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Personal Growth and Psychobiological Stress Responsiveness to the Trier Social Stress Test in Students

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Abstract: The current study aimed to examine the effects of personal growth (PG) on psychobiological responses at baseline and responsiveness to laboratory acute stress in students. Twenty-four healthy students were recruited as participants. Participants were screened from 203 candidates according to levels of PG using Ryff's scale and classified into high and low PG groups. During the laboratory session, 13 high and 11 low PG participants underwent the Trier Social Stress Test. Heart rate and high-frequency (HF) heart rate variability were monitored throughout the experiment. Salivary free-3-methoxy-4-hydroxyphenylethyleneglycol (MHPG) and perceived stress were measured at baseline, immediately after tasks and after a recovery period. Baseline and recovery perceived stress (tense arousal) were significantly lower in the high PG group compared with the low PG group. Free-MHPG and HF component returned to baseline levels during recovery significantly more rapidly in the high PG group compared with the low PG group. There were no significant group differences in heart rate. The results showed that high PG students have lower noradrenaline and higher parasympathetic nervous system activity before and after acute stress. These findings suggest a protective psychobiological pathway linking PG with better psychosomatic health in students.

Keywords: personal growth; eudaimonic well-being; salivary free-MHPG; HF component; heart rate; Trier Social Stress Test

1. Introduction

Personal growth has recently received substantial attention as a positive psychological factor associated with favorable health outcomes and longevity. Personal growth is reported to be associated with mental health and quality of life, and reduced depression and chronic disease, thereby playing an adaptive role in psychosomatic health [1–3]. Personal growth is a central concept in eudaimonic well-being, which emphasizes purpose and meaning [4]. Personal growth is generally defined as a tendency to realize one's potential, be open to new experiences, and continuously develop as a person [5–7].

Personal growth is a particularly important concept for students. College is often considered a time of “soul searching” in which young people enthusiastically struggle to develop their own sense of self by finding answers to questions about who they are, who they want to be and what roles they will play in life. In addition, college students commonly face the need to adapt to changes in their

living environment and the format of their classes, to make decisions about their next steps, such as work or continuing education, and to have other experiences that require them to face themselves. For this reason, it has been reported that the level of personal growth in students is higher than that of other age groups [8,9]. However, students with lower levels of personal growth have been reported to exhibit burnout in their post-graduation professional and personal lives [10]. Thus, the development of interventions to increase personal growth for the prevention and treatment of common mental health problems such as anxiety, depression and burnout has been increasingly encouraged [11].

Fundamental psychobiological processes, particularly neuroendocrine, immune and cardiovascular responses, are thought to be deeply involved in the connection between personal growth and health outcomes [12,13]. For example, personal growth is linked to low levels of noradrenaline (NA) [14] and a diurnal rhythm that is adapted to cortisol secretion (cortisol slope) [15], and has been found to act as a buffering factor against increased glycosylated hemoglobin (HbA1c) [16]. In addition, some research indicates that eudaimonic well-being is associated with reduced conserved transcriptional response to adversity (CTRA) gene expression profiles, which are characterized by up-regulation of genes involved in inflammation and down-regulation of genes involved in antiviral defenses [17–21]. However, no correlation has been observed between personal growth and the high-frequency (HF) component of heart rate variability (HRV), which is an indicator of parasympathetic nervous system activity [22]. Furthermore, many studies of the association between personal growth and psychobiological function have been conducted with older participants [23–25]. Importantly, almost all of these studies have been cross-sectional, and no experimental studies have confirmed a causal relationship between personal growth and psychosomatic health. Thus, the fundamental psychobiological processes linking personal growth to health outcomes are still not well understood.

In recent years, the enhanced allostasis model has gained attention as an effective model for understanding the adaptive role of positive psychological states and traits to fundamental biological processes [26–28]. The enhanced allostasis model is an extension of the allostatic load model. Allostasis is a process by which an organism changes its autonomic nervous, endocrine, and immune system in response to stress. According to the enhanced allostasis model, when allostasis increases, physiological responses to stress become more efficient, and physiological functions are more strictly regulated than normal. For example, the archetypal response pattern of enhanced allostasis indicates (a) lower tonic arousal in physiological stress systems due to baseline differences in restorative physiological processes, and (b) a peak response with rapid recovery to baseline following the termination of a stressor. In the enhanced allostasis model, positive psychological states and traits are considered to act on the hypothalamic–pituitary–adrenal (HPA) system, the sympathetic–adrenal–medullary (SAM) system, and other physiological functions in a beneficial way.

There is accumulating evidence that personal growth is beneficial for psychosomatic health in daily life. However, it is not clear how personal growth affects psychobiological stress responsiveness to laboratory acute stress; that is, it is unclear whether personal growth affects baseline responses, reactivity, or recovery. Clarifying this issue could inform the development of new intervention methods that enhance personal growth to promote positive health for individuals and organizations [29,30].

The purpose of the current study was to examine the effects of personal growth, which is regarded as particularly important for students, on the following psychobiological indicators at rest and in responses to laboratory acute stress: (a) perceived stress; (b) salivary free-3-methoxy-4-hydroxyphenylglycol (MHPG), which is a metabolic end-product of NA; (c) the HF component, which reflects parasympathetic nervous activity; and (d) heart rate (HR). To determine whether the effects of personal growth on responses to psychobiological stress are independent from confounding factors such as negative affect, body mass index (BMI), and sex, we controlled them as covariates in the analysis.

Based on the enhanced allostasis model [26–28], our main hypotheses were as follows: (1) the resting psychobiological level of arousal in students with a high level of personal growth would be

low; and (2) recovery of psychobiological stress responses to laboratory acute stress would be more rapid if students exhibited a higher level of personal growth.

2. Materials and Methods

2.1. Participants

Participants were 27 university students aged 19–25 years who gave consent to participate. A total of 203 candidates for the experiment underwent a preliminary personal growth screening test, and those who scored at least 0.5 standard deviations above average (41 points or more) along with those who scored -0.5 standard deviations or lower below average (35 points or fewer) were selected. Participants were recruited via advertising among the student population of Kurume University. All participants were non-smokers, consumed fewer than five units of alcohol per week and reported having a regular sleep routine and good health at the time of the study. Participants who reported having a physiological or psychiatric disease, or who used medications or dietary supplements that affect the activity of the autonomic nervous or immune systems were excluded from the study. Any influence of sex hormones on autonomic activity was minimized by having female students participate during the late luteal or early follicular phase of the menstrual cycle. All participants gave informed consent, and the study was approved by the Kurume University Institutional Review Board (approval no. 131).

Participants were instructed to refrain from taking medicine or consuming alcohol the night before the experiment and to refrain from consuming caffeinated beverages, engaging in strenuous exercise, or eating large meals 2 h prior to the experiment. Three participants who did not follow these instructions were excluded from the analysis. There were 13 participants with high personal growth scores and 11 with low personal growth scores (13 men, 11 women, mean age 20.6 ± 1.6 years).

2.2. Procedure

The experiment was conducted individually for each participant between 1:00 p.m. and 5:30 p.m. in a light- and temperature-controlled laboratory.

Before the experimental session, participants completed the General Health Questionnaire (GHQ-28) and the Positive and Negative Affect Schedule (PANAS). In addition, height and weight were measured to calculate BMI values before starting the experiment. Participants were asked to gargle with water to avoid contamination of their saliva samples. A Heart Rhythm Scanner Version 2.0 (Biocom Technologies, Poulsbo, WA, USA) was used throughout the experiment to provide continuous measurements of participants' HF and HR non-invasively from the earlobes.

Once the experiment began, participants were asked to sit quietly and remain still for 10 min, after which saliva was collected (baseline). The Trier Social Stress Test (TSST) was used as a stress task [31]. Directly after the TSST, collection of saliva samples and assessment of workload in the task were conducted. Participants were then asked to remain still during a recovery period of 30 min, and their saliva was collected after 10, 20, and 30 min had passed. Perceived stress was evaluated at baseline, directly after the tasks, and after the recovery period.

2.3. Mental Stress Test

The TSST elicits psychosocial stress in participants under laboratory conditions by asking them to give a speech and perform mental arithmetic to induce interpersonal stress, and by leading them to believe that their speech is being video-recorded and that their performance is being assessed by two interviewers (one man, one woman), compounding the interpersonal stress [31]. For the speech task, participants were asked to talk about their strengths as best they could. Participants were given 5 min to speak after 3 min of preparation. For the mental arithmetic task, participants were asked to perform consecutive mental math problems as accurately and quickly as possible (5 min). If participants made a mistake, they were told by the interviewers to start from the beginning.

2.4. Questionnaire

2.4.1. Personal Growth

A subscale of the Psychological Well-Being Scale (PWBS) was used to evaluate personal growth [32,33]. Specifically, this subscale assesses the extent to which an individual is open to new experiences, sees oneself as growing and expanding, and has a sense of “changing in ways that reflect more self-knowledge and effectiveness” [32]. This subscale consists of eight items (e.g., “I enjoy accumulating new experiences”), rated from 1 (completely disagree) to 6 (completely agree) on a 6-point Likert scale [33]. Scores are calculated by summing the responses to the items, and can range from 8 to 48. Higher scores indicate greater personal growth. The content and factorial validity of this subscale has been confirmed using factor analysis in a Japanese population [33]. Ryff (1989) reported a Cronbach’s α value (a measure of internal consistency) of 0.87 for the personal growth subscale [32]. The Cronbach’s α value for the personal growth subscale of the Japanese version was reported to be ≥ 0.76 [33]. In the present study, the Cronbach’s α value was 0.88.

2.4.2. Perceived Health

The Japanese version of the GHQ-28 was used to evaluate perceived health [34]. The GHQ-28 is a questionnaire measuring respondents’ level of mental health over the past week. This questionnaire consists of 28 items across four subscales of physical symptoms, somatic symptoms, anxiety/insomnia, social dysfunction, and severe depression, on which respondents assess themselves using a 4-point scale. Responses were converted to scores of 0 and 1 according to Nakagawa and Daibo’s (1985) binary scoring method. Higher scores indicate poorer mental health. The Cronbach’s α values for the subscales were as follows: somatic symptoms = 0.90, anxiety/insomnia = 0.86, social dysfunction = 0.80, severe depression = 0.94, and total = 0.94.

2.4.3. Positive and Negative Affect

The Positive and Negative Affect Schedule (PANAS) was used to evaluate positive (e.g., excited, interested) and negative affect (e.g., afraid, irritable) [35,36]. The PANAS consists of two subscales and 20 items scored on a 6-point Likert scale (1 = not at all or very slightly to 6 = extremely). Watson et al. (1988) reported a Cronbach’s α value of 0.93 for PA and 0.93 for NA [35]. The reliability of the Japanese-translated PANAS has been confirmed (Cronbach’s α = 0.85 for PA and α = 0.88 for NA) [36]. In the present study, the Cronbach’s α values were PA = 0.89 and NA = 0.93.

2.4.4. Perceived Stress

The Japanese version of the UWIST Mood Adjective Checklist (JUMACL) was used to evaluate perceived stress [37,38]. The JUMACL consists of two subscales of energetic arousal (EA) (feeling lively/active versus tired/sluggish) and tense arousal (TA) (feeling anxious/nervous versus relaxed/calm), each consisting of six items on which respondents assessed themselves using a 4-point scale. Higher EA and TA values reflect greater energetic arousal and tension, respectively. The JUMACL has been reported to exhibit adequate internal consistency (Cronbach’s α values ranging from 0.86 to 0.92) [38].

The Japanese version of the NASA-TLX was used to evaluate perceived workload in the stress task [39]. The NASA-TLX evaluates respondents’ subjective mental workload of a task on a 10-point scale across 6 sub-scales: mental demand (how much mental and perceptual activity was required?), physical demand (how much physical activity was required?), temporal demand (how much time pressure did you feel because of the rate or pace at which the task element occurs?), performance (how successful do you think you were in accomplishing the task?), effort (how hard did you have to work?), and frustration (how irritated, stressed, and annoyed did you feel?). The NASA-TLX evaluation was conducted after the stress task.

2.5. Physiological Indicators

2.5.1. Salivary Free-MHPG

Salisoft (Sarstedt, Inc., Numbrecht, Germany) was used to collect saliva by inserting a sponge into the participant's mouth to absorb a liquid sample. After collection, the sponges were placed in designated Spitz tubes and centrifuged at 3000 rpm for 5 min in a centrifuge (KR-180B, Kubota Corporation, Tokyo, Japan), and the saliva that separated at the bottom was used as the specimen for analysis. The saliva collection method used in this study involved almost no contact between the saliva and the air and thus made it possible to control exposure to foreign contaminants in the atmosphere. Specimens were cryopreserved at $-80\text{ }^{\circ}\text{C}$ until they were analyzed. Free-MHPG content was measured according to the method described by Yajima, Tsuda, Yamada, and Tanaka (2001) [40]. The intra- and inter-assay coefficients of variation were less than 7%.

2.5.2. HF and HR

A Heart Rhythm Scanner Version 2.0 (Biocom Technologies, Poulsbo, WA, USA) was used to continuously measure HF and HR. Participants' measurements were recorded after confirming that they were seated upright and breathing regularly and that no motion artifacts were included. The HF component of HRV (0.15–0.4 Hz) was used as an indicator of parasympathetic nervous system activity. Signals were measured and processed according to an internationally-recommended method [41].

2.6. Statistical Analysis

We used the personal growth score as an independent variable and psychobiological stress responses (perceived stress, free-MHPG, HF component, and HR) as dependent variables. Due to being considerable individual variation in HF components, they were converted to natural logarithms (\ln) to bring them closer to a normal distribution before analysis. The HF component and HR were averaged at baseline (5 min in the second half), during the stress task, then at 10, 20, and 30 min after the task. To demonstrate differences in characteristics between the personal growth groups (high vs. low), a *t*-test was used to compare baseline values.

To examine the effects of personal growth on psychobiological stress responses, we performed a repeated measures analysis of variance (ANOVA) with the personal growth group (high vs. low) as the between-subjects factor; free-MHPG, the HF component, HR, and perceived stress response as within-subjects factors (baseline, tasks, recovery); and sex, BMI, and PANAS negative affect controlled for as covariates. If the ANOVA revealed any significant main effects or interactions, we performed post hoc tests with the Bonferroni method. If it was necessary to correct the degrees of freedom, we used the Greenhouse–Geisser method. Based on the “contrast analysis” approach advocated by Rosenthal and Rosnow (1985) [42], we performed a multiple-regression analysis (forced-input method) with the personal growth score (continuous value) as an explanatory variable, psychobiological stress responses as the object variable, and negative affect, sex, and BMI controlled for as covariates. Multiple-regression results are presented as standardized (β) regression coefficients with 95% confidence intervals (CIs).

To examine differences in task workload between the personal growth groups (high vs. low), a *t*-test was used to compare NASA-TLX sub-scales. Statistical analyses were conducted using SPSS version 20. The level of significance was set at $p < 0.05$.

3. Results

3.1. Participant Characteristics

Participants' mean age was 20.6 ± 1.6 years and their mean BMI was $21.2 \pm 3.0\text{ kg/m}^2$. Their personal growth scores, as measured by the PWBS sub-scale, ranged from 27 to 48. Total scores on the GHQ-28 ranged from 0 to 14 (mean 6.3 ± 4.5), indicating that the level of mental health risk ranged from low to high. Table 1 shows the differences between the high and low personal growth groups. No significant intergroup differences were found for age, BMI, free-MHPG, HF component, EA score, GHQ-28

total score, somatic symptom score, social dysfunction score, or negative affect score. However, HR, TA score, anxiety/insomnia score, severe depression score, PA score, and personal growth score all exhibited significant intergroup differences.

Table 1. Baseline characteristics comparing subjects with lower and higher personal growth.

	Personal Growth	
	Low (n = 11)	High (n = 13)
Women, n (%)	6 (54.5)	5 (38.5)
Age, years	21.3 ± 1.6	20.1 ± 1.4
BMI, m ² /kg	22.0 ± 3.9	20.5 ± 2.0
free-MHPG, ng/ml	12.7 ± 3.0	11.3 ± 3.2
HF, ln ms ²	6.4 ± 0.4	6.6 ± 0.8
HR, bpm	84.9 ± 10.6	74.8 ± 12.4 *
EA score	14.6 ± 3.4	15.8 ± 3.0
TA score	14.5 ± 2.5	9.9 ± 3.6 **
GHQ-28 total score	8.2 ± 4.6	4.8 ± 3.9
GHQ-physical symptoms	2.7 ± 2.4	2.2 ± 1.9
GHQ-anxiety and insomnia	2.8 ± 1.3	1.5 ± 1.6 *
GHQ-social dysfunction	0.9 ± 1.4	0.8 ± 1.2
GHQ-depression	1.7 ± 1.7	0.3 ± 0.9 *
PANAS-positive affect	29.0 ± 4.3	36.1 ± 11.3 *
PANAS-negative affect	26.0 ± 13.1	23.8 ± 10.9
Personal growth score	32.2 ± 2.4	45.2 ± 1.9 **

BMI body mass index; HF high frequency; HR heart rate; EA energetic arousal; TA tense arousal. Mean score ± standard deviation. Significant difference between high and low personal growth groups (* $p < 0.05$, ** $p < 0.01$).

3.2. Perceived Stress

Figure 1 shows the pattern of perceived stress response in the two personal growth groups. We performed a repeated measures ANOVA on the EA scores that controlled for sex, BMI, and PANAS negative affect scores as covariates, which revealed a significant main effect of time ($F [2,38] = 3.75$, $p = 0.033$) but no significant main effect of group. Post hoc comparisons revealed that EA scores were significantly lower during task performance compared with baseline and during recovery. In a multiple regression analysis that controlled for the covariates, none of the measurement times exhibited a significant correlation with personal growth scores (continuous value).

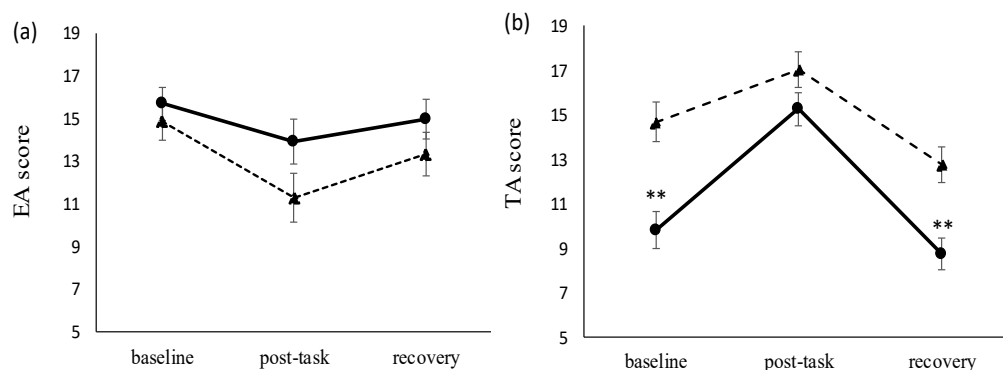


Figure 1. (a) Tension arousal (TA) and (b) energy arousal (EA) scores on JUMACL in Trier Social Stress Test (TSST). Perceived stress levels for the high personal growth (solid line, squares) and low personal growth groups (dotted line, triangles) during baseline, after both tasks, and after recovery following task performance. Error bars represent the standard error of the mean; adjusted for negative affect, sex, BMI. ** $p < 0.01$ compared with the low personal growth group.

A repeated measures ANOVA of TA scores demonstrated a significant interaction between time and personal growth group ($F [2,38] = 5.38$, $p = 0.009$). A simple main effect test revealed that the

high personal growth group at baseline ($p < 0.001$) and during recovery ($p = 0.002$) was significantly lower than that of the low personal growth group. In a multiple regression analysis that controlled for covariates, greater personal growth was associated with lower baseline and recovery TA scores (baseline: $\beta = -0.633$, CI -3.738 to -1.119 , $p = 0.001$, recovery: $\beta = -0.619$, CI -3.142 to -0.833 , $p = 0.002$). There was no association between personal growth score and post-task TA scores.

A t -test was used to compare the groups' mean scores on the NASA-TLX scale (Figure 2), revealing that the high personal growth group scored significantly lower than the low personal growth group on mental demand and temporal demand (mental demand: $p < 0.05$; temporal demand: $p < 0.01$).

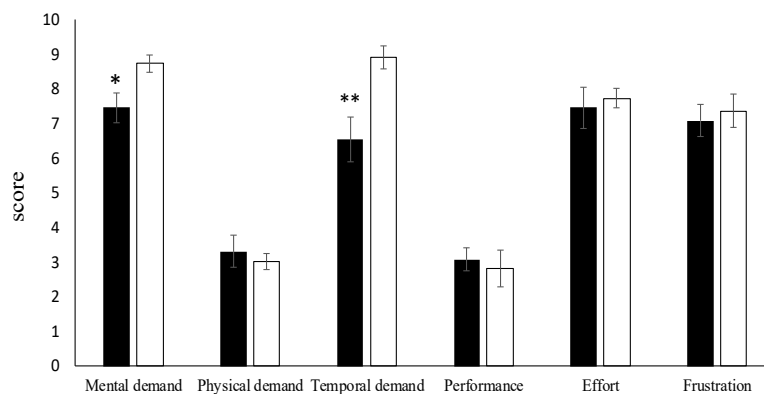


Figure 2. NASA-TLX scores (mean \pm SE) in Trier Social Stress Test (TSST). The black bar shows the scores in the high personal growth group and the white bar shows the scores in the low personal growth groups. * $p < 0.05$, ** $p < 0.01$ compared with the low personal growth group.

3.3. Salivary Free-MHPG

There was a significant interaction between time and personal growth group ($F [4,76] = 2.81$, $p = 0.031$). As shown in Figure 3, participants with high personal growth exhibited a lower recovery free-MHPG compared with that of low personal growth participants (10 min after tasks: $p < 0.001$, 20 min after tasks: $p = 0.006$). In a multiple regression analysis that controlled for the covariates, greater personal growth was associated with free-MHPG at 10 min and 20 min after tasks (10 min after the task: $\beta = -0.752$, CI -0.514 to -0.186 , $p < 0.001$; 20 min after the task: $\beta = -0.486$, CI -0.429 to -0.042 , $p = 0.02$). There was no association between personal growth score and free-MHPG at baseline, post-task, or 30 min after the tasks.

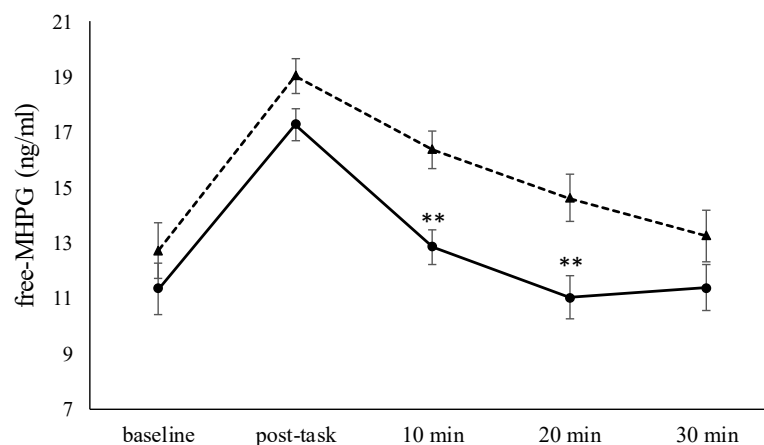


Figure 3. Free-MHPG stress responses for high personal growth (solid line, squares) and low personal growth groups (dotted line, triangles) during baseline, immediately post-task, and 10 min, 20 min and 30 min following the tasks. Error bars represent the standard error of the mean; adjusted for negative affect, sex, BMI. ** $p < 0.01$ compared with the low personal growth group.

3.4. HF and HR

Figure 4 shows the pattern of HF component responses in the two personal growth groups. There was a significant interaction between time and personal growth group ($F [4,76] = 5.624, p = 0.01$). A simple main effect test revealed that the HF component was significantly higher in the high personal growth group compared with the low personal growth group at 10 min after the tasks ($p = 0.028$) and 20 min after the tasks ($p = 0.019$). In the multiple regression analysis that controlled for covariates, greater personal growth was associated with the HF component at 10 min and 20 min after the tasks (10 min after the task: $\beta = 0.433, CI 0.003$ to $0.089, p = 0.037$; 20 min after the task: $\beta = 0.491, CI 0.01$ to $0.104, p = 0.021$). There was no association between personal growth scores and the HF component at baseline, post-task, or 30 min after the tasks.

A repeated measures ANOVA examining HR revealed a main effect for time ($F [4,76] = 2.562, p = 0.045$) with no interaction between time and group. HR increased during the tasks and returned to the baseline level by the first recovery measure. However, there were no differences between the two groups in baseline, reactivity or recovery. In the multiple regression analysis including the covariates as inputs, none of the measurement times showed a significant correlation with personal growth.

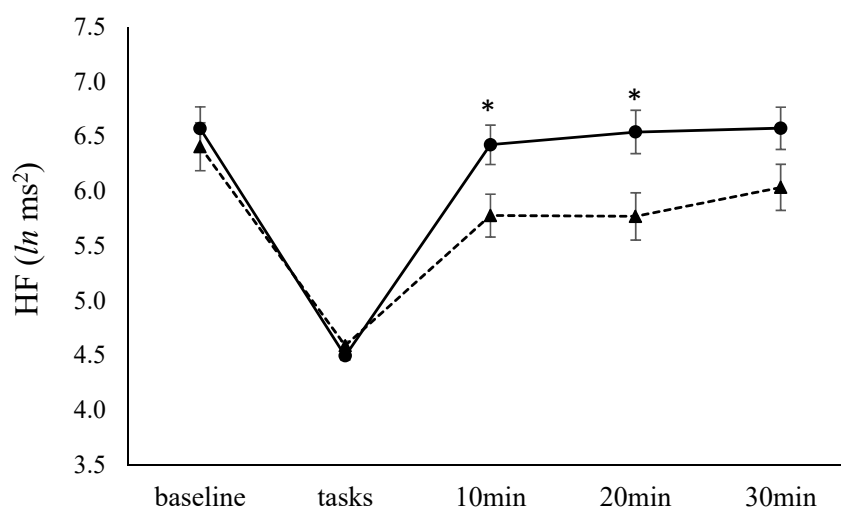


Figure 4. HF (high-frequency) stress responses for the high personal growth (solid line, squares) and low personal growth groups (dotted line, triangles) during baseline; tasks; and 10 min, 20 min and 30 min following the tasks. Error bars represent standard error of the mean; adjusted for negative affect, sex, and BMI. * $p < 0.05$ compared with the low personal growth group.

4. Discussion

In the current study, we investigated the effects of personal growth on perceived stress, salivary free-MHPG, the HF component and HR at rest, and responses to laboratory acute stress in students. Based on the enhanced allostasis model [26–28], we hypothesized that students with a high level of personal growth would have a low resting psychophysiological level of arousal and recover more quickly from psychosocial stress. The results indicated that students with a high level of personal growth had a lower baseline level of perceived stress (TA) and that their free-MHPG and HF component values recovered more quickly after the stress task, independent of negative affect and other covariates. This finding suggests that a high level of awareness about personal growth in students is a positive psychological factor that influences (a) low resting levels of TA, and (b) more rapid recovery of perceived stress levels, and in NA and parasympathetic nervous activity in response to psychosocial stress.

The current findings revealed that the high personal growth group exhibited significantly more rapid recovery in free-MHPG and HF component values after being presented with a mental stressor compared with the low-scoring group. Free-MHPG acutely reflects the type of activity in the central NA nervous system, and is reported to be correlated with anxiety, stress, and depression [43,44].

Meanwhile, the HF component reflects respiratory sinus arrhythmia (RSA), a variation in heartbeat caused by breathing that is considered to be a useful indicator of parasympathetic nervous system activity. The HF component has been reported to decrease in stressful situations [45] and increase in relaxing situations [46], and blunted HF responses to acute stressors has been correlated with clinical depression [47]. In addition, regarding recovery from acute stress, previous studies have suggested that the efficiency of psychobiological recovery may be related to the development of disease rather than the magnitude of the stress response [48]. These previous findings and the results of the current study suggest that students with a high level of awareness about personal growth recover more quickly from stimulation of the NA nervous system and from the suppression of parasympathetic nervous activity due to psychosocial stress, ultimately leading to better psychosomatic health.

Both personal growth groups in the current study exhibited increased HR in response to a mental stressor and an immediate subsequent recovery to baseline levels, with no significant difference between them. Compared with other cardiovascular responses, previous studies have indicated that HR changes more rapidly and recovers more rapidly after an acute stressor [49,50]. Although the current study was not able to confirm a direct correlation, positive affect is thought to be correlated with the recovery of diastolic blood pressure and HRV (LF, LF/HF) after a stressor, but not with HR [51–53]. It is therefore possible that no differences were observed between the two personal growth groups in this study because HR recovers more rapidly than other cardiovascular indicators after a stressor. In future, multiple cardiovascular indicators, such as blood pressure and peripheral vascular resistance, should be used to study this issue in more detail.

Psychobiological responses to psychosocial stressors in laboratory settings have also been reported to manifest in daily life [54]. Delayed recovery from acute stress and a high resting level of physiological arousal are thought to indicate a failure of allostatic control [55]. Chronic stress places a cumulative burden on homeostatic systems like the HPA and SAM systems, and causes a decline in adaptive regulatory function in response to stress, which may ultimately lead to mental and physical illness. In contrast, positive psychological states and traits have been found to be correlated with rapid recovery of diastolic blood pressure [51] and low baseline levels of inflammatory markers interleukin-6 and monocyte chemoattractant protein-1 in response to an acute stressor [56]. Furthermore, we previously determined that high eudaimonic well-being, which encompasses personal growth, is correlated with mental health and low levels of salivary free-MHPG and cortisol [57]. These findings and the results of the current study suggest that, in daily life, a high level of awareness about personal growth in students is correlated with (a) low levels of psychobiological arousal and (b) rapid recovery in response to psychosocial stress and other adaptive psychobiological regulatory functions, which is ultimately thought to decrease the risk of developing mental and physical illness and contribute to active health promotion.

Previous studies of personal growth and the central nervous system revealed that personal growth is positively correlated with gray matter volume in the right insula [58]. Eudaimonic well-being, which encompasses personal growth, has also been shown to correlate with activity in the cingulate cortex [59]. The cortical limbic system, which includes the insula and cingulate cortex, is correlated with regulation of the cardiovascular system and neuroendocrine processes. Thus, personal growth is thought to play an important role in the central nervous mechanisms that regulate psychobiological stress responses. Consequently, the findings of previous studies and the results of the current study suggest that the correlation between personal growth and eudaimonic well-being, and adaptive psychobiological functioning, may be mediated by subcortical regulatory mechanisms.

Finally, several limitations of the study should be considered. First, because the sample size was relatively small, we were not able to examine personal growth separately from the positive psychological states and personality traits correlated with it. For example, self-esteem is correlated with a decline in cardiovascular and inflammatory responses to acute stress [60], and optimism is correlated with a decline in cortisol secretion following a self-affirmation task in a laboratory [61].

To better determine the effects of personal growth on psychobiological stress responses, future studies should test a larger sample size and examine a wider variety of psychosocial factors.

Second, we conducted the current study with relatively healthy non-smoking students. It has been reported that awareness about personal growth is at its peak in youth and decreases with advancing age [8,9]. For this reason, it is difficult to generalize the results of the current study to other age groups, as the findings may be particular to young people. The confounding factors considered in the current study were limited to negative affect, sex, and BMI. Future studies should be conducted with workers and other people in different age groups, and should consider additional confounding factors such as socioeconomic status and health behaviors. Such psychobiological studies could help to empirically demonstrate the importance of improving personal growth and eudaimonic well-being to promoting positive health not only for university students, but also workers. Recently, various positive psychological intervention methods have been developed as applied practices for psychosomatic health [62–64]. In particular, eudaimonic well-being, which includes personal growth, has been the focus of preventive interventions for emotional disorders [65], which are closely related to biological function [12,13]. For example, some previous research indicates that interventions enhancing eudaimonic well-being promote biological processes such as increased expression of antiviral and antibody-related gene expression [20,21]. Therefore, it is important to elucidate positive psychological interventions aiming to promote positive health development in individuals and organizations, and the psychobiological processes underlying personal growth and eudaimonic well-being. These basic and clinical bridging studies are expected to lead to real-world evidence of sustainable well-being, toward the realization of a society with health and longevity [29,30].

Third, this study defined two personal growth groups: a high-scoring group and a low-scoring group. The concept of passion is related to personal growth, which Vallerand et al. (2003) define as “a strong inclination toward an activity that people like, that they find important, and in which they invest time and energy” [66]. They propose two contrasting types of passion: harmonious and obsessive. While the former is beneficial for health at an appropriate level, in the latter case, a person cannot desist from the target activity even if continuing it is harmful to their health. Thus, obsessive passion ultimately has a negative effect on health. Furthermore, it has been shown that people have lower levels of perceived stress the closer their positivity ratio (ratio of positive to negative effect) is to the middle [67]. These findings suggest that the ability to respond to and recover from stress may be greater among those who approach personal growth in moderation, and that these individuals may exhibit better psychosomatic health. To elucidate this issue in more detail, as well as clarifying the effects of personal growth on psychosomatic health and the underlying fundamental psychobiological processes, future studies should compare three groups, including a “moderate” group.

5. Conclusions

The purpose of the current study was to examine the effects of personal growth on subjective stress responses, and NA and cardiovascular acute responses among university students. Lower perceived stress (TA) was observed at baseline and recovery among participants with higher personal growth scores, as well as lower levels of free-MHPG and higher levels of HF component activity at recovery, independent of covariates. These findings suggest that greater personal growth in daily life is related to decreased psychobiological risk factors in students. Personal growth in students may contribute to better psychosomatic health through reduced NA and increased parasympathetic nervous system activity.

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