Exploring Biomechanical and Clinical Factors in Diabetic Foot Ulcer Risk Assessment

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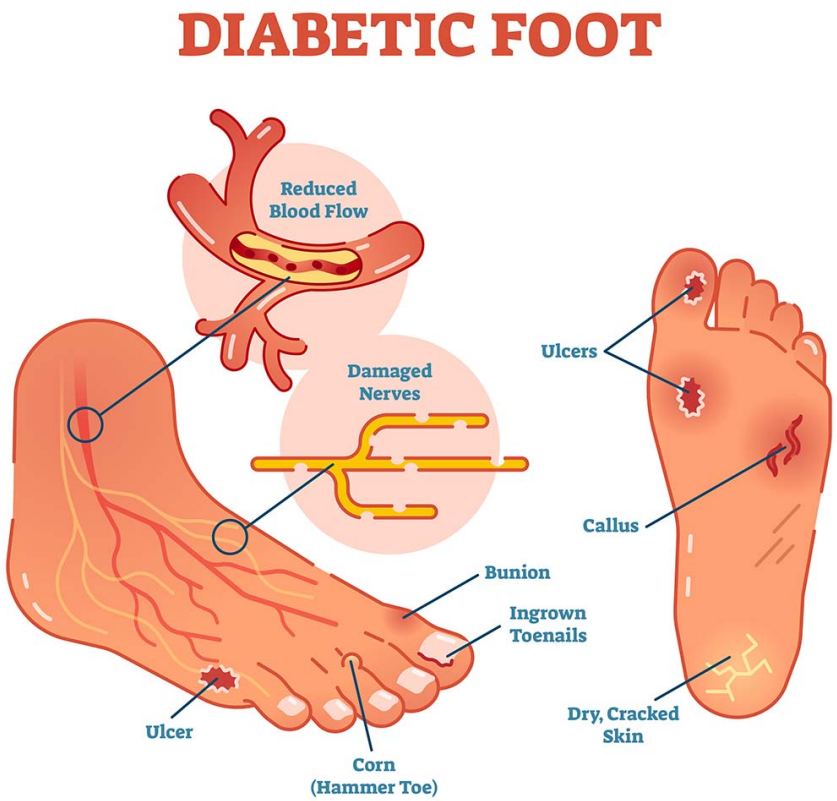
Outline

Introduction

- **Diabetes:** A long-term disease where blood sugar stays high because the body makes too little insulin or does not use it well. It can harm nerves and blood vessels.
- **Neuropathy:** Nerve damage from diabetes that can cause foot pain, numbness, or weakness.

Diabetic Foot Ulcers



Risk Factors for Diabetic Foot Ulcers

- **Neuropathy:** Less feeling in the feet, so injuries happen more easily.
- **Poor Circulation:** Blood flow is weak, so wounds heal slowly.
- **Foot Deformities:** Feet have unusual shapes, causing more pressure on some spots.

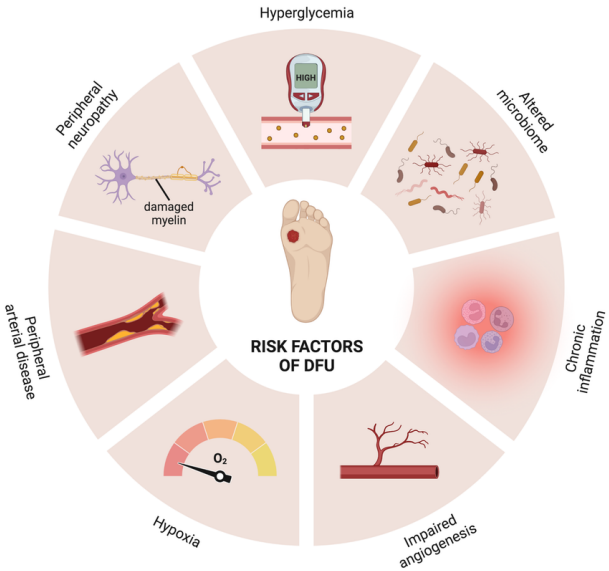


Figure: Plantar Pressure Map

Why Study Diabetic Foot Ulcers?

- Over 4 million adults in France are living with diabetes (2024).
- Diabetic Foot Ulcers (DFUs) cause more than 10,000 amputations each year.
- **Goal:** Create a tool to study diabetic foot data and help doctors make decisions.

Objectives

Internship Goals

- Find key risk markers (e.g., tissue stiffness, plantar pressure).
- Study how tissue properties relate to foot loading.
- Explore left–right foot differences as warning signs.
- Group patients and compare with IWGDF risk levels (grades that show how likely a diabetic foot is to get ulcers).

Data Collection

- Study done in a day-hospital with ethical approval.
- Participants signed consent forms.
- Included adults 18–65 with diabetes.
- Excluded pregnant, breastfeeding, or legally protected people.

The DIAFOOT Dataset

- **Participants**: 21 diabetic patients (11 females, 10 males).
- **Age**: Mean 56.8 years.
- **BMI**: Mean 25.83 kg/m^2
- **IWGDF Grades**: 0 (n=11), 1 (n=2), 2 (n=1), 3 (n=7) (Risk levels for diabetic foot ulcers.)

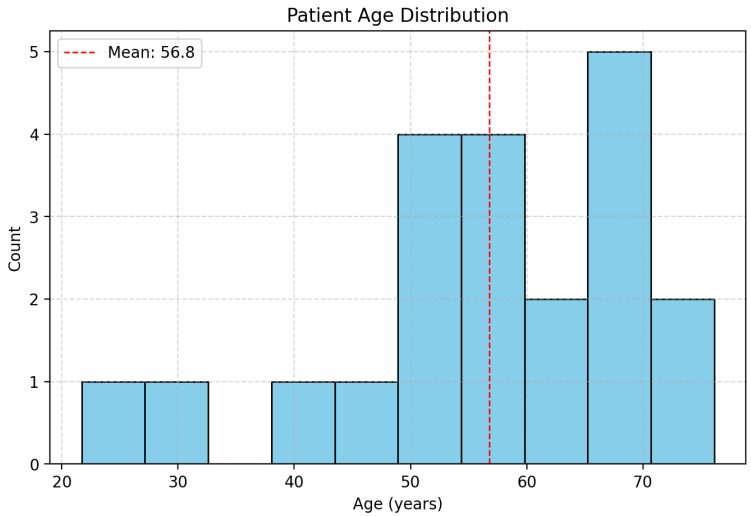


Figure: Age Distribution

Data Parameters

- **Anthropometric:** BMI, height, weight
- **Vascular:** Ankle and big toe blood pressure
- **Neurological:** Michigan score, SUDOSCAN (hands/feet)
- **Biomechanical:** Foot pressure (SESA, hallux, TM5), tissue stiffness
- **Imaging:** Ultrasound tissue thickness
- **Thermal:** Foot temperature and normalized values

Analysis Pipeline

Streamlit Dashboard

- **Platform**: Built using Streamlit, A dynamic, Python-driven platform for real-time data exploration and visualization.
- **Data Source**: Excel file with 'DIAFOOT' sheet containing patient metrics.
- **Key Features**: Descriptive statistics, normality tests, clustering,correlations and comparative analyses.
- **Tools**: Pandas (data handling), NumPy (numerical), Scikit-learn (ML), Matplotlib Seaborn (visuals).

Explore the DIAFOOT Analysis Dashboard

https://diafoot-analysis.streamlit.app/

Upload data, analyze it, and see important results easily.

Try it now!

Review of Statistics: p-value

- **p-value:** Shows if a result is real or by chance.
- Small p-value $< 0.05 \rightarrow$ **significant** (result likely real)
- Large p-value $\geq 0.05 \rightarrow$ **not significant** (result may be by chance)
- Used to decide whether to reject the null hypothesis.

Asymmetry Insights

Significant Left-Right Differences

- **TM5 Pressure**: Right (36.93 kPa) $>$ Left (26.34 kPa), p = 0.0054.
- **Hallux Stiffness**: Right higher, p = 0.0498.
- **Temperature (Plantar Arch, Lateral Sole)**: Right warmer, p $<$ 0.01.

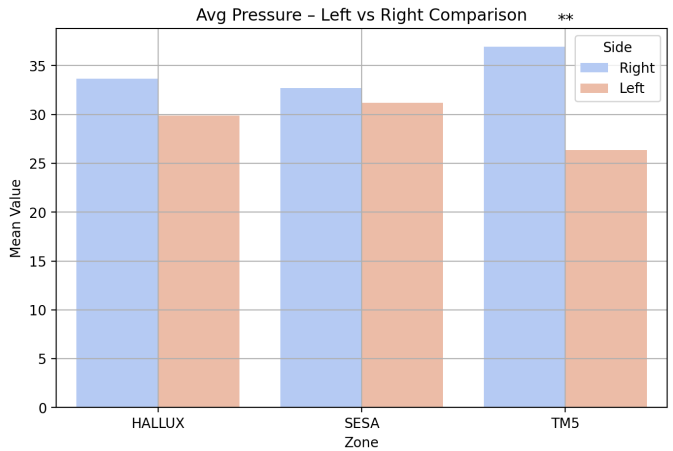


Figure: Pressure Asymmetry

Group Differences: Low vs. High Risk

Parameter	Grades 0-1	Grades 2-3	p-value
Michigan Score	11.69	4.13	0.00053
Tissue Thickness SESA R (mm)	9.55	4.17	0.0099
Heel Temperature R (°C)	25.85	28.55	0.0188

Table: Significant Group Differences

- Higher-risk patients have lower Michigan scores, thinner tissue, and warmer heels, showing higher ulcer risk.

Clustering Analysis

- Clustering done with and without IWGDF grades
- Analyses run on:
  - Key parameters: IWGDF grade, MESI, Michigan, pressure, stiffness, thickness, amplitude, temperature.
  - Full dataset: 70+ clinical and biomechanical variables.
- **PCA:** 2D visualization of patient data.
- **Clustering:** Agglomerative, KMeans, GMM; 2–6 clusters.
- **Metrics:** Silhouette, Calinski–Harabasz, Davies–Bouldin, ARI, NMI.
- **Feature importance:** LASSO, Random Forest, ANOVA.
- **Group differences:** MANOVA, p-values indicate significance.

Clustering Results

Key Insights

- Focused parameters (e.g., Michigan Score, tissue thickness) yield better clusters (Silhouette 0.55) than full set (0.22).
- Top predictors: Michigan Score, tissue thickness (HALLUX, TM5), temperature.
- IWGDF grades improve clustering but miss some variability.

Correlations

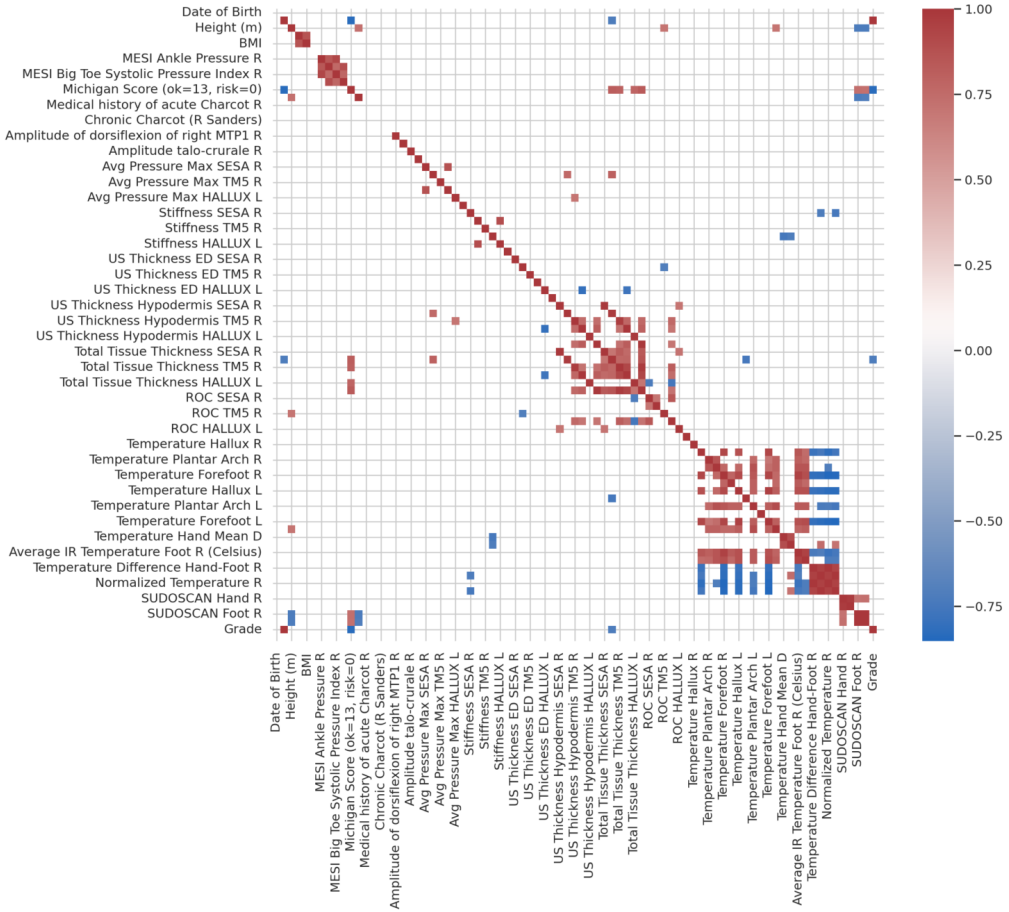


Figure: Correlogram ($|r| > 0.7$)

Key Takeaways

- **Asymmetries** in pressure, stiffness, and temperature show which patients are at risk.
- **Clustering** using selected features reveals meaningful patient groups.
- **Important indicators** include Michigan Score, tissue thickness, and temperature.
- **Take-home message**: Combining clinical and biomechanical data improves risk screening.

Limitations and Future Directions

Challenges

- Small sample (21 patients) limits statistics.
- Uneven patient numbers in IWGDF grades.
- Some measurements (ultrasound, pressure) may be biased.

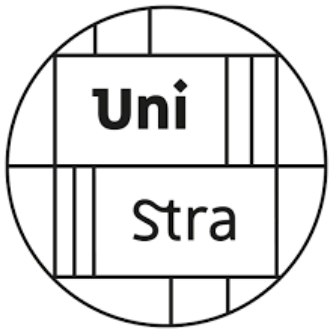
Next Steps

- Include more patients for stronger results.
- Use better ways to handle missing data and track patients over time.
- Try deep learning to improve prediction.

Personal Reflections

Internship Experience

- Improved Python and data analysis skills.
- Collaborated with supervisors to ensure medical accuracy.
- Learned to apply data science in healthcare.



Useful URLs

- Streamlit Cloud
- Scikit-learn Clustering Documentation

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Thank You!

Questions?

Thank you for your attention!