Effect of 12 weeks of water aerobics on capillary glycemia among individuals with type II diabetes *mellitus*

Efeito de 12 semanas de hidroginástica sobre a glicemia capilar em portadores de diabetes *mellitus* tipo II

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Resumo

O crescente aumento da obesidade tem levado cada vez mais pessoas a ter algum tipo de doença crônica não transmissível como o diabetes *mellitus* tipo II, cujo número de portadores vem aumentando nos últimos anos. Portanto, o presente trabalho objetivou avaliar a glicemia capilar em jejum após 12 semanas de aulas de hidroginástica em homens e mulheres com diabetes *mellitus* tipo II. O estudo contou com a participação de 29 indivíduos de ambos os sexos, distribuídos em um grupo masculino (n=10) e outro feminino (n=5) exercitados com hidroginástica, e, dois grupos controles, um masculino (n=5) e outro feminino (n=9). Foram avaliados a massa corporal (MC), o índice de massa corporal (IMC) e a glicemia capilar em jejum (GJ) no início do estudo (M0), após seis (M1) e 12 semanas de acompanhamento (M2). As aulas tiveram duração de uma hora, três sessões semanais, durante 12 semanas. Houve redução na MC entre (M0: 78,0±8,6kg e M2: 75,5±8,5 kg; p=0,01) e GJ entre (M0: 199,8±87,5mg/dL; M1: 125,0±38,6 mg/dL e M2: 138,0±40,4mg/dL; p=0,003), ambos para o grupo masculino exercitado. Quanto ao grupo hidroginástica feminino, houve redução significativa apenas para a GJ entre (M0: 213,8±77,1mg/dL e M2: 134,0±38,2mg/dL; p=0,04). Não houve diferença estatística quando comparados os grupos entre si. Em conclusão, a prática regular de hidroginástica favorece o controle da massa corporal assim como da glicemia em jejum de diabéticos tipo II. No entanto, tais efeitos necessitam ser melhor investigados quanto à influência do gênero e à idade dos indivíduos, particularmente em mulheres no climatério.
Palavras-chave: Diabetes; Hidroginástica; Glicemia em jejum.

Abstract

The growing increase in obesity has led more and more people to some kind of cronic non-transmittable disease such as diabetes mellitus type II, whose number of patients has increased in recent years. Thus, this paper aimed to evaluate the fasting glycaemia after 12 weeks of hydrogymnastics classes in men and women with diabetes mellitus type II. The study counted on the participation of 29 individuals from both sexes, distributed in a male group (n=10) and in a female (n=5) exercised with water aerobics, and two control groups, a male (n=5) and a female (n=9). Body mass (BM), body mass index (BMI) and fasting glycaemia (FG) were assessed at the beginning of the study (M0), after six (M1) and 12 weeks of follow-up (M2). Classes lasted for an hour, three week sessions, for twelve weeks. There was a reduction on BM between (M0: 78.0±8.6 and M2: 75.5±8.5kg; p=0.01) and FG between (M0: 199.8±87.5; M1: 125.0±38.6 mg/dL and M2: 138.0±40.4 mg/dL; p=0.03), both for the male group exercised. About the female hydrogymnastics group, there was significative reduction only for the FG between (M0: 213.8±77.1mg/dL and M2: 134.0±38.2mg/dL; p=0.04). There was no statistical difference when the groups were compared among themselves. In conclusion, the regular practice of hydrogymnastics favors the body mass control just like the fasting glycaemia in diabetes type II porters, however, such effects need an in depth investigation, about the influence of gender and age of the individuals, particularly in women on climacteric.
Keywords: Diabetes; Hydrogymnastics; Fasting glycaemia.

INTRODUCTION

Diabetes is a disease characterized by hyperglycemia and is associated with complications, dysfunctions and insufficiency of several organs, especially the eyes, kidneys, nerves, brain, heart and blood vessels[1]. Its etiology relates to defects of insulin secretion and/or action involving specific pathogenic processes, for example destruction of pancreatic beta cells (insulin producers), resistance to insulin action and insulin secretion disorders, among others[1]. The most frequent types of diabetes are insulin-dependent diabetes (type I), non-insulin-dependent diabetes (type II) and gestational diabetes. Type II diabetes has the highest incidence, accounting for around 90% to 95% of the cases[2].

Occurrences of diabetes around the world have reached epidemic status over recent years, especially as a result of urbanization, aging of the population, sedentarism and increased prevalence of obesity[3]. In this respect, Wild *et al.*[3] highlighted occurrences of increased numbers of cases of diabetes both in developed and in developing countries like Brazil. According to data in their study, 4.6 million Brazilians had diabetes in the year 2000, and this could reach 11.3 million in 2030, consisting particularly of individuals between the ages of 45 and 64 years. Thus, it has been proposed that reduction of fatty body mass and diminution of sedentary lifestyles should be targets to be achieved.

In this regard, it has been recommended that physical exercise should be practiced on most days of the week, with the aim of regulating glycemic levels and thus avoiding the complications relating to diabetes[4]. Both aerobic and strength exercises have presented efficient results with regard to both treating and preventing type II diabetes[5]. However, some particular features need to be noted, such as the physiological and morphological differences between male and female individuals[6], along with the age factor, given that women at the climacteric and postmenopausal women in particular present higher predisposition towards diabetes as a result of the hormonal changes inherent to this stage of life[7-10].

In this manner, water aerobics has emerged as an excellent alternative for aiding in improving aerobic conditioning, muscle strength, muscle resistance and flexibility. Moreover, immersion in a liquid medium favors biological effects that extend across all homeostatic systems, and these effects may be both acute and chronic[11]. In relation to the musculoskeletal system, the effects are caused by the compressive effect of immersion, as well as the reflex regulation of blood vessel tonus[11]. Thus, the practice of water aerobics has been indicated for middle-aged and elderly individuals because of the differentiated environment, which favors greater adherence; because this is an activity that enables activation of major muscle groups in synergy, thereby further accommodating aerobic exercises; and because of the lower risk of falls. The fact that water aerobics classes are group activities also encourages sociability. These activities may also have lower impact on the joints[11,12], promote a blood pressure-lowering effect, increase cardiac output and promote pleural pressure and diuresis due to increased hydrostatic pressure[13], among other effects.

Hence, the present study had the objective of evaluating fasting capillary glycemia after 12 weeks of water aerobics classes, among men and women with type II diabetes.

METHODS

This was an experimental study with a duration of 12 weeks that was conducted using a convenience sample. The inclusion criteria were that the individuals should have a medical diagnosis of type II diabetes, should not be under treatment with insulin and should not be subject to dietary restrictions. The exclusion criteria were the presence of any of the following: physical incapacity that would prevent the practice of water aerobics, any skin infections, body mass index greater than 35 kg/m^2, uncontrolled diabetes, severe arterial hypertension, adherence to any dietary control, or some of the following signs and/or symptoms: cyanosis, acute rises or falls in arterial pressure, general indisposition, dyspnea, precordial pain or other conditions that could expose the individual to the risk of death or accidents during the classes. The volunteers were recruited in a family heath strategy unit (FHS-IV) in the municipality of Primavera do Leste, Mato Grosso, by means of analyzing medical records and then making invitations via telephone. Initially, 20 male volunteers and 20 female volunteers were randomly allocated to two possible groups: male control group (n = 10), female control group (n = 10), male water aerobics group (n = 10) and female water aerobics group (n = 10).

Out of the 40 volunteers previously recruited, 29 (72.5%) completed the 12 weeks of follow-up. The other participants gave up for a variety of reasons (engaging in other physical activities, starting a calorie-restricted diet, difficulty in coming to the gym and other unexplained reasons). Of these, five were in the male control group, five in the female group with exercise and one in the female control group.

General procedures

Fasting capillary glycemia (FG) was measured by means of the G-TECH® device (China), after the subjects had fasted for 12 hours, had abstained from alcoholic drinks for 72 hours and had rested for a 30-minute period prior to the measurements, which were made in the mornings. To determine the volunteers' body mass (BM), they were positioned standing at the center of the platform of the weighing scale, with their feet together and arms at the sides of the body, in accordance with the technique recommended by Fett *et al.*[14], using a Filizola® mechanical scale (Brazil), with a capacity of 200 kg and precision of 100 g. Height was measured with the volunteers barefoot and standing upright, with the feet together and close to the scale. It was measured using the stadiometer that was attached to the weighing scale, with precision of 0.5 cm, in accordance with the procedure previously described by Fett *et al.*[14]. Subsequently, the body mass index (BMI) was calculated according to the equation BMI = BM (kg)/height (m)^2. Both the anthropometric and the capillary glycemia measurements were made three times: firstly at the start of the study (M0), then after six weeks (M1) and after 12 weeks (M2) of follow-up. All the measurements were made by a single experienced evaluator.

The experimental intervention consisted of participation in water aerobics classes in a covered swimming pool (15 m x 6 m), with a water temperature of between 27 and 30°C, for 12 weeks. The classes were held three times a week (Mondays, Wednesdays and Fridays) and each class lasted on average for 60 minutes. In each class, there was 10 minutes of warm-up: skipping and movements; 40 minutes of localized exercises: (a) dynamic exercises for the upper limbs (adduction and abduction of the shoulders (deltoid muscles); flexion and extension of the elbow, (biceps and triceps muscles); horizontal adduction and abduction of the shoulders associated with flexion and extension of the elbow (pectoral and costal muscles); (b) dynamic exercises for the lower limbs: abduction and abduction of the hip (adductor and abductor muscles); flexion and extension of the hip (flexor and extensor muscles); flexion and extension of the knee (quadriceps and posterior thigh muscles); and stationary gait; and finally, 10 minutes of returning to calmness. Three sets were performed, with 20 repetitions for each exercise and maintaining an interval between the sets of one to two minutes, to rest. For some exercises, the following accessories were used: float boards, dumbbells, rubber balls, floats and batons (tubes).

The working load was progressively increased as suggested by Ramos[15] for diabetic individuals, with initial adaptation to the liquid medium, movements and postural corrections, and then aerobic and localized exercises. The intensity was maintained at between 11 and 13 (reasonably light to slightly difficult), according to the subjective strength perception scale[16]. The volunteers were dispersed in the pool so as to maintain the water level at chest height, thereby promoting a reduction of 80% in the impact on the locomotor apparatus due to floatability[17].

All the volunteers were previously assessed by the physician in charge at the FHS-IV and were released to participate in the study. These individuals were then informed about the aims of the study and signed a free and informed consent statement in accordance with Resolution 196/96 of the National Health Council, thereby agreeing to collaborate with the present study. The project was registered and approved by the Research Ethics Committee of the University General Hospital (HGU/UNIC), under protocol number 2010-183.

Statistical analysis

The data were analyzed using the BioEstat® 5.0 statistical package (Brazil) and were expressed as the mean ± standard deviation. The Kolmogorov-Smirnov test was firstly performed to examine whether the data presented normal distribution and then the Mann-Whitney and Friedman tests were used for intragroup analysis of variance and the Kruskal-Wallis test for intergroup variance. The significance level was preestablished at 5%.

RESULTS

In relation to use of oral blood glucose-lowering agents, the male water aerobics group included three individuals who were using metformin and three who were using glibenclamide, while the others (n = 4) were not using any medication. In the female water aerobics group, three individuals were using metformin, one was using glibenclamide and one was not using any medication. In the male control group, two individuals were using metformin, two were using glibenclamide and one was not using any oral blood glucose-lowering agents. In the female control group, four individuals were using metformin, two were using glibenclamide and three were not using any medication.

Table 1 shows the classification of overweight according to BMI for both male groups, along with the elevated capillary glycemia levels. The control group presented a shorter duration of diabetes diagnosis than shown by the exercise group, although there was no statistical difference between the groups.

Table 2 likewise shows the situation regarding overweight for the female water aerobics and control groups, along with the elevated capillary glycemia levels. The length of time for which the subjects had had a diagnosis of diabetes was greater in the control group than in the exercise group, but without any statistically significant difference between the groups.

Table 1 **General characteristics and differences between the male diabetic groups.**

Variables	Water aerobics (n = 10)	Control (n = 5)	p-value
Age (years)	63.7 ± 7.5	67.0 ± 10.5	0.54
Length of time with diabetes (months)	114.0 ± 37.2	88.8 ± 13.7	0.20
Duration of treatment (months)	12.0 ± 17.6	6.4 ± 5.4	0.81
Body mass (kg)	78.0 ± 8.6	81.6 ± 10.5	0.76
Height (m)	1.69 ± 0.08	1.75 ± 0.06	0.20
BMI (kg/m^2)	27.2 ± 2.3	25.8 ± 3.3	0.58
FG (mg/dL)	199.8 ± 87.5	190.0 ± 46.4	0.85

BMI = body mass index; FG = fasting glycemia; Mann-Whitney test. Significance level: $p<0.05$.

Table 2 **General characteristics and differences between the female diabetic groups.**

Variables	Water aerobics (n = 5)	Control (n = 9)	p-value
Age (years)	63.8 ± 14.5	65.0 ± 9.2	1.00
Length of time with diabetes (months)	129.6 ± 36.4	150.7 ± 31.2	0.26
Duration of treatment (months)	17.6 ± 19.3	22.7 ± 19.4	0.74
Body mass (kg)	72.6 ± 3.8	77.7 ± 7.8	0.35
Height (m)	1.60 ± 0.04	1.67 ± 0.08	0.14
BMI (kg/m^2)	27.2 ± 3.6	26.3 ± 2.4	0.55
FG (mg/dL)	213.8 ± 77.1	183.9 ± 55.2	0.32

BMI = body mass index; FG = fasting glycemia; Mann-Whitney test. Significance level: $p<0.05$.

The results after 12 weeks of intervention with water aerobics for the male subjects (Table 3) showed that there were statistically significant reductions in the variables BM and FG and a tendency towards significance for BMI. The control group showed increases in BM and BMI and a reduction in FG, but none of the variables presented statistically significant differences between the times analyzed. For the female group that did exercises, Table 3 also shows that there were reductions in all the variables, although only the reduction in FG was statistically significant. Surprisingly, there were reductions in all the variables analyzed in the female control group, but without statistically significant differences between the times analyzed.

Regarding the variance between the groups (Table 4), there were no statistical differences between the groups for any of the variables analyzed, between the three times (M0: initial; M1: six weeks; and M2: 12 weeks). There was only a tendency towards statistical significance for the variable FG after six weeks of follow-up (M1).

DISCUSSION

The scarcity of studies investigating the effects of water aerobics on capillary glycemia among individuals with type II diabetes makes it difficult to extrapolate and compare the results that we have presented here. Therefore, the present

Table 3 **Effect of 12 weeks of training with water aerobics on body mass, body mass index and capillary glycemia among type II diabetics.**

Male water aerobics group (n = 10)	M0	M1	M2	p-value
Body mass (kg)	78.0 ± 8.6[a]	75.9 ± 8.1	75.5 ± 8.5[b]	0.01
BMI (kg/m^2)	27.2 ± 2.3	26.6 ± 2.3	26.4 ± 2.4	0.06
FG (mg/dL)	199.8 ± 87.5[a]	125.0 ±38.6[b]	138.0 ± 40.4[b]	0.003
Male control group (n = 5)	**M0**	**M1**	**M2**	**p-value**
Body mass (kg)	81.6 ± 10.5	81.0 ± 10.2	81.8 ± 9.7	0.55
BMI (kg/m^2)	25.9 ± 3.3	25.6 ± 3.4	25.8 ± 3.2	0.35
FG (mg/dL)	190.0 ± 46.4	168.0 ±61.2	166.0 ± 34.4	0.45
Female water aerobics group (n = 5)	**M0**	**M1**	**M2**	**p-value**
Body mass (kg)	72.6 ± 3.8	71.4 ± 5.7	69.8 ± 6.0	0.09
BMI (kg/m^2)	27.2 ± 3.6	26.7 ± 3.9	26.2 ± 3.9	0.12
FG (mg/dL)	213.8 ± 77.1[a]	162.0 ±42.1	134.0 ± 38.2[b]	0.04
Female control group (n = 9)	**M0**	**M1**	**M2**	**p-value**
Body mass (kg)	77.7 ± 7.8	76.2 ± 8.3	76.8 ± 8.2	0.70
BMI (kg/m^2)	26.3 ± 2.4	26.1 ± 2.5	26.0 ± 2.4	0.46
FG (mg/dL)	183.9 ± 55.2	180.0 ±56.3	151.1 ± 49.5	0.06

BMI = body mass index; FG = fasting glycemia; M0 = start; M1 = after six weeks; M2 = after 12 weeks. Friedman test. Different superscript letters indicate differences between the times ($p < 0.05$).

Table 4 **Analysis of variance on body mass, body mass index and capillary glycemia among type II diabetics after 12 weeks of training.**

Groups/Variables (M0)	BM (kg)	BMI (kg/m^2)	FG (mg/dL)
Male water aerobics (n = 10)	78.0 ± 8.6	27.2 ± 2.3	199.8 ± 87.5
Female water aerobics (n = 5)	72.6 ± 3.8	27.2 ± 3.6	213.8 ± 77.1
Male control (n = 5)	81.6 ± 10.5	25.9 ± 3.3	190.0 ± 46.4
Female control (n = 9)	77.7 ± 7.8	26.3 ± 2.4	183.9 ± 55.2
p-value	0.36	0.79	0.72
Groups/Variables (M1)	**BM (kg)**	**BMI (kg/m^2)**	**FG (mg/dL)**
Male water aerobics (n = 10)	75.9 ± 8.1	26.6 ± 2.3	125.0 ± 38.6
Female water aerobics (n = 5)	71.4 ± 5.7	26.7 ± 3.9	162.0 ± 42.1
Male control (n = 5)	81.0 ± 10.2	25.6 ± 3.4	168.0 ± 61.2
Female control (n = 9)	76.2 ± 8.3	26.1 ± 2.5	180.0 ± 56.3
p-value	0.41	0.93	0.06
Groups/Variables (M2)	**BM (kg)**	**BMI (kg/m^2)**	**FG (mg/dL)**
Male water aerobics (n = 10)	75.5 ± 8.5	26.4 ± 2.4	138.0 ± 40.4
Female water aerobics (n = 5)	69.8 ± 6.0	26.2 ± 3.9	134.0 ± 38.2
Male control (n = 5)	81.8 ± 9.7	25.8 ± 3.2	166.0 ± 34.4
Female control (n = 9)	76.8 ± 8.2	26.0 ± 2.4	151.1 ± 49.5
p-value	0.18	0.99	0.42

BM = body mass; BMI = body mass index; FG = fasting glycemia. Kruskal-Wallis test. Significance level: $p < 0.05$.

study conducted in the aquatic medium with both aerobic and anaerobic characteristics was compared with other studies that were not conducted in water, such as strength and endurance training.

Recently, two studies were conducted using water aerobics as the training method: one by Lopes *et al*.[18] and the other by Nuttamonwarakul *et al*.[19]. Lopes *et al*.[18] evaluated the acute effect of one session of aerobic gymnastics using free weights and another using water aerobics, on capillary glycemia in a group of 12 middle-aged and elderly volunteers (one man and eleven women). In their study, reductions in capillary glycemia were observed after 15, 30 and 45 minutes of water aerobics and also after 15 minutes of rest. This demonstrates the efficacy of water aerobics for controlling acute glycemia and thus corroborates the findings from the present study, in which there were chronic reductions in this variable both in the male and in the female group (Table 3) after 12 weeks of intervention.

In the study by Nuttamonwarakul *et al*.[19], significant chronic reductions in glycated hemoglobin (HbA_{1c}) and circulating insulin levels were identified, thus demonstrating the benefits of water aerobics for glycemic control among elderly individuals with type II diabetes. The results from the present study corroborate some of the results observed by Nuttamonwarakul *et al*.[19], particularly with regard to the reductions in BM, BMI and FG seen in the male and female groups that did water aerobics exercises.

Silva and Lima[2] also observed reductions in capillary glycemia and HbA_{1c} among individuals with and without insulin treatment after 10 weeks of physical exercises of aerobic nature that were done on four days per week with one hour per training session, at mild to moderate intensity (50% to 80% of FCmax, respectively). In addition to their study, others[20-22] with an aerobic profile have also reported the same effects on glycemia reduction.

Although aerobic training may have a reductive effect on capillary glycemia and on other glycemic profile markers, other studies have also found that strength training may control glycemia in individuals with type II diabetes. Among these, the study by Misra *et al*.[23] can be highlighted: this had a duration of 12 weeks of strength training with progressively increasing loads and resulted in reductions in glycemia and insulin resistance. The same benefit was found by Cauza *et al*.[24], who observed that strength training was more effective for reducing glycemia than was a 30-minute protocol on a cycle ergometer at 60% of VO_{2max}. Furthermore, in a study conducted by Holten *et al*.[25], reductions in plasma glycemia and HbA_{1c} were reported, along with increased sensitivity to insulin, after six weeks of strength training three times a week.

Although Sigal *et al*.[26] recognized that both aerobic exercises and strength exercises promoted reductions in the glycemic profile, they suggested that a combination between aerobic exercises and strength training presented better results regarding glycemic control than shown by either of these separately. This was confirmed by Arora *et al*.[27], who identified similar effects relating to glycemic control, promoted both by strength training with progressive loads and by a walking protocol of 30 minutes duration, done three times a week for two months. The present study corroborates these authors' results in that it identified significant reductions in FG, both in men and in women, after 12 weeks of water aerobics training. Although the training was predominantly aerobic, it also had resistance exercise characteristics, due either to the liquid medium *per se* or to the implements that were used with the purpose of increasing the subjects' strength.

In relation to body mass, the present study found a statistically significant reduction in the male group and a tendency towards significance for the female group (Table 3), but without any significant reflection in reduced BMI in either of the groups that did the exercises. In a study conducted by Cambri *et al*.[28] on individuals treated with insulin or oral blood glucose-lowering agents, no reductions in BM or in BMI were observed. This can at least partly be explained by bias in conducting the final analysis on the results, in which the researchers analyzed, in the same group, individuals who did walking exercises (n = 3) at an intensity of between 60 and 70% of the predicted FC_{max} and others who did strength training (n = 5) with a load stipulated as between 12 and 15 maximum repetitions. Diverging from their study, a significant reduction in BM was observed in the present study for the male group that did exercises, along with a tendency towards significance for BMI ($p = 0.06$). However, these variables did not present statistical significance for the female group, despite reductions. This can at least partly be explained by the fact that the women were at the climacteric or were postmenopausal, which contributed towards greater accumulation of fatty mass in these women[6].

Another study[29] was conducted among non-insulin-dependent diabetic women who were participants in a nutritional monitoring program and, at that time, were taking part in circuit strength training three times a week for two months. In this, statistically significant reductions were observed in relation to BM and percentage fat, although little change in BMI was observed. Regarding FG values before and after the intervention, there was a reduction, but without statistical significance. However, that study did not use any control group to identify whether the effects from the training were sufficient, or whether there was any confounding factor that might have interfered in the results presented. This concern existed in the present study and, thus, a control group for each sex was inserted in order to ascertain whether the improvements were random or whether the water aerobics training really would promote improvements additional to treatment with blood glucose-lowering agents. In this respect, although the statistically significant results were seen in the groups that did water aerobics exercises, improvements were also seen in the male and female control groups, possibly reflecting their use of blood glucose-lowering medications, given that none of the groups investigated were adhering to any nutritional monitoring.

Although a confounding factor of this nature may have occurred, reductions in BM, BMI and FG could be seen in the present study both for the male and for the female group that did water aerobic exercises, yet neither of these groups was under dietary monitoring.

In conclusion, practicing water aerobics promoted benefits similar to those from other training methods outside of the liquid medium, for individuals with type II diabetes. However, these effects need to be better investigated with regard to the influence of the individuals' gender and age, particularly among women at the climacteric.

Authors' contributions

Adilson Domingos dos Reis Filho drew up the project, guided and conducted the statistical analyses and wrote and reviewed the final version of the article; Patrícia Dantas de Amorim gathered the data, applied the water aerobics training and wrote and reviewed the final version of the article; Andreia Zimpel Pazdziora co-guided and reviewed the final version of the article; Eliana Santini assisted in drawing up the project and reviewed the final version of the article; Christianne de Faria Coelho-Ravagnani and Fabrício Azevedo Voltarelli reviewed the final version of the article and assisted in the statistical analyses.

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