https://doi.org/10.46389/rjd-2026-2070
www.rjdnmd.org

Rom J Diabetes Nutr Metab Dis
2026; volume 33, issue 1, pages 56–63

Original Article

# Managing type 1 diabetes mellitus in algerian children: the positive impact of diet and physical activity

**Fatima Zahra Ghanemi [1] *, Zoubida Soualem-Mami [2], Nouha Benghalem [3], Fatima Zohra Chenni [4], Youssouf Kachekouche [5], Meriem Bekkar [2], Ratiba Abib [2]**

[1] Department of Agronomy, Laboratory of Natural Product, University of Abou-Bekr Belkaid, Tlemcen, Algeria
[2] Department of Biology, Laboratory of Natural Product, University of Abou-Bekr Belkaid, Tlemcen, Algeria
[3] Faculty of Medicine, Laboratory of Natural Product, University of Blida, Hospital of Douera, Algiers, Algeria
[4] Department of Biology, Laboratory of Biotoxicology, University Djilali Liabes, Algeria
[5] Department of Biology, Hassiba Benbouali University, Chlef, Algeria

* Correspondence to: Fatima Zahra Ghanemi, Department of Agronomy, Laboratory of Natural Product, University of Abou-Bekr Belkaid, Rocade II, Tlemcen, Algeria. E-mail: fatimazahra.ghanemi@univ-tlemcen.dz; ghanemifatimazohra@gmail.com

Received: 29 September 2025 / Accepted: 5 January 2026

## Abstract

Nutritionists recommend that people with type 1 diabetes mellitus (T1DM) should engage in physical activity alongside healthy dietary habits. This study was designed to determine the effect of diet and physical activity on T1DM progression in children aged 8 to 15. Young patients with T1DM were enrolled in this quasi-experimental descriptive study at Sebdou and Maghnia hospitals (Tlemcen wilaya, north-west Algeria). The study involved a questionnaire and the prescription of dietary measures and physical exercises. Anthropometric (BMI) and biological (glycaemia and HbA1c) parameters were measured at baseline and after three months of follow-up. Statistical software was used to perform comparison tests at a significance level of $p<0.05$. Thirty T1DM patients were recruited. The sex ratio was 0.76, with an average age of 12.83±1.98 years. BMI, which was 22.36±5.16 kg/m² at baseline, improved to 21.72±3.71 kg/m² after the experiment. Glycated haemoglobin and glycaemia levels decreased from 9.02%±0.80% and 1.51 g/L±1.007, respectively, at baseline to 7.72%±1.01% and 1.57 g/L±0.41, respectively, at the end of the experiment. Combining drug treatment with a healthy lifestyle and regular monitoring of biological parameters improves the quality of life of diabetic children.

**Keywords:** healthy diet, physical activity, types 1 diabetes, children, HbA1C

## Introduction

Type 1 diabetes (T1DM) is one of the most common chronic diseases affecting children and adolescents, with 355,900 cases declared worldwide in the International Diabetes Federation in 2021. T1DM is an autoimmune illness, causing the destruction of beta cells that produce insulin.

The only treatment for patients with type 1 diabetes is intensive insulin therapy, which comprises multiple subcutaneous insulin injections or a continuous subcutaneous insulin infusion via an insulin pump to attain normoglycaemia [1, 2]. Despite significant advances in medical therapy and technology, a healthy diet remains vital for managing T1DM [3]. For instance, a study on the Mediterranean diet demonstrated its effectiveness in preventing and managing T1DM [4].

It is therefore important to understand how to check blood sugar levels and adjust insulin dosages according to each person's individual circumstances, such as their diet and the length of time they spend practicing physical activity [5–7]. Furthermore, people with diabetes mellitus are 30% more expected to develop heart failure and cardiovascular disease than healthy individuals. Heart and cardiovascular complications are the leading cause of death worldwide,

resulting in high healthcare charges. Such complications can be delayed or avoided by taking prescribed medication combined with a healthy lifestyle (*i.e.* a balanced diet and regular exercise) [8].

Algeria is ranked seventh in the world among nations with the largest estimated number of children under the age of 15 with type 1 diabetes. According to the 8th edition of the International Diabetes Federation, this amount was last updated in 2017. Additionally, the incidence of diabetes in Algeria has increased to 7.2% of people aged from 20 to 79 years, equating to one adult in every 16. As a result, improving diabetes management remains a national public health priority [9]. Algeria is also the country with the highest number of new cases of T1DM in the Middle East and North Africa (MENA) region with 3,100 children registered in 2019 [10]. However, there is a lack of available scientific data on the incidence and prevalence of T1DM in Algerian children. There are only three functional regional registries for T1DM in children under 15 years of [11]. Indeed, Tlemcen is classified as a region with a very high risk of T1DM incidence [12]. Khater *et al.*, (2021) have reported that the incidence of T1DM in children under the age of 15 years was 38.5/100,000 between 2015 and 2018.

The aim of this study was to evaluate the benefits of combining a healthy diet with physical activity in the management of type 1 diabetes over a period of three months. Specifically, we analysed certain anthropometric parameters and blood analyses, such as glycaemia and HbA1c in diabetic patients.

## Material and methods

### Study design and patients

The study involved a population of thirty T1DM patients (n=30), experimental group at Tlemcen hospitals (Maghnia and Sebdou). The inclusion criteria for this study were any male or female subject suffering from T1DM and aged 8 to 16 years. A questionnaire was given to diabetic children and/or their parents before and after the implementation of a diet, the concerned patients were given a questionnaire.

### Laboratory, anthropometric and clinical data collection

Anthropometric measurements concerning weight, size, BMI, blood sugar and glycated haemoglobin were taken. Glycemia and glycated haemoglobin levels were registered. All participants agreed to provide verbal consent to answer the various questions with the permission of their parents.

The following informations were collected: last name, first name, age, gender, address, family history of diabetes, duration of diabetes. As well as lifestyle habits concerning: diet, physical activity and treatment undertaken.

#### Diet

Prescription of an adequate diet (Table 1) for diabetic children according to the protocol inspired from the Mediterranean diet and established by the nutritionist Karim Massous Algiers center.

#### Physical activity

A daily physical activity was recommended (walking to and from school, sports activity at school, playing sport in a gym). Patients without complications can practice all levels of physical activity and whose glycemic control is regular. The adjustment of their insulin and food was taken accordingly.

#### Biological parameters

Some biological parameters have been assessed. These include glycaemia, HbA1c, urea and creatinine levels, as well as BMI measurements taken before and after the diet.

#### Inclusion criteria

The inclusion criteria for this study were as follows: (1) Written informed consent; (2) patients with a confirmed diagnosis of T1DM for more than one year at the time of inclusion. Personal information and social characteristics were collected from these patients.

Patients were asked to complete a questionnaire prepared by the researchers in a face-to-face interview technique. The duration of the interview varied from one patient to another.

On average, it took 15 to 20 minutes to complete the survey form. All subjects were informed about the study protocol and gave their written informed consent to participate in this trial.

#### Statistical analysis

Quantitative variables are expressed as mean±SD, while qualitative variables are expressed as percentages. We used a Student's t-test to compare the means of quantitative variables before and after the diet, and the Khi-square test to determine the association between the diet and physical activity and eating habits. Comparative

Table 1: A daily menu example covering 1700 Kcal and 220 g of carbohydrates recommended for children, BMI* of 20, 30 min of physical activity.

| Type of meal | | Carbohydrates | Fat | Calories |
|---|---|---|---|---|
| **Breakfast** 7–8 a.m. 477 kcalories | 1 cup of whole milk (100 mL) | 5 | 4 | 68 |
| | 2 spoon of chocolate powder (20 g) | 16 | 1.2 | 73 |
| | 100 g of white cheese at 40% of fat | 2.6 | 9.8 | 140 |
| | 70 g of bread (1/4 baguette) | 40 | 0.7 | 190 |
| | 1 egg of 25 g | 0.3 | 6 | 80 |
| **Snack** 175 kcalories | 1 flavored yogurt (1 pot = 125 ml) | 14 | 1 | 85 |
| | 1 medium banana | 20 | 0.5 | 90 |
| **Lunch** 12–1 p.m. 442 kcalories | 100 g of raw vegetables (salads, carrots, cucumber, tomatoes) with a drizzle of olive oil | 5 | 0.2 | 40 |
| | 100 g dried vegetables (40 g beans, lentils, broad beans, peas) | 59 | 1.7 | 132 |
| | 100 g of lean meat | 0 | 8 | 160 |
| | 40g of bread | 23 | 0.4 | 110 |
| **Snack** 90 kcalories | 1 glass of fruit juice (orange, apple, grapefruit) 100 ml | 10 | 0 | 46 |
| | 1 glass of skimmed milk (100 ml) | 4 | 0.1 | 36 |
| | 2 rusks | 16 | 0.8 | 54 |
| **Dinner** 8–9 p.m. 340 kcalories | 100 g cooked green vegetables (broccoli, zucchini) | 6 | 0.2 | 50 |
| | 100 g of white forming at 40 of MG | 2.6 | 9.8 | 14 |
| | 100 g chicken breast or fish | 0.1 | 6 | 150 |
| **Snack** 340 kcalories | 5 nuts (25 g) | 3.75 | 15 | 132 |
| | 1 apple | 5 | 4 | 68 |

tests were performed using GraphPad Prism statistical software at a significance level of $p<0.05$.

## Results

### Main features

The most common risk factors for diabetes mellitus are generally gender, age, family history, environmental factors and genetics.

### Age and heredity parameters

The incidence of type 1 diabetes is increasing in younger populations. The average age at diagnosis is 12.83±1.98 years. The risk increases with age, particularly in the 12–14 age group, accounting for 28.3% of diabetic children. Diabetes may have genetic causes and inheritance varies depending on whether it is type 1 or type 2. For illustration, if one parent has type 2 diabetes, there is a 30% risk of transmission to offspring, compared to 5% for type 1 diabetes. Of the total study population, 63.3% has a family history of diabetes, whereas 36.7% of cases have no family history of diabetes mellitus (Table 2).

Table 2: Main characteristics of children with type 1 diabetes (n=30).

| Main characteristics | | N (%) |
|---|---|---|
| **Age** | 8–10 | 16.60 |
| | 10–12 | 10 |
| | 12–14 | 56.6 |
| | 14–16 | 16.60 |
| **Gender** | Boys | 43.33 |
| | Girls | 56.66 |
| **Family history** | Yes | 63.30 |
| | No | 36.70 |


https://doi.org/10.46389/rjd-2026-2070

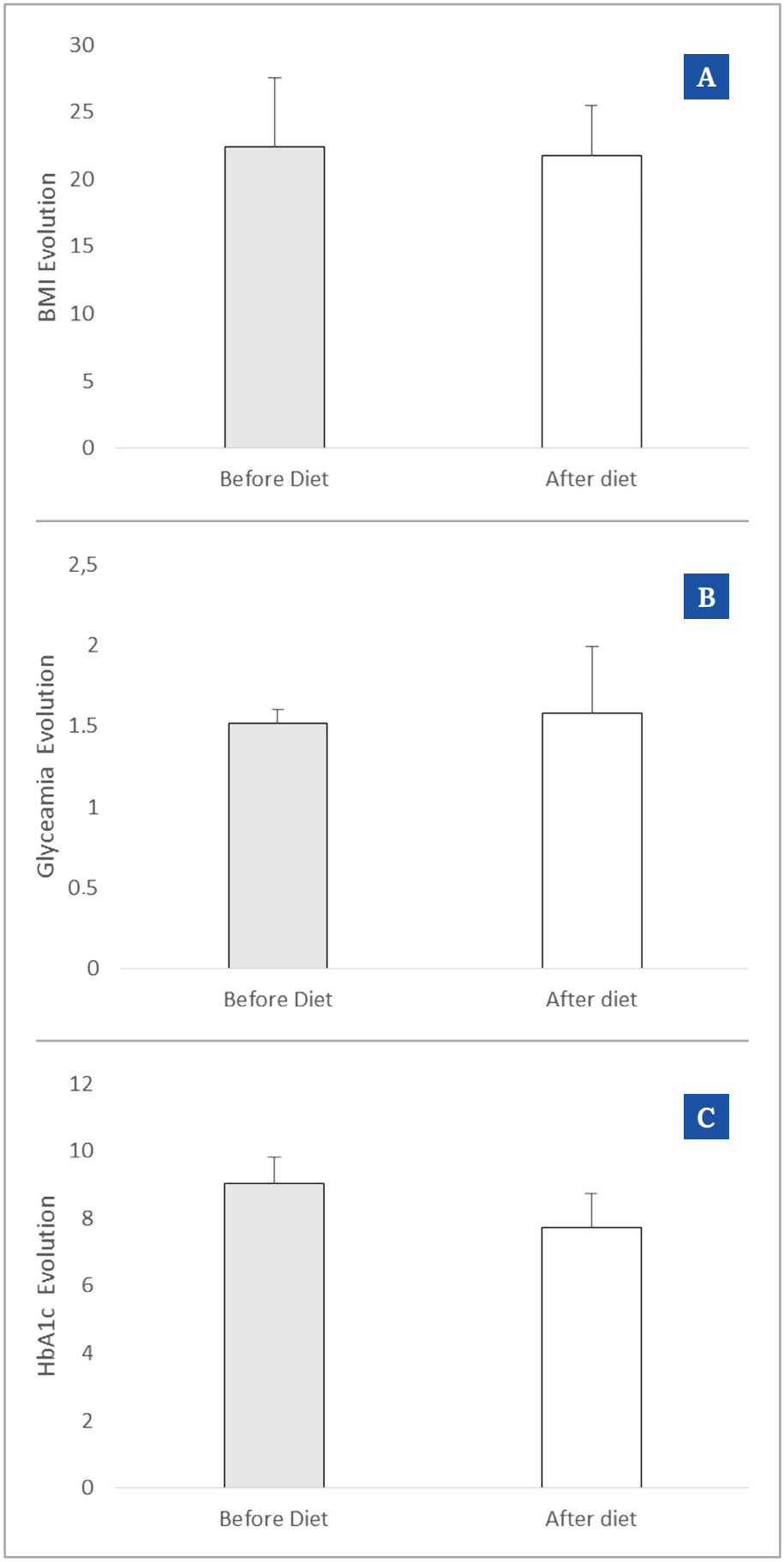


Figure 1: Evolution of BMI (kg/m²) (A), glycaemia (g/L) (B) and HbA1c (%) (C) before and after the diet. Mean±SD, p-value p<0.05.

## Sex predominance

Our results show a slight female predominance, with 17 girls (56.7% of diabetics) *versus* 13 boys (43.3% of diabetics), as shown in Table 2, giving a sex ratio of 0.76. These findings suggest that diabetes is more prevalent in girls than in boys. However, these findings are inconsistent with those of other studies. Indeed, in the most studied populations, T1DM is described as being more prevalent in men than women.

## Evolution of weight and BMI before and after diet

As shown in Figure 1, the average body size of diabetic children was 1.47±0.12 m. Their average weight before the diet was 49.63±16.35 kg, decreasing to 48.97±13.28 kg after the diet. Thus, the BMI of diabetic children before the diet was 22.36±5.16, decreasing compared to an estimated BMI of 21.72±3.71 after the diet. We suggest that being overweight could be a risk factor in the development of type 1 diabetes.

## Eating habits

Some variables concerning the monitoring of the proposed diet have been summarized in Table 3. Physical activity was strongly encouraged, with an increase of more than 60% after the diet. There was a significant increase in daily fruit and vegetable consumption, with more than three portions consumed per day. Additionally, a significant decrease in daily fast food consumption was observed. Similarly, soda drink consumption improved significantly ($X^2$=42.857, p<0.0001).

## Blood parameters

Glycated haemoglobin is the reference parameter. If the diagnosis of diabetes is based on fasting blood sugar, glycemic targets and treatment should be expressed in terms of glycated haemoglobin rather than blood sugar. The HbA1c level was 9.02±0.80% before the diet; a significant difference was noted afterwards, with a level of 7.72±1.01%. However, only a slight difference in glycemia level was observed before the diet at 1.51±1.007 g/L compared to after the diet compared to after the diet at 1.57±0.41 g/L.

Additionally, urea and creatinine decreased from 0.2829±0.0565 g/L and 10.34±2.63 mg/L before the diet to 0.2590±0.0432 g/L and 9.23±1.70 mg/L, respectively.

# Discussion

Physical activity (PA) is typically recommended as part of the management of T1DM and type 2 (T2DM) diabetes mellitus. It can enhance glucose uptake by boosting

Table 3: Improvement in diet quality with the introduction of physical activity, fruits and vegetables in type 1 diabetic children.

| | Before diet | After diet | Khi deux | DL | P-value |
|---|---|---|---|---|---|
| **Physical activity** | | | | | |
| Yes | 30% | 93.33% | 25.452 | 1 | 0.000 |
| No | 70% | 6.66% | | | |
| **Fruits and vegetables** | | | | | |
| 1 time/day | 23% | 0% | | | |
| 2 times/day | 73% | 6% | 48.805 | 2 | 0.000 |
| 3–4 times/day | 3% | 93% | | | |
| **Fast food** | | | | | |
| 2 times or less/day | 20% | 83.33% | | | |
| 3 times/day | 26.66% | 16.66% | 28.337 | 2 | 0.000 |
| 3 times or more/day | 53.33% | 0% | | | |
| **Soda consumption** | | | | | |
| Yes | 100% | 6.66% | 42.857 | 1 | 0.000 |
| No | 0% | 83.33% | | | |


https://doi.org/10.46389/rjd-2026-2070

insulin sensitivity and facilitating the transportation of glucose into cells, while also reducing body fat [8]. Nevertheless, in T1DM, the expected improvements in glycemic control with PA have not been clearly established. Still, significant physical and psychological benefits of exercise can be achieved through careful education, screening and planning, which allow metabolic, microvascular and macrovascular risks to be predicted and mitigated [13]. The risk of hypoglycaemia was the greatest barrier to exercise in individuals with T1DM and insulin-resistance (IR), whereas non-diabetes-related barriers to exercise were more significant in individuals with T1DM and without IR [14]. Recommending physical exercise is not generally undertaken, either by the general practitioner or by the diabetologist. This may be due to insufficient awareness of the benefits of physical exercise or a lack of specific knowledge regarding current recommendations. Thus, when suggested, prescriptions tend to be generic, focusing more on "physical activity" than "exercise therapy", with no clear guidance on type, intensity, frequency, timing, progression and precautions [15].

Physical activity (PA) improves glucose tolerance by enhancing insulin sensitivity in patients with either T1DM or T2DM [16]. Physical exercise is traditionally promoted in T2DM, where insulin action is limited due to insulin resistance and/or inappropriate insulin secretion. However, even in the immune system dysfunction found in T1DM, β-cell toxicity is facilitated by a complex interaction between oxidative stress and inflammation, against which chronic exercise could have a protective effect. Physical exercise reduces stress levels, improves mood and promotes overall mental well-being. Regular exercise improves blood sugar control, weight management and cardiovascular health, thereby lowering the risk of diabetes-related complications such as heart disease, stroke, nerve damage, kidney disease and eye problems [17–19].

Patients with T1DM may become obese for a multiplicity of reasons. For this reason, losing weight may help T1DM patients achieve better health outcomes than the general population, particularly with regard to cardiovascular health, kidney disease, and mortality. On the other hand, treatment can cause side effects and risks, particularly in T1DM patients, which can lead to hypoglycaemia and diabetic ketoacidosis. Further studies are required to evaluate the effectiveness and safety of weight loss treatments [20]. In addition, it is all the more important to prescribe the right diet as adolescents with T1DM can suffer from diabulimia. Evaluating the nutritional status of these adolescents can help reduce the occurrence of short- and long-term complications [21]. Interestingly, the findings of Catamo *et al*. (2024) showed that food neophobia was inversely associated with the taste of fruit, vegetables, fish, carbohydrates, and sweets [22]. Furthermore, parental eating practices exhibited an inverse association between "restriction", "monitoring" and "pressure to eat" and attraction to carbohydrates and vegetables. Additionally, high BMI and total cholesterol levels were detected in patients with HbA1c values >8.5%. Therefore, it is important that the HbA1c value is close to the target level to decrease the risk of complications [23, 24]. The International Child and Adolescent Diabetes Association has determined an optimal HbA1c value of less than 7.0% for adolescents with type 1 diabetes.

Dietary recommendations for children and adolescents with T1DM are based on healthy eating guidelines. The basic principle is to monitor carbohydrate intake, and reducing simple carbohydrates, saturated fatty acids and trans-fatty acids is recommended. Consumption of fibre-rich foods, such as vegetables, fruits, and whole grain cereals, should be encouraged [25]. Furthermore, restoring the integrity of the gut barrier through an anti-inflammatory diet containing soluble fibre, inulin, and omega-3 polyunsaturated fatty acids (PUFAs) is suggested [26]. A high-protein diet has been shown to improve glycemic control after exercise in adolescents with type 1 diabetes [27].

In light of our results, heredity plays an important role in the prevalence of diabetes. In fact, the prevalence of T1DM varies considerably around the world and even within parts of the same country. This could be explained by geographical disparities in epidemiological patterns of pediatric diabetes worldwide [28]. Finland, Sweden and Sardinia had the highest incidence rates, while East Asian and American Indian populations had the lowest [29]. This heterogeneity in incidence trends is caused by several factors, including genetic predisposition and environmental conditions that trigger the autoimmune destruction of beta pancreatic cells [10, 30].The environmental triggers have been suggested to play a crucial role in the development of childhood diabetes due to the notable variation in the onset of pediatric diabetes [31].

Dennouni and colleagues have recommended magnesium and selenium as well as vitamin D supplementation in diabetes management [32–34]. Fasting has also been reported by Bentaleb *et al*., (2023) to be a healthy method of managing diabetes with subjects suffering from T1DM, especially during Ramadan [35]. Therefore,

it is important to adopt a healthy lifestyle with early clinical monitoring.

Our results are in accordance with those of Nóvoa-Medina *et al*. (2024), who confirmed that the Mediterranean diet, age, insulin supply methods and the number of years with T1DM are important factors to consider when monitoring T1DM in children [36]. Track and field exercises are considered safe and suitable for adolescents with T1DM under proper guidance and assistance [37].

## Conclusion

Healthy lifestyle and regular glycemic monitoring combined medical treatment improves glycemic control in children with T1DM. This simple combination improves anthropometric status and stabilizes HbA1c levels. Consequently, patients with T1DM can safely exercise with appropriate dietary guidance. The most significant outcome was the improvement in HbA1c and glycemic levels. However, this study was limited by the small number of patients involved. It would be beneficial to increase the number of patients and raise awareness among children through special events in schools and colleges.

## Conflict of interest

The authors declare no conflict of interest.

## References


1. McCall AL, Farhy LS. Treating type 1 diabetes: from strategies for insulin delivery to dual hormonal control. Minerva Endocrinolocica 38(2):145-163, 2013.
2. Janež A, Guja C, Mitrakou A, Lalic N, Tankova T, Czupryniak L, et al. Insulin therapy in adults with type 1 diabetes mellitus: a narrative review. Diabetes Therapy 11(2):387-409, 2020.
3. Dłużniak-Gołaska K, Panczyk M, Szostak-Węgierek D, Szypowska A, Sińska B. Analysis of the diet quality and dietary habits of children and adolescents with type 1 diabetes. Diabetes, Metabolic Syndrome and Obesity: Targets and Therapy 12:161-170, 2019.
4. Rebollo-Román Á, Tabernero-Urbieta MC, Villaécija J, Luque-Salas B. Mediterranean diet adherence and glycemic control in children and adolescents with type 1 diabetes. European Journal of Pediatrics. 2023.
5. McKnight JA, Wild SH, Lamb MJE, Cooper MN, Jones TW, Davis EA, et al. Glycaemic control of Type 1 diabetes in clinical practice early in the 21st century: an international comparison. Diabetic Medicine 32(8):1036-1050, 2015.
6. Vézina-Im L-A, Morin CM, Desroches S. Sleep, Diet and Physical Activity Among Adults Living With Type 1 and Type 2 Diabetes. Canadian Journal of Diabetes 45(7):659-665, 2021.
7. Bull FC, Al-Ansari SS, Biddle S, Borodulin K, Buman MP, Cardon G, et al. World Health Organization 2020 guidelines on physical activity and sedentary behaviour. British Journal of Sports Medicine 54(24):1451-62, 2020.
8. Piras A, Raffi MA. Narrative Literature Review on the Role of Exercise Training in Managing Type 1 and Type 2 Diabetes Mellitus. Healthcare 11(22):2947, 2023.
9. Boukli MN, Zatla YT, Saker M, Abbou Z, Youcef A, Boulenouar H, et al. Factors associated with non-adherence to insulin in Type 1 and Type 2 diabetes mellitus patients in Western region of Algeria, Tlemcen: a cross-sectional study. Pan African Med Journal 41, 2022.
10. Patterson CC, Dahlquist G, Soltész G, Green A. on behalf of the EURODIAB ACE Study Group Is childhood-onset Type I diabetes a wealth-related disease? An ecological analysis of European incidence rates. Diabetologia 44(S3):B9-16, 2001.
11. Lamri L, Gripiotis E, Ferrario A. Diabetes in Algeria and challenges for health policy: a literature review of prevalence, cost, management and outcomes of diabetes and its complications. Global Health 10(1):11, 2014.
12. Khater S, Aouar A, Bensmain N, Bendedouche S, Chabni N, Hamdaoui H, et al. Very High Incidence of Type 1 Diabetes Among Children Aged Under 15 Years in Tlemcen, Northwest Algeria (2015-2018). Journal of Clinical Research in Pediatric Endocrinology 13(1):44-51, 2021.
13. American Diabetes Association. Physical Activity/Exercise and Diabetes Mellitus. Diabetes Care 26(1):s73-7, 2003.
14. Alobaid AM, Zulyniak MA, Ajjan RA, Brož J, Hopkins M, Campbell MD. Barriers to Exercise in Adults With Type 1 Diabetes and Insulin Resistance. Canadian Journal of Diabetes. 47(6):503-508, 2023.
15. Peirce NS. Diabetes and exercise. British Journal of Sports Medicine 33(3):161-172, 1999.
16. Kahn SE, Prigeon RL, McCulloch DK, Boyko EJ, Bergman RN, Schwartz MW, et al. Quantification of the Relationship Between Insulin Sensitivity and β-Cell Function in Human Subjects: Evidence for a Hyperbolic Function. Diabetes 42(11):1663-1672, 1993.
17. Roglic G. WHO Global report on diabetes: A summary. International Journal of Non communicable Diseases 1(1):3, 2016.
18. Wasserman DH, Zinman B. Exercise in individuals with IDDM. Diabetes Care 17(8):924-937, 1994.
19. Gracia-Sánchez A, López-Pineda A, Chicharro-Luna E, Gil-Guillén VF. A Delphi study protocol to identify recommendations on physical activity and exercise in patients with diabetes and risk of foot ulcerations. International Journal of Environmental Research and Public Health 18(20):10988, 2021.
20. Freeby M, Lane K. Treating obesity in type 1 diabetes mellitus – review of efficacy and safety. Current Opinion in Endocrinology, Diabetes and Obesity 31(1):1-7, 2024.
21. Şahin-Bodur G, Keser A, Şıklar Z, Berberoğlu M. Determining the risk of diabulimia and its relationship with diet quality and nutritional status of adolescents with type 1 diabetes. Nutrition Clinique et Métabolisme 35(4):281-7, 2021.
22. Catamo E, Tornese G, Dovc K, Tinti D, Di Tonno R, Cauvin V, et al. Food Behaviour and Metabolic Characteristics of Children and Adolescents with Type 1 Diabetes: Relationship to Glycaemic Control. Foods 13(4):578, 2024.



https://doi.org/10.46389/rjd-2026-2070

23. Warshauer JT, Bluestone JA, Anderson MS. New Frontiers in the Treatment of Type 1 Diabetes. Cell Metabolism 31(1):46-61, 2020.
24. Patiño-Fernández AM, Eidson M, Sanchez J, Delamater AM. What Do Youth With Type 1 Diabetes Know About the HbA1c Test? Children's Health Care 38(2):157-167, 2009.
25. Smart CE, Annan F, Higgins LA, Jelleryd E, Lopez M, Acerini CL. ISPAD Clinical Practice Consensus Guidelines 2018: Nutritional management in children and adolescents with diabetes. Pediatric Diabetes 19:136-154, 2018.
26. Lo Conte M, Antonini Cencicchio M, Ulaszewska M, Nobili A, Cosorich I, Ferrarese R, et al. A diet enriched in omega-3 PUFA and inulin prevents type 1 diabetes by restoring gut barrier integrity and immune homeostasis in NOD mice. Frontiers in Immunology 13:1089987, 2023.
27. Muntis FR, Smith-Ryan AE, Crandell J, Evenson KR, Maahs DM, Seid M, et al. A high protein diet is associated with improved glycemic control following exercise among adolescents with type 1 diabetes. Nutrients 15(8):1981, 2023.
28. Borchers AT, Uibo R, Gershwin ME. The geoepidemiology of type 1 diabetes. Autoimmunity Reviews 9(5):A355-365, 2010.
29. Tuomilehto J. The emerging global epidemic of type 1 diabetes. Current Diabetes Report 13(6):795-804, 2013.
30. Dzidzonu DK, Skrivarhaug T, Joner G, Moger TA. Ethnic differences in the incidence of type 1 diabetes in Norway: a register-based study using data from the period 2002-2009: Immigrants and type 1 diabetes. Pediatric Diabetes 17(5):337-341, 2016.
31. Afoke A, Ludvigsson J, Hed J, Lindblom B. Raised IgG and IgM in «epidemic» IDDM suggest that infections are responsible for the seasonality of type I diabetes. Diabetes Research (Edinburgh, Scotland) 16(1):11-17.1991.
32. Behar A, Dennouni-Medjati N, Dali-Sahi M, Harek Y, Belhadj M, Benslama Y, et al. Dietary selenium intake and risk of type 2 diabetes in a female population of western Algeria. Nutrition Clininique et Métabolisme 34(3):254-8, 2020.
33. Benslama Y, Dennouni-Medjati N, Dali-Sahi M, Kahloula S, Behar A, Kachekouche Y, et al. Dietary intake of magnesium in a type 1 diabetic pediatric population. Magnesium Research 33(2):37-44, 2020.
34. Kalaidji MS, Dennouni-Medjati N, Harek Y, Bentelha A, Chebieb I, Kachekouche Y, Dali-Sahi M. Association between vitamin D deficiency and insulin resistance assessed by the triglyceride-glucose index in type 2 diabetes mellitus adults in Northwest Algeria. Romanian Journal of Diabetes Nutrition and Metabolic Diseases, 32(3), 315-323, 2025.
35. Bentaleb M, Sersar I, Bencharif M, Lahlah N, Bendjama RFN, Djaafri Z. Type 1 diabetes mellitus and Ramadan fasting: A case of adolescents and adults from Algeria. Nutrition Clininique et Métabolisme 37(4):214-220, 2023.
36. Nóvoa-Medina Y, Pérez-Lemes A, Suárez-Ramírez N, Barreiro-Bautista M, Fabelo H, López-López S, et al. Impact of a Mediterranean diet, physical activity, body composition, and insulin delivery methods on metabolic control in children with type 1 diabetes. Frontiers in Nutrition 10:1338601, 2023.
37. Zimmer RT, Birnbaumer P, Sternad C, Zunner BEM, Schierbauer J, Fritsch M, et al. Impact of a 4-week intensive track and field training intervention on glycaemia in adolescents with type 1 diabetes: The CHILDFIT1 study. Diabetes, Obesity and Metabolism 26(2):631-41, 2024.