Journal of Physical Activity and Hormones
Vol 2, No. 4, Ser. 8 (December 2018), 051-062

Physical activity and type 2 diabetes: A narrative review

Eskandar Rahimi*

Received: 3 October 2018 / Accepted: 22 December 2018

(*) Associate Professor in Exercise Physiology, Department of Physical Education and Sports Science, Zand Institute of Higher Education, Shiraz, Iran. E.mail: erahimi58@gmail.com

Abstract

Type 2 Diabetes (T2D) is a metabolic disease that is brought about by either insufficient production of insulin or the inability of the body to respond to the insulin formed within the system. The prevalence of T2D is increasing worldwide in the 21st century. The main reason for the increase is the changes in lifestyle, specifically doing less exercise and consuming excessive calories. Physical activity is an important component of T2D treatment plan, because it improves glycemic control and reduces the risk of cardiovascular disease. Just as the main reason for the increased prevalence of T2D is lifestyle changes, the cornerstones of treatment must also incorporate lifestyle changes to control and reduce the complications of T2D.

Physical activity has been recommended as one of the alternatives. This review focuses on the association between physical activity [Aerobic training (AT), Resistance training (RT) and Concurrent training (CT)] and metabolic syndrome.

Keywords: Type 2 diabetes, Aerobic training, Resistance training, Concurrent training, Metabolic syndrome

1. Introduction

Type 2 Diabetes (T2D) is a metabolic disease that is brought about by either insufficient production of insulin or the inability of the body to respond to the insulin formed within the system. Obesity and lack of physical activity are two of the most common causes of this form of diabetes (1).

The prevalence of T2D is increasing worldwide in the 21st century (2). The main reason for the increase is the changes in lifestyle, specifically doing less exercise and consuming excessive calories. According to World Health Organization (WHO), the number of people diagnosed with diabetes in the year 2014 was 422 million (3-5). This number may rise up to 600 million in the year2030- 2036 if appropriate measures are not taken to prevent and cure this disease (4,5).

T2D accounts for approximately 90%- 96% of all diabetes cases in adults aged over 25 (6) and is followed by some complications such as eye, neural and renal problems and also cardiovascular failures (7,8).

The four main tools for T2D management are exercise, diet, medication and control of stress (9-11). In relation to structured exercise, many studies were conducted and significant reductions were found in the glycaemia responses of individuals who suffer from this disease (12,13). Just as the main reason for the increased prevalence of T2D is lifestyle changes, the cornerstones of treatment must also incorporate lifestyle changes to control and reduce the complications of T2D. Physical activity has been recommended as one of the alternatives (14-16).

Researches Show that physical activity such as aerobic training, resistance training and concurrent training result in reduction of metabolic syndrome (11,17). Metabolic syndrome is a cluster of conditions – increased blood pressure, high blood sugar, excess body fat around the waist, and abnormal cholesterol or triglyceride levels – that occur together, increasing risk of heart disease, stroke and diabetes. Having just one of these conditions doesn't mean one has metabolic

syndrome. However, any of these conditions increase one risk of serious disease. Having more than one of these might increase risk even more (18). Blood glucose control is determined by reducing Hb A1C, a measure to monitor the effectiveness of therapeutic interventions and any reduction in Hb A1C is associated with a reduction in the complications of the disease. A review of the literatures suggests that physical activity in T2D patients reduces Hb A1C levels by 6% (19). Most of the researches done so far have displayed the effects of aerobic and resistance training alone on metabolic syndrome. Little research has been carried out on the effects of CT on metabolic syndrome (4,20,21).

In recent decades, different types of physical activity have been investigated with varying intensities, and the results indicate the effect of AT, RT, or CT on T2D. Proving the effectiveness of physical activity on T2D requires the final examination of the exercises in terms of severity, duration, frequency, and number of sessions per week (22). However, in the meta-analysis of Schwingshackl et al. (2014), the effect of CT was greater than AT and RT alone (23).

2. Effects of physical activity on metabolic syndromes

Physical activity is defined as any bodily movement produced by skeletal muscles that require energy expenditure. Physical inactivity (lack of physical activity) has been identified as the fourth leading risk factor for global mortality (6% of deaths globally). Moreover, physical inactivity is estimated to be the main cause for approximately 27% of diabetes and approximately 30% of ischaemic heart disease burden (24).

3. Aerobic training

The American College of Sports Medicine (ACSM) defines **AT** as "any activity that uses large muscle groups, can be maintained continuously, and is rhythmic in nature." It is a type of exercise that overloads the heart and lungs and causes them to work harder than at rest.

AT is a part of ally in the treatment of T2D by reducing insulin resistance and increased metabolic rate improvement. Investigators show that training such as walking, bicycling, jogging, running and resistance training like weight lifting result in reduction of HbA1c. A decrease in

the amount of HbA1C up to 1% diminishes the danger of cardiovascular disease up to 15 to 20 percent and eventually results in a reduction of the complications of micro vasculature up to 37 percent (24). Some researchers have demonstrated that training (either AT or RT alone) causes a drop in HbA1c level from 7.9 % to 7% and the fasting plasma, blood glucose dropped from 8.3m mol to 7.9 m mol, (25-27), and when performed with adequate intensity and frequency, it could reduce blood pressure, overweight, obesity, increased peripheral blood flow, reduced atherosclerosis progression, and decreased oxygen demand of the myocardium and also reduces risk of developing anxiety, and depression (28-30). Plasma insulin level and total cholesterol decrease significantly and HDL increases via AT (31,32).

4. Resistance training

RT is included in anaerobic exercise defined by the ACSM as intense physical activity of very short duration, fueled by the energy sources within the contracting muscles and independent of the use of inhaled oxygen as an energy source (33). RT is a growing therapeutic tool that has the potential for increased muscle strength, endurance, flexibility, body composition and reducing cardiovascular disease (34). Also, RT with sufficient intensity and duration can reduce glucose and HbA1C alone (35). Based on the findings of studies, RT resulted in a significant increase in the level of HDL and a significant reduction in glucose, fructosamine, HBA1c, plasma insulin and Resistance to insulin (36,37). Recent studies suggest increased fat free mass and decreased fat mass after RT, which can affect insulin resistance (38,39). Blood lipid disorders are one of the undesirable changes in type 2 diabetic patients, which lead to the development of vascular complications and increased risk of cardiovascular disease in these individuals. Therefore, therapeutic goals are to improve lipid disorders in patients with this disease. Most studies have shown that glycemic index and higher blood glucose levels are associated with lower HDL levels and higher LDL levels (40,41).

5. Concurrent training

The report of the American Association for Diabetes suggests that CT have a greater impact on blood glucose levels in people with T2D.

Although AT is a suitable method for diabetic patients, some diabetic patients do not have the ability to perform large amounts of AT. As a result of CT with less time is an appropriate alternate. CT is known as a more effective form of physical activity to control of blood sugar, body composition and cardiovascular risk factors (42,43).

Base on the studies concurrent training has more effect on glucose metabolism, body composition, insulin resistance adjustment and increasing insulin sensitivity (44). Based on a meta-analysis that examined the effects of different kinds of physical activity, CT has more superior on metabolic syndrome than resistance and aerobic training alone (45).

The results of a clinical investigation on 251 adult patients during 26 weeks of training showed that in comparison with AT and RT alone, CT decreased HbA1c more prominently (46-48). Baldoucci et al. (2004) monitored effects of concurrent training on the level of HbA1c and certain other metabolic factors in type 2 diabetic patients for one year. Change in the amount of HbA1c revealed that the CT and the RT had produced a more significant decrease in blood sugar compared with the control (49). In addition, LDL and total cholesterol also decreased significantly in CT, while HDL level increased (4,50,51). But the research results are inconsistent with the effects of CT on A1C, although its effect is greater than the effect of AT or RT (47,51-53).

6. Conclusion

Physical activity is a strong toll to prevent and treatment of T2D. With regard to the articles selected for this review, it can be said that all three types of physical activity (AT, RT and CT) affect the metabolic syndrome. But the CT seems to be more effective. Unfortunately, information about the effects of varied intensities and durations of CT on metabolic syndrome is limited.

It can also be concluded that the effect of continuous activity is 3-4 sessions per week and 30-45 minutes each session, and between 60-75% VO_{2max} in the aerobic section and with 60-80% 1RM in the training section resistance and with 10-12 repetitions each exercise has the most effect on metabolic syndrome.

References

1. Rahimi E, Safari S, Pirozan F, Rahimi A. Effects of 12-weeks physical activity and omega-3 supplementation on serum ghrelin and insulin levels in young women. Iran South Med J 2014; 17: 161-72.

2. Rahimi E, Mousavi nejad ZOS, Rahimi A. Effects of twelve weeks of aerobic training, resistance training or combination of both trainings on the levels of blood sugar, HbA1c and cardiovascular risk factors in women with type 2 diabetes. Int J Appl Exerc Physiol 2014; 3: 1-12.

3. Atlas ID. International Diabetes Federation, 2013. ISBN 2930229853 2015; 7.

4. Eskandary S, Mousavi nejad ZOS, Rahimi E. Effects of eight weeks aerobic training, resistance training and concurrent training on the metabolic syndrome and HbA1c in men with type 2 diabetes. J Physic Act Horm 2017; 2: 51-64.

5. NCD Risk Factor Collaboration. Worldwide trends in diabetes since 1980: a pooled analysis of 751 population-based studies with 4.4·million participants. The Lancet 2016; 387: 1513-1530.

6. Cameron AJ, Magliano DJ, Dunstan DW, Zimmet PZ, Hesketh K, Peeters A, et al. A bi-directional relationship between obesity and health-related quality of life: evidence from the longitudinal AusDiab study. Int J Obes 2012; 36: 295.

7. Shaw JE, Sicree RA, Zimmet PZ. Global estimates of the prevalence of diabetes for 2010 and 2030. Diabetes Res Clin Pract 2010; 87: 4-14.

8. Desroches S, Lamarche B. The evolving definitions and increasing prevalence of the metabolic syndrome. Appl Physiol Nutr Metab 2007; 32: 23-32.

9. Barr E, Magliano D, Zimmet P, Polkinghorne K, Atkins R, Dunstan D. Tracking the accelerating epidemic: its causes and outcomes. Australian Diabetes, Obesity and Lifestyle Study 2006, Available at: https://slideplayer.com/slide/6981/.

10. Colberg SR, Sigal RJ, Yardley JE, Riddell MC, Dunstan DW, Dempsey PC. Physical activity/exercise and diabetes: a position

statement of the American Diabetes Association. Diabetes Care 2016; 39: 2065-2079.

11. Colberg SR, Sigal RJ, Yardley JE, Riddell MC, Dunstan DW, Dempsey PC, et al. Physical activity/exercise and diabetes: a position statement of the American Diabetes Association. Diabetes Care 2016; 2065-2079.

12. Umpierre D, Ribeiro PA, Schaan BD, Ribeiro JP. Volume of supervised exercise training impacts glycaemic control in patients with type 2 diabetes: a systematic review with meta-regression analysis. Diabetologia 2013; 56: 242-251.

13. Rahimi E, Tahmouresi K, Hosseini SA, Eskandary S. Effects physical activity on creatinine, and metabolic syndrome in females with transplanted kidney. J Physic Act Horm 2017; 1: 43-58.

14. Umpierre D, Ribeiro PA, Kramer CK, Leitão CB, Zucatti AT, Azevedo MJ, et al. Physical activity advice only or structured exercise training and association with HbA1c levels in type 2 diabetes: a systematic review and meta-analysis. JAMA 2011; 305: 1790-1799.

15. Mann S, Beedie C, Balducci S, Zanuso S, Allgrove J, Bertiato F, et al. Changes in insulin sensitivity in response to different modalities of exercise: a review of the evidence. Diabetes Metab Res Rev 2014; 30: 257-268.

16. Mehboodi M, Rahimi E, Choobineh S. Effect of eight weeks of moderate aerobic activity, the changes in obestatin and insulin plasma in male obese sprague dawley rats. Eur J Experiment Biol 2013; 3: 83-87.

17. Shenoy S, Arora E, Jaspal S. Effects of progressive resistance training and aerobic exercise on type 2 diabetics in Indian population. Int J Diabetes Metab 2009; 17: 27-30.

18. World Health Organization. Global recommendations on physical activity for health. World Health Organization 2010, Available at: https://www.who.int/dietphysicalactivity/global-PA-recs-2010.pdf.

19. American Diabetes Association. Erratum. Diabetes Care in the Hospital. Sec 14. In Standards of Medical Care in Diabetes-2017. Diabetes Care 2017; 40: S120-S127.

20. Bacchi E, Negri C, Targher G, Faccioli N, Lanza M, Zoppini G, et al. Both resistance training and aerobic training reduce hepatic fat content in type 2 diabetic subjects with nonalcoholic fatty liver disease (the RAED2 randomized trial). Hepatology 2013; 58: 1287-1295.

21. Liu Y, Ye W, Chen Q, Zhang Y, Kuo CH, Korivi M. Resistance Exercise Intensity is Correlated with Attenuation of HbA1c and Insulin in Patients with Type 2 Diabetes: A Systematic Review and Meta-Analysis. Int J Environment Res Public Health 2019; 16:140.

22. Karstoft K, Winding K, Knudsen SH, Nielsen JS, Thomsen C, Pedersen BK, et al. The effects of free-living interval-walking training on glycemic control, body composition, and physical fitness in type 2 diabetic patients: a randomized, controlled trial. Diabetes Care 2013; 36: 228-236.

23. Schwingshackl L, Missbach B, Dias S, König J, Hoffmann G. Impact of different training modalities on glycaemic control and blood lipids in patients with type 2 diabetes: a systematic review and network meta-analysis. Diabetologia 2014; 57: 1789-1797.

24. Selvin E, Marinopoulos S, Berkenblit G, Rami T, Brancati FL, Powe NR, et al. Meta- analysis: glycosylated hemoglobin and cardiovascular disease in diabetes mellitus. Ann Intern Med 2004; 141: 421-31.

25. Bruce CR, kriketos AD. Disassociation of muscle triglyceride content and insulin sensitivity after exercise training in patients with type 2 diabetes. Diabetologia 2004; 47: 23-30.

26. Wahid A, Manek N, Nichols M, Kelly P, Foster C, Webster P, et al. Quantifying the association between physical activity and cardiovascular disease and diabetes: a systematic review and meta-analysis. J Am Heart Assoc 2016; 5: e002495.

27. Krause M, Rodrigues-Krause J, O'Hagan C, Medlow P, Davison G, Susta D, et al. The effects of aerobic exercise training at two different intensities in obesity and type 2 diabetes: implications for oxidative stress, low-grade inflammation and nitric oxide production. Eur J Appl Physiol 2014; 114: 251-260.

28. Church TS, Earnest CP, Skinner JS, Blair SN. Effects of different doses of physical activity on cardiorespiratory fitness among sedentary, overweight or obese postmenopausal women with elevated blood pressure: a randomized controlled trial. JAMA 2007; 297: 2081-2091.

29. Wadden TA, Volger S, Sarwer DB, Vetter ML, Tsai AG, Berkowitz RI, et al. A two-year randomized trial of obesity treatment in primary care practice. New Engl J Med 2011; 365: 1969-1979.

30. Warburton DE, Nicol CW, Bredin SS. Health benefits of physical activity: the evidence. CMAJ 2006; 174: 801-809.

31. World Health Organization. WHO guidelines approved by the guidelines review committee. Geneva: WHO 2009, Available at: https://www.who.int/publications/guidelines/en/.

32. Hayes C, Kriska A. Role of physical activity in diabetes management and prevention. J Am Dietetic Assoc 2008; 108: S19-S23.

33. American College of Sports Medicine, editor. ACSM's health-related physical fitness assessment manual. Lippincott Williams & Wilkins; 2013.

34. Dixit S, Alahmari FA. Pharmacological and nonpharmacological therapies in the management of diabetic peripheral neuropathy in type 2 diabetes: A comprehensive review. J Cardiovasc Dis Res 2014; 5: 37.

35. Tokmakidis SP, Zois CE, Volaklis KA, Kotsa K, Touvra AM. The effects of a combined strength and aerobic exercise program on glucose control and insulin action in women with type 2 diabetes. Eur J Appl Physiol 2004; 92: 437-442.

36. Johannsen NM, Swift DL, Lavie CJ, Earnest CP, Blair SN, Church TS. Categorical analysis of the impact of aerobic and resistance

exercise training, alone and in combination, on cardiorespiratory fitness levels in patients with type 2 diabetes results from the HART-D study. Diabetes Care 2013; 36: 3305-3312.

37. Fenkci S, Sarsan A, Rota S, Ardic F. Effects of resistance or aerobic exercises on metabolic parameters in obese women who are not on a diet. Adv Ther 2006; 23: 404-413.

38. Gordon BA, Benson AC, Bird SR, Fraser SF. Resistance training improves metabolic health in type 2 diabetes: a systematic review. Diabetes Res Clin Pract 2009; 83: 157-175.

39. Castaneda C, Layne JE, Munoz-Orians L, Gordon PL, Walsmith J, Foldvari M, et al. et al. A randomized controlled trial of resistance exercise training to improve glycemic control in older adults with type 2 diabetes. Diabetes Care 2002; 25: 2335-2341.

40. Gerich JE. Type 2 diabetes mellitus is associated with multiple cardiometabolic risk factors. Clin Cornerstone 2007; 8: 53-68.

41. Shabanpoor omali J, Saghebjo M, Fathi R, Gharari A. The effect of 8weeks of resistance training with high intensity circular on serum level of lipids and insulin resistance index in male patients with type 2 diabetes. JAppl Sport Physiol 2014; 19: 135-142.

42. Schumann M, Rønnestad BR. Concurrent aerobic and strength training: Scientific basics and practical applications. Springer 2018.

43. American Diabetes Association. Standards of medical care in diabetes. Diabetes Care 2017; 40: S1-S104.

44. Lucotti P, Monti LD, Setola E, Galluccio E, Gatti R, Bosi E, et al. Aerobic and resistance training effects compared to aerobic training alone in obese type 2 diabetic patients on diet treatment. Diabetes Res Clin Practice 2011; 94: 395-403.

45. Oliveira C, Simões M, Carvalho J, Ribeiro J. Combined exercise for people with type 2 diabetes mellitus: a systematic review. Diabetes Res Clin Practice 2012; 98: 187-198.

46. Eriksson J, Taimela S, Eriksson K, Parviainen S, Peltonen J, Kujala U. Resistance training in the treatment of non-insulin-dependent diabetes mellitus. Int J Sports Med 1997; 18: 242-246.

47. Church TS, Blair SN, Cocreham S, Johannsen N, Johnson W, Kramer K, et al. Effects of aerobic and resistance training on hemoglobin A1c levels in patients with type 2 diabetes: a randomized controlled trial. JAMA 2010; 304: 2253-2262.

48. Schumann M, Yli-Peltola K, Abbiss CR, Häkkinen K. Cardiorespiratory adaptations during concurrent aerobic and strength training in men and women. PLoS One 2015; 10: e0139279.

49. Balducci S, Leonetti F, Di Mario U, Fallucca F. Is a long-term aerobic plus resistance training program feasible for and effective on metabolic profiles in type 2diabetic patients (Letter). Diabetes Care 2004; 27: 841-842.

50. Lakka TA, Laaksonen DE. Physical activity in prevention and treatment of the metabolic syndrome. Appl Physiol Nutr Metab 2007; 32: 76-88.

51. Shenoy S, Ekta A, Sandhu J. Effects of progressive resistance training and aerobic exercise on type 2 diabetics in Indian population. Int J Diabete Metab 2009; 17: 27-30.

52. 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. Biology of Sport 2012; 29: 135.

53. Sigal RJ, Kenny GP, Boulé NG, Wells GA, Prud'homme D, Fortier M, et al. Effects of aerobic training, resistance training, or both on glycemic control in type 2 diabetes: a randomized trial. Ann Intern Med 2007; 147: 357-369.