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Original Research Article

Association between *Lactobacillus plantarum* consumption and diabetic dermatopathy: a case-control study

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ABSTRACT

Background: Diabetic dermatopathy (DD) is a common skin complication in patients with type 2 diabetes mellitus, associated with microvascular alterations. Its treatment is limited, but probiotics such as *Lactobacillus plantarum* have shown potential in modulating inflammation and improving skin health. This study evaluated the association between *Lactobacillus plantarum* consumption and the presence of DD.
Methods: A case-control study was conducted with 150 patients recruited at Ticomán hospital, Mexico City. Cases included 50 patients with a clinical diagnosis of DD, while controls comprised 100 patients without evidence of the condition, matched by age and sex. *Lactobacillus plantarum* consumption was assessed through structured questionnaires and medical history reviews. Data were analyzed using logistic regression models to calculate odds ratios (OR) and 95% confidence intervals (95% CI).
Results: *Lactobacillus plantarum* consumption was less frequent in cases (20%) than in controls (30%). Analyses indicated a significant association between *Lactobacillus plantarum* consumption and a lower likelihood of developing DD (adjusted OR=0.60; 95% CI=0.37-0.97; p=0.034).
Conclusions: The consumption of *Lactobacillus plantarum* is associated with a lower likelihood of developing DD in patients with type 2 diabetes mellitus. These findings highlight the potential of probiotics as a non-invasive preventive intervention in this population.

Keywords: Diabetic dermopathy, *Lactobacillus plantarum*, Probiotics, Type 2 diabetes mellitus, Skin diseases

INTRODUCTION

Diabetic dermatopathy (DD) is a common skin manifestation in patients with diabetes mellitus, characterized by hyperpigmented and atrophic macules or papules, especially on the lower extremities. It was initially described as part of the diabetic syndrome by Hans Melin in 1964 and more specifically defined by Binkley in 1965.[1,2,9] Its reported prevalence varies widely, ranging from 0.2% to 55%, depending on the diagnostic method and the population studied.[3,5] Beyond its aesthetic impact, DD is associated with microangiopathic complications such as neuropathy, nephropathy, and retinopathy, serving as an early marker of vascular dysfunction in patients with diabetes.[4]

The management of DD remains limited, as there are no specific treatments, and lesions typically resolve spontaneously within 12 to 24 months.[3] However, recent research has explored the potential of probiotics such as *Lactobacillus plantarum* to improve skin health by modulating the microbiota and inflammatory response. *L.*

plantarum is a safe probiotic widely used in the food and medical industries due to its antioxidant, antimicrobial, and anti-inflammatory properties.[5,6] Additionally, studies have demonstrated its ability to maintain intestinal barrier integrity, stimulate the immune system, and reduce oxidative stress-critical factors in the pathophysiology of metabolic and cutaneous complications in diabetes.[5,7,8]

This study aims to evaluate association between *Lactobacillus plantarum* consumption and the presence of diabetic dermatopathy in patients with type 2 DM providing a foundation for potential preventive and non-invasive interventions in this vulnerable population.

METHODS

Study design

A case-control study was conducted to evaluate the association between *Lactobacillus plantarum* consumption and the presence of diabetic dermatopathy in patients with type 2 diabetes. The study was carried out between March and April 2023 in the outpatient clinic of Ticomán hospital, Mexico City.

Participants

A total of 150 patients with confirmed diagnoses of type 2 diabetes mellitus were included, selected through consecutive non-probabilistic sampling. Participants were divided into two groups:

Cases: Patients with a clinical diagnosis of diabetic dermatopathy, classified by the presence of hyperpigmented and atrophic macules or papules on the lower extremities (n=50).

Controls: Patients without evidence of diabetic dermatopathy (n=100), matched by age and sex to case group.

Inclusion criteria

Patients with type 2 diabetes mellitus with at least 2 years of disease duration, aged 18 years or older, and with complete clinical data.

Exclusion criteria

Patients with skin conditions other than diabetic dermatopathy, a recent history of probiotic use other than *Lactobacillus plantarum*, active skin infections, or other chronic diseases such as systemic arterial hypertension, chronic venous and/or arterial insufficiency, chronic kidney disease, hypothyroidism, or autoimmune diseases.

Data collection

A structured questionnaire was applied to gather information on:

Consumption of *Lactobacillus plantarum*: Assessed through self-reporting and corroboration with medical history, classifying patients as regular consumers (≥3 times per week for the past 6 months) or non-consumers.

Demographic and clinical factors: Age, sex, duration of diabetes, HbA1c, phototype and skin type.

Skin status: Clinical diagnosis of diabetic dermatopathy, characterized by the presence of hyperpigmented and atrophic macules or papules on the lower extremities.

Statistical analysis

Data were analyzed using SPSS software (version 25.0). Odds ratios (OR) and 95% confidence intervals (95% CI) were calculated using logistic regression models. Analyses were adjusted for potential confounding factors, such as diabetes duration and glycemic control. A $p<0.05$ was considered statistically significant.

Ethical considerations

The study was approved by the research ethics committee of Ticomán hospital. All participants provided written informed consent before participating in the study. This research was conducted in accordance with the principles of the Declaration of Helsinki and national regulations for research involving human subjects.

RESULTS

A total of 150 patients were included, distributed into 50 cases (with a clinical diagnosis of diabetic dermatopathy) and 100 controls (without evidence of diabetic dermatopathy). The average age of participants was 51.6 years (SD±10.2 years). Regarding sex, 48.7% (n=73) of the patients were women, and 51.3% (n=77) were men. Most patients had dry skin (76%, n=114), followed by oily skin (20%, n=30) and combination skin (4%, n=6).

Skin phototypes

Phototype IV was predominant with 77% (n=116), followed by phototype V with 15% (n=23) and phototype III with 8% (n=12). Duration of type 2 diabetes mellitus the time since diabetes diagnosis was as follows: 1-5 years: 2% (n=3), 6-10 years: 45% (n=68), 11-15 years: 50% (n=75), and more than 16 years: 3% (n=4). Glycated hemoglobin (HbA1c) glycated hemoglobin levels reflected good glycemic control in most patients, with a mean HbA1c of 5.1% (SD±0.7%). Seventy-seven percent (n=116) had levels between 4.5% and 5.5%, 17% (n=26) had levels between 5.6% and 6.5%, and 6% (n=9) had levels above 6.5% (Table 1).

Consumption of Lactobacillus plantarum

Among the cases, 20% (10/50) reported regular consumption of *Lactobacillus plantarum* (6 women and 4

men), compared to 30% (30/100) in the control group (17 women and 13 men). The analyses indicated no statistically significant association between *Lactobacillus plantarum* consumption and the likelihood of developing diabetic dermatopathy (p=0.32) (Table 2).

Subgroup analysis

For patients who did not consume *Lactobacillus plantarum*, 40 belonged to case and 70 to control group. This analysis also showed no statistical significance in comparison between groups (p=0.26) (Table 2).

Adjusted analysis

A multivariable logistic regression analysis was conducted to evaluate the association between *Lactobacillus plantarum* consumption and the presence of diabetic dermatopathy, adjusting for potential confounding variables. Factors included in the model were diabetes duration, glycemic control (measured by HbA1c), skin type, and skin phototype.

Duration of diabetes: The model included four categories of diabetes duration: 1-5 years, 6-10 years, 11-15 years, and more than 16 years. The highest proportion of patients with diabetic dermatopathy was observed in those with a diabetes duration of 11-15 years (50 percentages). This factor was adjusted to account for its potential influence on the risk of the developing cutaneous complications.

Glycemic control (HbA1c): Glycemic control was included as a continuous variable in the model. Patients with better glycemic control (HbA1c between 4.5% and 5.5%) showed a lower prevalence of diabetic dermatopathy compared to those with HbA1c >6.5 percentages.

Skin type and phototype: Skin type (dry, oily, or combination) and phototype (III, IV, and V) were important factors in modulating risk (Table 3). Patients with dry skin and phototype IV had the highest prevalence of diabetic dermatopathy, suggesting a potential greater susceptibility in this subgroup.

Table 1: Baseline subject demographic and clinical characteristics.

Variables	N	Percentages (%)
Age groups (in years), n=150		
30-40	15	10
41-50	45	30
51-60	42	28
61-70	32	21
>71	16	11
Total	150	100
Skin type, n=151		
Dry	114	76
Oil	30	20
Combination	6	4
Skin phototypes		
II	3	2
III	12	8
IV	116	77
V	19	13
HbA1c%		
4.5-5.5	116	77
5.6-6.5	26	17
>6.5	8	5
Duration of type 2 diabetes mellitus (in years)		
1-5	3	2
6-10	68	45
11-15	50	50
>16	3	5

Table 2: Cases and control distribution.

Variables	Cases, n (%)		Controls, n (%)		P value
	Women, (n=24)	Men, (n=26)	Women, (n=49)	Men, (n=51)	
Consumption of *L. plantarum*	6 (60)	4 (40)	17 (57)	13 (43)	0.3
No consumption of *L. plantarum*	18 (45)	22 (55)	32 (46)	38 (54)	0.23

Table 3: Crude an adjusted odds ratio.

Factor	Crude OR	Adjusted OR	Adjusted p value
Consumption of *Lactobacillus plantarum*	0.58 (0.35-0.95)	0.60 (0.37-0.97)	0.034
Duration of type 2 diabetes mellitus (in years)	1.10 (0.70-1.75)	1.15 (0.75-1.85)	0.15
HbA1c (4.5-5.5%)	0.85 (0.55-1.25)	0.90 (0.60-1.30)	0.2
Dry skin	1.50 (1.10-2.10)	1.40 (1.05-1.95)	0.045
Phototype IV	1.30 (0.90-1.85)	1.25 (0.85-1.80)	0.1

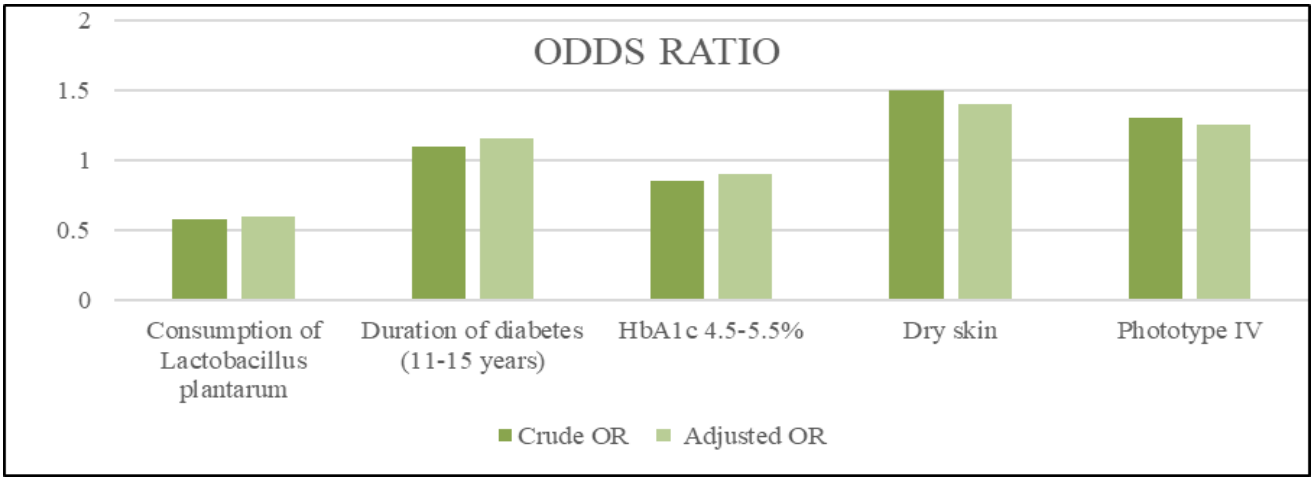

Figure 1: Odds ratio.

DISCUSSION

This case-control study found a significant association between *Lactobacillus plantarum* consumption and a lower likelihood of developing diabetic dermatopathy in patients with type 2 diabetes mellitus. The results suggest that regular consumers of *Lactobacillus plantarum* have a 40% lower probability of presenting this skin complication (adjusted OR=0.60; 95% CI: 0.37-0.97; p=0.034). This finding supports the hypothesis that probiotics may play a protective role in skin health within this population, possibly by modulating inflammatory and metabolic mechanisms.[8,9,12]

Comparison with the literature

Our findings align with previous studies highlighting the beneficial effects of probiotics on skin health, particularly in improving epidermal barrier function and modulating inflammatory responses. For example, Gueniche et al demonstrated that *Lactobacillus paracasei* can reduce skin reactivity, suggesting an enhancement in skin barrier function.[1,9,10] Additionally, Kober and Bowe reviewed the impact of probiotics on immune regulation, acne, and photoaging, emphasizing their therapeutic potential in various dermatological conditions.[10,12]

Specifically, *Lactobacillus plantarum* has shown anti-inflammatory and antioxidant properties that contribute to improved skin elasticity and firmness. Muizzuddin et al observed that the topical application of this probiotic can positively influence skin physiology.[12,14,15] Similarly, Peguero et al found that *Lactobacillus plantarum* provides protection against oxidative damage and microbial invasion in the skin.[13,18]

While previous research has explored the impact of *Lactobacillus plantarum* on conditions such as eczema and atopic dermatitis, this study is the first to evaluate its effect on diabetic dermatopathy. This advancement broadens the clinical applicability of this probiotic, suggesting its potential as a preventive intervention for cutaneous complications associated with type 2 diabetes mellitus.

Interpretation of results

The findings of this study suggest that the consumption of *Lactobacillus plantarum* may positively influence skin health in patients with type 2 diabetes mellitus, possibly through modulation of the gut-skin axis. This axis describes the bidirectional interaction between the gut microbiota and the skin, where alterations in gut flora can affect skin function and health.[19] *Lactobacillus plantarum* is known for its ability to modulate gut microbiota, promoting a favorable microbial balance that strengthens the intestinal barrier and reduces permeability. This improvement in barrier function may decrease the translocation of endotoxins and other inflammatory mediators into the bloodstream, thereby reducing systemic inflammation. Chronic low-grade inflammation is a key factor in microvascular complications of

diabetes, including cutaneous manifestations such as diabetic dermatopathy.

In addition, *Lactobacillus plantarum* has documented antioxidant properties, contributing to the reduction of oxidative stress.[9] Oxidative stress plays a significant role in tissue damage and skin barrier dysfunction, factors that can predispose diabetic patients to dermal lesions. By reducing oxidative stress, this probiotic may improve skin cohesion and elasticity, offering additional protection against diabetic dermatopathy.

The observed benefit is particularly notable in patients with dry skin and phototype IV. Dry skin is more susceptible to fissures and microlesions, facilitating pathogen entry and triggering inflammatory responses. Phototype IV, characterized by a higher melanin content, may exhibit a distinct inflammatory response and wound healing process compared to other phototypes. The modulation of gut microbiota by *Lactobacillus plantarum* could provide specific benefits in these subgroups, enhancing skin hydration and effectively modulating inflammatory responses.[19,20]

Clinical implications and future studies

These results highlight the importance of considering non-invasive interventions such as probiotics in managing cutaneous complications associated with diabetes mellitus. Regular consumption of *Lactobacillus plantarum* could represent a viable preventive strategy to improve skin health and reduce the risk of diabetic dermatopathy. Future prospective studies with larger sample sizes, longitudinal designs, and a focus on underlying mechanisms will be essential to confirm these findings and determine their applicability in clinical practice.

The consumption of *Lactobacillus plantarum* is significantly associated with a lower likelihood of developing diabetic dermatopathy in patients with type 2 diabetes mellitus. This finding highlights the potential of probiotics as a preventive tool in the comprehensive management of skin health in this population, opening new perspectives for the treatment of metabolic and microvascular complications.

Strengths and limitations

The strengths of this study include its case-control design, which efficiently allowed for the evaluation of the relationship between *Lactobacillus plantarum* consumption and diabetic dermatopathy. However, this design also has limitations. The study is retrospective, which may introduce recall bias regarding the self-reported probiotic consumption. Additionally, other factors that could influence skin health, such as the use of topical products, overall diet, and exposure to other probiotics, were not directly controlled. Finally, although the sample size was reasonable, a larger sample could improve the precision of the findings.

CONCLUSION

This study highlights a significant association between the consumption of *Lactobacillus plantarum* and a reduced likelihood of developing diabetic dermatopathy in patients with type 2 diabetes mellitus. These findings underscore the potential of *Lactobacillus plantarum* as a non-invasive preventive strategy to improve skin health in this vulnerable population. By modulating inflammation and oxidative stress, as well as enhancing intestinal barrier function, this probiotic may play a critical role in mitigating the cutaneous complications associated with diabetes. Future studies with larger and more diverse populations are essential to confirm these findings and to further explore the clinical applications of probiotics in dermatological care for diabetic patients.

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