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# The Correlation of Smoking and Coffee Consumption with Diabetic Foot Ulcer Using Wifi Criteria at Cut Meutia General Hospital, Lhokseumawe

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**ABSTRACT**

Diabetic Foot Ulcer (DFU) is a serious complication of diabetes mellitus. Risk factors such as smoking habits and coffee consumption have been associated with poor glucose control and vascular dysfunction; however, their relationship to the severity of DFU is not yet fully understood. The severity of DFU wounds can be assessed using the clinically validated WIFI system (Wound, Ischemia, and Foot Infection). This research aims to evaluate the association between smoking habits and coffee consumption with the severity of DFU based on the WIFI score in patients at *RSUD Cut Meutia*, *Aceh*. This was a cross-sectional study involving 188 DFU patients who met the inclusion criteria. Statistical analysis was performed using the Chi-square test of independence. Results show a significant association was found between moderate smoking and DFU severity (p=0.002). Coffee consumption was not significantly associated with the **severity** of DFU **(p=0.468)**. In multivariate analysis, no significant effect of smoking or coffee consumption on WIFI scores was found when analyzed simultaneously (p>0.05). Moderate smoking is associated with increased DFU severity, especially when combined with light or moderate coffee consumption. Coffee consumption alone did not show a meaningful relationship. The multivariate analysis did not reveal a significant simultaneous effect of both variables, suggesting the potential influence of other confounding factors on DFU severity.

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## INTRODUCTION

Diabetic Foot Ulcer (DFU) is one of the serious complications of diabetes mellitus which is characterized by wounds on the feet that are difficult to heal and remain open. DFU often occurs due to a combination of peripheral neuropathy (nerve damage) and ischemia (decreased blood flow) resulting from atherosclerosis. This combination results in a decrease in sensation and blood flow in the legs. Therefore, diabetics are at high risk of developing wounds on the legs that can become infected and are difficult to treat. These wounds for which there is no definitive cure have the potential to develop into gangrene and necessitate amputation (Senneville et al., 2024).

DFU is one of the global health problems that has a significant impact on the quality of life of individuals with diabetes. About 15% of diabetic patients are expected to experience DFU in their lifetime, and about 14-24% of them will have to undergo amputation of the lower extremities. This has an impact not only on the physical health of the patient, but also extends deeply into the psychological and economic aspects, both for the individual and the health system (Lavery et al., 2007). The prevalence of diabetic ulcers in Indonesia

reaches around 15%, with an amputation rate of 30%. In addition, the mortality rate within one year after amputation reached 14.8% (*Reference needed for Indonesian statistics*). The number of diabetic ulcer sufferers in Indonesia continues to increase, as can be seen from the increase in prevalence of 11%. Based on this data, about 13% of diabetic ulcer patients undergo hospital treatment, while 26% are treated on an outpatient basis (*Reference needed*). In Aceh itself, there were 184,527 patients with diabetes mellitus in 2021. Of these, 97,131 patients or around 53% received services that were in accordance with standards. Lhokseumawe City has achieved 100% service coverage according to the standard, while in North Aceh the coverage figure only reaches 68%.

Several factors that increase the risk of DFU in patients with diabetes mellitus (DM) include smoking, peripheral neuropathy, atherosclerosis, the duration of diabetes, poor blood sugar control, a history of previous ulcers, obesity as a complication of DM, and caffeine consumption. Smoking has a significant role in increasing the risk and worsening the condition of DFU (Ramirez-Acuña et al., 2019). Research shows that people who smoke and have diabetes have a higher risk of developing DFU and related complications compared to those who do not smoke. In addition, smokers who experience DFU also have a worse prognosis, including an increased risk of amputation. There are several physiological mechanisms that may explain the association between smoking and DFU, such as vasoconstriction and decreased blood flow, increased risk of peripheral neuropathy, and reduced wound healing ability (Sethuram et al., 2022).

Coffee consumption has been an interesting subject in health-related research, including in relation to diabetes mellitus and its complications such as DFU. Based on global coffee consumption data, around 70% of coffee consumers prefer arabica, while the remaining 30% prefer robusta coffee. In Indonesia, coffee consumption in 2016 reached 250,000 tons and increased by 10.54% to 276,000 tons in 2017. Of the total coffee production in Indonesia, around 94.5% comes from smallholder plantations. Although there is limited research on the direct effect of coffee consumption on the risk and development of DFU, several studies have attempted to establish the relationship between coffee consumption and blood sugar control and other risk factors associated with DFU. Several studies have shown that coffee consumption has the potential to affect blood sugar control. Poor blood sugar control is one of the main risk factors in the development of DFU, so excessive coffee consumption may increase the risk if it negatively affects blood glucose control (Deng et al., 2023; Rubitschung et al., 2021; Uçkay et al., 2015; Zare et al., 2021). While coffee consumption may temporarily increase blood pressure, there is still no clear consensus on how this affects blood circulation in cases of DFU. If blood pressure remains elevated over a long period of time, it can exacerbate peripheral vascular disease conditions that contribute to the risk of DFU. However, further research is needed to determine whether this pathway has a significant effect of coffee consumption on the development of DFU (Lim et al., 2017; Monteiro-Soares et al., 2020; Reardon et al., 2020; Suh & Hong, 2015).

The Wound, Ischemia, and Foot Infection (WIFi) score is an assessment system developed to assist in evaluating the risk of amputation and guiding the management of patients with foot ulcers, especially in those with peripheral artery disease (PAD) and DFU. The WIFi score integrates three main components relevant to the prognosis of a foot ulcer:

wound, ischemia, and infection. Each component is assessed independently, and a combined score is used to categorize risk levels and aid in clinical decision-making (Ahmed et al., 2023; Hendri et al., 2023; Hicks et al., 2018; Mayor et al., 2019; Mohapatra et al., 2019; Monteiro-Soares et al., 2024).

It is well-established that many factors can contribute to the occurrence of complications from diabetes mellitus, specifically diabetic foot ulcer (DFU). Various factors include those that can and cannot be modified. The severity of the ulcer is measured using the WIFi (Wound, Ischemia, and Foot Infection) score. Smoking is known to increase the risk of developing diabetes mellitus and is associated with a poor prognosis compared to those who do not smoke. Meanwhile, coffee consumption is often associated with excessive sugar consumption, making it difficult to control blood sugar levels. Although smoking is known to have a negative impact on vascular health and coffee consumption is often associated with a variety of effects on the cardiovascular system, the specific relationship between these two behavioral factors and the development and severity of DFU is still not fully understood.

Frykberg et al. (2020) highlighted that smoking significantly exacerbates vascular complications and delays wound healing in DFU patients, yet their study primarily focused on smoking without considering the interaction with other modifiable lifestyle factors such as coffee consumption. Similarly, Farzanegan et al. (2021) examined the role of dietary patterns and caffeine intake in glycemic control, indicating a potential indirect effect on DFU risk, but the study did not assess ulcer severity using validated clinical scoring systems like the Wound, Ischemia, and Foot Infection (WIFi) criteria. These limitations reveal a research gap in understanding the combined influence of smoking and coffee consumption on DFU severity in a clinical setting, especially in the Indonesian population.

Therefore, this study aims to identify whether there is a significant correlation between smoking and coffee consumption and an increase in the severity of diabetic foot ulcers using WIFi criteria, as well as how this may affect clinical approaches in the management of diabetic wounds. The benefits of this research are expected to be realized by various parties, including patients who will receive information about prognosis and therapy, researchers who will gain more experience in the field of Vascular-Endovascular Surgery, and hospitals that can improve the quality of services in handling DFU through more effective and efficient management planning.

## METHOD

This study was conducted with a cross-sectional design to collect data on smoking frequency, coffee consumption, and severity of diabetic foot ulcer (DFU) using WIFi criteria. Data were collected at *Cut Meutia* General Hospital, *Lhokseumawe*, North *Aceh*, from May to June 2025, with data analysis estimated to take two weeks. The target population includes all patients with DFU, and based on calculations, the minimum number of samples required was 151. The inclusion criteria include patients over 18 years of age who are willing to give consent, while the exclusion criteria include patients with severe comorbidities or cognitive impairment. The study variables included questionnaires on smoking and coffee consumption as the independent variables, the WIFi score as the

dependent variable, and age, gender, education, and socio-economic status as the confounding variables. Data were collected through questionnaires and medical records, and were analyzed using SPSS 26 with appropriate analysis methods.

## RESULTS AND DISCUSSION

### Sample characteristics

The cross-cutting research at Cut Meutia General Hospital, Lhokseumawe-North Aceh obtained data from medical records, interviews, and direct measurements on DFU patients from May 2025 to June 2025. There were 188 research samples that met the inclusion criteria.

**Table 1. Characteristics of Research Subjects**

| Category | Total (N=188) | |
|---|---|---|
| | N | Percentage |
| **Gender** | | |
| **Man** | 108 | 57,45% |
| **Woman** | 80 | 42,55% |
| **Age** | | |
| **<60 years old** | 131 | 69,68% |
| **≥60 years old** | 57 | 30,32% |
| **Education Level** | | |
| **SD** | 32 | 17,02% |
| **SMP** | 43 | 22,23% |
| **SMA** | 63 | 33,51% |
| **Bachelor** | 50 | 26,59% |
| **WIFi Score** | | |
| **Stage 1 (Very Low)** | 30 | 15,96% |
| **Stage 2 (Low)** | 71 | 37,77% |
| **Stage 3 (Moderate)** | 45 | 23,94% |
| **Stage 4 (High)** | 42 | 22,34% |
| **Hypertension Status** | | |
| **Normotensi** | 11 | 5,85% |
| **Pre-hypertension** | 71 | 37,77% |
| **Grade I Hypertension** | 82 | 43,62% |
| **Grade II Hypertension** | 24 | 12,77% |
| **Degree of Smoking** | | |
| **Non-smokers** | 91 | 48,40% |
| **Light Smokers** | 54 | 28,72% |
| **Moderate Smoker** | 40 | 21,28% |
| **Heavy Smokers** | 3 | 1,60% |
| **Degree of Coffee Consumption** | | |
| **Light** | 85 | 45,21% |
| **Keep** | 92 | 48,94% |
| **Tall** | 11 | 5,85% |

Based on table 1, the total number of subjects in this study is 188 patients. Based on gender, the majority of subjects were male, namely 108 people (57.45%), while women amounted to 80 people (42.55%). Based on age group, most of the patients were in the age group of <60 years, which was 131 people (69.68%), while the age group of ≥60 years amounted to 57 people (30.32%). The average age of the subjects of this study was 54.91 ± 9.23. Most of the subjects have the last education of high school, which is 63 people (33.51%), followed by Bachelor graduates as many as 50 people (26.59%), then junior high

school as many as 43 people (22.23%), and finally elementary school as many as 32 people (17.02%). The assessment of the severity of the ulcer based on WiFi scores showed that most of the patients were in Stage 2 (Low) as many as 71 people (37.77%), followed by Stage 3 (Moderate) as many as 45 people (23.94%), and Stage 4 (High) as many as 42 people (22.34%). As for those in Stage 1 (Very Low), there are 30 people (15.96%). For hypertension status, the majority were in the Grade I Hypertension category as many as 82 people (43.62%), followed by the Pre-hypertension group as many as 71 people (37.77%). A total of 24 people (12.77%) were recorded to have Grade II Hypertension, while only 11 people (5.85%) were in a condition of normotension or normal blood pressure. In terms of smoking, almost half of the subjects were non-smokers with 91 people (48.40%). Meanwhile, 54 people (28.72%) were light smokers, 40 moderate smokers (21.28%), and only 3 people (1.60%) were heavy smokers. Coffee consumption grading showed that most of the patients were in the medium category, namely 92 people (48.94%), followed by light consumption as many as 85 people (45.21%), and only 11 people (5.85%) had high consumption.

## Distribution of Hypertension Status to DFU Severity

**Table 2. Distribution of Cigarette Hypertension Status to DFU Severity**

| Hypertension Status | Grade 1 | Grade 2 | Grade 3 | Grade 4 | P* value |
|---|---|---|---|---|---|
| **Normotensi** | 2 | 4 | 4 | 1 | 0,003 |
| **Prehypertensive** | 16 | 25 | 23 | 7 | |
| **Grade I Hypertension** | 10 | 34 | 16 | 22 | |
| **Grade II Hypertension** | 2 | 8 | 2 | 12 | |

* Chi-square test of independence

There was a statistically significant relationship between hypertension status and DFU severity with a p = 0.003 value. Patients with grade I and II hypertension tend to experience DFU of higher severity, especially in grades 3 and 4. In contrast, normotensive and prehypertension patients were more found in DFU grades 1 and 2.

## Distribution of Smoking Degrees to DFU Severity

**Table 3. Distribution of Smoking to DFU Severity**

| Cigarette Consumption | Grade 1 | Grade 2 | Grade 3 | Grade 4 | P* value |
|---|---|---|---|---|---|
| **Non-smokers** | 12 | 37 | 28 | 14 | 0,037 |
| **Light** | 8 | 22 | 12 | 12 | |
| **Keep** | 9 | 10 | 5 | 16 | |
| **Heavy** | 1 | 2 | 0 | 0 | |

* Chi-square test of independence

There was a statistically significant relationship between the degree of cigarette consumption and the severity of DFU with a value of p = 0.037. A higher proportion of patients with severe and moderate smoking was found in the DFU group with higher degrees

of severity (grades 3 and 4). Meanwhile, non-smoking patients tend to have injuries of lower severity.

**Table 4. Distribution of Non-Smokers with Light, Moderate, and Heavy Smokers to DFU Severity**

| | Grade 1 | Grade 2 | Grade 3 | Grade 4 | P* value |
|---|---|---|---|---|---|
| **Non-smokers** | 12 | 37 | 28 | 14 | 0,605 |
| **Light Smokers** | 8 | 22 | 12 | 12 | |

* Chi-square test of independence

| | Grade 1 | Grade 2 | Grade 3 | Grade 4 | P* value |
|---|---|---|---|---|---|
| **Non-smokers** | 12 | 37 | 28 | 14 | 0,002 |
| **Moderate Smoker** | 9 | 10 | 5 | 16 | |

* Chi-square test of independence

| | Grade 1 | Grade 2 | Grade 3 | Grade 4 | P* value |
|---|---|---|---|---|---|
| **Non-smokers** | 12 | 37 | 28 | 14 | 0,438 |
| **Heavy** | 1 | 2 | 0 | 0 | |

* Chi-square test of independence

Based on the results of statistical analysis in the three tables, it can be concluded that there is a variation in the relationship between the severity of smoking and the severity of the disease (Grades 1–4). Comparisons between the non-smokers and light smokers groups showed no statistically significant difference in the distribution of severity, with a value of p = 0.605. This means that light smoking does not correlate significantly with an increase in the degree of the disease. However, when compared between non-smokers and moderate smokers, a statistically significant difference was found (p value = 0.002). This indicates that smoking at moderate intensity may increase the likelihood of experiencing a higher degree of severity. Meanwhile, in the comparison between non-smokers and heavy smokers, no significant difference was found (p value = 0.438). Although in absolute terms the number of cases of heavy smokers is smaller, this result can be influenced by the small number of samples in the group of heavy smokers, so the statistical strength is weak. Overall, these results indicate that there is a significant association between moderate smoking and an increase in disease severity, but it is not seen in both light and heavy smokers.

## Distribution of Coffee Consumption Degrees to DFU Severity

**Table 5. Distribution of Coffee Consumption Degrees to DFU Severity**

| Coffee Consumption | Grade 1 | Grade 2 | Grade 3 | Grade 4 | P* value |
|---|---|---|---|---|---|
| **Light** | 11 | 32 | 23 | 19 | 0,468 |
| **Keep** | 17 | 36 | 21 | 18 | |
| **Tall** | 2 | 3 | 1 | 5 | |

* Chi-square test of independence

No statistically significant association (p = 0.468) was found between the degree of coffee consumption and the severity of DFU. In both the group with light, moderate, and high coffee consumption, the distribution of DFU cases was almost even across all degrees

of severity. These findings indicate that coffee consumption, in the context of the amount of daily intake, does not significantly affect the severity of diabetic foot injuries.

**Table 6. Distribution of Light Coffee Consumption with Medium and High Coffee Consumption to DFU Severity.**

| | Grade 1 | Grade 2 | Grade 3 | Grade 4 | P* value |
|---|---|---|---|---|---|
| **Light** | 11 | 32 | 23 | 19 | 0.714 |
| **Keep** | 17 | 36 | 21 | 18 | |

* Chi-square test of independence

| | Grade 1 | Grade 2 | Grade 3 | Grade 4 | P* value |
|---|---|---|---|---|---|
| **Light** | 11 | 32 | 23 | 19 | 0,281 |
| **Tall** | 2 | 3 | 1 | 5 | |

* Chi-square test of independence

No significant association was found between severity (Mild vs. Moderate) and the patient's condition grade (Grade 1 to Grade 4), as indicated by a p-value of 0.714. In the second table, no significant relationship was found between severity (Mild vs High) and condition grade, with a p value of 0.281. Although there was a decrease in the number of cases in the high-severity group in each grade compared to the mild group, this difference was not statistically strong enough to show a significant association.

## Multivariate Analysis

**Table 7. Multivariate Analysis Table**

| Variable | Coefficient | P* value |
|---|---|---|
| **Degree of Smoking** | 0.124 | 0.525 |
| **Degree of Coffee Consumption** | -0.169 | 0.535 |

* Multiple linear regression test

There was no significant effect of smoking or coffee consumption on DFU risk level because the p-value for both variables > 0.05. The degree of smoking has a positive regression coefficient of 0.124, which means that every increase of one degree of smoking tends to increase the severity of DFU by 0.124, but it is not statistically significant because the p> value is 0.05. The Degree of Coffee Consumption has a negative coefficient of -0.169, which indicates that every increase in one level of coffee consumption tends to decrease the value of the dependent variable by 0.169. However, this effect is also not statistically significant.

## The Relationship between the Degree of Smoking and the Degree of Coffee Consumption

**Table 8. The Relationship between the Degree of Smoking and the Degree of Coffee Consumption**

| | Light Coffee Consumption | Moderate Coffee Consumption | High Coffee Consumption | P* Value |
|---|---|---|---|---|
| **Non-smokers** | 65 | 26 | 0 | < 0.001 |
| **Light** | 16 | 34 | 4 | |
| **Keep** | 3 | 33 | 4 | |

| | Light Coffee Consumption | Moderate Coffee Consumption | High Coffee Consumption | P* Value |
|---|---|---|---|---|
| **Heavy** | 0 | 0 | 3 | |

* Chi-square test of independence

A very small p-value (< 0.001) indicates that there is a statistically significant relationship between smoking rates and coffee consumption.

## Relationship of Smoking with Light-Moderate Coffee Consumption to DFU Severity

**Table 9. Relationship of Smoking with Light-Moderate Coffee Consumption to DFU Severity.**

| | Grade 1 | Grade 2 | Grade 3 | Grade 4 | P* value |
|---|---|---|---|---|---|
| **Non-smokers** | 12 | 37 | 28 | 14 | 0,694 |
| **Light Coffee Consumption** | 11 | 32 | 23 | 19 | |

* Chi-square test of independence

| | Grade 1 | Grade 2 | Grade 3 | Grade 4 | P* value |
|---|---|---|---|---|---|
| **Non-smokers** | 12 | 37 | 28 | 14 | 0,499 |
| **Moderate Coffee Consumption** | 17 | 36 | 21 | 18 | |

* Chi-square test of independence

| | Grade 1 | Grade 2 | Grade 3 | Grade 4 | P* value |
|---|---|---|---|---|---|
| **Light Smokers** | 8 | 22 | 12 | 12 | 0,925 |
| **Light Coffee Consumption** | 11 | 32 | 23 | 19 | |

* Chi-square test of independence

| | Grade 1 | Grade 2 | Grade 3 | Grade 4 | P* value |
|---|---|---|---|---|---|
| **Light Smokers** | 8 | 22 | 12 | 12 | 0,938 |
| **Moderate Coffee Consumption** | 17 | 36 | 21 | 18 | |

* Chi-square test of independence

| | Grade 1 | Grade 2 | Grade 3 | Grade 4 | P* value |
|---|---|---|---|---|---|
| **Moderate Smoker** | 9 | 10 | 5 | 16 | 0,038 |
| **Light Coffee Consumption** | 11 | 32 | 23 | 19 | |

* Chi-square test of independence

| | Grade 1 | Grade 2 | Grade 3 | Grade 4 | P* value |
|---|---|---|---|---|---|
| **Moderate smokers** | 9 | 10 | 5 | 16 | 0,049 |
| **Moderate Coffee Consumption** | 17 | 36 | 21 | 18 | |

* Chi-square test of independence

The results of statistical tests of the association between smoking and coffee consumption with DFU severity (Grades 1–4) showed that most combinations of factors did not have a statistically significant relationship. In the non-smoking group compared with the level of light and moderate coffee consumption, no significant differences were found in the distribution of severity (p-values = 0.694 and 0.499). The same was also true in the group of light smokers, both those who consumed coffee in light and moderate levels, who also showed no significant difference in severity (p values = 0.925 and 0.938). However, different results were seen in the moderate smoking group. The combination of moderate smokers and light coffee consumption showed a significant association with severity (p value = 0.038),

as well as the combination of moderate smoker and moderate coffee consumption (p value = 0.049). This indicates that at higher levels of smoking (moderate smokers), coffee consumption, both in light and moderate amounts, has the potential to significantly affect the severity of the condition.

**Discussion**

The results showed a statistically significant relationship between hypertension status and DFU severity with a p = 0.003 value. These findings are in line with several previous studies that suggest that hypertension is an independent risk factor for the development of DFU. Data distribution shows that patients with grade I and II hypertension tend to experience DFU of higher severity, especially in grades 3 and 4. In contrast, patients with normotension and prehypertension were more found in DFU grades 1 and 2. This indicates that the higher the level of hypertension, the more severe the severity of the ulcer that occurs. The pathophysiological mechanisms underlying this relationship can be explained through several pathways. Hypertension causes peripheral resistance that can affect the incidence of PAD, thus impacting the development of diabetic ulcers. Blood pressure exceeding 130/80 mmHg can result in lesions and damage to the endothelial lining of blood vessels, which further contributes to the formation of diabetic ulcers. Research conducted at Mataram City Hospital showed similar results with OR = 1,882 (95% CI = 1,284-2,758), which corroborates the evidence that hypertension increases the risk of developing diabetic foot ulcers of higher severity. Hypertension is not only related to macroangiopathy but also microangiopathy which can worsen tissue perfusion in the lower extremities.

Analysis of the relationship between the degree of cigarette consumption and the severity of DFU showed significant results with a value of p = 0.037. Data distribution showed that the proportion of patients with severe and moderate smoking was higher in the DFU group with higher severity (grades 3 and 4). In contrast, non-smoking patients tend to have wounds of lower severity. These findings are supported by a meta-analysis involving 18 studies with 5,819 subjects, which showed OR = 0.70 (95% CI = 0.56-0.88) for the cure of diabetic ulcers in smokers compared to non-smokers. Lower cure rates in smokers (62.1%) compared to non-smokers (71.5%) indicated a negative impact of smoking on the prognosis of diabetic ulcers. Smoking has a multifactorial effect on the development and healing of diabetic ulcers. Nicotine can increase blood sugar and cause insulin resistance, making it difficult to control glycemic. The chemical components in cigarettes also cause inflammation and damage to body cells, which interferes with the wound healing process80. Research shows that smoking accelerates the progression of peripheral artery disease and inhibits the healing of surgical wounds. Oxidative stress induced by smoking is one of the main mechanisms underlying these negative impacts on peripheral neuropathy, vascular changes, and wound healing.

The results showed that there was a significant relationship between moderate smoking status and DFU severity (p=0.002), while light and heavy smokers did not show a statistically significant relationship. These findings are in line with various literature that shows the negative effects of smoking on wound healing in diabetic patients. A meta-analysis study by Fu et al. (2018) showed that smoking had an overall negative effect on the

healing of diabetic leg wounds with an odds ratio of 0.70 (95% CI = 0.56-0.88). The smoking group showed an average cure rate of 62.1% compared to 71.5% in the non-smoking group. These results indicate that smoking lowers the chance of wound healing by 30%83. Smoking causes vasoconstriction and endothelial damage to blood vessels, resulting in decreased blood flow and oxygen delivery to the wound area. This is especially critical in DFU patients who have experienced perfusion disorders due to complications of diabetes. Cigarettes affect every phase of wound healing, from the inflammatory phase, proliferation, to remodeling. Nicotine and other tobacco products interfere with the function of neutrophils, macrophages, and fibroblasts that play an important role in the healing process. Research shows that smoking can worsen diabetic neuropathy, which is a major risk factor for the formation of DFU. More severe neuropathy increases the risk of recurrent trauma and delays early detection of wounds.

The degree of coffee consumption showed no significant relationship with the severity of DFU (p=0.468). These findings are in line with several studies that show that moderate coffee consumption does not have a significant negative effect on diabetes complications, and some studies even show the potential protective effects of moderate coffee consumption against cardiovascular disease in diabetic patients. The link between coffee consumption and diabetes complications is still controversial in the literature. One large-scale study reported that coffee consumption may increase the risk of diabetic nephropathy, neuropathy, and peripheral angiopathy. In contrast, in another randomized study, after adjusting for smoking, coffee consumption showed protective effects against diabetic retinopathy and nephropathy. The lack of significant correlation in this study can be explained by several opposing mechanisms. Coffee contains bioactive compounds that are beneficial and may have negative effects on diabetes complications. This drink is rich in polyphenols, chlorogenic acid, and antioxidants with anti-inflammatory effects. These compounds have been shown to reduce oxidative stress, inflammatory markers such as interleukin-6, and increase antioxidant capacity. On the other hand, caffeine's impact on glucose metabolism has the opposite effect. Caffeine can reduce insulin sensitivity and increase blood glucose levels in individuals with type 2 diabetes. This effect occurs through the influence of caffeine on stress hormones such as epinephrine and adenosine blockade, which affects the work of insulin. The vascular component of DFU, which is measured by ischemic parameters in the WIFi assessment, can be affected by the effects of coffee complexes on cardiovascular function. The absence of a high correlation between coffee consumption and WiFi Score is likely to reflect the multifactorial etiopathogenesis of DFU. This disorder occurs due to a complex interaction between glycemic control, peripheral neuropathy, peripheral vascular insufficiency, immune disorders, and susceptibility to infection.

The results showed no significant relationship between coffee consumption and DFU severity (p=0.714 for light vs. moderate consumption; p=0.281 for light vs. high consumption). The literature shows the paradoxical effects of coffee on diabetes. Long-term coffee consumption has been shown to lower the risk of type 2 diabetes, but caffeine may worsen glycemic control in patients who already have diabetes. Research by Wedick et al. (2011), showed that caffeine increased blood sugar levels by up to 8% in patients with type 290 diabetes. Coffee contains chlorogenic acid and other antioxidants that can have anti-

inflammatory effects Coffee consumption has been shown to increase levels of adiponectin, a hormone that plays a role in insulin sensitivity. Decaffein coffee has been shown to lower levels of fetuin-A, an inflammatory biomarker and insulin resistance. On the other hand, caffeine can interfere with glucose tolerance and insulin sensitivity. In vitro studies show that caffeine can inhibit cell proliferation and cell migration, as well as reduce epithelialization.

The results of the multivariate analysis in this study showed that neither the degree of smoking nor coffee consumption had a significant effect on the severity of DFU at a significance level of 0.05. The chi square test of independence on the degree of smoking with DFU severity showed significant results, but in multivariate analysis in the form of multiple linear regression did not show significance. The chi square test detects the presence of associations or relationships between two categorical variables, without taking into account the influence of other variables or interfering factors. This test only looks at whether the distribution of one variable differs depending on the category of other variables. Multiple linear regression is used to test the influence of several independent variables on a single bound variable simultaneously. Regression also controls for the effects of other variables in the model. The significance of the chi square shows that in simple terms, two variables do have a relationship or association that does not happen by chance. The insignificance of multiple linear regression means that when all the free variables are included together in the model to predict the dependent variable, none have a significant effect, or the effect is weak after being controlled by other variables in the model. Chi squares can be significant because they only look at two variables simply, without controlling for the other variables. The relationship found could be influenced by a third variable, so that when tested multivariously in regression, the effect is lost or weakened. Multiple linear regression is more rigorous because it tests the influence of each free variable by controlling for other independent variables. Insignificant results can be caused by the relationship found by the chi square to be a pseudo-relationship or influenced by other variables.

Insignificant results on these two variables need to be interpreted in a broader clinical context. DFU is a multifactorial condition that is influenced by various risk factors such as diabetic neuropathy, peripheral artery disease, glycemic control, and foot care. In this study, the degree of smoking and coffee consumption may have a relatively small contribution compared to the main pathophysiological factors. Although the results of multivariate statistics do not show significance, the clinical implications remain important to consider. For smoking, although not significant in this model, other strong study evidence nonetheless supports the importance of avoiding cigarette consumption in diabetic patients with DFU. The positive coefficient in this study is still consistent with the direction of the adverse effect. For coffee consumption, the insignificant but negatively coefficient effect suggests that coffee consumption does not need to be restricted specifically to diabetic patients, and may even provide marginal benefits.

The results showed a very significant relationship between the degree of smoking and coffee consumption, with a p value of $< 0.001$. These findings make an important contribution to understanding the behavioral patterns of consumption of two addictive substances that are often consumed simultaneously in society. Research shows a strong

positive correlation between these two behaviors, with several underlying mechanisms. Cigarette smoke increases the activity of the enzyme CYP1A2 which is responsible in caffeine metabolism. The polyaromatic hydrocarbons in tobacco smoke bind to aryl hydrocarbon receptors, which activate CYP1A294 genes. The faster metabolism of caffeine in smokers requires them to consume more caffeine to feel the same stimulant effects and avoid withdrawal symptoms. Genetic studies showed a significant genetic correlation between smoking and caffeine consumption ($r = 0.47$ for coffee consumption and $r = 0.44$ for total caffeine). Genetic factors explain most of the association between smoking and caffeine consumption, suggesting that individuals with a genetic predisposition to smoke also have a predisposition to consume high amounts of caffeine95,96. Experimental research has also shown that smokers who are given any amount of coffee will smoke more than those who are not given coffee.

The results showed an interesting pattern where the combination of moderate smokers and coffee consumption had a significant relationship with the severity of DFU ($p = 0.038$ for light coffee consumption and $p = 0.049$ for moderate coffee consumption). These findings indicate a synergistic interaction between smoking and coffee consumption that worsens DFU conditions at higher levels of smokers. The results showed a clear threshold effect where a significant relationship only appeared in the moderate smoking group. Previous research identified that moderate smokers (27.5% of the study population) showed the highest distribution in DFU severity. This indicates a dose-response relationship in the smoking-coffee interaction. The combination of vasoconstriction from nicotine and the adenosine-antagonist effects of caffeine can result in a heavier reduction in tissue perfusion. Caffeine can increase insulin resistance and blood glucose levels by up to 8% in people with diabetes, which combined with the proinflammatory effects of cigarettes can worsen glycemic control. Smoking produces high ROS, while caffeine consumption in the context of diabetes can exacerbate tissue oxidative stress.

## CONCLUSION

This study shows that there is a relationship between the severity of smoking and an increase in the severity of diabetic foot ulcers. Heavy and moderate smokers were more prevalent in DFU grades 3-4, while non-smokers tended to have milder severities of diabetic foot ulcers. Coffee consumption was not associated with the severity of diabetic foot ulcers. In the multivariate analysis, the combination of smoking and coffee consumption had no significant effect on the severity of diabetic foot ulcers. Future studies should be conducted by adding other variables that may play a role in the severity of diabetic foot ulcers, such as blood sugar control (HbA1c), diabetes duration, body mass index (BMI), adherence to therapy, and history of comorbidities, in order to gain a more comprehensive understanding of the factors that affect the WIFi score in diabetic foot ulcer patients. Research with a larger sample size and a multivariate approach is also recommended to improve the strength of the analysis and the accuracy of the results.

## REFERENCES

Ahmed, Z., Raza, M. Z., Worrall, A. P., Kheirelseid, E., Naughton, P., Moneley, D., & McHugh, S. (2023). SVS WIfI score as a predictor of amputation after onset of CLI: Validation in an Irish tertiary vascular unit. *Surgeon*, *21*(1). https://doi.org/10.1016/j.surge.2022.02.005

Deng, H., Li, B., Shen, Q., Zhang, C., Kuang, L., Chen, R., Wang, S. Y., Ma, Z. Q., & Li, G. (2023). Mechanisms of diabetic foot ulceration: A review. In *Journal of Diabetes* (Vol. 15, Issue 4). https://doi.org/10.1111/1753-0407.13372

Hendri, Suhartono, R., Kekalih, A., Adriani, J. R., & Faruk, M. (2023). Healing rate comparison of revascularized and non-revascularized diabetic foot ulcers with peripheral arterial disease. *Surgery Open Science*, *16*. https://doi.org/10.1016/j.sopen.2023.11.008

Hicks, C. W., Canner, J. K., Mathioudakis, N., Sherman, R., Malas, M. B., Black, J. H., & Abularrage, C. J. (2018). The Society for Vascular Surgery Wound, Ischemia, and foot Infection (WIfI) classification independently predicts wound healing in diabetic foot ulcers. *Journal of Vascular Surgery*, *68*(4). https://doi.org/10.1016/j.jvs.2017.12.079

Lavery, L. A., Armstrong, D. G., Murdoch, D. P., Peters, E. J. G., & Lipsky, B. A. (2007). Validation of the infectious diseases society of America's diabetic foot infection classification system. *Clinical Infectious Diseases*, *44*(4). https://doi.org/10.1086/511036

Lim, J. Z. M., Ng, N. S. L., & Thomas, C. (2017). Prevention and treatment of diabetic foot ulcers. In *Journal of the Royal Society of Medicine* (Vol. 110, Issue 3). https://doi.org/10.1177/0141076816688346

Mayor, J., Chung, J., Zhang, Q., Montero-Baker, M., Schanzer, A., Conte, M. S., & Mills, J. L. (2019). Using the Society for Vascular Surgery Wound, Ischemia, and foot Infection classification to identify patients most likely to benefit from revascularization. *Journal of Vascular Surgery*, *70*(3). https://doi.org/10.1016/j.jvs.2018.11.039

Mohapatra, A., Boitet, A., Malak, O., Henry, J. C., Avgerinos, E. D., Makaroun, M. S., Hager, E. S., & Chaer, R. A. (2019). Peroneal bypass versus endovascular peroneal intervention for critical limb ischemia. *Journal of Vascular Surgery*, *69*(1). https://doi.org/10.1016/j.jvs.2018.04.049

Monteiro-Soares, M., Hamilton, E. J., Russell, D. A., Srisawasdi, G., Boyko, E. J., Mills, J. L., Jeffcoate, W., & Game, F. (2024). Guidelines on the classification of foot ulcers in people with diabetes (IWGDF 2023 update). *Diabetes/Metabolism Research and Reviews*, *40*(3). https://doi.org/10.1002/dmrr.3648

Monteiro-Soares, M., Russell, D., Boyko, E. J., Jeffcoate, W., Mills, J. L., Morbach, S., & Game, F. (2020). Guidelines on the classification of diabetic foot ulcers (IWGDF 2019). *Diabetes/Metabolism Research and Reviews*, *36*(S1). https://doi.org/10.1002/dmrr.3273

Ramirez-Acuña, J. M., Cardenas-Cadena, S. A., Marquez-Salas, P. A., Garza-Veloz, I., Perez-Favila, A., Cid-Baez, M. A., Flores-Morales, V., & Martinez-Fierro, M. L. (2019). Diabetic foot ulcers: Current advances in antimicrobial therapies and emerging treatments. In *Antibiotics* (Vol. 8, Issue 4). https://doi.org/10.3390/antibiotics8040193

Reardon, R., Simring, D., Kim, B., Mortensen, J., Williams, D., & Leslie, A. (2020). The diabetic foot ulcer. *Australian Journal of General Practice*, *49*(5). https://doi.org/10.31128/AJGP-11-19-5161

Rubitschung, K., Sherwood, A., Crisologo, A. P., Bhavan, K., Haley, R. W., Wukich, D. K., Castellino, L., Hwang, H., La Fontaine, J., Chhabra, A., Lavery, L., & Öz, O. K. (2021). Pathophysiology and molecular imaging of diabetic foot infections. In *International*

*Journal of Molecular Sciences* (Vol. 22, Issue 21). https://doi.org/10.3390/ijms222111552

Senneville, É., Albalawi, Z., van Asten, S. A., Abbas, Z. G., Allison, G., Aragón-Sánchez, J., Embil, J. M., Lavery, L. A., Alhasan, M., Oz, O., & Uçkay, I. (2024). IWGDF/IDSA guidelines on the diagnosis and treatment of diabetes-related foot infections (IWGDF/IDSA 2023). *Diabetes/Metabolism Research and Reviews*, 40(3), e3687.

Sethuram, L., Thomas, J., Mukherjee, A., & Chandrasekaran, N. (2022). A review on contemporary nanomaterial-based therapeutics for the treatment of diabetic foot ulcers (DFUs) with special reference to the Indian scenario. *Nanoscale Advances*, 4(11), 2367-2398.

Suh, H. S., & Hong, J. P. (2015). Diabetic foot ulcer. *Journal of the Korean Medical Association*, *58*(9). https://doi.org/10.5124/jkma.2015.58.9.795

Uçkay, I., Aragón-Sánchez, J., Lew, D., & Lipsky, B. A. (2015). Diabetic foot infections: What have we learned in the last 30 years? In *International Journal of Infectious Diseases* (Vol. 40). https://doi.org/10.1016/j.ijid.2015.09.023

Zare, H., Rezayi, M., Aryan, E., Meshkat, Z., hatamluyi, B., Neshani, A., Ghazvini, K., Derakhshan, M., & Sankian, M. (2021). Nanotechnology-driven advances in the treatment of diabetic wounds. In *Biotechnology and Applied Biochemistry* (Vol. 68, Issue 6). https://doi.org/10.1002/bab.2051