ORİJİNAL ARAŞTIRMA ORIGINAL RESEARCH

DOI: 10.5336/pediatr.2022-88803

Evaluation of Physical Activity and Related Conditions in Children with Type 1 Diabetes: A Cross-Sectional Study

Tip 1 Diabetes Mellitus'lu Çocuklarda Fiziksel Aktivite ve İlişkili Durumların Değerlendirilmesi: Kesitsel Bir Çalışma

Nevin USLU[a], Gül DİREK[b], Zeynep UZAN TATLI[b], Filiz ARICAN[b], Nurten VARİYENLİ[b], Nihal HATİPOĞLU[c]

[a]Department of Pediatric Nursing, Burdur Mehmet Akif Ersoy University, Burdur, Türkiye
[b]Department of Pediatric Endocrinology, Erciyes University Mustafa Eraslan and Fevzi Mercan Children's Hospital, Kayseri, Türkiye
[c]Department of Pediatric Endocrinology, Erciyes University Medical Faculty, Kayseri, Türkiye

ABSTRACT Objective: This study was conducted to determine the physical activity level of children with Type 1 Diabetes Mellitus and to evaluate the conditions that may be associated with physical activity. **Material and Methods:** This cross-sectional study was conducted in the pediatric endocrinology outpatient clinic of a university hospital between September 1, 2018, and March 30, 2019. Data were collected through the Personal Information Form for Children and the Physical Activity Questionnaire for Children (PAQC). Data analysis included the Independent t-test, One-way Anova test, Pearson Correlation, and Linear Regression Model. **Results:** Results showed that the physical activity mean score of children with Type 1 Diabetes Mellitus (n=111) was 2.75±0.6, and the children had a moderate physical activity level. No statistically significant relationships were detected between hemoglobin A1c (HbA1c) levels, Body Mass Index values, daily TV viewing time, and PAQC averages of children with Type 1 Diabetes Mellitus. It was found that fathers'education level, adherence to medical nutrition therapy, regular physical activity, total daily insulin dose, and daily sleep duration were effective variables on the total PAQC averages. Regular physical activity, total daily insulin dose, and sleep duration were found to explain 26.6% of the PAQC averages. **Conclusion:** This study found that the total daily insulin dose and sleep duration decreased as the physical activity level increased. It was determined that there was no correlation between physical activity and HbA1c level.

Keywords: Child; Type 1 Diabetes Mellitus; physical activity; HbA1c; glycemic control

ÖZET Amaç: Bu çalışma, Tip 1 Diabetes Mellitus'lu çocukların fiziksel aktivite düzeyini belirlemek ve fiziksel aktivite ile ilişkili olabilecek durumları değerlendirmek için yapılmıştır. **Gereç ve Yöntemler:** Kesitsel özellikteki bu çalışma, bir üniversite hastanesinin çocuk endokrinoloji polikliniğinde 1 Eylül 2018-30 Mart 2019 tarihleri arasında yapılmıştır. Veri toplamada Çocuğu Tanıtıcı Anket Formu ve Çocuk Fiziksel Aktivite Anketi (ÇFAA) kullanılmıştır. Veriler, Independent t-testi, One-way Anova testi, Pearson Korelasyon ve Doğrusal Regresyon Modeli ile değerlendirilmiştir. **Bulgular:** Çalışmada, Tip 1 Diabetes Mellitus'lu çocukların (n=111) fiziksel aktivite ölçek puan ortalamalarının 2.75±0.6 olduğu ve orta düzeyde fiziksel aktivite yaptıkları belirlenmiştir. Tip 1 Diabetes Mellitus'lu çocukların hemoglobin A1c (HbA1c) düzeyleri, Beden Kitle İndeksi değerleri ve günlük TV izleme süresi ile ÇFAA ortalamaları arasında istatistiksel olarak önemli bir ilişki olmadığı saptanmıştır. Tip 1 Diabetes Mellitus'lu çocukların baba eğitim düzeyi, tıbbi beslenme tedavisine uyum, düzenli fiziksel aktivite yapma, günlük toplam insülin dozu ve günlük uyku süresi toplam ÇFAA ortalamaları üzerinde etkili değişkenler olduğu bulunmuştur. Düzenli fiziksel aktivite yapma, günlük toplam insülin dozu ve günlük uyku süresinin fiziksel aktivite düzeyi ölçek puan ortalamalarının %26.6'sını açıkladığı belirlenmiştir. **Sonuç:** Bu çalışmada, fiziksel aktivite arttıkça günlük toplam insülin dozunun ve uyku süresinin azaldığı saptanmıştır. Fiziksel aktivite ile HbA1c düzeyi arasında bir korelasyon olmadığı belirlenmiştir.

Anahtar Kelimeler: Çocuk; Tip 1 Diabetes Mellitus; fiziksel aktivite; HbA1c; glisemik kontrol

Type 1 diabetes mellitus (T1DM) is one of the most common chronic diseases in childhood, and its incidence has been increasing worldwide.[1] More than 1.2 million children in the world between the ages of 0-19 are reported to have T1DM; more than half of them (54%) are under the age of 15; and the number of new T1DM cases between the ages of 0-19 is 184.100 each year. The prevalence of children with T1DM between the ages of 0-19 was reported 5.8/1000 in 2021, and the incidence was reported 2.8/1000 in Türkiye.[2]

Correspondence: Nevin USLU
Department of Pediatric Nursing, Burdur Mehmet Akif Ersoy University, Burdur, Türkiye
E-mail: nuslu@mehmetakif.edu.tr

Peer review under responsibility of Turkiye Klinikleri Journal of Pediatrics.

Received: 07 Feb 2022 ***Received in revised form:*** 15 Aug 2022 ***Accepted:*** 01 Sep 2022 ***Available online:*** 07 Sep 2022

2146-8990 / Copyright © 2022 by Türkiye Klinikleri. This is an open access article under the CC BY-NC-ND license (http://creativecommons.org/licenses/by-nc-nd/4.0/).

T1DM is a serious problem with morbidity and mortality risk and reduces life expectancy at birth. Therefore, disease management is very important. Physical activity (PA) is also a valuable and necessary part of therapy in the disease management of children with T1DM.[3] Strong muscle and bone strengthening activities at least 3 days a week and at least 60 minutes of moderate or vigorous aerobic activity per day are recommended for children with diabetes.[3-5] Both national and international guidelines advice regular PA in T1DM to improve cardiometabolic control and significantly reduces complications.[3-5] PA in children with T1DM is acknowledged to reduce cardiovascular risks, insulin resistance, insulin requirement, blood glucose levels, and ketone formation and improve lipid profile, muscle strength, sense of well-being, and quality of life of children.[3-6] However, the effects of PA on glycemic control in T1DM are not yet clear in the literature, which has reported different results.[7-10] Various studies indicate that children with T1DM do not reach the recommended PA levels and do less physical activities than their healthy peers.[11,12] It has also been noted that children with T1DM do not engage in PA due to fear of hypoglycemia, loss of glycemic control, and work schedule.[13]

This study was conducted to determine the PA level of children with T1DM and to evaluate the conditions that may be associated with PA.

MATERIAL AND METHODS

STUDY DESIGN

This cross-sectional study was conducted between September 1, 2018 and March 30, 2019 and included children with T1DM.

THE SETTING OF THE STUDY

This study was conducted in the pediatric endocrinology polyclinic of a university hospital located in the Central Anatolia Region of Türkiye. The diabetes team in the pediatric endocrinology polyclinic consists of pediatric endocrinologist, nurses, psychologist and dietician. The education is given periodically in line with the needs of the patients and within the framework of the guidelines of the "International Society for Pediatric and Adolescent Diabetes."[4]

SAMPLING

The sample size of the study was determined as 111 children with T1DM. The effect size was calculated as proposed by Cohen, and the calculation included an alternative correlation coefficient =0.3, α=0.05, power 95% for PA and HbA1c variables.[14-16] The sample included children who had been diagnosed with T1DM for at least 1 year; who were diagnosed with T1DM between the ages of 9 and 14; who did not have any physical, cognitive, and psychological disabilities; who were literate, and who could speak Turkish. Exclusion criteria were having been diagnosed with T1DM recently or less than one year ago; not being aged between 9 and 14, and having some kind of physical, cognitive and psychological disability.

DATA COLLECTION

Before the data collection phase, children and their families were informed about the study, their consent was obtained. The Personal Information Form for Children and the Physical Activity Questionnaire for Children (PAQC) were used to collect data. The data collection tools were filled in by the children. The sociodemographic data of the children were obtained from the children's self-reports. Participants' economic levels were categorized as high, medium, and low. The participants were asked to choose one option that suited them most. The activities done in and out of school were assessed as reported by the children using the PAQC. Children's daily sleep and TV viewing times were obtained from children's self-reports. The children completed the questionnaires in 25-30 minutes. The child's extra clothes and shoes were removed during the measurement of body weight from anthropometric measurements with a calibrated digital weighing machine. A digital standard height meter was utilized for the measurement of height. Body Mass Index (BMI) was calculated by dividing weight in kilograms by height in meters squared (kg/m^2). Standard deviation score (SDS) values for each anthropometric parameter were calculated according to Neyzi using the TPEDS Metrics of the Pediatric Endocrinology and Diabetes Associa-

tion system.[17] Daily insulin doses were taken as the average of the last 3 days by looking at the glucose monitoring chart. A questionnaire was applied to the patients when they came to their routine outpatient clinic control. HbA1c levels were also recorded as the measured value in this control.

DATA COLLECTION TOOLS

Personal Information Form for Children

The form, developed by the researcher in line with the literature, aimed to collect data about children's age, gender, economic level, place of residence, age of parents, education level, body weight, height, daily insulin dose, daily sleep duration, daily TV viewing time, performing regular physical activities regularly or not, adherence to nutrition therapy or not, and hemoglobin A1c (HbA1c) level.[3-12]

Physical Activity Questionnaire for Children

Crocker, Bailey, Faulkner, Kowalski, and McGrath conducted the reliability study of the PAQC, while Kowalski, Crocker, and Faulkner conducted its validity study.[14,15] Psychometric analyses of the Turkish version of the questionnaire were conducted by Erdim, Ergün and Kuğuoğlu, and the questionnaire was found to be reliable and valid.[16] PAQC aims to assess PA of children between the ages of 9 and 14 and is filled out by the children themselves. It consists of 10 questions evaluating the PA status within the last 7 days, and the average of the first nine questions is taken for the assessment of the scale. The questionnaire contains the following questions: 1) The frequency of the 14 different physical activities they do in their free time, 2) Status and frequency of being active in physical education courses, 3) Physical activities they do during recess at school, 4) Physical activities they do other than eating during lunch break, 5) Physical activities they do immediately after school, 6) The intensity and frequency of physical activities they perform in the evening, 7) The intensity and frequency of their physical activities on the weekend, 8) How often they are active in their free time and 9) Frequency of PA for each day of the past week. Each item in the questionnaire is evaluated with an activity score from 1-5 points. While "1 point" refers to low PA, "5 points" refers to vigorous PA. In our study, clustering analysis was performed on the data obtained from children. Three groups were formed for the activities according to the clustering analysis: low level- below 2.33; moderate level- 2.33 to 2.99; and vigorous level- 3.00 and above.

DATA ANALYSES

The statistical analyses were evaluated using the SPSS Statistics 22.0 (IBM Corp., Armonk, New York, USA) program. The data were demonstrated as percentages (%) and means and standard deviations (±SD). The normality of data for the numerical variables was analysed using the Shapiro-Wilk test and the data were found to distribute normally. To compare the differences between the 2 groups was used of the independent t-test, and the One-way Anova test was used to compare the differences between the 2 groups. Tukey HSD test was used as a multiple comparison test in case of a difference in the result of the One-way Anova test. The relationships between numerical variables were analyzed by Pearson Correlation Analysis. In univariate analyses, variables with $p<0.10$ values were included in the Linear Regression Model. Categorical variables were taken as dummy variables in the regression analysis. The variables in the final model were determined by the stepwise method. Shapiro Wilk normality test, Q-Q plot for normality of residuals and tolerance and Variance inflammation factor (VIF) statistics for collinearity were used for suitability of the established model for linear regression analysis. The necessary assumptions for the established model were found to be provided. $p<0.05$ value was considered statistically significant for final (final) model of the regression analysis in univariate analyses.

ETHICS APPROVAL

Ethics committee approval was received from the Non-Invasive Clinical Studies Ethics Committee of Mehmet Akif Ersoy University to conduct this study (date: January 03, 2018, no: GO2018/4). Before data were collected, the aim of study was explained to children with T1DM and their families by the researchers, and their oral and written consent was obtained. The study complies with the Declaration of Helsinki.

RESULTS

CHARACTERISTICS OF THE CHILDREN WITH T1DM

The mean age of 111 children with T1DM was 12.3±1.5 years, and 55.9% of the participants were females. Results showed that 64.0% of the children had a medium economic condition, and 57.7% lived in the city center. The average age of mothers of children with T1DM was 37.5±5.8 years, and the education level of 39.6% was a primary school. The mean age of fathers was 41.8±6.0 years, and 36.0% were high school graduates (Table 1).

Participating children's daily TV viewing time was 2.1±1.2 hours/day; their daily sleep duration was 8.2±1.4 hours/day; the diagnosis time of diabetes was 4.9±2.8 years; and their HbA1c levels were 8.6±1.8%. In addition, 13.5% of the children had diseases other than diabetes mostly accompanied by celiac disease. It was also found that 97.2% of the insulin treatment was taken as multiple daily injections, and the total daily insulin doses were 0.8±0.2 IU/day/kg. According to the anthropometric measurements, body weight for age was -0.50±1.39 SDS, height for age was -0.24±0.92 SDS, and BMI was -0.24±1.23 SDS. Besides, 72.1% of the children in the study stated that they adhered to nutrition therapy, 84.7% did physical activities regularly, and 97.3% had regular follow-ups every 3 months.

PA LEVELS OF THE CHILDREN WITH T1DM AND THEIR EFFECTS ON HBA1C LEVELS

The mean PAQC of children with T1DM was found 2.75±0.6, and they had moderate-level PA. According to the socio-demographic characteristics of the children, there was no statistically significant difference between the groups in terms of PAQC averages according to gender, economic status, place of residence, and mother's education level. The PAQC averages of the children were found to differ between the groups only according to the education level of fathers, and the illiterate ones had the lowest average score (Table 1). In Table 1, PA levels are given according to the sociodemographic characteristics of the children. PA levels of children with T1DM had no statistically significant difference according to gender, economic status, place of residence, and education level of parents (Table 1).

Table 2 shows the PAQC averages and PA levels of children with T1DM according to the characteristics related to disease management. PAQC averages were found to show a statistically significant difference between the groups according to daily blood glucose measurements and regular follow-ups for 3 months. Children with T1DM who reportedly adapted to medical nutrition therapy had higher PAQC averages than those who did not. However, there was no statistically significant difference between the PA levels of children who adapted to medical nutrition therapy. On the other hand, children with T1DM who stated that they did physical activities regularly had higher PAQC averages and moderate PA levels than those who didn't do physical activities regularly (Table 2).

No statistically significant relationships were found between the age, maternal age, fathers' age, duration of diagnosis of diabetes, HbA1c levels, BMI values and daily TV viewing time, and PAQC averages ($p>0.05$). A negative and moderate relationship was found between the total daily insulin dose and the mean of PAQC (rho=-0.305, $p=0.001$). In addition, a negative and weak correlation was found between the PAQC averages of children with T1DM and the daily sleep duration (rho=-0.200, $p=0.036$).

In single analyses between all variables and PAQC means, variables with significance values of $p<0.10$ were included in the regression model. Results showed that fathers' education level, adherence to medical nutrition therapy, regular PA, total daily insulin dose, and daily sleep duration were related variables on PAQC averages in children with T1DM. It was determined that regular PA, total daily insulin dose, and sleep duration explained 26.6% of the PA level score averages. Those who did not do regular physical activities were found to have 0.675 times less PAQC average than those who did. It was found that a 1-unit increase in the PAQC means caused a 0.012-fold decrease in total insulin dose and a 0.125-fold decrease in daily sleep duration (Table 3).

TABLE 1: Children's physical activity scores and levels according to their sociodemographic characteristics.

		Low		Moderate		Vigorious		Total		
	PAQC $\bar{x}$±SD (minimum-maximum)	n	%	n	%	n	%	n	%	p value***
Gender										
Female	2.7±0.5 (1.3-4.1)	16	51.6	32	62.7	14	48.3	62	55.9	0.390
Male	2.7±0.7 (1.1-4.5)	15	48.4	19	37.3	15	51.7	49	44.1	
p value*	0.841									
Income level										
High	2.8±0.6 (1.8-4.5)	7	22.6	19	37.3	11	37.9	37	33.3	0.505
Middle	2.7±0.6 (1.1-4.1)	23	74.2	30	58.8	18	62.1	71	64.0	
Low	2.1±0.6 (1.4-2.5)	1	3.2	2	3.9	-	-	3	2.7	
p value**	0.145									
Place of residence										
City	2.7±0.6 (1.1-3.9)	18	58.0	30	58.8	16	55.2	64	57.7	0.976
Town	2.7±0.7 (1.5-4.5)	11	35.5	16	31.4	10	34.5	37	33.3	
Village	2.7±0.7 (1.4-4.1)	2	6.5	5	9.8	3	10.3	10	9.0	
p value**	0.900									
Mother's education level										
Illiterate	3.0±0.6 (2.0-3.8)	1	3.2	2	3.9	4	13.8	7	6.3	0.223
Primary school	2.6±0.6 (1.1-3.9)	16	51.6	19	37.3	9	31.0	44	39.6	
Secondary school	2.7±0.7 (1.4-4.1)	7	22.6	7	13.7	8	27.6	22	19.8	
High school	2.9±0.6 (2.1-4.5)	5	16.1	16	31.4	6	20.7	27	24.4	
University	2.7±0.4 (2.1-3.2)	2	6.5	7	13.7	2	6.9	11	9.9	
p value**	0.422									
Father's education level										
Illiterate	1.9±0.7 (1.1-2.6)[a]	2	6.4	2	3.9	-	-	4	3.7	0.071
Primary school	2.6±0.6 (1.8-4.1)[ab]	11	35.5	9	17.6	8	27.6	28	25.2	
Secondary school	3.0±0.8 (1.4-3.9)[b]	4	12.9	6	11.8	10	34.5	20	18.0	
High school	2.8±0.5 (1.7-4.5)[ab]	8	25.8	24	47.1	8	27.6	40	36.0	
University	2.6±0.6 (1.33-3.8)[ab]	6	19.4	10	19.6	3	10.3	19	17.1	
p value**	0.038									
Total	2.7±0.6 (1.1-4.5)	31	100.0	51	100.0	29	100.0	111	100.0	

*Independent samples t-test; **One-way Anova test; ***Chi-square test; Demonstrated the groups that led to a,b differences; SD: Standard deviation.

TABLE 2: Physical activity scores and levels of children with T1DM according to characteristics related to disease management.

		Low		Moderate		Vigorious		Total		
	Physical activity $\bar{x}$±SD (minimum-maximum)	n	%	n	%	n	%	n	%	p value***
Insulin treatment type										
Multiple daily injections	2.7±0.6 (1.1-4.5)	31	100.0	48	94.1	29	100.0	108	97.3	-
Insulin pumps	2.7±0.3 (2.4-3.1)	-	-	3	5.9	-	-	3	2.7	
p value*	-									
Adherence to medical nutrition treatment										
Those who adhere	2.8±0.6 (1.3-4.1)	18	58.1	39	76.5	23	79.3	80	72.1	0.118
Those who do not adhere	2.5±0.7 (1.1-4.5)	13	41.9	12	23.5	6	20.7	31	27.9	
p value*	0.046									
Daily blood glucose measurement										
Once	2.7±0.6 (2.1-3.6)	2	6.5	2	3.9	2	7.0	6	5.4	0.924
Twice	2.7±0.6 (1.9-3.8)	5	16.1	7	13.7	5	17.2	17	15.3	
4 times and more	2.7±0.7 (1.1-4.5)	21	67.7	32	62.8	17	58.6	70	63.1	
Other*	2.7±0.6 (1.1-4.5)	3	9.7	10	19.6	5	17.2	18	16.2	
p value**	0.993									
Doing physical activities regularly										
Those who do regularly	2.8±0.6 (1.4-4.5)	19	61.3	46	90.2	29	100.0	94	84.7	<0.001
Those who do not do regularly	2.1±0.4 (1.1-3.1)	12	38.7	5	9.8	-	-	17	15.3	
p value**	<0.001									
Having regular follow-ups every three months										
Those who do	2.7±0.6 (1.1-4.5)	30	96.8	50	98.0	28	96.6	108	97.3	0.905
Those who do not	2.6±0.5 (2.3-3.2)	1	3.2	1	2.0	1	3.4	3	2.7	
p value**	0.827									
Total		31	100.0	51	100.0	29	100.0	111	100.0	

T1DM: Type 1 diabetes mellitus; *Independent samples t-test; **One-way Anova test; ***Chi-square test; SD: Standard deviation.

TABLE 3: Regression analysis results for physical activity levels in children with Type 1 diabetes mellitus.

Variables	Regression coefficients					Collinearity statistics		95.0% confidence interval for B	
	β	se	z(β)	t	p	Tolerance	VIF	Lower bounds	Upper bounds
Constant	4.356	0.375		11.625	<0.001				
Physical activity									
Those who do it regularly	Ref								
Those who do not do it regularly	-0.675	0.154	-0.363	-4.389	<0.001	0.974	1.027	-0.980	-0.370
Total insulin dose	-0.012	0.004	-0.291	-3.467	0.001	0.947	1.056	-0.019	-0.005
Daily sleep time	-0.125	0.039	-0.263	-3.177	0.002	0.971	1.030	-0.202	-0.047

VIF: Variance inflammation factor; Variables modelled: Father education level, adherence to medical nutrition therapy, regular physical activity, total daily insulin, daily sleep duration
Model Summary: F=14.310; p<0.001; R^2=0.286; Adj R^2=0.266.

DISCUSSION

PA is one of the cornerstones of T1DM treatment, and healthy children are recommended to perform moderate-level physical activities daily. The children with T1DM in this study were found to perform a moderate-level PA. The literature reports that PA levels of children decrease with age, which is reported to be more apparent, particularly in the adolescence period.[3,18,19] This study found no relationships between age and PA. The reason for this may be that we have a relatively narrow age range compared to the literature.

Gender is one of the most important factors affecting the PA levels of children with T1DM. Studies show that PA levels of children with T1DM differ between genders, and girls have lower PA levels than boys.[18,20] Another study in the literature reported no differences in PA participation of children with T1DM according to gender.[21] The present study found that PAQC mean scores and PA levels of children with T1DM didn't differ between genders.

Parents are the greatest help in the disease management of children with T1DM. The education level of parents could affect children's PA levels. Civil et al. reported that there was no relationship between parents' education level and children's PA participation.[21] The study conducted by Valerio et al. reported that fathers' education level was positively associated with sports participation of children with T1DM.[22] Although fathers' education level was found to have no effects in the regression model, preliminary analyses showed that the lowest PAQC mean scores belonged to children whose fathers were illiterate. As the father's education level increases, his socio-economic status increases. High economic status of the father may enable fathers to provide more support and participation in PA both in and out of school.[23-25] In addition, educated fathers can understand the importance of exercise in the treatment of diabetes and support the child's exercise. Although the present study found no effects of economic condition on children's PAQC mean scores, future studies could determine family income numerically to investigate its effect.

One of the important findings of this study is that there is no correlation between the PAQC mean scores of children with T1DM and their HbA1c levels. Previous studies report controversial results about the effects of PA on HbA1c in children with T1DM. While some studies reported that PA decreased HbA1c, some others, similar to the present study, reported that there was no relation between PA and HbA1c levels.[7-12,22,26-28] Different HbA1c values could be caused by the different duration, type, and intensity of the physical activities as well as the age groups of the children in this study. Besides, the lack of effects of PA on the HbA1c value could be associated with various factors affecting glycemic conditions

such as different medical nutrition treatments, insulin doses used, medical follow-ups, stress levels, and having more carbohydrates with hypoglycemia fear, etc. This study was conducted in the autumn and winter months, which could be another factor affecting the findings. Hence, HbA1c levels are reported to demonstrate changes depending on seasons. HbA1c levels are reported to change due to factors such as the increase in food consumption, decrease in PA and insulin sensitivity, increase in the frequency of infectious diseases, etc.[29,30] On the other hand, the lack of effect of PA on HbA1c level could be associated with children's not comprehending the importance of PA and not seeing it as a main component of the treatment.

Generally, aerobic exercise decreases blood glucose levels; anaerobic exercise or vigorous aerobic exercises increase blood glucose levels; and resistance activities are associated with relative glucose stability. Therefore, carbohydrate intake and daily insulin doses may need to be managed.[3-5] Some studies reported that the increase in PA of children with T1DM decreased daily insulin doses while some others reported no changes.[7-12,22,26-28] In this study, although it was determined that the daily total insulin dose decreased as the PA level of children with T1DM increased, it was observed that the correlation coefficient with PA was not high.

This study detected no relationships between children's PAQC mean scores and their BMI. The literature on children with T1DM includes studies demonstrating an association between low PA levels and higher BMI values as well as the ones indicating no relationships.[7-12,22,26-28] Differences between the studies in the literature and the findings in this study could be caused by the methodological differences, differences in the duration and frequency of physical activities, and data collection performed in the autumn-winter months. Hence, the majority of the studies were experimental studies, so the exercise types and durations were different and PA levels could demonstrate seasonal changes.[7-12,22,26-30]

Sleep is one of the important factors affecting the disease management of children with T1DM. American Academy of Sleep Medicine reports that school-age children and adolescents should sleep 9-12 hours and 8-10 hours, respectively.[31] Children with T1DM are reported to sleep 26.6 minutes less than their peers with no diabetes, and the total sleep duration of children with T1DM is reported to be between 6.2 and 7.2 hours.[32,33] Total sleep duration of children in this study is reported to be 8.2±1.4 hours/day. Similar to the findings of this study, Aslan and Saka also reported that activity levels decreased as the sleep duration increased in children with T1DM.[34]

Different findings of this study could be associated with a different objective and subjective methods utilized in studies in the literature. Besides, the longer sleep duration of the children in this study might have effects on their decreased PA levels.

LIMITATIONS

The limitations of this study; it was conducted at one center and relatively with small sample size. It did not assess the whole year; it utilized a cross-sectional method. For glucose monitoring wasn't used to continuous blood glucose monitoring. PA levels, the sleep duration and screen time duration of children with T1DM were determined based on participating children's self-report. It would be helpful to get the opinion of the parents as the child may give the wrong answer. This was the cross-sectional study. In order to make causal inferences about PA and related factors in children with T1DM, longitudinal studies are needed.

CONCLUSION

This study found that children with T1DM had a moderate level of PA. In correlation analysis; daily insulin dose decreased as the PA level increased and the PA averages increased as the daily sleep duration decreased. There was no relation between PA and HbA1c levels. However, future studies could utilize randomized controlled and prospective designs in a way to include the effects of various factors such as PA education and frequency, daily insulin dose, nutrition, seasonal changes, parent characteristics, etc.

Acknowledgements

The authors are grateful to the children with Type Diabetes Mellitus and their families for their participation in this study.

Source of Finance

During this study, no financial or spiritual support was received neither from any pharmaceutical company that has a direct connection with the research subject, nor from a company that provides or produces medical instruments and materials which may negatively affect the evaluation process of this study.

Conflict of Interest

No conflicts of interest between the authors and / or family members of the scientific and medical committee members or members of the potential conflicts of interest, counseling, expertise, working conditions, share holding and similar situations in any firm.

Authorship Contributions

Idea/Concept: *Nevin Uslu, Nihal Hatipoğlu;* ***Design:*** *Nevin Uslu;* ***Control/Supervision:*** *Nevin Uslu, Gül Direk, Zeynep Uzan Tatlı;* ***Data Collection and/or Processing:*** *Filiz Arıcan, Nurten Variyenli, Nurten Variyenli, Gül Direk, Zeynep Uzan Tatlı;* ***Analysis and/or Interpretation:*** *Nevin Uslu, Nihal Hatipoğlu;* ***Literature Review:*** *Nevin Uslu, Gül Direk, Zeynep Uzan Tatlı;* ***Writing the Article:*** *Nevin Uslu, Gül Direk, Zeynep Uzan Tatlı;* ***Critical Review:*** *Nevin Uslu, Gül Direk, Zeynep Uzan Tatlı,Filiz Arıcan, Nurten Variyenli, Nihal Hatipoğlu;* ***References and Fundings:*** *Nevin Uslu, Nihal Hatipoğlu, Filiz Arıcan, Nurten Variyenli;* ***Materials:*** *Nevin Uslu, Filiz Arıcan, Nurten Variyenli.*

REFERENCES

1. International Diabetes Federations. Diabetes Atlas 10th edition 2021. Cited: July 25, 2022. Available from: [Link]
2. International Diabetes Federations [Internet]. ©2022 diabetesatlas.org. [Cited: July 25, 2022]. Diabetes Atlas 10th edition 2021, Turkey Diabetes report 2000-2045. Available from: [Link]
3. American Diabetes Association Professional Practice Committee, Draznin B, Aroda VR, Bakris G, Benson G, Brown FM, Freeman R, et al. 14. Children and Adolescents: Standards of Medical Care in Diabetes-2022. Diabetes Care. 2022;45(Suppl 1):S208-31. [Crossref] [PubMed]
4. Adolfsson P, Riddell MC, Taplin CE, Davis EA, Fournier PA, Annan F, et al. ISPAD Clinical Practice Consensus Guidelines 2018: Exercise in children and adolescents with diabetes. Pediatr Diabetes. 2018;19 Suppl 27:205-26. [Crossref] [PubMed]
5. T.C. Sağlık Bakanlığı Halk Sağlığı Genel Müdürlüğü. Çocukluk Çağı Diyabeti Eğitimci Rehberi. Sağlık Bakanlığı Yayın No: 1178. Ankara: Alban Tanıtım; 2020. [Link]
6. Riddell MC, Gallen IW, Smart CE, Taplin CE, Adolfsson P, Lumb AN, et al. Exercise management in type 1 diabetes: a consensus statement. Lancet Diabetes Endocrinol. 2017;5(5):377-90. [Crossref] [PubMed]
7. MacMillan F, Kirk A, Mutrie N, Matthews L, Robertson K, Saunders DH. A systematic review of physical activity and sedentary behavior intervention studies in youth with type 1 diabetes: study characteristics, intervention design, and efficacy. Pediatr Diabetes. 2014;15(3):175-89. [Crossref] [PubMed]
8. Absil H, Baudet L, Robert A, Lysy PA. Benefits of physical activity in children and adolescents with type 1 diabetes: a systematic review. Diabetes Res Clin Pract. 2019;156:107810. [Crossref] [PubMed]
9. Kennedy A, Nirantharakumar K, Chimen M, Pang TT, Hemming K, Andrews RC, et al. Does exercise improve glycaemic control in type 1 diabetes? A systematic review and meta-analysis. PLoS One. 2013;8(3):e58861. [Crossref] [PubMed] [PMC]
10. Quirk H, Blake H, Tennyson R, Randell TL, Glazebrook C. Physical activity interventions in children and young people with Type 1 diabetes mellitus: a systematic review with meta-analysis. Diabet Med. 2014;31(10):1163-73. [Crossref] [PubMed] [PMC]
11. McCarthy MM, Funk M, Grey M. Cardiovascular health in adults with type 1 diabetes. Prev Med. 2016;91:138-43. [Crossref] [PubMed] [PMC]
12. Miculis CP, De Campos W, da Silva Boguszweski MC. Correlation between glycemic control and physical activity level in adolescents and children with type 1 diabetes. J Phys Act Health. 2015;12(2):232-7. [Crossref] [PubMed]
13. Roberts AJ, Yi-Frazier JP, Carlin K, Taplin CE. Hypoglycaemia avoidance behaviour and exercise levels in active youth with type 1 diabetes. Endocrinol Diabetes Metab. 2020;3(3):e00153. [Crossref] [PubMed] [PMC]
14. Crocker PR, Bailey DA, Faulkner RA, Kowalski KC, McGrath R. Measuring general levels of physical activity: preliminary evidence for the Physical Activity Questionnaire for Older Children. Med Sci Sports Exerc. 1997;29(10):1344-9. [Crossref] [PubMed]
15. Bervoets L, Van Noten C, Van Roosbroeck S, Hansen D, Van Hoorenbeeck K, Verheyen E, et al. Reliability and Validity of the Dutch Physical Activity Questionnaires for Children (PAQ-C) and Adolescents (PAQ-A). Arch Public Health. 2014;72(1):47. [Crossref] [PubMed] [PMC]
16. Erdim L, Ergün A, Kuğuoğlu S. Reliability and validity of the Turkish version of the Physical Activity Questionnaire for Older Children (PAQ-C). Turk J Med Sci. 2019;49(1):162-9. [Crossref] [PubMed] [PMC]
17. Pediatric Endocrinology and Diabetes Association [Internet]. ©2016-2022 Infomedika. [Cited: July 23, 2022]. TPEDS Metrıcs, 2022.
18. Aman J, Skinner TC, de Beaufort CE, Swift PG, Aanstoot HJ, Cameron F; Hvidoere Study Group on Childhood Diabetes. Associations between physical activity, sedentary behavior, and glycemic control in a large cohort of adolescents with type 1 diabetes: the Hvidoere Study Group on Childhood Diabetes. Pediatr Diabetes. 2009;10(4):234-9. [Crossref] [PubMed]
19. Roberts AJ, Taplin CE, Isom S, Divers J, Saydah S, Jensen ET, et al. Association between fear of hypoglycemia and physical activity in youth with type 1 diabetes: The SEARCH for diabetes in youth study. Pediatr Diabetes. 2020;21(7):1277-84. [Crossref] [PubMed] [PMC]
20. Särnblad S, Ekelund U, Aman J. Physical activity and energy intake in adolescent girls with Type 1 diabetes. Diabet Med. 2005;22(7):893-9. [Crossref] [PubMed]
21. Civil T, Gündüz N, Ersöz G, Koz M, Emeksiz H, Gören Atalay N. 6-17 yaş Tip 1 diyabetli hastalarin fiziksel ve sportif aktivitelere katilimlarinin bir takim değişkenler açisindan incelenmesi [Examination of participation in physical activity of with 6-17 age type 1 diabetes patients in terms of team variables]. Hacettepe University Faculty of Health Sciences Journal. 2019;6(2):139-50. [Crossref]

22. Valerio G, Spagnuolo MI, Lombardi F, Spadaro R, Siano M, Franzese A. Physical activity and sports participation in children and adolescents with type 1 diabetes mellitus. Nutr Metab Cardiovasc Dis. 2007;17(5):376-82. [Crossref] [PubMed]

23. Durkaya M, Hüsnüoğlu N. İstihdamda eğitimin rolü [The role of education in employment]. Journal of Social Sciences and Humanities Researches. 2018;19(41):51-70. [Link]

24. Galobardes B, Shaw M, Lawlor DA, Lynch JW, Davey Smith G. Indicators of socioeconomic position (part 1). J Epidemiol Community Health. 2006;60(1):7-12. [PubMed] [PMC]

25. Kantomaa MT, Tammelin TH, Näyhä S, Taanila AM. Adolescents' physical activity in relation to family income and parents' education. Prev Med. 2007;44(5):410-5. [Crossref] [PubMed]

26. Ostman C, Jewiss D, King N, Smart NA. Clinical outcomes to exercise training in type 1 diabetes: a systematic review and meta-analysis. Diabetes Res Clin Pract. 2018;139:380-91. [Crossref] [PubMed]

27. Aljawarneh YM, Wardell DW, Wood GL, Rozmus CL. A systematic review of physical activity and exercise on physiological and biochemical outcomes in children and adolescents with type 1 diabetes. J Nurs Scholarsh. 2019;51(3):337-45. [Crossref] [PubMed]

28. Tonoli C, Heyman E, Roelands B, Buyse L, Cheung SS, Berthoin S, et al. Effects of different types of acute and chronic (training) exercise on glycaemic control in type 1 diabetes mellitus: a meta-analysis. Sports Med. 2012;42(12):1059-80. [Crossref] [PubMed]

29. Melin EO, Thunander M, Landin-Olsson M, Hillman M, Thulesius HO. Depression, smoking, physical inactivity and season independently associated with midnight salivary cortisol in type 1 diabetes. BMC Endocr Disord. 2014;14:75. [Crossref] [PubMed] [PMC]

30. Mianowska B, Fendler W, Szadkowska A, Baranowska A, Grzelak-Agaciak E, Sadon J, et al. HbA(1c) levels in schoolchildren with type 1 diabetes are seasonally variable and dependent on weather conditions. Diabetologia. 2011;54(4):749-56. [Crossref] [PubMed] [PMC]

31. Paruthi S, Brooks LJ, D'Ambrosio C, Hall WA, Kotagal S, Lloyd RM, et al. Recommended amount of sleep for pediatric populations: a consensus statement of the American Academy of Sleep Medicine. J Clin Sleep Med. 2016;12(6):785-6. [Crossref] [PubMed] [PMC]

32. Reutrakul S, Thakkinstian A, Anothaisintawee T, Chontong S, Borel AL, Perfect MM, et al. Sleep characteristics in type 1 diabetes and associations with glycemic control: systematic review and meta-analysis. Sleep Med. 2016;23:26-45. [Crossref] [PubMed]

33. Griggs S, Redeker NS, Grey M. Sleep characteristics in young adults with type 1 diabetes. Diabetes Res Clin Pract. 2019;150:17-26. [Crossref] [PubMed] [PMC]

34. Aslan B, Saka M. Tip 1 diyabetli adölesan bireylerde uyku kalitesi ve beslenme durumu arasındaki ilişkinin belirlenmesi [Determination of the relationship between sleep quality and nutritional status in adolescents with type 1 diabetes]. Journal of Health Sciences. 2020;29(1):7-13. [Crossref]