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Original Article

Lifestyle, Mental Health Status and Salivary Secretion Rates

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Abstract

The relations between salivary variables, lifestyle and mental health status were investigated for 61 healthy female university students. The salivary secretion rates were significantly higher in the good lifestyle group compared with the poor lifestyle group. Among the 8 lifestyle items tested, "eating breakfast" and "mental stress" were significantly related to the salivary secretion rates. The present findings suggest that the acquisition of a good lifestyle is also very important from the viewpoint of the prevention of oral disease.

A highly significant correlation ($r=0.97$; $p<0.01$) between the salivary cortisol levels and the cortisol secretion rates when controlled for the salivary secretion rates was also observed. This suggests that there is a high correlation between the intact salivary cortisol levels and the total cortisol quantity per unit time. Therefore, both these values can be used as a good index for the salivary cortisol determination.

Key words: lifestyle, saliva secretion, cortisol, mental stress, breakfast eating

Introduction

Saliva functions as a digestive fluid and helps maintain the oral environment[1)]. The latter includes the oral washing function, the pH-regulating function, and so on. Therefore, saliva is very important from the viewpoint of prevention of oral diseases such as oral caries or periodontitis. By comparing vegetarians with omnivores, Johansson et al.[2,3)] found that the salivary secretion rates were influenced by lifestyle. Namely, vegetarians showed significantly higher secretion rates. In addition, salivary secretion rates increased significantly by a long-term (12 months) change from a mixed to a lacto-vegetarian diet. However, such a difference in lifestyle is not general. Therefore, in this study, we investigated the effect of a more general lifestyle on the salivary secretion rates.

Meanwhile, the use of the saliva sample as a component of the human body is very effective because of convenience and not requiring any injections[1)]. The determination methods of some salivary components have been well established[4,5)]. However, it remains an important problem whether the salivary secretion rates should be considered in the sample analysis. In the present study, therefore, we also investigated this problem with regard to cortisol that is well known as a stress marker.

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Materials and Methods

Subjects and protocol

Subjects were 61 healthy female university students (mean age; 21.1±1.5 years). All individuals were non-smokers and did not take any drugs. Their basic characteristics are shown in Table 1. To this group, the lifestyle (Health Practice Index; HPI[6–8)]) and the mental health status (GHQ-28[9)], Zung-SDS[10,11)]) were measured, and the saliva samples were collected between 16:00 and 16:20.

The saliva samples were collected using Salivette® (Sarstedt Co. Ltd., Nümbrecht) after discharging the saliva completely for 2 minutes. This device obtains the saliva by centrifuging (at 3,000 rpm for 15 min) cotton that subjects bit (for 2 min). The saliva samples were stored at −50°C until the assay.

The salivary cortisol levels were determined by ELISA as described previously[12)]. In addition, the cortisol secretion rates

Table 1 Characteristics of subjects (n=61)

Age (yr.)	21.1±1.5
Height (cm)	158.2±4.9
Body weight (kg)	50.0±5.8
Salivary secretion rates (ml/min)	0.98±0.36
Salivary cortisol levels (μg/dl)	0.21±0.23
Cortisol secretion rates (10^{-2} μg/min)	0.23±0.30
Health practice index	4.5±1.4
Zung-SDS	42.3±7.1
GHQ-28	6.3±4.2

Values are expressed as means±SD.

Table 2 Lifestyle and salivary variables

	Lifestyle		
	Poor (n=17)	Moderate (n=28)	Good (n=16)
Salivary secretion rates (ml/min)	0.85±0.31	1.01±0.39	1.08±0.32*
Salivary cortisol levels (μg/dl)	0.15±0.17	0.23±0.26	0.23±0.22
Cortisol secretion rates (10^{-2} μg/min)	0.15±0.21	0.25±0.35	0.26±0.27

Lifestyle is defined as "poor" when the HPI score is 0–3, "moderate" when the HPI score is 4–5 and "good" when the HPI score is 6–8.
Values are expressed as means±SD.
Significantly different from the poor lifestyle group, * $p<0.05$ (Student's *t* test)

Table 3 Lifestyle and salivary secretion rates (ml/min)

Lifestyle†	Poor		Good	
Consuming alcohol	0.86±0.35	n=2	0.99±0.36	n=59
Eating breakfast	0.80±0.32	n=13	1.03±0.35*	n=48
Sleeping hours	1.00±0.36	n=39	0.96±0.35	n=22
Working hours	0.95±0.36	n=35	1.03±0.36	n=26
Physical exercise	0.97±0.37	n=42	1.01±0.34	n=19
Nutrient balance	0.98±0.38	n=49	1.00±0.27	n=12
Mental stress	0.90±0.35	n=34	1.10±0.34*	n=27

† All individuals are non-smokers.
Values are expressed as means±SD.
Significantly different from the poor lifestyle group, * $p<0.05$ (Student's *t* test)

per 1 minute (10^{-2} μg/min) were obtained using the following equation:

Salivary cortisol levels (μg/dl)×Salivary secretion rates per 1 minute (ml/min)

Here, we defined the specific gravity of the saliva as 1[13].

Statistical analysis

All values were expressed as means±SD. Student's *t*-test was used for the comparison between groups. In addition, Pearson's correlation coefficients were used to examine the relations between the variables. Values were considered to be significantly different if $p<0.05$.

Results

The salivary secretion rates were significantly higher in the good lifestyle group (HPI: 6–8) compared with the poor lifestyle group (HPI: 0–3) (Table 2). Investigation on the lifestyle items showed that "eating breakfast" and "mental stress" contributed significantly to the salivary secretion rates (Table 3). In addition, with regard to the GHQ-28 and its subscales (somatic symptoms, anxiety-insomnia, social dysfunction, and severe depression), the salivary secretion rates were higher in individuals who had less "somatic symptoms" compared with those who had more (1.06±0.33 vs. 0.88±0.37; $p=0.05$). On the other hand, there was no significant correlation between the salivary secretion rates and Zung-SDS.

There was a highly significant correlation between the salivary cortisol levels and the cortisol secretion rates ($r=0.97$; $p<0.01$) (Fig. 1). These cortisol values were not significantly correlated with the lifestyle (HPI) or the mental health status (GHQ-28, Zung-SDS). On the other hand, there was a highly significant correlation between the GHQ-28 and Zung-SDS ($r=0.86$; $p<0.01$). In addition, these two stress indices were significantly correlated with lifestyle ($r=-0.35$; $p<0.01$ and $r=-0.31$; $p<0.05$, respectively). The total GHQ-28 and "somatic symptoms", one of its subscales, were significantly lower in the good lifestyle group compared with the poor lifestyle group (4.8±3.4 vs. 7.7±3.9, 0.6±1.0 vs. 1.8±1.7, respectively).

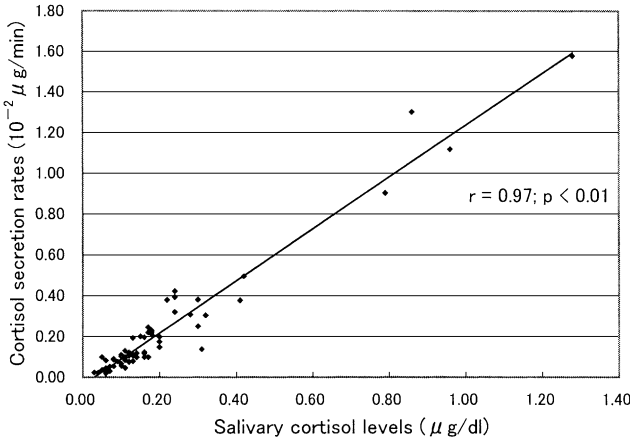

Fig. 1 Correlation between salivary cortisol levels and cortisol secretion rates

Discussion

The relation between the lifestyle and the salivary secretion rates should be noted. That is to say, the salivary secretion rates were significantly higher in the good lifestyle group compared with the poor lifestyle group. In addition, with regard to the lifestyle items, they were significantly higher in individuals who ate breakfast almost every day and/or kept mental stress levels adequate. The importance of mastication for the salivary secretion rates was reported in some previous studies[14–16]. The significant contribution of "eating breakfast", the lifestyle item related to mastication, to the salivary secretion rates in the present study supports the findings of previous studies. In addition, with regard to "mental stress", the salivary secretion rates appeared to be especially related to "somatic symptoms". The somatic symptoms can become the cause of anorexia, therefore, result in a decrease in mastication. On the other hand, "nutritional balance" was not significantly related to the salivary secretion rates. Although one possible explanation is that one or more nutrients may contribute to the salivary secretion rates[2,3], the present findings do not support this.

In previous studies, the saliva samples were collected by mainly chewing paraffin wax[2,3,14], and in the present study, they were collected using Salivette®. However, these methods include the possibility that the salivary secretion rates are affected by the individual variation of mastication during the collection of the

saliva. Further examinations are required with regard to the method of collecting the saliva samples.

In the present study, the saliva samples were collected at 16:00. Ferguson et al.[17] investigated the circadian rhythms in the secretion rates and composition of stimulated whole saliva, and showed that mid-afternoon could be a useful collecting time since many components have maximum or minimum concentrations near that time. The salivary cortisol levels also appear to be stable in that time, because they show a spiking in the early morning and then decrease gradually[6,12,18,19]. In addition, Navazesh et al.[20] found the high test-retest correlation (r=0.95) with regard to the measurement of the salivary secretion rates using the chewing method. Meanwhile, the present subjects were all females. Therefore, effects due to the menstrual cycle could not be avoided. Since all females had different timing of the cycle, however, this does not appear to have contributed to the findings in a significant way.

With regard to the determination of the salivary cortisol levels, it may be an important problem to consider whether the salivary secretion rates should be used, because the high and low salivary secretion rates may result in the dilution and concentration of the cortisol, respectively. In the determination methods described previously[5,12], however, the salivary secretion rates were not taken into account. Therefore, in the present study, we calculated the cortisol secretion rates per minute from the salivary cortisol levels and the salivary secretion rates and investigated the correlation between the salivary cortisol levels and the cortisol secretion rates. As a result, there was a highly significant correlation between these two cortisol values ($r=0.97$; $p<0.01$). Namely, there was a high correlation between the intact salivary cortisol levels and the total cortisol quantity per unit time. In addition, some previous studies reported a high correlation between the salivary and serum cortisol levels[5,12,18]. Therefore, both these values can be used as a good index for salivary cortisol determination.

In the present study, two stress indices (GHQ-28, Zung-SDS) were significantly correlated with lifestyle (HPI). These findings agree with those of previous studies[21,22]. On the other hand, these stress indices were not significantly correlated with the salivary cortisol levels or the cortisol secretion rates. According to previous studies, although daily stress increases the cortisol levels of individuals[23,24], the baseline cortisol levels are not always related to the stress levels of that point[25,26]. This may mainly result from the individual variation of the baseline cortisol levels.

In addition, although the salivary cortisol levels were higher to some extent in the good lifestyle group compared with the poor lifestyle group, it may also be due to such individual variation. Since the difference was not significant, and the total GHQ-28 and "somatic symptoms", one of its subscales, were significantly lower in the good lifestyle group compared with the poor lifestyle group.

In conclusion, a good lifestyle not only reduces the somatic symptoms but increases the salivary secretion rates, and therefore it is also very important from the viewpoint of the prevention of oral disease. A good oral condition may be fed back to a pleasant meal and the consequent systemic health. In addition, both the salivary cortisol levels and the cortisol secretion rates can be a good index for the salivary cortisol determination.

References

1) Yamaguchi M, Takai N. Saliva as a mirror of the body (in Japanese). Tokyo; Kougyou-chousakai, 1999.
2) Johansson G, Ravald N. Comparison of some salivary variables between vegetarians and omnivores. Eur. J. Oral. Sci. 1995; 103: 95–98.
3) Johansson G, Birkhed D. Effect of a long-term change from a mixed to a lacto-vegetarian diet on human saliva. Arch. Oral. Biol. 1994; 39: 283–288.
4) Tenovuo JO. Human saliva: clinical chemistry and microbiology. Florida; CRC press, 1989.
5) Kirschbaum C, Hellhammer DH. Salivary cortisol in psychoneuroendocrine research: recent developments and applications. Psychoneuroendocrinology 1994; 19: 313–333.
6) Morimoto K. "*Stress-kiki no yobo-igaku*"(in Japanese). Tokyo; NHK books, 1997.
7) Kusaka Y, Kondou H, Morimoto K. Healthy lifestyles are associated with higher natural killer cell activity. Prev. Med. 1992; 21: 602–615.
8) Hagihara A, Morimoto K. Personal health practices and attitudes toward nonsmokers' legal rights in Japan. Soc. Sci. Med. 1991; 33: 717–721.
9) Goldberg DP. Manual of the General Health Questionnaire. Windsor; NFER Publishing, 1978.
10) Zung WWK. A self-rating depression scale. Arch. Gen. Psychiatry 1965; 12: 63–70.
11) Fukuda K, Kobayashi S. The Japanese version of the SDS (in Japanese). Kyoto; Sankyobo, 1983.
12) Shimada M, Takahashi K, Ohkawa T, Segawa M, Higurashi M. Determination of salivary cortisol by ELISA and its application to the assessment of the circadian rhythm in children. Horm. Res. 1995; 44: 213–217.
13) Nakamura Y, Morimoto T. Basic physiology for dental students (in Japanese). Tokyo; Ishiyaku Publishers, 1987.
14) Johansson I, Ericson T. Effects of a 900-kcal liquid or solid diet on saliva flow rate and composition in female subjects. Caries Res. 1989; 23: 184–189.
15) Jenkins GN, Edgar WM. The effect of daily gum-chewing on salivary flow rates in man. J. Dent. Res. 1989; 68: 786–790.
16) Dodds MWJ, Hsieh SC, Johnson DA. The effect of increased mastication by daily gum-chewing on salivary gland output and dental plaque acidogenicity. J. Dent. Res. 1991; 70: 1474–1478.
17) Ferguson DB, Botchway CA. Circadian variations in the flow rate and composition of whole saliva stimulated by mastication. Archs. Oral. Biol. 1980; 24: 877–881.
18) Kirschbaum C, Hellhammer DH. Salivary cortisol in psychobiological research: an overview. Neuropsychobiology 1989; 22: 150–169.
19) Åkerstedt T, Levi L. Circadian rhythms in the secretion of cortisol, adrenaline and noradrenaline. Eur. J. Clin. Invest. 1978; 8: 57–58.
20) Navazesh M, Christensen CM. A comparison of whole mouth resting and stimulated salivary measurement procedures. J. Dent. Res. 1982; 61: 1158–1162.
21) Ezoe S, Morimoto K. Behavioral lifestyle and mental health status of Japanese factory workers. Prev. Med. 1994; 23: 98–105.
22) Morimoto K, Takeshita T, Takeuchi T, Maruyama S, Ezoe S, Inoue C, Nakajima M. What mental stress reactions mean—from

gene alterations to job satisfaction—(in Japanese). Job Stress Res. 1995; 3: 12–24.
23) Kreuz LE, Rose RM, Jennings JR. Suppression of plasma testosterone levels and psychological stress: A longitudinal study of young men in officer candidate school. Arch. Gen. Psychiatry 1972; 26: 479–482.
24) Payne RL, Rick JT, Smith GH, Cooper RG. Multiple indicators of stress in an 'active' job—cardiothoracic surgery. J. Occup. Med. 1984; 26: 805–808.
25) Perna FM, McDowell SL. Role of psychological stress in cortisol recovery from exhaustive exercise among elite athletes. Int. J. Behav. Med. 1995; 2: 13–26.
26) Perna FM, Antoni MH, Kumar M, Cruess DG, Schneiderman N. Cognitive-behavioral intervention effects on mood and cortisol during exercise training. Ann. Behav. Med. 1998; 20: 92–98.