12-Weeks Aquatic Exercise, Consumption of Pumpkin and Probiotic Yogurt, in Women with Type 2 Diabetes

Abstract

The purpose of this study was to examine the effect of 12 weeks of aquatic exercise and consumption of pumpkin and probiotic yogurt and insulin resistance index in women with type 2 diabetes**.** The current study is a quasi-experimental study in which 32 women with type 2 diabetes were selected using convenience and purposive sampling and hence assigned randomly to one of the four experimental groups: the 12-week aquatic exercise group (8 people), pumpkin and probiotic consumption group (8 people), the 12-weeks aquatic exercise + pumpkin and probiotic consumption group (8 people), and the control group (8 people)., glucose, insulin resistance, were measured as dependent variables in the pre-test and post-test for all participants. The training routine took 12 weeks to complete.

Three training sessions per week were administered for the first month, which increased to 4 sessions per week for the second month and 5 sessions per week for the third month. Each training session was devised to take 45 minutes. Analysis of covariance was used to compare the mean of dependent variables. Also, all statistical calculations were performed using Excel and SPSS v. 25. The results showed that aerobic exercise along with consumption of pumpkin and probiotic yogurt leads to a significant decrease in fasting glucose. According to the results of the present study, consumption of pumpkin and probiotic yogurt along with water-based exercises can have a positive effect on fatty liver markers and insulin resistance index in women with type 2 diabetes.

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Keywords: *diabetes, insulin resistance, exercise in water, consumption of pumpkin, probiotic yogurt*

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Introduction

Diabetes mellitus, commonly known as diabetes, is a group of chronic metabolic disorders and is one of the most common endocrine diseases, which is known today as a silent epidemic of the current century. It is deemed by many as one of the biggest health-related challenges in all countries, as more than 230 million people worldwide and 3.5 million people in Iran have been diagnosed with the disease (Amini Larzi et al., 2013). Chronic hyperglycemia in diabetes is associated with long-term damage and dysfunction and failure of various organs, namely, the eyes, kidneys, liver, nerves, heart, and blood vessels. Moreover, diabetes, especially type 2 diabetes, is often associated with lipid metabolism disorders (Hosseini et al., 2013). Type 2 diabetes is a metabolic disorder that occurs as a result of insulin secretion inefficiency. Recent evidence suggests that regular exercise is effective in improving the corresponding risk factors. For example, Debbie et al. (2005) reported that higher body mass index (BMI) and hip-to-waist ratio, and less physical activity are independently associated with higher levels of CGT (cited by Bani Talebi et al., 2019).

By increasing the total sugar consumption of the muscle cells within the body and also accelerating the metabolism of fats, physically demanding activities can lead to lesser concentrations of glucose and improved blood fat levels. Therefore, diabetic patients can employ training routines, either aerobic, resistance training, or stretching, to better control their blood glucose, fat profile, weight, and blood pressure. Nevertheless, aerobic exercises have been proven to be more efficient in the treatment of type 2 diabetic patients (Ejtehad et al., 2010).

Water sports are a suitable alternative for the elderly. Water sports in diabetic patients become more important when the limitations and problems of land and dry sports, such as causing skin problems, foot wounds, and loss of balance, are considered. As such, water sports and aquatic exercises are potentially more desirable for elderly diabetic patients (Hosseini et al., 2013). Performing water-based resistance exercises have been shown to decrease subcutaneous, visceral, and abdominal fat tissue, which improves insulin sensitivity (Nabavi et al., 2014).

Probiotic yogurt is one of the most beneficial foods with a plethora of proven positive effects on people's health. Several studies on animals have established the effect of probiotics in reducing blood sugar and delaying the occurrence of increased blood sugar and insulin resistance. Probiotics can also be effective in controlling blood sugar by preventing the production of reactive oxygen species, the antioxidant property of access to diabetic drugs (Ejtihad et al.,2010). Studies indicate that the consumption of probiotic foods or supplements of these compounds may lead to a decrease in serum cholesterol levels and an improvement in insulin sensitivity (Ataei et al., 2014). The effects of probiotics on the lipid pattern and the level of inflammation have been examined in different studies (Moras and Alba, 2019; Silva, 2019, Paul et al., 2020; Jahormi, 2017; Nasiri, 2020; Keyhanian et al., 2017; Hosseini et al. 2012).

Given the aforementioned discussion, the purpose of this research was to examine the effect of 12 weeks of water exercise combined with the consumption of pumpkin and probiotic yogurt on the indicators of fatty liver and insulin resistance index in women priorly diagnosed with type 2 diabetes.

Research methods

The current study is a quasi-experimental study in which 32 women with type 2 diabetes were selected using convenience and purposive sampling and hence assigned randomly to one of the four experimental groups: the 12-week aquatic exercise group (8 people), pumpkin and probiotic consumption group (8 people), the 12-weeks aquatic exercise + pumpkin and probiotic consumption group (8 people), and the control group (8 people). The variables of insulin, glucose, insulin resistance, and liver enzymes were measured as dependent variables in the pre-test and post-test for all participants. The training routine took 12 weeks to complete. Three training sessions per week were administered for the first month, which increased to 4 sessions per week for the second month and 5 sessions per week for the third month. Each training session was devised to take 45 minutes. Analysis of covariance was used to compare the mean of dependent variables. Also, all statistical calculations were performed using Excel and SPSS v. 25.

A treadmill test was used to measure maximal oxygen uptake ($\dot{V}O_2$ max). In this test, the individual starts running on the treadmill for 3 minutes at a speed of 3.5 miles per hour, and after 3 minutes, the speed increases to 4.5 miles per hour. From there, the speed is increased by 0.5 miles per hour, and the inclination is increased by 2 degrees every one minute. When the person's heart rate reaches 85% of the maximum heart rate, the treadmill will stop, and the person's heart rate in one minute is measured, and $\dot{V}O_2$ max is calculated using the following formula, which is known as the Tayari method:

$$VO_2\ max = \frac{0.263(W_b + 10)V + 13.15}{HR + G - 72}$$

Where W_b is the Weight of a person in kg

G is the gender factor, 10 for men and zero for women.

HR=220-age

In the present study, all the training steps were done in the swimming pool and the shallow water area. The training routine consisted of warming up, stretching exercises, aerobics, strength training, flexibility, and then cooling down and recovery. During the exercises, the heart rate started at 65% of the maximum heart rate and increased to 75% at the end of the exercises. The duration of the exercise program was 45 minutes in each session. To control the intensity of the exercises, the heart rate was measured 3 times in each session, that is, before and after the aerobic exercises, and once during the cool-down using a Polar heart rate monitor.

The training routine for the experimental group

Duration and timeslot*:* First two weeks (3 sessions per week), Second two weeks (3 sessions *per week), Third two weeks (4* sessions ,per week), Fourth two weeks (4 sessions per week) Fifth two weeks (5 sessions)

, **Warm-up**: Walking with bent knees and elbows around the pool (5 min), Walking with bent knees, slowly running in the water (5 min), Walking with bent knees and hand weights (5 min), Side-way walking in the water (5 min), Walking sideways with bent knees (5 min)

Aerobic phase: Walking with straight knees and elbows in the water (10 min), Power walking in the water (15 min) – 65% VO2 max, Water aerobics (15 min) - 65% VO2 max, Water aerobics with 0.5 kg hand weights (15 min) - 65% VO2 max, Water aerobics with 0.5 kg hand weights (15 min)

Recovery: Stretching movements and lying in the water (10 min), Stretching movements and lying in the water (5 min), Walking and Stretching movements in the water (5 min), Walking and Stretching movements in the water (5 min), Walking and Stretching movements in the water (5 min)

Strength training phase: Flexing leg and hand muscles in various directions (5 min), Flexing hand muscles in various directions with small training balls, flexing leg in various directions (10 min), Walking in the water while hanging on the 5 kg rope (5 min), Walking in the water while hanging on the 5 kg rope (10 min), Walking in the water while hanging on the 10 kg rope (5 min)

Cool-down: Stretching movements, walking with bent and straight knees, and lying in the water (15 min), Stretching movements, walking with bent and straight knees, and lying in the water (10 min), Stretching movements, walking with bent and straight knees, and lying in the water (15 min), Walking with bent and straight knees and lying in the water (15 min), Stretching movements, walking with bent and straight knees, and lying in the water (15 min)

Pumpkin and probiotic yogurt were consumed at lunch. Probiotic yogurt in this study contained 4.35 x 107 colonies of live bacteria per gram and 1.5% fat.

Findings

In this section, the physical characteristics of the participants, including age, height, weight, and variables related to the research, are presented in Table 2.

Table 2: Mean values and standard deviation of research variables

Variable	Stage	Mean	SD
Age	Pre-test	57.9	6.11
	Post-test	57.9	6.11
Weight (kg)	Pre-test	71.51	12.02
	Post-test	70.75	11.67
BMI	Pre-test	28.86	3.97
	Post-test	28.43	3.75
Glucose	Pre-test	152	39.40
	Post-test	135.28	42.28
Insulin	Pre-test	11.84	9.70
	Post-test	9.17	8.95
Insulin resistance	Pre-test	3.86	3.36
	Post-test	2.78	2.58
ALT	Pre-test	23.75	9.87
	Post-test	22.65	7.66
AST	Pre-test	21.15	7.03
	Post-test	20.53	5.38
ALP	Pre-test	195.25	41.17
	Post-test	198.84	78.05
HbA1c	Pre-test	8.01	1.11
	Post-test	7.51	1.12
VO2 max	Pre-test	25.68	4.10
	Post-test	27.50	5.68

Table 3: Results of covariance analysis test for ALT of research groups

Effect	Sum of squares	df	Mean of squares	F	Sig. level	Eta
Pre-test	229.40	1	229.40	197.6	0.019	0.18
Group	356.43	3	118.81	3.19	0.039	0.26
Error	405.16	27	0.15			

The results obtained from the analysis of the covariance test showed a significant level of less than 0.05 that there is a significant difference between the ALT of the research groups (P=0.039). As can be seen, the eta coefficient also shows that

more than 0.26 of the changes are explained by the difference between the two groups. The results of Bonferroni's post hoc test also showed that the exercise and the combined routine groups significantly increased ALT compared to the control and nutrition groups.

Table 4: Results of covariance analysis test for AST of research groups

Effect	Sum of squares	df	Mean of squares	F	Sig. level	Eta
Pre-test	239.71	1	239.71	15.97	0.000	0.37
Group	150.37	3	50.12	3.34	0.034	0.27
Error	405.16	27	15.00			

The results obtained from the analysis of the covariance test revealed with a significance level of less than 0.05 that there is a significant difference between the AST of the research groups in the post-test stage (P=0.034). As can be seen, the eta coefficient also reflects that more than 0.27 of the changes can be explained by the difference between the two groups. The results of Bonferroni's post hoc test also showed that the nutrition and the combined routine groups had significantly lower AST than the training and control groups.

Table 5: Results of covariance analysis test for ALP of research groups

Effect	Sum of squares	df	Mean of squares	F	Sig. level	Eta
Pre-test	105455.632	1	105455.632	58.426	0.000	0.68
Group	2557.798	3	852.599	0.47	0.70	0.50
Error	48733.493	27	1804.944			

The results obtained from the analysis of the covariance test revealed with a significance level of less than 0.05 that there is a significant difference between the ALP of the research groups in the post-test stage (P=0.70). As can be seen, the eta coefficient also reflects that more than 0.50 of the changes can be explained by the difference between the two groups. The results of Bonferroni's post hoc test also showed that the nutrition and the combined routine groups had significantly lower ALP than the training and control groups.

Table 6: Results of covariance analysis test for Insulin of research groups

Effect	Sum of squares	df	Mean of squares	F	Sig. level	Eta
Pre-test	105455.632	1	105455.632	58.426	0.000	0.68
Group	2557.798	3	852.599	0.47	0.70	0.50
Error	48733.493	27	1804.944			

The results showed that there is no significant difference between the insulin variables of the research groups in the post-test stage (P=0.70). The eta coefficient also indicates that more than 0.27 of the changes can be explained by the difference between the two groups. The results of the Bonferroni post hoc test also showed that the nutrition and exercise groups had significantly less insulin than the combined routine and control groups.

Table 7: Results of covariance analysis test for glucose indicator of research groups

Effect	Sum of squares	df	Mean of squares	F	Sig. level	Eta
Pre-test	86.264	1	86.264	60.42	0.000	0.61
Group	16.124	3	56.415	69.6	0.02	0.042
Error	63.35	27	2.34			

The results obtained from the covariance analysis test indicated with a significance level of less than 0.05 that there is a significant difference between the insulin of the research groups in the post-test stage (P=0.02). The eta coefficient also shows that more than 0.27 of the changes can be explained by the difference between the two groups. The results of Bonferroni's post hoc test also showed that the training and combined routine groups had significantly lower glucose levels than the control and the nutrition groups.

Table 8: Results of covariance analysis test for glucose indicator of research groups

Effect	Sum of squares	df	Mean of squares	F	Sig. level	Eta
Pre-test	121.36	1	121.36	51.71	0.000	0.65
Group	4.51	3	1.50	0.64	0.59	0.66
Error	63.35	27	2.34			

The results obtained from the analysis of covariance showed a test with a significance level greater than 0.05 that there was no significant difference between the glucose levels of the research groups in the post-test stage (P=0.59). The eta coefficient also shows that more than 0.66 of the changes are explained by the difference between the two groups. The results of Bonferroni's post hoc test also showed that the exercise and nutrition groups had significantly less glucose than the combined and control groups.

Table 9: Results of covariance analysis test for HA1C indicator of research groups

Effect	Sum of squares	df	Mean of squares	F	Sig. level	Eta
Pre-test	17.72	1	17.72	45.79	0.000	0.62
Group	7.14	3	2.38	6.14	0.03	0.40
Error	10.45	27	0.38			

The results obtained from the analysis of the covariance test revealed with a significance level smaller than 0.05 that there is a significant difference between the HA1C of the research groups in the post-test stage (P=0.03). The eta coefficient also shows that more than 0.40 of the changes can be explained by the difference between the two groups. The results of Bonferroni's post hoc test also depicted that the training and the combined routine groups had significantly less HA1C than the nutrition and control groups.

Table 10: Results of covariance analysis test for maximal oxygen consumption of research groups

Effect	Sum of squares	df	Mean of squares	F	Sig. level	Eta
Pre-test	536.836	1	536.836	205.849	0.000	0.97
Group	101.023	3	33.674	12.912	0.000	0.58
Error	9.477	27	0.351			

The results obtained from the covariance analysis test revealed with a significance level of less than 0.05 that there is a significant difference between the maximal oxygen consumption of the research groups in the post-test stage (P=0.000). The eta coefficient also shows that more than 0.58 of the changes are explained by the difference between the two groups. The results of Bonferroni's post hoc test also showed that the exercise and the combined routine groups had significantly higher maximal oxygen consumption than the control and supplement groups.

Table 11: Results of covariance analysis test for BMI of research groups

Effect	Sum of squares	df	Mean of squares	F	Sig. level	Eta
Pre-test	420.662	1	420.662	1198.506	0.000	0.97
Group	1.358	3	0.453	1.290	0.29	0.125
Error	9.477	27	0.351			

The results obtained from the covariance analysis test indicated with a significance level greater than 0.05 that there is no significant difference between the BMI of the research groups in the post-test stage (P=0.29). The eta coefficient also shows that more than 0.125 of the variances are explained by the difference between the two groups. The results of Bonferroni's post hoc test also showed that the exercise and the combined routine groups had significantly lower BMI than the control and the nutrition groups.

Discussion

The results showed that aquatic training combined with the consumption of probiotic yogurt and pumpkin leads to the improvement of fatty liver markers and insulin resistance index

in women with type 2 diabetes. Descriptive results indicated that the combined routine, water training, and consumption of probiotic yogurt and pumpkin, respectively, leads to a decrease in fasting blood sugar and an increase in the maximal oxygen outtake. Yet there was no significant decrease in the amount of insulin and insulin resistance, ALT, AST, HBA1C, BMI, and ALP. These findings are in line with those of Bani Talebi et al. (2017), Babaei et al. (2019), Torabi et al. (2016), and Jahromi et al. (2017) while being inconsistent with those of Kakhak et al. (2013), Esmailzadeh et al. (2018) and Attarzadeh et al. (2015). One of the possible reasons for this inconsistency can be attributed to the difference in the age range of the participants. With age, many human physiological functions worsen, while the decrease in carbohydrate metabolism of the whole body is one of the symptoms of the menopause process, and evidence shows that aging is associated with a decrease in glucose tolerance and type 2 diabetes. On the other hand, it has been well proven that the increase in body fat is the main cause of metabolic abnormalities such as hyperinsulinemia and insulin resistance in postmenopausal women. This metabolic abnormality, in turn, is one of the causes of dangerous diseases such as blood pressure, cardiovascular diseases, and type 2 diabetes (Torabi and Tabrizi 2016).

The findings of the current study indicated that water exercise and consumption of probiotics and pumpkin yogurt, whether performed independently or in combination, lead to a decrease in fasting sugar, ALT, AST, and HbA1C in type 2 diabetic women. These findings are consistent with those of Ejtehadi et al. (2010), Babaei et al. (2019), Hosseini et al. (2012), and Bani Talebi et al. (2017). Nevertheless, the results are contradictory to those of Esmailzadeh et al. (2018) and Attarzadeh et al. (2015), which can be attributed to the difference in training method, training intensity, and the type of participants.

Descriptive findings revealed that aquatic exercises in combination with probiotic yogurt and pumpkin were more effective than each performed alone. Therefore, both treatments were shown to have positive effects on ALT, AST, and HBA1C when performed independently, while the combined routine had far more pronounced effects on reducing the blood sugar level of the participants.

Various reports have attributed diabetes to lifestyle-related issues, including physical inactivity, professional and academic stress, and poor diet (Valizadeh et al., 2018). Numerous studies have evidenced the role of physical training on the body's response to insulin and insulin sensitivity, thereby proving its function in preventing obesity and its subsequent complications, type 2 diabetes being no exception (Mohammadi et al. 2015). The present study also showed that with 12 weeks of water exercise and consumption of probiotic yogurt and fasting blood sugar levels. It showed a significant decrease.

The results of the study also revealed that water exercise and consumption of probiotic and pumpkin yogurt, whether performed independently or in combination, lead to a significant decrease in fasting glucose levels in women with type 2 diabetes, along with indicators of ALT, AST, and HBA1C. According to the descriptive findings, water exercise in combination with the consumption of probiotic yogurt and pumpkin prove to yield more desirable results than either alone. Therefore, it can be stated that both factors individually had effective and significant effects and, in combination, had far more severe effects on the reduction of fasting glucose and ALT, AST, and HBA1C levels of the participants and did not have a significant effect on insulin resistance. The results showed that exercising in water and consuming probiotic yogurt and pumpkin alone and in combination lead to a significant decrease in the level of liver enzymes aspartate aminotransferase, aminotransferase, and aminotransferase in women with type 2 diabetes. According to descriptive findings, water exercise in combination with probiotic yogurt and pumpkin was more effective than either alone. Therefore, both routines, that is, performed independently or in combination with each other, have significant effects on reducing the level of liver enzymes of aspartate aminotransferase, aminotransferase, and aminotransferase of the participants, the effects of which were far more pronounced for the combined routine. These results were inconsistent with those of Torabi et al. (2016), Ismailzadeh et al. (2018), and Tohidi et al. (2016), the latter of which examined the relationship between liver enzymes and the occurrence of type 2 diabetes. One study examined the occurrence of type 2 diabetes independently of the classic risk factors. This inconsistency can be attributed to the type of study. One of the important physiological variables that play a significant role in the optimal performance of athletes is the anaerobic threshold, which is defined as the intensity of work with the amount of oxygen consumed, which starts with acidosis caused by metabolism and is related to changes in the respiration output (Bahari et al., 2018).

Findings further indicated that water-based exercise and consumption of probiotic yogurt and pumpkin, whether independently or in combination with each other, significantly increased the maximal oxygen consumption of women with type 2 diabetes. As such, Descriptive findings revealed that the combined routine of aquatic exercises and consumption of probiotic yogurt and pumpkin resulted in more significant effects compared to each performed independently. Therefore, both routines, that is, performed independently or in combination with each other, have significant effects on the maximal oxygen consumption of the participants, the effects of which were far more pronounced for the combined routine. These results were consistent with the findings of Rahimi et al. (2015) and Zarei et al. (2016). Insulin resistance is defined as an incomplete response of glucose to a certain amount of insulin. In many of these patients, to compensate for this defect and hence maintain the glucose level, the circulating insulin

level increases. Evidence highly suggests that there is a strong correlation between insulin resistance in the liver and risk factors for cardiovascular disease (Motalabi and Ranjbar 2016).

The results showed that exercising in water and consuming probiotic yogurt and pumpkin alone and in combination with each other did not have a significant effect on the insulin resistance of women with type 2 diabetes. According to the descriptive findings, water exercise in combination with the consumption of probiotic yogurt and pumpkin was more effective than each of the routines alone. Nevertheless, both treatments, that is, performed independently or in combination with each other, did not have significant effects on the insulin resistance of the participants. These results were inconsistent with those of Attarzadeh et al. (2015), Enteshari et al. (2018), and Ghorbanian et al. (2016). This inconsistency can be attributed to the intensity of the exercises employed and the duration of these exercises.

Conclusion

The results from the current study indicate that water-based exercises, with or without the consumption of probiotic yogurt and pumpkin, can affect physiological indicators, leading to improved fatty liver markers, insulin resistance index, fasting blood sugar, and HBA1C. Therefore, the results of the present research have significant implications for the medical sciences, sports sciences, and nutrition, as people with type 2 diabetes can be administered the corresponding routines.

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