Influence of music training on academic examination-induced stress in Thai adolescents

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ABSTRACT

Several pieces of evidence suggest that academic examinations fulfill the classical requirement of a psychological stressor. Academic examinations represent a stressful challenge to many students, but studies on examination-dependent corticosteroid response, a sensitive physiological indicator of a stress response, are inconsistent. In addition, several studies showed that music can decrease cortisol and adrenocorticotropic hormone (ACTH) levels, and other studies have found that music also may enhance a variety of cognitive functions, such as attention, learning, communication and memory. The present study investigated cortisol response in saliva of Thai adolescents taking academic examinations and analyzed the differences of the stress response between musician and control subjects. Also, we observed whether the academic examination-dependent corticosteroid response affected learning and memory in the test subjects, which comprised 30 musician and 30 control students, age ranging from 15 to 17 years. Mathematical examinations were used as the stressor. Pre- and post-academic examination saliva cortisol levels were measured including self-estimated stress levels. Results showed that the pre-academic examination saliva cortisol concentrations of the musician group are significantly lower than those of the control group, whereas there is no difference in the stress inventory scores. Interestingly, among students with grade point average (GPA) of >3.50, pre-academic examination cortisol levels are significantly lower in the musician compared with control group. This study suggests that under academic examination-induced stress condition, music training can reduce saliva cortisol level in Thai adolescents.

It has been shown that music enhances a variety of cognitive functions, such as attention, learning, communication and memory [1]. Functional analyses also have demonstrated that music can decrease cortisol and adrenocorticotropic releasing hormone (ACTH) [8,10]. It is believed that exposure to a variety of acute psychological stressors (e.g. giving a speech, doing difficult cognitive tasks, taking academic examinations) for short durations can cause an increase in the levels of the hormone cortisol in the plasma, urine, and saliva. This increase is due to activation of the hypothalamic–pituitary–adrenal (HPA) axis [2]. Stressful life experience can have significant effects on a variety of physiological systems, including the autonomic nervous system, HPA axis, and immune system [7]. Activation of the HPA axis increases the release of corticotropin-releasing hormone (CRH) from the hypothalamus, which stimulates the anterior pituitary to release ACTH into the bloodstream, and thereby stimulating the adrenal cortex to release cortisol [2].

Recent studies showed that the academic-dependent corticosteroid response can affect learning and memory, and when conducting a music performance in a short time period, cortisol level can be decreased as well as improving learning and memory [3,16]. Schlaug et al. [14] also have demonstrated that music training in children results in long-term enhancement of visual–spatial, verbal, and mathematical performance. In addition, the concentration of saliva cortisol decreases more rapidly in the subjects exposed to music than in the control group recovering from stress in silence [8]. On the other hand, no differences have been found in saliva cortisol level to mood induction by music [5], or in urine cortisol when listening to relaxing music [13].

These contradictory data on the impact of academic examinations on cortisol response may be due to variation of age, time of

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day and individual differences on personality traits. Therefore, the present study investigated the effect of music training on academic examination by analyzing saliva cortisol levels between music and control Thai student groups.

Adolescent pupils (22 males, 38 females; 15–17 years of age) from Triam Udom Suksa Pattanakarn Bangyai High School in Nonthaburi, Thailand, participated in the present study. Subjects were classified into 2 groups: amateur musician ($n = 30$, 12 males and 18 females) and control ($n = 30$, 10 males and 20 females). All subjects gave written informed consent. This study protocol was approved by the Ethical Clearance Committee on Human Rights Related to Human Experimentation, Mahidol University, Thailand. Information of age, weight, height, body mass index, medical history, activity in free time, age of commencement of musical training, and intensity of lifelong practice (self estimate of hours of practice per day and days of practice per week) were obtained by general questionnaire. In addition, subjects were asked to indicate stress level using the stress inventory from Department of Mental Health, Ministry of Public Health, Thailand, on day pre- and post-academic examination at similar time of the day. All music students attended the same class taking guitar lessons in contemporary music for 3 h a week.

Saliva samples were taken approximately 30–60 min before and after the mathematical examination. To determine the baseline level of cortisol, one month before the examination, saliva samples were obtained at similar time of the day. To collect saliva samples for measurement of cortisol level, 5 min before providing saliva, all subjects were required rinse their mouth with clean water. Then, subjects chewed collection swab for up to 3 min, and the swabs were kept in an icebox and immediately transported to the laboratory, where the samples were centrifuged at 1400 × g for 15 min. Supernatant saliva samples were stored at −80 °C until use. Cortisol in saliva was measured using a radioimmunoassay kit (CORT-CT2; CIS Bio International, Gif-sur-Yvette, France) according to manufacturer’s instructions. In brief, 150 μl aliquots of saliva samples and standards were incubated 500 μl aliquot of 125I-labeled cortisol in coated tubes for 30 min at 37 °C. Then, following washing with distilled water, bound radioactivity was measured in a gamma scintillation counter (Wallac 1470, PerkinElmer Ltd., USA). Each individual sample was determined run in duplicate. A one-way Analysis of Variance (ANOVA) and Tukey post hoc were employed to compare the mean values of music and control student groups. Difference is considered statistically significant at a $P$ value < 0.05.

The characteristics of the study groups are shown in Table 1. The subjects of 2 groups do not differ significantly with regards to age, sex, weight, height and body mass index (BMI). Behavioral tests showed a higher index post-examination in music compared to control student group, but there was no difference in stress level (data not shown). The saliva cortisol concentration of pre-academic examination music student group is significantly lower than that of control group ($p < 0.001$) (Fig. 1). In control group, mean pre-academic examination saliva cortisol concentration is significantly

**Table 1**

<table>
<thead>
<tr>
<th>Parameter $^a$</th>
<th>Music student</th>
<th>Control</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sample size (number)</td>
<td>30 (12 M, 18 F)</td>
<td>30 (10 M, 20 F)</td>
</tr>
<tr>
<td>Age (years)</td>
<td>15.70 ± 0.60</td>
<td>15.5 ± 0.51</td>
</tr>
<tr>
<td>Weight (kg)</td>
<td>54.30 ± 8.57</td>
<td>53.78 ± 11.37</td>
</tr>
<tr>
<td>Height (m)</td>
<td>1.66 ± 0.08</td>
<td>1.63 ± 0.07</td>
</tr>
<tr>
<td>BMI (kg/m$^2$)</td>
<td>19.77 ± 2.51</td>
<td>20.14 ± 3.48</td>
</tr>
</tbody>
</table>

$^a$ Mean ± SD. M = male, F = female.

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![Fig. 1. Effect of academic examination on saliva cortisol concentration in Thai music and control students. Saliva cortisol concentration (mean ± SD) was measured using a radioimmunoassay before and after taking an academic examination, and on a non-examination day (baseline). ***$p < 0.001$.](https://example.com/f1.png)

![Fig. 2. Stratification of saliva cortisol levels according to average GPA score of all test students. Saliva cortisol levels were measured as described in legend to Fig. 1. Control group with GPA of 3.50–4.00, $n = 14$, 3 males and 11 females; with GPA of 3.00–3.49, $n = 11$, 5 males and 6 females; with GPA of 2.00–2.99, $n = 5$, 1 male and 4 females. Music student group with GPA of 3.50–4.00, $n = 13$, 5 males and 8 females; with GPA of 3.00–3.49, $n = 10$, 4 males and 6 females; with GPA of 2.00–2.99, $n = 7$, 4 males and 3 females. ***$p < 0.001$.](https://example.com/f2.png)
higher than baseline level ($p < 0.001$) but significantly decreases post-examination ($p < 0.001$), whereas those of the music student group were unchanged.

When the saliva cortisol levels were stratified according to the students’ grade point average (GPA, total score = 4), mean pre-academic examination cortisol level is statistically lower in music students ($n = 13$, 5 males and 8 females) compared with control ($n = 14$, 3 males and 11 females) group with GPA of $3.50–4.00$ ($p < 0.001$) (Fig. 2). Interestingly, among these students the control group has a significantly higher mean pre-examination cortisol than baseline and post-examination level respectively ($p < 0.001$), whereas these values are unchanged in the music student group. Among those with GPA of 3.00–3.49, mean pre-examination cortisol level is significantly higher than post-examination ($p < 0.001$) in control group ($n = 11$, 5 males and 6 females) but this was not observed in the music student group ($n = 10$, 4 males and 6 females). On the other hand, with GPA of 2.00–2.99, no differences between pre-examination and post-examination cortisol levels in both music students ($n = 7$, 4 males and 3 females) and control group ($n = 5$, 1 male and 4 females) were observed.

These data indicate that music students were more emotionally stable and less anxious than controls before and after a stressful situation. Watkins [17] demonstrated that music may facilitate a reduction in stress response include decreased anxiety level, decreased blood pressure and heart rate, and changes in plasma cortisol level is significantly higher than post-examination ($p < 0.001$) in control group ($n = 11$, 5 males and 6 females) but this was not observed in the music student group ($n = 10$, 4 males and 6 females). On the other hand, with GPA of 2.00–2.99, no differences between pre-examination and post-examination cortisol levels in both music students ($n = 7$, 4 males and 3 females) and control group ($n = 5$, 1 male and 4 females) were observed.

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