, the situation is appraised as stressful, and TPR increases, while CO increases are attenuated or absent. Consequently, the belief that one's resources are inadequate to meet the demands of a given task contributes to a vulnerable, "stressed" motivation state that has distinct physiological markers. Conversely, performance outcomes are usually better when individuals feel challenged rather than stressed.[21]

Generating a physiological stress response to common situations is metabolically costly, and repeated activation of stressed states may ultimately lead to cardiovascular and immune system dysfunction.[20,35] The increased allostatic load associated with repeated or chronic exposure to stress may warrant special attention to the cardiovascular health of adults born at ELBW, particularly as they get older.

Two decades of empirical demonstrations (see Blascovich et al[33] for a review) attest to the reliability of cardiovascular markers in representing psychological states during motivated performance situations, and their usefulness for making predictions about behavior. Cardiovascular indices have now been empirically established as markers of motivation states in more than 30 studies,[17] spanning nearly 2 decades.[18,36] Moreover, they have been validated by subsequent real-world, physical[22] and cognitive performance.[34] In all cases, cardiovascular reactivity in the laboratory that is consistent with challenge motivation (as opposed to stress motivation) predicted better performance outcomes in everyday life.

In contrast, doubts about the likely success of one's efforts, decreased performance expectations, and attendant feelings of vulnerability all serve to impair performance because they reduce one's estimation of personal resources.[23,37] To tip the balance of situational evaluations toward a challenged state may thus require increasing the personal resources of ELBW survivors for dealing with motivated performance situations. Skills-training, increasing familiarity about specific situations such as job interviews, and choosing situations commensurate with one's skill level all work to improve one's personal resources.[23] Any of these strategies could be adopted to reduce the experience of stress experienced by young ELBW survivors in motivated performance situations.

Comparison of Early Adversity Associated With ELBW and Lifetime Adversity

The present findings converge with those of a similar natural experiment involving typically developing young adults.[37] In that study, the degree of cumulative lifetime adversity reported by participants moderated their cardiovascular responses to a significant laboratory stressor. Plotting cardiovascular responses as a function of lifetime adversity yielded an inverted U-shaped function. Little or no exposure to adversity, and at the other extreme, high levels of adversity, were both associated with cardiovascular responses reflecting stress motivation states, whereas moderate exposure to adversity (in the middle of the U) was linked to cardiovascular responses typical of challenge motivation. The stressed states were associated with either consistent protection from adversity, which may preclude opportunities to develop necessary coping skills, or, continuous exposure to adversity, which may overwhelm and exhaust personal resources.[16] In contrast, limited exposure to adversity may provide opportunity to learn how to cope in difficult circumstances, thereby contributing to the perception of novel stressors as manageable.[38]

The present results appear to replicate the moderate- and high-adversity conditions of Seery's inverted U. Here, young adults born at ELBW who had experienced serious early adversity generated cardiovascular responses to a stressor that resembled those of typically developing young adults who reported high levels of lifetime adversity. In like manner, cardiovascular markers in term-born controls resembled those of resilient young adults who reported moderate levels of lifetime adversity. The group differences suggest that being born at ELBW may influence cardiovascular responding in motivated performance situations, with consequences that are like those arising from high levels of lifetime adversity.

Limitations

Our sample size was necessarily small, due partly to the labor-intensive nature of the TSST and the relatively limited numbers of adults who survived being born at ELBW in the late 1970s and early 1980s. Nonetheless, the sample size was sufficient to reflect group differences in motivation states that fit Blascovich's biopsychosocial theory, and to suggest testable predictions for future study. For example, assuming the degree of resilience mobilized during TSST stress in the laboratory is similar to that of a real job interview, one could test for associations between cardiovascular markers during TSST performance and interview success (eg, being hired or promoted within a year of study participation), similar to other studies linking laboratory cardiovascular responses with real-world performance.[22,34] As well, cardiovascular profiles and subjective confidence levels of ELBW participants might begin to resemble those of controls, if these participants were given coaching on interview behavior and time to prepare a job interview speech in advance of testing.

A second limitation may concern the model of challenge versus stress motivation. Some researchers[39] have argued that constructs such as situational demands and resource appraisals are poorly specified by the model, putting a special onus on researchers to demonstrate that participants indeed perceive motivated performance situations as the researchers propose. Our tests of association between cardiovascular markers and subjective states during TSST performance were designed to provide such a demonstration. Correlational analyses showed that cardiovascular reactivity reflecting stress motivation was associated with anxiety uniquely in ELBW survivors, whereas in control participants, cardiovascular reactivity was associated with a more carefree state. Both dissociations support the ecological validity of the biopsychosocial model in the context of job interview performance. While Blascovich and colleagues acknowledge the lack of narrowly defined constructs in their model,[33] they maintain that this strategy is intentional, as it reflects the complexity of real-world perceptions and a wide variety of influences on human motivation, including some that are unconscious or not easily observed.

Conclusions

For reasons that are not entirely clear, young adults born at ELBW have been slower to achieve financial stability and other forms of independence in young adulthood than their term-born counterparts. Vulnerability in motivated performance situations may have adverse effects that directly affect employment and other opportunities in young adulthood, as performance outcomes are usually better when individuals feel challenged, rather than stressed. Given that the tasks of young adulthood are indeed difficult, increased skills-training, practice with specific situations such as job interviews, and choosing situations commensurate with one's skill level would all work to improve the personal resources of ELBW survivors, with positive consequences for cardiovascular responding, motivation, and ultimately, behavioral performance.

Acknowledgments

We would like to thank research nurses Anne Kaski and Paula Nyholm, data manager Sigrid Rosten, and research assistant Jarkko Volanen for their excellent contributions. This research was part of the Helsinki Study of Very Low Birth Weight Adults.

Author Contributions

KJM contributed to conception and design; contributed to acquisition, analysis, and interpretation; drafted manuscript; critically revised manuscript; gave final approval; agrees to be accountable for all aspects of work ensuring integrity and accuracy. RP contributed to design; contributed to acquisition, analysis, and interpretation; critically revised manuscript; gave final approval; agrees to be accountable for all aspects of work ensuring integrity and accuracy. PH contributed to interpretation; critically revised manuscript; gave final approval; agrees to be accountable for all aspects of work ensuring integrity and accuracy. KR contributed to analysis and interpretation; critically revised manuscript; gave final approval; agrees to be accountable for all aspects of work ensuring integrity and accuracy. RJVL contributed to analysis and interpretation; critically revised manuscript; gave final approval; agrees to be accountable for all aspects of work ensuring integrity and accuracy. MHB contributed to analysis and interpretation; critically revised manuscript; gave final approval; agrees to be accountable for all aspects of work ensuring integrity and accuracy. SS contributed to interpretation; critically revised manuscript; gave final approval; agrees to be accountable for all aspects of work ensuring integrity and accuracy. KMM contributed to interpretation; critically revised manuscript; gave final approval; agrees to be accountable for all aspects of work ensuring integrity and accuracy. EK contributed to analysis and interpretation; critically revised manuscript; gave final approval; agrees to be accountable for all aspects of work ensuring integrity and accuracy. LAS contributed to analysis and interpretation; critically revised manuscript; gave final approval; agrees to be accountable for all aspects of work ensuring integrity and accuracy.

Declaration of Conflicting Interests

The author(s) declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

Funding

The author(s) disclosed receipt of the following financial support for the research, authorship, and/or publication of this article: Canadian Institutes of Health Research (CIHR) Team Grant (2009H00529), the Academy of Finland, the University of Helsinki, the Finnish Medical Society Duodecim, Finska Läkaresällskapet, the Finnish Foundation for Pediatric Research, the Finnish Special Governmental Subsidiary for Health Sciences, the Jalmari and Rauha Ahokas Foundation, the Juho Vainio Foundation, the Novo Nordisk Foundation, the Päivikki and Sakari Sohlberg Foundation, the Signe and Ane Gyllenberg Foundation, the Yrjö Jahnsson Foundation, the Orion-Pharma Foundation, the Sigrid Juselius Foundation, and the Pediatric Graduate School of the University of Helsinki.

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