Observational Study

Medicine®

OPEN

Sedentary behaviors in children and adolescents with type 1 diabetes, depending on the insulin therapy used

Ewelina Czenczek-Lewandowska, PhD[a,*], Justyna Leszczak, PhD[a], Aneta Weres, PhD[a], Joanna Baran, PhD[a], Justyna Wyszyńska, PhD[a], Joanna Grzegorczyk, PhD, MD[a], Bogumił Lewandowski, DDS, PhD[a], Artur Mazur, MD[a,b]

Abstract

Assessment of sedentary behaviors in children and adolescents with type 1 diabetes (T1D), relative to the method of insulin therapy used, and in comparison to healthy controls.

The study group consisted of 215 children with T1D, including 109 (50.7%) insulin pen and 106 (49.3%) insulqsain pump users. The control group comprised 115 healthy children. The subjects' sedentary time was measured with a tri-axial accelerometer ActiGraph GT3X+, used continuously for 7 days.

The diabetes group was characterized by a significantly higher "% in sedentary time" score ($P = .024$) and a lower "mean daily breaks in sedentary time" result ($P = .007$), which means that they spent much more time on sedentary activities compared to the control group. There were no significant differences between the children using insulin pump and insulin pen in the "% in sedentary time" score ($P = .294$) and "mean daily breaks in sedentary time" ($P = .251$).

The T1D is a serious encumbrance, leading to longer duration of sedentary time, in comparison to healthy controls. The type of insulin therapy did not significantly affect the percentage of the wear-day spent in sedentary time and mean daily breaks in sedentary time.

Abbreviation: T1D = type 1 diabetes.

Keywords: insulin pen, insulin pump, insulin therapy, sedentary activity, type 1 diabetes

1. Introduction

Insufficient physical activity observed in society and the related adverse health consequences are reflected by the fact that today problems associated with public health worldwide are connected with an increasing incidence of cardiovascular, neoplastic, and metabolic diseases, also affecting young populations.[1] This problem is magnified particularly in the case of children and adolescents with chronic conditions, for example, type 1 diabetes (T1D), since these constitute a significant burden, contributing to their insufficient daily engagement in physical activity.[2,3]

Like in the case of childhood obesity, T1D is a problem faced by a growing number of young children worldwide.[4,5] The condition poses a significant challenge to children and adolescents as they find it difficult to follow the necessary discipline and change their lifestyles to control their diabetes. The disease is associated with numerous duties; those affected must regularly conduct blood glucose tests, follow a diet, and apply insulin therapy.[6] All of these challenging aspects of diabetes may adversely affect relations with peers, lead to difficulties at school, impair the quality of sleep, cause mood swings, and disturb daily functioning. There is a risk that the necessity to regularly administer insulin, using an insulin pump or pen, may adversely affect involvement in physical activity, which is of great importance from the viewpoint of diabetes management. In addition to the obligatory insulin therapy and customized diet, it is recognized that indispensable elements of diabetes control include sufficient physical activity and reduced sedentary time, with a maximum duration of 2 hours per day.[7] According to the guidelines defined by the American Academy of Pediatrics Policy Statement (2016) sedentary time in excess of 1.5 hours per day is considered to pose a risk of obesity in children aged 4 to 9 years.[8]

The existing literature on the sedentary behavior of children with T1D describes above all too frequent (>2 hour per day) spending of free time on watching TV, electronic media use and computer use. Much less research has been carried out on the total daily sedentary time spent, with regard to the method of applied insulin therapy, hence the results presented add to this small number.[9]

Editor: Hidetaka Hamasaki.

The authors have no funding and conflicts of interest to disclose.

[a] Faculty of Medicine, University of Rzeszów, [b] Clinical Provincial Hospital No. 2, Rzeszów, Poland.

[*] Correspondence: Ewelina Czenczek-Lewandowska, Institute of Physiotherapy, University of Rzeszów, Al. Kopisto 2A, 35-959 Rzeszów, Poland (e-mail: e.czenczek@univ.rzeszow.pl).

Medicine (2019) 98:19(e15625)

Received: 7 February 2019 / Received in final form: 27 March 2019 / Accepted: 17 April 2019

http://dx.doi.org/10.1097/MD.0000000000015625

Devices used in insulin therapy are constantly being improved, their dimensions are being reduced, and they require less involvement from patients.[10] The related developments and the growing effectiveness of contemporary medicine are likely to continuously improve the quality of life of those affected by diabetes.[11] It is, however, necessary to find out in what way children and adolescents cope with their obligatory daily insulin therapy, and in what way the necessity to regularly wear an insulin pump or to perform injections affect their physical functioning, including their sedentary behaviors.[12]

The aims of the study were the assessment of sedentary behaviors in children and adolescents with T1D, relative to the method of insulin therapy used, and in comparison to healthy controls.

2. Materials and methods

2.1. Participants

At the start, the study took into account 451 children, including 286 patients with T1D receiving treatment in the children's Diabetes Clinic in a Clinical Provincial Hospital, and 165 healthy children constituting the control group. The final analyses did not take into account children under 6 years old who were in preschool education, diagnosed with T1D with the condition <1 year before the start of the study, diagnosis of type 2 diabetes, other specific subtypes of diabetes, for example, latent autoimmune diabetes in adults, monogenic diabetes, endocrinopathy, diseases of the exocrine part of the pancreas, other chronic comorbid diseases, for example, Down syndrome or cystic fibrosis, children with current complications in the course of T1D. Also, children were excluded who did not provide informed consent, those who failed to meet the requirements of the study design, that is, they wore the accelerometer for <500 minutes during a minimum of 4 out of the 7 days of the study, and those who were ill during the study. An additional criterion for inclusion in the study group was a minimum duration of insulin therapy with the current method (at the time of the study), which had to be at least 6 months. The measurements were not conducted during the summer break, holidays, or periods of extremely bad weather. Ultimately the eligibility criteria were met by 330 school-age children. The sample size was calculated with reference to the total number of children with T1D living in the south-eastern region of the country where the study was conducted, with a 95% confidence level and a confidence interval of 0.05.

2.2. Procedures

Sedentary behaviors were assessed using a tri-axial accelerometer ActiGraph wGT3X-BT Monitor (ActiGraph, Pensacola, FL), worn in the hip-waist area and attached with a flexible strap. The measurements were carried out for 7 consecutive days, but not at night time, or during activities involving contact with water, that is, bathing and swimming. During each procedure, informed consent was provided in writing by the parent and orally by the child, subsequently the accelerometer was installed and then information on the use of the device was given to the parent and the child. The same routine was applied in the case of the healthy controls.

The accelerometers were programmed to apply the sampling rate of 30 Hz, and the data were reintegrated into 10 seconds epochs. The parameters representing sedentary time, that is, "number of breaks in sedentary time," "total duration of breaks in sedentary time," "mean duration of breaks in sedentary time," "maximum duration of breaks in sedentary time," "mean daily breaks in sedentary time," "% of sedentary time," and "total duration of the device recording" were computed using the dedicated Actilife software (Actilife software, version 6.8.3; ActiGraph).

The data were calculated in the time unit (min/h) following the algorithm Freedson Children (2005) and as percentage values, as defined by the algorithm Evenson Children (2008). The minimum required duration of accelerometer recording was >500 minutes, in 4 out of the 7 days of the study.

Using standard count-based intensity threshold values, the determination "% of sedentary time" is the percentage of the wear-day spent in sedentary time at <100 cpm activity counts/min.[13] The number of "breaks in sedentary time" is the total number of breaks in sedentary activity of at least 1 minute, where the accelerometer registers ≥100 counts/min.[14] It should be understood that the higher the number of breaks in sedentary time, the fewer the extended periods of sedentary time, which are the so-called "breaking sedentary time."[15] The "total duration of breaks in sedentary time" means the total length of time in all breaks in sedentary time in minutes and hours, the "mean duration of breaks in sedentary time" is the average length of "breaks in sedentary time," the "maximum duration of breaks in sedentary time" is the length of the longest "break in sedentary time," the "mean daily breaks in sedentary time" is the total length of "breaks in sedentary time" divided by the total valid days in the dataset.[16]

Participation in the study was voluntary and anonymous. The patients signed an informed consent to participate in the study. The research project was approved by the Local Bioethics Commission, resolution no. 17/12/2015.

2.3. Statistical analysis

Descriptive statistics, that is, mean and median values, were calculated for all the numerical variables. The numerical characteristics in the 2 populations were examined for differences in the average levels by using the nonparametric Mann–Whitney U test. Statistical significance was assumed at $P < .05$. Statistical analyses were computed using Statistica 10.0 from StatSoft, based on data records from a minimum of 4 valid days of the study.

3. Results

3.1. Characteristics of the subjects

The analysis of the results included 330 children and adolescents with T1D of ages 6 to 18 years old. The DIABETES group consisted of 215 children with T1D (from 6 to 18 years/o ± 3.26 standard deviation [SD], mean age 12.61 ± 3.26 years), including 109 insulin pen users (50.7%) and 106 insulin pump users (49.3%); the CONTROL group comprised 115 healthy children (7–18 years/o ± 2.76 SD, mean age 11.98 ± 2.76 years). The subjects with T1D included 119 girls (55.4%) and 96 boys (44.7%); in the control group there were 50 girls (43.5%) and 65

Table 1

Characteristics of the groups.

	Characteristics of the groups								
	Sex								
	Boys	n	%	Girls	n	%	Total	n	%
Pen		58	53.2		51	46.8		109	100
Insulin pump		38	35.9		68	64.2		106	100
Diabetes		96	44.7		119	55.4		215	100
Control		65	48.8		50	51.2		115	100
		$p_{(\text{diabetes vs control})}$						$\chi^2(1)=4.22,\ P=.039$	
		$p_{(\text{pen vs insulin pump})}$						$\chi^2(1)=6.55,\ P=.010$	

	Age, yrs							
	n	$\bar{x}$	Me	Min.	Max.	Q1	Q3	SD
Pen	109	12.37	13.00	6.00	18.00	10.00	15.00	3.26
Insulin pump	106	12.87	13.00	6.00	18.00	11.00	15.00	3.26
Diabetes	215	12.61	13.00	6.00	18.00	10.00	15.00	3.26
Control	115	11.98	12.00	7.00	18.00	10.00	14.00	2.76
	$p_{(\text{diabetes vs control})}$					$Z=2.13,\ P=.032$		
	$p_{(\text{pen vs insulin pump})}$					$Z=1.12,\ P=.259$		

	BMI, kg/m^2							
	n	$\bar{x}$	Me	Min.	Max.	Q1	Q3	SD
Pen	109	23.44	22.96	10.04	35.88	20.70	25.81	4.36
Insulin pump	106	24.31	24.05	16.29	36.97	20.35	27.27	4.65
Diabetes	215	23.87	23.23	10.04	36.97	20.47	26.99	4.52
Control	115	22.55	21.65	8.62	39.99	18.51	25.50	5.47
	$p_{(\text{diabetes vs control})}$					$Z=2.78,\ P=.005$		
	$p_{(\text{pen vs insulin pump})}$					$Z=1.19,\ P=.233$		

	Duration of insulin therapy with the current method, yrs							
	n	$\bar{x}$	Me	Min.	Max.	Q1	Q3	SD
Pen	109	3.57	3.00	0.50	13.50	1.50	4.00	3.08
Insulin pump	106	4.32	3.25	0.50	14.00	1.50	7.00	3.15
Diabetes	215	3.94	3.00	0.50	14.00	1.50	5.00	3.13
	$p_{(\text{pen vs insulin pump})}$					$Z=-1.97,\ P=.048$		

	Mean HBA1c (%) in the year preceding the study							
	n	$\bar{x}$	Me	Min.	Max.	Q1	Q3	SD
Pen	109	7.37	7.25	5.40	11.8	6.50	7.95	1.20
Insulin pump	106	7.40	7.25	5.60	11.4	6.65	7.85	1.03
Diabetes	215	7.38	7.25	5.40	11.8	6.55	7.90	1.12
	$p_{(\text{pen vs pump})}$					$Z=-0.49,\ P=.617$		

$\bar{x}$ = average, Me = median, n = number of participants, P = probability level, Q = quartile3, Q1 = quartile 1, SD = standard deviation, Z = result of Mann–Whitney U test.

boys (56.5%). Detailed characteristics of the group are presented in Table 1.

3.2. Sedentary time analysis

Statistically significant differences between the study group and the controls were identified in the following measures: "% in sedentary time" ($P=.024$), "number of breaks in sedentary time" ($P=.008$), "mean duration of breaks in sedentary time" ($P=.003$), and "mean daily breaks in sedentary time" ($P=.007$). In the study group, higher median values were observed for: "% in sedentary time" (Me = 73.34 vs 69.83) and "number of breaks in sedentary time" (Me = 42.78 vs 27). The median values in "mean duration of breaks in sedentary time" (Me = 4.78 hours vs 3.37 hours) and "mean daily breaks in sedentary time" (Me = 20.02 hours vs 19.32 hours) were higher in the control group (Table 2).

The rates representing sedentary behaviors were compared between the study subgroups – PEN and INSULIN PUMP. Statistically significant differences between the 2 groups were identified in the "mean duration of breaks in sedentary time" ($P=.043$) and "maximum duration of breaks in sedentary time" ($P=.022$). Higher median values were found in the case of the PEN subgroup (Table 3).

4. Discussion

Although today's children and adolescents have far more opportunities to keep active, they tend to prefer pastimes that do not require significant physical exertion, and they are less and less inclined to take exercise.[17] The presence of a chronic disease in developmental age is an additional burden; therefore, the problem of insufficient level of physical activity is especially concerning in the case of children with T1D.[18] Regular exercise

Table 2

Comparison of sedentary behaviors in the diabetes and the control groups.

Sedentary behavior rates/data from 7-d study		Diabetes group (n = 215)					Control group (n = 115)					*P*	
		$\bar{x}$	Me	Min.	Max.	SD	$\bar{x}$	Me	Min.	Max.	SD	*Z*	*P*
Number of breaks in sedentary time		42.78	42.78	1.00	203.00	30.84	33.20	27.00	5.00	134.00	22.24	**2.67**	**.008**
Total duration of breaks in sedentary time	min	7398.60	7828.60	1613.30	11,750.30	1662.17	7569.49	7948.10	3734.50	9297.80	1282.35	−0.80	.426
Mean duration of breaks in sedentary time	h	123.31	130.48	26.89	195.84	27.70	126.16	132.47	62.24	154.96	21.37		
	min	333.16	201.90	27.20	4226.80	442.30	341.77	286.80	45.10	1178.50	234.35	**−3.00**	**.003**
Maximum duration of breaks in sedentary time	h	5.55	3.37	0.45	70.45	7.37	5.70	4.78	0.75	19.64	3.91		
	min	1867.41	1476.50	533.10	6848.40	1106.82	1696.79	1393.40	659.80	5429.50	887.30	0.77	.443
Mean daily breaks in sedentary time	h	31.12	24.61	8.89	114.14	18.45	28.28	23.22	11.00	90.49	14.79		
	min	1175.84	1159.00	268.90	2553.10	290.55	1206.73	1201.00	686.90	1878.70	160.11	**−2.68**	**.007**
	h	19.60	19.32	4.48	42.55	4.84	20.11	20.02	11.45	31.31	2.67		
% in sedentary time		70.28	73.34	29.45	88.65	12.30	69.64	69.83	37.95	86.78	8.13	**2.25**	**.024**
Total duration of the device recording	min	5211.26	5322.42	2576.17	9399.67	1227.40	5119,93	5218,17	2792.92	8735.83	960.94	0.62	.535
	h	86.85	88.71	42.94	156.66	20.46	85.33	86.97	46.55	145.60	16.02		

$\bar{x}$ = average, Max. = maximal value, Me = median, Min. = minimal value, n = number of participants, *P* = probability level, SD = standard deviation, *Z* = result of Mann–Whitney *U* test.
Bold values are statistically significant.

is of particular importance in this disease, since it contributes to good physical condition, improves insulin sensitivity, lipid profile, and glycemic control, and reduces the risk of adverse cardiovascular complications.[19] As reported by Wilkie et al, approximately 2 in 3 children with T1D, aged 5 to 18, fail to engage in physical activity as recommended, and tend to have more sedentary time than their healthy peers.[20,21]

Although the present study shows no relationship between the insulin treatment method and sedentary behaviors, the children with T1D were found to spend significantly more time in sedentary activities, compared to their healthy peers. The diabetes group was characterized by a significantly higher "% in sedentary time" and a lower "mean daily breaks in sedentary time" result, which means that they spent much more time on sedentary activities than on exercise activities ≥100 counts/min. At the same time, children in the control group showed significantly higher scores in terms of "mean duration breaks in sedentary time" and "mean daily breaks in sedentary time," which means that both during the whole week and the daily average time spent actively physically ≥100 counts/min was significantly higher than in the group of children with T1D. It should be emphasized that the conclusions are primarily related to the parameters "mean daily break in sedentary time" and "% of sedentary time," because they are the most suitable for the analysis of the presented results.

The findings of the present study suggest that the lower physical activity of children with T1D may have resulted from

Table 3

Comparison of sedentary behaviors in the pen and insulin pump groups.

Sedentary behavior rates/ data from 7-d study		Insulin pen therapy (n = 109)					Insulin pump therapy (n = 106)					*P*	
		$\bar{x}$	Me	Min.	Max.	SD	$\bar{x}$	Me	Min.	Max.	SD	*Z*	*P*
Number of breaks in sedentary time		40.85	32.00	1.00	203.00	32.41	44.76	41.50	2.00	152.00	29.15	−1.54	.123
Total duration of breaks in sedentary time	min	7465.39	7845.80	1613.30	11,750.30	1569.22	7329.92	7814.25	2367.60	10,172.60	1757.47	0.23	.820
Mean duration of breaks in sedentary time	h	124.42	130.76	26.89	195.84	26.15	122.17	130.24	39.46	169.54	29.29		
	min	375.44	228.00	27.20	4226.80	505.64	289.68	176.45	39.50	2896.40	363.28	**2.02**	**.043**
Maximum duration of breaks in sedentary time	h	6.26	3.80	0.45	70.45	8.43	4.83	2.94	0.66	48.27	6.05		
	min	2034.54	1782.80	574.30	6378.90	1156.44	1695.54	1354.55	533.10	6848.40	1030.72	**2.29**	**.022**
Mean daily breaks in sedentary time	h	33.91	29.71	9.57	106.32	19.27	28.26	22.58	8.89	114.14	17.18		
	min	1203.00	1175.70	268.90	2553.10	295.32	1147.91	1151.90	473.50	2157.80	284.25	1.15	.251
	h	20.05	19.59	4.48	42.55	4.92	19.13	19.20	7.89	35.96	4.74		
% in sedentary time		69.00	72.94	29.45	88.65	13.50	71.60	74.27	29.61	88.24	10.84	−1.05	.294
Total duration of the device recording	min	5104.01	5268.08	2606.75	9300.00	1188.35	5321.55	5350.25	2576.17	9399.67	1262.41	−1.30	.195
	h	85.07	87.80	43.45	155.00	19.81	88.69	89.17	42.94	156.66	21.04		

$\bar{x}$ = average, Max. = maximal value, Me = median, Min. = minimal value, n = number of participants, *P* = probability level, SD = standard deviation, *Z* = result of Mann–Whitney *U* test.
Bold values are statistically significant.

other factors related to the disease. Jabbour et al described the most common exercise barriers in children and adolescents with T1D; according to the authors, these most importantly included loss of control of diabetes, fear of hypoglycemia, high temperature outside, and low fitness levels. The duty to perform insulin injections or to wear an insulin pump was not listed as one of the limitations.[22]

Many authors report an excessive tendency toward sedentary lifestyles in children with T1D. Even more concerning results were reported by Michaliszyn and Faulkner who focused on teenagers. Despite the small size of the study group, they showed results consistent with the current findings, saying that the teenagers spent 10 hours per day in sedentary activity, which accounted for 84% of the 16-week recording of their physical activity carried out by accelerometer.[23]

Similar results in a group of children with T1D were obtained by MacMillan et al, namely 10.2 ± 1.7 hours per day in sedentary activity, that is, $78.9 \pm 10.4\%$ of the entire accelerometer wear time. The older children tended to spend more time in sedentary activities than the younger ones. The children were most frequently involved in such activities as: watching TV/DVD, talking or texting on mobile phones, and using the Internet.[24]

On the contrary, Maggio et al carried out an interesting study comparing physical activity in children with various chronic conditions, including T1D. They established that in all of the study groups the existing chronic conditions adversely affected physical activity, in comparison to their healthy peers. Like in the present study, the children with T1D were found to spend 77% of their time in sedentary activities, compared to the significantly lower rate of 70% identified in the case of the healthy children; both of these results, however, are interpreted as unsatisfactory ($P < .01$).[25] Different results were obtained by Walker et al who reported that children with various chronic conditions, including T1D, and healthy children spent similar amounts of time in sedentary activities, watching TV, and playing computer games; in the study group these accounted for $76.5 \pm 7.1\%$ of the subjects' daily time.[26]

In a study conducted by Galler et al, young adults on average spent 2.9 ± 1.8 hours per day in front of TV or computer screens, which did not favorably affect glycemic control.[27] Likewise, Øverby et al emphasize the high number of subjects watching TV for more than 2 hours per day (43%), a factor which they closely associate with overweight and obesity among children and adolescents with T1D ($P = .002$).[28]

According to Mohammed et al, teenagers with T1D on average spend 2 hours lying down and resting, which is more than in the case of their healthy peers (1.3 hours, $P = .002$); these findings, however, are based on self-report questionnaires.[29] Nearly 54% of the adolescents with T1D, in a study by Kummer et al, report that they spend 1 to 2 hours daily in front of the TV, the relevant rate being identical among their healthy peers.[30]

A comparison of sedentary behaviors in children with T1D in relation to the insulin therapy method showed higher mean duration and maximum duration of "breaks in sedentary time" in the group of insulin pen users. However, the "total duration of breaks in sedentary time" and "% of sedentary time" did not differ considerably between the 2 groups, which suggests that the type of insulin therapy applied does not significantly affect sedentary behaviors.

The same conclusions were reached by Michaud et al, who carried out a study based on a self-administered questionnaire and found no significant disparities in sedentary habits and exercise barriers observed in children using an insulin pen or insulin pump. The researchers confirm that the level of physical activity was more affected by the fear of hypoglycemia than by the type of insulin therapy used.[31] Excessively frequent sedentary behaviors (on average 612 minutes per day) as well as lack of differences between groups of insulin pen and insulin pump users were also reported by MacMillan et al.[24]

The available data confirm that insufficient physical activity and excessive sedentary behaviors among children and adolescents with T1D are a widespread problem, increasingly common in younger age groups. In view of all the negative consequences of sedentary behaviors, and given the specificity of the disease, it is necessary to promote active lifestyles in educational campaigns addressing children and adolescents, taking into account their age and health status. Children who are naturally more active are also happier, healthier, and more willing to face new challenges; therefore, promotion of physical activity and efforts aimed at reducing sedentary behaviors in young people with chronic conditions is of utmost importance nowadays.[32]

The studied individuals did not supplement the accelerometer data by recording the type of activities in a physical activity diary. The technology used with accelerometry collect all forms of activity (sedentary, light, moderate, vigorous intensity) and is very useful in determining the total amount of activity; however, accelerometry does not record what types of behaviors are occurring during those intensities. Therefore, we are not able to present data on the types of sedentary activities, which typically include activities such as sitting or working quietly (e.g., reading, typing, listening to music, screen time, in a sitting position at a school desk during a lesson). Moreover, no consensus currently exists as to the most accurate accelerometer sedentary behavior cut-points for research with a pediatric population. In our study, we used cut-points that have been extensively used in pediatric research. Other accelerometer cut-points may have produced different findings.[33] In addition, a survey could be a helpful complementary tool that would provide more detailed knowledge in this area. It would be necessary to check the existing barriers in undertaking physical activity, for example, fear of hypoglycemia or loss of control of diabetes, or the form of transport that a child travels to and from school, for example, on foot or by motor transport. Other environmental factors would also be worth analyzing, such as the presence of a TV in the child's bedroom, or them having their own mobile phone, tablet, or other multimedia devices. Another limitation of the present study is failure to exclude children with T2D. Although the prevalence of pediatric T2D is increasing worldwide, it is still much less common compared with T1D.

5. Conclusion

The T1D is a serious encumbrance, leading to longer duration of sedentary time, in comparison to healthy controls. The type of insulin therapy did not significantly affect the percentage of the wear-day spent in sedentary time and mean daily breaks in sedentary time.

Author contributions

Conceptualization: Ewelina Czenczek-Lewandowska, Justyna Wyszyńska, Joanna Grzegorczyk, Artur Mazur.
Data curation: Ewelina Czenczek-Lewandowska, Justyna Leszczak, Artur Mazur.

Formal analysis: Aneta Weres, Justyna Wyszyńska, Bogumił Lewandowski.
Investigation: Ewelina Czenczek-Lewandowska, Artur Mazur.
Methodology: Ewelina Czenczek-Lewandowska, Aneta Weres, Bogumił Lewandowski, Artur Mazur.
Project administration: Justyna Leszczak, Aneta Weres, Joanna Baran, Justyna Wyszyńska, Joanna Grzegorczyk, Bogumił Lewandowski, Artur Mazur.
Resources: Ewelina Czenczek-Lewandowska, Aneta Weres, Joanna Baran, Justyna Wyszyńska, Joanna Grzegorczyk.
Supervision: Justyna Leszczak, Joanna Grzegorczyk, Bogumił Lewandowski, Artur Mazur.
Writing – original draft: Ewelina Czenczek-Lewandowska, Justyna Leszczak, Joanna Baran, Joanna Grzegorczyk.
Writing – review & editing: Ewelina Czenczek-Lewandowska, Justyna Leszczak, Joanna Baran.
Ewelina Czenczek-Lewandowska orcid: 0000-0001-6801-5290.

References

[1] Condello G, Puggina A, Aleksovska K. Behavioral determinants of physical activity across the life course: a "Determinants of Diet and Physical Activity" (DEDIPAC) umbrella systematic literature review. Int J Behav Nutr Phys Act 2017;14:58.
[2] Elmesmari R, Reilly JJ, Martin A, et al. Accelerometer measured levels of moderate-to-vigorous intensity physical activity and sedentary time in children and adolescents with chronic disease: a systematic review and meta-analysis. PLoS One 2017;12:e0179429.
[3] Durstine JL, Gordon B, Wang Z, et al. Chronic disease and the link to physical activity. J Sport Health Sci 2013;2:3–11.
[4] Mazur A, Matusik P, Revert K, et al. Childhood obesity: knowledge, attitudes, and practices of European pediatric care providers. Pediatrics 2013;132:e100–8.
[5] Matusik P, Małecka-Tendera E. Overweight prevention strategies in preschool children. Int J Pediatr Obes 2011;2:2–5.
[6] Malik FS, Taplin CE. Insulin therapy in children and adolescents with type 1 diabetes. Paediatr Drugs 2014;16:141–50.
[7] Sigal RJ, Armstrong MJ, et al. Canadian Diabetes Association Clinical Practice Guidelines Expert CommitteePhysical activity and diabetes. Can J Diabetes 2013;37:40–4.
[8] American Academy of PediatricsPolicy statement. Children, adolescents, and the media. Pediatrics 2013;132:958–61.
[9] Li C, Beech B, Crume T. Longitudinal association between television watching and computer use and risk markers in diabetes in the SEARCH for Diabetes in Youth Study. Pediatr Diabetes 2015;16:382–91.
[10] Schmidt S. New technologies in the treatment of type 1 diabetes. Dan Med J 2013;60:B4746.
[11] Galderisi A, Schlissel E, Cengiz E. Keeping Up with the Diabetes Technology: 2016 Endocrine Society Guidelines of Insulin Pump Therapy and Continuous Glucose Monitor Management of Diabetes. Curr Diab Rep 2017;17:111.
[12] Colberg SR, Laan R, Dassau E, et al. Physical activity and type 1 diabetes: time for a rewire? J Diabetes Sci Technol 2015;9:609–18.
[13] Tudor-Locke C, Camhi SM, Troiano RP. A catalog of rules, variables, and definitions applied to accelerometer data in the National Health and Nutrition Examination Survey, 2003-2006. Prev Chronic Dis 2012;9: E113.
[14] Jefferis BJ, Sartini C, Shiroma E, et al. Duration and breaks in sedentary behaviour: accelerometer data from 1566 community-dwelling older men (British Regional Heart Study). Br J Sports Med 2015;49:1591–4.
[15] Chastin SF, Egerton T, Leask C, et al. Meta-analysis of the relationship between breaks in sedentary behavior and cardiometabolic health. Obesity (Silver Spring) 2015;23:1800–10.
[16] How does Sedentary Analysis work? Available at: https://actigraphcorp.force.com. Accessed November 8, 2018
[17] Hallal PC, Andersen LB, Bull FC, et al. Global physical activity levels: surveillance progress, pitfalls, and prospects. Lancet 2012;380:247–57.
[18] Cliff DP, Hesketh KD, Vella SA. Objectively measured sedentary behaviour and health and development in children and adolescents: systematic review and meta-analysis. Obes Rev 2016;17:330–44.
[19] Anderson J, Couper JJ, Mpundu-Kaambwa C, et al. An extra 1,000 steps per day relates to improved cardiovascular health in children with type 1 diabetes. Diabetes Care 2016;39:e108–9.
[20] Wilkie L, Mitchell F, Robertson K, et al. Motivations for physical activity in youth with type 1 diabetes. Practical Diabetes 2017;34:151–5.
[21] Takken T. Chronic diseases, exercise, and physical activity in childhood: 2016 in review. Pediatr Exerc Sci 2017;29:57–9.
[22] Jabbour G, Henderson M, Mathieu ME. Barriers to active lifestyles in children with type 1 diabetes. Can J Diabetes 2016;40:170–2.
[23] Michaliszyn SF, Faulkner MS. Physical activity and sedentary behavior in adolescents with type 1 diabetes. Res Nurs Health 2010;33:441–9.
[24] MacMillan F, Kirk A, Mutrie N, et al. Physical activity and sedentary behaviour in Scottish youth with type 1 diabetes. Practical Diabetes 2014;31:228–33.
[25] Maggio AB, Hofer MF, Martin XE, et al. Reduced physical activity level and cardiorespiratory fitness in children with chronic diseases. Eur J Pediatr 2010;169:1187–93.
[26] Walker RG, Obeid J, Nguyen T, et al. Sedentary time and screen-based sedentary behaviors of children with a chronic disease. Pediatr Exerc Sci 2015;27:219–25.
[27] Galler A, Lindau M, Ernert A, et al. Associations between media consumption habits, physical activity, socioeconomic status, and glycemic control in children, adolescents, and young adults with type 1 diabetes. Diabetes Care 2011;34:2356–9.
[28] Øverby NC, Margeirsdottir HD, Brunborg C, et al. Physical activity and overweight in children and adolescents using intensified insulin treatment. Pediatr Diabetes 2009;10:135–41.
[29] Mohammed J, Deda L, Clarson CL, et al. Assessment of habitual physical activity in adolescents with type 1 diabetes. Can J Diabetes 2014;38:250–5.
[30] Kummer S, Stahl-Pehe A, Castillo K. Health behaviour in children and adolescents with type 1 diabetes compared to a representative reference population. PLoS One 2014;9:e112083.
[31] Michaud I, Henderson M, Legault L, et al. Physical activity and sedentary behavior levels in children and adolescents with type 1 diabetes using insulin pump or injection therapy - The importance of parental activity profile. J Diabetes Complications 2017;31:381–6.
[32] Sundberg F, Forsander G, Fasth A, et al. Children younger than 7 years with type 1 diabetes are less physically active than healthy controls. Acta Paediatr 2012;101:1164–9.
[33] Cain KL, Sallis JF, Conway TL, et al. Using accelerometers in youth physical activity studies: a review of methods. J Phys Act Health 2013;10:437–50.