Management of physical exercise in intensive insulin therapy for children with type 1 diabetes mellitus case report

Niewiadomska Monika*, Radziyevska Mariya*, Horodnicka-Jozwa Anita, Petriczko Elżbieta

** University of Szczecin, Department of Physical Culture and Health Promotion*
Pomorski Medical University, The Clinic of pediatrics, endocrinology, diabetology, metabolic diseases and cardiology of the children

Annotation:

Physical activity as a very active method of type I diabetes mellitus (DM) complex therapy must be systematic and load-graduated. For patients with diabetes mellitus (DM) they are strictly graded to each patient. This work presents our study data about effects of three-month physical training in 8-year old girl with type 1 DM. In her case with well compensated type 1 DM, the physical training brought about improvement of her health status and insulin dose reduction. Control over exercising is essential. Heart rate (HR) measuring was done not only before and after training. A continuous HR monitoring was conducted during whole workout in order to make, if necessary, a correction of load volume and intensity. The control testing conducted after 3- month use of physical exercises against a background of insulin therapy and balanced diet in the 8-year old patient showed that there took place a definite organism's adaptation to physical training. The length of distance in 6-min walking test increased from 700 to 780 m. The heart rate during test performance reduced from 165 to148 beats/min. The glycolyzed haemoglobin level reduced from 6.891% to 6.570 %.

Невядомска Моника, Радзиевская Мария, Хородницка-Джузва Анита, Петричко Эльжбета. Дозирование физических упражнений при инсулинзависимом сахарным диабетом на фоне интенсивной инсулинотерапии (клинический случай). Физическая активность является очень важным элементов стиля жизни больных с сахарным диабетом первого типа (ИЗСД). Для каждого пациента она должна быть дозирована строго индивидуально, чтобы не вызвать декомпенсации. Данная работа презентует анализ клинического случая 8-летней девочки с ИЗСД, которой в течении 3 месяцев было предложен курс занятий подвижными играми при строго регламентированной интенсивности нагрузки при помощи спорттестера. Контрольное тестирование, проведенное через 3 месяца после применения регламентированных по уровню интенсивности физических упражений игровой направленности показали, что у пациентки дистанция преодоленная в 6-минутном тесте ходьбы увеличилась с 700 до 780 м, частота сердечных сокращений снижилась с 165 до148 уд/мин. Уровень гликированного гемоглобина снизился с 6.891% до 6.570 %.

Невядомска Моника, Радзиевская Мария, Хородницка-Джузва Анита, Петричко Эльжбета. Дозування фізичних вправ при інсулінзалежному цукровому діабеті на тлі інтенсивної інсулінотерапії (клінічний випадок). Фізична активність є важливим елементом стилю життя хворих на інсулінзалежний цукровий діабет (ІЗЦД). Для кожного пацієнта вона повинна бути дозована індивідуально. Ця робота представляє аналіз клінічного випадку 8-річної дівчинки з ІЗЦД, якій протягом 3 місяців було застосовано курс фізичної активності з рухливих ігор при суворо регламентованій інтенсивності навантаження за допомогою спорттестера. Контрольне тестування, яке було проведене через 3 місяця після застосування регламентованої за рівнем інтенсивності фізичних вправ ігрової спрямованності показали, що довжина дистанції в 6-хвилинним тесті ходьби збільшилася з 700 до 780 м, а частота серцевих скорочень знизилася з 165 до 148 уд/хв. Рівень глікованого гемоглобіну знизився з 6.891% до 6.570 %.

Keywords:

physical exercises, type 1 diabetes mellitus, heart rate.

физические упражнения, инсулинзависимый сахарный диабет, частота сердечных сокращений.

фізичні вправи, інсулінзалежний цукровий діабет, частота серцевих скорочень.

Introduction.

A positive influence of the physical activity on the diabetes mellitus has been known since the ancient times. Positive effects of exercises are determined by an increased tolerance to carbohydrates during physical training, since the latter is accomplished at an expense of the energy resulting from the oxidation of fats and carbohydrates [4, 5, 6, 10]. Physical exercises have a positive influence on the body weight loss, visceral obesity, insulin sensitivity and dyslipoproteinemia [2, 3, 4, 5, 7, 8].

The use of physical exercises in complex treatment of type I diabetes mellitus (DM) in children is not adequately studied. Defining of work load dose for individuals of child age is quite challenging. If for adults, the volume and intensity for traditionally recommended aerobic exercises, stretching and resistance training are easily prescribed, this approach cannot be used for children. It is known that the main form of motor activity and leisure time organization for children would be exercises in the form of games. Functional expenditure for organism's energy provision in such event maybe not only within a zone of aerobic but also within a zone anaerobic work loads. Heart rate during mobile games in children can change from 104 to 216 beats/min [11]. In this view, management of physical exercising (games) with the purpose of attaining a maximal therapeutic effect in children of junior school age suffering from diabetes mellitus presents a topical issue of modern child diabetology.

Purpose. This work has been focused to study the management of physical exercises of game orientation in the patient with type 1 diabetes mellitus. We shall present the data describing a methodology of selection of physical exercises and control over their impact on the organism of an 8-year old patient with type I diabetes mellitus treated according to intensive insulin therapy scheme.

Material and Methods. This article presents the data of our study demonstrating effects of three-month physical exercising in a 8-year old girl with type 1 DM. Disease duration was 2 years. She had the height 133 cm and the body weight 28 kg, BMI was 15.8.

The patient was treated according to an intensive therapy method with the use of an individual insulin pomp (basal and bolus). The basal and bolus level was established after a 24-hour intermittent blood glucose monitoring, at the rate of 0.6-0.8 units of insulin per 1 kg body weight, where 30% of insulin was injected as basal (4.8 units) and the remaining via insulin pomp 3-4 times daily [1].

The patient's disease was found to be in the state of stable compensation, according to the requirements of the Polish Diabetology Society for treatment of children with

type 1 diabetes mellitus (2009). That is, in her analyses the blood glucose level was less than 12 mmol/l, insulin number 16.8-22.4 units per day (bolus) and urine sugar at norm (traces or absent).

The percentage of glycosylated haemoglobin (HbA_1c) was measured as the proportion of total haemoglobin concentration in the investigated sample by means of the immunoturbidimetric and colorimetric method (total Hb) on an Immulite apparatus using Tina-grant test (Roche, France). Blood glucose measurements were done on the Glukometr ACCU-CHEK AKTIVE (Roche, France).

Prior to the beginning of regular physical trainings and upon the receipt the patient's parents' consent and after being granted the permission from the Bioethical Committee to conduct our investigation, dated 27th May 2008 and taken at the meeting of the Bioethical Committee of the Pomorski Medical University Academy, Szczecin, Poland, and in accordance with the GCP (Good Clinical Practice), our study patient was proposed to perform a 6 min walking motor test.

Before test performance, the patient was instructed to move at a maximally tolerable speed enabling her to cover the longest distance. Should there be any complaints, the patient was allowed slow down the pace or stop and sit for having a rest. As 6 min passed, the number of meters covered by the patient was summed up. In the course of the test, there was a continuous monitoring of the patient's pulse by means of the sport-tester (Bauer-PM80, Germany). According to the American standards for physical loads, the children who are capable to cover a distance over 300 m are eligible to undergo testing. Our patient covered a 700 meter distance within 6 min. Besides, the patient gauged her intensity in the given test, according to the Borg Scale rate of perceived exertion in training [6]. Physical loads are counter indicated to patients with diabetes mellitus **at self-rating perceived intensity scored more than 12.** The score of our candidate was 9.

Long-term investigations focusing on the use of physical exercises for treatment purposes have shown that enhancement of heart and lungs performance or effect of aerobic load was more efficient when the patient was undergoing training with his heart rate making a definite percent of his maximum heart rate [5, 6]. The ideal heart rate value for our patient's trainings was determined by us from the Karvonen formula [6]:

HR during training = (maximum HR – resting HR) * 0.6 + resting HR, where HRmax = 220 – age

Resting HR is taking one's pulse for one minute when you first wake up in the morning without an alarm clock.

Characteristic of physical exercises for study patient. It was taken into account in the study program that the patient with diabetes mellitus selected by us for physical workouts had never before done any training. For this reason the maximum training heart rate for her by the Karvonen formula was 159 beats per min.

To control the influence of physical exercises upon her organism, we used the sport-tester manufactured by Bauer-PM80 Company (Germany). The results of measurements were processed by means of the 'Easy Fit' program. Apart from continuous heart rate monitoring, we obtained the average heart rate data registered for each training session. If the patient's HR tended to exceed the prescribed maximum training HR value, the load was reduced lest the procedure do any harm to the patient's health.

Before each training séance we measured the pulse and blood glucose level. So, with blood sugar concentration <3 mmol/l, the patient was recommended an additional carbohydrate food intake (a small sandwich or one apple) [3].

The sessions were conducted 3 times a week in the open air during three months. During first two weeks the session lasted 20 min and was increased to 30-35 min thereafter. The physical training session consisted of playing active games while walking individually with the child and her parents.

Traditionally, according to the methodology of using physical exercises for treatment purposes each training session was divided into three parts: the first **(an introductory)** consisting of a short warming-up followed by the known for children game in the form of walking; the second (**main**) focusing on walking exercises with simultaneous shoulder movements, games, competition and relay-race elements, and the third (**final)** comprising breathing and relaxation exercises. As an example we further give the plan of training session d at the 3rd week of application:

- blood sugar and pulse measurement (1 min);
- walking with simultaneous circular movements in the radio carpal joints (2 min);
- walking with simultaneous performance of exercises for neck muscles (circular movements, bending/tilting and turning) (2 min);
- the game **Picking apples**. Walking in a circle raising hands up, one by one, to show picking apples from the tree (3 min);
- the game **Peaches, go home**. A knee-hand position (on all fours). On command 'Peaches, go for a walk', walking around the room. On command 'Peaches, go home', trying as quicker reach a fixed place, the 'home' (3 min);
- the game **Jumping of hares**. Initial position is sitting on the knees with one's hands on the floor between the knees. Jumping lengthwise (3 min);
- the game **Running away from the storm**. On command 'Storm', trying as fast to reach a place where one can have shelter during storm (3 min);
- the game **Imitating cars**. While walking around, imitate cars (produce sounds) (3 min);
- the game **From snail to gepard**. Performing exercises while walking at different speed, first slowly like a snail, then quicker and, finally, as quickly as the gepard (3 min);
- the game **Walking in the forest**. Walking and trying to avoid obstacles coming one's way (3 min);
- the game **Touch the sky with your head**. Walking and trying to reach the ceiling (sky) with one's heads. Walking on tip toes with one's head up and stretched neck (3 min);
- breathing exercises during walking. Walking and trying to perform the following action: inhalation – raising one's hands up, exhalation – dropping them down, shaking with

Table 1

Mean values for blood glucose level in the 8-year patient with type 1 diabetes mellitus before and at the 4th, 8th and 12th weeks of training.

Time	Before training	4th week	8th week	12th week
Before breakfast	10.05±2.85	7.93±1.79	9.52±1.87	9.19±1.88
After breakfast	5.89±2.58	6.42±2.48	7.3±2.32	9.27±2.34
Before lunch	10±4.57	8.67±3.02	8.77±1.34	8.77±4.04
After lunch	4.88±3.11	5.6±1.67	6.08±1.66	7.81±2.81
Before dinner	8.21±4.93	6.63±0.88	7.11±2.11	8.89±3.95
After dinner	8.27±6.16	6.3±1.0	5.5±1.79	8.39±3.54
Before sleep	9.32±3.97	5.8±1.74	6.58±0.64	7.96±1.79

* – The differences between indices are statistically significant in the comparison with baseline measurements ($p<0.05$).

** – The differences between indices are statistically significant in the comparison with measurable data at 4th week of training ($p<0.05$).

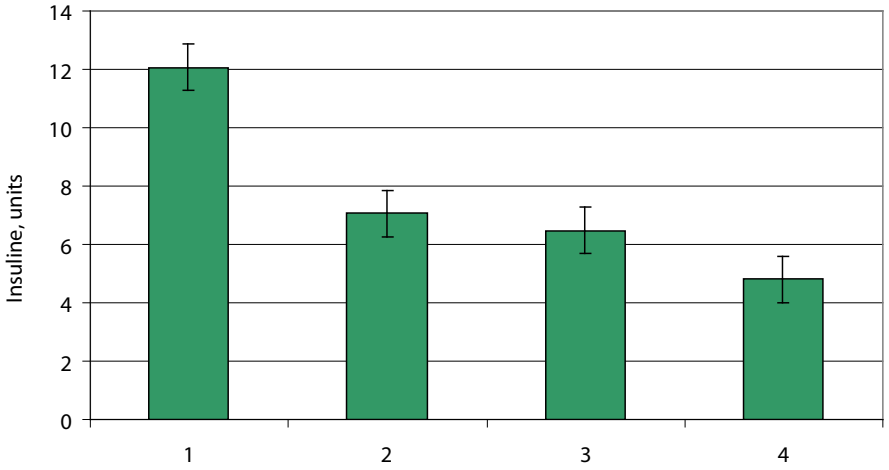

Fig. 1. *Changes of the insulin doses (bolus):*
a *– one week before physical exercises;* **b** *– at 4th week of training;* **c** *– at 8th week; and* **d** *– at 12th week of training (***1** *– before breakfast,* **2** *— before lunch,* **3** *– before dinner,* **4** *– before sleep).*

one's hands, and a slight tilting forward (2 x 1 min);

- blood sugar and pulse measurement (1-2 min).

Blood sugar measurement this patient was recommended after 2-3 hours.

Data were statistically analyzed by using the method of mean values for estimating the mean arithmetic (x), the standard deviation (SD), Student's criterion.

Results.

The statistical analysis data for daily monitoring of blood glucose level during the first, fourth and twelfth weeks of training are given in Table 1. The blood glucose level over three month period of prescribed physical exercising varied in the course of the day within the limits from 4.88 to 12.90 mmol/l (see table 1). Thus mean daily values for the glucose level based on 7 control measurements (before and after breakfast, before and after lunch, before and after dinner, and before sleep) done in the first, fourth, eighth and twelfth weeks of training did not go beyond the dynamic balance limits. This fact pointed to the stable disease compensation.

Of special importance, in none of the analyses cases the blood glucose level exceeded the average values obtained at the week preceding the beginning of trainings (see table 1).

Data of an in-depth analysis of insulin (bolus) doses given (injected) to the patient during a 12-week training period are presented in the figure 1. As can be seen, bolus insulin doses became statistically lower ($p<0.05$) with each subsequent stage of observation. What is more, insulin injections before sleep were abandoned (see figure 1)

Analogous data were obtained during analysis of average 24-hour insulin (bolus) injections (figure 2). It is noteworthy that the value of insulin injections compared to baseline level.

The mean values for the pulse regimens and blood glucose level variations measured before, after and 2-3 hours following the training session in 4th, 8th and 12th weeks of training are presented in the table 2.

The maximal pulse for our patient was 220 – 8 years = 212 beats/min. The training hart rate (HR) made 75% of the maximal level – 159 beats/min and 155 beat/min according to the Karvonen formula. During first month of training the training pulse was within admissible norm with singular deviations (Table 2).

Naturally, the continuous HR monitoring during exercises allowed us immediately reduce work load volume and intensity thus ensuring an estimate mean pulse value to remain within norm, between 116 and 144 beats/min (see Table 2). Work load correction was done in a like manner by HR level during exercise performance during 2nd and 3rd months.

After training, as shown by analysis data, the blood glucose level reduced significantly ($p<0.05$) in the comparison with its 4th week values (Figure 3).

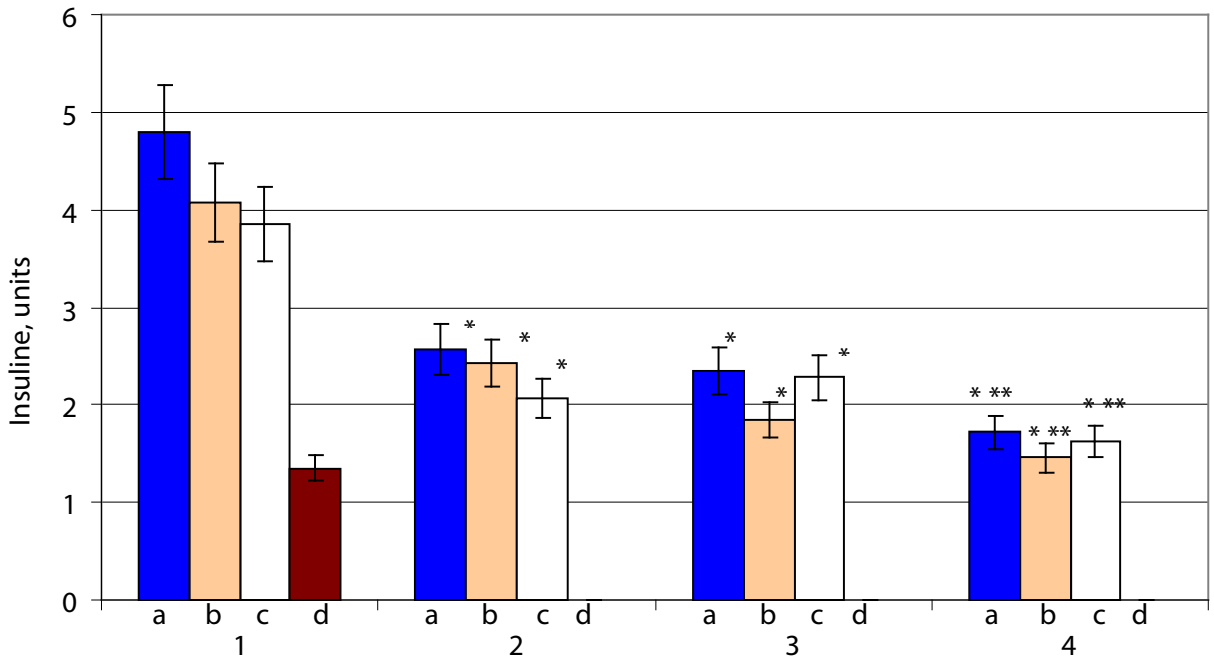

Fig. 2. Total average 24-hour insulin doses (bolus): **a** *– one week before physical exercises;* **b** *– at 4th week of training;* **c** *– at 8th week; and* **d** *– at 12th week of training.*

* – The differences between indices are statistically significant in the comparison with baseline measurements ($p<0.05$).

** – The differences between indices are statistically significant in the comparison with measurable data at 4th week of training ($p<0.05$).

Table 2

Characteristic of heart rate level at the 4th, 8th and 12th weeks of training.

Parameters	Min-max	M±m
1	2	3
Fourth week of trainings		
Resting HR, beats/min	57 – 104	83.17±11.28
HR means during session, beats/min	116 – 144	127.33±8.60
Maximum HR during exercise, beats/min	120 – 175	149.25±16.40
Eighth week of trainings		
1	**2**	**3**
Resting HR, beats/min	50 – 84	68.91±13.22
Mean HR during session, beats/min	122 – 150	136.33±10.40
Maximum HR during exercise, beats/min	158 -182	167.75±8.26
Twelfth week of trainings		
1	**2**	**3**
Resting HR, beats/min	66 -100	86 ±11.40
Mean HR during session, beats/min	123 -138	130.08±4.90
Maximum HR during exercise, beats/min	158 – 186	171.66±8.64

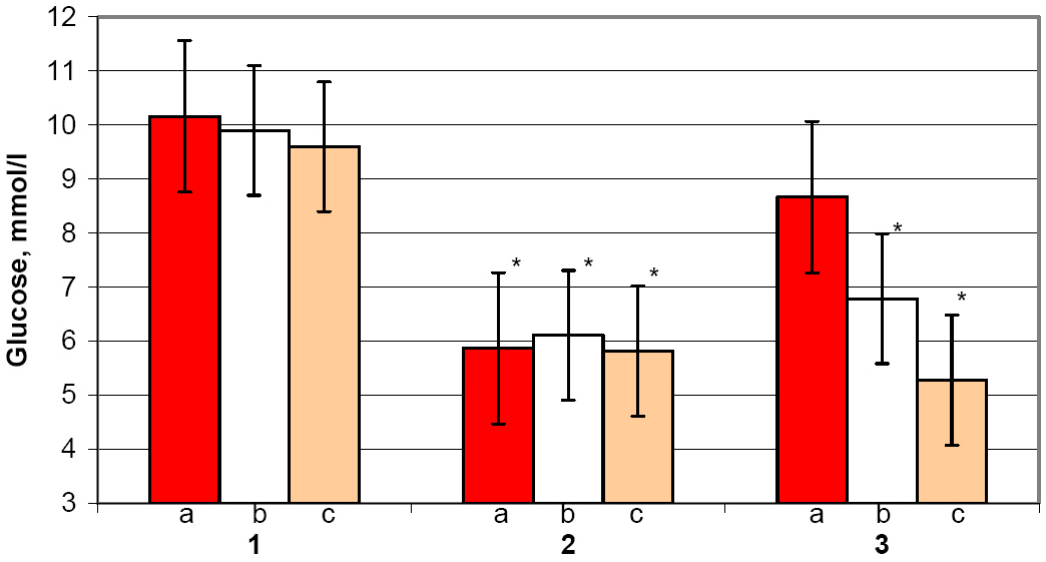

*Fig. 3. The mean blood glucose levels recorded before (a) and after training sessions (b) as well as 2-3 hours following the training (**c**) in the 4th (**1**), 8th (**2**) and 12th (**3**) weeks of training.*

** – The differences between indices are statistically significant in comparison with 4th week measurements (p<0.05).*

The control testing conducted after 3- month use of physical exercises against a background of insulin therapy and balanced diet in the 8-year old patient showed that there took place a definite organism's adaptation to physical training. For illustration, the length of distance in 6-min walking test increased from 700 to 780 m. The heart rate during test performance reduced from 165 to148 beats/min, and she made lesser efforts while performing greater in volume exercises (according to the Borg scale, 8 instead of 9 scores before three-month trainings). The glycolyzed haemoglobin level reduced from 6.891% to 6.570 %.

Conclusion.

Summing up the above-said, we would emphasize that the presented material can be interpreted only as a preliminary communication about individual approach to physical exercise dosing in children with diabetes mellitus. The data concerning one patient given in this article are only part of data collected by us in the group of study children (n=12) who have now been in the process of training. Still, even at this stage of study we may assume that physical training of game orientation in children with well-compensated type 1 diabetes mellitus can improve their physical state and reduce injected insulin dose and thereby fight successfully against insulin resistance.

Undoubtedly, the dosing of workload for diabetes patients should be done on the individual basis. After physical exercises have been included into the list of therapy measures, it is essential that their impact on patient's organism be controlled thoroughly. Such control is not limited with pulse measuring before and after training. A continuous heart rate monitoring during whole workout is equally important in order to make correction of exercise volume and intensity in case that their values exceed the recommended norms for the given patient. The control of blood glucose contents should be done before and after each training session, and 2-3 hours later. Besides, the number and volume of insulin injections should be thoroughly analysed.

In order to make more substantiated conclusions, there is a need to continue further investigations.

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Невядомска Моника
Радзиевская Мария
Хородницка-Джузва Анита
Петричко Эльжбета
monikaniewiadomska@wp.pl