Vegan Diet and Type2 Diabetes

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An association between a vegan diet and a reduced risk of total cancer incidence has been demonstrated in large prospective cohort studies, but its impact in diabetes mellitus (DM) is still under debate. As diet and lifestyle are the fundamental pillars of DM prevention and therapy and plant-based diets (PBD) are considered an example of healthful eating patterns and are recommended for individuals with DM, we may also expect some beneficial effects in the case of the vegan diet.

Keywords: vegan diet ; plant-based diet ; type 2 diabetes ; insulin resistance

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1. Introduction

Interest in vegan diets is increasing around the world: it is estimated that the number of vegans in the US grew by 600% from nearly 4 million in 2014 to 19.6 million in 2017 [1]. Ideological, environmental, ethical, political or religious arguments are the most important reasons for this rapid growth.

An association between a vegan diet and a reduced risk of total cancer incidence has been demonstrated in large prospective cohort studies [2], but its impact in diabetes mellitus (DM) is still under debate. As diet and lifestyle are the fundamental pillars of DM prevention and therapy and plant-based diets (PBD) are considered an example of healthful eating patterns and are recommended for individuals with DM [3], we may also expect some beneficial effects in the case of the vegan diet.

The aim of this paper is to conduct a systematic review of all observational and intervention studies that describe the relationship between vegan diets and the risk for type 2 diabetes (T2D), along with its effect on glycemic control and T2D-related complications.

2. Studies Evaluating Prevalence of Type 2 Diabetes

Out of the seven observational studies, two cross-sectional studies reported the prevalence of T2D among vegans[4][5] In the Adventist Health study-2 [4] that included more than 60,000 subjects (22,434 men and 38,469 women) from US and Canada and aged 30 years or older, the prevalence of T2D was higher among nonvegetarians (7,6%) than in the various types of vegetarianism (semi-vegetarians 6,1%; pesco-vegetarians 4,8%; lacto-ovo-vegetarians 3,2%; vegans 2,9%) and among these, the lowest prevalence of T2D was seen in vegans (2,6x lower than in omnivores). It is worth noting that the difference in the mean BMI between vegans and omnivores was more than 5 units (23.6 kg/m^2 vs. 28.8 kg/m^2, respectively), but also after adjustment for BMI and others variables (age, sex, ethnicity, education, income, physical activity, television watching, sleep habits, alcohol use), vegans had a lower risk of T2D than nonvegetarians (Odds Ratio (OR) 0.51, 95% Confidence Interval (CI) 0.40–0.66). Different results were observed in India's third National Family Health Survey [5]. In this cross-sectional study of 156,317 participants (56,742 men and 99,574 women) aged 20–49 years, no significantly different prevalence of T2D between vegans (n = 2560) and omnivores (n = 99,372) was observed (1.0% vs. 1.2%, respectively) and the difference between the mean BMI was also low (20.5 kg/m^2 in vegans vs. 20.7 kg/m^2 in omnivores).

3. Studies Evaluating Incidence of Type 2 Diabetes

From the seven observational studies, five prospective cohort studies evaluated the incidence rate of T2D among vegans[6][7] or people that consumed a PBD[8][9][10] .

In the population of the Adventist Health Study-2 [6] that included more than 40,000 participants (15,200 men and 26,187 women) free of DM at baseline, cases of T2D developed in 0.54% of vegans (n = 3545), respective to 2.12% of omnivores (n = 17,695) after 2 years. The vegan diet was resulted as protective for the development of T2D, respective to nonvegetarians in both non-Black (White non-Hispanic, Hispanic, Middle Eastern, Asian, Native Hawaiian/other Pacific Islander or American Indian) and Black (African American, West Indian/Caribbean, African or other Black) participants (OR 0.429, 95% CI 0.249–0.740 and OR 0.381, 95% CI 0.236–0.617, respectively) after adjustment for age, sex, education, income, television watching, physical activity, sleep, alcohol use, smoking and BMI.

Slightly different results were observed in the EPIC–Oxford cohort study of 45,314 UK adults (10,737 men and 34,577 women) aged 20–90 years. Over a mean follow-up of 17.6 years, the percentage of incident T2D cases among 1781 vegans was lower than in 22,796 omnivores (1.45% vs. 3.83%, respectively), and after adjustment for age, education, socio-economic status, physical activity, ethnicity, smoke and alcohol intake, the hazard ratio for developing T2D in vegans was significantly lower than in regular meat eaters (HR 0.53, 95% CI 0.36–0.79). However, when the analysis was further adjusted for BMI, the significance was lost (Hazard Ratio (HR) 0.99, 95% CI 0.66–1.48). It is important to notice that authors have evaluated regular meat eaters (defined as subjects who consumed ≥ 50 g of meat per day) and low meat eaters (consumption of <50 g of meat per day) separately, using regular meat eaters as a reference group but not a whole sample of omnivores.

In the ATTICA Cohort Study [9], the dietary habits of 1485 Greek adults (726 men and 759 women) aged 18–89 years and free of DM and any cardiovascular disease at baseline were evaluated. After 10 years of follow up, a crude T2D incidence rate of 12.9% was observed. Using a posteriori method for assessing the most healthful dietary pattern and after stratification by age-group, as well as after adjustment for sex, family history of DM, waist circumference and smoking status, it was observed that the consumption of fruits, vegetables, legumes, bread, rusk and pasta (all food groups “allowed” to be consumed by vegans) reduced the 10-year T2D risk by 40%, but only in the 45–55 years age group at baseline with marginal statistical significance (OR 0.60, 95% CI 0.34–1.07). When the analysis was additionally adjusted for the percentage of calories from carbohydrates and for total energy intake, statistical significance was lost completely (OR 0.62, 95% CI 0.34–1.13 and OR 0.72, 95% CI 0.35–1.49, respectively), indicating a partially mediating effect of carbohydrates and the importance of the total amount of assumed calories. Not all studies dichotomously classified dietary patterns as vegan or plant-based and omnivorous. Several studies investigated the variation in the degree of having a plant-based versus animal-based diet.

The impact of PBD, and its healthy and unhealthy version, on T2D incidence was studied on the sample of more than 200,000 participants (40,539 men and 160,188 women) aged 25–75 years, recruited in three US cohort studies: Nurses’ Health Study, Nurses’ Health Study 2 and Health Professionals Follow-up Study [8]. All participants were free of any chronic disease at baseline and were followed for more than 20 years. In these studies, there was 16,162 incident cases of T2D in 4,102,369 person–years of follow-up. Authors created an overall “Plant-based Diet Index” (PDI)—the more plant foods were consumed, a higher score was obtained, while the consumption of animal foods lowered the score. The PDI was then divided in deciles. After adjustment for BMI, age, smoking status, physical activity, alcohol intake, multivitamin use, family history of DM, margarine and energy intake, baseline hypertension and baseline hypercholesterolemia, it was observed that subjects with the highest decile of PDI compared to those in the lowest one had a reduction of about 20% in the risk of T2D (HR for extreme deciles 0.80, 95% CI 0.74–0.87). Then, healthful and unhealthful versions of PDI were created (hPDI and uPDI, respectively) with the same modalities; for instance, vegetables, fruits, legumes, whole grains or vegetable oils were considered healthy PDI; on the other hand, refined grains, fruit juices, sweetened beverages, potatoes, desserts, etc. were calculated as unhealthy PDI. Evaluating the difference between the highest and the lowest decile of hPDI, there was a further 34% reduction in T2D disease (HR 0.66, 95% CI 0.61–0.72). On the contrary, the difference in uPDI resulted in the increased risk of about 16% (HR 1.16, 95% CI 1.08–1.25).

Additionally, in the Rotterdam Study (RS) [10], a prospective population-based cohort study, the continuous PDI was constructed (range 0–92) in a population of 6798 participants (2808 men and 3990 women), with an age of 62.7 ± 7.8 years. Food-frequency questionnaires at baseline of three RS groups (RS-I-1: 1989–1993, RS-II-1: 2000–2001, RSIII-1: 2006–2008) were collected. After a median follow-up of 7.3 years and withdrawal of 28 subjects, during 54,024 person–years of follow-up, amongst 6670 subjects, 642 incident cases of T2D were documented. After adjustment for energy intake, sex, age, RS sub-cohort, smoking status, educational level, physical activity, dietary supplement use and family history of DM, a higher score on the PDI was associated with a lower diabetes incidence (per 10 units higher score on index HR 0.82, 95% CI 0.73–0.92) and also after adjustment for BMI, the significance was maintained (HR 0.87, 95% CI 0.79–0.99).

4. Studies Evaluating Risk Factors for Diabetes Related Complications

Five studies reported the BMI measurement as an outcome[11][12][13][14][15] and all of them noticed its significant reduction after the vegan diet that varied from −0.4 kg/m^2[14] to −2.4 kg/m^2 [15]. On the other hand, in control groups, four studies reported a reduction in BMI [11][13][14][15] (two of them [11][15] reached significance) that varied from −0.1 kg/m^2 [14]to −1.5 kg/m^2 [15] and Mishra et al. [12] reported no change from baseline. Only in two studies [12][13] was the mean between-group difference of changes from baseline to final values significant.

As regards the waist circumference, three studies evaluated this outcome[11][14][15] , and all of them reported its significant reduction in the intervention group that varied from −3.1 cm [14] to −4.7 cm [16]. In the control groups, Barnard et al. [11] reported a significant reduction by −1.8 cm, Lee et al. [14] a not significant reduction by −0.8 cm and Ferdowsian et al. [17] described a not significant increase by 0.8 cm. Two studies [18][14] reported a significant mean between-group difference.

All studies reported the evaluation of systolic (SBP) and diastolic (DBP) blood pressure. In the intervention groups, the changes in SBP varied from −11.5 mmHg [13] to +1.0 mmHg [14], but only in the study of Mishra et al. [12] did this change reach significance. Generally, five studies reported the reduction [17][16][12][13][15], two studies reported no variation [11][15] and only Lee et al. [14] described an increase in SBP. In the control groups, six studies[12][13][14][15][16][17] mentioned the reduction and two studies [11][15] the increase in SBP from baseline to final analysis that varied from −18.9 mmHg [16] to +5.7 mmHg [18], but only in two studies [12][15] did this difference reach statistical significance and Ferdowsian et al. [15] alone reported a significant mean between-group difference. As for the DBP, in the intervention groups, only Lee et al. [14] reported a not significant increase in DBP by +1.1 mmHg. In the other studies, its reduction was described, that varied from −5.8 mmHg [16] to −0.4 mmHg [18], and in four studies [11][12][13][17] these changes were significant. In the control groups, only Ferdowsian et al.[18] reported a significant increase in DBP by +5.1 mmHg; in the other studies, the described DBP variation was between −10.6 mmHg [16] to −1.4 mmHg [14] and three of them were significant[11][12][17]. Again, only Ferdowsian et al. [15] reported a significant mean between-group difference in DBP values.

All studies except Lee et al. [14] reported changes in total cholesterol, and all of them noticed its reduction after both the intervention and the control diet, omitting the control group in the study of Bunner et al. [13](increase by 2.2 mg/dL), and this reduction varied from −24.32 mg/dL [16] to −9.8 mg/dL[18] after the vegan diet (four reached statistical significance [11][12][15][17]) and from −24.32 mg/dL [16] to −1.3 mg/dL [12] in the control groups (three were significant [11][15][17]). Only Mishra et al. [12] noticed a significant in-between group difference of changes from baseline to final values.

All studies reported the evaluation of HDL cholesterol. In the intervention groups, the changes from baseline to final values varied from −7.72 mg/dL [16] to + 2.2 mg/dL [14] and in five studies, these changes reached the significance [16][13][12][15]. Generally, six studies reported the reduction [11][12][15][13][16][18], and two studies [17],[14] reported the increase in HDL cholesterol. Additionally, in the control groups, six studies[11][13][15] [16][17] [18]described its reduction (from −2.4 mg/dL [19] to −0.4 mg/dL [18]), in two studies[12] [14] HDL cholesterol increased (by + 0.5 mg/dL [14] and + 0.7 mg/dL [12]) and none of these changes were statistically significant. Regarding the mean in-between group difference, only in the studies of Ferdowsian et al. [18]and Mishra et al. [12] did HDL cholesterol values reach statistical significance.

On the other hand, not all studies evaluated changes in LDL cholesterol [11][12][13][14][15][18]. Only Bunner et al.[13] reported its slight increase in the control group by 0.4 mg/dL; in other studies, a reduction was observed in both intervention (varying from −13.5 mg/dL [11] to −2.8 mg/dL [14]) and control groups (from −12.7 mg/dL [15] to −1.0 mg/dL [14]). In intervention groups, the statistical significance was reached in three studies [11][12][15] and in control groups in two studies [15][11], with the mean in-between group difference significant in the study of Mishra et al.[12].

Relatively uneven results were observed assessing triglyceride levels; all studies reported changes from baseline to final values, expressed in mg/dL. Only Wheeler et al. [17]reported the change as the Area Under Curve (AUC). In the intervention groups, four studies noticed a reduction [11][16][17][18]] (varying from −33.9 mg/dL [11] to −4.4 mg/dL [18] and four an increase [12][13][14][15] (from + 4.7 mg/dL [13] to + 20.8 mg/dL [15]) in triglyceride levels, and only in two studies were these changes significant [11][12]. In the control groups, six studies reported a decrease [11][12][14][15][16][17] (from −38.93 mg/dL [16]to −2.9 mg/dL [12] and two studies an increase (by + 3.5 mg/dL [18] and + 21.9 mg/dL [13]) in this variable, and significance was only observed in the study of Barnard et al. [15]. Only in the study of Mishra et al. [[12]was the mean in-between group statistical significance reached, although Lee et al. [14] observed a marginal significance.

It is worth saying that in the study of Ferdowsian et al. [18] and Mishra et al. [12], not all participants, in whom the cardiometabolic risk factors mentioned above were measured, had DM.

Evaluating renal function, four studies reported diverse outcomes: Nicholson et al. [16] and Barnard et al. [16] evaluated the 24 h microalbuminuria. A decrease was observed in the intervention groups from 434.3 mg/24 h to 155.2 mg/24 h and from 33 mg/24 h to 20.2 mg/24 h in the study of Nicholson et al. [16]and in the study of Barnard et al. [11], respectively. Conversely, an increase (from 82.9 mg/24 h to 169.2 mg/24 h in the study of Nicholson et al. [16] and from 55 mg/24 h to 69.5 mg/24 h in the study of Barnard et al. [11]) was noticed in the control groups; however, none of these changes reached statistical significance (for a wide range of baseline values in the study of Nicholson et al. [16]), but the mean in-between group difference was resulted as marginally significant in the study of Barnard et al. [11]. Additionally, in the study of Barnard et al. [15], the 24 h albuminuria was assessed, but the authors expressed this outcome as median mg/dL. Differently from previous studies, a significant increase in albuminuria was observed in the intervention group, while in the control group values, dropped insignificantly, with a significant mean in-between group difference. Wheeler et al. [15] measured other parameters: Albumin Excretion Rate (AER), Glomerular Filtration Rate (GFR) and Renal Plasma Flow (RPF). However, there were not any significant differences in the change from baseline to 6 weeks or between the intervention and the control groups.

Changes in clinical outcomes from baseline to final values by group assignment are summarized in Supplementary Tables S2–S10.

Finally, Bunner et al. [13]evaluated the impact of the vegan diet on pain in chronic diabetic neuropathy. Different questionnaires or scales assessing the painful and sensory symptoms, as well as the electrochemical skin conductance as a measure of sudomotor nerve function were chosen as outcomes. From all these parameters, the foot conductance and two questionnaires (Short form McGill Pain Questionnaire and Michigan Neuropathy Screening Instrument-questionnaire) reached the statistically significant mean in-between group difference in favor of the 20-week intervention diet.

5. Conclusions

We can conclude that many large observational studies have demonstrated that the vegan diet is associated with lower T2D prevalence or incidence, although in some cohorts, it is not possible to distinguish if the beneficial effects derive from the vegan diet alone or from the overall healthy lifestyle. Furthermore, the results of randomized controlled studies performed in T2D patients have indicated its antihyperglycemic effect, even in the long-term.

Moreover, clinical trials with vegan diet in pre-diabetes and T2D people, in which the quantity of simple and complex carbohydrates and the quality of the nutrients taken will be evaluated, should be conducted. In this way, some unevenness of results obtained in the different reported clinical trials could be clarified and an appropriate vegan diet for pre-diabetic and T2D individuals could be created to be used as a nutraceutical intervention.

Finally, the vegan diet may be considered an acceptable and safe alternative to Western diets and seems to be comparable to other recommended healthful eating models (e.g., vegetarian, Mediterranean, Dietary Approaches to Stop Hypertension (DASH), etc.), but it must be stated that it has been considered to be a therapeutic diet with adverse effects associated with the long-term exclusion of some nutrients. Appropriate nutritional planning and surveillance conducted by dietitians and nutritionists trained in a vegan diet are recommended, as vegans are more likely to require vitamin B12 (especially who take metformin), vitamin D, calcium and iron supplementation, as well as a sufficient amount of protein. This is important, particularly in specific groups of diabetic patients such as frail elderly, adolescents, and pregnant and breastfeeding women.

Larger randomized controlled studies are necessary to confirm the effectiveness and safety of the vegan diet for diabetic patients.

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