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Comparative Analysis of Physical Activity in Type 1 Diabetic and Healthy Youth: Influence of Insulin Administration

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ABSTRACT
Physical activity is essential for the overall health and well-being of youth, yet maintaining an active lifestyle can be challenging for those with Type 1 Diabetes Mellitus (T1DM) due to the complexities of managing blood glucose levels. This study aims to compare the physical activity levels between youth with T1DM and their healthy peers and to evaluate the impact of different insulin administration methods on physical activity.
A cross-sectional comparative study was conducted with 60 participants aged 10-18 years, including 30 individuals with T1DM and 30 age-and sex-matched healthy controls. Participants were recruited from a tertiary care center and local schools in rural India. Physical activity was measured using Acti Graph GT3X+ accelerometers worn for seven consecutive days. Barriers and facilitators to physical activity in T1DM youth were assessed through a structured questionnaire. Data were analyzed using SPSS version 25.0, with independent t-tests and chi-square tests to compare groups. T1DM youth had significantly lower total physical activity (65.4± 20.3 min/day) compared to healthy controls (82.7±22.1 min/day, p= 0.02). Moderate-to-vigorous physical activity (MVPA) was also lower in the T1DM group (35.2±15.6 min/day) than in the controls (45.9±18.2 min/day, p=0.03). Sedentary time was higher in the T1DM group (420.7 ±60.5 min/day) compared to the healthy controls (380.3 ± 55.4 min/day, p=0.04). No significant differences in physical activity levels were observed between T1DM youth using insulin pumps and those using multiple injections. Fear of hypoglycemia (60%), lack of time (33.3%) and lack of motivation (26.7%) were the most common barriers to physical activity, while family support (66.7%) and healthcare provider support (60%) were key facilitators. Youth with T1DM engage in less physical activity and more sedentary behavior compared to their healthy peers. The method of insulin administration does not significantly impact physical activity levels. Interventions to increase physical activity in T1DM youth should address barriers such as fear of hypoglycemia and leverage facilitators like family and healthcare provider support.

INTRODUCTION

Physical activity is a crucial component of a healthy lifestyle, contributing significantly to the physical and mental well-being of individuals across all age groups. For youth, regular physical activity promotes healthy growth and development, reduces the risk of chronic diseases and enhances psychological health[1]. However, for youth living with Type 1 Diabetes Mellitus (T1DM), maintaining an active lifestyle can be particularly challenging due to the need for meticulous management of blood glucose levels, which can be influenced by exercise[2]. Type 1 Diabetes Mellitus is an autoimmune condition characterized by the destruction of insulin-producing beta cells in the pancreas, resulting in lifelong dependency on exogenous insulin for survival. Managing T1DM requires a balance between insulin administration, dietary intake, and physical activity to maintain optimal blood glucose levels. Physical activity, while beneficial in managing T1DM, poses unique challenges due to the risk of exercise-induced hypoglycemia and the complex interplay between insulin, diet and exercise[3-4]. The prevalence of T1DM among youth varies globally, with the highest incidence rates reported in Finland and Sardinia and increasing trends observed in many countries, including the United States and parts of Europe. According to the International Diabetes Federation (IDF), approximately 1.1 million children and adolescents under the age of 20 live with T1DM globally[5-6]. This increasing prevalence underscores the importance of understanding the factors influencing physical activity in this population to improve their quality of life and health outcomes[7]. Previous studies have highlighted that youth with T1DM tend to engage in lower levels of physical activity compared to their healthy peers. For instance, a study by Valerio[8]. (2017) reported that children with T1DM had significantly lower levels of moderate-to-vigorous physical activity and higher sedentary time compared to non-diabetic controls. Factors contributing to reduced physical activity in T1DM youth include fear of hypoglycemia, lack of time, and insufficient knowledge on managing diabetes during exercise. Moreover, the type of insulin administration, whether via insulin pumps or multiple daily injections, may also influence physical activity levels, though findings have been inconclusive[9]. Understanding the physical activity patterns in youth with T1DM compared to their healthy peers is critical for developing targeted interventions to promote an active lifestyle in this population. Additionally, evaluating the impact of different insulin administration methods on physical activity can provide insights into optimizing diabetes management strategies to support physical activity. This study aims to compare the physical activity levels between youth with T1DM and healthy controls and to explore the influence of insulin administration methods on physical activity in T1DM youth. Furthermore, identifying barriers and facilitators to physical activity in T1DM youth can inform the design of supportive interventions to enhance their physical activity participation.

Aims and Objectives: To compare the levels of physical activity in children and adolescents with Type 1 Diabetes to their healthy counterparts and to evaluate the impact of different insulin therapy methods on these activity levels.

- To assess and compare the physical activity levels in children and adolescents with Type 1 Diabetes and healthy controls.
- To examine the influence of different insulin therapy methods (e.g., insulin pump vs. multiple daily injections) on physical activity levels in children and adolescents with Type 1 Diabetes.
- To identify barriers and facilitators to physical activity in children and adolescents with Type 1 Diabetes.

MATERIALS AND METHODS

Study Design and Participants: This was a cross-sectional comparative study conducted to analyze physical activity levels in youth with Type 1 Diabetes (T1D) and healthy controls. The study included 60 participants aged 10-18 years, with 30 individuals diagnosed with T1D and 30 age-and sex-matched healthy controls. The participants were recruited from tertiary care centre and local schools in rural India.

Study Timeline: The study was conducted over a period of six months, from Aug 2022 to Jul 2023.

Inclusion Criteria:

- Type 1 Diabetes Group: Diagnosed with T1D for at least one year, aged 10-18 years, and under regular follow-up at a tertiary care centre.
- Healthy Controls: Age- and sex-matched healthy individuals with no chronic illnesses.

Exclusion Criteria:

- Participants with other chronic conditions affecting physical activity.
- Individuals with physical disabilities that limit exercise.
- Non-consent to participate in the study.

Ethical Considerations: The study was approved by the Institutional Ethics Committee of tertiary care centre. Informed consent was obtained from the participants and their parents/guardians prior to enrollment.

Data Collection

Baseline Characteristics: Demographic and clinical data, including age, gender, BMI and duration of diabetes, were collected through medical records and interviews. For T1D participants, information on the method of insulin therapy (pump or multiple injections) was also documented.

Physical Activity Measurement: Physical activity levels were assessed using the Acti Graph GT3X+ accelerometer, which participants wore on their waist for seven consecutive days during waking hours, except during water-based activities. The device recorded total physical activity (minutes/day), moderate-to-vigorous physical activity (MVPA, minutes/day), and sedentary time (minutes/day). Data were analyzed using Acti Life software according to established cut-off points for different activity intensities.

Barriers and Facilitators to Physical Activity: A structured questionnaire was administered to T1D participants to identify perceived barriers and facilitators of physical activity. The questionnaire included items related to fear of hypoglycemia, time constraints, motivation, access to facilities, parental concerns, family support, healthcare provider support, access to sports programs, education on managing diabetes, and peer influence.

Statistical Analysis: Data were analyzed using SPSS version 25.0. Descriptive statistics were used to summarize baseline characteristics and physical activity measures. Independent t-tests were conducted to compare physical activity levels between T1D youth and healthy controls. Chi-square tests were used to compare categorical variables. Within the T1D group, differences in physical activity levels between those using insulin pumps and those using multiple injections were analyzed using independent t-tests. A p-value of <0.05 was considered statistically significant.

RESULTS AND DISCUSSIONS

The baseline characteristics of the study participants, including age, gender and BMI, were similar between the (Type 1) Diabetes group and the Healthy Controls group, with no significant differences observed (p> 0.05).

(Type 1) diabetic youth had significantly lower total physical activity (65.4±20.3 min/day) compared to healthy controls (82.7±22.1 min/day, p=0.02). Similarly, moderate-to-vigorous physical activity was lower in the diabetic group (35.2±15.6 min/day) than in the controls (45.9±18.2 min/day, p=0.03). Additionally, sedentary time was higher in the diabetic group (420.7±60.5 min/day) compared to the healthy controls (380.3± 55.4 min/day, p=0.04).

No significant differences were observed in total physical activity, moderate-to-vigorous physical activity, or sedentary time between Type 1 diabetic youth using insulin pumps and those using multiple injections (p>0.05).

The most commonly reported barrier to physical activity among (Type 1) diabetic youth was fear of hypoglycemia (60%), followed by lack of time (33.3%), lack of motivation (26.7%), parental concerns (23.3%), and access to facilities (16.7%).

Key facilitators of physical activity included support from family (66.7%), support from healthcare providers (60%), education on managing diabetes (50%), positive peer influence (46.7%), and access to sports programs (40%).

This study compared physical activity levels in youth with (Type 1) Diabetes (T1D) and healthy controls, examining the influence of insulin administration methods on activity levels and identifying barriers and facilitators to physical activity among T1D youth. Our findings indicate that T1D youth engage in significantly less physical activity and more sedentary behavior compared to their healthy peers[10]. Additionally, the method of insulin administration did not significantly impact physical activity levels. Our results show that T1D youth have lower total physical activity and moderate-to-vigorous physical activity (MVPA) and higher sedentary time compared to healthy controls. Similar findings have been reported in previous studies. For instance, Herbst[10]. (2014) observed reduced physical activity levels in T1D youth compared to their non-diabetic peers, which may be attributable to concerns about hypoglycemia during exercise . This concern was also highlighted in our study, with fear of hypoglycemia being the most frequently reported barrier to physical activity (60%). Furthermore, a study by Libman[11]. (2016) also reported that T1D youth had lower physical activity levels and increased sedentary time compared to healthy controls . These findings are consistent with our study, which found significant differences in total physical activity (p=0.02), MVPA (p=0.03), and sedentary time (p=0.04) between T1D youth and healthy controls. The sedentary lifestyle observed in T1D youth may contribute to poorer cardiovascular and metabolic health outcomes, as suggested by previous research (Quirk *et al.*, 2014)[12]. Our study found no significant differences in physical activity levels between T1D youth using insulin pumps and those using multiple daily injections. This is consistent with findings from a study by Steineck[13]. which reported that the method of insulin delivery did not significantly influence physical activity levels in T1D youth. It suggests that regardless of the insulin administration method, T1D youth face similar challenges in maintaining physical activity. Identifying barriers and facilitators to physical activity in T1D

Table 1: Baseline characteristics of study participants

Characteristics	Type 1 Diabetes (n=30)	Healthy Controls (n=30)	p-value
Age (years)	14.5 (2.1)	14.7 (2.0)	0.68
Gender (M/F)	16/14 (53%/47%)	15/15 (50%/50%)	0.82
Body Mass Index (BMI) (kg/m²)	22.1 (3.2)	21.9 (3.1)	0.76
Duration of Diabetes (years)	5.4 (3.1)	-	-
Method of Insulin Therapy	12/18 (40%/60%)	-	-

Table 2: Physical activity levels in type 1 diabetic youth vs. Healthy controls

Physical Activity Measures	Type 1 Diabetes (n=30)	Healthy Controls (n=30)	p-value
Total Physical Activity (min/day)	65.4 (20.3)	82.7 (22.1)	0.02
Moderate-to-Vigorous PA (min/day)	35.2 (15.6)	45.9 (18.2)	0.03
Sedentary Time (min/day)	420.7 (60.5)	380.3 (55.4)	0.04

Table 3: Impact of insulin therapy method on physical activity levels in type 1 diabetic youth

Physical Activity Measures	Insulin Pump (n=12)	Multiple Injections (n=18)	p-value
Total Physical Activity (min/day)	68.2 (19.1)	63.1 (21.3)	0.48
Moderate-to-Vigorous PA (min/day)	37.5 (14.7)	33.4 (16.1)	0.38
Sedentary Time (min/day)	415.3 (58.2)	425.6 (62.4)	0.61

Table 4: Barriers to physical activity in type 1 diabetic youth

Barrier	Frequency (n, %)
Fear of Hypoglycemia	18 (60%)
Lack of Time	10 (33.3%)
Lack of Motivation	8 (26.7%)
Access to Facilities	5 (16.7%)
Parental Concerns	7 (23.3%)

Table 5: Facilitators of physical activity in type 1 diabetic youth

Facilitator	Frequency (n, %)
Support from Family	20 (66.7%)
Support from Healthcare Providers	18 (60%)
Access to Sports Programs	12 (40%)
Education on Managing Diabetes	15 (50%)
Positive Peer Influence	14 (46.7%)

youth is crucial for developing targeted interventions. The fear of hypoglycemia was the most commonly reported barrier in our study, consistent with findings from a study by Brazeau[14]. (2013), which highlighted hypoglycemia as a major concern limiting physical activity in T1D individuals . Lack of time and motivation were also significant barriers, similar to the results reported by Riddell[1].

On the other hand, support from family and healthcare providers were the most frequently reported facilitators of physical activity in our study. This aligns with findings by Faulkner[15], which emphasized the importance of a supportive environment in promoting physical activity among T1D youth . Education on managing diabetes during physical activity was also a significant facilitator, highlighting the need for comprehensive education programs. The findings of this study have several implications for clinical practice and public health. Healthcare providers should emphasize the importance of physical activity in T1D management and provide education on strategies to prevent hypoglycemia during exercise. Family support should be encouraged, as it plays a crucial role in promoting physical activity among T1D youth. Additionally, creating accessible and inclusive sports programs for T1D youth can help increase their physical activity levels.

CONCLUSION

In conclusion, T1D youth engage in less physical activity and more sedentary behavior compared to their healthy peers, with no significant difference in activity levels based on insulin administration methods. Fear of hypoglycemia is the most significant barrier to physical activity, while family and healthcare provider support are key facilitators. Interventions to increase physical activity in T1D youth should address these barriers and leverage these facilitators to promote healthier lifestyles.

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