

## Physical activity and the level of HbA1c in children and adolescents with type 1 diabetes mellitus

### Aktywność fizyczna a poziom HbA1C u dzieci i młodzieży chorych na cukrzycę typu 1

A – preparing concepts  
B – formulating methods  
C – conducting research  
D – processing results  
E – interpretation and conclusions  
F – editing the final version

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#### Abstract

*Introduction:* The correlation between physical activity and the level of HbA1c in children and adolescents with type 1 diabetes mellitus is poorly understood. This study sought to assess the effects of physical activity on the level of HbA1c. The results draw attention to the benefits of physical activity regarding general metabolism and HbA1c levels. Decreased HbA1c levels are associated with health benefits in patients with diabetes patients and result in a lower risk for a variety of potential health complications.

*Material and methods:* The research was carried out in 2014 and included 92 patients with type 1 diabetes mellitus (50 girls and 42 boys) aged 7-20 with a mean disease duration of 6.5 years who were being treated in a diabetes clinic in Olsztyn. To assess physical activity the International Health Behaviour in School-Aged Children (HBSC) survey was administered. Physical activity level was determined using both minutes of moderate/vigorous physical activity (MVPA) and vigorous physical activity (VPA). The study participants were divided into the following groups: A – physically active boys and girls (3 days a week or more) and B – physically inactive boys and girls (less than 3 days a week).

*Results:* The analysis of correlations between MVPA, VPA and HbA1c revealed that there were no statistically significant differences between physically active and inactive girls. However, there were slight differences in HbA1c levels in favour of active girls. The results of boys regarding MVPA and HbA1c demonstrated statistically significant differences between active and inactive boys, in favour of the active group. While analysing the results concerning the correlation between VPA and HbA1c in boys, no statistically significant differences were noted; however, the level of HbA1c was lower in active boys.

*Conclusions:* Contrary to boys, the majority of girls manifested reluctance to do physical activity. Girls and boys who were active had a slightly lower level of HbA1c than inactive individuals. Physical activity of the study participants did not reduce the level of HbA1c significantly.

**Key words:** adolescents, physical activity, children, HbA1c level, type 1 diabetes mellitus

#### Streszczenie

*Wstęp:* Związek między aktywnością fizyczną a poziomem HbA1c dzieci i młodzieży chorującej na cukrzycę typu 1. Starano się zbadać wpływ aktywności fizycznej na obniżenie poziomu HbA1c. Wyniki mają zwrócić uwagę na korzyści dotyczące ogólnej

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poprawy metabolizmu, poprawę poziomu HbA1c oraz szeroko rozumiane korzyści zdrowotne u cukrzyków, wynikające z obniżenia ryzyka wystąpienia ewentualnych powikłań zdrowotnych.

*Material and metody:* Badania przeprowadzono 2014 r. Objęto 92 pacjentów (50 dziewcząt i 42 chłopców) z poradni diabetologicznej w Olsztynie. Byli to chorzy z cukrzycą typu 1 w wieku 7-20 lat ze średnim czasem choroby 6,5 lat. Posłużono się międzynarodowym standardowym kwestionariuszem HBSC. Aktywność fizyczną wyznaczały wskaźniki: MVPA oraz VPA. Badanych podzielono na grupy: A – chłopcy i dziewczęta aktywni fizycznie (3 i powyżej 3 dni w tygodniu) oraz B – chłopcy i dziewczęta nieaktywni fizycznie (poniżej 3 dni w tygodniu).

*Wyniki:* Analizując związki pomiędzy MVPA, VPA a poziomem HbA1c stwierdza się, że nie występują różnice statystycznie istotne pomiędzy dziewczętami aktywnymi a nieaktywnymi fizycznie. Pomimo, to widać niewielkie różnice w poziomach HbA1c, na korzyść dziewcząt aktywnych. W wynikach chłopców dotyczących MVPA a HbA1c odnotowano niewielkie różnice statystycznie istotne pomiędzy chłopcami aktywnymi a nieaktywnymi na korzyść grupy aktywnej. Analizując wyniki VPA a HbA1c u chłopców nie stwierdzono różnic statystycznie istotnych, mimo to w grupie chłopców aktywnych poziom HbA1c jest niższy niż u nieaktywnych.

*Wyniki:* Dziewczęta wykazały w większości niechęć do aktywności fizycznej w przeciwieństwie do chłopców. Dziewczęta i chłopcy, którzy byli aktywni wykazali nieznacznie niższy poziom HbA1c niż osoby nieaktywne. Aktywność fizyczna badanych nie wpływa istotnie na obniżenie poziomu HbA1c.

**Słowa kluczowe:** młodość, aktywność fizyczna, dzieci, poziom HbA1c, cukrzyca typu 1

## Introduction

Diabetes mellitus is an increasing epidemiological problem and is considered a lifestyle disease. Current morbidity rate in the world population is estimated at approximately 2.8%. In 2006, there were 220 million people with diabetes mellitus. It is predicted that in 2025, the number of patients with diabetes will exceed 300 million (5.0-7.6% of the general population), while in the USA morbidity rate will have increased by over 165% by 2050. According to the estimates, 5% of the Polish population, i.e. approximately 2 million people, have diabetes mellitus [1-5].

At the turn of the 20<sup>th</sup> century, the first scientific findings regarding correlations between regular physical activity and lifespan were published. However, it was only in the second half of the 20<sup>th</sup> century that a breakthrough came in this field, which is exemplified by opinions such as those by Wojciech Drygas and Anna Jegier who stated that “the majority of doctors do not pay enough attention to the use of specific physical exercises in the prevention and treatment of chronic diseases and recommend increasing the amount of everyday physical activity too rarely. What is more, due to a large number of activities and duties, many of

us neglect our own health and physical fitness by conducting an inactive, sedentary lifestyle” [6].

In type 1 diabetes mellitus, physical activity is helpful in self-control and prophylaxis of this disease. Muscular effort increases the transport of glucose from the blood and extracellular matrix to the cells of working muscle. This process is independent from the activity of insulin. Moreover, physical effort decreases insulin resistance, i.e. increases the sensitivity of muscle cells to insulin [7-8]. For long-term glycemic control, it is helpful to determine the value of HbA1c (a fraction of adult hemoglobin, glycated hemoglobin), which makes it possible to assess the mean glycemic control over the long term. The value of HbA1c is given as a percentage of glucose-related hemoglobin found in erythrocytes. HbA1c also reflects mean glucose concentration in blood from the last 3 months [9].

The aim of the study was to examine the correlation between the level of glycated hemoglobin HbA1c and habitual physical activity performed by children and adolescents with type 1 diabetes mellitus.

The following research question was investigated in the study:

- What influence does physical activity exert on the level of glycated hemoglobin HbA1c in children and adolescents with type 1 diabetes mellitus?

## Material and methods

The research was conducted in the first quarter of 2014. The study sample was selected in the process of purposive sampling. It included 92 patients (50 girls and 42 boys) from a diabetes clinic at the Regional Specialist Children's Hospital in Olsztyn. They were 7- to 20-year-old patients with clinically diagnosed type 1 insulin-dependent diabetes mellitus with a mean disease duration of 6.5 years.

The study was carried out with the use of the international, standard Health Behaviour in School-Aged Children (HBSC) survey [10-11]. Only the area of subjective health indicators and health behaviours regarding physical activity was considered. In order to determine the levels of physical activity, the following two indicators were used:

- MVPA – moderate-to-vigorous physical activity. In order to calculate this indicator, a question was asked concerning the total amount of physical activity within the last 7 days, with at least 60 minutes of activity per day. Categories of responses: 0-7 days.

- VPA – vigorous physical activity. In order to determine this indicator, two questions were asked concerning:

- the frequency of vigorous physical activity: In your free time, how often do you perform physical exercise which is vigorous, i.e. during which you feel that you are “short of breath” or you sweat? Categories of responses: every day; 4-6 times a week; 2-3 times a week; once a week; once a month; less than once a month; never.

- the duration of vigorous physical activity per week: In your free time, how many hours a week do you perform physical exercise which is vigorous, i.e. during which you feel that you are “short of breath” or you sweat? Categories of responses: I don't exercise at all; about half an hour; about 1 hour; about 2-3 hours; about 4-6 hours; 7 hours or more.

Prior to the study, the consent was obtained from the head of the diabetes clinic and parents/guardians. The respondents were informed about the aim of the study and about the rules of responding to questions. Younger pupils were assisted by their parents/guardians while completing the survey. Before completing the survey, the following definition of physical activity was provided: physical activity includes all free time activities during which your

heart rate increases and you feel that you are “short of breath” (you breathe faster). Physical activity is related to physical education classes at school, sports, physical games played with friends as well as walking to school. Running, walking, cycling, ice skating or playing football are examples of physical activity.

The respondents were divided into two groups:

- Group A – physically active boys and girls (being physically active 3 or more days a week/4 or more hours a week). The guidelines of the Polish Diabetological Association regarding physical effort of children and adolescents taken up a minimum of 3 times a week for at least 60 minutes a day were considered [9].

- Group B – physically inactive boys and girls (less than 3 days a week/less than 4 hours a week).

Considering the MVPA indicator, 28 boys and 18 girls were qualified to group A, while 14 boys and 32 girls were qualified to group B. In turn, considering the VPA indicator, 22 boys and 18 girls were included in group A, while 20 boys and 32 girls were assigned to group B.

Research results were statistically analysed with the use of Statistica PL software. The module of descriptive statistics, the test of equal or given proportions and Mann-Whitney U test were applied. The obtained results were analysed and presented in tables which reflected their empirical values [12].

## Results

The research revealed that only 8% of the girls and 14.3% of the boys maintained metabolic control of diabetes mellitus, where glycated hemoglobin was at the level of  $\leq 6.5\%$ . In turn, 56% of the girls and 52.4% of the boys had their HbA1c in the range between 6.6% and 8.9%, which means that diabetes mellitus was not controlled and that changes should be introduced in treatment. The level of HbA1c exceeding 9% was found in 36% of the females and 33.3% of the males, which indicated the lack of control over diabetes mellitus.

The analysis of the results regarding body mass and height as well as BMI in active and inactive boys and girls revealed no significant differences. In group A, mean body mass among boys was at the level of  $63.4 \pm 14.5$  kg, body height was  $171 \pm 11.8$  cm and BMI – 21.55, while in group B, mean body mass was at the level of  $63.1 \pm 19.2$  kg, body height was  $170 \pm 18.6$  cm

and BMI – 21.8. In group A, mean body mass among girls was  $53.5 \pm 11.5$  kg, body height was  $161 \pm 13.3$  cm and BMI – 20.45, while in group B, mean body mass of girls was at the level of  $59 \pm 19.7$  kg, body height –  $164 \pm 9.7$  cm and BMI – 21.94. Patients with type 1 diabetes mellitus assessed their own health with the use of a 5-point scale (health: very good, good, average, poor, very poor). The girls' responses revealed that the majority of them, i.e. 64%, assessed their health as good, 10% – very good, 11% – average, while only 4% thought it was poor. Boys demonstrated higher results when they assessed their health and thus, 28.6% thought it was very good, 45.2% – good, 23.8% – average, while 2.4% considered it to be poor.

None of the male and female respondents found their health to be very poor.

The results regarding the values of MVPA and VPA indicators are presented in table 1. The percentage of the respondents who achieved the recommended level of physical activity (MVPA – 7 days) was low among the girls (10%). In the case of the boys it was 31%. There were statistically significant differences between the respondents ( $p=0.0047$ ) in favour of boys. A very low level of physical activity (MVPA – 1-2 days) was noted in 58% of the girls and 31% of the boys. In this case, the differences were also statistically significant ( $p=0.0081$ ) in favour of boys.

**Tab. 1.** The values of MVPA and VPA among girls and boys

MVPA – number of days within the last 7 days during which children and adolescents devoted at least 60 minutes a day to physical activity							
Study group	Girls		Boys		Total		p
	N	%	N	%	N	%	
0 days	3	6	1	2.3	4	4.3	0.19
1-2 days	29	58	13	31	42	45.6	0.01
3-4 days	10	20	13	31	23	25	0.11
5-6 days	3	6	2	4.7	5	5.5	0.26
7 days	5	10	13	31	18	19.6	0.01
Total	50	54.3	42	45.7	92	100	
VPA – the frequency of performing vigorous physical activity							
Every day	0	0	0	0	0	0	0.50
4-6 times a week	8	16	13	30.9	21	22.8	0.04
2-3 times a week	10	20	9	21.4	19	20.6	0.47
Once a week	10	20	17	40.8	27	29.4	0.01
Once a month	16	32	1	2.3	17	18.5	0.00
Less than once a month	1	2	1	2.3	2	2.2	0.15
Never	5	10	1	2.3	6	6.5	0.07
Total	50	54.3	42	45.7	92	100	
VPA – number of hours devoted to performing vigorous physical activity							
Every day	0	0	0	0	0	0	0.50
4-6 times a week	8	16	13	30.9	21	22.8	0.04
2-3 times a week	10	20	9	21.4	19	20.6	0.47
Once a week	10	20	17	40.8	27	29.4	0.01
Once a month	16	32	1	2.3	17	18.5	0.00
Less than once a month	1	2	1	2.3	2	2.2	0.15
Never	5	10	1	2.3	6	6.5	0.07
Total	50	54.3	42	45.7	92	100	

Source: The author's own resources

$p < 0.05$  – the probability of exceeding the calculated value, test of equal proportions

While analysing the results regarding the frequency of VPA and the number of hours devoted to VPA in the respondents' free time, it was revealed that VPA was often (at least 4 times a week) performed by 22.8% of the study participants, including 16% of the girls and 30.9% of the boys. Statistically significant differences between the

girls and boys were noted in this case ( $p=0.0449$ ). Also, significant differences were observed between the respondents who performed VPA once a week ( $p=0.0044$ ) and once a month ( $p=0.0001$ ) for at least 60 minutes a day. Moreover, 4.6% of the boys (less than once a month – 2.3%, never – 2.3%) and 12% of the girls (less than once a month – 2%, never

– 10%) did not devote 60 minutes a day to physical activity and did not prefer VPA.

The analysis of the results of the examined boys (table 2), revealed that more boys were physically active and their mean HbA1c level was 10% lower than in the case of physically inactive respondents. Standard deviation in groups A and B was comparable but in the case of the boys who were physically inactive, the results of HbA1c were more diverse. There were statistically significant differences ( $p=0.049$ ) between active and inactive boys in favour of those who were physically active.

**Tab. 2.** Comparison of physically active and inactive boys with regard to MVPA and HbA1c levels

MVPA and the level of HbA1c in boys					
Study group	HbA1c N	HbA1c(%) M	HbA1c SD	HbA1c SE	P
A	28	7.54	1.05	0.28	0.049
B	14	8.63	1.67	0.32	
Total	42	8.26	1.57	0.24	

Source: The author's own resources  
 Key: N – number; M – mean; SD – standard deviation; SE – standard error; p – Mann-Whitney U test, the results are significant when  $p < 0.05$

When interpreting the results of boys regarding the frequency of performing VPA (table 3), it was observed that physically active boys demonstrated lower percentage results of HbA1c than physically inactive individuals. In turn, standard deviation in both groups was very similar. While analysing the correlations between the two variables, i.e. the frequency of performing VPA and the level of HbA1c, no statistically significant differences ( $p=0.22$ ) between physically active and inactive boys were noted.

**Tab. 3.** Comparison of the groups of physically active and inactive boys with regard to VPA (frequency of performing VPA) and HbA1c levels

VPA and the level of HbA1c in boys					
Study group	HbA1c N	HbA1c(%) M	HbA1c SD	HbA1c SE	P
A	22	8.04	1.59	0.34	0.22
B	20	8.51	1.54	0.35	
Total	42	8.26	1.57	0.24	

Source: The author's own resources

The comparison between groups A and B (table 4) also revealed that the respondents who were physically active had better levels of HbA1c. Standard deviation was similar in both groups but larger differences in the levels of HbA1c were noted in inactive individuals.

**Tab. 4.** Comparison of the groups of physically active and inactive boys with regard to VPA (number of hours devoted to VPA) and HbA1c levels

VPA and the level of HbA1c in boys					
Study group	HbA1c N	HbA1c(%) M	HbA1c SD	HbA1c SE	P
A	22	7.97	1.44	0.37	0.31
B	20	8.59	1.67	0.31	
Total	42	8.26	1.57	0.24	

Source: The author's own resources.

While analysing the number of hours devoted to VPA with regard to the level of HbA1c, no statistically significant differences ( $p=0.31$ ) between the patients from groups A and B were noted.

The analysis of the groups (table 5) revealed that there were more physically inactive girls and their mean level of HbA1c was higher by 9% on average than in physically active girls. Standard deviation in group A was lower than in group B, which confirms the fact that there were similar levels of HbA1c among physically active girls. While interpreting the results of Mann-Whitney U test, it was noted that there were no statistically significant differences ( $p=0.06$ ) between physically active and inactive girls.

**Tab. 5.** Comparison of physically active and inactive girls with regard to MVPA and HbA1c levels.

MVPA and the level of HbA1c in girls					
Study groups	HbA1c N	HbA1c(%) M	HbA1c SD	HbA1c SE	P
A	18	8.04	1.28	0.30	0.06
B	32	8.97	1.77	0.31	
Total	50	8.63	1.66	0.23	

Source: The author's own resources.

It turned out that the results of the girls presented in table 5 are identical to the results regarding VPA indicators (the frequency of performing VPA and the number of hours devoted to VPA) and the level of HbA1c. No statistically significant differences were revealed but, despite this, the level of HbA1c in the group of physically active girls was lower than in inactive girls, which may indicate a positive influence of physical activity on diabetes mellitus control.

In this study it was found that there occurred differences regarding the assessment of physical activity of girls and boys.

- In girls, the level of physical activity measured with the use of MVPA indicator was low (64% of the girls were not physically active), while in

the case of the boys, the level was satisfactory (66.7% of the boys were physically active).

- The analysis of the results regarding the level of vigorous physical activity measured with the use of VPA indicators (frequency and number of hours devoted to exercises) revealed that only 22.8% of the examined boys and girls devoted at least 4 hours a week to physical activity. The differences between gender groups were also statistically significant ( $p=0.0449$ ) in favour of the boys; however, the level of their physical activity may be perceived as insufficient.
- While analysing the results of MVPA and VPA indicators with regard to HbA1c of the girls, it was concluded that there were no statistically significant differences between physically active and inactive girls. However, there were slight differences in HbA1c levels in favour of the respondents from the active group.
- The results of boys regarding MVPA and HbA1c showed that there were statistically significant differences between physically active and inactive boys in favour of the respondents who performed physical activity. It was noted that the study participants who were physically active had lower levels of HbA1c.
- While seeking correlations between such variables as the frequency of performing VPA or the number of hours devoted to VPA and HbA1c levels in boys, no statistically significant differences were found. However, physically active boys demonstrated a lower mean level of HbA1c than their physically inactive counterparts.

## Discussion

Human beings develop and improve their skills while in motion. Movement stimulates not only their functional and mental but also physical and motor development, and prevents or delays the development of lifestyle diseases [13]. A positive role of physical activity in the control of blood glucose and HbA1c levels in type 1 diabetes mellitus patients has not been fully proved and is still a highly debatable issue. It seems that in Poland, there is a scarcity of research on the effects of physical activity on the control of the levels of HbA1c. Numerous research results published in foreign journals point to the benefits of regular

physical activity among children and adolescents with type 1 diabetes mellitus. These benefits are related to the control of glucose levels in blood, increased sensitivity to insulin as well as a general improvement in metabolism and an improvement in the levels of HbA1c [14-25]. An improvement in HbA1c levels is a priority in the case of children and adolescents with type 1 diabetes mellitus as in the near future they may experience complications [26]. According to Zielke, Jeszka and Szot, more vigorous and longer physical activity decreases the values of HbA1c in women [27]. Also, Boule et al. noted that regular physical activity at a moderate level decreases HbA1c [28]. The meta-analysis of 10 studies on youth below 18 years of age with type 1 diabetes mellitus revealed a considerable improvement in HbA1c among physically active individuals [29].

It is also worth pointing out that physical activity decreases the incidence of coronary disease and the risk of vascular complications among patients with type 1 diabetes [30-35]. The results of this study demonstrated that the majority of children and adolescents are not physically active. Similar results were obtained by the researchers from Great Britain. Their research revealed that adolescents with diabetes mellitus did not follow the recommendations of daily amount of physical activity (60 minutes of MVPA) [36-39].

The results of this study did not demonstrate a positive correlation between physical activity and a decreased level of HbA1c in children and adolescents with type 1 diabetes mellitus. Metabolic control of diabetes mellitus was noted only in 8% of the girls and 14.3% of the boys. A few studies suggest that only children with controlled diabetes mellitus may benefit from physical activity [40-41]. In the systematic literature reviews, Kennedy et al. [42] and Kavookijana et al. [43] also revealed a decrease in HbA1c but it was not statistically significant. In their research, Edmunds et al. [44] as well as Sarnblad et al. [45] did not find a significant correlation between physical activity and HbA1c, either. Moreover, positive effects of exercises on metabolic control in children and adolescents with type 1 diabetes mellitus were not found by Tunar et al. [46].

The research did not reveal correlations between physical activity and lower levels of HbA1c. Perhaps, the research should be extended by issues regarding nutrition, regularity of meals or

self-control of diabetes mellitus, which also affect the level of HbA1c significantly. For these reasons, the problem analysed in this study is complex and individualised, which causes difficulties to researchers dealing with it.

### Conclusions

The analysis of the results made it possible to draw the following conclusions which also address the research question.

1. The level of physical activity of the examined girls is generally low; in turn, the level of

physical activity of boys may be perceived as good.

2. Both girls and boys with diabetes mellitus who were physically active demonstrated slightly lower levels of HbA1c than physically inactive individuals.
3. Physical activity of the study participants did not decrease the level of HbA1c significantly.
4. A general conclusion can be drawn that it is recommended to take up physical activity due to general health benefits.

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