

The effect of long-term swimming program on body composition, aerobic capacity and blood lipids in 14–19-year aged healthy girls and girls with type 1 diabetes mellitus

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Key words: type 1 diabetes mellitus, long-term swimming program, blood lipid/cholesterol.

Summary. *Objective.* To evaluate the effect of long-term swimming program on body composition, aerobic capacity, and blood lipid/cholesterol level.

Material and methods. Nineteen girls aged 14–19 years with duration of diabetes of 8.1 ± 0.9 years and 28 healthy girls aged 14–19 years participated in the study. Before and after 14-week swimming program, weight, height, and four skinfold thickness were measured, body mass index (kg/m^2) and body fat mass (%) were calculated, blood lipid levels (total cholesterol, high-density/low-density lipoprotein, and triglyceride) were estimated. Aerobic capacity was assessed by Ruffie test. Training sessions (each lasted for 45 min) were held twice per week for 14 weeks. A total of 28 trainings were performed in the swimming pool. Workload intensity was corrected by pulse measurement before and after every session in the water.

Results. After 14-week swimming program, body mass index did not change, but body fat mass decreased significantly in healthy (27.2 ± 1.0 vs. $25.5 \pm 0.8\%$, $p < 0.001$) and diabetics (34.8 ± 1.2 vs. $32.1 \pm 1.2\%$, $p < 0.001$) subjects. Both groups improved their aerobic capacity ($p < 0.01$ in healthy and $p < 0.05$ in diabetics). No significant changes in blood lipid profile were found in all subjects, only high-density lipoprotein concentration significantly increased in healthy girls ($p < 0.001$).

Conclusion. Long-term swimming program improved aerobic capacity, reduced body fat mass in all participants, and reduced high-density lipoprotein levels only in healthy subjects.

Introduction

Diabetes is one of the most serious clinical and social problems in the 21st century. The prevalence of diabetes is increasing all over the world. Lithuania is not an exception. According to the Lithuanian Health Information Center, during 2001–2003, the rate of type 1 diabetes mellitus among people aged 10–14 and 15–19 years has increased from 16.97 to 29.97 and from 26.14 to 26.98 cases per 100,000 citizens, respectively (1).

We still have no means that would stop the development of the disease or would prevent it. Diabetes cannot be cured yet, though it can be successfully controlled, and serious complications can be prevented, so people can lead a normal life. Insulin deficiency has drastic effects on carbohydrate, lipid, and protein metabolism (2, 3), so balanced nutrition, regular physical activity, appropriate insulin injections combined with patient's teaching and self-control are very important (4, 5).

Diabetes, diagnosed at the young age, determines

not only functional changes but also has a great influence on psychological and sexual maturation, physical development, and social adaptation in the society. It affects females the most. More and more women take part in social and political life, and the role of women is becoming increasingly important. It is very important that the young girl having type 1 diabetes mellitus could adapt socially and that she could manage her disease with the help of nutrition, insulin, and physical activity. Regular physical activity improves the metabolic control and body's ability to use insulin, helps to manage weight, lowers blood glucose concentration and blood pressure, gives more energy, and reduces stress and depression (6–11).

The aim of this study was to evaluate the peculiarities of physical development and aerobic capacity among healthy girls and girls with type 1 diabetes mellitus aged 14–19 years and to estimate the effect of regular physical activity in the water on the blood lipid profile.

Material and methods

Altogether, 28 healthy girls and 19 girls with type 1 diabetes mellitus (duration of diabetes 8.1 ± 0.9 years) aged 14–19 years took part in long-term physical activity program in the water. The research duration was 14 weeks, and 28 trainings were done. The participants attended swimming trainings two times per week. Every training in the swimming pool lasted for 45 minutes. The intensity of the training was always adjusted according to pulse rate, which we did not want to get higher than 144–156 beats/min. The trainings took place in a swimming pool, the length of which is 25 meters. At the beginning of the training a 15–20-minute exercise was done, and the remaining 30 minutes the participants swam breaststroke and crawl. At the beginning short swimming distances (up to 200 meters) with the breaks were chosen, which later were increased to 400 meters with the short breaks. The trainings took place at 12 p.m.

Before the long-term swimming program and right after it, anthropometrical measurements, biochemical analysis of venous blood, and Ruffie test were performed.

Height (in centimeters), body mass (in kilograms), and four skinfold thickness (in millimeters) of all participants were measured. Body mass index (BMI, kg/m^2) was calculated. Fat mass (FM, %) was assessed according to A. Raslanas and J. Skernevičius (12), J. Skirius (13).

Aerobic capacity was assessed by Ruffie test. The results of Ruffie test were evaluated according to the method proposed by J. Chadenska-Pavlikovska (14).

Before the beginning of long-term swimming program and right after it, the analysis of lipids in venous blood (total cholesterol, low-density lipoprotein – cholesterol, high-density lipoprotein – cholesterol, triglyceride) was performed for type 1 diabetes mellitus and healthy subjects. This analysis was done using enzymatic colorimetric glycerol phosphate oxidase/peroxidase and cholesterol oxidase/peroxidase assays.

Descriptive data are presented as mean \pm SD. To check the hypothesis of the quantitative variable, Student's t-test were used. The groups (healthy persons and diabetics) were compared with a two-way analysis of variances (ANOVA). Pearson's correlation coefficient was used for the quantitative values. Statistical significance was set at $p < 0.05$.

Results

Comparing BMI value between the healthy girls and girls with type 1 diabetes mellitus before and after the long-term swimming program, a significantly

difference has been recorded. Although the average value of BMI does not exceed recommended norms for either group (12, 13), BMI value for type 1 diabetes mellitus subjects is higher than BMI value for healthy girls before ($p < 0.001$) and after ($p < 0.001$) the swimming program. Comparing FM value between the healthy girls and girls with type 1 diabetes mellitus before and after long-term swimming program, a statistically significant difference was found too. The average value of FM exceeded recommended norm (12, 13) for the type 1 diabetes mellitus subjects, and it was greater than the FM value for healthy girls before ($p < 0.001$) and after ($p < 0.001$) the swimming program.

Statistically significant differences in height ($p < 0.001$), body mass ($p < 0.05$), and FM ($p < 0.001$) have been noticed after the long-term physical training for healthy subjects: body mass and height have significantly increased after the long-term swimming program. FM value after the long-term swimming program decreased significantly by 6.25% ($p < 0.001$). BMI value increased insignificantly ($p > 0.05$) and was within normal range (12, 13).

A significant increase in height ($p < 0.01$) and body mass ($p < 0.001$) and significant decrease in FM ($p < 0.01$) for the type 1 diabetes mellitus subjects after the long-term swimming program were noticed. BMI value increased insignificantly ($p > 0.05$), and it did not exceed the recommended norms (12, 13). FM value decreased significantly by 7.76% after the long-term swimming program ($p < 0.01$); however, it remained rather high and exceeded the recommended norms (12, 13).

Comparing the Ruffie index between the healthy girls and girls with type 1 diabetics before and after long-term swimming program, no statistically significant difference was found ($p > 0.05$). A statistically significant difference was observed comparing the values of Ruffie index in both groups of participants before and after the long-term swimming program: the values of Ruffie index for the healthy girls and girls with type 1 diabetes mellitus after the long-term swimming program decreased significantly by 16.9% ($p < 0.01$) and 15% ($p < 0.05$), respectively (Fig.).

Comparing total serum cholesterol concentration between healthy girls and girls with type 1 diabetes mellitus before long-term swimming program, a significant difference was found ($p < 0.05$). After long-term physical training, difference in this index between groups was insignificant ($p > 0.05$). Total cholesterol level did not change significantly ($p > 0.05$) in both groups after the long-term swimming program.

Table 1. Anthropometrical data of participants before and after the long-term 14-week duration swimming program

Variable		Healthy n=28	Type 1 diabetes mellitus n=19	p-value
		mean±SD	mean±SD	
Age (years)		16.9±0.24	17.0±0.36	
Height (cm)	before	168±0.88	166.3±1.06	0.206
	after	168.9±0.89	167.1±1.19	0.238
		p_1 -value		–
Body mass (kg)	before	55.9±1.31	64.0±2.42	0.003
	after	56.7±1.33	64.7±2.38	0.003
		p_2 -value		–
Body mass index (kg/m ²)	before	19.8±0.44	23.3±0.88	0.001
	after	19.9±0.42	23.3±0.83	0.001
		p_3 -value		–
Fat mass (%)	before	27.2±1.02	34.8±1.21	0.001
	after	25.5±0.77	32.1±1.15	0.001
		p_4 -value		–

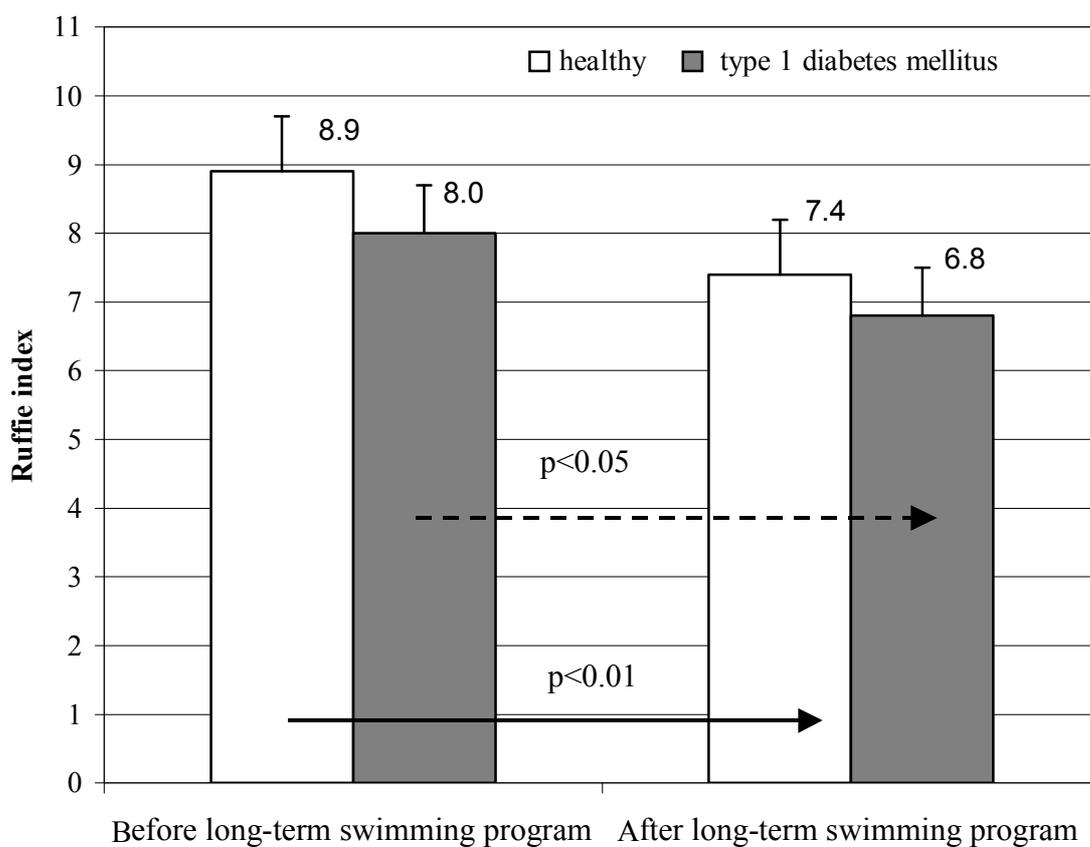
**Fig. Average value of Ruffie index for the healthy girls (n=28) and girls with type 1 diabetes mellitus (n=19) before and after long-term 14-week duration swimming program**

Table 2. Venous blood lipid profile before and after long-term 14-week duration swimming program

Variable		Healthy n=28	Type 1 diabetes mellitus n=19	p-value
		mean±SD	mean±SD	
TCH (mmol/l)	before	4.82±0.45	4.43±0.15	0.019
	after	4.96±0.40	4.68±0.14	0.083
	p ₁ -value	0.181	0.084	–
HDL-ch (mmol/l)	before	1.13±0.25	1.14±0.78	0.929
	after	1.24±0.16	1.15±0.61	0.158
	p ₂ -value	0.001	0.847	–
LDL-ch (mmol/l)	before	3.32±0.74	2.92±0.14	0.009
	after	3.42±0.76	2.97±0.16	0.021
	p ₃ -value	0.326	0.751	–
TG (mmol/l)	before	0.80±0.042	0.90±0.073	0.186
	after	0.74±0.021	1.03±0.096	0.009
	p ₄ -value	0.251	0.334	–

TCH – total cholesterol; HDL-ch – high-density lipoprotein cholesterol;

LDL-ch – low-density lipoprotein cholesterol; TG – triglycerides; SD – standard deviation.

After long-term swimming program, the high-density lipoprotein level has significantly increased by 9.7% only in the group of healthy girls ($p < 0.001$). Comparing the value of this index between the groups before and after swimming program, the difference was insignificant ($p > 0.05$).

A statistically significant difference in low-density lipoprotein concentration was found comparing healthy subjects and girls with type 1 diabetes mellitus before ($p < 0.01$) and after long-term swimming program ($p < 0.05$). An insignificant increase of this index was observed ($p > 0.05$) in both groups after the long-term swimming program.

No significant decreases in triglyceride concentration were observed in healthy girls and girls with type 1 diabetes mellitus after long-term swimming program ($p > 0.05$). Comparing triglyceride concentration between the groups, triglyceride value differed significantly between the groups only after long-term physical activity ($p < 0.01$).

Discussion

Our study has showed that body mass ($p < 0.05$), BMI ($p < 0.001$) and FM ($p < 0.001$) values were lower in healthy girls than in type 1 diabetes mellitus subjects. So, the following conclusion could be made: girls with type 1 diabetes mellitus are overweight as compared to the healthy girls of the same age. The

data gathered during our research are similar to those of other studies showing that adolescent girls with type 1 diabetes mellitus tend to be overweight, and this overweight is explained by an increased fat mass (15, 16). However, long-term swimming program had a positive effect on FM for healthy girls and girls with type 1 diabetes mellitus: it was significantly reduced for all subjects ($p < 0.001$). R. Lechmann *et al.* (1997) and P. E. Mosher *et al.* (1998) reported that after their studies of physical activity, healthy and diabetic subjects also had a lower percent body fat (17, 18).

No significant differences were observed between healthy girls and girls with type 1 diabetes mellitus comparing the functional capacity of cardiorespiratory system after our experiment by Ruffie test. Long-term physical activity in the water had a positive effect on aerobic capacity for all subjects: this index significantly increased for healthy ($p < 0.01$) and for diabetic subjects ($p < 0.05$). Our findings are similar to the results of study by M. Rigla *et al.* that after 3-month physical exercise program, participants showed an improvement in physical capability (19). It was also reported that long-term physical activity significantly increases the functional capability of cardiorespiratory system (17, 18, 20).

Analyzing the values of serum lipid concentration of healthy girls and girls with type 1 diabetes mellitus, it was determined that serum lipid concentration was

within normal range. The results obtained after 14-week swimming program showed that long-term physical activity did not have a significant impact on blood lipid levels either for healthy girls or girls with type 1 diabetes mellitus. H. Wallberg-Henriksson and his colleagues (1986) also reported about the minor changes in serum lipoprotein profiles after long-term physical training (21). Other foreign scientists reported that under the effect of long-term aerobic physical activity, blood lipid and lipoprotein levels decreased (22, 23). The data obtained during our research show a significant increase in high-density lipoprotein cholesterol level only in healthy girls after the long-term swim-

ming program ($p < 0.01$). D. Vizbaraitė reported that this index increased after long-term physical activity (24). The data of our research confirmed this statement.

Conclusions

A 14-week swimming program had a positive effect on fat mass and aerobic capacity for all subjects. Long-term physical training did not improve lipid profile (total cholesterol, high-density lipoprotein, low-density lipoprotein, triglyceride) for type 1 diabetes mellitus subjects. For healthy subjects, only high-density lipoprotein concentration increased significantly after long-term physical program.

Ilgalaikio fizinio krūvio vandenyje poveikis 14–19 metų sveikų ir sergančių 1 tipo cukriniu diabetu merginų kūno sandarai, aerobinei ištvermei, glikozilinto hemoglobino ir kraujo lipidų reakcijai į fizinį krūvį

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Raktažodžiai: 1 tipo cukrinis diabetas, ilgalaikis fizinis krūvis, glikozilintas hemoglobinas.

Santrauka. *Tikslas.* Įvertinti 14–19 metų sveikų ir sergančių 1 tipo cukriniu diabetu merginų ilgalaikio fizinio krūvio vandenyje poveikį fiziniam išsivystymui bei pajėgumui, glikozilinto hemoglobino ir lipidų koncentracijai.

Tirtųjų kontingentas ir tyrimo metodai. Tyrime dalyvavo 19 14–19 metų merginų, sergančių 1 tipo cukriniu diabetu (sirgimo trukmė – $8,1 \pm 0,9$ metų), ir 28 sveikos merginos 14–19 metų. Prieš ir po ilgalaikio fizinio krūvio vandenyje programos buvo matuota: 1) svoris, ūgis, keturių riebalinių raukšlių storis bei apskaičiuotas kūno masės indeksas (kg/m^2) ir riebalų masė (proc.); 2) aerobinė ištvermė įvertinta atliekant Ruffjė testą; 3) atliktas biocheminis kraujo lipidų (bendrojo cholesterolio, mažo/didelio tankio lipoproteinų, triacilglicerolių) ir glikozilinto hemoglobino tyrimas. Aerobinio pobūdžio užsiėmimai vandenyje vyko 14 savaitių, du kartus per savaitę, trukmė – 45 min. Krūvio intensyvumas buvo koreguojamas skaičiuojant pulsą.

Rezultatai. Po ilgalaikės 14 savaitių trukmės fizinės programos vandenyje kūno masės indeksas nepakito, tačiau reikšmingai sumažėjo riebalų masė ir sveikų (nuo $27,2 \pm 1,0$ proc. iki $25,5 \pm 0,8$ proc., $p < 0,001$), ir sergančių 1 tipo cukriniu diabetu (nuo $34,8 \pm 1,2$ proc. iki $32,1 \pm 1,2$ proc., $p < 0,001$) merginų. Pagerėjo visų tiriamųjų aerobinė ištvermė ($p < 0,01$ sveikų ir $p < 0,05$ sergančių). Ilgalaikis fizinis krūvis neturėjo įtakos visų tiriamųjų kraujo lipidų koncentracijai, tik sveikų merginų kraujyje padidėjo didelio tankio lipoproteinų koncentracija ($p < 0,001$). Reikšmingai sumažėjo ($p < 0,001$) glikozilintas hemoglobinas (proc.) sergančiųjų 1 tipo cukriniu diabetu.

Išvada. Ilgalaikis fizinis krūvis vandenyje sumažino visų tiriamųjų riebalų masę bei pagerino aerobinę ištvermę, o sveikų tiriamųjų pagerino tik lipidų profilį.

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