ORIGINAL ARTICLE

Inter-measurement variation of masticatory performance test using gummy jelly

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Abstract

The purpose of this study was to clarify the inter-measurement variation of the masticatory performance test. Forty healthy adults were divided into group A (10 males and 10 females), who did not chew the test food before experiment, and group B (10 males and 10 females) who chewed the test food before the experiment. Subjects were asked to chew a gummy jelly for 20 s on the habitual chewing side, and the amount of glucose extraction was measured. The test was repeated three times with an interval of 1 min in both groups (Group A: A1, A2, A3; Group B: B1, B2, B3). In both groups A and B, the difference between the measured values was compared and the reliability between measurements was investigated. In group A, the value of A1 was small, and a statistically significant difference was observed between A1 and other measured values. In group B, the three measured values were similar and no significant difference was observed among the measured values. The intraclass correlation coefficient (ICC) values for determining inter-measurement reliability in group A were 0.758 for A1–A2–A3, 0.708 for A1–A2, and 0.901 for A2–A3. The ICCs in group B were 0.924 for B1–B2–B3, 0.945 for B1–B2, and 0.926 for B2–B3. Based on these results, it can be suggested that high reliability between the measurements can be obtained if the subjects are accustomed to chewing the test food before the experiment, and that the measured values were similar whether it was performed two or three times. Consequently, one measurement was sufficient if subjects were accustomed to chewing the test food before the experiment.

Keywords Masticatory function · Masticatory performance · Gummy jelly · Inter-measurement reliability · Inter-measurement variation

Introduction

Many attempts have been made to extend the healthy life expectancy and maintaining and improving oral function is extremely important to achieve this. In order to maintain healthy oral function, it is necessary to have good masticatory function. Masticatory function has been reported to decrease due to tooth loss [1, 2] and improve with dental treatment [3, 4]. Masticatory performance has been listed as an important parameter for objectively evaluating masticatory function. Therefore, many methods have been reported to objectively evaluate the masticatory performance. Among these, the masticatory performance test, which measures the amount of glucose extraction after chewing a gummy jelly, is simpler than the conventional sieving method, and the results can be obtained quickly; therefore, it is used in clinical settings [5–8].

However, the number of measurements required for the masticatory performance test has not been often described, and it varies from two to five times for multiple measurements [3, 5, 6, 9–15] with no definite consensus at present. For the multiple measurements, three times was the most frequently reported number [3, 6, 9, 13, 14]. It can be attributed to the fact that it is not clear whether the masticatory performance should be measured only once or repeated, and how many times.

Therefore, in this study, in order to clarify the inter-measurement variation in the masticatory performance test, the masticatory performance test using a gummy was performed three times, and the measured values were analyzed. Examining the inter-measurement variation of masticatory performance test is clinically significant because it could help

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clarify the number of the test when evaluating masticatory performance.

Materials and methods

Ethic statement

This study was conducted in accordance with the principles of the Declaration of Helsinki. All experimental procedures were approved by the Ethics Committee of the Nippon Dental University (approval number: NDU-T2020-31). The content of the experiment was fully explained to each subject, and the experiment was performed after obtaining consent.

Subjects

Forty healthy subjects (20 men, 20 women; average age 31.1 ± 4.7 years) participated in the study. The inclusion criteria were as follows: (1) no clinical abnormalities in the masticatory system, (2) natural dentition, with the possible exception of the third molars, and (3) no complaints related to occlusion. The exclusion criteria were as follows: (1) previous/current orthodontic treatments, (2) currently undergoing dental treatment, and (3) signs or symptoms of TMD and/or orofacial pain.

Test food

A gummy jelly (GC, Tokyo) having a diameter of 14 mm, height of 8 mm, and weight of about 2 g was used as the test food.

Recording method

For the experiment, 40 subjects were first divided into group A (10 males and 10 females) and group B (10 males and 10 females). In group A, the habitual chewing side was determined by an interview by asking the subjects on which side it was easier to chew. Next, the amount of glucose extraction when the subject chewed the gummy jelly on the habitual chewing side for 20 s was measured. Group B was explained that they were to chew gummy jelly before the experiment to get used to the taste and hardness of the test food. Except for this point, the measurement procedures of groups A and B were the same. In group B, after a gummy jelly was freely chewed before the experiment, the habitual chewing side was determined by an interview. Subsequently, the amount of

glucose extraction when the subject chewed the gummy jelly in the same manner as in group A was measured. The measurement was repeated three times with an interval of 1 min in both groups A and B (Group A: A1, A2, A3, Group B: B1, B2, B3).

Measurement of amount of glucose extraction

Subjects were asked to chew a gummy jelly on one side for 20 s and then were asked to hold 10 mL of water in their mouth and to spit into a cup with a filter. Then, the filtrate in the cup was collected as a test sample, and the glucose concentration measured using a glucose measuring device (GS-2; GC, Tokyo, Japan) was used as the amount of glucose extraction.

Statistical analysis

All data were analyzed using statistical software (SPSS for Windows 15.0 J, SPSS, Chicago, IL, USA). The Shapiro–Wilk test was used to confirm normality. Next, the differences among the three measurements of glucose extraction were investigated by ANOVA, and Bonferroni's correction for multiple comparisons was performed. Furthermore, the intraclass correlation coefficient (ICC) was calculated to evaluate the reliability of the measurements. The significance level was set at $P = 0.05$.

Results

In Group A, in which the subjects were not allowed to chew the test food before the experiment, A1, A2, and A3 were 199.3, 217.6, and 219.1 mg/dL, respectively (Table 1); the first measurement value was the smallest, while the second and third measurement values were similar. Furthermore, there were significant differences between A1 and A2, and between A1 and A3 (Table 2). In group B, in which the subjects chewed the test food before the experiment, B1, B2, and B3 were 221.9, 217.7, and 219.3 mg/dL, respectively (Table 3); the three values were similar, and no significant differences were observed among the measurements. The

Table 2 Comparison of the amount of glucose extraction

Groups compared	A1–A2	A1–A3	A2–A3
P value	0.000	0.000	1.000

Table 1 Mean values and standard deviations of the amount of glucose extraction in group A

	A1	A2	A3	A1, A2, A3	A1, A2	A2, A3
Mean (mg/dL)	199.3	217.6	219.1	211.9	208.5	218.3
SD	33.3	33.2	36.3	47.4	34.1	33.7

Table 3 Mean values and standard deviations of the amount of glucose extraction in group B		B1	B2	B3	B1, B2, B3	B1, B2	B2, B3
	Mean (mg/dL)	221.9	217.7	219.3	219.6	219.8	218.5
	SD	35.2	37.1	36.3	35.6	35.8	36.2

inter-measurement reliability (ICC) of group A was high at 0.901 between A2 and A3, but low (0.758) among A1,A2, and–A3, and 0.708 between A1 and A2 (Table 4). The ICC of group B was 0.924 for B1–B2-B3, 0.950 for B1–B2, and 0.926 for B2-B3, all of which were extremely high values (Table 4).

Discussion

The number of measurements required for the masticatory performance test has not been clarified yet. On searching the English literature on masticatory performance in the 10 years from 2011 to December 2020 on PubMed, 1168 articles were extracted. By examining the contents of these articles and extracting the articles that objectively investigated masticatory performance, we selected 273 articles; however, 229 articles (83.9%) did not describe the number of measurements.

The number of articles in which multiple measurements were undertaken was as small as 15 for three measurements, 10 for two measurements, and 2 for five measurements. In studies that investigated the ICC by performing the measurements two or three times, almonds [16] (5 chewing 0.958, 15 chewing 0.797), sausages [16] (5 chewing 0.783, 15 chewing 0.911), two-color gum (0.714 [17], 0.83 [18], 0.884 [19]), fuchsin capsule (0.65 [20]), silicone (0.93 [20], 0.95–0.98 [21]), gummy jelly (0.879 [5]), etc. were reportedly used. Although there were some differences depending on the test food, it can be concluded that all masticatory performance tests have relatively high inter-measurement reliability. These results show that the test is reliable and at the same time requires only one measurement, which may be the reason many studies do not mention the number of measurements. Thus, it is highly likely that only one measurement was performed in the studies that did not describe the number of measurements.

On the other hand, there are also studies in which the gum or test food was chewed before the experiment [8, 22, 23]. It is empirically known that stable data cannot be obtained unless the subjects chew the test food and get accustomed to it before the experiment. According to the results of the present study, in group A, in which three measurements were performed without chewing the gummy jelly before the experiment, the first measurement value was significantly smaller than the second and third measurement values. In comparison, in group B, in which the subjects were accustomed to chewing the gummy jelly freely before the experiment, the three measurement values were similar. This may be because the group A was not accustomed to chewing the gummy jelly at the time of the first measurement.

The ICC of group B was 0.924 for B1–B2–B3, 0.950 for B1–B2, and 0.926 for B2–B3, all of which are extremely high values. These results indicate that being accustomed to chewing the test food before the experiment may lead to high inter-measurement reliability and that the measurement value was the same whether it was performed two or three times. Furthermore, it can be deduced that one measurement is sufficient if the subjects are accustomed to chewing the test food before the experiment.

In Group A, the first measured value was significantly smaller than the other measured values; therefore, the mean value of the three measurements was also lower than the second and third measured values. This indicates that the mean value or first measured value should not be used for the analysis if the subject is not accustomed to chewing the test food before the experiment.

Conclusion

In order to clarify the inter-measurement variation of the masticatory performance test, the masticatory performance test using a gummy jelly was performed three times for 40 healthy adults, and the measured values were analyzed. The results suggest that high reliability between measurements can be obtained if the subjects are accustomed to chewing the test food before the experiment, and one measurement was sufficient.

Table 4 Intraclass correlation coefficient (ICC) values for the amount of glucose extraction		A1, A2, A3	A1, A2	A2, A3	B1, B2, B3	B1, B2	B2, B3
	ICC	0.758	0.708	0.901	0.924	0.950	0.926

Declarations

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