ORIGINAL

Medical History of Infancy, Weaning Foods and Nutrient Intake of Indian Type 1 Diabetic Children aged 2 to 18 years

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ABSTRACT *Background and purpose:* Worldwide prevalence of Type 1 Diabetes in children has been increasing. Various environmental factors have been identified as triggering agents in the development of Type 1 Diabetes. The current study assesses the medical history, weaning practices during infancy and present nutrient intake of type-1-diabetic children. *Method*: A cross section study was conducted on 126 children (63 Type-1-diabetic-mellitus) aged 2-18 years. Anthropometry, symptoms at diagnosis, insulin prescribed, medical history during infancy, food intake during weaning and present food intake of children was assessed using pretested standardized tool and techniques. *Results*: More diabetic children were classified as being underweight as compared to non-diabetic children. Common symptoms observed in diabetic children at time of diagnosis were polyuria, unexplained weight loss, tiredness, nocturia and excessive hunger. Significantly higher percentage of diabetic children had received antibiotics and had suffered from jaundice, mumps and hand-mouth disease during infancy ($p<0.05$). Significantly higher percentage of non-diabetic children were given cereals, pulses and fruits during weaning foods ($p<0.05$). Percentage recommended intake in boys (girls) for energy was 59.1±2.8% (57.3±2.5%) and for protein was 84.8±3.4% (79.5±3.4%). In both boys and girls aged 10 to 12 years and more than 13 years, diabetics had significantly higher nutrient intake as compared to non-diabetics. *Conclusion*: The present study highlights the correlation of increased morbidity and weaning practices during infancy with the precipitation of Type 1 Diabetes in later age. A compromised nutrient adequacy was also observed in the present intake in both Type 1 diabetic and non-diabetic children.

Keywords: Type 1 diabetes, nutritional status, weaning, infections during infancy, diet, medical history.

INTRODUCTION

Type 1 Diabetes is a lifelong heterogeneous metabolic disorder, caused by immune-mediated destruction of β cells of the pancreas leading to insulin deficiency in genetically susceptible individuals. Type 1 diabetes is the most common chronic endocrine disorder in childhood (1). Worldwide prevalence of Type 1 Diabetes in children has been increasing and it represents a rising global health burden (2). In the last few decades, there has been an overall increment in the incidence of Type 1 diabetes by 3-5% per year and an estimated 65,000 new cases are reported in children <15 years per year (2,3). As of 2014, an estimated 387 million people had diabetes of which Type 1 Diabetes accounts for 5-10% (4). Type 1 Diabetes contributes to ≥85 % of all diabetes cases in youth <20years of age worldwide. Onset of occurrence peaks between 10-14 years of age and declines after puberty, appearing to stabilize in adulthood (15-29 years) (4).

Given to the rapid rise in the last two decades it may be said that genetic susceptibility may not be the sole contributing factor, but it may be caused largely due to changes in lifestyle and diet. The underlying autoimmunity in genetically susceptible individuals is triggered by environmental factors. This indicates significance of interactions between environmental factors and genetic factors in the multi-factorial etiological components of Type 1 diabetes. Only 10% -15 % newly diagnosed cases report a positive family history (2,5-6).

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Environmental factors potentiate and triggers of β cell destruction either by directly affecting β cells or by aggravating abnormal immune responses to proteins normally expressed in the cells (7). This destruction ultimately leads to absolute insulin deficiency. Environmental factors involved in the destruction include nutritional factors, exposure to Vitamin D, viral infections, gut microflora, socio-economic condition, exposure to antibiotics, pollutants, perinatal and fetal influences and psychosocial stress. The factors may act directly on the pancreas, or provoke abnormal immune responses to proteins normally expressed in the cells (4-10).

Amongst nutritional factors, an early exposure to cow's milk or formula milk and a short breastfeeding period has been associated with increased risk of Type 1 Diabetes in ecological and analytical epidemiological studies. Besides this, nutritional inadequacy also leads to compromised immunity giving rise to opportunistic infections and thus resulting in an immune mediated destruction of β cell (8).

Viruses such as enteroviruses, mumps, rubella, cytomegalovirus, rotavirus have long been implicated in the pathogenesis of Type 1 diabetes. These viruses may either trigger an autoimmune reaction gradually causing destruction of β cell mass or may have a direct cytolytic effect (7,8).

The emerging global epidemic of Type 1 diabetes makes it crucial to identify relevant triggering factors and generate optimum awareness programs to prevent it from rising further. Thus, the aim of this study was to assess the medical history, weaning practices during infancy and present nutrient intake of type-1-diabetic children.

METHODS

A cross sectional study was conducted on 126 children [63 Type 1 diabetic (28 boys, 35 girls), 63 non-diabetics (26 boys, 37 girls)] aged 2- 18 years. Diabetic children were recruited from a pediatric endocrinologists clinic where as non-diabetic children were recruited from community. A written consent was obtained from parents of all children. Ethics approval was obtained from institutional ethic committee.

Anthropometry:

Weight of children was measured using an electronic weighing scale. Height was measured by a wall mounted non-stretchable tape. Body mass index (BMI) was calculated by dividing weight in kg by height in squared meter. Weight, height and BMI for ae Z-scores were calculated in comparison to Indian reference curves (11).

Diabetes related data:

A pre-structured questionnaire was used to identify the symptoms that noticed at time of diagnosis in children. Questions regarding the type of insulin were also inquired.

Details regarding birth:

The type of delivery for the child, details regarding gestation period, health issues at birth and use of antibiotics at birth were inquired using a pre-structured questionnaire.

Breastfeeding and weaning:

The pre-structured questionnaire was also used to inquire details regarding exclusive breastfeeding and foods used during weaning for children.

Nutrient intake:

Dietary intake was assessed by 24-hour recall on three random days of a week (2 weekdays and 1 holiday). Each parent was asked about intake of food and beverage items by their child at each breakfast, lunch, dinner and mid-meals, using standard household measured (cups, spoons and chapati cut-outs) through face to face interview. The type of food consumed, recipe of each food item and amount consumed at each meal were recorded. Daily nutrient intake was calculated by applying the nutritive value tables of the National Institute of Nutrition (NIN), India (12) with help of Dietcal software (AIIMS, Delhi, India). Intake of energy, proteins, carbohydrates and fats were calculated. Percentage recommended dietary allowance was calculated for energy and proteins using age and gender specific Indian reference (Table 1) (13).

Statistical methods:

Analyses were performed using SPSS software for Windows (version 16.0, 2007, SPSS Inc, Chicago, IL). Data are presented as Mean ± SE or frequency (percentage). Independent Sample T test was used to analyse difference in parameters between diabetics and non-diabetics. The frequency distributions were tabulated for various parameters by prevalence of Type 1 diabetes and were compared using cross tabulations and chi-square test. $p<0.05$ was considered to be statistically significant.

Table 1. Indian Recommended Dietary Allowance for Energy and Proteins (ICMR 2010)

	RDA Energy (kcal/day)		RDA Protein (g/day)	
	Boy	Girl	Boy	Girl
2-3 years	1060	1060	16.7	16.7
4 to 6 years	1350	1350	20.1	20.1
7 to 9 years	1670	1670	29.5	29.5
10 – 12 years	2190	39.9	2010	40.4
13-15 years	2750	54.3	2330	51.9
16 – 17 years	3020	61.5	2440	55.5

RESULTS

Data on 126 [63 Type 1 diabetic (28 boys, 35 girls), 63 non-diabetics (26 boys, 37 girls)] aged 2- 18 years is presented in the current study.

Age and Anthropometry:

The mean age of boys (girls) was 10.8±0.5 years (10.8±0.5 years), height was 134±4.5 cm (136.2±1.5 cm), weight was 34.3±2.2 kg (35.1±1.6 kg), BMI was 18±0.6 kg/m2 (18±0.5 kg/m2), height for age Z-score was -0.6±0.2 (-0.5±0.2), weight for age Z-score was -0.7±0.3 (-0.5±0.4) and BMI for age Z-score was -0.1±0.3 (0.2±0.3).

Table 2 presents anthropometric characteristics of diabetics and non-diabetic children separately for boys and girls. There was no significant difference in the age of diabetic and non-diabetic boys and girls ($p>0.05$) (Table 2). Diabetic girls had significantly lesser weight and height for age Z-score as compared to non-diabetic girls ($p<0.05$) (Table 2). There was no significant difference in the anthropometric characteristics of diabetic boys and non-diabetic boys ($p>0.05$) (Table 2).

In comparison to reference Indian standards, 10 children were stunted (height for age Z-score < -2). For age for weight Z-score, 16 children were undernourished (weight for age Z-score <-2), 5 children were overweight (weight for age Z-score between 2 to 3) and 1 child was obese (weight for age Z-score < -3). For BMI for age Z-score, 7 children were undernourished (BMI for age Z-score < -2), 5 children were overweight (BMI for age Z-score between 2 to 3) and 1 child was obese (BMI for age Z-score < -3). Figure 1 gives children in various Z-score categories when classified as diabetics and non-diabetics. As seen in Figure 1, more diabetic children were underweight for when classified according to BMI for Z score whereas more non-diabetic children were underweight when classified according to weight for Z-score (Figure 1).

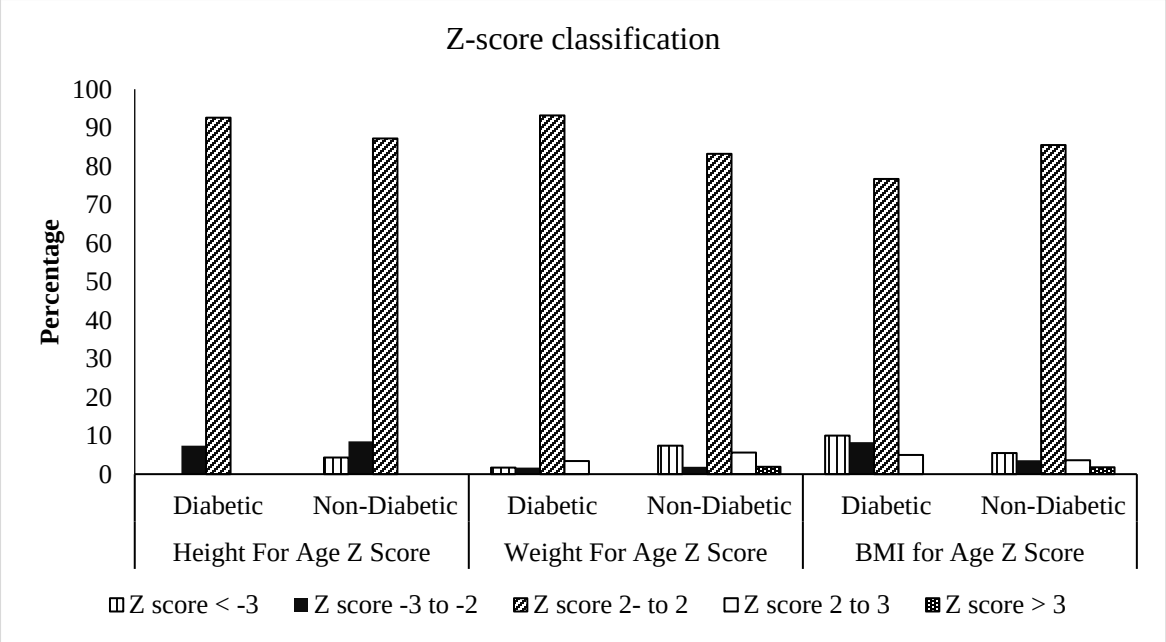
Symptoms noticed at time of diagnosis

Parents of the 63 type 1 diabetic children were asked about symptoms that they observed in their child at time of diagnosis (Figure 2). As seen in Figure 2, most common symptoms observed in diabetic children at time of diagnosis in the current study were polyuria, unexplained weight loss, tiredness, nocturia and excessive hunger. Smaller number of children reported symptoms of urinary tract infection, fever and diabetic ketoacidosis (Figure 2).

Table 2. Age And Anthropometric characteristics of Diabetic and Non-Diabetic Boys and Girls

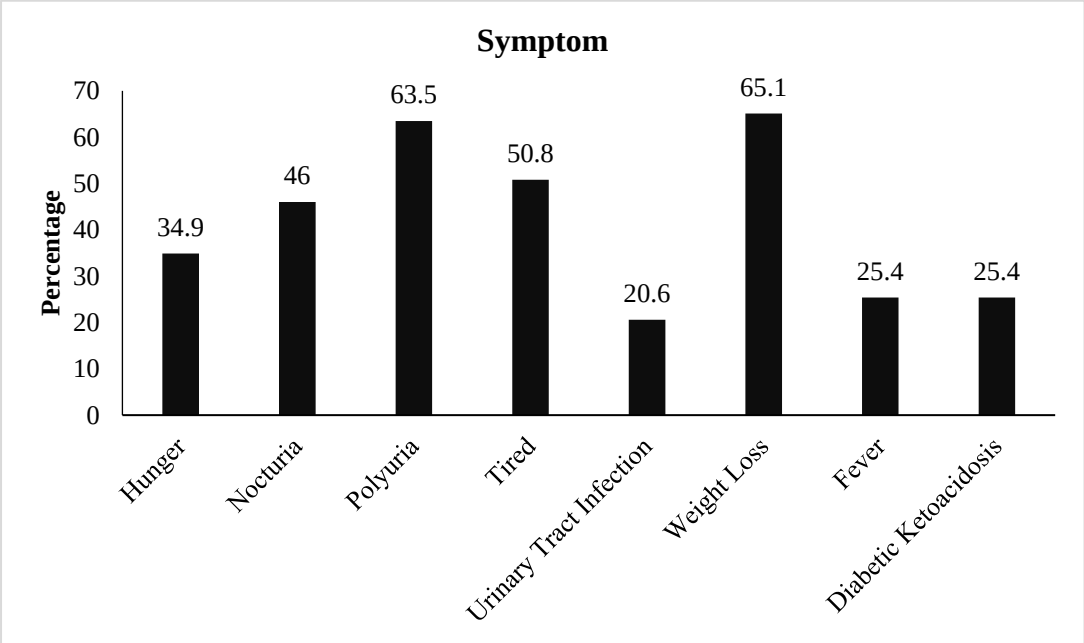
	Boys			Girls		
	Diabetic (n=28)	Non-diabetic (n=26)	P value	Diabetic (n=35)	Non-diabetic (n=37)	P value
Age (years)	11.2±0.7	10.3±0.8	0.425	10.3±0.6	11.3±0.8	0.334
Height (cm)	139.5±5.2	128.6±7.1	0.221	131.5±3.4	140.8±3.5	0.059
Weight (kg)	36.7±2.8	31.8±3.5	0.274	31.3±2.0	39.0±2.3	0.014
BMI (kg/m^2)	18.0±0.7	18.0±0.9	0.980	17.6±0.6	18.3±0.7	0.428
Height for age Z-score	-0.3 ±00	-0.9 ±0.3	0.067	-0.9±0.2	0.1±0.4	0.012
Weight for age Z-score	-0.5±0.3	-0.9±0.4	0.485	-1.0±0.3	0.1±0.6	0.094
BMI for age Z-score	0.1±0.4	-0.2±0.4	0.528	-0.1±0.2	0.6±0.6	0.349

Data presented as Mean±SE



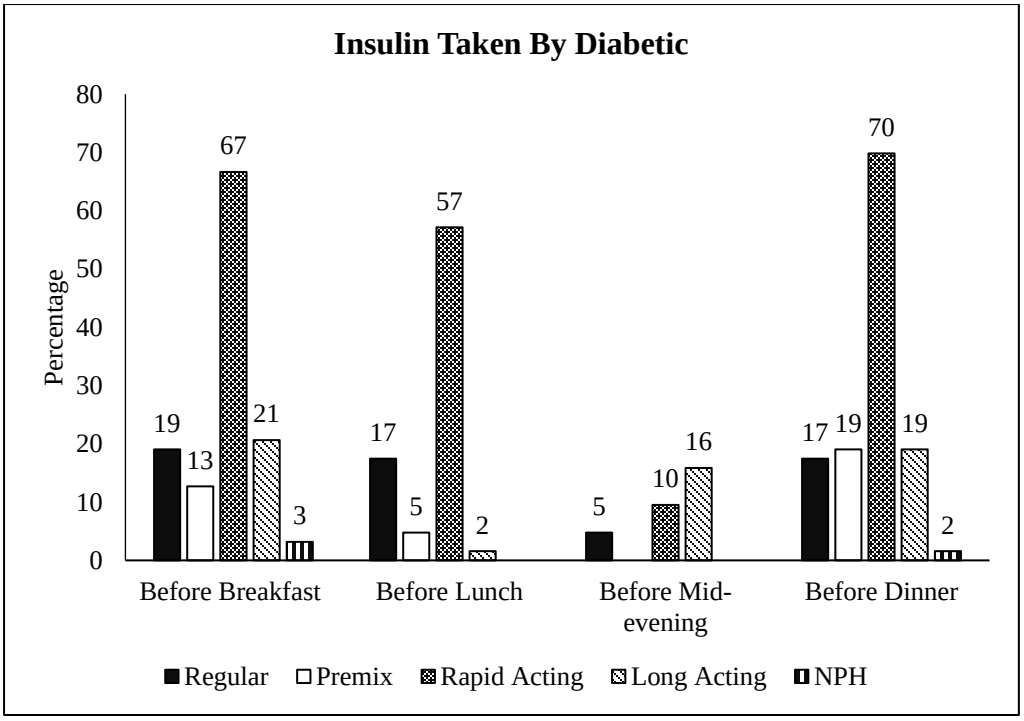
Data presented as percentage

Figure 1. Z-score categories of Diabetic and Non-Diabetic Children



Data presented as percentage

Figure 2. Symptoms observed by Diabetics at the time of diagnosis



Data presented in percentage

Figure 3. Insulin taken by type 1 diabetic children

Insulin taken by Type 1 Diabetic Children:

Figure 3 gives the type of insulin taken by children in the current study. As seen in Figure 3, the most common insulin taken by children in current study was rapid acting insulin at breakfast, lunch and dinner followed by long acting insulin. A small percentage of children were prescribed regular insulin, premix and NPH (Figure 3).

Type of delivery, medical history and Antibiotic usage in children:

Of the 126 children, 63 (50%) were born of normal delivery, 59 (46.8%) were born of C-section and 4 (3.2%) were born of other types of delivery. Twelve (9.5%) children were born pre-term, 14 (11.1%) children had allergies, 57 (45.2%) were given antibiotic from birth and 64 (50.8%) were given antibiotics from 1st – 3rd year of life. For medical history, 14 (11.1%) had suffered from jaundice, 18 (14.8%) had suffered from Mumps, 4 (3.2%) had suffered from hand and mouth disease, 2 (1.6%) had suffered from measles, 29 (23%) had suffered from febrile illness and 32 (25.4%) had suffered from other diseases. 27 (21.4%) children had never suffered from any illness.

Table 3 gives information regarding type of delivery, medical history and antibiotic usage in diabetic and non-diabetic children. Significantly higher percentage of diabetic children had received antibiotic at birth and during 1st – 3rd year of life as compared to non-diabetic children ($p<0.05$) (Table 3). There was a significant association of medical history between diabetic and non-diabetic children with higher percentage of diabetic children having suffered from jaundice, mumps and hand-mouth disease as compared to non-diabetic children ($p<0.05$) (Table 3). No significant association was seen between pre-term birth or allergy with the Type 1 Diabetes ($p>0.05$) (Table 3)

Foods consumed during infancy:

Of the 126 children, 123 (97.6%) were breastfed, 61 (48.4%) were given water along with breastfeeding. For weaning foods, 114 (90.5%) were given cereals, pulses; 106 (84.1%) were given fruits, 94 (74.6%) were given milk and 47 (37.3%) were given commercial supplement. Table 4 gives the foods given to baby during infancy. As seen in Table 4, significantly higher percentage of children without diabetes were given cereals, pulses and fruits during weaning foods as compared to diabetic children ($p<0.05$). There was no significant difference in the percentage of children with or without diabetes who were breastfed, given water with breastfeeding, given milk during weaning and given commercial supplement ($p>0.05$) (Table 4).

Nutrient intake in children:

The nutrient intake in children was calculated and percentage recommended dietary intake was assessed in comparison to Indian recommended values. The mean intake in boys (girls) for energy was 1158±78 kcal/day (1091±45 kcal/day), protein was 31.1±1.6 g/day (29.5±1.4

g/day), fat was 49.0±1.7 g/day (47.8±2.0 g/day) and carbohydrate was 137.4±9.0 g/day (128.3±7.7 g/day). Percentage recommended intake in boys (girls) for energy was 59.1±2.8% (57.3±2.5%) and for protein was 84.8±3.4% (79.5±3.4%).

Table 5a and 5b gives nutrient intake and percentage recommended intake in diabetic and non-diabetic boys and girls respectively. There was no significant difference in nutrient intake of diabetic and non-diabetic boys and girls age less than 6 years and 7 to 9 years ($p>0.05$) (Table 5a and 5b). In boys aged 10 to 12 years, protein, fat and percentage recommended protein intake was significantly higher in diabetics as compared to non-diabetics ($p<0.05$) (Table 5a). In boys aged more than 13 years, protein, carbohydrate and percentage recommended protein intake was significantly higher in diabetics as compared to non-diabetics ($p<0.05$) (Table 5a). In girls aged 10 to 12 years, energy and carbohydrate intake was significantly higher in diabetics as compared to non-diabetics ($p<0.05$) (Table 5b). In girls aged more than 13 years, energy, protein, carbohydrates and percentage recommended energy and protein was significantly higher in diabetics as compared to non-diabetics $p<0.05$) (Table 5b).

Table 3. Type of Delivery, Medical History and Antibiotic Usage in Diabetic and Non-Diabetic Children

	Diabetics (n=63)	Non-diabetic (n=63)	Chi square value	P value
Type of delivery				
Normal delivery	27 (42.9)	36 (57.1)		
C-section delivery	34 (54)	25 (39.7)	2.659	0.26
Other type	2 (3.2)	2 (3.2)		
Medical history at birth				
Preterm birth	5 (7.9)	7 (11.1)	0.368	0.544
Allergy	4 (6.3)	10 (15.9)	2.893	0.089
Antibiotics from birth	39 (61.9)	18 (28.6)	14.10	0.001
Antibiotics 1st - 3rd year of life	38 (60.3)	26 (41.3)	4.573	0.032
Medical history during infancy				
Jaundice	9 (14.3)	5 (7.9)		
Mumps	15 (23.8)	3 (4.8)		
Hand and mouth disease	3 (4.8)	1 (1.6)		
Measles	1 (1.6)	1 (1.6)	16.60	0.011
Febrile illness	13 (20.6)	16 (25.4)		
Any other	9 (14.3)	23 (36.5)		
No disease	13 (20.6)	16 (22.2)		

Data presented as frequency (%)

Table 4. Food consumed by Diabetic and Non-Diabetic Children during Infancy

	Diabetics (n=63)	Non-diabetic (n=63)	Chi square value	P value
Breastfed	61 (96.8)	62 (98.4)	0.341	0.559
Water given along with breastfeeding	31 (49.2)	30 (47.6)	0.032	0.859
Cereals given during weaning	52 (82.5)	62 (98.4)	9.211	0.002
Pulses given during weaning	53 (84.1)	61 (96.8)	5.895	0.015
Fruits given during weaning	45 (71.4)	61 (96.8)	15.20	0.001
Milk given during weaning	45 (71.4)	49 (77.8)	0.670	0.413
Commercial supplement given during weaning	22 (34.9)	25 (39.7)	0.305	0.581

Data presented by frequency (percentage)

Table 5a. Nutrient intake in boys with or without Type 1 Diabetes

	Up to 6 years		**7 to 9 years**		**10 to 12 years**		**More than 13 years**	
	Diabetic	Non - diabetic	Diabetic	Non - diabetic	Diabetic	Non – diabetic	Diabetic	Non – diabetic
Energy (kcal/day)	903± 180	994± 129	1272± 132	1099± 155	1314± 99	1028± 139	1363± 121	1110± 79
Protein (g/day)	21.2± 2.2	20.2± 2.7	25.4± 2.5	26.2± 3.4	43.8± 2.6	24.3± 1.6*	45.3± 3.4	30± 2.6*
Fat (g/day)	48.8± 5.7	46.5± 5.6	44.8± 7.9	45.4± 3.9	55.8± 2.6	44.3± 3.4*	49.5± 3.5	54.3± 6.4
Carbohydrates (g/day)	95.0± 46.1	123.6± 20.3	191.8± 19.6	144.2± 35.6	144.4± 18.5	121.1± 23.5	159.4± 17.7	104.2± 12.5*
RDA Energy (%)	66.9± 13.4	81.1± 12.0	75.3± 7.8	61.9± 6.9	59.7± 3.6	51.6± 7.0	49.5± 4.1	40.7± 3.0
RDA Protein (%)	105.3± 11	107± 11.6	86± 8.3	82.9± 5.7	104.8± 8.2	67.2± 6.2*	80.3± 6.4	55.9± 5.0*

**p<0.05 for comparison between diabetic and non-diabetics. Data presented as Mean±SE*

Table 5b. Nutrient Intake in Girls with or without Type 1 Diabetes

	Up to 6 years		**7 to 9 years**		**10 to 12 years**		**More than 13 years**	
	Diabetic	Non - diabetic	Diabetic	Non - diabetic	Diabetic	Non – diabetic	Diabetic	Non – diabetic
Energy (kcal/day)	971± 94	892± 92	1050± 142	930± 32	1467± 113	1071± 139*	1329± 126	931± 76*
Protein (g/day)	19.5± 1.5	17.3± 17	26.5± 1.5	25.0± 1.8	43.9± 3.2	35.3± 3.8	39.1± 2.9	25.4± 2.5*
Fat (g/day)	35.6± 3.1	47.4± 4.9	47.0± 4.3	40.6± 0.9	50.8± 5.4	50.7± 7.3	55.9± 8.0	46.5± 4.0
Carbohydrates (g/day)	141.6± 22	99.1± 19.8	130.3± 33.3	116.1± 4.3	199.8± 17.5	108.6± 16.4*	159.3± 11.7	87.8± 9.4*
RDA Energy (%)	72.1± 8.4	66.4± 7.4	62.1± 8.4	55.0± 1.9	69.4± 5.5	52.4± 6.7	56.8± 5.5	39.5± 3.4*
RDA Protein (%)	92.6± 10.4	80.2± 7.6	89.9± 5.2	84.8± 6.0	106.7± 9.1	90.4± 8.9	74.9± 5.7	49.6± 5.4*

**p<0.05 for comparison between diabetic and non-diabetics. Data presented as Mean±SE*

DISCUSSION

In the current study we have studied the growth, medical history at birth, weaning practices and nutrient intake of children suffering from Type 1 diabetes and compared them with non-diabetic children. Higher percentage of diabetic children had history of viral and bacterial infections as compared to non-diabetic children. Nutrient intake also differed between the 2 groups.

Growth impairment is a well-known complication of Type 1 diabetes. In the ICMR registry data 16% of Type 1 Diabetics had shown growth retardation (14). Factors affecting growth in Type 1 diabetic children include include gender, genetic endowment, puberty, metabolic control and status of growth hormone, Insulin like Growth Factor (IGF) and Insulin like Growth Factor Binding Proteins (IGFBP). The main cause of poor height and weight gain is under-insulinization leading to low circulating levels of IGF-1 and IGFBP-3 and high circulating levels of IGFBP-1. Poor glycemic control ultimately leads to delayed puberty, poor bone health and other health problems (15-16).

In a case controlled cohort study in children with an early diagnosis of Type 1 diabetes (<3 months), HbA1C was related to growth alteration during the first year of follow-up irrespective of other factors (17). In another study, children with Type 1 diabetes from 1 to 18 years of age, 30.9% were stunted, 17.7% were moderately stunted and 13.2% were severely stunted and was not associated with glycemic control (16). Even study conducted in Indian children suffering from Type 1 diabetes, it was observed that the mean height for age Z score and weight for age Z score were lower in children with diabetes as compared to controls (18). In our study, diabetic girls were significantly shorter as compared to non-diabetic.

The classic symptoms of diabetes are polydipsia, polyuria, polyphagia and weight loss. Levy-Marchal et al (2001) observed polyuria, weight loss and fatigue as the most commonly observed symptoms (19). Other typical symptoms for children at diagnosis include metabolic deterioration to diabetic ketoacidosis, presented with nausea, vomiting and lethargy (20). Similar symptoms were observed in children in our study at the time of diagnosis.

Maternal and pregnancy factors such as age, parity, gestational age (21). Higher percentage of diabetic children in the current study were born via caesarean as compared to non-diabetic children. Caesarean delivery has been associated with the development of type 1 diabetes in the offspring. Caesarean delivery may increase the risk of Type 1 diabetes due to differences in gut micro biotic compositions as compared to vaginal delivery (22-23).

Studies in mice have shown that early use of antibiotics in life leads to changes in gut microbiota that cause an increase the risk of developing Type 1 diabetes (24-25). This is also supported by literature that indicates a difference in microbial composition of children with and without Type 1 Diabetes (26). In the current study also, significantly higher percentage of children suffering from Type 1 diabetes had received antibiotics at birth as compared to non-diabetic children.

Several viruses such as enterovirus, rubella, mumps, rotavirus and cytomegalovirus have been associated with Type 1 diabetes (7-8, 27-29). Various mechanisms have been linked to the development of Type 1 Diabetes which depends on the type of virus (27,29). These involve non-immune mediated cytolytic infection leading to β-cell lysis or an immune mediated reaction. Mump, measles and rubella has been associated with type 1 diabetes as it was noted that children with mumps appear to have islet cell antibodies (27,30). Similarly, viral and bacterial infections were higher in diabetic children in our study. Neonatal jaundice has been associated with a small increase in the risk of Type 1 Diabetes. Phototherapy used for its treatment further increases the risk of developing type 1 diabetes. (30-32). We found similar results. We also observed no significant association was found between allergy and type 1 diabetes and is in line with results reported by Karavanaki et al (33).

Early nutrition is clearly the first environmental exposure to which infants are exposed. Dietary factors are critical factors that predispose or protect against Type 1 diabetes (34). Early exposure to cow's milk, cereals, fruits, berries, root vegetables and hydrolysed milk formula during weaning increase the risk of development of type 1 diabetes. (34-35). Similarly, in our study, higher percentage of diabetic children consumed cereals and fruits during weaning.

Children with Type 1 Diabetes have been reported to consume a diet that lacks in micronutrients. Their diets are nutritionally inadequate compared to children without Type 1 Diabetes. Previous studies on dietary assessment indicate that children with type 1 diabetes consume higher calories, carbohydrates, refined sugars, saturated fat and protein as compared to their counterparts and is in line with results observed in the current study. This indicates a lack of healthy eating approaches and a need to implement behaviour modification programs that promote wholesome nutrition in children with Type 1 Diabetes. (36-38).

In conclusion, the present study highlights the correlation of increased morbidity and weaning practices during infancy with the precipitation of Type 1 Diabetes in later age. A compromised nutrient adequacy was also observed in the present intake in both Type 1 diabetic and non-diabetic children. There is a felt need to strengthen awareness programs for parents towards exclusive breast feeding, correct weaning practices to prevent early childhood illness and predisposition to Type 1 diabetes.

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