Correlation of Salivary Amylase Activity With Eustress in Patients With Severe Motor and Intellectual Disabilities

Kazunori TAKEDA*, Maiko WATANABE**, Mieko ONISHI**, and Masaki YAMAGUCHI***

Patients with severe motor and intellectual disabilities (SMID) who require ongoing medical care to sustain their life often experience severe emotional and physical distress and require intervention to relieve this distress. In patients with severe motor and intellectual disabilities with whom communication is extremely difficult, objective parameters must be established for the assessment of emotional changes. To investigate the usefulness of salivary amylase activity as an index of emotional changes, we examined the correlation between salivary amylase activity and “Snoezelen” therapy (therapeutic and educational activities) designed to produce eustress (pleasurable stimuli to reduce distress) in 10 patients with severe motor and intellectual disabilities. We found that regardless of the severity of their disabilities, salivary amylase activity significantly decreased during Snoezelen therapy as compared to the activity before Snoezelen therapy. Our findings suggest that salivary amylase activity is useful as a noninvasive index of changes reflecting eustress in patients with severe motor and intellectual disabilities. Furthermore, real-time measurement of amylase activity using a hand-held salivary amylase activity monitor with disposable test strips is useful for assessment of eustress in patients with severe motor and intellectual disabilities.

Key Words: eustress, salivary amylase, people with intellectual disabilities, people with motor disabilities, people with severe motor and intellectual disabilities (SMID)

Introduction

Patients with severe motor and intellectual disabilities (SMID) have difficulty expressing their physical and emotional feelings with words and/or gestures, and health care providers, caregivers, and teachers involved with these patients must rely on observations and experience to gauge the patients’ emotional changes (Lancioni,

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Singh, O'Reilly, Oliva, & Basili, 2005; Petry & Maes, 2006).

Despite advances in medical technology, many patients with multiple disabilities are bedridden and require constant care, including nasogastric tube feeding and mechanical ventilation, in order to sustain life. This type of environment creates severe unpleasant stress (distress) (Chaney, 1996; Lancioni et al., 2005). In contrast, an optimal amount of pleasant stimulation is considered to be positive stress or "eustress". This type of stress activates positive effects on the body as a defense response to distress (Niki, 2007).

In facilities for patients with severe motor and intellectual disabilities, it is important to provide therapy and special supportive education that produces eustress, or, in other words, to provide pleasurable stimuli aimed at reducing distress and providing relaxation (Lancioni et al., 2005; Milsum, 1985; Szabo, 1998). Assessment of the emotional changes induced by various forms of relaxation is essential to improve the quality of life (QOL) in patients with severe motor and intellectual disabilities. However, caregivers must rely on subjective factors when assessing these patients. Thus, development of an objective index to assess emotional changes is important in providing treatment, education, and supportive care for these patients.

Salivary amylase is a digestive enzyme stored in the zymogen granules of acinar cells in the serous parotid and maxillary glands. This enzyme degrades polysaccharides like starch and glycogen into maltose, maltooltriose, and dextrins. Groza, Zamfir, and Lungu (1971) first reported transient elevation of salivary amylase levels as a marker for postoperative stress in pediatric patients. Subsequent studies have reported increased salivary amylase activity with both physical stress and emotional stress (Bosch, Brand, Ligtenberg, Bermond, Hoogstraten, & Nieuw Amerongen, 1996; Chatterton, Vogelsong, Lu, Ellman, & Hudgens, 1996; Gilman, Fischer, Biersner, Thornton, & Miller, 1979; Nater, Rohleder, Gaab, Berger, Jud, Kirschbaum, & Ehlert, 2005).

Chatterton, Vogelsong, Lu, and Hudgens (1997) reported that healthy novice skydivers had an increase in salivary amylase activity several hours before skydiving and a rapid decrease in salivary amylase activity immediately after the skydiving was completed. In that study of healthy volunteers, the findings suggested that salivary amylase activity compared favorably to other stress markers and was acknowledged as a useful marker for changes in psychological stress over a short period of time.

However, chromogenic methods of measuring amylase, such as the traditional blue starch method, require a relatively long time due to complex measurement techniques that involve collection of a fixed amount of saliva sample, followed by centrifugation in the laboratory. This may be one of the reasons why a correlation between salivary amylase activity and eustress in patients with severe motor and intellectual disabilities has not been previously reported.

In recent studies of patients with severe motor and intellectual disabilities with communication difficulties, salivary amylase activity was found to be a useful, noninvasive, rapid, and reliable marker of stress. In the present study, we examined the correlation between salivary amylase activity and eustress produced by Snoezelen
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TABLE 1 Characteristics of Study Participants

<table>
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<tr>
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<td>J</td>
<td>12</td>
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<td>CP, MR, Noonan syndrome</td>
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</table>

therapy in patients with severe motor and intellectual disabilities in order to evaluate the usefulness of this index for assessing positive emotional changes.

Participants and Methods

In Japan, patients with a combination of severe intellectual disability (IQ ≤ 35) and motor disability (bedridden, or able to sit but not stand) are defined as having severe motor and intellectual disabilities.

The present study was conducted at National Hospital Organization Ibaraki Higashi Hospital. Ten inpatients with severe motor and intellectual disabilities (6 males, 4 females) with a mean age of 34.1 years (range: 12 to 45 years), were included. Seven patients were bedridden with an IQ ≤ 20; 2 patients were able to sit and had an IQ ≤ 20, and 1 patient was bedridden with an IQ of 20 to 35. Three patients required feeding with a nasogastric tube (Table 1).

Salivary amylase activity was measured with a hand-held monitor and disposable test strips. This device was jointly developed by Toyama University, Yamaha Motor Co. Ltd., and Nipro Co. Ltd. (Fig. 1) (Yamaguchi, Kanemori, Kanemaru, Takai, Mizuno, & Yoshida, 2004). All saliva samples were collected by direct placement of a disposable test strip under the tongue. These strips were then transferred to a reagent strip containing a chromogen with a saliva transcription device. Subsequently, changes in color density were measured with an optical analyzer.

Snoezelen therapy was performed in a quiet, dimly lit room. The Snoezelen environment included a combination of color "healing light", background "healing music", and aromas. The posture of each patient was adjusted by using mats, cushions, and other objects to support muscle tone and respiratory function. Each patient was accompanied by specialist staff. The therapy was performed for approximately 1 hour.

Specialist staff who were involved in the routine care of the patients and were capable of subjectively determining changes in the physical condition of the patients
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to some extent during care lay next to the patients in order to maintain the patients' posture, and also checked their vital signs.

Implementation of Snoezelen therapy was divided into three phases, a 30-minute period prior to the start of therapy, approximately 1 hour of therapy, and a 30-minute period following therapy. During each phase, salivary amylase activity was sampled twice during each of the first and the last halves of the phase, at times when body motion and muscle tone was minimal. The sampling points were spaced more than 10 minutes apart. Measurements before and after Snoezelen therapy were performed at the bedside.

In addition, heart rate was recorded throughout therapy using the Polar S610i sports heart rate monitor. Heart rates during saliva sampling were recorded for comparison.

The general condition of each patient, including his or her facial expressions, was monitored with a digital video camera (Canon FVM100) during Snoezelen therapy.

Figure 2 depicts the experimental protocol.

Salivary amylase activity and heart rate were compared both within and among the phases, using a t-test. Pearson’s correlation was used to measure the correlation between salivary amylase activity and heart rate. Stat View 5.0 (SAS Institute, CA, USA) was used for the statistical analysis.

**Fig. 1** Hand-held Salivary Amylase Activity Monitor Using a Disposable Test Strip
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The protocol of the present study was approved by the Ethics Committee at Tsukuba University and the Ethics Committee at National Hospital Organization Ibaraki Higashi Hospital. All patients or their guardians provided verbal and written informed consent.

Results

Snoezelen therapy was performed a mean of 1.9 times for each patient. Observations during therapy and analysis of video footage revealed various behavioral changes (e.g., sleep, reduction in body motion and muscle tone, and irregular vocalization).

Figure 3 shows salivary amylase activity at two time points. At each point, the patient was at rest: before (AMY-pre 1, AMY-pre 2), during (AMY-mid 1, AMY-mid 2), and after Snoezelen therapy (AMY-post 1, AMY-post 2). Salivary amylase activity was $81.2 \pm 36.9$ kU/L at AMY-pre 1, $73.9 \pm 42.0$ kU/L at AMY-pre 2, $36.4 \pm 29.9$ kU/L at AMY-mid 1, $31.8 \pm 29.1$ kU/L at AMY-mid 2, $83.0 \pm 55.2$ kU/L at AMY-post 1, and $79.4 \pm 44.1$ kU/L at AMY-post 2.

During Snoezelen therapy, salivary amylase activity was significantly lower ($p < .01$) than before or after Snoezelen therapy. Comparison of salivary amylase activity before and after Snoezelen therapy showed no significant difference ($p > .1$). There were no significant differences between the two time points during Snoezelen therapy ($p > .1$).

Figure 4 shows changes in heart rate before (HR-pre 1, HR-pre 2), during (HR-mid 1, HR-mid 2), and after Snoezelen therapy (HR-post 1, HR-post 2).
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**FIG. 3** Changes in Salivary Amylase Activity During Snoezelen Therapy in Patients With Severe Motor and Intellectual Disabilities

*Notes.* Values shown are the mean ± SD. Salivary amylase activity during Snoezelen therapy was significantly decreased compared to before and after Snoezelen therapy (**p < .01**). There were no significant differences between the 2 time points in each phase.

**FIG. 4** Changes in Heart Rate During Snoezelen Therapy in Patients With Severe Motor and Intellectual Disabilities

*Notes.* Values shown are the mean ± SD. Heart rate during Snoezelen therapy was significantly decreased compared with time points (pre-1) before and (post-2) after Snoezelen therapy (*p < .05*). There were no significant differences between the 2 time points in each phase.
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Heart rate was \(84.7 \pm 11.7\) bpm at HR-pre 1, \(83.4 \pm 14.4\) bpm at HR-pre 2, \(77.6 \pm 16.7\) bpm at HR-mid 1, \(76.4 \pm 20.4\) bpm at HR-mid 2, \(80.6 \pm 17.8\) bpm at HR-post 1, and \(86.5 \pm 15.7\) bpm at HR-post 2.

Heart rate during Snoezelen therapy was significantly lower compared to before (HR-pre 1) \((p<.05)\) and after Snoezelen therapy (HR-post 2) \((p<.05)\). However, there were no significant differences between heart rate during Snoezelen therapy and immediately before (HR-pre 2) as well as immediately after Snoezelen therapy (HR-post 1). Furthermore, no significant differences were observed between heart rate before and after Snoezelen therapy. In addition, significant differences were not observed for heart rates at the two time points during Snoezelen therapy.

Figure 5 (a) to (c) shows the correlation between heart rate and salivary amylase activity before, during, and after Snoezelen therapy. The statistics were calculated using all the data \((N=38)\) for salivary amylase activity and heart rate of the patients in each phase.

A significant correlation was obtained between heart rate and salivary amylase activity during Snoezelen therapy \((r = .421, p < .01)\). However, there was no significant correlation between before or after Snoezelen therapy \((p > .1)\).

![Correlation of Salivary Amylase Activity and Heart Rate in Patients With Severe Motor and Intellectual Disabilities](image-url)
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Discussion

At both time points during Snoezelen therapy (AMY-mid 1, AMY-mid 2), salivary amylase activity was significantly decreased compared to before (AMY-pre 1, AMY-pre 2) and after (AMY-post 1, AMY-post 2) Snoezelen therapy. Changes in heart rate showed a similar pattern, but the changes in salivary amylase activity were more pronounced.

Thus, the present findings suggest that salivary amylase activity is a useful objective marker for eustress in patients with severe motor and intellectual disabilities.

The hand-held salivary amylase activity monitor used in the present study was very convenient. Saliva was collected on a disposable test strip and transferred to a reagent strip containing a chromogen (Gal-G2-CN: 2-chloro-4-nitrophenyl-4-O-β-D-galactopyranosylmaltoside) with a saliva transcription device. Changes in color density were measured with an optical analyzer. Only 20 to 30 μLs of saliva sample were needed, and measurements took about 60 seconds to perform. This allowed immediate measurement of salivary amylase activity at the patient's bedside.

Similar reports on salivary chromogranin A (CgA) as a marker of psychological stress have recently been published (Kanamaru, Kikukawa, & Shimamura, 2006; Lee, Shimizu, Iijima, Obinata, Yamashiro, & Nagasawa, 2006). However, the novel hand-held monitor used in the present study produced results that were equal to or more sensitive than CgA as a stress marker. In addition, the present method is much more convenient, because unlike our method, measurement of CgA requires radioimmunoassay or EIA.

The present study disclosed a significant correlation between salivary amylase activity and heart rate during Snoezelen therapy. A significant correlation was not observed before or after Snoezelen therapy.

Salivary amylase production may be associated with the release of norepinephrine from the adrenal medulla. Therefore, salivary amylase activity would be regulated by the sympathetic nervous-adrenomedullary system.

Recently, it has been noted that salivary amylase activity is a marker for sympathetic nerve activity during stress (Chatterton et al., 1996; Speirs, Herring, Cooper, Hardy, & Hind, 1974; van Stegeren, Rohleder, Everaerd, & Wolf, 2006). Incidentally, when the body is exposed to acute stress, salivary amylase activity is known to increase due to the direct stimulation of the salivary gland by sympathetic nerves that occurs with the activation of the sympathetic nervous system. This response, which occurs faster than, and thus prior to, the effects of noradrenaline secreted from the adrenal medulla, has been reported to occur usually within several minutes of the stress (Skosnik, Chatterton, Swisher, & Park, 2000; Yamaguchi, Kanemori, Kanemaru, Mizuno, & Yoshida, 2001). Our research has also shown that amylase activity changes rapidly during the distress caused by medical procedures. Therefore, amylase activity is useful as a real-time stress marker (Takeda, Onishi, Yamaguchi, & Takeya, 2006).
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The high correlation between salivary amylase activity and heart rate also supports relaxation in the patients with severe motor and intellectual disabilities due to Snoezelen therapy. Therefore, the decrease in salivary amylase activity under conditions of eustress is probably linked to autonomic nervous activity.

Although correlations between salivary amylase and heart rate were observed during Snoezelen therapy in the present study, no significant relationships were observed before or after therapy. These findings suggest the hypothesis that salivary amylase activity is an index that may also vary depending on emotional states, such as a high degree of anxiety or tension, that do not affect the balance of the autonomic nervous system.

Additionally, during rest on the ward, the positive and negative emotional states among individuals with severe motor and intellectual disabilities do not necessarily change according to the activation state of the sympathetic nervous system, which is reflected by heart rate. However, during eustress interventions such as Snoezelen therapy, an autonomic nerve condition in which the parasympathetic nervous system was dominant, as well as a mentally relaxed state, were observed in almost all patients, and responses in salivary amylase and heart rate were thought to have occurred simultaneously.

Further investigation is warranted to determine the significance of amylase activity at rest during daily hospital care among patients not undergoing interventions aimed at relaxation, such as Snoezelen therapy.

Conclusions

The present study reports a correlation between salivary amylase activity and eustress produced by Snoezelen therapy in patients with severe motor and intellectual disabilities. These findings suggest that salivary amylase activity is a useful noninvasive marker for changes reflecting eustress in patients with severe motor and intellectual disabilities.

In addition, the use of a hand-held salivary amylase activity monitor with disposable test strips was convenient for real-time monitoring of amylase activity as a marker of eustress in patients with severe motor and intellectual disabilities.

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