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EVALUATING THE NUTRITIONAL STATE IN ADOLESCENTS AND ADULTS HAVING TYPE 1 DIABETES MELLITUS

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ABSTRACT

Background: Diabetes mellitus is a chronic condition affecting a large population globally and is associated with chronic undernutrition and obesity. It is vital to monitor the nutritional state of child subjects affected with type 1 diabetes mellitus owing to their growing age and correlation with celiac disease.

Aim: The present study was aimed at evaluating the nutritional state of child subjects having type 1 diabetes mellitus in the Indian scenario and identifying the possible risk factors responsible for undernutrition.

Methods: The study assessed child subjects with type 1 diabetes mellitus in a case-control manner where type 1 diabetics were cases compared to the healthy controls. For all the subjects, detailed history was recorded followed by clinical examination and anthropometric measures.

Results: The mean age for controls and cases were 10.2±3.75 and 8.66±3.3 years respectively. Significantly lower anthropometric measures were seen in diabetic subjects compared to the controls with $p<0.001$. The subjects comprising the undernourished group belonged to large-size families compared to the subjects from the normal nutrition group with significant differences. Disease onset age for the undernourished group was higher compared to the undernourished group with 8.81±2.87 and 6.63±2.76 years. The significant negative correlation of HbA1c was seen with BMI-z and weight for age with $p=0.005$ and 0.003 respectively.

Conclusion: The study concludes that subjects with type 1 diabetes mellitus have significantly lower anthropometric measures compared to normal subjects. Disease duration, large family size,

female gender, and old children are independent predictors for undernutrition in subjects with type 1 diabetes mellitus. A significant negative correlation is seen in the metabolic control of diabetes (HbA1c) with weight for age and BMI.

Keywords: Anthropometric measures, nutritional state, type 1 diabetes mellitus, undernutrition

INTRODUCTION

Diabetes mellitus is a chronic and non-communicable disease persisting for a lifetime and affects a large population globally including India. Diabetes mellitus has been widely correlated to chronic undernutrition and obesity. Earlier literature data has previously mentioned type 1 diabetes mellitus as one of the etiologic factors for severe retardation of growth. In India, the healthcare system is largely burdened that negatively affects the glycemic control in child subjects with type 1 diabetes mellitus.[1]

Diet plays a vital role in the management of Type 1 diabetes mellitus where the poor quality of the diet can affect the health outcomes by affecting the metabolic control. However, literature data are scarce on the quality of diet in children and adolescent subjects with diabetes mellitus.[2] Hence, it is vital to regularly assess the nutritional status of children and adolescents having type 1 diabetes mellitus as they are in the growing stage of their life and are at risk of developing malnutrition owing to the debilitating and chronic nature of the disease and its association with the celiac disease.[3]

In subjects with diabetes mellitus, growth is affected by various factors including puberty, metabolic control, disease duration, levels of growth hormone, onset age, genes, and gender of the affected subjects.[4] Nutrition in children and adolescents is explained as a disproportion in nutrition intake and demand causing the deficiency of micronutrients, energy, and proteins posing a negative impact on their normal development and growth. It is a growing concern in child subjects with diabetes mellitus and the growth factors shall be assessed during their regular follow-up.[5]

Assessment of undernutrition requires anthropometric measures including length/height and body weight and plotting them on the growth charts to compare these against the normal values. However, controversy still exists concerning the most useful measurement of these parameters in subjects with diabetes mellitus follow-up and the reproducibility of the anthropometric measures.[6] Hence, various measurements including TSFT, MUAC, mass index, height, and body weight should be assessed and combined with other clinical parameters to evaluate nutritional status in child subjects with diabetes mellitus.[7]

The present study aimed to assess the nutritional state of children and adolescents having type 1 diabetes mellitus in the Indian scenario and to identify the possible risk factors responsible for undernutrition.

MATERIALS AND METHODS

The present case-control clinical study was aimed to assess the nutritional state of children and adolescents having type 1 diabetes mellitus in an Indian scenario and to identify the possible risk

factors responsible for undernutrition. The study was done at Department of General Medicine of the institute. Written informed consent was taken from the parents of the participating subjects.

The study included child subjects with diabetes mellitus from both genders and the age range of 3 to 18 years with a minimum diabetes duration of 1 year and was on insulin treatment. The study included 168 genders and age-matched controls against 168 subjects with type 1 diabetes mellitus. The exclusion criteria for the study were subjects with type 2 diabetes mellitus, medical syndromes, inflammatory bowel diseases, hypothyroidism, celiac disease, and not willing to participate.

In all the included subjects, detailed history was recorded followed by clinical examination. The data on study subjects were gathered using the performed structured questionnaire. The questionnaire was divided into 3 types based on the age of the participating subjects preschool, school-going, and adolescents with respective age groups as <6, 6-12, and 13-18 years. The questionnaire assessed gender, family income, and family size. The family size was divided as large and small with 3 or more children and ≤ 2 children. The subjects were divided into low, medium, and high-income groups with <100,000, 100,000-250000, and >250000 INR.

Also, in subjects with diabetes, further data were collected concerning the most recent HbA1c values assessed within the last 3 months, number of ketoacidosis events during illness, diabetes duration since diabetes, and age of diabetes onset. HbA1c values were assessed using a direct enzymatic assay. The HbA1c values were assessed as good, intermediate, and poor glycemic control with HbA1c values of <7.5%, 7.5% to 9%, and >9% following the criteria of the International Society of Pediatric and Adolescent Diabetes website.

All subjects were assessed for general and systemic assessment of anthropometric parameters including MUAC (mid-upper arm circumference), TSFT (triceps skin fold thickness), BMI (body mass index), height, and weight. To assess their height and weight, participants were asked to wear no shoes and only light clothes. A manual scale was used to measure weight with arms extending to the side of the body and back straight. Stadiometer with 0.1cm precision was used to assess height.

BMI was assessed by dividing the weight in kilograms by the square of height in meters. MUAC was assessed with Gulick tape and 0.5 cm accuracy following NHANES (National Health and Nutrition Examination Survey).

Also, the thickness of triceps skin folds was assessed just below the shoulder blades in a horizontal grip, at stomach level in an oblique grip, and above the triceps muscle of the upper arm vertical grip. The test was repeated thrice in each location, and the average was assessed from the measurements. Growth parameters were converted to z scores and corrected for age. Z scores were used as they allow better accuracy to express anthropometric status compared to conventional placement "below" or "near" a certain percentile curve. Normal measures were within 2 standard deviations from the mean, whereas, more than 2 standard deviations depicted malnutrition.

The data gathered were assessed statistically using SPSS software version 25.0 (SPSS, Chicago, USA) with student t-test, Chi-square test, and Mann-Whitney U test. The data were expressed as mean and standard deviation. The correlation was assessed using Pearson's correlation. The p-value of <0.05 was considered a significance level.

RESULTS

The present case-control clinical study was aimed to assess the nutritional state of children and adolescents having type 1 diabetes mellitus in an Indian scenario and to identify the possible risk factors responsible for undernutrition. The study included 168 genders and age-matched controls against 168 subjects with type 1 diabetes mellitus. On comparing the anthropometric parameters in cases and controls, it was seen that mean z scores for triceps skinfold thickness for controls was significantly higher compared to cases with 0.62±1.13 and 0.53±0.92 respectively, and p<0.001. For MUAC, z scores were 1.55±2.36 and -1.51±1.35 respectively for controls and cases which was a statistically significant difference with p<0.001. BMI z scores were significantly higher for controls with 2.17±0.94 compared to 0.11±1.0 for cases (p<0.001). Height z scores were also significantly higher for controls compared to cases with p<0.001. Weight z had no significant difference in controls and cases with p=0.26 as shown in Table 1.

On assessing the association of clinical and demographic data in study subjects to BMI z scores, it was seen that the majority of the undernourished as well as normally nourished subjects had HbA1c of >9 with 55.5% (n=20) and 63.6% (n=84) study subjects respectively followed by 7.5-9 % HbA1c in 33.3% (n=12) and 24.2% (n=32) study subjects respectively showing a non-significant difference with p=0.71. For the number of diabetic ketoacidosis episodes, the majority of undernourished as well as normal nourished subjects had 0-2 episodes with 88.8% (n=32) and 78.7% (n=104) study subjects showing non-significant difference with p=0.12. Disease duration showed a non-significant difference in undernourished and normally nourished study subjects with p=0.13. The mean age of disease onset was significantly higher in undernourished study subjects at 8.81±2.87 years compared to normally nourished study subjects at 6.63±2.76 years with p=0.004. All the undernourished subjects were from large families, whereas, 75.7% (n=100) subjects were from large families which was a significant difference with p=0.03. No significant difference was seen for income group and gender for undernourished and normally nourished subjects with p=0.17 and 0.13 respectively. There were 55.5% (n=20) undernourished adolescents and 19.7% (n=26) normal-nourished adolescents, 33.3% (n=12) undernourished and 71.2% (n=94) normal nourished school going subjects, and 11.1% (n=4) and 9.09% (n=12) preschool subjects. The difference was statistically significant with p=0.006 (Table 2).

Concerning the correlation of growth parameters to HbA1c and disease duration, it was seen that z scores for Triceps skinfold thickness, with HbA1c and disease duration, the correlation was -0.104 and 0.139 and respective p-values were 0.15 and 0.203 showing a non-significant correlation. MUAC z scores had correlation values for HbA1c and disease duration as -0.104 and 0.143 which was non-significant with p=0.35 and 0.17 respectively. BMI z scores had correlation values of 0.043 and -0.293 respectively for HbA1c and disease duration and p-values of 0.66 and

0.007 showing a significant association of BMI with disease duration. Height z scores had correlation values of -0.022 and -0.162 respectively for HbA1c and disease duration which was non-significant with p=0.83 and 0.11. Weight z scores had a correlation value of 0.105 and -0.310 where a significant association was seen in weight for age and disease duration (Table 3).

On predicting the factors for undernutrition in child subjects with type 1 diabetes mellitus based on BMI, significant results were seen for larger disease duration, larger family size, gender, and age with respective p-values of 0.03, 0.01, 0.03, and 0.2 as depicted in Table 4.

DISCUSSION

The present study included 168 genders and age-matched controls against 168 subjects with type 1 diabetes mellitus. On comparing the anthropometric parameters in cases and controls, it was seen that mean z scores for triceps skinfold thickness for controls was significantly higher compared to cases with 0.62±1.13 and 0.53±0.92 respectively, and p<0.001. For MUAC, z scores were 1.55±2.36 and -1.51±1.35 respectively for controls and cases which was a statistically significant difference with p<0.001. BMI z scores were significantly higher for controls with 2.17±0.94 compared to 0.11±1.0 for cases (p<0.001). Height z scores were also significantly higher for controls compared to cases with p<0.001. Weight z had no significant difference in controls and cases with p=0.26. These data were similar to studies of Aljuhani FM et al[8] in 2018 and Cole TJ[9] in 2007 where authors assessed subjects with comparable anthropometric measures as in the present study.

The study results showed that for the association of clinical and demographic data in study subjects to BMI z scores, it was seen that the majority of the undernourished as well as normally nourished subjects had HbA1c of >9 with 55.5% (n=20) and 63.6% (n=84) study subjects respectively followed by 7.5-9 % HbA1c in 33.3% (n=12) and 24.2% (n=32) study subjects respectively showing a non-significant difference with p=0.71. For the number of diabetic ketoacidosis episodes, the majority of undernourished as well as normal nourished subjects had 0-2 episodes with 88.8% (n=32) and 78.7% (n=104) study subjects showing non-significant difference with p=0.12. Disease duration showed a non-significant difference in undernourished and normally nourished study subjects with p=0.13. The mean age of disease onset was significantly higher in undernourished study subjects at 8.81±2.87 years compared to normally nourished study subjects at 6.63±2.76 years with p=0.004. All the undernourished subjects were from large families, whereas, 75.7% (n=100) subjects were from large families which was a significant difference with p=0.03. No significant difference was seen for income group and gender for undernourished and normally nourished subjects with p=0.17 and 0.13 respectively. There were 55.5% (n=20) undernourished adolescents and 19.7% (n=26) normal-nourished adolescents, 33.3% (n=12) undernourished and 71.2% (n=94) normal nourished school going subjects, and 11.1% (n=4) and 9.09% (n=12) preschool subjects. The difference was statistically significant with p=0.006. These results were consistent with the previous studies of Galli-Tsinopoulou A et al[10] in 2009 and Bonfig

W et al[11] in 2012 where authors reported a similar association of clinical and demographic data in subjects with type 1 diabetes Mellitus as in the present study.

It was seen that concerning the correlation of growth parameters to HbA1c and disease duration, it was seen that z scores for Triceps skinfold thickness, with HbA1c and disease duration, the correlation was -0.104 and 0.139 and respective p-values were 0.15 and 0.203 showing a non-significant correlation. MUAC z scores had correlation values for HbA1c and disease duration as -0.104 and 0.143 which was non-significant with p=0.35 and 0.17 respectively. BMI z scores had correlation values of 0.043 and -0.293 respectively for HbA1c and disease duration and p-values of 0.66 and 0.007 showing a significant association of BMI with disease duration. Height z scores had correlation values of -0.022 and -0.162 respectively for HbA1c and disease duration which was non-significant with p=0.83 and 0.11. Weight z scores had a correlation value of 0.105 and -0.310 where a significant association was seen in weight for age and disease duration. These findings were in agreement with the findings of Hassan NE et al[12] in 2014 and Mousa WI et al[13] in 2021 where authors a comparable correlation of growth parameters to HbA1c and disease duration in their respective studies.

On predicting the factors for undernutrition in child subjects with type 1 diabetes mellitus based on BMI, significant results were seen for larger disease duration, larger family size, gender, and age with respective p-values of 0.03, 0.01, 0.03, and 0.2. These results were in line with the findings of Khalidkar VV et al[14] in 2013 and Grabia M et al[15] in 2021 where similar results were reported by authors in their studies.

CONCLUSION

Considering its limitations, the present study concludes that subjects with type 1 diabetes mellitus have significantly lower anthropometric measures compared to normal subjects. Disease duration, large family size, female gender, and old children are independent predictors for undernutrition in subjects with type 1 diabetes mellitus. A significant negative correlation is seen in the metabolic control of diabetes (HbA1c) with weight for age and BMI.

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Variables	**HbA1c**		**Disease duration**	
	Correlation	**p-value**	**Correlation**	**p-value**
Weight for age (z score)	0.105	0.31	-0.310	**0.003**

Parameters	Controls (n=168)	Cases (n=168)	p-value	
Triceps skinfold thickness (z score)	0.62±1.13	0.53±0.92	**<0.001**	
Mid-upper arm circumference (z score)	1.55±2.36	-1.51±1.35	**<0.001**	
BMI for age (z score)	2.17±0.94	0.11±1.0	**<0.001**	
Height for age (z score)	0.25±1.1	-0.64±1.27	**<0.001**	
Weight for age (z score)	0.64±1.21	-0.26±0.11	0.26	
Variables	HbA1c		Disease duration	
	Correlation	p-value	Correlation	p-value
Weight for age (z score)	0.105	0.31	-0.310	**0.003**

Table 1: Comparison of anthropometric parameters in controls and subjects with type 1 Diabetes Mellitus in the present study

S. No	Parameters	Undernourished (n=36)	Normal (n=132)	p-value
1.	**HbA1c (%)**			
a)	<7.5	4 (11.1)	16 (12.1)	0.71
b)	7.5-9	12 (33.3)	32 (24.2)	
c)	>9	20 (55.5)	84 (63.6)	
2.	**Diabetic ketoacidosis (number)**			
a)	0-2	32 (88.8)	104 (78.7)	0.12
b)	3-5	4 (11.1)	20 (15.1)	
c)	6-8	0	8 (6.06)	
3.	**Disease duration (years)**			
a)	<5	32 (88.8)	96 (72.7)	0.13
b)	≥5	4 (11.1)	36 (27.2)	
4.	**Mean age at onset (years)**	8.81±2.87	6.63±2.76	0.004
5.	**Family size**			
a)	Small	0	32 (24.2)	0.03
b)	Large	36 (100)	100 (75.7)	
6.	**Income**			
a)	Low	20 (55.5)	44 (33.3)	0.17
b)	Medium	16 (44.4)	84 (63.6)	
c)	High	0	4 (3.03)	
7.	**Gender**			
a)	Males	8 (22.2)	56 (42.4)	0.13
b)	Females	28 (77.7)	76 (57.5)	
8.	**Age (years)**			
a)	Preschool	4 (11.1)	12 (9.09)	**0.006**

b)	School going	12 (33.3)	94 (71.2)	
c)	Adolescent	20 (55.5)	26 (19.7)	

Table 2: Association of clinical and demographic data in study subjects to BMI Z scores

S. No	Variables	HbA1c		Disease duration	
		Correlation	p-value	Correlation	p-value
1.	**Triceps skinfold thickness (z score)**	-0.104	0.15	0.139	0.203
2.	**Mid-upper arm circumference (z score)**	-0.104	0.35	0.143	0.17
3.	**BMI for age (z score)**	0.043	0.66	-0.293	**0.007**
4.	**Height for age (z score)**	-0.022	0.83	-0.162	0.11
5.	**Weight for age (z score)**	0.105	0.31	-0.310	**0.003**

Table 3: Correlation of growth parameters to HbA1c and disease duration

S. No	Parameters	Odd's ratio	95% CI	p-value
1.	**Diabetic ketoacidosis (number)**			
a)	0-2	8.0		0.12
b)	3-5	0.86	0.14-2.63	**0.**25
c)	6-8	0.65	0.24-4.34	0.45
2.	**Disease duration (years)**			
a)	<5	1.0	1.16-19.65	**0.03**
b)	≥5	2.6		
3.	**Family size**			
a)	Small	1.0	1.21-22.96	**0.01**
b)	Large	3.24		
4.	**Gender**			
a)	Males	1.0	1.06-28.43	**0.03**
b)	Females	2.4		
5.	**Age (years)**			
a)	Preschool	1.0		**0.03**
b)	School going	0.44	0.14-0.89	**0.02**
c)	Adolescent	3.15	1.12-32.52	**0.01**

Table 4: Predicting factors for undernutrition in child subjects with type 1 diabetes mellitus based on BMI