



Original Research Article

ROLE OF ADHERENCE TO DIETARY AND EXERCISE RECOMMENDATIONS IN DIABETIC CONTROL OF TYPE 1 DIABETES MELLITUS CHILDREN: A CROSS-SECTIONAL STUDY IN A TERTIARY CARE CENTRE

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ABSTRACT

Background: Children affected by Type 1 Diabetes Mellitus (T1DM) need management throughout life, involving physical activity and diet control, which are crucial determinants in achieving glycemic control. In spite of well-established guidelines, compliance with such lifestyle modifications is not followed by many, particularly in developing countries like India. This study aimed to evaluate the effect of adherence to dietary and physical activity patterns on glycemic control in T1DM children.

Materials and Methods: A prospective, hospital-based, cross-sectional study was performed in 46 T1DM children aged 4-18 years visiting a tertiary care hospital, after obtaining Ethical committee approval. Physical activity was assessed by WHO recommendations (>60 minutes/day), and dietary adherence was evaluated by ISPAD 2022 guidelines. HbA1c values were used to evaluate glycemic control. Statistical tests employed were chi-square test and independent t-test, with p-value <0.05 considered statistically significant.

Results: Among the 46 children, 56.5% (n=26) were females. Mean age was 11.8 + 4.1 years, and mean HbA1c was 9.4 + 2.5%, suggesting suboptimal glycemic control. Around 52.2% (n=24) of children were adherent to physical activity recommendations, and only 17.4% (n=8) were fully adherent to dietary guidelines. Children adherent to physical activity guidelines demonstrated better glycemic control (HbA1c 8.1 + 1.6%) when compared to non-adherent children (HbA1c 9.9 + 2.6%, p = 0.008). Children who were fully adherent to diet had significantly lesser HbA1c values (7.1 + 1.1%) than children who were non-adherent to diet (8.1 + 1.6% vs 9.9 + 2.6%, p = 0.001). Combined adherence yielded the best outcomes.

Conclusion: Adherence to physical activity & dietary recommendations substantially enhances glycemic control. Integrated lifestyle-based interventions should be emphasized in pediatric diabetes care.

Keywords: Adherence, Diet, HbA1c, ISPAD, Physical Activity, Type 1 Diabetes Mellitus.

INTRODUCTION

Type 1 Diabetes Mellitus (T1DM) is a chronic autoimmune disease that occurs due to pancreatic β -cells destruction through autoimmune-mediated mechanisms. It is among the most prevalent endocrine diseases that occur in children and adolescents in most countries worldwide, and its

prevalence is on the increase in both developed and developing nations.^[1] The growing global prevalence of T1DM has become a major challenge to health care systems, especially in resource-constrained environments.

In India, the disease burden of T1DM is high, but there is a lack of in-depth epidemiological data since no nationwide registry has been formed yet.^[2]

Regional research indicates a high degree of incidence and prevalence fluctuations in the form of genetic predisposition, environmental exposures and access to healthcare. Moreover, delayed diagnosis and low awareness levels usually lead to poor disease outcomes, such as early development of complications and high mortality.

T1DM is a complex disease that needs to be managed through a holistic approach, which includes insulin use, physical activity and diet control. Although insulin is still the backbone of treatment, lifestyle changes are important to ensure the best glycemic control and avoidance of complications. Medical nutrition therapy (MNT) is one of them, and it is regarded as one of the key pillars of managing diabetes.^[3] MNT helps not only in glycemic control but also in the proper growth and development of children.

The International Society of Paediatric and Adolescent Diabetes (ISPAD) offers evidence-based dietary recommendations in children with T1DM, with balanced distribution of carbohydrates 45-55%, fats 30-35%, and proteins 15-20% of the total energy intake each day.^[4] These guidelines focus on healthy eating habits and not on restricting diets, providing flexibility to meet cultural and personal choices. Nevertheless, compliance with these principles in practice is a major problem.

It has been reported that a significant percentage of children with T1DM fail to follow dietary guidelines, resulting in poor glycemic control.^[5] Dietary adherence has multifactorial influences that encompass socioeconomic status, parental education, access to dietary counselling, cultural food habits, and psychosocial influences.^[6] The patterns of diet in most Indian families are mostly carbohydrate-based, and this might attribute to variability in glycemic levels and the inability to bring the levels to optimal control levels.

Another important aspect of diabetes management is physical activity. It has also been discovered that regular exercise can increase insulin sensitivity, decrease glucose uptake, and decrease the chances of developing long-term complications.^[7] World Health Organization (WHO) suggests that children and adolescents should be involved in at least 60 minutes of moderate-to-vigorous physical activity each day.^[8] Although these are the recommendations, most children with T1DM do not engage in sufficient physical exercise because of the obstacles, such as fear of hypoglycemia, unstructured exercise programs, and the unhealthy habits of a sedentary lifestyle.

Past studies have shown that dietary and physical activity recommendations are independent predictors of better glycemic control.^[9] Nevertheless, limited evidence has been gathered to assess their impact, especially in children in developing nations. T1DM children also have difficulties in following lifestyle recommendations, such as reliance on caregivers, school environment factors, and psychosocial factors.^[10]

Moreover, adolescence is a highly susceptible stage, as it is a time of behavioural changes, peer pressure, and lack of parental control, which can adversely affect adherence. The growing accessibility of processed foods and the growing popularity of sedentary lifestyles also make it more difficult to manage diabetes among the population of this age group.

In light of these challenges, it is important to know how modifiable lifestyle factors can be used to achieve optimal glycemic control. Determining adherence gaps and their influence on metabolic outcomes can be used to develop specific interventions to improve the management of the disease. Indian contexts have limited evidence that evaluates the combined impact of adherence to dietary and physical activity recommendations on glycemic control in children with T1DM. Hence, this study aims to assess the prevalence of dietary and exercise adherence among children diagnosed with type 1 diabetes mellitus and to evaluate the effect of adherence to dietary and physical activity patterns on glycemic control.

MATERIALS AND METHODS

Study Design, Setting and Period: This prospective, hospital-based, cross-sectional study was conducted in the Department of Paediatric Endocrinology at R.L. Jalappa Hospital, Kolar. The study was conducted over a period of two months from March 2026 to April 2026.

Study Population (Inclusion and exclusion criteria): The study included children aged 4-18 years who had been diagnosed with Type 1 Diabetes mellitus for more than 6 months and followed up in the study setting. Children with diabetic ketoacidosis, symptomatic hypoglycemia, and those with acute illnesses that could hamper data collection were excluded from the study.

Sampling Technique and Sample Size: A convenience sampling technique was used in this study.

Based on the study by Kyokunzire et al, the prevalence of adherence to dietary recommendations among children with type 1 diabetes mellitus was 29%. Considering it as a prevalence with a 95% confidence interval, the allowable error of 13%, the sample size is calculated as,

$$n = \frac{(Z_{\alpha/2})^2 pq}{d^2}$$
$$n = \frac{(1.96)^2 * 29 * 71}{13 * 13} = 46$$

$$n \approx 46$$

Hence, the number of participants was 46 children.

In this formula,

$Z_{\alpha/2}$ = standard normal variate for a 5% significance level = 1.96

p = prevalence (based on existing literature) = 29%

q = 100-p = 71%

d = absolute precision = 13%

Procedure: Children affected by Type 1 Diabetes mellitus attending the Department of Paediatric Endocrinology at R.L. Jalappa Hospital, Kolar, were included after applying the inclusion and exclusion criteria. Participants were recruited by convenience sampling technique until the required sample size was achieved.

After obtaining written informed consent from the parents of the children, data were collected by use of a pre-tested, structured questionnaire comprising questions related to socio-demographic characteristics, duration of type 1 diabetes mellitus, physical activity. Dietary history was assessed using the 24-hour recall method, and adherence was evaluated using ISPAD 2022 guidelines. Adherence to physical activity was assessed by the WHO recommendation guidelines (≥ 60 minutes/day). Anthropometric measurements, such as height and weight, were measured to calculate the body mass index of children (BMI). HbA1c levels were measured to assess glycemic control.

Outcome Measures

- Prevalence of dietary and physical activity adherence among children with Type 1 Diabetes mellitus (T1DM)

- Effect of dietary and physical activity adherence on glycemic control among T1DM children

Statistical Analysis: The collected data were entered in a Microsoft Excel sheet and analyzed using IBM-SPSS software version 22.0. The qualitative variables were expressed in frequency & percentage, and the quantitative variables were expressed as mean & standard deviation. Chi-square test and independent t-test were used to find out the statistical significance between variables. A p-value less than 0.05 were considered statistically significant.

Ethical Considerations: Ethical Committee approval was obtained from the Institutional Ethics Committee (IEC) of Sri Devaraj Urs Medical College before the commencement of the study. Written informed consent was obtained from parents of all participants regarding the procedure and the use of their data for research. The study adhered to ethical standards, maintaining confidentiality.

RESULTS

Overall, 46 children with Type 1 Diabetes mellitus were included in the study.

Table 1: Characteristics of children (N = 46)

Characteristics	No. of children (N = 46)
Mean age (years)	11.8 ± 4.1
Males	20 (43.5%)
Females	26 (56.5%)
Mean duration of T1DM (years)	3.2 ± 1.9
Mean HbA1c (%)	9.4 ± 2.5
Mean BMI (kg/m ²)	21.4 ± 4.2

The socio-demographic profile of the children is summarized in [Table 1]. The mean age of children was 11.8 ± 4.1 years. Gender distribution showed 20 males (43.5%) and 26 females (56.5%). The mean duration of type 1 diabetes mellitus (T1DM) was 3.2 ± 1.9 years, while the mean HbA1c was 9.4 ± 2.5%, indicating suboptimal glycemic control in these children. The mean & SD of BMI among children were found to be 21.4 ± 4.2 kg/m².

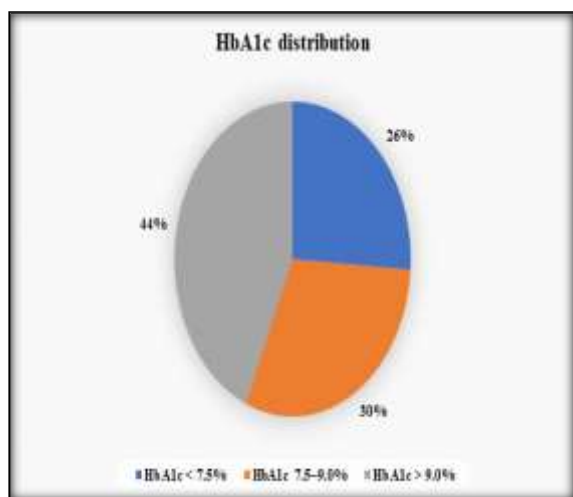


Figure 1: Distribution of HbA1c levels (N = 46)

The distribution of HbA1c levels among the children was illustrated in [Figure 1]. Around 26% (n=12) of children had HbA1c < 7.5%, 30% (n=14) had HbA1c between 7.5–9.0%, and 44% (n=20) had HbA1c > 9.0%, highlighting that nearly half of the children exhibited markedly elevated HbA1c levels. The distribution of adherence of children to dietary recommendations (ISPAD 2022) is demonstrated in [Table 2]. Children fully adherent to ISPAD 2022 dietary recommendations (8/46; 17.4%) had a mean HbA1c of 7.1 ± 1.1%, whereas non-adherent children (38/46; 82.6%) showed markedly higher HbA1c at 10.1 ± 2.4%, with the difference reaching statistical significance (p = 0.001).

The distribution of adherence of children to physical activity recommendations (WHO) is demonstrated in [Table 3]. Around 24 children (52.2%) met WHO recommendations for physical activity (≥ 60 min/day), while 22 (47.8%) had insufficient activity. Mean daily activity time was significantly higher in the adherent group (68.4 ± 8.2 min) compared to the insufficient group (31.5 ± 12.7 min, p = 0.001). Correspondingly, mean HbA1c was lower among adherent children (8.1 ± 1.6%) versus those with insufficient activity (9.9 ± 2.6%, p = 0.008), indicating better glycemic control with adequate physical activity.

Table 2: Adherence to Dietary Recommendations (ISPAD 2022) (N = 46)

	Fully adherent	Non-adherent	p-value
No of Children	8 (17.4%)	38 (41.3%)	-
Mean HbA1c (%)	7.1 ± 1.1	10.1 ± 2.4	0.001*

Table 3: Adherence to Physical Activity Recommendations (WHO) (N = 46)

	Adherent (≥60 min/day)	Insufficient activity	p-value
No of Children	24 (52.2%)	22 (47.8%)	-
Mean daily activity time (min)	68.4 ± 8.2	31.5 ± 12.7	0.001*
Mean HbA1c (%)	8.1 ± 1.6	9.9 ± 2.6	0.008*

Table 4: Combined Effect of Diet + Physical Activity Adherence (N = 46)

Group	n (%)	Mean HbA1c (%)	p-value
Both adherent	7 (15.2%)	6.8 ± 0.9	0.001*
Only physical activity adherent	17 (36.9%)	8.4 ± 1.5	
Only diet adherent	1 (2.1%)	8.0	
Neither adherent	21 (45.6%)	10.4 ± 2.3	

The distribution of combined adherence to diet and physical activity recommendations is exhibited in [Table 4]. Participants adherent to both diet and physical activity (7/46; 15.2%) demonstrated the lowest mean HbA1c at 6.8 ± 0.9%, with a statistically significant difference (p = 0.001). That adherent only to physical activity (17/46; 36.9%)

had a higher mean HbA1c of 8.4 ± 1.5%, while the single participant adherent only to diet (1/46; 2.1%) showed HbA1c of 8.0%. The largest subgroup, neither adherent (21/46; 45.6%), exhibited the poorest glycemic control with a mean HbA1c of 10.4 ± 2.3%.

Table 5: Macronutrient status among children (N = 46)

Macronutrient	Adequate n (%)	Deficient n (%)	Excess n (%)
Carbohydrate	25 (54%)	8 (17%)	13 (28%)
Fat	16 (35%)	17 (37%)	13 (28%)
Protein	28 (61%)	15 (33%)	3 (7%)

The distribution of macronutrient intake among the children is shown in [Table 5]. Among 46 children, carbohydrate intake was adequate in 25 children (54%), deficient in 8 (17%), and excessive in 13 (28%) children. Fat intake was adequate in 16 children (35%), deficient in 17 (37%), and excessive in 13 children (28%). Protein intake showed adequacy in 28 children (61%), deficiency in 15 (33%), and excess in only 3 children (7%).

DISCUSSION

The current research paper emphasizes the importance of adherence to dietary and physical activity guidelines to attain optimal glycemic control in T1DM children. The results indicate that combined & individual compliance to such lifestyle variables are strongly correlated with better metabolic outcomes.

The mean HbA1c of the study was 9.4%, suggesting that the participants didn't have optimal glycemic control. This result is in line with other studies related to paediatrics that have indicated a challenge in attaining target glycemic levels regardless of the evolution of insulin therapy.^[11] Children with poor glycemic control are of concern since they are prone to acute complications like hypoglycemia and diabetic ketoacidosis, and long-term microvascular and macrovascular complications.

In the current study, dietary adherence was quite poor, with only 17.4% (n=8) of the participants adhering to the ISPAD 2022 recommendations. This is a serious disparity in providing diabetes care and can be compared to the results of the past research, where the adherence rate was 30-50%.^[12] The reduced adherence in this research can be explained by the following factors like lack of access to dietary counselling, socioeconomic status and cultural food habits that promote consumption of high-carbohydrate foods.^[13]

Notably, the children adherent to dietary guidelines showed much lower levels of HbA1c than their non-adherent counterparts. This observation highlights the significance of balanced nutrition in achieving glycemic control. The proper intake of macronutrients is beneficial to regulate blood glucose levels and to appropriately dose insulin.^[14] Moreover, dietary reduction of saturated fat consumption and increased protein intake has proven to enhance insulin sensitivity and general metabolic well-being.^[15]

The adherence to physical activity was relatively good, and over half of the participants were adherent to the WHO guidelines. Children who practiced sufficient physical activity had much better glycemic control. This aligns with past research findings that documented how exercise can positively affect the metabolism of glucose and insulin sensitivity.^[16] Exercising regularly improves

skeletal muscle uptake of glucose and decreases insulin resistance, thus providing optimal glycemic outcomes.

Nevertheless, even with the known benefits, a significant number of children in this study failed to comply with the recommendations regarding physical activity. Fear of hypoglycemia due to exercise, low awareness levels, and absence of organized physical exercise opportunities may be some of the barriers. Other studies have also reported similar findings in which physical inactivity was found to be a big challenge in the management of diabetes.^[17]

The synergistic nature of compliance with both dietary and physical activity recommendations is one of the key results of this study. Children who complied with both interventions had the lowest levels of HbA1c, whereas children who were not compliant with either intervention had the least glycemic control. This also underscores the significance of a comprehensive approach to the management of diabetes, where various lifestyle issues are treated concomitantly. Past research has also highlighted the fact that combined lifestyle interventions are more effective than isolated ones.^[18]

The macronutrient analysis in this research found imbalances in the intake of food, with patterns of high carbohydrate intake and fluctuating fat intake. These feeding habits are typical of Indian communities and can lead to inadequate glycemic control.^[19] Moreover, consumption of processed and high-fat foods has also been linked to poor metabolic effects, such as insulin resistance and dyslipidaemia.^[20]

Psychosocial determinants are important factors in establishing compliance with lifestyle recommendations. Determinants of successful diabetes management are family support, parental involvement, and patient motivation. It has been demonstrated that children who have supportive family backgrounds have higher chances of adhering to treatment regimes and attaining improved glycemic control.^[21] On the other hand, adherence can be adversely affected by a family conflict and the absence of supervision.

Adolescents are a high-risk group as they are more prone to poor adherence as a result of both behavioural and psychological factors. Young people can be influenced by their peers, will to become independent, and engage in risky activities, resulting in avoidance of adherence to physical activity and dietary guidelines.^[22] Thus, specific interventions targeted to mitigate these factors are needed to enhance the results in this age group.

The results of this research underscore the importance of multidisciplinary management of diabetes. Paediatricians, dieticians, and diabetes educators are healthcare providers who are critical in advocating adherence by use of regular counselling and education. Diabetes education programs have been demonstrated to enhance

knowledge, self-management behaviours, and glycemic results.^[23]

Healthy lifestyle behaviours among children with T1DM can also be enhanced through community-based interventions, such as school health programs. Schools offer a significant avenue through which physical activities can be encouraged, and the promotion of adopting proper diets can be advised.^[24] Also, technology, including mobile health applications and continuous glucose monitoring systems, provides new possibilities to improve self-management and adherence.^[25]

Overall, the results of this research support the significance of lifestyle changes as a critical component of diabetes management. Although insulin therapy is still crucial, optimal glycemic control is not possible without the proper consideration of diet and physical activity.

Strengths and Limitations:

Strengths: The current research offers a valuable understanding of the synergistic effect of dietary and physical activity adherence on glycemic control among children with T1DM. The validity and comparability of the results are improved by the use of standardized guidelines like ISPAD and WHO. HbA1c is an objective measure of glycemic control that enhances the accuracy of the results. Also, assessing diet and physical activity conditions collectively offers a more in-depth overview of lifestyle determinants of diabetes management.

Limitations: Regardless of its merits, the study has some limitations. The sample was rather small, which can restrict the generalization of the results. The study is a single-centre study, so the results might not be generalized to the larger population. The cross-sectional design does not allow causality to be established between adherence and glycemic control. A 24-hour recall method of dietary assessment can be vulnerable to recall bias and may not be a true reflection of long-term dietary practices. Moreover, no in-depth discussion of psychosocial factors that affect adherence was conducted.

CONCLUSION

The current research shows that adherence to dietary and physical activity guidelines are key to the attainment of optimal glycemic control in T1DM children. Participants with adherence to dietary and physical activity measures had significantly lower levels of HbA1c than non-adherent children, demonstrating the significance of combined lifestyle changes.

These results highlight the importance of reinforcement of non-pharmacological interventions in the management of diabetes, such as routine counselling, structured education programs, and involvement of family members. Although it is likely that future studies will be based on large-scale multicentric studies and intervention-based methods,

it is necessary to enhance adherence and long-term outcomes.

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