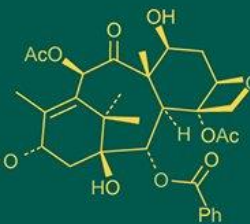
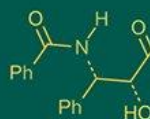
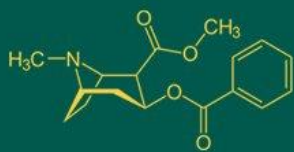


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The role of diet and exercise in fat distribution and type 2 diabetes prevention

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Abstract

Type 2 Diabetes mellitus is the most common form of metabolic disease, accounting for more than 90% of all diabetes worldwide. The disorder is due to insulin resistance and decreased production of insulin and has a massive impact on health in general because of its increasing prevalence, complications, and mortality. Factors that predispose an individual to T2DM include non-modifiable factors, including genetics, and modifiable ones such as diet, physical inactivity, and prediabetes. Major contributors to obesity are abdominal fat, which increases inflammation and oxidative stress. Dietary habits include high-calorie diets and unhealthy fats, increasing insulin resistance, whereas Mediterranean and low-calorie diets improve metabolic health. Physical activity, including aerobic and resistance training, reduces the risk of diabetes by enhancing glycemic control and insulin sensitivity. Clinical trials of lifestyle interventions were confirmed to provide efficacy, making diet, exercise, and caloric restriction interventions important in the prevention and management of T2DM. Emerging evidence in the literature suggests long-chain omega-3 fatty acids are beneficial, and diets rather than nutrients are effective against diabetes. An important approach to limit the global rise in diabetes incidence is through education and promotion of healthier lifestyles, primarily in high-risk populations.

Keywords: Type 2 diabetes mellitus, insulin resistance, obesity, glycemic control, prediabetes, lifestyle interventions

Introduction

Type 2 diabetes mellitus (T2DM) is a common chronic metabolic disorder and accounts for over 90% of diabetes cases worldwide (DeFronzo *et al.*, 2015) ^[13]. It is characterized by the simultaneous presence of both peripheral tissue resistance to insulin, in tissues such as skeletal muscle, liver, and adipose tissue, and insufficient production of insulin in the pancreatic β -cells. This disorder involves carbohydrate, lipid, and protein metabolism and may cause great health and social harm considering the high prevalence, complications, and death rate. In 2019, it was estimated that diabetes was present in 9.3% of adults globally, with the forecast projecting it will rise to 10.9% by 2045 (González *et al.*, 2022) ^[2]. Obesity, especially central obesity, has an important role in the pathophysiology and management of T2DM. Central obesity accounts for 80-95% of T2DM incidences, hence adding to the enormity of the medical burden to T2DM. Women with a BMI of between 23 and 24 are four times more likely than others with a BMI of 22 or less to develop diabetes, while BMI exceeding 35 elevates this risk 93 times over (Astrup, 2001) ^[4].

Risk factors for type 2 diabetes (T2DM) are classified into non-modifiable such as age, gender, genetics and ethnicity and modifiable including diet, physical activity and prediabetes. Prediabetes characterized by high blood glucose and signs of metabolic syndrome (MetSy) such as obesity, dyslipidemia and hypertension increases T2DM risk substantially. One of the largest contributors is abdominal obesity that causes chronic inflammation and oxidative stress. While Body Mass Index is one of the easiest measures for obesity a more precise measurement for metabolic disease risk would be waist circumference and body fat percentage according to (Derrick *et al.* 2023) ^[22]. Risk is further exacerbated by recent weight gain, for example, quantity and distribution of fat are responsible for a vast majority of cases of diabetes. Dietary habits have a strong influence on fat distribution and T2DM risk. PUFA was found to have an association with improved blood glucose control and low diabetes risk.

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On the other hand the impact of SFA varies due to its origin. SFA in meat would have a likelihood of increasing the risk of developing diabetes but the SFA from dairy may reduce it (Brayner *et al.*, 2023) ^[8]. Understanding the role of diet in preventing T2DM through dietary patterns instead of isolated nutrients is significant (Gaeini *et al.*, 2019) ^[14]. Physical activity is just as important in the prevention or delay of T2DM, regardless of weight status. Regular moderate-intensity exercise reduces the risk of diabetes by 30% and improves glycemic control, reducing glycated haemoglobin (HbA1c) by 0.6% (Bazhan *et al.*, 2013) ^[6]. The combination of aerobic and resistance training will improve blood glucose regulation, lipid metabolism, and cardiorespiratory fitness. Exercise also reduces visceral fat and promotes skeletal muscle adaptations that are crucial for glucose uptake and metabolism (Liu *et al.*, 2024) ^[17]. Moreover, T2DM results in decreased cardiorespiratory fitness, decreased exercise capacity, and increased blood pressure responses to exercise (Green *et al.*, 2015) ^[9].

Dietary Factors Contributing to Insulin Resistance

High-calorie diets and unhealthy fat: Such high caloric diets have been reported to cause insulin resistance. It elevates the level of ceramides in tissue such as the liver, muscle and fat affecting insulin function (Mirabelli *et al.*, 2020) ^[10].

Processed Carbohydrates and Unhealthy Fats: Diets with high intake of processed carbohydrates and unhealthy fats elevate free fatty acids and ceramides, leading to the exacerbation of impaired insulin signalling. Furthermore, diets rich in these components induce metaflammation (chronic low-grade inflammation) and gut microbiota imbalances that worsen insulin resistance (Magalhães *et al.*, 2022) ^[3].

Natural Compounds that Enhance Insulin Sensitivity

Sulforaphane and Oleacein: Sulforaphane, a compound in broccoli, and oleacein, an extra virgin olive oil compound, have been demonstrated to decrease ceramide levels and inflammation, enhancing insulin sensitivity (Mirabelli *et al.*, 2020) ^[10].

Healthy dieting patterns in controlling insulin resistance

Mediterranean Diet (MD): MD is rich in monounsaturated fats, antioxidants, and polyphenols; it is correlated with improved insulin sensitivity and has reduced risks for obesity, inflammation, and CVD. This diet has been observed to prevent metabolic syndrome and T2D (Radu *et al.*, 2023) ^[12].

Low-Calorie and Balanced Diets: A hypercaloric (excessive calorie) diet causes impairment of insulin sensitivity, contributes to weight gain, and results in hyperinsulinemia, beta-cell dysfunction, and IR. Balanced eating patterns, such as those recommended by the Mediterranean lifestyle, can also be protective against these metabolic disorders (Radu *et al.*, 2023) ^[12].

Meal Timing and Consistency Are Very Important

Meal Timing: Studies have shown that meal timing and consistency are important in the regulation of blood glucose levels. To improve insulin sensitivity, late dinners should be avoided and most calories and carbohydrates should be consumed earlier in the day (Magalhães *et al.*, 2022) ^[3].

Effect of dietary fiber on insulin sensitivity and type 2 diabetes

Dietary fiber and lifestyle factors significantly affect insulin sensitivity and risk of developing type 2 diabetes (T2D). Dietary fiber intake especially from cereals, affects postprandial glucose and insulin response. The higher the fiber intake, especially insoluble fiber, the lower the risk of T2D.

Low glycemic index (GI) foods: Foods with a low glycemic index help reduce glucose elevation and improve glycemic control. Diets high in fiber and low-GI foods improve glycemic control, lower LDL cholesterol, and lower postprandial glucose levels even in people without diabetes (Steyn *et al.*, 2004) ^[18].

Key factors include smoking, excessive alcohol consumption, lack of exercise, and sedentary lifestyle. 1960s Since then, childhood obesity has increased, contributing to the rise in diabetes in children and adolescents. Environmental toxins may also contribute to the increased prevalence (Khudair *et al.*, 2024) ^[16].

Lifestyle Factors and Prevention of Type 2 Diabetes

Mediterranean Lifestyle: The Mediterranean lifestyle, focusing on a plant-based diet, olive oil, physical activity, rest, and socialization, has been related to lower risks of metabolic syndrome, cardiovascular diseases, and chronic conditions such as T2D. The MEDLIFE index, which assesses adherence to this lifestyle, has been shown to relate to a reduced risk of diabetes (Rodriguez *et al.*, 2023) ^[15].

Healthy Lifestyle Promotion: Promoting the mediterranean lifestyle among non -mediterranean populations may prove an effective approach in reducing the increasing number of cases of T2D across the globe.

Physical Activity: Systematic exercise at a moderate to vigorous intensity improves insulin sensitivity, reduces A1C levels, and prevents diabetes. It controls blood glucose level with decreased cardiovascular risk and helps maintain body weight. Aerobic activities such as running, cycling, resistance training, and stretching promote good health. Balance-exercise, tai chi, among others prevent falls and also in the elderly (Amanat *et al.*, 2022) ^[23].

Evidence from clinical trials and cohort studies

Clinical trials and cohort studies have established that lifestyle and physical activity interventions significantly reduce the risk of type 2 diabetes in people with impaired glucose tolerance (IGT). The Da Qing Study showed that diet or exercise alone reduced the incidence of diabetes. The Finnish Diabetes Prevention Study and the U.S. Studies in the Diabetes Prevention Program (DPP) demonstrated an 58% decrease in risk for diabetes through alteration of lifestyle, comprising weight loss, moderate-intensity exercise, and dietary changes (Husam Hadi Jasim *et al.*, 2024) ^[21]. Nonrandomized studies, such as the Malmo study, demonstrate the value of lifestyle interventions on the incidence and mortality rates of diabetes. Cohort studies repeatedly associate greater physical activity and cardiorespiratory fitness with a decreased risk for diabetes, regardless of population (SIGAL *et al.*, 2004) ^[11].

Studies on Exercise in Type 2 Diabetes

1. **Aerobic Exercise:** 21 studies with sessions 1-7 times per week, mostly 3, lasting 40-75 minutes. Intensity

- ranged from 50-85% VO₂ max or 55-85% max heart rate, with interventions lasting 2 months to 1 year.
2. Resistance Training: 8 studies with 3 supervised weekly sessions, reduced at times to biweekly. The intensity of 50-80% one-repetition maximum for 8 weeks to 6 months.
 3. Concurrent Aerobic and RT: 10 studies with 2-5 weekly sessions. The intensity of aerobic exercise ranged from 35 to 85% max HR, and resistance protocols were heterogeneous. Interventions lasted between 8 weeks and 24 months, with a median duration exceeding 3 months.
 4. Compliance: Compliance was checked with the usage of supervised sessions or activity logs (Chudyk A. and Petrella R., 2011) ^[11].

Safety of Physical Exercise in Type 2 Diabetes

For individuals with type 2 diabetes, physical exercise is safe, and there are no critical adverse events. Small problems include back pain, tendinitis, hypoglycemia, or muscle injuries that are associated rarely and have no limits or contraindications for adults with type 2 diabetes to engage in physical activity, as says (Ribeiro *et al.* 2023) ^[7].

Calorie restriction enhances insulin sensitivity

Calorie Restriction (CR): Calorie restriction, ensuring ample nourishment while lowering energy consumption, prevents and manages T2D through improved glucose control and obesity. A typical CR study improved insulin sensitivity by 40% and increased β -cell responsiveness to glucose while lowering acute insulin response, (Shakoor *et al.* 2021) ^[19].

Role of Physical Activity

Physical Inactivity

Physical inactivity causes a high risk factor of T2D, especially in those with other factors like high BMI, hypertension, or family history of diabetes. Studies have shown that intensive exercise decreases the incidence of T2D; also, the physically active have low risk, even at an equal level of obesity (Steyn *et al.*, 2004) ^[18].

Effect of Long-Chain Omega-3 Fatty Acids

Omega-3 Fatty Acids: Long-chain Omega-3 fatty acids, including EPA and DHA from fish oil, are associated with enhanced insulin sensitivity. Human studies correlate greater concentrations of these fatty acids in skeletal muscle membranes with enhanced insulin sensitivity, implying that higher intakes of fish oil may be protective (Hu *et al.*, 2001) ^[17].

Dietary Interventions for Type 2 Diabetes Prevention

Fats: The Dietary recommendations for the prevention of type 2 diabetes include reducing total and animal fats and increasing vegetable fats. They recommend higher intakes of MUFAs, PUFAs, and omega-3 fatty acids and lower intake of SFAs and trans fatty acids (Sivri D. and Akdevelioglu Y. *et al.*, 2020) ^[24].

Conclusion

Type 2 diabetes mellitus (T2DM) is a major global health challenge that is primarily driven by modifiable lifestyle factors, especially diet and physical activity. Abdominal obesity and poor dietary habits enhance insulin resistance, thereby increasing the risk of T2DM. Conversely, healthier

dietary patterns like the Mediterranean diet, calorie restriction, and optimization of meal timing enhance glycemic control and improve insulin sensitivity. Likewise, regular physical activity, including aerobic and resistance training, is an essential component in preventing T2DM, improving glycemic control, and reducing the risk of cardiovascular complications. Research on dietary fiber, low GI foods, and long-chain omega-3 fatty acids suggests that certain nutrients and dietary patterns could prevent or control diabetes.

Lifestyle interventions have thus become the cornerstones for the prevention and management of T2DM, as concluded based on clinical trials and cohort studies. These can be promoted with significant effects in reducing the burden and prevalence of diabetes in many parts of the world.

Future Recommendations

Public education should focus on improving healthy eating and active lifestyle initiatives that support the affordability of nutritious foods and the availability of physical activity spaces to combat type 2 diabetes. This can take the form of community-centered programs targeting groups at higher risk for developing type 2 diabetes. Scientists can analyse how food choices and when meals are taken contribute to the disease of diabetes, further refining nutrition science which encompasses things such as omega-3 fatty acids. Technology also includes the tools of a fitness tracker and the mobile app for better prevention and management of the disease. Achieving this will require country-specific strategies based on individual health needs and international cooperation to share the best ideas and solutions to meet the diabetes challenge.

References

1. Chudyk A, Petrella RJ. Effects of exercise on cardiovascular risk factors in type 2 diabetes: A meta-analysis. *Diabetes Care.* 2011;34(5):1228-1237. <https://doi.org/10.2337/dc10-1881>
2. González ÁAL, Sbert PR, Fe BR, Fe NR, Bote SA, Manent JIR. Relationship between healthy habits and sociodemographic variables and risk of diabetes type 2. *Afr Health Sci.* 2022;22(4):133-139. https://scholar.google.com/scholar?hl=en&as_sdt=0%2C5&q=Relationship+between+healthy+habits+and+sociodemographic+variables+and+risk+of+type+2+diabetes.&btnG=
3. Magalhães A, Barra C, Borges A, Santos L. Diet modifications towards restoration of insulin sensitivity and daily insulin fluctuations in diabetes. *Diabetology.* 2022;3(4):606-614. <https://typeset.io/pdf/diet-modifications-towards-restoration-of-insulin-3d76haei.pdf>
4. Astrup A. Healthy lifestyles in Europe: prevention of obesity and type II diabetes by diet and physical activity. *Public Health Nutr.* 2001;4(2B):499-515. https://scholar.google.com/scholar?hl=en&as_sdt=0%2C5&q=Healthy+lifestyles+in+Europe%3A+Prevention+of+obesity+and+type+II+diabetes+by+diet+and+physical+activity.&btnG=
5. Dan L, Rui H, Di C, Wenli G, Jiacheng N, Qichen F, Weiping J. Exercise-induced improvement of glycemic fluctuation and its relationship with fat and muscle distribution in type 2 diabetes. *J Diabetes.* 2024;16(4):e13549.

- <https://onlinelibrary.wiley.com/doi/pdfdirect/10.1111/1753-0407.13549>
6. Bazhan M, Mirmiran P, Mirghotbi M, Vafaei R. Lifestyle interventions and risk of Type 2 diabetes. *Arch Adv Biosci*. 2013;4(1). <https://typeset.io/pdf/lifestyle-interventions-and-risk-of-type-2-diabetes-1958tbjo55.pdf>
 7. Ribeiro AKPDL, Carvalho JPR, Bento-Torres NVO. Physical exercise as treatment for adults with type 2 diabetes: a rapid review. *Front Endocrinol (Lausanne)*. 2023;14:1233906. <https://www.frontiersin.org/journals/endocrinology/articles/10.3389/fendo.2023.1233906/full>
 8. Brayner B, Kaur G, Keske MA, Marchese LE, Livingstone KM. Novel approach to investigate the association between type 2 diabetes risk and dietary fats in a dietary pattern context: a scoping review. *Front Nutr*. 2023;10:1071855.
 9. Green S, Egaña M, Baldi JC, Lamberts R, Regensteiner JG. Cardiovascular control during exercise in type 2 diabetes mellitus. *J Diabetes Res*. 2015;2015:654204. <https://onlinelibrary.wiley.com/doi/epdf/10.1155/2015/654204>
 10. Mirabelli M, Russo D, Brunetti A. The role of diet on insulin sensitivity. *Nutrients*. 2020;12(10):3042.
 11. Sigal RJ, Kenny GP, Wasserman DH, Castaneda-Sceppa C. Physical activity/exercise and type 2 diabetes. *Diabetes Care*. 2004;27(10):2518-2539. <https://paulogentil.com/pdf/Physical%20Activity-Exercise%20and%20Type%20%20Diabetes.pdf>
 12. Ionita-Radu F, Ranetti AE, Vasile TM, Sirbu AM, Axelerad A, Sirbu CA. The impact of the hypercaloric diet versus the Mediterranean diet on insulin sensitivity. *Rom J Mil Med*. 2023;126(3):275-279. <https://revistamedicinamilitara.ro/wp-content/uploads/2023/02/RJMM-vol-CXXVI-nr-3-din-2023-part-6.pdf>
 13. DeFronzo RA, Ferrannini E, Groop L, Henry RR, Herman WH, Holst JJ, *et al*. Type 2 diabetes mellitus. *Nat Rev Dis Primers*. 2015;1(1):1-22. https://drive.google.com/file/d/1KS_agmG9-x0kYOf9mRgRBSCi3wcdezHs/view
 14. Gaeini Z, Bahadoran Z, Mirmiran P, Djazayeri A. The association between dietary fat pattern and the risk of type 2 diabetes. *Prev Nutr Food Sci*. 2019;24(1):1. <https://typeset.io/pdf/the-association-between-dietary-fat-pattern-and-the-risk-of-b058qtmr22.pdf>
 15. Maroto-Rodríguez J, Ortolá R, Carballo-Casla A, Iriarte-Campo V, Salinero-Fort MÁ, Rodríguez-Artalejo F, *et al*. Association between a Mediterranean lifestyle and Type 2 diabetes incidence: a prospective UK Biobank study. *Cardiovasc Diabetol*. 2023;22(1):271.
 16. Khudair S, Hussein LF, Hameed SI, Khadhum MK, Hussein SAM. The relationship between fatty acids and Type II diabetes mellitus. *Int J Med Sci Dent Health*. 2024;10(7):39-47. <https://www.ijmsdh.org/index.php/ijmsdh/article/view/237/218>
 17. Hu FB, van Dam RM, Liu S. Diet and risk of type II diabetes: The role of types of fat and carbohydrate. *Diabetologia*. 2001;44(7):805-817. <https://typeset.io/pdf/diet-and-risk-of-type-ii-diabetes-the-role-of-types-of-fat-40294jz5m1.pdf>
 18. Steyn NP, Mann J, Bennett PH, Temple N, Zimmet P, Tuomilehto J, *et al*. Diet, nutrition, and the prevention of type 2 diabetes. *Public Health Nutr*. 2004;7(1A):147-165. <https://auspace.athabasca.ca/bitstream/handle/2149/1199/Diet,%20nutrition%20and%20the%20prevention%20of%20type%20%20diabetes.pdf?sequence=1&isAllowed=y>
 19. Shakoor H, Apostolopoulos V, Feehan J, Ali HI, Ismail LC, Al Dhaheri ASOS, *et al*. Effect of calorie restriction and exercise on type 2 diabetes. *MASA Contributions, Sect Med Sci*. 2021;42(1):110-124. <https://typeset.io/pdf/effect-of-calorie-restriction-and-exercise-on-type-2-26cu2j5rgu.pdf>
 20. Sivri D, Akdevelioğlu Y. Effect of fatty acids on glucose metabolism and type 2 diabetes: Narrative review. *Nutr Rev*. 2024;00(0):1-11.
 21. Husam HH, Saud MA, Abed SK. Ketogenic diets: An overview of metabolism within the body and their effects. *Int J Adv Chem Res*. 2024;6(1):221-224. doi:10.33545/26646781.2024.v6.i1c.189
 22. Derrick SA, Nguyen ST, Marthens JR, Dambacher LL, Sikalidis AK, Reaves SK. A Mediterranean-style diet improves the parameters for the management and prevention of type 2 diabetes mellitus. *Medicina*. 2023;59(10):1882. <https://www.mdpi.com/1648-9144/59/10/1882>
 23. Amanat S, Ghahri S, Dianatinasab A, Fararouei M, Dianatinasab M. Exercise and type 2 diabetes. In: Xiao J, editor. *Physical Exercise for Human Health*. Singapore: Springer Nature; 2020. p. 91-103. <https://sci-hub.gg/downloads/2020-05-03/5b/10.1007@978-981-15-1792-16.pdf>