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Effect of Moderate Swimming Exercise on Hyperglycaemia, Polyphagia, Polydipsia and Weight Loss in Streptozotocin-Induced Diabetic Rats

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ABSTRACT

Purpose: The purpose of the current study is to evaluate the efficacy of regular exercise as a useful nonpharmacological strategy in attenuating the diabetes symptom such as hyperglycaemia, polyuria, polydipsia, polyphagia, and weight loss.

Materials and Methods: Twenty male Wistar rats (200±20 gr) were divided to four groups (n = 5 per group): sedentary normal (N), trained normal (NE), sedentary diabetes (D) and trained diabetes (DE). Diabetes was induced by a single intraperitoneal injection of streptozotocin (50 mg/kg). The exercise protocol consisted of moderate intensity swimming of 30 min/day, 5 days/week for eight weeks. Plasma glucose was evaluated at initiation and end of the experiment. Weekly weight change was calculated according to initial weight. Food conception and intake water were measured in certain day of week.

Results: Induction of diabetes significantly raised plasma glucose (P = .001), increased food and water intake (P = .05) and decreased weight-gain (P = .05) in diabetic rats. Swimming exercise had small effect on plasma glucose, weight change, food intake and water intake of trained rats.

Conclusion: According to the result of this study, it seems that exercise alone has small effect on management of diabetes symptoms and medical approach is necessaryfor this purpose.

Keywords: swimming exercise; moderate intensity; diabetes symptoms.

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INTRODUCTION

Diabetes is a group of common chronic metabolic diseases characterized by disturbance in carbohydrate, fat and protein metabolism as a result of relative or absolute deficiency in insulin.[1,2] Prevalence of diabetes in global world is about 246 million and is expected to affect 380 million by 2025, which represent 7.1% of the adult population.[3] Diabetes symptoms are hyperglycaemia, polyuria, polyphagia, polydipsia and weight loss.[1,2] Many efforts were done to understand and manage this disease and its complications such as cardiovascular disease, hypertension, nephropathy and neuropathy.[4] It is known that tight blood glucose control delays the onset and progression of complications in diabetes.[5] The major aim of diabetes management is to reduce hyperglycaemia, because it plays a main role in acute and chronic complications of diabetes.[4] Due to many severe side effects of drugs used in the control of hyperglycaemia and hyperlipidaemia of diabetes, a current, safe, suitable and cheap treatment is still a challenge for medical system.[2] Physical activity, intensive daily control of blood glucose and diet are three cornerstones in the management of diabetes.[6] Diabetes treatment emphasizes on serious daily control of blood glucose by matching insulin, food intake and physical activity.[7] Many studies indicated that regular physical exercise helps in maintenance a healthy lifestyle in diabetes. Regular exercise with or without dietary modulation and/or medication have been recognized as a therapeutic strategy in Type 2 diabetes.[3] Evidence

indicated that exercise will be a powerful component in the treatment of diabetes.[4] Regular exercise is a useful nonpharmacological strategy in control of diabetes.[8] The ability of exercise to improve diabetes symptoms like hyperglycaemia, polyuria, polydipsia, weight loss and polyphagia will provide an evidence of its efficacy in the treatment of diabetes, thus there is a critical need to define the characteristics of appropriate exercise in diabetes. The aim of present study is to examine the effects of 8 weeks of moderate swimming exercise on diabetes symptom such as blood glucose, food intake, water intake and weight changes in streptozotocin-induced diabetic rats.

MATERIALS AND METHODS

Animals

Male Wistar rats (200±20 gr) were purchased from Pasture Institute of Iran (Tehran). During the experiment, all animals were kept in standard polyester cages (two rats in each cage) in a room with standard temperature (22 ± 2ºC) and humidity (55 ± 5%) with 12 hour light/dark cycle and free access to water and standard rodent chow. All protocols of the study were approved by Institutional Animal Ethics Committee of AJA University of Medical Sciences (Iran), which follows the NIH guidelines for care and use of animals.

Induction of Diabetes

Diabetes was induced by a single intraperitoneal injection of 50 mg/kg streptozotocin (Sigma, USA) dissolved in citrate buffer (0.01 mol/L, pH 4.5) while the non-diabetic rats received citrate buffer solution in the same volume. Five days later, blood samples obtained from retro-orbital plexuses vein were used for monitoring serum glucose. The rats included hyperglycaemic when the serum glucose concentration was more than 400 mg/dl, and those with serum glucose less than 400 mg/dl were excluded from the study.

Exercise Protocol

In the present study, endurance swimming was used as a model of exercise intervention. The training included daily moderate-intensity swimming for eight weeks, which induces cardiac hypertrophy.[9] The rats in swimming groups performed swimming in a rubber swimming tank with dimension of 55×100×60cm for 30 minutes in the morning. The water depth was enough to prevent from resting and eliminate bobbing behavior. The tank was filled with tap water and was sufficient for six rats to swim simultaneously. Water temperature was fixed at 32±1ºC to prevent hypothermia. The exercise protocol in the first week of training began with acclimatization to water. In the first day, rats swam for 10 minutes. Then, the duration of training increased daily 10 minutes until each rat could swim continuously for 30 minutes. In subsequent weeks, the rats could swim 30 minutes a day five times a week (30 min/day; 9:00-11:00 AM on Saturday to Wednesday).[10] The control groups (normal and diabetes) were remained sedentary in the swimming tank while it was filled with tap water in 5 cm depth that animal's paws reached to the bottom of tank. After each session, the animals were dried and kept in a warm place to prevent from hypothermia stress.

Experimental Groups and Design

Rats were randomly divided into four groups (n = 5per group): Normal rats (sedentary normal) were healthy animals that remained sedentary (N), trained normal group were healthy animals that did exercise for eight weeks (NE), sedentary diabetic group were diabetic animals that remained sedentary (D), and trained diabetic group were diabetic animal that did exercise for eight weeks (DE).

Forty-eight hours after the last training session of exercise, under light anesthesia with ether, blood samples were collected from retro-orbital plexuses. Serum was separated by centrifugation at 3500×*g for 15 min*utes, and the concentration of serum glucose was determined by using the available commercial kit (ZiestChemie Diagnostic Co, Iran).

Weekly weight change was calculated according to the initial weight. Food conception and intake water were measured in certain days of week. To determine food and water intake, each rat was given pre-weighed pellet and water, and after 24 hours; its remnants were measured to determine their consumption.

Statistical Analyses

The results were expressed as the means ± SEM. All statistical comparisons were carried out using one-way analysis of variance (ANOVA) and Tukey's test as post-hoc analysis. P = .05 was considered statistically significant.

RESULTS

Plasma Glucose

The plasma concentration of glucose in different groups of experiment at the end of the 8th week is shown in **Figure 1**. Induction of diabetes significantly (P = .001) increased the concentration of plasma glucose (above 400 mg/dl). Swimming exercise had no significant effect

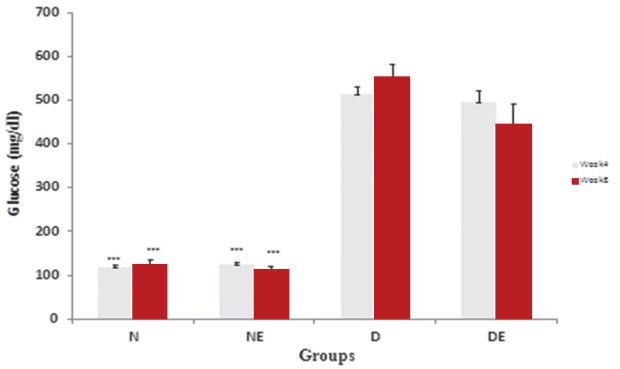

Figure 1. Effects of an eight-week swimming exercise on plasma glucose level. All values are presented as mean ± SEM.
***significantly different from D and D/E groups (*P* = .001).

on plasma glucose level of NE and DE groups in the 8th week.

Bodyweight Change

The weight change of sedentary (Nand D groups) and exercised rats (NE and DE groups) during experiment is shown in **Figure 2**. There was a gradual body weight increase in all groups during the experiment. Diabetes decreases (P = .05) weight gain in D and DE groups in comparison with N and NE groups and swimming exercise has no significant effects on the bodyweight changes shown in **Figure 2**.

Daily Food Intake

The mean daily food intake in N, NE, D and DE groups is shown in **Figure 3**. The food intake in D and DE groups was significantly higher (P = .05) than that of N and NE groups. However, swimming exercise had no significant effects on daily food intake in NE and DE groups.

Daily Water Intake

The mean daily water intake per rat for N, NE, D and DE groups is shown in **Figure 4.** There was a significant increase (P = .001) in volume of water intake in D and DE groups in comparison with N and NE groups. Swimming exercise had no significant effects on the mean daily water intake in DE and NE groups.

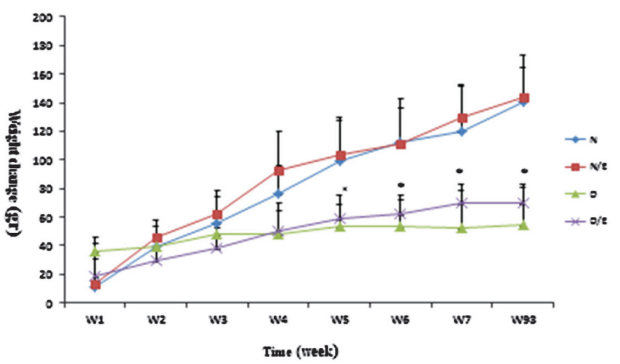

Figure 2. Body weight changes of experimental groups. All values are presented as mean ± SEM.
*significantly different from N and NE groups (*P* = .05).

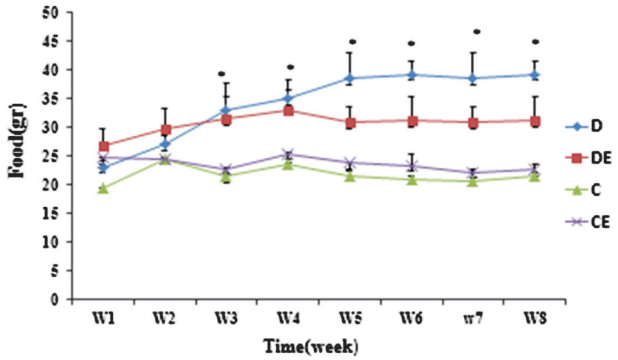

Figure 3. Mean food intake of different experimental groups. All values are presented as mean ± SEM.
*significantly different from N and NE groups (*P* = .051).

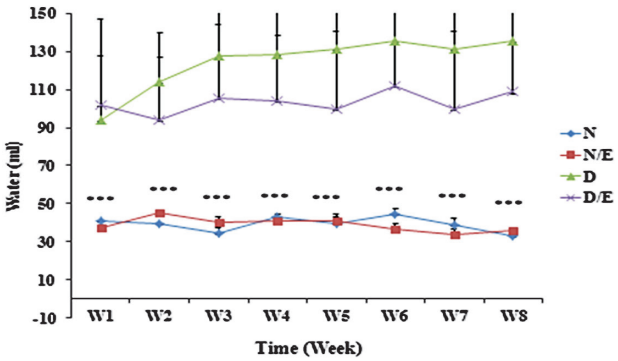

Figure 4. Mean volume of water intake by different experimental groups. All values are presented as mean ± SEM.
***significantly different from N and NE groups (*P* = .001).

DISCUSSION

The present studies showed that diabetes significantly increases glucose level, food intake and volume of water intake and reduces weight gain. Eight weeks daily moderate swimming exercise couldn't significantly attenuate these symptoms in STZ-diabetic rats and its effect was small but beneficial.

In diabetes due to absence or resistance to insulin action, glucose cannot pass cell membrane and enter to cell, which leads to cellular starvation and increases blood glucose and finally glycosuria. Hyperglycaemia is the main cause of polyuria, polydipsia, weight loss and polyphagia.[11] In this study insulin deficiency due to injection of STZ induced hyperglycaemia which was accompanied with weight loss, polydipsia and polyuria. Hypersmolarity of urine causes polyuria by excessive loss of water which

leads to dehydration and ultimately to polydipsia. Weight loss due to hyperglycaemia is a result of its effect on glycosuria that causes polyuria and leads to dehydration and weight loss.[7] Incapability of cells to use glucose as an energy resource and compensatory consumption of muscle protein and fat of adipose tissues for energy production is another cause of weight loss.[11] Insulin has a regulatory role in the control of body weight and food intake through its effect on brain in long term.[12] Signal from metabolism of glucose and fat is another factor in regulation of food intake.[13] Feeding centers in brain regulates feeding response and deficiency of glucose in these neurons causes polyphagia. So, despite the increases in food intake, diabetic individual loses weight. Degree of hyperglycaemia determines the level of polydipsia and polyuria and weight loss.[1] In our study hyperglycaemia is accompanied with weight loss, polydipsia and polyuria which is in agreement with other studies.

In this study 8 weeks moderate swimming exercise has small but beneficial reduction on blood glucose, according to causal role of hyperglycaemia and its degree on other symptoms of diabetes; it is reasonable that the effects of exercise on food intake, water intake and weight changes is small too.

The effects of exercise training on glucose control has been broadly studied. Studies indicated that aerobic exercise has an important role in prevention, management and treatment of diabetes.[4] Data strongly emphasizes on the positive effects of exercise in the management of diabetes.[4,14] The benefits of exercise are owing to the adaptations with chronic exercise. A meta analysis indicated that exercise has small to moderate beneficial effects on glucose control in diabetic patients.[6] Glucose uptake in skeletal muscle is mediated by glucose transporter in cell membrane (GLUT4), which translocates to plasma membrane of muscle cell in response to exercise and increases insulin sensitivity[15] by activating intracellular pathway that is different from insulin path way.[16]

In the current study, the swimming exercise did not significantly decrease the blood glucose of normal and diabetic rats (**Figure 1**). Our finding is in agreement with the study which recorded beneficial effects of exercise on glucose control in diabetes toa small to moderateextend.[6] The type and intensity of exercise is an important factor in reduction of blood glucose during hyperglycaemic condition.[17] Additional studies are necessary to determine the precise mode, frequency, volume and intensity of exercise necessary to optimize the blood glucose control.

CONCLUSIONS

Results of this study indicated that, daily moderate swimming exercise alone is not effective in the management of diabetes, so it is obvious that other interventional programs are necessary.

CONFLICT OF INTEREST

None declared.

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