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**Original Research Article**

# Physical activity during COVID-19 pandemic and its impact on glycemic control in children with type 1 diabetes mellitus

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## ABSTRACT

**Background:** Physical activity is one of the important factors affecting glycemic control in type 1 diabetes mellitus (T1DM). During COVID-19 pandemic the government imposed restrictions to prevent the spread of COVID and physical activity of children was curtailed. We assessed the physical activity during COVID-19 pandemic restrictions (from September 2020 to September 2021) and its association with their glycemic control.
**Methods:** 48 children with T1DM receiving treatment in paediatric endocrinology outpatient department (OPD), AIIMS, New Delhi were enrolled. Socio-clinical data were collected using pre-validated and tested self-structured tool, physical activity was assessed using global physical activity questionnaire and glycemic control was assessed by glycated haemoglobin (HbA1C) and compared to baseline level before the onset of pandemic.
**Results:** Among 48 children (11.2±3.7 years, 25 M: 23 F), 79.2% fulfilled the 60 minutes' requirement of physical activity/day. Moderate negative correlation was found in recommended physical activity duration and HbA1c during COVID-19 pandemic. However, there was a significant increase in the HbA1C level from 7.6±1.5 to 8.5±1.8 during COVID-19 pandemic.
**Conclusions:** There was a moderate negative correlation between duration of physical activity and HbA1c of children. In spite of restrictions imposed by the government, children who were physically active were able to maintain good glycemic control. Although there was significant increase in the mean HbA1c of children during COVID-19 pandemic but the percentage of hyperglycemic events was significantly lower among the children who had walked/rode bicycle for going from one place to another and who had more rooms to play at home had good glycemic control.

**Keywords:** Physical activity, HbA1c, Diabetes mellitus

## INTRODUCTION

Type 1 diabetes mellitus (T1DM) is the chronic disease in children that results from autoimmune destruction of the pancreatic β-cells which leads to insulin deficiency. Treatment of T1DM consists of parenteral insulin therapy and self-monitoring of blood glucose, to maintain euglycemia and prevent short term and long term complications of diabetes. Different factors can influence the glycemic control of children. Among various factors, physical activity is one of the most important components and a minimum of daily 60 minutes of moderate physical activity is recommended.[1] During adolescence, physical activity often declines as there is no longer compulsion of physical activity at school; adolescents stop playing weekend sports and sometimes receive weekend jobs, but in paediatric population frequency of regular physical activity is a major factor influencing the control of glycemia hence children with T1DM require ongoing care and support to manage physical activity which may not be seen as priority by adolescents.[2,3] COVID-19 pandemic lead to worldwide public health concerns and lockdown in many countries leading to restrictions in physical activity the physical activity.[4] The International society for

pediatric and adolescent diabetes (ISPAD) emphasized the importance of continued attentiveness to standard diabetes care to avoid the need for hospitalization and emergency or urgent care visits during this period.

This study aimed to assess the level of physical activity and glycemic control of children with T1DM during COVID-19 pandemic, the impact of level of physical activity on their glycemic control and the association of physical activity and glycemic control with demographic variables of children with T1DM during COVID-19 pandemic.

## METHODS

A quantitative cross-sectional study was conducted at the pediatric endocrinology OPD of All India Institute of Medical Sciences (AIIMS), New Delhi, India. The study was conducted from September 2020 to September 2021 when the schools were closed. During this time the children were attending online classes or were taught by parents at home. Children (6 to 18 years) with T1DM for more than one year, on insulin therapy, under follow up in pediatric OPD, following diabetic diet as prescribed by dietician, regularly assessing blood glucose level at home were included. Children with other chronic illnesses and other endocrine disorders were excluded.

Children were recruited using convenient sampling technique and sample size was calculated using following formula.

$$n = \{Z^2 \times P(1-P)\}/d^2$$

Where Z is the statistic corresponding to level of confidence and at 95% confidence interval; Z=1.96), P is expected prevalence of physical activity among children with T1DM; P=0.3, d is precision; d=10% i.e., 0.1. A sample size of 81 was calculated. In the month of September 2021 due to reopening of schools the data collection was stopped. Therefore, only 48 children could be enrolled in the study.

Ethical clearance was obtained from institute ethics committee AIIMS New Delhi (reference no. IECPG-59/27.02.2020. Informed consent and assent were obtained from primary caregivers and subjects. Demographic and disease/treatment related data was collected.

Physical activity (PA) was assessed using global physical activity questionnaire (GPAQ).[5,6] Physical activity of previous one week was assessed in five components i.e. duration of total physical activity/day, moderate (brisk walking, bicycle riding on flat surfaces, hiking, riding a scooter without a motor, swimming, catching and throwing of baseball and softball) and vigorous intensity activity (running, bicycle riding on hilly surfaces, tag or flag football, jumping rope, martial arts, sports including soccer, basketball, swimming, and tennis, vigorous dancing), how did child travel from one place to another by walking/riding bicycle, sedentary behavior was assessed by duration of sitting/reclining per day.[7,8]

PA was analysed in five components i.e. fulfilment of the 60 min/day duration of total physical activity/day, intensity of physical was assessed in the form of metabolic equivalents (METs) min/week and one MET is the energy cost of sitting quietly, and is equivalent to a caloric consumption of 1 kcal/kg/hour and energy expenditure of moderate and vigorous intensity PA was four and eight times of sitting quietly respectively, fulfilment of vigorous PA requirement of at least thrice a week, fulfilment of walking/riding a bicycle requirement for at least ten minutes/day while travelling from one place to another, sedentary duration in hours/day.[5,7,8]

Pre COVID-19 pandemic glycemic control was ascertained by assessing their HbA1C just before commencement of the COVID-19 pandemic (January-March 2020) from children's records. Current HbA1C was assessed at the time of their visit during COVID-19 pandemic. P<0.05 was considered significant. Data regarding the percentage of the hypoglycemic events (blood sugar level <70 mg/dl) and hyperglycemic events (blood sugar level >200 mg/dl) in the current visit were collected from their daily blood sugar records maintained at home. Data was analysed using statistical package for the social sciences (SPSS) 26 and stata 14. Categorical variables were assessed by $Chi^2$ test or Fisher's exact test.

## RESULTS

Mean age of children with T1DM (25 M: 23 F) enrolled in the study was 11.2±3.7 years (6-18 years). 4 (8.3%) needed hospitalization for management of complications (diabetic ketoacidosis) associated with T1DM in the preceding 2 months (Tables 1 and 2).

**Table 1: Socio demographic profile of children with type 1 diabetes mellitus (N=48).**

| Demographic profile | Frequency (percentage) |
|---|---|
| **Age (in years)** | 11.2±3.7* |
| **Gender** | |
| Male | 25 (52.1) |
| Female | 23 (47.9) |
| **Place of living** | |
| Rural | 10 (20.1) |
| Urban | 38 (79.2) |

Continued.

| Demographic profile | Frequency (percentage) |
|---|---|
| **Education level** | |
| Not yet started | 1 (2.1) |
| Up to 5th std. | 23 (47.9) |
| 6- 8th | 15 (31.2) |
| 9-12th | 9 (18.8) |
| **Child's occupation** | |
| Student | 45 (93.8) |
| Self-employed | 3 (6.2) |
| **Family's monthly income (in rupees)** | |
| <9,999 | 10 (20.8) |
| 10,000-19,999 | 10 (20.8) |
| 20,000-29,999 | 9 (18.8) |
| >30,000 | 19 (39.6) |
| **Father's education** | |
| Illiterate | 4 (8.3) |
| High school | 8 (16.7) |
| Senior secondary | 18 (37.5) |
| Graduation or above | 18 (37.5) |
| **Mother's education** | |
| Illiterate | 6 (12.5) |
| High school | 5 (10.4) |
| Senior secondary | 19 (39.6) |
| Graduation and above | 18 (37.5) |
| **Demographic profile** | |
| **Father's occupation** | |
| Govt. job | 12 (23.5) |
| Private job | 11 (21.6) |
| Business | 6 (11.8) |
| Self-employment | 18 (35.3) |
| Unemployed | 1 (2) |
| **Mother's occupation** | |
| Govt. job | 2 (4.2) |
| Private job | 4 (8.3) |
| Housewife | 37 (77.1) |
| Self-employment | 5 (10.4) |
| **Type of family** | |
| Nuclear | 29 (6.4) |
| Joint | 19 (39.6) |
| **Size of house (land area in square yard)** | |
| <100 | 23 (47.9) |
| 100-200 | 15 (31.2) |
| 200-300 | 7 (14.6) |
| >300 | 3 (6.2) |
| **Number of rooms in the house** | |
| 1 | 4 (8.3) |
| 2 | 25 (52.1) |
| 3 | 14 (29.2) |
| 4/> | 5 (10.4) |
| **Family history of diabetes mellitus** | |
| Parents | 6 (12.5) |
| Siblings | 1 (2.1) |
| Grandparents | 10 (20.9) |
| None | 31 (64.5) |
| **Height (in cms)** | |

Continued.

| Demographic profile | Frequency (percentage) |
|---|---|
| Normal for age | 46 (95.8) |
| Stunted (height<2SD) | 2 (4.2) |
| **Weight (in kgs)** | |
| Normal for age | 45 (93.7) |
| Moderately underweight (between -3SD to -2SD) | 3 (6.3) |
| **Demographic profile** | |
| **BMI (kg/m$^2$)** | |
| Thinness | 7 (14.6) |
| Normal | 31 (64.6) |
| Overweight | 6 (12.5) |
| Obese | 4 (6.3) |

**Table 2: Clinical demographic profile of children with type 1 diabetes mellitus (N=48).**

| Demographic profile | Frequency (Percentage) |
|---|---|
| **Duration of disease (months)** | |
| 12 to 24 | 13 (27.1) |
| 24 to 36 | 8 (16.7) |
| >36 | 27 (56.2) |
| **Blood sugar monitoring was done by** | |
| Parents | 27 (56.2) |
| Siblings | 2 (4.2) |
| Self | 18 (37.5) |
| Others | 1 (2.1) |
| **Frequency of blood sugar monitoring (per day)** | |
| Once | 5 (10.4) |
| Twice | 10 (20.8) |
| Thrice | 26 (54.2) |
| Quadruple/> | 7 (14.6) |
| **Types of insulin used**** | |
| SA+IA | 20 (41.7) |
| RA+LA | 16 (33.3) |
| RA+IA+LA | 2 (4.2) |
| SA+RA+LA | 10 (20.8) |
| **Dose of insulin (units/kg/day)** | |
| <0.8 | 9 (18.8) |
| 0.8-1.6 | 33 (68.7) |
| 1.6-2.4 | 4 (8.3) |
| >2.4 | 2 (4.2) |
| **Insulin regimen (per day)** | |
| Once | 2 (4.2) |
| Twice | 4 (8.3) |
| Thrice | 28 (58.3) |
| Quadruple/> | 14 (29.2) |
| **Source of support (insulin)** | |
| Hospital | 23 (47.9) |
| Self | 17 (35.4) |
| Parent's office | 8 (16.7) |
| **Demographic profile** | |
| **Percentage of hypoglycemic events in last month** | |
| <5 | 7 (14.6) |
| >5 | 41 (85.4) |
| **Percentage of hyperglycemic events in last month** | |
| <25 | 17 (35.4) |

Continued.

| Demographic profile | Frequency (Percentage) |
|---|---|
| >25 | 31 (64.6) |
| Pre-COVID-19 pandemic HbA1c | 7.6±1.5* |
| **Glycemic control** | |
| Good (<7.5%) | 33 (68.7) |
| Poor (>7.5%) | 15 (31.3) |
| During COVID-19 pandemic HbA1c | 8.5±1.8* |
| **Glycemic control** | |
| Good (<7.5%) | 13 (27.1) |
| Poor (>7.5%) | 35 (72.9) |
| Celiac disease (positive) | 4 (8.3) |
| Needed hospitalization for complications associated with T1DM | 4 (8.3) |

*Mean±SD, ** SA: short acting, IA: intermediate acting, RA: rapid acting, LA: long acting

As shown in Table 3, five components were used to assess the physical activity of children.

**Table 3: Physical activity of children with type 1 diabetes mellitus (N=48).**

| Variables | Frequency (percentage) |
|---|---|
| **60 min PA*/day** | |
| Yes | 38 (79.2) |
| No | 10 (20.8) |
| **Total METS** min/week** | |
| Low <1680 | 12 (25) |
| Moderate 1680-8400 | 33(68.7) |
| High ≥8400 | 3(6.3) |
| **Vigorous activity** | |
| Yes | 26(54.2) |
| No | 22(45.8) |
| **Sitting (time in hours)/day** | |
| 0-4 | 4 (8.3) |
| 4-8 | 33 (68.8) |
| ≥8 | 11 (22.9) |
| **Transportation (by walking/rides bicycle)** | |
| Yes | 37 (77.1) |
| No | 11 (22.9) |

*PA- Physical activity, **METS – metabolic equivalents

The mean HbA1C level of children, pre COVID-19 and during COVID-19 pandemic was 7.6±1.5 and 8.5±1.8 respectively (p<0.0001).

Before COVID-19 pandemic 33 (68.8%) had good glycemic control (HbA1c≤7.5) while during COVID-19 pandemic only 13 children (27.1%) had good glycemic control.

Among 33 children who had good pre COVID-19 glycemic control, 29 (87.8%) were doing 60 minutes physical activity/day and among them 14 (41.3%) were able to maintain good glycemic control even during COVID-19 pandemic but among those who were not physically active only one was able to maintain good glycemic control during COVID-19 pandemic.

Moderate correlation between duration of total physical activity and glycemic control (HbA1c) of children during COVID-19 pandemic with correlation coefficient -0.263, $\hat{y}$=9.386-0.001x, 0.069 coefficient of determination which suggests that 6.9 percent of variation in glycemic control ((HbA1c)/y of children is explained by variation in physical activity/x of their physical activity (Figure 1).

Children who were fulfilling criteria of minimum 60 minutes' physical activity per day had significantly less percentage of hyperglycemic events in one month during COVID 19 pandemic with p=0.027. The percentage of hyperglycemic events were significantly lower among the children who had walked/rode bicycle for going from one place to another with p value 0.001 (Table 4).

Children living in rural area had significantly higher METS min/week expenditure than children staying in urban area (p value=0.002), Children studying in higher classes had significantly long sitting hours (p value=0.0001).

Children whose mothers were on government job/private job/house wives were fulfilling the criteria of vigorous activity with p value 0.001 during COVID as they were supervising their children at home as compared to the children whose mothers were self-employed because they were still working and unable to supervise their children appropriately.

There is significant association of percentage of hypoglycemic events of the children with their occupation (p value=0.002) and duration of disease (p value=0.047), those children who were self-employed had more hypoglycemic events during COVID-19 pandemic and whose duration of disease were less than one year/two years had less than five percent hypoglycemic events during COVID-19 pandemic respectively.

Those children who had more 2 or 4 rooms in their house had good glycemic control than those who had one room in their house (p value=0.017) as they had more space to walk around and play at home during COVID-19 pandemic.

**Table 4: Association of different components of physical activity variables with glycemic control (N=48).**

| Variables | Glycemic control | | P value* | Percentage of hypoglycemic events | | P value | Percentage of hyperglycemic events | | P value* |
|---|---|---|---|---|---|---|---|---|---|
| | Good | Poor | | >5 | <5 | | >25 | <25 | |
| **Physical activity duration in 60 min/day** | | | | | | | | | |
| Yes | 12 (31.6) | 26 (68.4) | 0.248 | 5 (13.2) | 33 (86.8) | 0.625 | 11 (28.9) | 27 (71.1) | 0.027* |
| No | 1 (10) | 9 (90) | | 2 (20) | 8 (80) | | 7 (70) | 3 (30) | |
| **Transportation by walking/riding bicycle** | | | | | | | | | |
| Yes | 11 (14.3) | 26 (85.7) | 0.702 | 5 (14.3) | 30 (85.7) | 1.00 | 9 (24.3) | 28 (75.7) | 0.001* |
| No | 2 (18.2) | 9 (81.8) | | 2 (18.2) | 9 (81.8) | | 9 (81.8) | 2 (18.2) | |

Fisher's exact test, *p value ≤0.05, frequency (percentage)

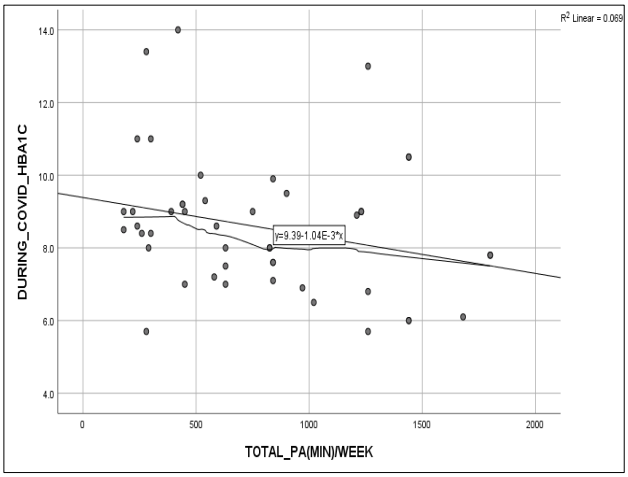


**Figure 1: Correlation between duration of total physical activity and glycemic control (HbA1c) of children during COVID-19 pandemic.**

Total_PA(MIN)/WEEK: Total physical activity in minutes/ week

## DISCUSSION

Majority of the children 38 (79.2%) fulfilled the 60 minutes requirement of PA/day with 33 (68.7%) had moderate energy expenditure/week. Before commencement of pandemic 33 had good glycemic control (HbA1c≤7.5) but during pandemic only 13 children had good glycemic control. Children who fulfilled the requirement of 60 minutes PA/day had significantly less percentage of hyperglycemic events in one month (p value=0.027). There was increase in HbA1C of children from 7.541±1.483 to 8.391±1.487.

Moderate negative correlation was found between duration of total physical activity and glycemic control (HbA1c) of children during COVID-19 pandemic with correlation coefficient -0.263. As their duration of physical activity increases HbA1c decreases.

The percentage of hyperglycemic events was significantly lower among the children who had walked/rode bicycle for going from one place to another (p value=0.001). There was significant association of percentage of hypoglycemic events of the children with their occupation, those children who were self-employed had more hypoglycemic events during COVID-19 pandemic. As, they were going to their work place by walking although there was not significant association between transportation component of physical activity and percentage of their hypoglycemic events, which may be due to small sample size.

There is significant association between duration of disease and hypoglycemic events of the children, those children whose duration of disease were less than two years had less than five percent hypoglycemic events during COVID-19 pandemic. Those children who had more 2 or 4 rooms in their house had good control than those who had one room in their house with p value 0.017 as they had more space to walk around and play at home during COVID-19 pandemic.

During pre-COVID-19 period, out of 48 children, 33 children (46.9%) had good glycemic control in pre-COVID-19 period and 13 children (40%) had good glycemic control even during COVID-19 pandemic as most of them were moderately active with METS min/week expenditure between 1680-8400, fulfilled the requirement of 60 mins/day and less sitting time in hours/day. These findings were consistent with a previous study conducted by Tornese et al, which reported that glycemic control of T1DM in adolescents using high closed loop system did not worsen during the restrictions due to COVID-19 pandemics and further improved in those who continued physical activity during the quarantine.[9]

There was a significant increase in the mean HbA1C of children with T1DM during COVID-19 (p value=0.0001) and similar results were reported in a previous study conducted by Verma et al and contradictory with a study conducted by Shah et al.[10,11]

The impact of COVID-19 pandemic on health of children with T1DM can be clearly seen as there was significant worsening of glycemic control as before COVID-19 pandemic, among 48 children 33 had good glycemic control while after COVID-19 pandemic only 13 children had good control and 4 children needed hospitalization for management of complications and these results were in agreement with a recent systematic review of health effects

of storms and floods by Saulnier et al which reported an increase in HbA1c levels and need of hospitalization for management of diabetic complications post events.[12] Another recent study by Ghosal et al has also concluded that duration of lockdown in COVID-19 is directly proportional to the worsening of glycaemic control and diabetes-related complications.[13]

In the present study, 4 children developed serious emergencies like diabetic ketoacidosis (DKA) requiring hospitalisations similar results were reported in a previous study conducted by Tomio and Sato et al, and had also recommended development of more educational resources for patients and health care workers about the specific needs of people with diabetes in disaster time.[14]

Different factors like the physical activity, media consumption habits, socioeconomic status, sedentary lifestyle, duration of disease influence the glycemic control of children with T1DM, as in present study, among the children who had sitting time less than 4 hours/day, 50% had good glycemic control and among the children who had sitting time more than 8 hours/day only 9.1% had good glycemic control and with respect to duration of disease, among 13 children whose duration was between 12 -24 months, 46.2% had good glycemic control while among 19 children, whose duration was more than more than 36 months only 15.8% had good glycemic control, although their association was not statistically significant which may be due to enrolment of less number of children under pandemic period. These findings are consistent with the results of a previous study conducted by Galler et al.[15]

### *Strength*

This study comprehensively assessed the level of physical activity, glycemic control and their association with selected sociodemographic and clinical variables in children with diabetes mellitus type 1 during COVID-19 pandemic. Specific standardized tool was used.

This study gave insight to the researcher and health team about the physical activity and glycemic control of children during COVID-19 pandemic.

### *Limitations*

This is a single center study on small size and the children were recruited by convenient sampling. We assessed physical activity using a questionnaire while pedometers can be used for the assessment of physical activity to enhance the objectivity of the data.

The required sample size couldn't be achieved due to reopening of schools by September 2021.

## CONCLUSION

There was a moderate negative correlation between duration of physical activity and HbA1c of children. In spite of restrictions implied by the government children who were physically active were able to maintain good glycemic control. Although there was significant increase in the mean HbA1c of children during COVID-19 pandemic but the percentage of hyperglycemic events was significantly lower among the children who had walked/rode bicycle for going from one place to another and who had more number of rooms in their house had good glycemic control as they had more space to walk around and play at home during COVID-19 pandemic. Children living in rural area had more METs expenditure and those studying in higher classes had long sitting hours.

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