

Community cardiometabolic screening in Slovakia: a cross-sectional study

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Research Article

Keywords: hypertension, screening, dysglycaemia, cardiometabolic risk, body mass index, multiple imputation

Posted Date: October 18th, 2026

DOI: <https://doi.org/10.21203/rs.3.rs-11241231/v1>

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Additional Declarations: No competing interests reported.

Abstract

Objectives: To describe cardiometabolic risk factors detected by a community screening programme and to identify independent predictors of hypertension and dysglycaemia.

Background: Community screening may identify persons with unrecognised cardiometabolic risk outside routine healthcare contacts. Screening datasets often contain incomplete measurements.

Methods: We analysed anonymised cross-sectional data from 356 participants of the Zdravie na dosah project. Measurements included blood pressure, anthropometry, capillary glycaemia and point-of-care lipid profile. Hypertension was defined as blood pressure at least 140/90 mmHg and dysglycaemia as random capillary glycaemia at least 7.8 mmol/L. Logistic regression with multiple imputation was used.

Results: Median age was 47 years (interquartile range 37-62) and median body mass index was 26.0 kg/m² (22.4-29.4). Hypertension was present in 39.7% of participants with measured blood pressure and dysglycaemia in 14.0% with measured glycaemia. In imputed models, hypertension was independently associated with age (odds ratio 1.03 per year, $p=0.002$) and male sex (odds ratio 1.85, $p=0.016$). Dysglycaemia was independently associated with age (odds ratio 1.03, $p=0.017$).

Conclusion: Community screening identified hidden burden of elevated blood pressure and dysglycaemia. Structured follow-up after screening may support earlier prevention of cardiometabolic complications.

Introduction

Cardiovascular disease and diabetes mellitus are major causes of morbidity, premature mortality and long-term health burden in Europe and globally. Their common feature is a long asymptomatic phase during which modifiable risk factors accumulate, especially elevated blood pressure, overweight, abdominal obesity, dysglycaemia and dyslipidaemia. Contemporary preventive recommendations emphasise early identification of individuals at risk, assessment of overall cardiometabolic risk and timely lifestyle or pharmacological intervention according to risk level [1-4].

Hypertension remains one of the most important modifiable risk factors for coronary artery disease, stroke, heart failure and chronic kidney disease. Its epidemiological importance is amplified by the fact that many affected individuals remain asymptomatic and undiagnosed unless blood pressure is actively measured. Current European recommendations emphasise standardised blood pressure measurement, repeated confirmation of abnormal values and risk stratification that considers age, sex, metabolic factors and comorbidities [1,2,5-7].

Dysglycaemia and type 2 diabetes mellitus represent another key component of cardiometabolic risk. The global prevalence of diabetes is increasing and a considerable proportion of cases may remain unrecognised, especially among individuals who do not attend regular preventive examinations. Diagnostic standards distinguish between screening detection of elevated glycaemia and definitive

diagnostic confirmation by standardised laboratory testing, including fasting plasma glucose, glycated haemoglobin or an oral glucose tolerance test. In the community setting, random capillary glycaemia should therefore be interpreted mainly as a triage marker indicating the need for subsequent diagnostic confirmation [8-11].

Overweight, obesity and central adiposity are closely linked to hypertension, insulin resistance and atherogenic dyslipidaemia. Body mass index is a simple and widely used measure of general adiposity, whereas waist circumference better captures abdominal fat accumulation and its metabolic consequences. Combining anthropometry, lipid profile, glycaemia and blood pressure in screening conditions may identify a cardiometabolic risk cluster that is clinically more informative than isolated assessment of a single parameter [12-18].

Community screening programmes are a practical public-health tool that can complement routine ambulatory care. Their main benefit is that they reach people outside regular healthcare contacts and allow early detection of risk values at a stage when preventive measures are most effective. If followed by a defined pathway - repeated measurements, diagnostic confirmation, education and linkage to a general practitioner or specialist - such programmes may reduce the future burden of complications, hospitalisations and costly treatment of advanced disease [19-25].

Analysis of real-world screening data also brings methodological challenges. Measurements obtained outside a strictly controlled research environment often contain missing values because not all tests are performed in every participant. Complete-case analysis may reduce statistical power and introduce selection bias if participants with complete data differ from those with incomplete data. Multiple imputation is an appropriate approach for incomplete predictor data when missingness can plausibly be explained by available variables and is transparently described [26-29].

The aims of this study were to describe demographic and cardiometabolic characteristics of participants in the community project Zdravie na dosah, to evaluate associations among risk factors and to identify independent predictors of hypertension and dysglycaemia using multiple imputation. We hypothesised that community screening would identify a clinically relevant proportion of individuals with hidden cardiometabolic risk and that abnormal findings would be associated mainly with age, sex and adiposity markers.

Materials and Methods

Study design and participants. This was a cross-sectional observational analysis of anonymised data from participants in a community screening project. One record per participant was analysed. The report follows the principles of observational study reporting [30].

Data collection. Data were obtained within the community screening project Zdravie na dosah during public community measurement events in several locations. The one-visit protocol included demographic information (age and sex), basic anthropometric measurements (height, body weight, body

mass index and waist circumference), vital signs (systolic and diastolic blood pressure, heart rate, oxygen saturation and body temperature), capillary glycaemia and lipid profile (total cholesterol, LDL cholesterol, HDL cholesterol and triacylglycerols). Data were recorded in a study form and anonymised before statistical analysis. Participants included in the analysis had not previously been treated or followed by an internist or general practitioner for the screened conditions, according to the information available in the source dataset.

Blood pressure measurement. Blood pressure was measured under screening conditions using a validated automatic oscillometric device. Measurements were performed in a sitting position after at least 5 minutes of rest, with the back supported, feet on the floor and the arm supported at heart level. An appropriate cuff size was used according to arm circumference. At least two consecutive measurements were performed at 1-2-minute intervals, and the mean of two measurements was used for analysis. If systolic values differed by more than 10 mmHg, an additional measurement was obtained. Hypertension for regression modelling was defined as systolic blood pressure at least 140 mmHg and/or diastolic blood pressure at least 90 mmHg [1,2].

Glycaemia and lipid measurements. Glycaemia was measured from capillary blood using a point-of-care glucometer and reported in mmol/L. Because fasting status could not be ensured at community events, glycaemia was interpreted as a screening measure. Dysglycaemia was defined as random capillary glycaemia at least 7.8 mmol/L; values at least 11.1 mmol/L were interpreted as screening values compatible with suspected diabetes mellitus and requiring confirmation by standard diagnostic tests. The lipid profile was measured from capillary blood using a point-of-care lipid analyser. Manufacturer instructions were followed, including disposable strips or cartridges, expiry-date control and basic internal quality checks where applicable [8,9].

Data preprocessing. Missing values were quantified for each variable. Extreme values were checked using the 1.5 x interquartile range rule and the modified Z-score. Values outside biologically plausible ranges were kept as participant records, but the specific implausible value was set to missing to avoid distortion of analyses.

Missing data. Missingness varied across variables and was typical of real-world community screening data. The highest missingness was observed for rhythm (197/356; 55.3%) and body temperature (170/356; 47.8%). Moderate missingness was present for LDL cholesterol (83/356; 23.3%) and waist circumference (69/356; 19.4%). Missingness was lower for triacylglycerols (47/356; 13.2%), HDL cholesterol (45/356; 12.6%), heart rate (32/356; 9.0%) and total cholesterol (17/356; 4.8%). Outcome availability was high: blood pressure was available in 350/356 participants (missingness approximately 1.7%) and glycaemia in 343/356 participants (missingness approximately 3.7%). Thus, missing values occurred mainly in predictors and auxiliary variables rather than in outcome variables.

Statistical analysis. Normality was assessed using the Shapiro-Wilk test. Continuous variables are presented as median (interquartile range) or mean +/- standard deviation as appropriate. Associations between continuous variables were assessed by Spearman correlation. Group comparisons used Welch

t test or Mann-Whitney U test for two groups and analysis of variance or the Kruskal-Wallis test for three or more groups. Categorical variables were compared using the chi-square test or Fisher exact test. False discovery rate was controlled by the Benjamini-Hochberg method when multiple comparisons were interpreted [31].

Multivariable models and imputation. Logistic regression models were constructed for hypertension and dysglycaemia. Instead of a complete-case approach, missing predictor values were handled by multiple imputation with chained equations ($m=20$). The imputation model included the outcome, all predictors in regression models and auxiliary variables related to cardiometabolic risk, such as height, body weight, lipid parameters and physiological measurements. Outcome variables were not imputed; only participants with measured outcomes were analysed. Estimates from individual imputations were pooled using Rubin rules and are reported as odds ratios with 95% confidence intervals [26-29].

Software. Analyses were performed in Python using pandas, SciPy and statsmodels. Multiple imputation was implemented using IterativeImputer, with pooled estimates calculated according to Rubin rules.

Ethics. The study protocol and informed consent documentation were reviewed and approved by the Ethics Committee of Faculty Hospital AGEL Kosice-Saca a.s. on 18 June 2025. All data were anonymised before analysis.

Results

The study included 356 participants; 231 (64.9%) were women and 125 (35.1%) were men. Baseline characteristics are shown in Table 1. The prevalence of hypertension, defined as blood pressure at least 140/90 mmHg, was 39.7% among participants with measured blood pressure (139/350). Dysglycaemia, defined as glycaemia at least 7.8 mmol/L, was present in 14.0% of participants with measured glycaemia (48/343).

In bivariate analyses, strong positive correlations were observed between body mass index and waist circumference (Spearman $\rho=0.833$) and between total cholesterol and LDL cholesterol ($\rho=0.810$). Systolic blood pressure increased with age ($\rho=0.246$). Men had higher body weight, body mass index, waist circumference and systolic blood pressure, whereas women had higher HDL cholesterol. These relationships are illustrated in Figures 1-4.

Multiple-imputation pooled logistic regression estimates are shown in Tables 2 and 3. In the basic hypertension model, age and male sex were independent predictors of hypertension. Body mass index showed a positive but statistically non-significant trend. In the dysglycaemia model, age was the only significant independent predictor.

Discussion

This community screening analysis identified a substantial burden of cardiometabolic risk factors. Median body mass index was in the overweight range and hypertension was present in nearly two fifths of participants with measured blood pressure. These findings are clinically relevant because elevated blood pressure is a major modifiable determinant of cardiovascular events. The results support the role of community screening as a complement to primary care: it can identify individuals with increased risk and enable timely recommendation for further diagnostic evaluation, lifestyle advice and treatment when indicated.

Anthropometric parameters showed expected relationships, particularly the strong correlation between body mass index and waist circumference. Waist circumference is clinically important because it is a simple marker of central adiposity, which is associated with insulin resistance, low-grade inflammation and increased cardiovascular risk. The strong correlation between total cholesterol and LDL cholesterol supports the internal consistency of measurements in the screening setting. Together with the observed glycaemia and blood pressure findings, these relationships suggest clustering of cardiometabolic risk factors in a community sample.

Age was a stable independent factor for both hypertension and dysglycaemia. This is biologically plausible, because ageing is associated with progressive arterial stiffness, changes in neurohumoral regulation and cumulative exposure to behavioural risks. In glucose metabolism, age is linked to reduced insulin sensitivity and declining beta-cell functional reserve. From a prevention perspective, our findings support targeted screening and intervention programmes in middle-aged and older groups, with an emphasis on repeated measurement and follow-up rather than one-time detection only.

Male sex was independently associated with hypertension in the multiple-imputation pooled model. In bivariate analyses, men had higher body weight, body mass index, waist circumference and systolic blood pressure, while women had higher HDL cholesterol. The association between sex and hypertension persisted after statistical handling of missing data, making the estimate more reliable and suggesting that analysis based only on complete records might be biased. Behavioural determinants such as diet, alcohol use, smoking and physical activity were not systematically recorded and should be included in future screening rounds.

Body mass index and waist circumference were not independently associated with hypertension or dysglycaemia in the basic multivariable models after adjustment for age and sex. This does not refute the clinical importance of obesity. Rather, it probably reflects the strong relationship between body mass index and waist circumference, the cross-sectional design, absence of information about duration of exposure and lack of treatment and lifestyle data. Future analyses may use a simpler modelling approach by selecting one adiposity marker at a time and by adding behavioural and clinical variables such as physical activity, diet, smoking and medication use.

Dysglycaemia was present in 14.0% of participants with measured glycaemia and was independently associated mainly with age. Systolic blood pressure appeared higher in the group with suspected diabetes mellitus, which is consistent with the concept of cardiometabolic clustering. However,

interpretation is limited by the small number of persons in the highest glycaemia category and by the fact that glycaemia was measured randomly during the day rather than fasting. In practice, screening-detected hyperglycaemia should therefore serve mainly for triage and should prompt confirmation by standard tests such as fasting glycaemia, glycated haemoglobin or an oral glucose tolerance test [8,9].

The implementation implication is that community screening needs a clearly defined follow-up pathway. Participants with elevated blood pressure should undergo repeated standardised measurements and should be linked to general practitioners or specialists. Participants with elevated glycaemia should receive confirmatory diagnostic testing and lifestyle counselling. From a public-health and economic perspective, prevention and early detection are likely to be more efficient than the treatment of late complications such as stroke, myocardial infarction, heart failure, chronic kidney disease and diabetes-related disability.

In conclusion, the Zdravie na dosah community screening project identified a high proportion of persons with elevated blood pressure and dysglycaemia, indicating a hidden burden of cardiometabolic risk outside routine healthcare contacts. Higher age and male sex were independently associated with hypertension, while higher age was independently associated with dysglycaemia. These findings support prevention-oriented community screening with structured follow-up, because early identification of abnormal blood pressure and glycaemia allows timely confirmation, counselling and management before serious complications develop. The study also shows that real-world screening datasets with incomplete predictor values can be analysed in a publishable and methodologically transparent manner when multiple imputation is applied appropriately.

Learning points

Community screening identified a substantial proportion of adults with elevated blood pressure and dysglycaemia.

Higher age and male sex were independent predictors of hypertension, while higher age predicted dysglycaemia.

Multiple imputation provided a robust approach to regression modelling in a real-world screening dataset with incomplete predictor values.

Declarations

Grant support: None.

Ethics approval: The study protocol and informed consent documentation were reviewed and approved by the Ethics Committee of Faculty Hospital AGEL Kosice-Saca a.s. on 18 June 2025.

Acknowledgements

The authors thank all participants and members of the screening teams involved in data collection.

Funding

This study received no external funding.

Conflict of interest

The authors declare no conflict of interest.

Data availability

The anonymised dataset is not publicly available. Access may be considered by the corresponding author upon reasonable request and subject to applicable ethical and legal requirements.

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Tables

Table 1. Baseline characteristics of participants.

Variable	N	Median (IQR)
Age (years)	355	47.00 (37.00-62.00)
Body mass index (kg/m ²)	350	26.00 (22.40-29.40)
Waist circumference (cm)	286	90.00 (77.00-100.00)
Systolic blood pressure (mmHg)	351	133.00 (124.50-146.00)
Diastolic blood pressure (mmHg)	350	80.00 (71.00-87.00)
Glycaemia (mmol/L)	343	6.00 (5.50-6.80)
Total cholesterol (mmol/L)	338	4.70 (4.10-5.60)
LDL cholesterol (mmol/L)	273	2.10 (1.50-2.80)
HDL cholesterol (mmol/L)	310	1.50 (1.20-1.70)
Triacylglycerols (mmol/L)	309	2.20 (1.40-3.20)

Note: HDL, high-density lipoprotein; IQR, interquartile range; LDL, low-density lipoprotein.

Table 2. Multiple-imputation pooled logistic regression: factors associated with hypertension.

Variable	OR	95% CI	P value
Age (per 1 year)	1.03	1.01-1.04	0.0022
Male sex vs female	1.85	1.12-3.05	0.0156
Body mass index (per 1 kg/m ²)	1.06	0.99-1.14	0.1028

Note: CI, confidence interval; OR, odds ratio. Hypertension was defined as blood pressure at least 140/90 mmHg.

Table 3. Multiple-imputation pooled logistic regression: factors associated with dysglycaemia.

Variable	OR	95% CI	P value
Age (per 1 year)	1.03	1.01-1.05	0.0170
Male sex vs female	1.24	0.59-2.61	0.5752
Body mass index (per 1 kg/m ²)	1.02	0.94-1.11	0.6064
Triacylglycerols (per 1 mmol/L)	1.07	0.91-1.26	0.4195
HDL cholesterol (per 1 mmol/L)	1.50	0.59-3.84	0.3894
Total cholesterol (per 1 mmol/L)	1.00	0.70-1.43	0.9964

Note: CI, confidence interval; HDL, high-density lipoprotein; OR, odds ratio. Dysglycaemia was defined as random capillary glycaemia at least 7.8 mmol/L.

Figures

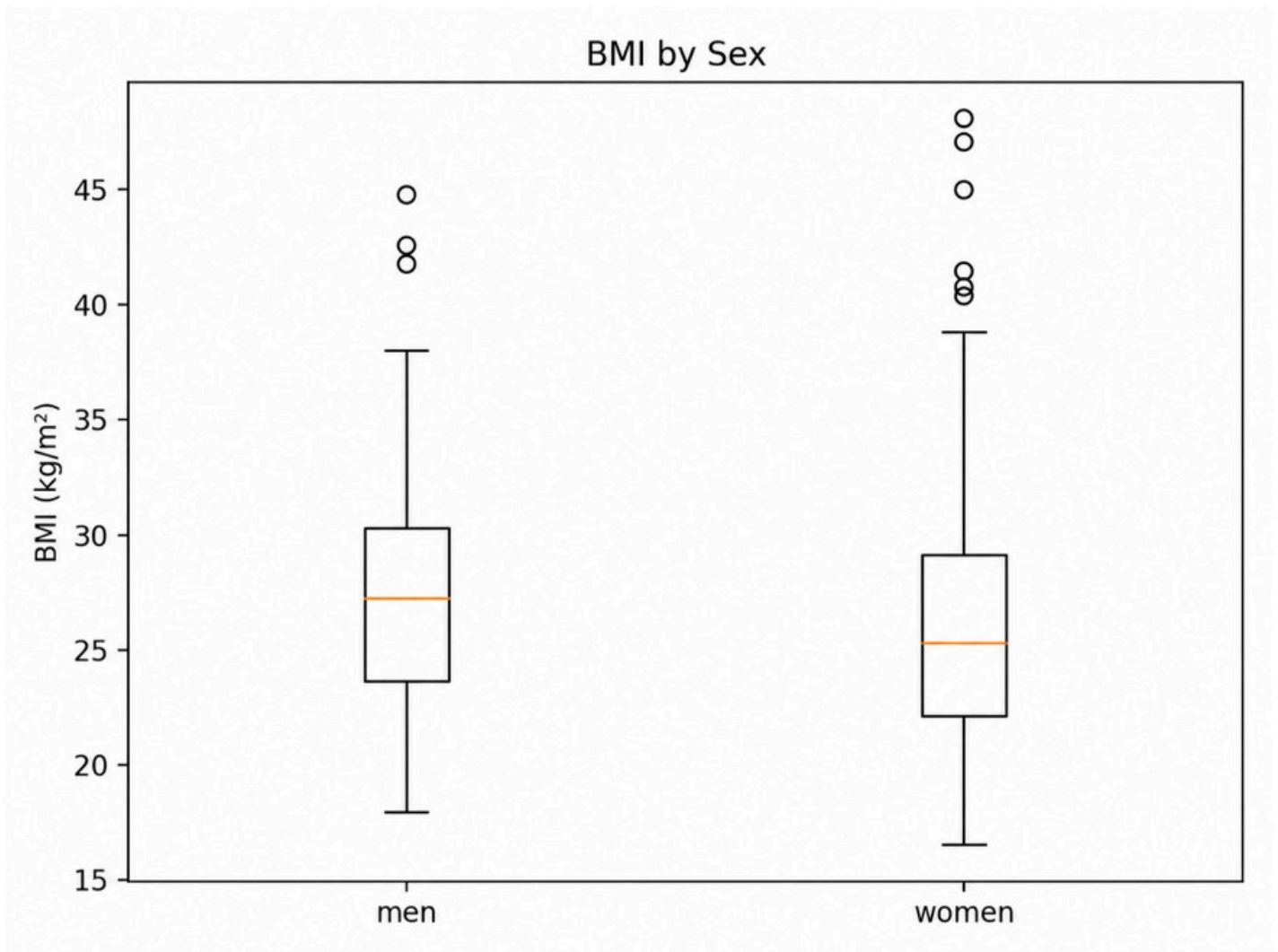


Figure 1

Body mass index by sex. Boxplot: median (line), interquartile range (box), 1.5 x interquartile range whiskers and outliers.

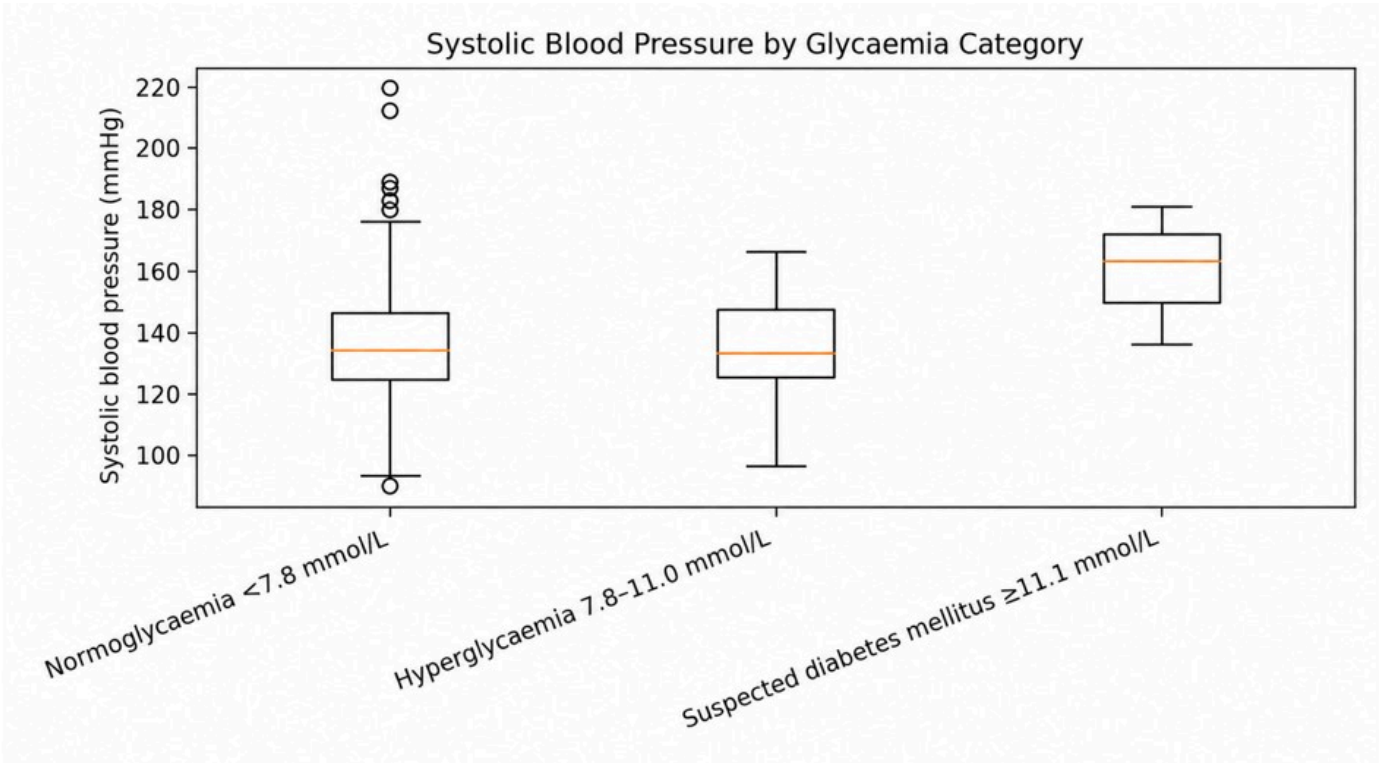


Figure 2

Systolic blood pressure by glycaemia category. Boxplot: median (line), interquartile range (box), 1.5 x interquartile range whiskers and outliers. Interpretation of the suspected diabetes mellitus category is limited by small numbers.

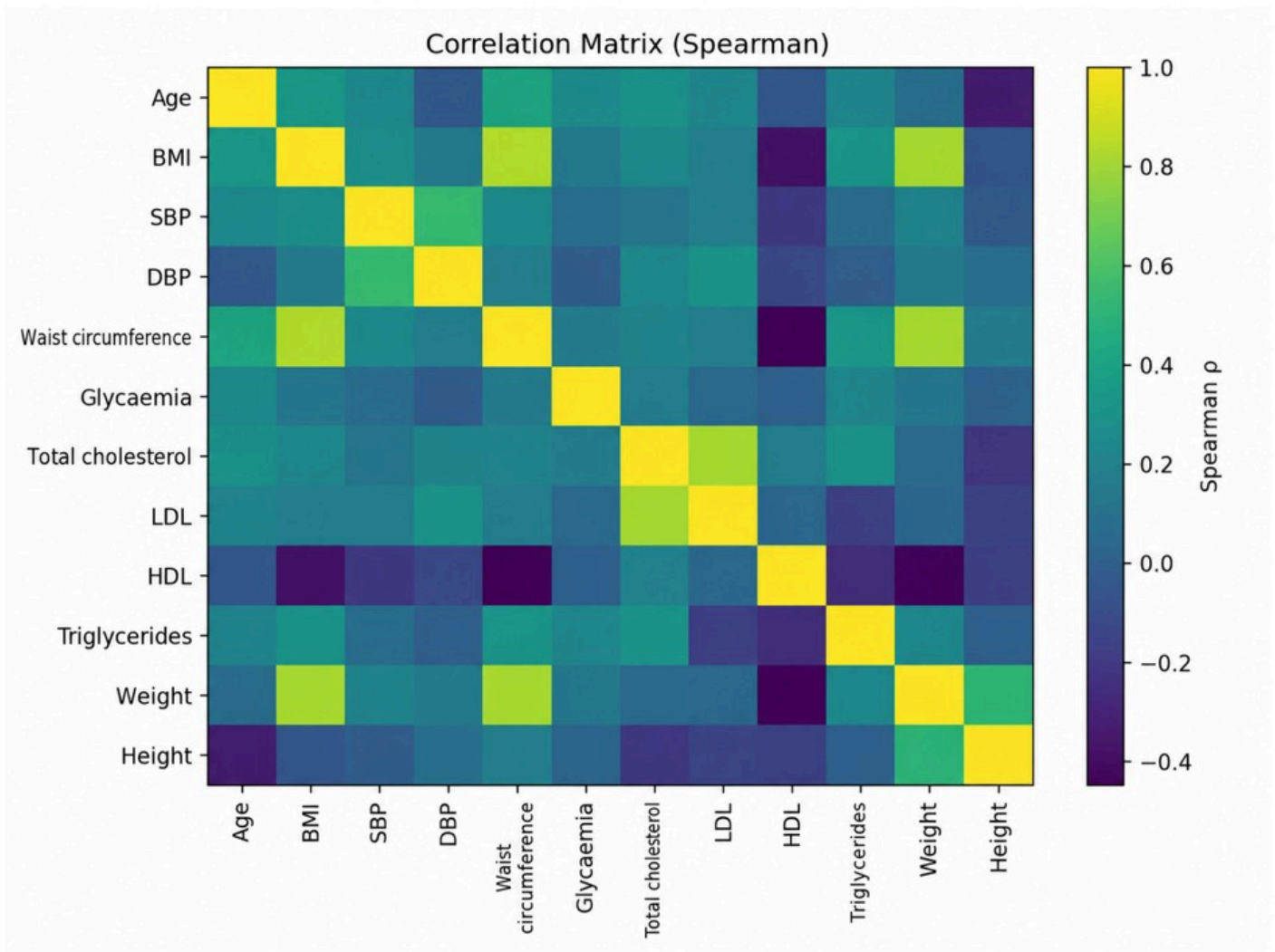


Figure 3

Spearman correlation matrix of selected continuous variables. The colour scale represents Spearman rho. Strong positive correlations were observed between body mass index and waist circumference (rho approximately 0.83) and between total cholesterol and LDL cholesterol (rho approximately 0.81).

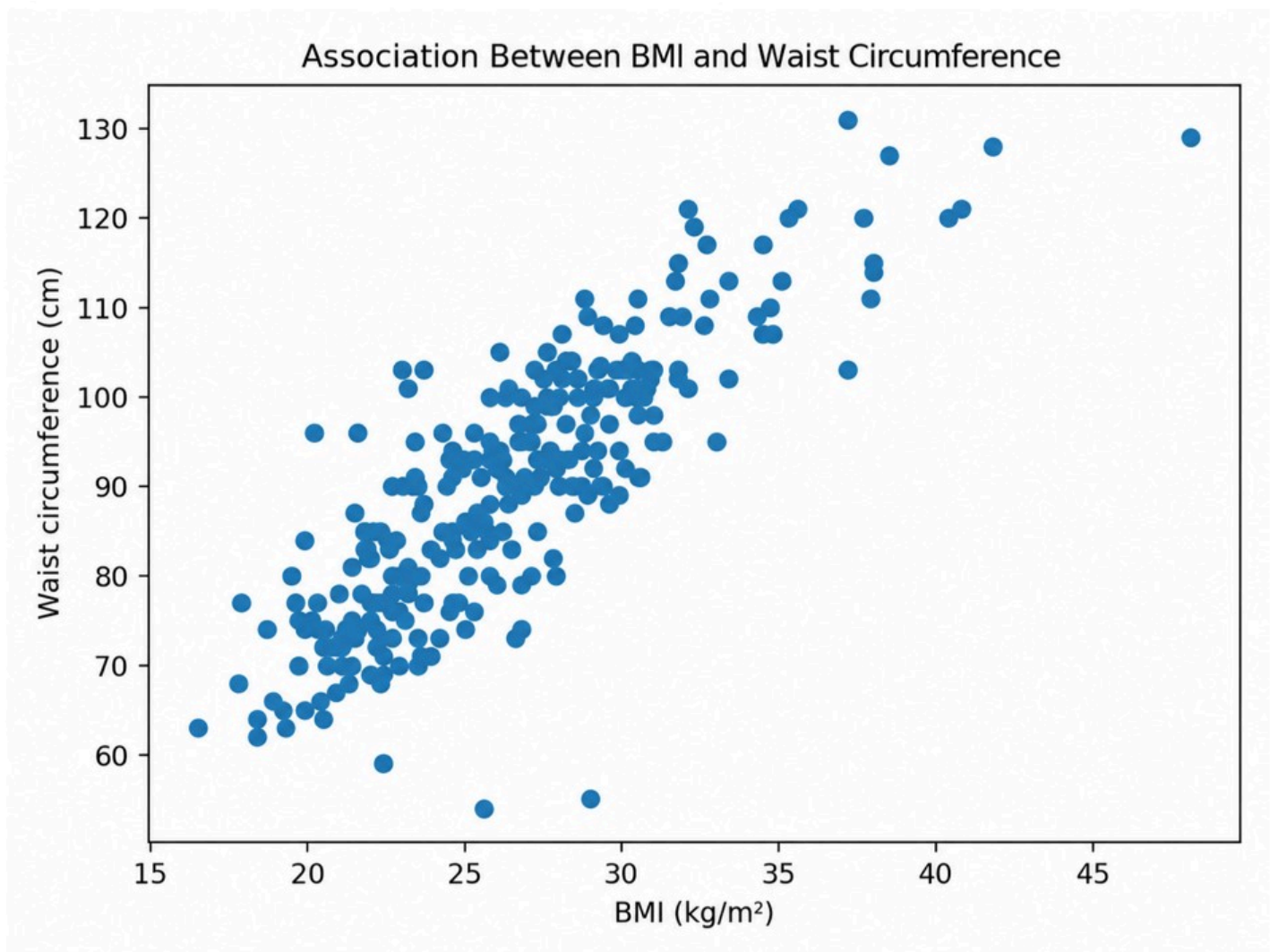


Figure 4

Association between body mass index and waist circumference. Each point represents one participant; a strong positive association was observed (Spearman rho=0.83; $p<0.001$).