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Adiposity, Blood Glucose and Insulin Levels in Adolescents and Young Adults in Mumbai City: Association with Consumption of Milk and Milk Products

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ABSTRACT

Background & Aim: Milk has been studied extensively for its potential benefits, and some possible harmful effects on health. However, there is a paucity of Indian data in this context. Therefore, this study examined the association between milk consumption and anthropometric measurements, body composition and biochemical markers of glycaemic control in young adults (16-25 years) in Mumbai city.
Material & Methods: 1313 young adults who had participated in a previous study between 2017 to 2019, were approached, among whom 563 agreed to participate. Anthropometric measurements, blood pressure, body composition and biochemical markers of glycaemic control had been done during the original screening. These data were used to examine the association with milk consumption. Information about their milk consumption practices was obtained in 2020 and 2021 through personal interviews of participants.
Results: 28 participants did not consume milk and were excluded from the statistical analysis. Daily mean milk consumption was 314 ± 239 mL. Daily milk consumption was divided into quartiles. Although, anthropometric measurements and glycaemic markers did not differ significantly between the four quartiles of milk consumption, participants in Q1 and Q2 tended to have a higher per cent body fat, HC, and fasting and stimulated insulin. Also, mean muscle mass in Q4 was significantly higher than in the lower three quartiles.
Conclusion: Results show some trends that are in line with existing literature supporting the beneficial role of milk in health. Larger epidemiological studies on Indians are warranted to confirm these trends.

Keywords: milk, diabetes, obesity, body fat, milk products, adolescents.

INTRODUCTION

In 2021, global milk production was estimated to be 544 million metric tons.[1] Milk is consumed by billions of people worldwide, but per capita consumption of milk varies by country. India ranks second in the world in milk production, and in 2021, about 83 million metric tons of milk were consumed in India.[1] In recent times, however, there has been scepticism in the public, about the health effects of milk and this is partly reflected in the increasing market availability of milk substitutes such as soy, almond, or oat milk.[2]

Reports in the literature are equivocal about the association between milk and dairy product consumption with body weight, adiposity, insulin resistance and risk of diabetes mellitus, cardiovascular disease, cancer, etc.[3,4] Berkey et al., (2005)[5] reported that higher milk intake among children was associated with greater weight gain, although the authors attributed this more to the added calories provided by milk. Also, they observed that weight gain was associated with dietary calcium, skim and 1% milk but not dairy fat. Some investigators have shown that dairy consumption may be associated with metabolic syndrome.[6,7] Milk and dairy products have been said to be potent insulin secretagogues that could stimulate acute hyperinsulinemia upon consumption.[8,9,10] In 2015, Tucker and colleagues[11] reported that a high dairy intake was a significant predictor of insulin resistance in non-diabetic, middle-aged women. Melnik (2015)[12] has suggested that continued intake of bovine milk is associated with uptake of cow's milk-derived microRNAs, that may transfer bioactive bovine microRNAs that are likely to be diabetogenic.

In contrast, a recent report of a 10-year longitudinal study by Chiang and Pan (2021)[13] on Taiwanese adults, indicated an inverse association between milk consumption at baseline and increments in body mass index (BMI). Earlier in 2017, Hruby and co-workers[14] reported the results of a 12-year follow-up study on 1867 persons who were free of diabetes at the start of the study. They observed that total, low-fat and skim milk, whole milk, and yoghurt intakes were associated non-linearly with incident prediabetes; with a moderate intake being associated with the most amount of reduction in relative risk. There was a dose-response between the highest and lowest intake categories. They concluded that the association of dairy intake with incident prediabetes or diabetes varied with the dairy product and its type. Further, recent studies indicate that milk and dairy intake are protective and reduce risks for metabolic syndrome. Fahed et al., (2020)[15] recently found in a cross-sectional study conducted in Lebanon that dairy intake was not associated with HOMA-IR. Yuzbashian et al., (2021)[16] reported that among individuals with prediabetes, higher consumption of low-fat dairy, low-fat milk, and low-fat yoghurt was associated with a lower risk of subsequent type 2 diabetes mellitus (T2DM). These authors suggested that low-fat dairy products may prevent progression to T2DM in prediabetics.

In this context, given the dearth of data on Indians, we examined the association between BMI, body weight, anthropometric markers, per cent body fat, visceral fat per cent, blood glucose and insulin; and milk consumption in young adults living in Mumbai city, India.

MATERIALS AND METHODS

Ethics Approval

The study was approved by the Intersystem Biomedica Ethics Committee (ISBEC) (Approval No. ISBEC/NR-30/KM-MN/2019) (July 22, 2019).

Sample Size and Cohort Selection

The participants were adolescents and young adults aged 16-25 years from Mumbai city; who had undergone screening for anthropometry, fasting and stimulated 2-hour glucose and insulin for a larger intervention project conducted between September 2017 and February 2019. The results of the intervention study have been published elsewhere.[17] One thousand three hundred and thirteen individuals, who had participated in the screening were contacted between July 2019 and September 2020, for the present study via telephone, email, and personal visits after seeking an appointment. Among the 1313 participants, 471 (35.9%) participants did not respond to any form of communication; for 249 (19%) persons, the contact information was no longer valid and 30 (2.3%) individuals refused to participate. Thus, the study sample comprised the remaining 563 participants.

Data Collection

Each participant was personally interviewed by a trained dietitian to obtain retrospective information regarding their milk consumption practices at the time of the screening. The participants were asked about the amount of milk consumed per day in household utensils, i.e., cups or mugs or glasses and whether the utensil was filled to the brim. If not, they were asked the height up to which the utensil was filled. In addition, the participants interviewed online/on the telephone were requested to photograph their utensils and share them with the dietitian. These were then equated with standard measures and the amount of milk consumed in a day was calculated in mL.

Anthropometric measurements

Measurements included weight, height, waist circumference (WC), and hip circumference (HC), using standard methods and standardized equipment. These measurements had been taken on the day of screening as part of the previous intervention study by trained research assistants. BMI, waist to hip ratio (WHR), and waist to height ratio (WHtR) were calculated. Body composition was measured using a TANITA body composition analyser (Model MC 780 MA) on the day of screening. WC and HC were measured with a SECA tape accurate to 0.1 cm. Body composition measurements included muscle mass, visceral fat, and per cent body fat. All measurements were taken in triplicate and the average was calculated.

Subjects were categorised as underweight (BMI = <18 kg/ m^2), normal weight (BMI = 18.501 – 22.99 kg/ m^2), overweight (BMI = 22.991 – 24.99 kg/ m^2) and obese (BMI = ≥25 kg/ m^2) based on the BMI cut-offs recommended by the WHO for Asians (2004).[18] Participants with a WC ≥ 80 cm (for females) and ≥ 85 cm (for males) were considered at risk of metabolic disorders.[19] The cut-off for WHR was 0.80 for women and 0.90 for men.[19] A WHtR ≥0.50 was considered the cut-off for high risk of metabolic disorders irrespective of gender.[20]

Biochemical markers

Blood glucose and insulin – fasting and stimulated (2 hours after consumption of 75g of glucose), as well as glycosylated haemoglobin (HbA1c), were measured on the day of screening. The details have been reported elsewhere.[17] Glucose was measured by the GOD POD method (Accurex Biomedical Pvt. Ltd) and insulin was measured by radioimmunoassay using a Beckman Coulter Counter. HbA1c was measured using a Nycocard reader (Alere Technologies, Norway).

A fasting blood glucose (FBG) value of 100-125 mg/dL and a 2-hour postprandial blood glucose (PPBG) value of 140-199 mg/dL was considered as an indicator of impaired glucose metabolism. Also, a fasting blood insulin level of ≥15 mIU/L and glucose-challenged insulin level of ≥80 IU/mL was considered the cut-off for hyperinsulinemia.[21]

Blood Pressure

At the time of screening, all participants underwent a physical examination conducted by a physician. The physician also took the systolic and diastolic pressure measurements, with a sphygmomanometer.

Data Analysis

Data were analysed using SPSS version 20. The daily milk consumption was divided into four quartiles: – (i) Quartile 1: 10-200 mL, (ii) Quartile 2: 201-250 mL, (iii) Quartile 3: 251-400 mL and (iv) Quartile 4: >400mL. The four quartiles were compared for body composition, anthropometric measurements, and biochemical markers of glycaemic control of the participants. One-way analysis for variance was applied and a p-value <0.05 was set to determine statistically significant differences.

RESULTS

Among the 563 participants, 380 were females (67.5%) and 183 were males (32.5%). The mean age of the participants was 19.6 ± 2.1 years. Among the 563 participants, 28 reported that they did not consume milk or dairy products at all and were excluded therefore, from the analysis. Daily mean consumption of milk was 314 ± 239 mL and varied from as little as 10 mL to as much as 2000 mL. Mean daily milk consumption by males was 363 ± 273 mL (95% CI: 323, 404 mL); and was significantly higher (t = 3.584, p = 0.000) than the mean consumption by females (285 ± 215 mL, 95% CI: 262, 308 mL).

The daily milk intake of participants is illustrated in Figure 1. A very small number of participants consumed more than 1 litre of milk in a day. A little less than one-tenth (9.5%) of the participants consumed less than 100 mL of milk in a day. This was essentially the milk used to whiten the tea or coffee they consumed. Almost 60% of participants consumed between 110 and 310 mL/day, with 26.7% consuming 110-210 mL nad 31.9% consuming between 210 and 310 mL/day. Another 23.3% participants' daily milk consumption was 410-510 mL in a day. A small percentage (8.1%) consumed between 510-1010 mL/day. Thus, majority of the study participants' intakes ranged frm 110 to 310 mL /day.

Among the majority of milk consumers, i.e., from 10 mL to 1000 mL/ day (n=502); the mean daily milk intake was 303 ± 186 mL (95% CI: 286, 319 mL). Within these, the mean intake for males (n=174) was 342 ± 214 mL/ day (95% CI: 206, 269 mL); whereas that of females (n=328) was 282 ± 166 mL/ day (95% CI: 264, 300 mL).

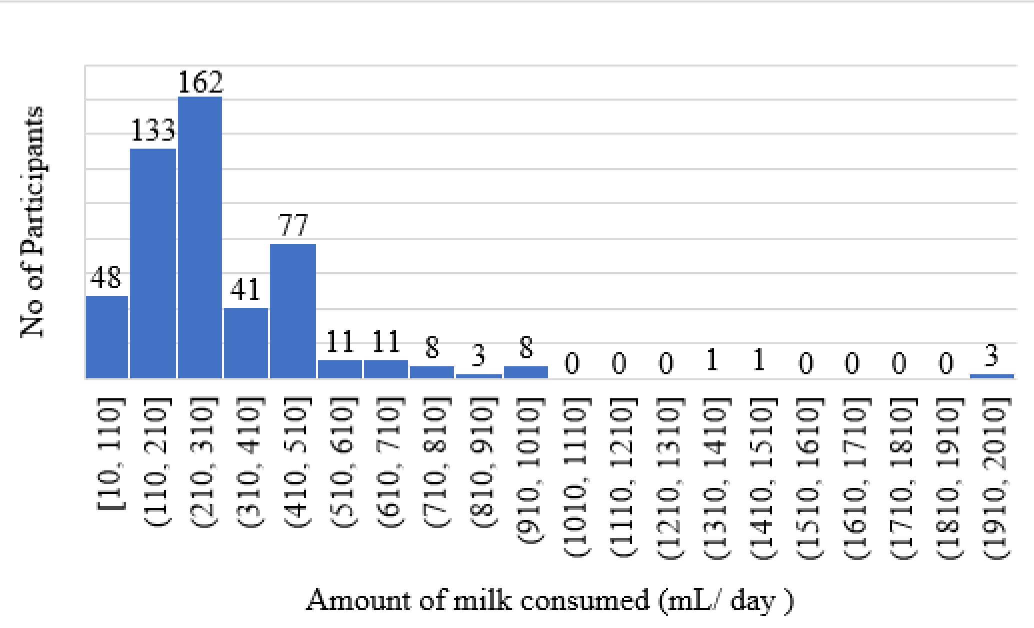

Figure 1: Distribution of participants by amount of milk consumption

Further, the amount of milk consumed per day by the participants was divided into quartiles and used for analysis. The quartiles were (i) Quartile 1: 10-200 mL, (ii) Quartile 2: 201-250 mL, (iii) Quartile 3: 251-400 mL and (iv) Quartile 4: >400mL.

The body weight, circumference measurements and body composition of the participants were compared between the four quartiles of milk consumption (Table 1).

Table 1: Comparison of body weight, circumference measurements and body composition by quartiles of milk consumed in a day

Measurement	**Q 1**	**Q 2**	**Q 3**	**Q 4**	**F, *p***
	10 – 200 ml (n=180)	**200.01 – 250 ml (n=134)**	**250.01 – 400 ml (n=70)**	**≥400 ml (n=123)**	
Weight (kg)	57.6 ± 13.7[1]	56.6 ± 12.5	57.1 ± 12.7	59.2 ± 13.2	0.904, 0.439
	55.7, 60.1[2]	54.4, 59.2	54.5, 60.9	56.9, 62.1	
BMI (kg/m^2)	22.3 ± 4.5	22.5 ± 5.0	22.0 ± 4.2	22.7 ± 5.0	0.331, 0.803
	21.8, 23.2	21.6, 23.5	21.2, 23.3	22.0, 24.0	
WC (cm)	72.3 ± 10.9	72.0 ± 10.3	70.5 ± 9.2	72.7 ± 11.1	0.707, 0.548
	70.8, 74.4	70.1, 74.0	68.3, 73.0	70.8, 75.2	
HC (cm)	92.9 ± 10.1	91.6 ± 10.0	91.5 ± 9.0	91.9 ± 10.0	0.605, 0.612
	91.6, 94.8	90.1, 93.9	89.9, 94.4	90.3, 94.2	
WHR	0.78 ± 0.06	0.79 ± 0.06	0.77 ± 0.06	0.79 ± 0.06	2.072, 0.103
	0.77, 0.79	0.77, 0.79	0.75, 0.78	0.78, 0.80	
WHtR	0.45 ± 0.07	0.45 ± 0.07	0.44 ± 0.05	0.45 ± 0.07	0.946, 0.418
	0.44, 0.46	0.44, 0.47	0.43, 0.45	0.44, 0.47	
Body Fat (%)	27.1 ± 8.4	27.0 ± 9.6	25.6 ± 8.5	25.0 ± 9.3	1.832, 0.140
	26.3, 28.9	25.8, 29.4	24.1, 28.2	24.0, 27.5	
Visceral Fat (%)	4.5 ± 3.3	4.3 ± 3.2	4.3 ± 3.1	4.6 ± 3.4	0.235, 0.872
	3.9, 4.9	3.6, 4.8	3.4, 5.0	3.9, 5.2	
Muscle Mass (kg)	38.7 ± 9.1	38.0 ± 7.6	39.6 ± 8.1	41.0 ± 8.6	2.671, 0.047
	37.7, 40.5	36.8, 39.5	37.8, 41.8	39.7, 42.9	

[1]Mean ± SD, [2]95% CI
BMI – Body Mass Index, WC – Waist Circumference, HC – Hip Circumference, WHR – Waist-to-Height Ratio, WHtR – Waist-to-Height Ratio

The mean body weight of participants in Q4 of milk intake was higher than the three lower quartiles but the difference was not statistically significant. Similarly, no significant differences were observed between the four quartiles for BMI, WC, HC, WHR, WHtR as well as visceral fat. Per cent body fat tended to be higher in the two lower quartiles of milk intake. Mean muscle mass was slightly but significantly higher in the Q4 of milk intake than in the lower three quartiles.

Blood glucose and insulin, both fasting and 2-hour glucose-stimulated values, as well as HbA1c were compared between the four quartiles (Table 2). There were no significant differences between the four quartiles for all the markers. However, participants from Q1 and Q2, i.e., with a lower daily milk intake, tended to have slightly higher stimulated glucose values as compared to Q3 and Q4. Similarly, mean fasting and stimulated insulin in Q1 and Q2 were higher as compared to Q3 and Q4.

Table 2: Comparison of Blood glucose, Insulin and Glycosylated Haemoglobin between quartiles of milk consumed per day (ml)

Measurements	**Q 1**	**Q 2**	**Q 3**	**Q 4**	
	10 – 200 ml (n=180)	**200.01 – 250 ml (n=134)**	**250.01 – 400 ml (n=70)**	**≥400 ml (n=123)**	**F, *p***
FBG (mg/dl)	83.1 ± 17.2[1]	84.0 ± 9.0	84.7 ± 12.4	81.6 ± 9.5	1.077, 0.358
	80.5, 88.2[2]	82.7, 86.6	81.7, 90.0	78.5, 82.2	
Stimulated Glucose (mg/dl)	95.5 ± 38.6	95.7 ± 21.7	93.2 ± 31.0	91.2 ± 19.7	0.678, 0.566
	90.3, 106.6	92.1, 102.0	88.6, 109.5	86.9, 95.4	
Fasting Insulin (mIU/ L)	8.9 ± 5.1	8.8 ± 4.1	7.9 ± 4.4	8.4 ± 4.7	1.008, 0.389
	8.3, 10.3	8.8, 10.6	7.3, 9.8	7.3, 9.8	
Stimulated Insulin (mIU/ L)	75.2 ± 61.0	67.1 ± 43.5	64.4 ± 51.2	68.3 ± 48.6	1.033, 0.378
	66.9, 88.3	60.4, 78.9	58.0, 93.0	57.7, 87.1	
HbA1c (%)	5.4 ± 0.5	5.5 ± 0.4	5.5 ± 0.5	5.4 ± 0.3	0.226, 0.878
	5.3, 5.5	5.4, 5.5	5.3, 5.6	5.3, 5.5	

[1]Mean ± SD, [2]95% CI
FBG – Fasting Blood Glucose, HbA1c – Glycosylated Haemoglobin

DISCUSSION

Milk has been studied extensively for its beneficial effects on health as well as a potential association with diseases and disorders. We undertook this study on young adults because most of the data related to milk intake are from other countries and there are few reports from the Indian subcontinent. Therefore, we deemed it worthwhile to examine whether the amount of milk consumed influences body weight and anthropometric indices, per cent body fat and visceral fat, as well as whether it affects biochemical markers of glycaemic control, particularly because we had an opportunity to analyse the blood glucose and insulin levels in the 563 participants. Such studies are essential for Indians because milk is a valued food commodity in Indian cuisines. Shifts from cow milk to plant-based milk or from A1 milk to A2 milk should be evidence-based. The results of the present study would certainly help to fill the gap in an area in which there is a paucity of Indian data, especially because India is reputed to have the second-largest number of diabetes patients in the world[22] and Asian Indians are at greater risk of developing diabetes mellitus.

Early reports in the literature indicated that dairy product consumption is associated with a risk of weight gain. A meta-analysis conducted by Barr in 2003[23] shortlisted nine studies of dairy product supplementation out of which seven studies did not show any association between dairy product consumption and body weight and only two studies with older adults showed significant weight gain with dairy intake. However, later studies do not support these early reports. In a large cohort study of 12,829 children between 9 to 14 years, weight gain was higher in children who drank more milk, but this was attributed to daily energy consumption being a stronger predictor of weight gain. Also, in this study, dairy fat was not associated with weight gain.[5] Beck., et al, (2017) and Vanderhout., et al, (2021) have shown that consumption of full-fat milk is associated with lower odds of overweight and obesity in childhood.[24,25]

Later studies have indicated that several components in milk such as calcium, vitamin D, and dairy proteins can reduce adipose mass, and visceral fat in addition to body weight, among not only healthy individuals but also overweight or obese and people with diabetes, and cardiovascular diseases including blood pressure. These benefits have been observed among different age groups such as adolescents and postmenopausal women. Besides observational studies, these effects have also been evidenced by randomized clinical trials.[26] These benefits have been attributed to several components in milk including the proteins such as lactoferrin, short-chain fatty acids like butyric acid, tripeptides, calcium, phosphorus, oligosaccharides, and trans-palmitoleic acid (trans-16:1, n–7).[27]

The results of the present study are in line with reports in the literature regarding milk consumption. We found that those who were in the two lower quartiles for daily milk intake i.e., <250 ml per day, tended to have higher levels of fasting and 2-hour stimulated insulin, a higher percentage of body fat and a slightly lower percentage of muscle mass. Panahi et al., (2014) reported that the lowering of blood glucose by either whole milk or simulated milk was greater than the predicted lowering based on equivalent content of either complete milk protein, lactose or milk fat, individually.[28]

The possible mechanisms for this putative benefit in maintaining glycaemic control have been attributed to increased insulinemic response, less glycaemic fluctuations, more secretion of gastric inhibitory polypeptide (GIP) and glucagon-like peptide-1 (GLP-1) triggered by milk proteins, suppression of ghrelin secretion, as well as the satiating effect of α-lactalbumin.[29-31] Hidayat et al., (2019) reported that milk proteins stimulate postprandial insulin response and reduce the postprandial rise in blood glucose levels.[32] They proposed that the bioactive peptides in milk cause the release of GLP-1 and GIP, which reduces gastric emptying and stimulates insulin secretion. This, in turn, reduces postprandial blood glucose elevation.

In our study, this was reflected in the fasting and 2-hour blood sugar levels in the glucose tolerance test results. The participants in the highest quartile of milk intake (≥400 ml milk consumed daily) had the lowest blood glucose levels, whereas the highest mean fasting and stimulated insulin were seen in Q1 (10-200 ml milk daily). Although these results were not statistically significant, they are in line with multiple meta-analyses that have indicated milk to have a slightly positive or no effect on glycaemic management in T2DM.[32,33] In a recent review, Leary and Tanaka (2020) pointed out that in the results of an oral glucose tolerance test (OGTT), the two-hour glucose concentration is an independent and better predictor of cardiovascular disease risk than the fasting glucose concentration.[34] These authors have also suggested that when milk/milk products are consumed as part of a meal, the proteins in these products may lead to a hyperinsulinemic response. When insulin binds to the receptors on endothelial and vascular smooth muscle cells, it may initiate vasodilation. This, in turn, could enhance blood flow and facilitate the disposal/ clearance of glucose that was accrued from the meal.

This is because different types of dairy products may have different effects on glucose response. In one clinical trial on overweight/obese males, consumption of low-fat milk and yoghurt did not affect fasting glucose,[35] whereas a study on women showed beneficial effects.[36]

Besides the effects on blood glucose, milk consumption has been reported to help in the reduction of adipose tissue. Josse et al., (2011) observed, in overweight and obese postmenopausal women, that after consumption of milk and dairy products as part of a hypocaloric diet for four months, a reduction in adipose tissue, particularly visceral adipose tissue with a concomitant increase in lean body mass occurred.[37]

Schwingshackl and coworkers (2016) in a meta-analysis of 27 studies of which 22 met the criteria for inclusion, noted that consumption of whole fat, as well as low-fat dairy products, was not associated with changes in body weight.[38] Consumption of cheese was in fact positively associated, whereas yoghurt consumption was inversely associated with changes in body weight. Also, they reported that the risk of abdominal obesity and of being overweight was lower in the highest dairy intake category. These authors concluded that there was no positive relationship between changes in body weight and dairy consumption, except for a beneficial effect from yoghurt consumption. Although milk is consumed in India, its products curd/yoghurt and buttermilk are common food items included on an almost daily basis. The possible benefits of consuming milk, curd or buttermilk need to be studied to enable appropriate dietary advice and modifications for patients and the public.

Contrary to the benefits of milk, some reports in the literature have indicated that metabolic health is adversely influenced by milk consumption. Melnik and Schmitz (2017) reported that milk induces epigenetic changes through exosomal microRNA, transmitting genetic information from the maternal lactation genome to the milk recipients i.e., offspring.[39] This has been observed in breastfed newborns as well as human consumers of bovine milk. Also, prolonged cow milk consumption during the formative years may be associated with increased BMI thereby increasing the risk of obesity, T2DM and cancers in later life. Melnik (2021),[40] in his recent review of the role of milk exosomes and galactose on T2DM and Parkinson's disease, highlighted that consumption of milk and other dairy-derived sources of galactose can contribute to oxidative stress in the pancreatic β-cells thus playing a role in the pathology of T2DM. This highlights the need for clarifying this with well-designed longitudinal studies on populations at-risk, like Asian Indians.

One of the major limitations of this study was that slightly less than half of the original sample size could be reached or agreed to participate. The data regarding milk consumption practices were collected over telephonic interviews at a later time than the original data collection, and we relied on the memory of the participants. There may have been some recall bias in the amounts mentioned by the participants.

CONCLUSION

The present study compared anthropometric measurements, body composition and biochemical markers of glycaemic control based on the amount of milk consumed per day. There were no significant differences between any of the markers. However, participants in the lower two quartiles of milk consumption tended to have a higher per cent body fat, HC, fasting insulin as well as 2-hour stimulated insulin. Given the retrospective nature of the study, it would be worthwhile to undertake a well-designed large epidemiological study wherein, the type of milk is confirmed by testing and then correlated with the OGTT findings as well as anthropometric indices and body composition measurements.

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Ethical Approval: Approved

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