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Original article

COVID-19 and post-pandemic changes in physical activity and glycated haemoglobin in children with type 1 diabetes: a case-control study

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Abstract. *Background:* Exercise is crucial for managing T1DM by improving insulin sensitivity and reducing cardiovascular risk. However, the COVID-19 pandemic's impact on physical activity and glycaemic control in adolescents with T1DM in resource-limited settings like Indonesia remains unclear. This study compares these factors in T1DM patients during and after the pandemic to highlight diabetes care in Indonesia. *Research design and Methods:* This case-control study was carried out in the Indonesian pediatric endocrine clinic department of Dr. Soetomo Hospital between July 2020 and August 2024. Data were collected from 120 pediatric T1DM patients two years after COVID-19 restrictions were implemented. The study used a validated Physical Activity Questionnaire (PAQ), with a validity of 0.881 and reliability of 0.745, which had been translated into Indonesian. *Result:* Of 120 subjects, 70 submitted data during the COVID-19 pandemic, and 50 did so two years later. HbA1c levels showed a non-significant decrease post-pandemic (10.1 ± 2.44 vs. 9.77 ± 1.96). Physical activity levels did not significantly change ($p = 0.135$) or correlation between activity and HbA1c ($p = 0.314$). However, 29 subjects reported reduced physical activity after the restrictions. *Conclusion:* This study found no evidence of a significant relationship between physical activity and glycaemic control in adolescents with T1DM during and after the COVID-19 pandemic, suggesting other factors influence blood sugar levels. The findings emphasize the need for tailored treatments in low-resource settings like Indonesia, while still underscoring the importance of reducing sedentary behavior and promoting regular physical activity. (www.actabiomedica.it)

Key words: type 1 diabetes, adolescents, glycated haemoglobin, physical activity, covid-19, limited resource settings, pandemic impact, case control study, children with diabetes, post-covid changes

Introduction

Physical activity is crucial for managing Diabetes Mellitus Type 1 (T1DM), an autoimmune disorder that affects beta cells in the pancreas, leading to lifelong dependency on exogenous insulin (1,2). Adolescents with T1DM face unique challenges due to hormonal, psychological, and lifestyle changes. The global prevalence of T1DM is expected to reach 8.4 million individuals by 2040, with the mean life span of a 10-year-old child diagnosed with T1DM being 13 years in low-income countries and 65 years in high-income countries (3). In Indonesia, the management of T1DM in adolescents poses significant challenges due to diverse socioeconomic conditions. The incidence of T1DM has increased sevenfold over a decade, from 3.88 per 100 million people in 2000 to 28.19 per 100 million population in 2010 (4). Limited access to healthcare resources, cultural factors, and varying levels of awareness about diabetes management may also hinder optimal diabetes care (6). The main barrier to implementing adequate physical activity is fear of intensive physical activity causing hypoglycemia, which can lead to anxiety and mental health problems for patients and their parents (7). An essential measure for evaluating the long-term management of glucose in patients with Type 1 Diabetes Mellitus (T1DM) is the level of glycated hemoglobin (HbA1c), which represents the average blood glucose levels through the previous two to three months (8). The study aims to evaluate the levels of physical activity and glycemic control in individuals diagnosed with T1DM during the COVID-19 pandemic compared to healthy controls. Understanding this association emphasizes the importance of physical activity as a modifiable element that may potentially enhance diabetes management in this population.

Material and Methods

Study design and setting

We conducted a case-control study from July 2, 2020 to August 6, 2024 in the Dr. Soetomo Hospital's pediatric endocrine clinic department in Indonesia.

Participants

Study participants were children diagnosed with T1DM based on the guidelines provided by the International Society for Pediatric and Adolescent Diabetes (ISPAD) (2). Pediatric patients with severe medical conditions and those who refused to take part were not included.

Variables

The variables in this study include patient characteristics (gender, age, duration of diagnosis of T1DM, age at diagnosis of T1DM, daily insulin dose, last HbA1c measurement, educational background and the physical activity frequency).

Data sources/measurement

Data from all respondents were collected online during COVID-19 restrictions and after COVID-19. Participants filled out the message to the researchers to complete informed consent forms, which were then printed, signed, and returned to the study team. Through telephone interviews, the respondents provided the patient demographic data. For children under 13, parents completed the questionnaire (parent-reported), and children over 13 completed the questionnaire on their own (child-reported or patient-reported). The questionnaire used is the Physical Activity Questionnaire (PAQ) which has been translated into Indonesian and has been tested for validity and reliability by Dapan et al. with a validity value of 0.881 and a reliability of 0.745 (9). The Indonesian version of the PAQ demonstrated a moderate level of validity and has an acceptable reliability (10). PAQ were classified as Occasional, light exercise if the children engaged in light physical activities during their leisure time (e.g., playing sports, running, swimming, biking, or doing aerobics) in Once or twice weekly, Regular light exercise occurs when children engage in physical activities 3-4 times per week, while regular exercise is defined by participation in physical activities 5-6 times per week (10). Each person got twenty to thirty minutes to collect the required information. Subjects are provided with an online form and an extensive guide for completing the form. Regarding ethical clearance, we sent a separate form containing informed consent, which was filled in by the subject's parent or guardian and returned to us.

Bias

The study's duration was chosen to ensure test-retest reliability while avoiding recall bias.

Study size

The sample size used in research to determine the existence of a correlation in a study uses a formula

Denote N as [(Za + Zb) × C] Assuming a sample size of N, the normal standard deviation (Za) is 1.96 when a=0.05, and the normal standard deviation (Zb) is 0.84 when b=0.20. The expected correlation coefficient (r) is -0.60, and C is 0.5 x ln [(1+r)/(1-r)], When this formula is used, N is 19.47, so the minimum sample required in this research is 20.

Quantitative variables

All data, including characteristics, are presented on a numerical scale.

Statistical methods

Statistical analysis was conducted using SPSS version 25.0 (IBM). Descriptive data were presented as frequencies (n) and percentages (%). Correlations between physical activity and HbA1c were conducted using Spearman's correlation test. Whereas comparison between physical activity of patients during COVID-19 pandemic and two years after COVID-19 restrictions was analyzed using Wilcoxon signed rank test.

Result

Participants

A total of 120 pediatric patients with diagnosed with T1DM were obtained, 70 patients filled out the form during the COVID-19 pandemic, and 50 filled out the form 2 years after COVID-19 restrictions.

Descriptive data

The number of male participants was greater during the pandemic restriction (52.8% vs. 36%), and the majority of patients both during and after the restriction were in the 10-15 year age group (48.5% vs. 42%). There was a decrease in HbA1c levels after the pandemic restrictions (10.1 ± 2.44 vs. 9, 77 ± 1.96). The majority of patients have a tendency to do light exercise during their free time both during and after the pandemic restrictions (47.1% vs. 40%). Tables 1 and 2 demonstrate the characteristics of the patients who were included.

Table 1. Subjects Characteristics

	Frequency (n, %)	
Variable	**During (n=70)**	**Post (n=50)**
Sex		
Male	37 (52,8)	18 (36)
Female	33 (47,1)	32 (64)
Age (year/SD)**		
0-5	4 (5,7)	5 (10)
5-10	15 (21,4)	5 (10)
10-15	34 (48,5)	21 (42)
15-20	17 (24,3)	19 (38)
Duration of T1DM (year/SD)*		
< 5 years	48 (68,5)	27 (54)
5-10 years	18 (25,7)	5 (10)
> 10 years	4 (5,7)	18 (36)
Age at Onset (year)*	7,7±3,36	7,8 ±3,86
Dose of Insulin (unit/kg/day):	0,3±0,4	0,3±0,1
HbA1c level (%):	10,1±2,44	9, 77±1,96
<6,5	6 (8,5)	3 (6)
6,5-7.6	10 (14,2)	6 (12)
7.6-9	18 (25,7)	11 (22)
>9	46 (65,7)	35 (70)

Table 2. Physical Activity Data Prior to and Following COVID-19 Restrictions

	Frequency (n, %)	
Physical Activity	**During (n=70)**	**Post (n=50)**
Occasional, light exercise	33 (47,1)	20 (40)
Regular, light exercise	19 (27,1)	16 (32)
Regular exercise	18 (25,7)	14 (28)

Outcomes

Physical activity showed no significant correlation with the level of glycated hemoglobin ($p = 0.314$; $r=0.147$)

Main results

Moreover, physical activity of patients during COVID-19 pandemic and two years after COVID-19 restrictions showed no significant statistical difference in physical activity ($p = 0.135$). The Spearman's correlation coefficient between HbA1c and physical activity During COVID-19 restrictions is 0.197, with a p-value of 0.103. This indicates a weak, non-significant positive correlation. The Spearman's correlation coefficient between HbA1c and physical activity Post COVID-19 Restrictions is 0.147, with a p-value of 0.314. This also indicates a weak, non-significant positive correlation. The comparison of physical activity during and after COVID-19 restrictions shows 29 participants had lower physical activity after the restrictions (mean rank = 25.10), while 19 participants showed increased physical activity (mean rank = 23.58). There were 22 ties, indicating no significant difference in physical activity levels before and after the pandemic.

Discussion

Overall, physical activity was not significantly correlated with HbA1c level in this study. PAQ in this study evaluates low-impact exercise. A study by Urniaż et al. also demonstrated that there were no statistically significant differences HbA1c levels between individuals who were physically active and those who were inactive (11) The finding is relevant to the meta-analyses and systemic reviews conducted by Otsman et al. and Kennedy et al., which found no evidence of an association between exercise interventions and glycemic improvements in patients with T1DM (12,13). In contrast to the findings of a prior study conducted by Aljarwaneh et al., which found a positive correlation between improved glycemic management and increased physical activity (14). Statistically significant lower mean physical activity was found in participants with poor control. A meta-analysis reported that exercise treatments in children with T1DM have moderate impact on lowering HbA1c levels and lowering the daily insulin dosage (15). Engaging in physical activity and exercise is linked to improved glycemic control in young individuals with T1DM (16). Physical activity can help manage blood glucose levels by enhancing insulin sensitivity, leading to optimal HbA1c (5,17). Assessing the clinical importance of exercise in improving physiological and biochemical outcomes in children and adolescents with T1DM, however, a number of studies have contradictory results. This could be the result of a variety of factors affecting glycaemic response to physical activity, such as the type, intensity, and length of the activity (18), the quantity of insulin administered, and the person's stress/anxiety levels (19,20). Furthermore, it remains unclear whether different training modalities and intensities will have varied impacts on chronic glycaemic management in T1DM populations (18,21). According to the current study, exercise interventions significantly lower daily insulin doses and HbA1c in T1DM patients while also improving their cardiorespiratory fitness. The findings suggest that longer interventions (i.e., ≥ 24 weeks and sessions ≥ 60 minutes) and concurrent high-intensity exercise (e.g., 77–95% of maximum heart rate and ≥70–84% of one-repetition maximum) may be more advantageous (10). Uribe et al. revealed that children and adolescents with T1DM exhibited greater levels of sedentary behavior compared to their healthy counterparts. Subgroup analysis indicated that this disparity persisted significantly among adolescents but was not observed in children. Specifically, adolescents with T1DM engaged in sedentary activities for an average of 63.3 minutes per day longer than their peers without diabetes (22). A review from Sari et al. underscored children and adolescents with T1DM have numerous of challenge and barrier to physical activity, including fear of hypoglycemia. In this context, the term "challenge" refers to factors related to an inaccurate understanding of hypoglycemia, while "barrier" denotes factors that actively impede the ability of these youths and their parents to engage in physical activity. Another study reported that teachers in educational institutions identified several deficiencies in supporting effective diabetes management. These shortcomings included a lack of comprehensive knowledge regarding diabetes, a lack of governmental support, and a lack of effective parent and healthcare professional communications (23). This study also highlights that the majority of subjects, both during and post-pandemic restrictions, had a high degree of HbA1c control. This result is similar to a study by Respati et al., found that 11 patients (11.5%) were in the suboptimal category and 76 paediatric patients in

Surabaya, Indonesia (79.2%) had high-risk HbA1c levels (24) Similarly, In the study conducted by Kayirangwa et al., 41.2% of patients had HbA1c levels that exceeded 10% (25). Furthermore, research by Pulungan (2021) indicated that 79.1% of the children studied (34 patients) had HbA1c levels above 8.5%, categorizing them as suboptimal (5). Elevated HbA1c levels are commonly observed in children with T1DM due to glucose intolerance resulting from impaired insulin function (26). Insulin resistance is strongly associated with clinical conditions such as hypertension, low HDL cholesterol, high C-reactive protein, and hypertriglyceridemia, which are more prevalent in obese children (27).

Conclusions

In conclusion, encouraging frequent physical activity among children and adolescents with T1DM appears to be an important issue. These challenges not only causes distress for those with T1DM but also has a substantial impact on their parents. For effective resolution of this issue, it is strongly recommended to emphasise minimising the amount of sedentary behaviour and the implementation of measures aimed at decreasing the duration of such activities among adolescents with T1DM.

Ethic Approval: Each procedure was carried out in compliance with the principles of ethics that were authorised by the Dr. Soetomo General Hospital Institutional Review Board. Every participant given informed consent, either through a parent or legal guardian. Provide a statement confirming that the Dr. Soetomo General Hospital's Institutional Review Board has approved the ethical proposal (protocol number 0272/KEPK/X/2021).

Conflict of Interest: Each author declares that he or she has no commercial associations (e.g. consultancies, stock ownership, equity interest, patent/licensing arrangement etc.) that might pose a conflict of interest in connection with the submitted article.

Declaration on the Use of AI: All of the authors' scientific content, analyses, and conclusions are completely original. The authors undertake full accountability for the manuscript's content's accuracy and integrity. The ethical standards of the journal and the policies of our respective institutions are respected by the utilization of AI in the preparation of this manuscript.

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References

1. Adolfsson P, Taplin CE, Zaharieva DP, et al. ISPAD Clinical Practice Consensus Guidelines 2022: Exercise in children and adolescents with diabetes. Pediatr Diabetes. 2022 Dec 20;23(8):1341–72. doi:10.1111/pedi.13452.
2. Lindholm Olinder A, DeAbreu M, Greene S, et al. ISPAD Clinical Practice Consensus Guidelines 2022: Diabetes education in children and adolescents. Pediatr Diabetes. 2022 Dec 20;23(8):1229–42. doi:10.1111/pedi.13418.
3. Gregory GA, Robinson TIG, Linklater SE, et al. Global incidence, prevalence, and mortality of type 1 diabetes in 2021 with projection to 2040: a modelling study. Lancet Diabetes Endocrinol. 2022 Oct;10(10):741–60. doi:10.1016/S2213-8587(22)00218-2.
4. Pulungan A. Increasing incidence of DM type 1 in Indonesia. Int J Pediatr Endocrinol. 2013 Oct 3;2013(S1):O12. doi:10.1186/1687-9856-2013-S1-O12.
5. Pulungan AB, FGAD. Type 1 diabetes mellitus in children: experience in Indonesia. Clin Pediatr Endocrinol. 2021; 30(1):11–8. doi:10.1297/cpe.30.11.
6. Soewondo P, Ferrario A, Tahapary D. Challenges in diabetes management in Indonesia: a literature review. Global Health. 2013;9(1):63. doi:10.1186/1744-8603-9-63.
7. Sekar S, Ika YW, Elida U. Challenges and Barriers of Physical Activity Among Pediatric Patients with Type 1 Diabetes Mellitus and Their Parents: A Systematic Review. Pediomaternal Nursing Journal. 2022 Aug 12;8(2):111–20. doi: 10.20473/pmnj.v8i2.38720.
8. Yun I, Joo HJ, Park YS, et al. Association between Physical Exercise and Glycated Hemoglobin Levels in Korean Patients Diagnosed with Diabetes. Int J Environ Res Public Health. 2022 Mar 10;19(6):3280. doi:10.3390/ijerph19063280.
9. Dapan AFD, Indra EN. Uji Validitas dan Reabilitas Instrumen Physical Activity Qestionnaire for Older Children (PAQ-C) dan hysical Activity Qestionnaire for Older Adolescent (PAQ-A). [Jogja]: Universitas Negri Yogyakarta; 2017.

10. Rahayu A, Sumaryanti S, Arovah NI. The Validity and Reliability of the Physical Activity Questionnaires (PAQ-A) among Indonesian Adolescents during Online and Blended Learning Schooling. Physical Education Theory and Methodology. 2022 Jun 25;22(2):173–9. doi:10.17309/tmfv.2022.2.04.
11. Urniaż AJ. Physical activity and the level of HbA1c in children and adolescents with type 1 diabetes mellitus. Advances in Rehabilitation. 2018;32(3):19–26. doi:10.5114/areh.2018.80966.
12. Kennedy A, Nirantharakumar K, Chimen M, et al. Does Exercise Improve Glycaemic Control in Type 1 Diabetes? A Systematic Review and Meta-Analysis. PLoS One. 2013 Mar 15;8(3):e58861. doi:10.1371/journal.pone.0058861.
13. Ostman C, Jewiss D, King N, et. al. Clinical outcomes to exercise training in type 1 diabetes: A systematic review and meta-analysis. Diabetes Res Clin Pract. 2018 May;139:380–91. doi:10.1016/j.diabres.2017.11.036.
14. Aljawarneh YM, Wood GL, Wardell DW, et al. The associations between physical activity, health-related quality of life, regimen adherence, and glycemic control in adolescents with type 1 diabetes: A cross-sectional study. Prim Care Diabetes. 2023 Aug;17(4):392–400. doi:10.1016/j.pcd.2023.04.003.
15. García-Hermoso A, Ezzatvar Y, Huerta-Uribe N, et al. Effects of exercise training on glycaemic control in youths with type 1 diabetes: A systematic review and meta-analysis of randomised controlled trials. Eur J Sport Sci. 2023 Jun 24;23(6):1056–67. doi:10.1080/17461391.2022.2086489.
16. Colberg SR, Sigal RJ, Yardley JE, et al. Physical Activity/Exercise and Diabetes: A Position Statement of the American Diabetes Association. Diabetes Care. 2016 Nov 1;39(11):2065–79. doi:10.2337/dc16-1728.
17. Piercy KL, Troiano RP, Ballard RM, et al. The Physical Activity Guidelines for Americans. JAMA. 2018 Nov 20;320(19):2020. doi:10.1001/jama.2018.14854.
18. Tonoli C, Heyman E, Roelands B, et al. Effects of Different Types of Acute and Chronic (Training) Exercise on Glycaemic Control in Type 1 Diabetes Mellitus. Sports Medicine. 2012 Dec 23;42(12):1059–80. doi:10.1007/BF03262312.
19. American Diabetes Association. Diagnosis and Classification of Diabetes Mellitus. Diabetes Care. 2010 Jan 1;33(Supplement_1):S62–9. doi:10.2337/dc10-S062.
20. Lifestyle Management: Standards of Medical Care in Diabetes—2019. Diabetes Care. 2019 Jan 1;42(Supplement_1):S46–60. doi:10.2337/dc19-S005.
21. Riddell MC, Gallen IW, Smart CE, et al. Exercise management in type 1 diabetes: a consensus statement. Lancet Diabetes Endocrinol. 2017 May;5(5):377–90. doi:10.1016/S2213-8587(17)30014-1.
22. Huerta-Uribe N, Hormazábal-Aguayo IA, Izquierdo M, et al. Youth with type 1 diabetes mellitus are more inactive and sedentary than apparently healthy peers: A systematic review and meta-analysis. Diabetes Res Clin Pract. 2023 Jun;200:110697. doi:10.1016/j.diabres.2023.110697.
23. Gutzweiler RF, Neese M, In-Albon T. Teachers' Perspectives on Children With Type 1 Diabetes in German Kindergartens and Schools. Diabetes Spectrum. 2020 May 1;33(2):201–9. doi:10.2337/ds19-0054.
24. Grawira PR, Muhammad F, Agung P, et al. Clinical Profile Of Type-1 Diabetes Pediatric Patients In Dr. Soetomo General Academic Hospital Surabaya: Correlation Of Growth Status And Metabolic Control. Majalah Biomorfologi. 2023 Jan 10;33(1):7–13. doi:10.20473/mbiom.v33i1.
25. Kayirangwa A, Rutagarama F, Stafford D, et al. Assessment of Growth among Children with Type 1 Diabetes Mellitus: A Cross-Sectional Study of Factors Contributing to Stunting. J Diabetes Metab. 2018;09(04). doi:10.4172/2155-6156.1000793.
26. Ray S, Howlader S, Chakraborty S, et al. Hemichorea-Hemiballism as the First Presentation of Type 2 Diabetes. Clinical Diabetes. 2015 Apr 1;33(2):87–9. doi:10.2337/diaclin.33.2.87.
27. Tagi VM, Giannini C, Chiarelli F. Insulin Resistance in Children. Front Endocrinol (Lausanne). 2019 Jun 4;10. doi:10.3389/fendo.2019.00342.

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