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PHYSICAL ACTIVITY AND HEALTH: THE BENEFITS OF PHYSICAL ACTIVITY IN THE PREVENTION OF DIABETES MELLITUS AND CARDIOVASCULAR DISORDERS

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Abstract:
Public health of people and individuals is the most important resource in the modern world. The sugar epidemic and cardiovascular diseases are linked to the obesity epidemic. As obesity appears at younger and younger ages, it is to be expected that the proportion of people who have been obese for the number of years will increase and that those practicing a "sedentary lifestyle" will move less and less. Diabetes mellitus type 2 (DMT2) and cardiovascular diseases (CD) are among the top ten causes of death in the world. It is observed that the association between DMT2 and CD risk is not the same for both sexes, with the cardiovascular risk associated with DMT2 being greater in women. Among the different strategies for the prevention and treatment of DMT2 and risk factors for CD, physical exercise has been largely recommended because of its positive effects on glycemic control, body mass, blood pressure, and lipid profile. A higher level of daily physical activity significantly reduces the risk of contracting numerous diseases such as:

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diabetes, diseases of the heart and blood vessels, certain forms of malignant diseases, obesity, asthma, osteoporosis and others.

Keywords: diabetes mellitus, cardiovascular diseases, physical activity, benefits, prevention

1. Introduction

Modern and fast lifestyle, sedentary style, industrial development, the rapidly advancing technological advancements in the world have greatly facilitated this way of living in people, but on the other hand in man, it caused a great an increase in a number of chronic diseases including diabetes mellitus (DM) and cardiovascular disease (CD) (Pavlovski, 2021). The World Health Organization (WHO) emphasized in its annual report from 2012 that mortality, morbidity and disability associated with chronic non-communicable diseases are responsible for more than 60% of mortality in the world, and that unhealthy diet and lack of physical activities are the main risk factors for those diseases. The number of people with diabetes increased from 108 million in 1980 to 422 million in 2014 (Bennett, Knowler, 2016). Diabetes in all its forms imposes high human, social and economic costs on countries. In 2019, there were an estimated 351.7 million able-bodied people (20-64 years) with diagnosed or undiagnosed diabetes (International Diabetes Federation, 2019). That number is expected to rise to 417.3 million by 2030 and to 486.1 million by 2045. According to the estimates of the American diabetes association, the 2017 annual cost of diagnosed diabetes is 327 billion dollars (American Diabetes Association, 2020). Of that, 237 billion dollars represents direct treatment costs and $90 billion represents loss due to a reduction in productivity. The greatest increase in diabetes is expected in countries that are now developing, probably as a consequence of adopting lifestyle habits. The sugar epidemic is linked to the obesity epidemic. As obesity appears at younger and younger ages, it is to be expected that the proportion of people who have been obese for the number of years will increase and that those practicing a "sedentary lifestyle" will move less and less. The population is ageing and the metabolic consequences will be more pronounced, so it can be expected that the incidence of diabetes will increase. According International Diabetes Federation IDF (2019) estimates show that in 2019, the incidence of diabetes in adults is the lowest in the 20-24 age group (1.4% in 2019). Where adults aged 75-79, the incidence of diabetes is 19.9% in the 2019 year, and it is predicted to increase to 20.4% by 2030 and 20.5% by 2045. It is slightly lower in women aged 20 to 79 than in men (9.0% compared to 9.6).

Sugar disease or diabetes mellitus (DB) is one of the leading chronic diseases of our population, and it is directly related to lifestyle. DB is seen as a heterogeneous group of metabolic disorders characterized by permanent hyperglycemia, while chronic hyperglycemia is related to a disorder of carbohydrate, fat and protein metabolism, arising as a disorder of insulin secretion, its action or both (Bennet, & Knowler, 2016, Beretić, 2017) At the root of the disease is a disorder in the transport of glucose from the

blood into the cells of tissues and organs. DB is a disease that develops due to a lack of insulin, a hormone secreted by the pancreas, which then goes into the blood and acts all over the body. Its role is to reduce the amount of glucose in the blood. The hormone insulin acts on the cell membrane, which becomes permeable to glucose. When glucose enters the cell, it burns and then energy is released, necessary for the life of every cell. An important feature of DB is an increased level of glucose in the blood because there is not enough insulin to store glucose in the cells. We distinguish between 2 types of diabetes, diabetes mellitus type 1 (DMT1-juvenile), the pancreas has almost stopped producing insulin, so there is no insulin in the body at all, the so-called insulin-dependent diabetes. Insulin dependent diabetes mellitus occurs primarily in younger people, most often under the age of 30. Although it can also occur in older people, it affects about 10-15% of all diabetes patients. The cause of the disease is the destroyed beta cells pancreas as a result of immune disorder or viral damage (Mišigoj-Duraković, 1999).

In diabetes mellitus type 2 (DMT2), there is insulin, sometimes very much, but it is not valuable enough to do its job, or the person is obese, and the large fat cells need significantly more insulin to let glucose into them and allow it to be there burn. That's why type 2 diabetes is also called non-insulin dependent diabetes. Non-insulin dependent diabetes mellitus affects a slightly larger population, approximately 80% of all patients with diabetes. It is caused by insulin resistance in the muscles and liver, as well as fat tissue. It is associated with obesity, and with reduced and/or abnormal insulin secretion. Insulin independent diabetes can be divided into two subgroups. In the first subset, there is insufficient insulin secretion to metabolize glucose due to disorders in the beta cells. Such patients are usually thin. The second subgroup is primarily elevated insulin resistance in tissues, i.e. skeletal muscles and liver. Conditions associated with insulin resistance increase the risk of developing insulin-independent diabetes, the most significant of which are obesity, older age, and a sedentary lifestyle.

Type 1 does not change to type 2 in old age, but if someone with type 1 diabetes becomes very obese, they will need a significantly larger amount of insulin. If blood glucose values are high for several days, it binds to proteins on blood vessel cells, changing their function. Such blood vessels, especially the small ones, no longer perform their function, they do not feed the surrounding tissue, and without food, the tissue decays. This is how complications arise in the eyes, kidneys and nerves, but also everywhere in the body. If a person is treated well, he is actually healthy. Therefore, it is important to know well all the ways of treatment. The only medicine that a person suffering from diabetes needs is insulin, important proper nutrition and, of course, physical activity, and exercise (Kadrnka Lovrenčić, 1998). The goal of diabetes treatment is not only good glycemic control but also an intervention in the pathophysiology of the disease itself and preservation of endogenous insulin reserves for as long as possible (which refers to type 2). The goal of therapy is not only the avoidance of acute complications, but the possibility for a person with diabetes to live as long and as well as possible with a minimum of chronic complications (Yoneda, Ikagami, & Yamamoto, 1992; DCCT, 1993).

Next to Diabetes mellitus and cardiovascular disease (CD) are among the diseases that kill the most in the world. Data from the World Health Organization estimate that, in 2016, 1.6 million people died directly from diabetes mellitus and 17.7 million died from CD. These numbers tend to grow, as the global prevalence of DMT2 is expected to increase from 415 million in 2015 to 642 million in 2040, with more than 90% of cases corresponding to type 2 diabetes mellitus (DMT2) (Zheng, Ley, & Hu, 2017). Interesting to note that, DMT2 prevalence is 47% in women and 53% in men, with no difference between the sexes. DMT2 is characterized by impaired glucose uptake by tissues, resulting in hyperglycemia associated with resistance and/or insufficient production of insulin (Laakso, & Kuusisto, 2014). Both hyperglycemia and insulin resistance are associated with an increased risk of CD. Thus, it is not expected that patients with DMT2 have a higher prevalence of CD compared to a non-diabetic (Nathan, 1993). Furthermore, CD is the leading cause of death in individuals with DMT2. It is observed that an association between DMT2 and CD is not equal for the sexes. According to a meta-analysis by Peters et al. (Peters, Huxley, & Woodward, 2014), the cardiovascular risk associated with DMT2 is greater in women than in men. In addition, women showed a risk of death from CD 1.5 times higher than men (Ding, Song, Malik, et al. 2006) and when diagnosed with DMT2, the risk of myocardial infarction followed by death was 3 to 6 times higher (Kautzky-Willer, Harreiter, & Pacini, 2006). Among the different strategies for the prevention and treatment of DMT2 and the risk factors for CD, physical exercise has been recommended due to its positive effects in controlling glycemia, body mass, arterial blood pressure and lipid profile (Van Gaal, Mertens, & De Block, 2006).

The aim of this study is to explain the effects of physical activity in the regulation of diabetes, that is, the beneficial effects of exercise on the health of the body and in the prevention of diabetes mellitus and cardiovascular disorders

2. Relationship between Diabetes Mellitus and Cardiovascular Diseases

Diabetes mellitus type 2(DMT2) and cardiovascular diseases (CD) are among the top ten causes of death in the world. It is observed that the association between DMT2 and cardiovascular risk is not the same for both sexes, with the cardiovascular risk associated with DMT2 being greater in women. Among the different strategies for the prevention and treatment of DMT2 and risk factors for CD, physical exercise has been largely recommended because of its positive effects on glycemic control, body mass, blood pressure, and lipid profile (Boschetti, Martucci, Evangelista, et al. 2021).

The risk factors that are commonly associated with CD in individuals with DMT2 are: obesity, especially visceral obesity, hypertension, dyslipidemia and a sedentary lifestyle (Van Gaal, Mertens, De Block, 2006). Women, after menopause, have a higher prevalence of obesity (Abarca-Gómez, Abdeen, Hamid, et al. 2017), an increase in visceral fat deposition and in the prevalence of dyslipidemia and perform less regular physical exercise when compared to men. (Regitz-Zagrosek, 2006; Arnetz, Ekberg, Alvarsson, 2014)

The first gear between DMT2 and CD is obesity, and more than 60% of individuals with DMT2 are obese (BMI ≥30kg/m2) revealing a close relation between these comorbidities (Chatterjee, Khunti, Davies, 2017). Women tend to develop DMT2 with a higher BMI than men. In fact, at the time of diagnosis of DMT2, women have, on average, a BMI 1.8 kg/m2 higher than men (Paul, Thomas, Majeed, et al. 2012). In addition, for each unit of increment in women's BMI, cardiovascular risk increases by 8% (Li, Rana, Manson, et al. 2006). More important than the amount of total body fat in predicting cardiovascular risk is the accumulation of visceral fat. Under physiological conditions, there is sexual dimorphism in fat distribution, so women are more likely to deposit fat in subcutaneous deposits, mainly in the gluteal-femoral region, while men are prone to greater visceral fat deposition (Tchernof, Després, 2013). However, in the presence of DMT2, this sexual dimorphism tends to be lost, such that 70% of women with DMT2 have visceral obesity against 40% of men (Arnetz, Ekberg, Alvarsson, 2014). Visceral fat accumulation and DMT2 share mechanisms associated with the development of CD, such as inflammation and oxidative stress. Thus, diabetic and obese individuals have high levels of circulating inflammatory cytokines. One of the effects of these inflammatory cytokines is to reduce the bioavailability of nitric oxide (NO). Nitrix oxide is a vasodilator molecule capable of promoting vascular remodeling, protecting it from damage and maintaining the endothelium in a quiescent and anti-inflammatory state (Tabit, Chung, Hamburg, 2010). With the reduction of nitric oxide bioavailability, the endothelium changes from a quiescent state to an activated state (Climie, Sloten, Bruno, 2019). This condition maintains and potentiates inflammation, as it stimulates the expression of other inflammatory cytokines, which may chronically be associated with atherogenesis. Regarding oxidative stress, the hyperglycemia characteristic of DMT2 and the large amount of nonesterified fatty acids released by the visceral adipose tissue are responsible for triggering the excessive production of reactive oxygen species (Tan, Zhang, Zheng, 2020). Similar to inflammation and insulin resistance, ROS reduce the bioavailability of nitric oxide (Tabit, Chung, Hamburg, 2010).

Another transmission that connects DMT2 and CD is high blood pressure. Individuals with DMT2 are more likely to develop hypertension, while the diagnosis of hypertension in people with DMT2 doubles the risk of cardiovascular disease in men and quadruples in women (Sehestedt, Hansen, Li, 2011; Martín-Timón, Sevillano-Collantes, Segura Galindo, 2014). The additive cardiovascular risk resulting from the presence of these two morbidities is associated with their cumulative effect on the production of inflammatory cytokines and oxidative stress and consequent reduction in •NO bioavailability (Katayama, Hatano, Issiki, 2018). In hypertension, the walls of the arteries are damaged due to the excessive shear stress to which they are submitted. This triggers inflammatory and oxidative stress responses. Additionally, this shear stress on the artery wall accelerates the degradation of elastin fibers, such that collagen fibers may eventually replace the elastin fibers, increasing arterial stiffness. Stiffer arteries increase cardiovascular risk and favor the continuation of the process of injury to arterial walls by shear (Climie, Sloten, Bruno, 2019).

According to study (Oparil, Acelajado, Bakris, 2018), high blood pressure is associated with increased activity of the sympathetic nervous system and the renin-angiotensin system. The greater sympathetic activity favors vasoconstriction, as well as the greater proliferation of vascular smooth muscle cells. The proliferation of these cells leads to an increase in arterial stiffness. While with greater activation of the renin-angiotensin system, there is the greater formation of angiotensin-2, which is associated with endothelial dysfunction and has proinflammatory and pro-fibrotic effects. The third transmission that somehow connects DMT2 to the risk of developing CD is dyslipidemia. This condition is characterized by low levels of high-density lipoprotein (HDL) and high levels of low-density lipoprotein (LDL) and very low-density lipoprotein (VLDL). HDL works by promoting the removal of cholesterol from vessel walls to the liver and has anti-inflammatory, anti-thrombotic and antioxidant properties. While LDL and VLDL, when accumulated in the subendothelial space, activate inflammatory pathways responsible for the formation of atherosclerotic plaques (Boschetti, Martucci, Evangelista, 2021). In DMT2, the LDL clearance rate is reduced because of insulin resistance, which is also responsible for accentuating oxidative stress (Tchernof, Després, 2013; Climie, Sloten, Bruno, 2019), increasing the levels of oxidation of lipotroteins. This explains how dyslipidemia increases cardiovascular risk in DMT2. Notably, women have lower values for total cholesterol and LDL fraction and higher values for HDL cholesterol (Cífková, Krajčoviechová, 2015). However, in the condition of DMT2, this female characteristic is nullified. Women, in this condition, start to present lower HDL values than healthy women or even men, while the amounts of total cholesterol and LDL fraction are equal to those of men, becoming higher than in healthy women (Mooradian, 2009). Finally, sedentarism is the fourth piece that connects DMT2 with the increased risk of CD. This condition is directly correlated with visceral obesity, hypertension, dyslipidemia and DM (Lin, Zhang, Guo et al. 2015) and is more prevalent in women. When DMT2 is combined with a sedentary lifestyle, mortality from CD is dramatic. Specifically for women with DMT2 and sedentary, the risk of developing CD is 40% higher than in women who perform the physical exercise (Martín-Timón, Sevillano-Collantes, Segura Galindo, 2014). Considering these data, the practice of physical exercise becomes an important ally for the prevention and treatment of DMT2 and the risk factors that bridge the gap with cardiovascular diseases.

3. Physical Exercise: The Prevention of Diabetes Mellitus and Cardiovascular Disorders

Regular physical activity is a very effective and inexpensive tool for the prevention and treatment of most chronic diseases. Regular physical activity has been shown to help in the prevention treat non-communicable diseases, such as heart disease, stroke, diabetes disease, and breast and colon cancer (Umpierre, 2011; Mansfield, et al., 2017; Nistoriak in Bhatnagar, 2018). It also helps prevent hypertension, overweight and obesity and can improve mental capacity, quality of life and well-being (Poggenpoel, Myburgh, 2017; Lin,

et al., 2019; Magobe,). ACSM (American College of Sport Medicine) recommends all healthy adults between the ages of 16 and 65 years engage in moderate aerobic physical activity at least 5 times a week for a time of 30 minutes or intense aerobic physical activity at least 3 times a week. ACSM recommends in its physical activity guidelines:

- Moderate aerobic physical activity at least 150 minutes per week, 75 minutes of intense aerobic activity per week or a combination of both activities;
- Additional aerobic physical activity of 300 minutes per week, or 150 minutes of vigorous exercise per week, provides additional health benefits;
- Adults are recommended to be physically active with strengthening activities muscles of moderate or high intensity and include all major muscle groups twice a week, as these activities provide additional health benefits.

Recognizing the positive connection between sports, physical activity and health, WHO 2004 adopted a document on Global Strategy on Diet, Physical Activity and Health and a Resolution on Health Promotion and Healthy lifestyles. Both documents emphasize the importance of acquiring habits of regular physical activities already in childhood. Physical activity today is realized in different ways, at different times, with different people with props or without them, with different intensity and extent. Physical exercise is divided into recreational and professional. In the recreational mode of physical exercise, only interest and motivation for physical exercise, physical exercise and the absence of health contraindications for a certain physical activity are sufficient. On the other hand, there is also a professional or high-level sport characterized by a strong focus on achieving goals, selectivity in choosing those for whom it is intended, professionalization of the majority of its participants, and specific technology of preparation, implementation and control of the training process (Milanović, 2013). Regardless of the type and degree of physical activity, it is important that every person knows his goal. Whether it's health status, physical appearance, or a psychological feeling of a better quality of life, a person must perform physical activity regularly, continuously and under the control of an expert. Especially when it comes to some kind of more complex kinesiology activities. If it is about simple activities such as walking in nature, riding a bicycle, etc. it is important that a person enjoys these activities and spends them as often as possible, while more complex activities such as sports games, exercising in fitness centers, etc. the person must spend in consultation with experts, by which we mean doctors, kinesiologists, kinesitherapists, physiotherapists, trainers, etc. (Lekić, 2017). It is very important to note that the term physical or physical activity should be distinguished from the term exercise or sport. Both physical activity and exercise include body movements caused by the contraction of skeletal muscles that result in lower or higher energy expenditure, and both types of exercise are positively associated with improving physical abilities. However, unlike physical activity, exercise or sport is a planned, structured and repeated activity aimed at improving or maintaining components of physical fitness. In this context, physical activity refers to the entire lifestyle and includes all forms of daily physical activity: from household chores, physical activity during the care of a child or an adult, walking to the place of work and the like,

to exercise as an organized and structured form physical activities. Physical activity plays a fundamental role in maintaining human health. A higher level of daily physical activity significantly reduces the risk of contracting numerous diseases such as: diabetes, diseases of the heart and blood vessels, certain forms of malignant diseases, obesity, asthma, osteoporosis and others (Andrijašević, 2010).

The benefits of engaging in sports activities in maintaining a person's physical and mental health are numerous:

- Due to increased caloric consumption, regular physical activity enables maintaining optimal body mass, preventing obesity and the like.
- Regular physical activity improves the abilities of the cardio-respiratory system, which enables the easier performance of daily professional and other tasks, with more efficiency.
- Over a long period of time, regularly engaging in sports activities leads to a decrease in blood pressure, and a decrease in the level of fat and sugar in the blood.
- Cardiovascular risk factors that, in combination with diabetes, lead to atherosclerotic heart and blood vessel disease, reduce serum lipid levels, and reduce stress. Physical activity reduces these risk factors
- Daily physical activity strengthens muscle strength and muscle endurance, which enables the easier performance of daily physical actions without stress and excessive fatigue.
- By strengthening the bone structures, as well as by increasing the flexibility of the joints, injuries to the musculoskeletal system are prevented, which is of particular importance in adulthood.
- Regular physical activity leads to improvement of coordination, balance and endurance.
- During physical activity, brain cells release substances (endorphins) that have important, long-term effects on a person's psychological health. Regularly playing sports increases the level of self-confidence, relieves tension and stress and improves the general mood, increases the ability to concentrate and study, etc.
- Exercise has a great psychological effect. Establishing control over diabetes is also reflected in other areas of life. Self-confidence increases, and dependence on drugs is reduced - control over one's illness is actually control over an important part of everyday life.

Bearing in mind the mentioned benefits, it is quite clear why the inactive (sedentary) lifestyle is classified as one of the most important causes of numerous diseases in today's modern society, among which diabetes is particularly important. The morning is the best time to exercise because the daily rhythm of the secretion of some other hormones, which cooperate with insulin, is such that the morning is the most suitable and the evening the worst time of the day for exercise.

During physical activity, whole-body oxygen consumption may increase by as much as 20-fold, and even greater increases may occur in the working muscles. To meet its energy needs under these circumstances, skeletal muscle uses, at a greatly increased

rate, its own stores of glycogen and triglycerides, as well as free fatty acids (FFAs) derived from the breakdown of adipose tissue triglycerides and glucose released from the liver. To preserve central nervous system function, blood glucose levels are remarkably well maintained during physical activity. Hypoglycemia during physical activity rarely occurs in nondiabetic individuals. The metabolic adjustments that preserve normoglycemia during physical activity are in large part hormonally mediated. A decrease in plasma insulin and the presence of glucagon appears to be necessary for the early increase in hepatic glucose production during physical activity, and during prolonged exercise, increases in plasma glucagon and catecholamines appear to play a key role. These hormonal adaptations are essentially lost in insulin-deficient patients with type 1 diabetes. As a consequence, when such individuals have too little insulin in their circulation due to inadequate therapy, an excessive release of counter insulin hormones during physical activity may increase already high levels of glucose and ketone bodies and can even precipitate diabetic ketoacidosis (American Diabetes Association-ADA, 2003).

Conversely, the presence of high levels of insulin, due to exogenous insulin administration, can attenuate or even prevent the increased mobilization of glucose and other substrates induced by physical activity, and hypoglycemia may ensue. Similar concerns exist in patients with DMT2 on insulin or sulfonylurea therapy; however, in general, hypoglycemia during physical activity tends to be less of a problem in this population. Indeed, in patients with DMT2, physical activity may improve insulin sensitivity and assist in diminishing elevated blood glucose levels into the normal range. The purpose of this position statement is to update and crystallize current thinking on the role of physical activity in patients with type 1 and 2 diabetes. With the publication of new clinical reviews, it is becoming increasingly clear that physical activity may be a therapeutic tool in a variety of patients with, or at risk for diabetes, but that like any therapy its effects must be thoroughly understood (Wasserman, Zinman, 1994; Devlin, Ruderman, 2002). From a practical point of view, this means that the diabetes health care team will be required to understand how to analyze the risks and benefits of physical activity in a given patient. Furthermore, the team, consisting of but not limited to the physician, nurse, dietitian, mental health professional, and patient, will benefit from working with an individual with knowledge and training in exercise physiology. Finally, it has also become clear that it will be the role of this team to educate primary care physicians and others involved in the care of a given patient.

The Earlier report Surgeon General's Report on Physical Activity and Health (WHO, 2016) underscores the pivotal role physical activity plays in health promotion and disease prevention. It recommends that individuals accumulate 30 min of moderate physical activity on most days of the week. In the context of diabetes, it is becoming increasingly clear that the epidemic of type 2 diabetes sweeping the globe is associated with decreasing levels of activity and an increasing prevalence of obesity. Thus, the importance promoting physical activity as a vital component of the prevention as well as management of DMT2 must be viewed as a high priority.

Every person can perform physical activity at the level that suits him, be it recreational or professional. The type of physical activity that a person will carry out is again left up to the individual choice of each person (aerobic, anaerobic, continuous, interval, training with or without resistance). It is important that this activity must be carried out daily and regularly, without long breaks in the activity. Each type of activity has a favorable effect on the regulation of blood glucose in its own way, and altogether has one goal, which is to reduce the level of glucose in the blood, reduce the intake of insulin units, and reduce hemoglobin, which are key factors in the proper regulation of the disease (Lekić, 2017).

Regular physical exercise cannot prevent the onset of insulin-dependent diabetes, but it can improve the possibility of remission and prolong its duration, increasing insulin sensitivity. It is estimated that at least 20% of the incidence of insulin-dependent diabetes can be attributed to a sedentary lifestyle (Eriksson, Taimela, Koivisto, 1997). It has been found that muscle work can increase glucose consumption by 7 to 20 times. The best preventive effect was established among persons with increased risk such as the obese, especially those of the android type of obesity, and persons with a family tendency to develop non-insulin-dependent diabetes.

Physically active persons are much less susceptible to developing insulin-independent diabetes than inactive people. In addition, it has been shown that changing the lifestyle of people with impaired glucose tolerance can reduce the incidence of non-insulin-dependent diabetes (Manson, Spelsberg, 1994). The potential risk of developing non-insulin-dependent diabetes disappears with moderate or intense exercise, and with regular exercise, it is reduced by 30 to 50% compared to inactive people. Physical exercise reduces the incidence of non-insulin-dependent diabetes by increasing insulin sensitivity directly or indirectly by reducing adipose tissue in the body or changing the redistribution of adipose tissue (Clark, Cooper, Gibbons, 1989).

A person must decide for himself which type of activity suits him best, in relation to his lifestyle, habits and obligations. Each activity has a different effect on the regulation of the disease itself and the reduction of glucose in the blood, each activity reacts differently on a person, and it is up to each diabetic to choose what suits him best. Brlečić, & Ružić (2014) investigate the extent to which aerobic and anaerobic physical activity affects blood glucose levels and the required number of insulin units in patients with type 1 diabetes who previously did not exercise regularly. The results confirmed that with a longer duration of training, glycemia is better regulated, and the need for insulin is reduced. Subjects who exercised an average of less than an hour a day had a 3.08% decrease in blood GUC, while subjects who exercised over an hour a day had an average 6.48% decrease in GUC.

The same rule applies to children as it does to adults, namely that physical activity significantly helps regulate blood glucose, that is, it is much easier to reduce the blood glucose level with physical activity, which entails lower doses of insulin, than without physical activity. Garcia-Garcia, Kumareswaran, Hovorka, et al. (2015) investigated the impact of a particular training method on blood glucose regulation during exercise and

recovery in people with type 1 diabetes and compared the impact of different types of activities on blood glucose regulation. The results of the research show that aerobic continuous activity of moderate intensity significantly reduces blood glucose levels, during the activity itself, compared to a day without activity or a day of rest. A slight increase in blood glucose was also recorded immediately after activity, which tends to return to normal levels during the recovery phase. The relationship between high-intensity interval training and resistance training and non-training days also favors training days showing a significant drop in blood glucose. The relationship between resistance training and moderate-intensity aerobic training shows that blood glucose reductions are milder during resistance training compared to aerobic training. In the original article, Nguyen, Obeid, Walker, (2015) talk about poorer muscle function in diabetic children with poor hemoglobin, i.e. poorer regulation of diabetes, compared to children with diabetes who are well regulated. The aim was to determine the association between fitness variables related to muscle composition in type 1 diabetic children with good blood glucose regulation and diabetics with poorer regulation and children without diabetes. Aerobic and anaerobic muscle functions were tested with an isometric maximum load test, Wingate's test and progressive load on a bicycle ergometer. Research results show that children who have good blood glucose regulation do not show any signs of change in muscle function, while children who have poor blood glucose regulation show signs of changes in muscle aerobic capacity. Balancing blood glucose during and after physical activity requires different carbohydrate intakes and/or insulin doses. Frequent measurement of blood glucose is necessary to maintain the blood glucose level in normal values, and in case of deviation, it is necessary to intervene either with food intake or insulin in order to bring the glucose level back to normal. Diabetics who use insulin can exercise using either insulin injections or an insulin pump to control the disease, and there are advantages and disadvantages of using a particular therapy in the control of the disease, as confirmed by the results of the study (Codella, Terruzzi, Luzi, 2017).

There are many benefits of physical exercise practice for health promotion and prevention and treatment of non-communicable chronic diseases, such as DMT2 and CD. According to the American Diabetes Association, lifestyle changes based on physical exercise and dietary re-education are essential for the management of DMT2 (Cradock, ÓLaighin, Finucana, 2017). These changes can promote a moderate reduction in body mass (5%), reflecting an improvement in insulin action, a reduction in fasting glucose and the risk of micro and macrovascular complications (Martín-Timón, Sevillano-Collantes, Segura Galindo, 2014; Freitas, Ceschini, Ramallo, 2014).

A research by Lin, Zhang, Guo, et al. (2015) showed that aerobic physical exercise of moderate or high intensity practiced by women and men with or without DMT2 was efficient in increasing insulin sensitivity and reducing glycated hemoglobin (HbA1c) and fasting insulin. They also observed that the reduction in fasting insulin was less pronounced in women than in men. However, they did not identify a reduction in fasting glucose, nor a difference in the magnitude of response to exercise intensity. On the other

hand, Johnson, Slentz, Houmard, et al. (2007) found an improvement in insulin sensitivity in overweight or obese women and men undergoing moderate aerobic exercise, which was not observed after high-intensity physical exercise results of the therapeutic strategies adopted, conducts based on the findings of studies carried out in men or experimental models of males are frequently observed. Given this scenario, it is possible that only a part of the population responds effectively to the prescribed treatment (Regitz-Zagrosek, 2006). Regarding the effects of physical exercise, both men and women respond positively in controlling blood glucose, body mass, arterial blood pressure and lipid profile. However, the magnitude of the response, the type of physical exercise and the execution time to obtain the effects may differ between men and women. Considering these aspects is essential to enhance the treatment of DMT2 and minimize the risk factors for CD. According to the meta-analysis by Snowling & Hopkins (2006), the resistance exercise in women and men with DMT2 resulted in a reduction in HbA1c levels and an improvement in insulin sensitivity. There were no differences in postprandial and fasting blood glucose, nor between sexes. Resistance to physical exercise also improved insulin sensitivity in women without DMT2, although this is not observed in men in the same condition (Ahtiainen, Sallinen, Häkkinen, 2020). The high-intensity interval physical exercise (HIIT) was effective in increasing insulin sensitivity and reducing fasting blood glucose, especially in overweight or obese individuals who trained for at least 12 weeks (Campbell, Kraus, Powell, 2019). Notably, these effects of HIIT on insulin sensitivity outweigh those of aerobic exercise. However, HIIT does not appear to be effective in reducing HbA1c levels in individuals with DMT2. Furthermore, there is no evidence to support sex differences in responses to HIIT. As previously mentioned, inflammation is one of the factors responsible for the impairment of glycemic metabolism, which is typical of DMT2. If the reduction in body mass is important to improve carbohydrate metabolism, choosing physical exercises that promote greater lipid oxidation favors this condition. Aerobic exercise with moderate intensity is a widely used non-pharmacological strategy for the loss of body mass (Arslan, Ipekci, Kebapcilar et al. 2104; Alghadir, Gabr, Al-Eisa, 2016). However, variables such as sex, age, level of physical fitness, exercise intensity, nutritional consumption and health condition influence the maximum rate of fat oxidation (Venables, Achten, Jeukendrup, 2005). Apparently, women oxidize more lipids and less carbohydrates than men during submaximal aerobic exercise with the same intensity, which is possibly associated with the effects of estrogens. During exercise, they cause a reduction in the circulating levels of catecholamines, by stimulating the degradation of these neurohormones in the brain and/or by inhibiting secretion by the adrenal gland (Hedrington, Davis, 2015).

As the intensity of aerobic exercise generally used is between 55% to 70% of the maximum oxygen consumption (VO2 max) (Mendelson, Jinwala, Wuyam, et al. 2012), it is extremely important to consider the health condition and age to obtain a better effect of physical exercise. Studies carried out with elderly obese or diabetic adult women (Suk, Moon, Park, et al. 2015: Cao, Jiang, Li, 2019) indicated that the highest rate of lipid oxidation occurs when exercise is performed with intensity below 55% of VO2 max (with

intervals between 24% and 51% of VO2 max). In addition, all women in the trained groups had a reduction in body mass, BMI, percentage of body and visceral fat and a reduction in waist-to-hip ratio compared to their control peers. When obese and/or diabetic women are compared to obese and/or diabetic men, they present less reduction in the percentage of visceral fat and body mass, although both reduce several variables that determine body composition (BMI, waist circumference, body mass, percentage of fat body) (Jiang, Tan, Wang, 2020; Quartuccio, Yalamanchi, Golden, et al. 2018). Resistance exercises are another strategy to promote general metabolic health in individuals with DMT2 through improvements in mitochondrial performance and an increase in muscle mass (Pesta, Goncalves, Madiraju, et al. 2017). High-intensity resistance exercises (75% to 85% 1RM) were efficient in reducing fat mass and increasing lean mass in elderly diabetics of both sexes, with no difference between them (Lee, Kim, Kim, 2017). A 6-week protocol of moderate to high-intensity resistance exercises (65% to 85% 1RM) was effective in reducing the fat mass percentage and increasing lean mass in middle-aged diabetic men and women (Hu, Russell, Remash, et al. 2018).

However, because men have a higher percentage of fat-free mass, they tend to obtain greater effects with resistance exercises (Quartuccio, Yalamanchi, Golden, et al. 2018). A previous study that investigated the combined practice of aerobic and resistance exercises by obese and DMT2 women for 16 weeks, revealed the effectiveness of this type of training in reducing subcutaneous and visceral adiposity (Cuff, Meneilly, Martin, 2003). In another study comparing aerobic, resistance and combined exercise protocols in obese and hypertensive individuals of both sexes for 8 weeks (1h per session, 3x/week), the authors showed that aerobic exercise promoted a greater reduction in body mass, BMI and fat mass. On the other hand, combined exercise induced a lower percentage of fat mass and a higher percentage of lean mass compared to sedentary individuals (Schroeder, Franke, Sharp, et al. 2019). In this study, there was no comparison between the sexes. Although there is a lot of divergence in high-intensity exercise protocols for diabetics, both men and women benefit from this type of exercise, mainly with a reduction in visceral fat (Maillard, Rousset, Pereira, et al. 2016; Zhang, Tong, Qiu et al. 2017; Baasch-Skytte, Lemgart, Oehlenschläger, et al. 2020). The beneficial effect of physical exercise on blood pressure is widely known in the literature. Aerobic exercises performed at low and moderate intensities promote a reduction in systolic, diastolic, and mean blood pressure in obese, diabetic, and hypertensive individuals of both sexes.

This effect can be observed both acutely, right after an exercise session, and chronically, after a training period. However, when comparing the magnitude of response, women have a smaller reduction in blood pressure (Kanaley, Goulopoulou, Franklin, 2012; Alonso-Domínguez, Recio-Rodríguez, Patino Alonso, et al. 2019). The resistance and strength physical exercises are essential for the maintenance of the health of individuals with hypertension. In a study carried out with diabetic and hypertensive individuals submitted to 12 weeks of resistance physical exercise, a decrease in systolic and diastolic blood pressure was observed only immediately after the physical exercise session (acute effect). However, there was no reduction in resting blood pressure after

the training period (chronic effect) in both sexes (Machado, Botton, Brusco, 2020). In another study, resistance exercise with moderate intensity induced a decrease in systolic and diastolic blood pressure at rest and in norepinephrine levels in obese individuals with DMT2. There were no differences in the magnitude of blood pressure response between sexes (Dempsey, Sacre, Larsen, et al. 2016).

Other types of physical exercises were conducted to investigate blood pressure responses. In one of the studies, obese and diabetic women who underwent 16 weeks of HIIT (90% -100% of heart rate reserve, with active recovery less than 70% of heart rate reserve), had a reduction only in systolic blood pressure (Alvarez, Ramirez-Campillo, Martinez-Salazar, et al. 2016). Another research showed that the association between high-intensity physical exercise and resistance exercise for 12 weeks reduced the systolic and diastolic blood pressure of individuals with DMT2 and hypertension of both sexes (Rehman, 2019). Regarding the effects of aerobic exercise on the lipid profile, data from meta-analysis with men and women revealed the potential of this type of exercise to reduce triglyceride levels and increase HDL cholesterol levels. On the other hand, the LDL cholesterol only showed a tendency to reduction and total cholesterol remained unchanged. According to the authors, more significant LDL cholesterol responses to aerobic exercise may occur in individuals with DMT2, hypertension and dyslipidemia, mainly due to the higher values found in this population (Lin, Zhang, Guo, 2015). The effects of resistance exercise are much less pronounced on the lipid profile. According to a meta-analysis, individuals with DMT2 undergoing this type of exercise do not present significant differences in the levels of triglycerides, total cholesterol, and HDL and LDL fractions. Furthermore, no differences were shown between the sexes (Snowling, Hopkins, 2006). These results are also consistent in healthy men and women (Winett, Carpinelli, 2001). Similarly, HIIT did not promote changes in the levels of triglycerides, total cholesterol, and HDL and LDL fractions.

4. Conclusion

In the era of modern living, physical activity comes as a benefit to the organism. Due to the large number of complications that diabetes and CD bring with it, patients are limited in daily physical activities. From this study, we can conclude that physical activity is of great importance for the prevention and treatment of diabetes and CD itself as a disease. Physical activity also helps reduce obesity, positively affects people with mental difficulties, reduces the osteoporosis index and most importantly, we can conclude that it has a positive effect on insulin regulation in humans with diabetes. The benefits of physical activity for the prevention of DM and CD are multiple. Aerobic, resistance and HIIT physical exercises are beneficial for the control of risk factors that connect DMT2 and CD, such as obesity, hypertension, dyslipidemia, and physical inactivity itself. It was evident that both women and men benefited from the practice of physical exercise, although some different responses between the sexes are observed.

Conflict of interest statement

The authors declare that they have no conflicts of interest.

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