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Letter to the Editor

Machine Learning Analysis of Blood Glucose Regulation in Korean Male Workers with Type 2 Diabetes

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Dear Editor-in-Chief

Type 2 Diabetes Mellitus (T2DM) poses a significant health challenge, with inadequate glycemic control leading to severe complications. Diabetes mellitus (DM) is a critical global health issue, with its incidence rising due to factors like aging populations, sedentary lifestyles, and dietary changes. In South Korea, the prevalence of DM among adults is significant (1), necessitating effective management strategies. Managing T2DM requires comprehensive self-care and lifestyle modifications alongside medical treatment to prevent complications. Recent advancements in machine learning, particularly SVM and regression techniques, offer new avenues for analyzing complex data sets to enhance predictive models and diabetes management (2).

The study investigated factors affecting blood glucose control in male workers with T2DM in South Korea, employing a hybrid machine learning model that combines Support Vector Machine (SVM) and regression analysis. Data from the Korea National Health and Nutrition Examination Survey (KNHANES) from 2017 to 2020 involving 1,012 male workers were utilized. The study's design involved analyzing data from the KNHANES, focusing on male workers with T2DM. The dataset underwent preprocessing including normalization of continuous variables and one-hot encoding of categorical data to optimize machine learning model performance. The SVM method was used to classify HbA1c levels, while linear regression quantified the impact of various factors on glycemic control. Performance metrics such as accuracy, precision, recall, and F1-score were employed to evaluate model efficacy.

The results indicate that 78.1% of the subjects had inadequate glycemic control (HbA1c $\geq$ 6.5%), influenced by factors such as younger age, higher BMI, hypertension, high cholesterol and triglyceride levels, depression, and stress. Lifestyle factors including smoking, alcohol consumption, physical inactivity, and lack of diabetes education were significant contributors. The integrated SVM-regression model achieved high predictive accuracy (85.4%), precision (82.1%), and recall (88.7%), highlighting machine learning's potential in personalized diabetes management strategies.

Descriptive statistics highlighted significant differences between well-controlled and poorly controlled groups concerning demographic, physiological, and lifestyle factors (Table 1).

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Table 1: Characteristics of the study population

Variable	Well-controlled (n=227)	Poorly controlled (n=785)	p
Age (yr)	55.8 ± 8.3	52.6 ± 7.7	<0.01
BMI (kg/m^2)	24.9 ± 3.2	27.5 ± 4.4	<0.01
Hypertension (%)	46.0	63.3	<0.01
Cholesterol (mg/dL)	189.8 ± 35.5	203.5 ± 40.2	<0.01
Triglycerides (mg/dL)	150.5 ± 45.5	178.8 ± 60.4	<0.01
Depression (%)	18.7	35.9	<0.01
Stress (%)	25.4	43.1	<0.01
Smoking (%)	23.2	36.4	<0.01
Alcohol consumption (%)	61.0	71.4	<0.01
Physical activity (%)	49.1	32.9	<0.01
Diabetes education (%)	28.7	18.2	<0.01

Also, the integrated SVM-regression model demonstrated robust predictive capabilities, with high accuracy and sensitivity in classifying and analyzing glycemic control. Regression analysis revealed that age, BMI, hypertension, cholesterol, triglycerides, depression, stress, smoking, alcohol consumption, physical activity, and diabetes education significantly influenced blood glucose regulation (Fig. 1).

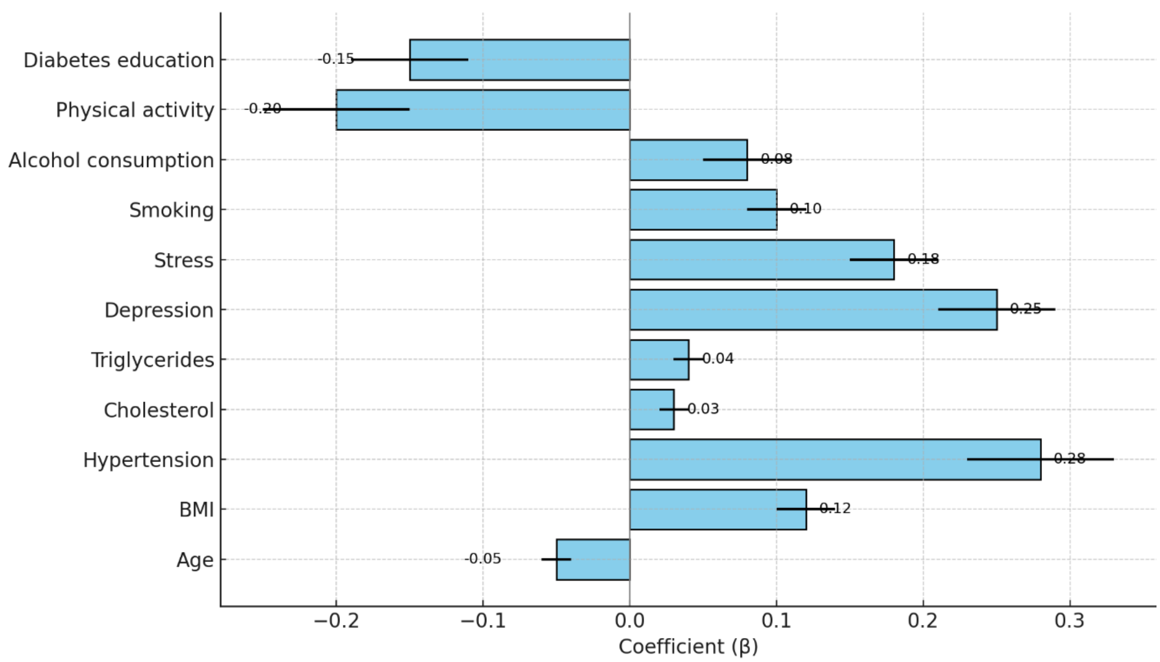

Fig. 1: Regression coefficients

By employing a hybrid machine learning framework that integrates SVM and regression analysis, the study identified that 78.1% of male workers had inadequate glycemic control. This highlights the urgent need for effective diabetes management strategies tailored to this demographic.

The use of SVM and regression analysis in diabetes research is growing, offering new possibilities for understanding complex datasets and uncovering patterns those traditional methods might miss

(1). These tools have shown strong potential in predicting health outcomes and identifying key risk factors, indicating a promising path for enhancing predictive models in diabetes management (2).

Age emerged as a significant determinant, with younger workers exhibiting poorer glycemic control, likely necessitating additional support and education (3). Physiological factors such as higher BMI, hypertension, cholesterol, and triglycerides were significantly linked to poorer glycemic outcomes (4). Psychological factors, notably depression and stress, also played crucial roles, suggesting the importance of integrating mental health support into diabetes care (5).

Lifestyle factors including smoking, alcohol consumption, physical activity, and diabetes education were critical in determining glycemic control. Smoking and alcohol were associated with poorer outcomes, while regular physical activity and diabetes education correlated with better management of blood glucose levels (6). This underscores the need for promoting healthy lifestyle behaviors and continuous education to empower patients in managing their diabetes effectively.

The integration of SVM and regression analysis provided a robust framework for identifying and quantifying factors affecting glycemic control. The study's findings have significant implications for clinical practice and public health interventions, emphasizing the need for targeted interventions, particularly for younger male workers. Tailored educational programs and support systems can enhance understanding of T2DM management, addressing both physiological and psychological needs.

Future research should address the limitations of this study, including its cross-sectional design and reliance on self-reported data, by employing longitudinal studies and incorporating objective measures. Expanding the focus beyond male workers to include diverse populations will enhance the generalizability of findings. These steps are crucial for refining diabetes management strategies and improving health outcomes.

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Conflict of Interest

The authors declare that there is no conflict of interests.

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