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Influence of Mastication Rate on Prandial Glycemia among Prediabetics: An Observation

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Abstract

Background: Thorough mastication has the potential to affect postprandial blood sugar levels (BSL) by improving digestibility and absorption of nutrients. Associations between mastication and glucose metabolism in diabetics have been shown in previous studies. However, the association between mastication and BSL in pre-diabetes has not been clarified. Our objective was to examine association between frequency of chewing and BSL in prediabetes population-based cohort.

Method: On attaining Institutions ethical committee clearance, considering all inclusion and exclusion criteria and after taking informed consent, we conducted a cross-sectional study in 95 prediabetic individuals. Subjects recruited to study received a fixed calorific load of 150 calories in form of 25 grams of groundnuts on two successive days. We decided to use groundnuts as substrate for our study as we hypothesized this would result in elevated cephalic phase insulin secretion, since it requires thorough mastication for deglutition and is rich in protein (26%), fat (49%) but little carbohydrate (16%), of which >50% is insoluble fiber. On Day 1 subjects were observed as they were chewing at their routine habituated rates without them being conscious that they are being observed while on Day 2 they were asked to chew each bolus forty times before swallowing. Postprandial BSL were estimated, all parameters and their obtained values were scrutinized on both days and data was statistically analyzed.

Results: On comparing the mean post prandial BSL between normal chewing versus 40 time chewing, statistically significant decrease was observed with respect to 40 chews per bolus ($p < 0.000$).

Conclusions: These findings support hypothesis that when in pre-diabetic individuals a simple yet effective method of thorough mastication will decrease postprandial BSL vis –a-vis faster chewing and swallowing.

Keywords: *Prediabetes, mastication frequency, groundnuts, food, blood sugar.*

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Background

In India currently prevalence of diabetes has increased tenfold, from 1.2% to 12.1%, between 1971 and 2000. [(1)] It was recently estimated that there are 61.3 million people with type 2 diabetes in India and this number is expected to increase to 101.2 million by 2030. Pre-diabetic individuals have a significant risk of progressing to overt diabetes over time, with as many

as 10% progressing to diabetes mellitus per year. Pre-diabetes comprises of either Impaired Glucose Tolerance (IGT) or Impaired Fasting Glucose (IFG) values. The American diabetes Association (ADA) currently defines IFG as fasting plasma glucose between 100 – 125mg/dL, and IGT as two-hour glucose levels of 140 to 199 mg/dL on the 75-g oral glucose tolerance test. Those with IGT are particularly at higher risk of developing overt diabetes and cardiovascular complications [(2)]. For such individuals a variety of non-pharmacological strategies have been suggested such as increased aerobic exercise, reduced calorie intake and dietary modification. However, these measures are often poorly adhered to by patient population. Hence, there is a need for other simple yet sustainable and effective measures of blood sugar regulation in pre-diabetic population to prevent onset of diabetes. One such potentially useful measure can be 'thorough mastication'. This study attempts to find out if thorough mastication has any effect on post prandial blood sugar levels - BSL in prediabetic individuals.

Aim: To evaluate effect of mastication on post prandial blood sugar levels in individuals with IFG and IGT.

Materials and Method: The study protocol was approved by local institutional research ethics committee and all study participants provided voluntary consent before being recruited to the study. It was a cross sectional study carried out in Tertiary Care Medical College affiliated Hospitals. Otherwise healthy individuals of age >18 years with impaired glucose tolerance (2 hours post prandial BSL) or IFG were included. Individuals with acute severe illnesses, hepatic or renal impairment, on medications which are known to alter glycemic levels, recent surgery, trauma or burns, pregnancy and edentulous individuals were excluded.

We designed a simple pre-test post-test quasi-experimental protocol for this study. 95 Subjects recruited to the study received a fixed calorific load of 150 calories in the form of 25 grams of groundnuts on Day 1 and Day 2 each. On Day 1, the subjects were asked to chew in their usual manner and the number of chews per bite was recorded. Subjects were observed as they chew habitually without their knowledge to avoid conscious self-imposed change in chewing frequency and pattern. On Day 2, the subjects were asked to chew each bolus forty times before swallowing. Blood sugar levels were taken on both days immediately prior to the intake of groundnuts and also 2 hours following the meal. Subjects were prohibited from taking any oral calorific consumption/other food bolus 3 hours before the start of the test on both days and also between the meal and post-prandial blood sugar test. They were also told not to engage in any strenuous physical activity and to be preferably at rest. Patients were allowed to drink water during the periods of fasting if required.

Data was collected and analyzed using Microsoft Excel and SPSS version 17. The strength of the association between the variables of interest was evaluated using Chi-square and Student-t tests. A two-tailed p-value of less than 0.05 was defined as statistically significant for all analysis.

Results

Our study enrolled total 95 subjects. We had 9 patients with IGT and 86 patients with IFG. Majority of subjects were in the age group of 31-40 years (28.4%). About 26% of the subjects were in the age group of 51-60 years, 24% were in the age group of 41-50 years 12% in the age group of above 60 years and 10% of them were in the age group less than 30 years. In our study, 47% of the subjects were females and 53% were males.

Subjects recruited to the study received a fixed calorific load of 150 calories in the form of 25 grams of groundnuts on Day 1 and Day 2. The average number of chews was 24 on day 1 .All the subjects chewed each bolus forty times before swallowing on Day 2.

Table 1: Table depicting the Day 1 & Day 2 sugar values of the subjects

N	N	Mean	Std. Deviation	Mean difference	S.D of difference	Change (%)	t test, p value
Pre Day 1	95	113.18	8.908	21.147	8.162	18.68	.000 HS
Post Day 1	95	134.33	8.998				
Pre Day 2	95	115.02	8.913	12.358	7.302	10.74	
Post Day 2	95	127.38	8.363				

On day 1, there was a drop in BSL two hours after chewing (mean difference 21.147, %change – 18.62) which was statistically significant (p value of 0.000). On day 2, the mean BSL prior to intake of groundnuts was 115.02 and two hours after meal was 127.38. The mean difference was 12.358 with a percentage change of 10.74 % which was highly significant (p value of 0.000). All the subjects chewed each bolus forty times before swallowing (Table 1).

When we analyzed both Day 1 and Day 2, both the pre and post chewing values showed a highly significant correlation (Fig 1) with respect to post prandial BSL.

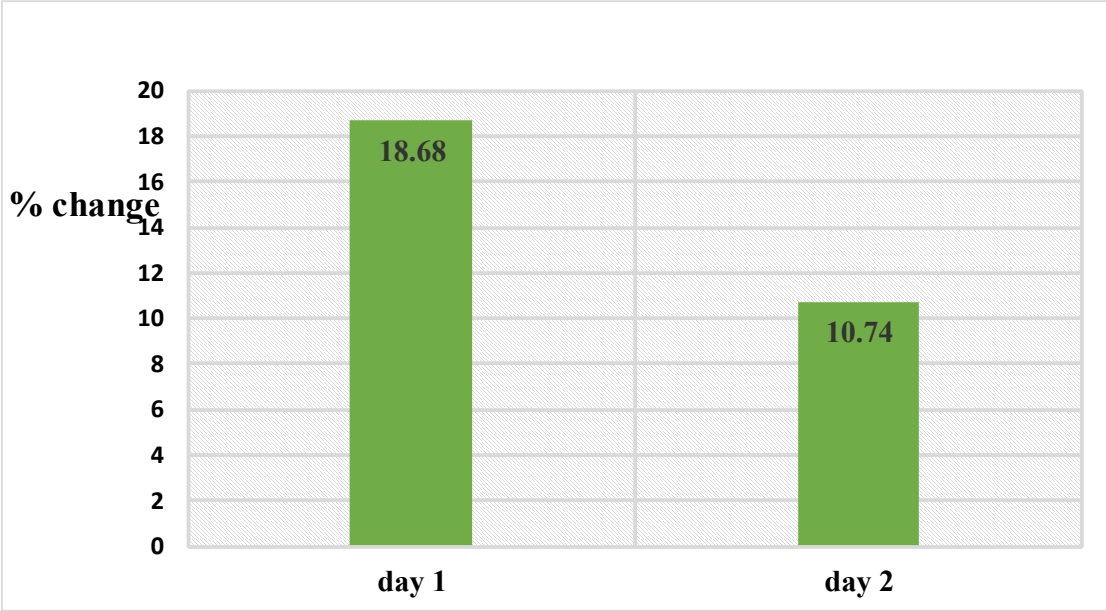

Fig 1: Bar diagram depicting the comparison between Day 1 and Day 2 mean BSL percentage change of the subjects

When we analyzed the mean change in sugars age group wise and gender wise, we did not find significant correlation. While considering analysis based on categories of prediabetes following results were obtained.

Table 2: Table depicting the comparison between Day 1 and Day 2 sugar values of the subjects – IGT/IFG

		N	Mean	Std. Deviation	t test p value	
Post D1 - Pre D1	IGT	9	21.78	8.273	.809	NS
	IFG	86	21.08	8.196		
	Total	95	21.15	8.162		
Post D2 - Pre D2	IGT	9	13.56	8.833	.608	NS
	IFG	86	12.23	7.173		
	Total	95	12.36	7.302		

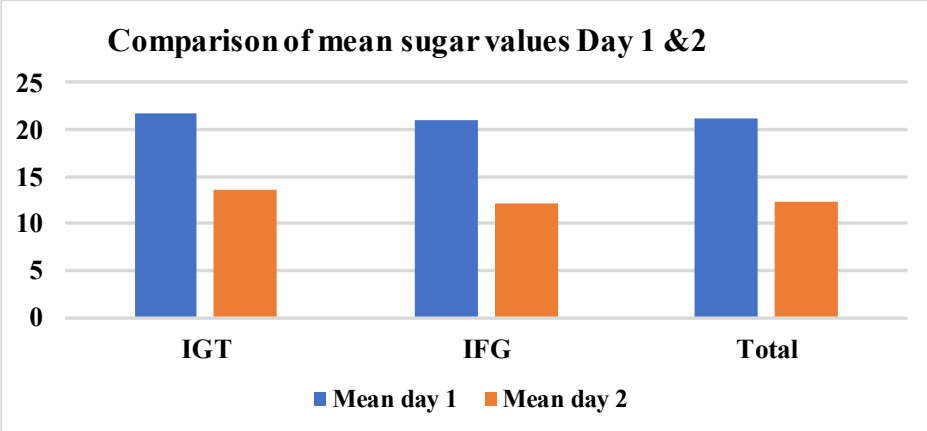

Fig 2: Bar diagram depicting the comparison between Day 1 and Day 2 sugar values of the subjects – IGT/IFG

Mean change in sugar values (table 2 & figure 2) did not show statistically significant correlation when categories of prediabetes namely impaired glucose tolerance and impaired fasting glucose were separately analyzed.

Discussion

Our study demonstrates that thorough mastication of 40 chews per bite/morsel/bolus in comparison to routine habituated frequency of mastication in pre-diabetes, results in a statistically significant reduction of post-prandial blood glucose levels.

Although it has been hypothesized that thorough mastication can reduce post-prandial BSL by increasing the cephalic phase of insulin release, previous studies have failed to report consistent or reliable findings with regards to the physiological effects of mastication (Table 3).

Table 3: Comparison of studies looking into postprandial sugar, GLP-1 and insulin

Study	Study Design	Sample Size	Substrate	Frequency of Chewing	2hr Ppbs	Glp-1	Post Masication Insulin
Sonoki (13)	Cross sectional	30	Regular meal	30	83.1+/-15.28	8.6+/-1.9	21.3+/-12
Zhu (15)	Cross sectional	20	Carrots	Normal	80+/-15.8	-	-
Li (36)	Case control (obese & lean)	30	2200KJ meal	15 & 40	61+/-0.4 61+/-0.7	1278.6+/-219.3 1231.6+/-205.6	5.0+/-0.2 4.9+/-2.3
Madhu (6)	Cross sectional	200	Ground nut	40	119.7+/-9.06	-	-
Read (26)	Cross sectional	160	Apple Sweet corn Rice Potato	Normal	8.3 mmol/l 6.3 mmol/l		
Our study	Cross sectional	95	Ground nuts	40	127.38+/-8.363	-	-

In one study, it was found that chewing 30 times per bite caused elevated plasma active GLP-1 concentrations, without affecting the concentrations of blood glucose or serum insulin levels in 10 normogylcaemic subjects but not in type 2 diabetic subjects [3]. Another study, however, reported that postprandial BSL significantly decreased following thorough mastication of approximately 30 times per bite in 16 normogylcaemic individuals through potentiation of early-phase insulin secretion [4]. The same study also showed that in 10 subjects predisposed to type 2 diabetes, thorough mastication did not potentiate early-phase insulin secretion and elicited higher postprandial

BSL. In a randomized crossover trial of 21 healthy males, it was demonstrated that plasma concentrations of glucose, insulin and GIP were higher with thorough mastication of 40 chews per portion in comparison to 15 chews per portion [5]. Another study also showed that thorough mastication of 40 chews in both lean and obese subjects resulted in lower postprandial ghrelin concentrations and higher postprandial glucagon-like peptide 1 and cholecystokinin concentrations [6]. Recently, a study in south India [7] demonstrated that thorough mastication of forty-chews improved the post prandial BSL in 86 normogylcaemic subjects but not in 14 dysglycemic subjects, the latter comprising of both type 2 diabetics and pre-diabetic individuals. The results from our study, which was sufficiently powered, shows with considerable statistical confidence that thorough mastication results in reduced post-prandial blood glucose levels in pre-diabetic individuals possibly indicating importance of increased frequency of chewing per morsel as a non-pharmacological intervention in preventing progression to dysglycemic.

However, it is important to note, that this phenomenon was observed in our study in subjects who consumed a substrate (i.e. groundnuts) that was low in carbohydrate content but rich in protein and fat. Results from previous studies suggest that the type of food ingested is important for determining the physiological effects of mastication (Table 3). A study in 1986 demonstrated that chewing a variety of foods including sweetcorn, white rice, diced apple and potato, led to elevated postprandial glucose levels, though the extent to which they rose differed according to the food ingested [8]. Conversely, the peak glucose response and the areas under the blood glucose profiles in response to ingestion of these foods, were significantly reduced when the subject swallowed these foods whole instead of chewing them thoroughly. Another study showed significant correlations between the degree of substrate breakdown during mastication and the blood glycemic response for rice [9]. The results from the study suggest that individual differences in mastication and masticated particle size distribution may be one of the causes for inter-individual differences in the glycemic response to rice. In a separate randomized, controlled, crossover trial on 15 healthy young subjects, rice chewed 15 times produced a total glycemic response (GR), peak GR and glycemic index significantly lower than when chewed 30 times [10]. Groundnuts are readily available, require thorough mastication for deglutition and are rich in protein (26%) and fat (49%) but have a total carbohydrate content of only 16%, of which more than 50% is insoluble fiber. In comparison, 90% of the total dry weight and 87% of the total caloric content of rice is carbohydrate in the form of starch [11]. Therefore, we decided to use groundnuts as the substrate for our study as we hypothesized this would result in elevated cephalic phase insulin secretion.

In turn this may result in better glycemic control and reduce progression to overt diabetes in pre-diabetic patients. Although poorly powered, previous studies have shown that higher rates of mastication may actually result in elevated post-prandial BSL when ingesting carbohydrate rich foods such as rice. Studies also show varying effects in diabetic individuals. Hence, we cannot extend our recommendation of thorough mastication to carbohydrate rich foods or in individuals with overt type 2 diabetes. It would be important to qualify the relationship between thorough mastication, carbohydrate rich foods and type 2 diabetes in well-designed future studies.

Our results are statistically robust, based on simple pre-test post-test quasi-experimental study design, rather than a randomized controlled trial (RCT). Hopefully the results of our study will encourage the development of future well-designed RCTs to further qualify the physiological effects of mastication in dysglycemic.

Conclusion

Chewing could increase the digestibility and absorption of carbohydrate in several ways; the reduction in particle size would enhance the delivery of food from the stomach to the small intestine the larger surface area of masticated food increases access to pancreatic enzymes; enhancement of salivation associated with chewing would increase digestion of food in the mouth and stomach.

Our study confirms the fact that chewing decreases the postprandial sugars significantly in patients with impaired glucose tolerance and impaired fasting glucose, and also differences may be seen in post prandial blood sugar level depending on the type of food substrate.

Implications: Based on the findings from our study, we would recommend pre-diabetic individuals to employ the simple yet effective method of thorough mastication of approximately 40 chews per bite to lower post-prandial blood sugar levels.

Conflict of Interest: There is no conflict of interest.

Source of Fund: Self-funded.

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