The influence of music on cortisol - as a marker of stress and depression

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ABSTRACT:

Music reduces stress through different mechanisms. Firstly there are the physical and mental relaxation mechanisms. Secondly, music helps in stress relief activities. It also reduces negative emotions. Furthermore, music can distract from negative thoughts and activities and can help to achieve a positive and more optimistic state of mind. Therefore music proves its effectiveness in reducing the levels of anxiety and depression and also in improving the mood. But the music itself reduces the amount of hormones released during stress and most studies have focused on measuring cortisol levels before and after exposure to different types of music.

Starting from the literature on the benefits of music on cortisol levels, we aimed to investigate the impact of classical music on salivary cortisol in a group of patients suffering from depression. Our study confirms the information gathered from literature regarding the favorable effect of music on cortisol. Although there are slight differences between lively and relaxing music (in favor of the relaxing type) study shows that the favorable effect of music is maintained for both types of music, the most important element being the satisfaction of the listener.

Keywords: music therapy, stress, depression, anxiety, cortisol, ACTH.

REZUMAT:

Muzica reduce stresul prin diferite mecanisme. În primul rând, există mecanismele fizice și mentale de relaxare. În al doilea rând, muzica ajută la activitățile de salvare de stres. De asemenea, reduce emoțiile negative. În plus, muzica poate distra atenția de la gândurile și activitățile

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negative și poate ajuta pentru a realiza o stare pozitivă și mai optimistă a minții. Prin urmare, muzica dovedește eficiență în reducerea nivelului de anxietate și depresie și, de asemenea, în îmbunătățirea starii de spirit. Muzica reduce cantitatea de hormonii eliberati în timpul stresului și cele mai multe studii s-au concentrat pe măsurarea nivelului de cortizol, înainte și după expunerea la diferite tipuri de muzică.

Pornind de la literatura de specialitate cu privire la beneficiile muzicii asupra nivelurilor de cortizol, ne-am propus să investighăm impactul muzicii clasice pe cortizolului salivar într-un grup de pacienți care suferă de depresie. Studiul nostru confirma informațiile culese din literatura de specialitate în ceea ce privește efectul favorabil al muzicii pe cortizol. Deși există diferențe minore între muzica plină de viață și de relaxare (în favoarea tipului de relaxare), studiul arată că efectul favorabil al muzicii se menține pentru ambele tipuri de muzică, cel mai important element fiind satisfacția ascultătorului.

Cuvinte cheie: terapia prin muzică, stress, depresie, anxietate, cortizol, ACTH

Music improves mood and reduces depression and anxiety levels

The information gathered from literature supports the beneficial effect of music on anxiety and depression levels of patients undergoing a difficult situation. For example, numerous studies have shown that music can be used to reduce anxiety before and during surgery.

Epinephrine, norepinephrine, ACTH and cortisol are commonly used as markers of surgical stress, particularly abdominal surgery (Cook, 1986; White et Shaw, 1991). The increase in the level of these hormones is proportional to the stress of surgery, which was clearly shown in one study (Wang et al., 2002). Rider (Rider et al., 1985) have already demonstrated that music and image therapy determine relaxation and maintain average levels of corticosteroids in subjects who are awake. Therefore, it seems that subjective effects of music on anxiety and depression are easily proven, but an objective demonstration regarding the physiological variables is difficult to achieve. (Bartlett et al., 1993)
Music can reduce patient anxiety before surgery. It has been demonstrated that listening to music in the pre-and postoperative period reduces anxiety related to surgery and reduces the need for analgesics (Kaminski et Hall, 1996; Burke et al., 1995). In patients under regional anesthesia, music decreases the need for sedation and analgesia, and also decreases plasma levels of cortisol, epinephrine and tissue plasminogen activator-type. (Coughlan, 1994; Rhoades et Tanner, 1995) Several pharmacological interventions have proven effective in reducing perioperative stress hormone release under general anesthesia (Weissman, 1990; Hall et al., 2000). The beneficial effects of music on stress and welfare and on the decrease of sedation during regional anesthesia have already been demonstrated (Koch et al., 1998; Lepage et al., 2001). Several studies have also shown that listening to music, sounds or therapeutic suggestions during general anesthesia may have a positive effect on postoperative recovery and decrease the need for analgesics (Ewans et Richardson, 1988). Other studies could not demonstrate these findings (Boeke et al., 1988).

The effects of music on cortisol, the most important marker of depression

Music reduces stress through different mechanisms. Firstly there are the physical and mental relaxation mechanisms. Secondly, music helps in stress relief activities. It also reduces negative emotions. Furthermore, music can distract from negative thoughts and activities and can help to achieve a positive and more optimistic state of mind. Numerous studies have focused on the hormones ACTH and cortisol, to investigate the effects of music on the neurohormonal pathway. Listening to music or singing can reduce levels of cortisol released during stress. Higher levels of cortisol can lead to decreased immune response (Roux et al., 2007; Kreutz et al., 2004). It has been proven that listening to quiet; classical music can significantly reduce stress (Khalfa et al., 20003; Labbe’E et al., 2007).

There are several studies that have tried to find out if the music itself reduces the amount of hormones released during stress. Most studies have focused on measuring cortisol levels before and after exposure to different types of music. The aim was to reduce cortisol levels or, more precisely, to prevent the increased release of this stress hormone during invasive diagnostic and surgical procedures. Escher investigated a group of patients undergoing endoscopy, who listened to their favorite music during the procedure. A control group did not listen to music. The control group
showed a large increase in cortisol and ACTH levels in their blood. However, the group that was listening to music presented a significantly lower level of release of these hormones. (Escher et al., 1993) In a similar approach, but in this case surgery-related, Miluk-Kolas and his collaborators (Miluk-Kolas et al., 1994) have measured cortisol levels in patients after informing them that they would undergo surgery the next day. These researchers found that information about impending surgery led to an increase of 50% of the cortisol level. Some patients were subjected to listening to music while others were the control group. An hour after the announcement the patients who did not listen to music had higher levels of cortisol compared to the group that had listened to music. Thus, music has greatly reduced the initial increase in cortisol levels, subsequent to stress. Schneider has studied the influence of music on stress response in patients undergoing cerebral angiography. (Schneider et al., 2001) Patients examined without music show increased plasma cortisol levels, indicating high levels of stress, while in patients examined with music cortisol levels remained constant. Also, systolic blood pressure was significantly lower for the group listening to music. These studies indicate that stress hormone levels can be reduced by exposure to music in a medical framework.

Various pharmacological interventions are used to reduce perioperative stress hormone release during surgery under general anesthesia. Listening to music for therapeutic use has been studied mainly in patients who are awake and it has been shown that music has a positive effect on postoperative recovery and can also have an analgesic role. Nilsson et al., in 2001, showed that hysterectomised patients who listened to music under general anesthesia required fewer narcotics for postoperative analgesia than patients who did not listen to music. According to this study it could be hypothesized that listening to music under general anesthesia can reduce the release of stress hormones as a result of the surgical act, which would result in lower levels of epinephrine, norepinephrine, cortisol and ACTH. On the other hand, some studies have not been able to show the positive effect of music under anesthesia on the neuroendocrine stress response system or perioperative opioid consumption. Migneault has evaluated the effect of music under general anesthesia on the neurohormonal response to surgical stress. They could not record a difference between the plasma levels of norepinephrine, epinephrine, cortisol and ACTH of the two groups although the initial blood hormone levels increased significantly in each group, as a result of the surgical stimulation. (Migneault et al., 2004) In conclusion, this study could not demonstrate a
significant effect of music on surgical stress while using it intraoperatively under general anesthesia.

Regarding the reduction of cortisol levels in healthy subjects who were listening to music, there was a randomized study performed (McKinney et al., 1997), organized in six sessions twice a week. They found significant decreases in cortisol levels and positive effects on depression, fatigue and mood. Decreased cortisol was significantly associated with decreased disturbance in the mood. In conclusion, music therapy positively affects mood and significantly reduces cortisol levels in healthy adults.

The aim of another study (Khalfa et al., 2003) was to determine whether relaxing music compared to silence may facilitate psychological recovery after a stressful task. To achieve this objective, the changes in salivary cortisol of 24 students were regularly monitored before and after the Trier social stress test. The data showed that in the presence of music, salivary cortisol level ceases to increase, while during silence it continued to rise for 30 minutes.

Although these findings seem to agree that music reduces stress hormone secretion, this is not universally valid. For example, Brownley and his collaborators have investigated how music affects cortisol levels in trained and untrained runners, in three conditions: relaxing music, lively music and no music. (Brownley et al., 1995) After strenuous exercise, the authors have recorded high levels of cortisol for fast music beats, compared to relaxing music, in both trained and untrained runners. So, music can actually increase stress hormone levels. Indeed, if it seeks to mobilize people in cases of stress, this effect would be desirable. For example, when work stress is needed to motivate someone. Therefore runners can adjust their optimum levels of hormones through music.

Other studies also show that music can both increase and decrease the release of stress hormones. In one such study (VanderArk et Ely, 1992), participants trained in music and biology have been exposed to music. Music did change hormone levels, but the effect did not vary depending on the type of music (relaxing vs. energizing) but on the field of study of the subjects. Biologists have shown a decrease in cortisol levels, however, musicians have had significant increases in cortisol levels. Explanation is given by the fact that when interviewed, Conservatory students were actively involved in the mental analysis of music. Some even said that they had used
the instruments mentally. The same authors have obtained similar results in a study by listening bad or even tragic music, with similar test subjects (VanderArk et Ely, 1993).

Taken together, these findings indicate that there is no simple relationship between music and stress hormones. Their interaction is not only about the type of music, but depends on other cognitive and mental activities, that the individual experiences. This seems to be a key element in understanding the complex interaction between music, hormones and brain.

**Personal research**

Based on the literature on the benefits of music on cortisol, we aimed to investigate the impact of classical music on salivary cortisol in a group of depressed patients, hospitalized at Obregia. For this we also formed a control group of healthy subjects.

**Materials and methods**

<table>
<thead>
<tr>
<th>Groups investigated</th>
<th>Number of subjects</th>
<th>Types of investigation</th>
<th>The average age</th>
</tr>
</thead>
<tbody>
<tr>
<td>Group of healthy subjects</td>
<td>40</td>
<td>Salivary cortisol before and after the hearing (40 subjects)</td>
<td>56</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Hearing lively music (20 subjects) and relaxing (20 subjects)</td>
<td></td>
</tr>
<tr>
<td>Group of patients suffering from depression</td>
<td>40</td>
<td>Salivary cortisol before and after listening Hearing lively music (20 subjects), relaxing (20 subjects).</td>
<td>61</td>
</tr>
</tbody>
</table>

The impact of music on cortisol levels was investigated through two sets of music:

- A set of fun, lively music:
  a. Richard Wagner - "Lohengrin" 3 min 32 sec
  b. Şostakovici - February 3 min
  c. Bela Bartok - 1 min 27 sec
  d. Sibelius - "Karelia" 3 min 2 sec
- A set of dreamy, relaxing, melancholic music:
  a. Mendelssohn op.30 2 min 41 sec
  b. Șostakovici - "Song" 2 min 59 sec
  c. Faure - "After a Dream" 2 min 49 sec
  d. Delius - "At Kalinda" 4 min 37 sec

Saliva was collected for measurement of salivary cortisol as an important marker of stress, before and after listening to music (a subset with relaxing music, and a subset with lively music). Saliva collection was done at the same time in all patients (3 P.M.).

**Study assumptions**

1. Cortisol levels after hearing the music are significantly low compared to cortisol levels measured before the audition on the group of patients with depression.

2. Cortisol levels after hearing the music is significantly low compared to cortisol levels measured before the hearing on the group of healthy subjects.

3. Salivary cortisol levels decreased similarly as a result of listening music in both groups of depressed and healthy patients.

**Statistical analysis of results**

In order to analyze the differences between initial and final cortisol levels for the group of patients with depression I used the T test for comparing two samples of correlated scores. The T test is used to assess the statistical significance of the difference between the averages for two sets of scores.

<table>
<thead>
<tr>
<th>Paired Samples Test</th>
<th>Paired Differences</th>
<th>t</th>
<th>df</th>
<th>Sig. (2-)</th>
</tr>
</thead>
</table>

7
Average salivary cortisol levels measured before listening (M = 11.14, SD = 2.74) and after listening (M = 8.94, SD = 1.98) differ significantly (t = 11.27, DF = 39, p <0.001).

We analyzed the influence of the type of music (lively or relaxing) on the salivary cortisol levels in depressed patients. Relaxing music produced a decrease of 21.5% in salivary cortisol level from an average of 12.06 to one of 9.46, which is a statistically significant difference (t = 8.278, DF = 19, p <0.001). Lively music led to a decrease of 17.88% of salivary cortisol from an average of 10.23 to an average of 8.40, which is also a statistically significant difference (t = 8.566, DF = 19, p <0.001).

Next, we used the t test for comparing two correlated scores to test whether cortisol levels were significantly improved after hearing music (relaxing and lively) on the group of healthy subjects as well.

**Paired Samples Test**

<table>
<thead>
<tr>
<th>Pair</th>
<th>CORTIZOL INITIAL</th>
<th>CORTIZOL FINAL</th>
<th>Paired Differences</th>
<th>Std. Deviation Mean</th>
<th>Std. Error Mean</th>
<th>95% Confidence Interval of the Difference</th>
<th>Lower</th>
<th>Upper</th>
<th>95% Confidence Interval of the Difference</th>
<th>Lower</th>
<th>Upper</th>
<th>T</th>
<th>Df</th>
<th>Sig. (2-tailed)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>2.197</td>
<td>1.2324</td>
<td>1.949</td>
<td>1.8034</td>
<td>2.5916</td>
<td>11.27</td>
<td>39</td>
<td>.000</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
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**Paired Samples Test**

| Paired Differences | Std. Deviation Mean | Std. Error Mean | 95% Confidence Interval of the Difference | Lower | Upper | T | Df | Sig. (2-tailed) |
Paired Samples Test

<table>
<thead>
<tr>
<th>Pair</th>
<th>Paired Differences</th>
<th>Mean</th>
<th>Std. Deviation</th>
<th>Std. Error Mean</th>
<th>95% Confidence Interval of the Difference</th>
<th>T</th>
<th>DF</th>
<th>Sig. (2-tailed)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cortisol control inainteauditie</td>
<td>Cortisol control dupa auditie</td>
<td>1.445</td>
<td>0.9265</td>
<td>0.1465</td>
<td>1.1487 to 1.7413</td>
<td>9.864</td>
<td>39</td>
<td>.000</td>
</tr>
</tbody>
</table>

Test results ($t = 9.864, p < 0.001$) demonstrate that there is a statistically significant difference between the average levels of cortisol before listening ($M = 7.22, SD = 2.45$) and after hearing recorded music ($M = 5.78, SD = 2.43$) in healthy subjects.

It also depended on the type of music (relaxing or lively). Relaxing music resulted in a decrease of 22.74% in salivary cortisol levels from $M = 7.08$ to $M = 5.47$, statistically significant difference ($t = 6.565, DF = 19, p < 0.001$). Lively music produced a 17.50% decrease in cortisol levels from $M = 7.37$ to $M = 6.08$, also a statistically significant difference ($t = 8.02, DF = 19, p < 0.001$).

Discussion

Hypothesis 1

Cortisol levels after hearing music are significantly low compared to cortisol levels measured before the audition for the group of patients with depression.

Average salivary cortisol level measured before and after the audition differs significantly. Relaxing music produced a decrease in salivary cortisol level of 21.5%, higher than lively music.
that caused a decrease in salivary cortisol of only 17.88%. Therefore, the hypothesis is confirmed, regardless of the type of music heard.

**Hypothesis 2**

*Cortisol levels after hearing the music is significantly low compared to cortisol levels measured before the hearing for the lot of healthy subjects.*

T test results show that there is a statistically significant difference between the levels of cortisol before and after hearing recorded music, for the healthy subjects as well. Depending on the type of music (relaxing or lively) the results differed slightly. Relaxing music resulted in a 22.74% decrease in salivary cortisol levels, compared to lively music that caused a 17.5% decrease in cortisol levels - both statistically significant differences. Thus, hypothesis 2 is also confirmed, for both types of music.

**Hypothesis 3**

*Salivary cortisol levels decreased similarly as a result of listening to music for both groups of depressed and healthy patients.*

Average cortisol levels before and after hearing the music in the two groups investigated.
Salivary cortisol levels decreased by approximately 20% in both groups (healthy and depressed patients). Therefore, there is no statistically significant difference between final and initial cortisol levels between the groups of depressed and healthy subjects. \((F = 0.221, \ p < 0.640)\). Hypothesis 3 is confirmed: salivary cortisol levels decreased similarly in both groups investigated, after listening to music.

Conclusions

Our study confirms the data gathered from the literature regarding the favorable effect of music on cortisol levels. Although there are slight differences between lively and relaxing music (in favor of relaxing) study shows that the favorable effect of music is maintained for both types. In addition, the most important factor is the satisfaction of the listener, since 98% of subjects (healthy and depressed) said they appreciated the music very much. When asked how much they enjoyed what they heard the majority said they enjoyed a lot. Interestingly enough, before the audition, the vast majority of subjects reported other musical preferences, such as pop or folk music and not so much symphonic, instrumental, opera or operetta. Therefore, we can conclude that the symphonic music has a beneficial effect on cortisol levels for both depressed and healthy subjects, regardless of the musical preferences of the listeners but directly related to the degree of pleasure produced by
listening to music. This study needs to be continued by extending the number of participants, broadening the types of music heard (including the selection of other pieces of symphonic music and also using the subjects’ favorite music), but also by increasing the frequency and listening time.

**Bibliography**


