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Original Article

Effect of High- Fiber Diet alongside with Aerobic Exercise on HbA_{1c}, Fasting Blood Glucose and BMI of Overweight Diabetic Women

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Abstract

Introduction: New lifestyle is one of the most important causes of increased prevalence of diabetes due to inappropriate nutrition, consecutive stress, and lack of physical activity. The aim of this study was to investigate the effect of high- fiber diet and aerobic exercise on fasting blood glucose, HbA1c, and BMI in diabetic overweight women.

Methods: 41 overweight females with type 2 diabetes (aged between 40- 60) were selected to participate in the study. Patients were randomly divided into four groups including (control, high-fiber diet, aerobic exercise, and high-fiber diet+ aerobic exercise). The high fiber diet group consumed 25-30 gr fiber daily during 12 weeks. The aerobic exercise intensity was 60% of maximum heart rate, and each session took 20- 45 minutes (every two weeks 5 minutes was added). High-fiber diet + exercise group did the aerobic exercises, in addition to receiving 25-30 gr fiber in a day. The control group had no regular exercise activities or a special diet. Fasting blood sugar (FBS) samples were taken before and after the test. Data was analysed by Mann-Whitney U-test and Covariance analysis tests.

Results: The results of the study showed a significant reduction in HbA1c in the exercise group and in the high- fiber diet + exercise group compared to the control group (p=0.001). There were no significant differences in fasting blood glucose in the experimental groups compared to the control group (p=0.482). BMI changes were significantly higher in both control, and high-fiber diet + exercise groups (p=0.050).

Conclusion: The findings of the present study showed that aerobic exercise can solely or combined with a high-fiber diet relieve the chronic symptoms of diabetes. Also, BMI could have a significant decrease due to exercise and high-fiber diet. As a result, it seems that a regular exercise program and a high-fiber diet can be a part of prevention and treatment of diabetes.

Keywords: Training, HbA1C, Glucose, High Fiber Diet, BMI, Diabetes

Introduction

New lifestyle is one of the most important causes of increased prevalence of diabetes due to inappropriate nutrition, consecutive stress, and lack of physical activity (1). It is clear that poor physical activity associated with obesity, or with the rise of obesity, and the person is exposed to many chronic complications (2). Amongst obesity-related diseases which is more common in Iranian women rather than men, are risk factors for type 2 diabetes and cardiovascular disease (3), as the national cholesterol education expert panel (NCEP) has declared that abdominal obesity is the most common cause of metabolic abnormalities (4). According to the latest estimates, there are currently 8% of the Iranian population (more than 5.5 million people) suffering from diabetes, which is more in Iranian women than men (5). The prevalence of diabetes in Iranian adults aged above 30 years with estimated at 10.6% (6). Since the high blood glucose fluctuations overnight, fasting blood glucose is not a precise measure of glycemic control in patients. Nowadays, haemoglobin glycosylated (HbA_{1C}), which is itself a function of the long-term glycemic status of patients, is used as the best indicator of glucose. This index is one of the criteria for diagnosis of diabetes and its severity (7). The amount of HbA1c formation depends on the concentration of glucose, in fact, with the increase of chronic plasma glucose, the amount of non-inactivation glycosylation would increase, and as this sugar is applied over the life of the red blood cells, and so its formation represents a concentration of blood glucose during its recent 2- 3 months (8). The American diabetes association suggests an HbA1C of less than 7%, which is an estimated average glucose (eAG) of 154 mg/dl (9). Studies related to diabetes in England found that one percent reduction in HbA1c levels reduced the risk of %21 death, %14 myocardial infarction, and %37 for the risk of microscope complications in diabetics (10). Evidence suggests that if adequate blood glucose is well controlled, therefore reducing HbA1c level and long-term complications of diabetes can be prevented or postponed (especially retinopathy, neuropathy and nephropathy) (11). One of the primary symptoms of insulin sensitivity in patients with type 2 diabetes is the low cardiovascular capacity or decreased aerobic capacity. In diabetics, aerobic power decreases due to the inability in oxygen transport. It has also been shown that diabetics are 15% less likely to have aerobic exercise capacity compared to their normal age, which can be due to high HbA1c levels (12). Low levels of aerobic exercise capacity in diabetics are associated with certain pathological mechanisms such as hyperglycaemia, low capillary density, and adverse changes in oxygenation (13). It seems that increased physical activity plays an important role in controlling of the risk factors associated with diabetic patients (14). Although some studies in exercises have reported no effect on HbA1c levels and fasting blood glucose (15), but the ADA recommends a minimum of 150 minutes/week (at least 3 days a week) regular aerobic activity to diabetic patients (16). In 2016, Dixit et al, found that 8 weeks of moderate exercise improved blood glucose in 87 patients with type2 diabetes (17). On the other hand, eating well-balanced meals is an essential part of taking better care and managing diabetes. The beneficial effects of dietary fiber on blood glucose levels is well documented (18). Consumption of dissolved fiber is an effective factor in reducing blood glucose and lipids. Therefore; it is recommended that diabetics consume 25-30 gr of fiber daily. Consumption of fiber improved hyperglycaemia in patients with diabetes (19). In a clinical trial conducted by Fuji et al. in Japan, on the association between dietary fiber consumption, obesity, blood glucose control, cardiovascular risk factors, and chronic renal disease investigated in patients with type 2 diabetes, it was found that using fiber meal in the diet was associated with reduction in the prevalence of abdominal obesity, hypertension, and metabolic syndrome (20). The effects of aerobic exercise and high-fiber diet on HbA1c levels are still unknown. In some studies, the effect of combined high-fiber diet and aerobic exercise on HbA1C levels in diabetic patients has been investigated separately. This study is one of the few studies that have investigated simultaneous use of high-fibre high-fiber diet and aerobic exercise as an exogenous intervention. Therefore, due to the prevalence of type2 diabetes and its complications, especially cardiovascular disease, this study was designed to investigate the effect of high-fiber diet and aerobic exercise on HbA1c levels in overweight women with type2 diabetes.

Methods

Subject recruitment: The present study was experimental and practical. This project involved 41 women with type2 diabetes whose fasting blood glucose levels were greater than 200 mg/dL (not taking metformin) and were diagnosed with the illness for an average of one year. The patients used metformin with the dose of 500 mg/day and were registered with Salman-Farsi Hospital in Bushehr with a range of 40-60 years old. Eligible participants lacked any form of complications arising from acute and chronic diabetes and did not exercise regularly. The participants did not have any history of other diseases such as chronic cardiovascular and inflammatory diseases, diabetic ulcers, and hepatitis. Patients consuming vitamins and supplements or those who smoked were excluded from the study. Patients were well informed about the study prior to the experiment and written consent was obtained from them. A blind study method was applied and the participants were randomly assigned into 3 experimental groups (high- fiber diet=10, aerobic exercise=10, aerobic exercise + high-fiber diet=11), and 1control group=10. All procedures involving experiments were carried out in strict accordance with the United States Institute of Research guidelines and approved by the Medical Centre Board of Bushehr Hospital. Blood samples were collected at the certain time of the trainings through the elbow antecubital vein of all patients, 24 hours before and 48 hours after the last session of the study for measurement of blood glucose and HbA1c.5 ml blood samples were collected in serum separating tubes (SST) and allowed to clot at room temperature for 30 min. The blood clot was then centrifuged at 3000 g for 15 min. Aliquots of the serum samples were stored at −20 °C for further use. Fasting serum glucose was determined using the glucose oxidase method with a digital spectrophotometer (Bionic Company, China) and HbA1c was measured by using high-performance Elisa kit (Bionic Company, China). In order to measure the patient's weight and height, the standard German Weighing Scales and Medical German Weighing Scale (SECA) were used. The quantities obtained from height and weight were used to calculate the BMI by dividing the weight (kg) by the square of height (m). Patients in exercise groups were introduced and performed their training under a trainer's supervision for 12 weeks, 3 sessions per week in a gym. Written informed consent was obtained from all patients before any study-related procedures were performed. Patients were familiarized with the protocol and a heart rate strap (Mark Polar) was applied on them to monitor their heart rate within the first two sessions. These training sessions included 10 minutes warm up through walking with light static and dynamic stretching, rhythmic movements, and cooling down with stretching in standing and lying position in the final 15 min. The main training was rhythmic movements with intensity of 60% of maximum heart rate with duration of 20-45 minutes (increased 5 minutes in duration every two weeks). In the group of aerobic exercise + high fiber diet, after calculating the daily calories intake by using the form of food frequency (21), a healthy fiber food (25-30 gr per day) replaced their previous diet, without changing the amount of calories that they received. All data were presented as mean ± standard deviation. Shapiro-Wilk test was conducted to determine the data are normally distributed. In this research, analysis of variance was performed using SPSS version 18 and applied to measures of central tendency and dispersion. A Tukey's post-hoc analysis was used to check for significant differences among the main effects of each dependent variable. Since the distribution of BMI data was not normal, Wilcoxon's nonparametric test was used to investigate the effect of each intervention. Kruskal- Wallis test was used to compare the intra- group effects. If significant difference was observed, Mann-Whitney U-test was used to compare the difference in the test and control group in different areas. Statistical significance was considered when p value was less than 0.05.

Results

The anthropometric characteristics of the subject are shown in Table 1. Additionally; the differences between groups in HbA1c variable (ANOVA) are shown in Table 2. According to the results of Table 2 and significant changes of HbA_{1c} among the groups, Tukey's post hoc test was run to determine the location of the difference. Tukey's post hoc test results are presented in Table 3. The results of Tukey's test showed that after 12 weeks of intervention, the change (decrease) rate of HbA_{1c} in the aerobic training group was significantly higher than high fiber diet group (p=0.005). Also, this difference was observed between high fiber diet group and aerobic exercise + high fiber diet group (p=0.004). On the other hand, the reduction of HbA_{1c} in the aerobic exercise group (p=0.001) and aerobic exercise + high fiber diet (p=0.001) was significantly higher than the control group. The results of independent analysis of variance analysis showed that there is no significant difference of fasting blood sugar level between pre-test and post-test of groups (F=0.337, p=0.482). In order to evaluate the difference between BMI, the Wilcoxon test was used before and after the high fiber diet and aerobic exercise (Table 4). Data from Table 4 shows that there is a significant difference between the BMI values in type 2 diabetic women before and after the period of high-fiber diet and aerobic exercise. BMI significantly decreased after the period of high-fiber diet and aerobic exercise (p=0.04).Kruskal- Wallis test was used to compare the difference between the pre-test and post-test values of BMI in groups. The results of Kruskal-Wallis test indicate that there is a significant difference between the groups (F=1.29, p=0.04). The Mann Whitney test was used to determine the location of the difference. The results of Mann Whitney test showed that after 12 weeks of intervention, BMI reduction in aerobic training group was significantly higher than high fiber diet group (p=0.04).The difference was also observed between the control group and high fiber diet group (p=0.02). On the other hand, the decrease of this variable was significantly higher in the aerobic training group compare to control group (p=0.04).

Table 1. Anthropometric characteristics of the subjects (mean ± SD).

Groups	Age (year)	Weight (kg)	Height (cm)	Duration of illness
High-fiber diet	46.10 ± 4.46	71.23 ± 6.42	159.7 ± 5.95	7.70 ± 3.27
Aerobic exercise	46.10 ± 4.46	70.62 ± 6.64	158.4 ± 5.06	6.40 ± 3.50
aerobic exercise + high-fiber diet	48.64 ± 5.08	71.19 ± 10.27	160.8 ± 7.28	8.18 ± 5.46
control	52.60 ± 4.99	71.52 ± 5.88	159.8 ± 6.01	8.80 ± 4.90

Table 2. One-way analysis of variance (ANOVA) in HbA1c (mg/dL)

Groups	Pre-test	Post-test	Mean difference	Sum of Squares	F	P
High-fiber diet	7.65 ± 1.63	7.51 ± 1.53	0.14 ± 0.28	5.06	10.23	0.001
Aerobic exercise	7.35 ± 1.08	6.09 ± 0.79	1.26 ± 0.77			
aerobic exercise + high-fiber diet	7.74 ± 1.68	6.46 ± 1.24	-1.27 ± 1.03			
control	7.80 ± 2.15	7.83 ± 1.87	0.03 ± 0.42			

Table 3. Tukey's Post Hoc test results in HbA1c (mg/dL) variable of four groups

Group	Groups	Mean difference	Bias Error	P
High fiber diet	Aerobic exercise	1.12	0.31	0.005
	aerobic exercise + high-fiber diet	1.13	0.30	0.004
				0.001
control	Aerobic exercise	-1.29	0.31	0.001
	aerobic exercise + high-fiber diet	-1.30	0.30	

Table 4. Wilcoxon test analysis results on BMI variable of four groups

Groups	Pre-test	Post-test	Mean difference	df	F	P
High-fiber diet	27.92 ± 1.28	27.75 ± 1.28	-0.17 ± 0.25	2	1.29	0.04
Aerobic exercise	28.08 ± 1.74	27.53 ± 1.73	0.55 ± 0.81			
aerobic exercise + high-fiber diet	27.39 ± 1. 8	26.73 ± 1.64	0.66 ± 0.88			
control	28.03 ± 1.73	28.04 ± 1.80	0.01 ± 0.14			

Discussion

The results of this study showed a significant decrease in HbA1c levels in the experimental group compared to the control group. These results are consistent with the findings of the Grace *et al,* which showed that exercise could reduce 0.031% in HbA_{1c} level among 27 people with type 2 diabetes (22). Moreover, Negri *et al.* reported a significant decrease in HbA_{1c} after a 2month walking exercise in 59 diabetic patients (23). In the present study, HbA_{1c} levels of the experimental group (aerobic exercise + high fiber diet) significantly decreased compared to the control group, which is consistent with the research carried out by Crowe *et al.* (24). However, HbA1c levels in the experimental group of the high diet did not show a significant decrease compared to control group, which was consistent with Jenkins et al. (25) and inconsistent with Fuji *et al.* (20). Researchers showed that muscle contraction has a similar role with insulin to send a large amount of glucose into the cell in energy production. Muscle contraction may increase the permeability of the membrane to glucose due to an increase in the number of glucose transporters type 4 (GLUT4) in the plasma membrane. During the exercise, GLUT4 levels increase in exercised muscle, which improves insulin action on glucose metabolism resulted in HbA_{1c} reduction (26). The finding of this study showed that after 12 weeks of aerobic training fasting blood glucose level decreased in the experimental group of aerobic training, but the difference between pre-test and post-test was not significantly changed. In a previous study, 6 weeks aerobic training had no significantly effect in blood glucose levels which is consisted of present study (15). Furthermore, significantly decreased in fasting blood glucose after exercises reported that is inconsistent with the findings of the present study (27). In this study, 25 diabetic patients performed 30/min aerobic training per session, three times weekly for 12 weeks. Although, it has been reported that aerobic exercise could improve glycemic level in 25 diabetic patients (28). Some of the inconsistency among the reports may be due to severity, duration, and type of exercise, or age, sampling time, and exercise conditions. In point of fact, regular exercise has been reported to prevent and protect of type 2 diabetes, increased insulin sensitivity and improved glucose metabolism (29). The benefits of physical activity in improving the health of diabetic patients may be related to the effects of aerobic exercise on increasing capillary density and enzymes involved in oxidation, resulted in reducing insulin resistance, as well as, improving of the process of transporting glucose to consume it in the cell and insulin resistance decrease. In this situation, aerobic training can often reduce the level of insulin in the rest of blood and insulin production, which suggest improved insulin sensitivity and control of glucose in type 2 diabetic patients (30). Aerobic exercise is well-known for controlling of blood glucose and cardiovascular risk factors. Thus, doing exercise activity, skeletal muscle can increase blood flow, levels of GLUT4, haemoglobin, and glycogen synthesis activity (31). Aerobic exercise activates lipoprotein lipase (LPL), and increased activity of this enzyme that may play an important role in reducing insulin resistance during exercising (32). Another finding of this study showed that the experimental group of aerobic exercise had a significant decrease in BMI. It seems that aerobic exercise is one of the best type of exercise in the controlling of weight (32). Indeed, reducing of body fat through liposuction has not been able to improve type 2 diabetes and other risk factors (33). This emphasizes the beneficial effect of exercise in weight loss. Visceral adipose tissue has been shown to have high lipolytic activity and source of free fatty acid indicator, leading to excessive glucose production and reduced uptake in tissues, can cause hyperglycemia. The effect of physical activity stayed significant on visceral adipose tissue, abdominal obesity, and body composition reduction, resulted in significant improve metabolic rate (31). BMI in the experimental group of high fiber regimen showed a significant decrease compared to the control group. Since fiber-rich foods usually have lower energy content, it helps to reduce the energy density of foods. It should be noted that fiber-rich foods need more time required for chewing, which increases the time needed to eat and feel satiety. This fiber, which forms viscous fibres could delay gastric emptying via a direct effect of the food nutrients trapped within a viscous or gelled matrix that will more slowly leave the stomach and helps to increase satiety and reduce energy consumption. In the intestines, the mixing of fiber may complicate the alliance between the digestive enzymes and the substrate, thus reducing the rate of absorption of food (including fat and sugar) (34). Describing the possible mechanisms of viscous fibres to improve glucose metabolism and insulin sensitivity included slow intake of glucose in the small intestine, colon fermentation and their potential effects on the digestive system hormones. Moreover, increased concentration of short chain fatty acids in the serum derived from colon fermentation may have beneficial effects on liver fat metabolism and improve glucose metabolism (35). A significant reduction in BMI was reported in experimental group of aerobic exercise and high fiber diet. Digestive properties and fiber viscosity in this regime, probably affected on diabetes and the risk of obesity, which may reducing the absorption of nutrients and energy metabolized (36). Regular exercise usually increase daily energy expenditure, improves and enhances oxidation of lipids in skeletal muscle and mitochondria of liver cells, decrease daily caloric intake and obesity, especially in the abdominal region, which cause a decreased visceral fat, intestinal free fatty acids in the liver, fat sedimentation in the liver, and also increase fat oxidation in the liver (37). Intensity physical activity reducing abdominal visceral fat. Researchers has shown that people who do regularly exercise are less likely to lose weight than non-active people. Aerobic exercise combined with dietary control leads to a further reduction in fat mass compared with dietary intake (37). The Intensity, type, and time of exercise to lose weight are still discussable. In addition, having a proper diet and maintaining energy consumption are also important (32). Therefore, exercise with a proper daily diet can be more effective in burning fat (3).

Conclusion

Based on the results of this study, 12 weeks of aerobic exercise alone or with a high-fiber diet reduced HbA_{1c} levels, which is an indicator for controlling and reducing the risk of diabetes mellitus complications in type 2 diabetic women. Therefore, these factors should be considered in prevention or part of the diabetes treatment process. However, further investigations are warranted, and such research should focus on identifying the specific properties of high fiber food, as well as the intensity, duration or type of exercise.

Ethical issues

Not applicable.

Authors' contributions

All authors equally contributed to the writing and revision of this paper.

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References

1. Kang S, Woo JH, Shin KO, Kim D, Lee H-J, Kim YJ, et al. Circuit resistance exercise improves glycemic control and adipokines in females with type 2 diabetes mellitus. J Sports Sci Med. 2009; 8: 682- 688.
2. Kim ES, Im JA, Kim KC, Park JH, Suh SH, Kang ES, et al. Improved insulin sensitivity and adiponectin level after exercise training in obese Korean youth. Obesity. 2007; 15: 3023- 3030.
3. Janghorbani M, Amini M, Willett WC, Gouya MM, Delavari A, Alikhani S, et al. First nationwide survey of prevalence of overweight, underweight, and abdominal obesity in Iranian adults. Obesity. 2007; 15: 2797- 2808.
4. Expert Panel on Detection E. Executive summary of the third report of the national cholesterol education program (NCEP) expert panel on detection, evaluation, and treatment of high blood cholesterol in adults (Adult Treatment Panel III). Jama. 2001; 285: 2486.
5. Larijani B, Abolhasani F, Mohajeri-Tehrani MR, Tabtabaie O. Prevalence of diabetes mellitus in Iran in 2000. Iranian J Diabetes Metab. 2005; 4: 75- 83.
6. Harati H, Hadaegh F, Saadat N, Azizi F. Population-based incidence of type 2 diabetes and its associated risk factors: results from a six-year cohort study in Iran. BMC Public Health. 2009; 9: 186.
7. Brinkmann C, Blossfeld J, Pesch M, Krone B, Wiesiollek K, Capin D, et al. Lipid-peroxidation and peroxiredoxin-overoxidation in the erythrocytes of non-insulin-dependent type 2 diabetic men during acute exercise. Eur J Appl Physiol. 2012; 112: 2277- 2287.
8. Dejkhamron P, Menon RK, Sperling MA. Childhood diabetes mellitus: recent advances & future prospects. Indian J Med Res. 2007; 125: 231.
9. Kasper D, Fauci A, Hauser S, Longo D, Jameson J, Loscalzo J. Harrison's principles of internal medicine, 19e. Mac Grow Hill Publication. 2015.
10. King P, Peacock I, Donnelly R. The UK prospective diabetes study (UKPDS): clinical and therapeutic implications for type 2 diabetes. Br J Clin Pharm. 1999; 48: 643- 648.
11. Pibernik- Okanovic M, Prasek M, Poljicanin- Filipovic T, Pavlic- Renar I, Metelko Z. Effects of an empowerment-based psychosocial intervention on quality of life and metabolic control in type 2 diabetic patients. Patient Edu Counsel. 2004; 52: 193- 199.
12. Nuttamonwarakul A, Amatyakul S, Suksom D. Twelve weeks of aqua-aerobic

exercise improve health-related physical fitness and glycemic control in elderly patients with type 2 diabetes. JEPonline. 2012; 15: 64- 70.
13. Delavar R, Heidarianpour A. The effect of aerobic exercise training on plasma apelin levels and pain threshold in T1DM rats. Iranian Red Crescent Med J. 2016; 18 (9): e31737.
14. Thomas D, Elliott EJ, Naughton GA. Exercise for type 2 diabetes mellitus. Cochrane Library. 2006.
15. Zoppini G, Targher G, Zamboni C, Venturi C, Cacciatori V, Moghetti P, et al. Effects of moderate-intensity exercise training on plasma biomarkers of inflammation and endothelial dysfunction in older patients with type 2 diabetes. Nutr Metab Cardiovas Dis. 2006; 16: 543- 549.
16. Francois ME, Little JP. Effectiveness and safety of high- intensity interval training in patients with type 2 diabetes. Diabetes Spectrum. 2015; 28: 39- 44.
17. Dixit S, Maiya A, Shastry B. Effect of moderate-intensity aerobic exercise on glycosylated haemoglobin among elderly patients with type 2 diabetes & peripheral neuropathy. Indian J Med Res. 2016; 145 (1): 129- 132.
18. Nader N, Weaver A, Eckert S, Lteif A. Effects of fiber supplementation on glycemic excursions and incidence of hypoglycemia in children with type 1 diabetes. Int J Pediatric Endocrinol. 2014; 2014 (1): 13.
19. Shen XL, Zhao T, Zhou Y, Shi X, Zou Y, Zhao G. Effect of oat β-glucan intake on glycaemic control and insulin sensitivity of diabetic patients: A meta-analysis of randomized controlled trials. Nutr. 2016; 8 (1): 39.
20. Fujii H, Iwase M, Ohkuma T, Ogata-Kaizu S, Ide H, Kikuchi Y, et al. Impact of dietary fiber intake on glycemic control, cardiovascular risk factors and chronic kidney disease in Japanese patients with type 2 diabetes mellitus: the Fukuoka Diabetes Registry. Nutr J. 2013; 12: 159-175.
21. Ebrahimi- Mameghani M, Behroozi-Fared- Mogaddam A, Asghari-Jafarabadi M. Assessing the reliability and reproducibility of food frequency questionnaire and identify major dietary patterns in overweight and obese adults in Tabriz, Iran. J Mazandaran Univ Med Sci. 2014; 23 (2): 46- 57.
22. Grace A, Chan E, Giallauria F, Graham PL, Smart NA. Clinical outcomes and glycaemic responses to different aerobic exercise training intensities in type II diabetes: a systematic review and meta-analysis. Cardiovas Diabetology. 2016; 16 (1): 37.
23. Negri C, Bacchi E, Morgante S, Soave D, Marques A, Menghini E, et al. Supervised walking groups to increase physical activity in type 2 diabetic patients. Diabetes Care. 2010; 33 (11): 2333- 2335.
24. Crowe C, Gibson I, Cunningham K, Kerins C, Costello C, Windle J, et al. Effects of an eight-week supervised, structured lifestyle modification programme on anthropometric, metabolic and cardiovascular risk factors in severely obese adults. BMC Endocrine Dis. 2015; 15: 37.
25. Jenkins DJ, Kendall CW, Augustin LS, Martini MC, Axelsen M, Faulkner D, et al. Effect of wheat bran on glycemic control and risk factors for cardiovascular disease in type 2 diabetes. Diabetes care. 2002; 25 (9): 1522- 1528.
26. Esteves JV, Enguita FJ, Machado UF. MicroRNAs-Mediated regulation of skeletal muscle GLUT4 expression and translocation in insulin resistance. J Diabetes Res. 2016; 2017.
27. Tan S, Li W, Wang J. Effects of six months of combined aerobic and resistance training for elderly patients with a long history of type 2 diabetes. J Sports Sci Med. 2012; 11 (3): 495- 501.

28. Aggarwala J, Sharma S, Saroochi AJ, Sarkar A. Effects of aerobic exercise on blood glucose levels and lipid profile in Diabetes Mellitus type 2 subjects. A Ameen J Med Sci. 2016; 9 (1): 65- 69.
29. Gordon LA, Morrison EY, McGrowder DA, Young R, Fraser YTP, Zamora EM, et al. Effect of exercise therapy on lipid profile and oxidative stress indicators in patients with type 2 diabetes. BMC Complement Alternative Med. 2008; 8: 21.
30. Ljones K, Ness HO, Solvang-Garten K, Gaustad SE, Høydal MA. Acute exhaustive aerobic exercise training impair cardiomyocyte function and calcium handling in Sprague-Dawley rats. PloS One. 2016; 12 (3): e0173449.
31. Yavari A, Najafipoor F, Aliasgarzadeh A, Niafar M, Mobasseri M. Effect of aerobic exercise, resistance training or combined training on glycaemic control and cardiovascular risk factors in patients with type 2 diabetes. Biol Sport. 2012; 29 (2): 135- 143.
32. Marandi SM, Abadi NGB, Esfarjani F, Mojtahedi H, Ghasemi G. Effects of intensity of aerobics on body composition and blood lipid profile in obese/overweight females. Int J Prevent Med. 2013; 4 (1): S118- 125.
33. Klein S, Fontana L, Young VL, Coggan AR, Kilo C, Patterson BW, et al. Absence of an effect of liposuction on insulin action and risk factors for coronary heart disease. New England J Med. 2004; 350 (25): 2549- 2557.
34. Babio N, Balanza R, Basulto J, Bulló M, Salas-Salvadó J. Dietary fibre: influence on body weight, glycemic control and plasma cholesterol profile. Nutr Hospitalaria. 2010; 25 (3): 327- 340.
35. Bays H, Frestedt JL, Bell M, Williams C, Kolberg L, Schmelzer W, et al. Reduced viscosity Barley β-Glucan versus placebo: a randomized controlled trial of the effects on insulin sensitivity for individuals at risk for diabetes mellitus. Nutr Metab. 2011; 8: 58.
36. Lattimer JM, Haub MD. Effects of dietary fiber and its components on metabolic health. Nutr. 2010; 2 (12): 1266- 1289.
37. Puglisi MJ, Vaishnav U, Shrestha S, Torres-Gonzalez M, Wood RJ, Volek JS, et al. Raisins and additional walking have distinct effects on plasma lipids and inflammatory cytokines. Lipids Health Dis. 2008; 7: 14.