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ORIGINAL ARTICLE

Association of glycemic and lipid markers with fall risk, kinesiophobi and cardiopulmonary endurance in post-stroke diabetic patients

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ABSTRACT

Objectives: To determine the relationship between glycemic control (HbA1c, blood sugar random [BSR]) and serum triglycerides with risk of falls, kinesiophobia and cardiopulmonary endurance in post-stroke diabetic patients.

Methods: This correlational study was conducted from June 2022 to July 2023 at The Diabetic Centre, Pakistan Institute of Medical Sciences, Islamabad. A total of 226 post-stroke diabetic patients of both genders were recruited through non-probability purposive sampling. Assessments included glycemic and lipid profiles, the Tampa Scale for Kinesiophobia, the six-minute walk test, and the timed up-and-go test. The age range of 45 to 85 years was considered, including individuals who had recovered from stroke, excluding those with hematological disorders, co-morbidities, or neurological complications. For statistical analysis, Pearson correlational performed using SPSS-21.

Results: Out of the 226 subjects, 54% were female and 46% were male, with a mean age of 61±10 years and a mean body mass index of 24.8±5.26 kg/m^2. Serum triglyceride levels showed a negligible and non-significant correlation with the risk of falls and kinesiophobia (r=0.088, r=0.096; p>0.05, respectively), but a negligible negative relationship with cardiopulmonary endurance (r= -0.09; p < 0.05). Blood sugar random demonstrated a negative moderate relation with cardiopulmonary endurance (r=-0.3; p<0.05). HbA1c exhibited a moderate negative correlation with cardiopulmonary endurance (r= -0.50; p <0.05).

Conclusion: Among post-stroke diabetic patients, poor glycemic control, particularly elevated HbA1c, was significantly associated with higher fall risk, increased kinesiophobia, and reduced cardiopulmonary endurance. Routine monitoring and optimization of HbA1c may be critical in mitigating functional decline in this population.

Keywords: Blood Glucose (MeSH); Blood Glucose Random (Non-MeSH); Cardiopulmonary Endurance (Non-MeSH); Diabetes Mellitus (MeSH); Glycated Hemoglobin (MeSH); Post-stroke (MeSH); Risk of Fall (Non-MeSH); Risk (MeSH); Triglycerides (MeSH); Stroke (MeSH); Kinesiophobia (MeSH).

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INTRODUCTION

Stroke and diabetes mellitus (DM) are two major chronic diseases with profound impacts on global morbidity and mortality. Although distinct entities, both share overlapping vascular mechanisms and risk factors, such as hypertension and dyslipidemia, thereby increasing the incidence of cardiovascular disease and mortality worldwide.[1,2] Good glycemic control is particularly critical in post-stroke diabetic patients, as elevated blood glucose levels are closely associated with increased serum triglycerides, which in turn heighten the risk of cardiovascular complications and recurrent stroke.[3,4] This highlights the importance of stringent metabolic regulation in this vulnerable population.

Globally, DM is highly prevalent, affecting an estimated 415 million people in 2015, with projections indicating a rise to 642 million by 2040.[5] Among stroke survivors, diabetes is a common comorbidity, substantially influencing recovery, functional outcomes, and the risk of secondary complications.[6,7] Poor glycemic control not only predisposes to neurovascular disease but also complicates rehabilitation efforts.

Rehabilitation in post-stroke diabetic patients presents unique challenges. Kinesiophobia, the fear of movement, is a recognized psychological barrier that reduces participation in rehabilitation, often exacerbated by pain, risk of re-injury, and diabetes-related complications.[8,9] In addition, fall risk is increased due to impaired balance, muscle weakness, peripheral neuropathy, and reduced coordination, all of which are aggravated by diabetes-related vascular and metabolic dysfunction.[10,11] Cardiopulmonary endurance is also frequently compromised in this group, owing to limited physical activity, vascular damage, and metabolic dysregulation, underscoring the importance of targeted aerobic training to improve cardiovascular health and functional capacity.[12]

Despite the growing recognition of these interrelated challenges, limited evidence exists on the relationship between metabolic control (glycaemia and serum triglycerides) and rehabilitation outcomes, including fall risk, kinesiophobia, and cardiopulmonary endurance. Addressing this gap, the present study was conducted to determine the association of glycemic control and serum triglycerides with these outcomes in post-stroke diabetic patients.

METHODS

The correlation study was conducted

between June 2022 and July 2023 at The Diabetic Center and the Pakistan Institute of Medical Sciences (PIMS), Islamabad, Pakistan. Ethical approval was obtained from the Institutional Review Committee (Ref. No. Riphah/RCRS/REC/01446). The required sample size was calculated as 221 using the UCSF sample size calculator, with assumptions of correlation coefficient (r)=0.19, significance level (α) = 0.05, and power (1–β)=0.81.[13] These values were selected based on the expected strength of association from previous studies in comparable populations and the anticipated effect size relevant to the study's primary outcomes.

A non-probability purposive sampling technique was employed. Informed written consent was obtained from all participants. Eligible participants were males and females aged 45-85 years who had recovered from stroke and were diagnosed with diabetes mellitus. Patients unable to stand, those with other neurological comorbidities, or those suffering from insomnia were excluded.

Each participant underwent a comprehensive assessment that included evaluation of glycemic control, lipid profile, fall risk, kinesiophobia, and cardiopulmonary fitness. Data collection included random blood sugar, HbA1c, and triglyceride levels, alongside functional tests such as the tampa Scale for kinesiophobia, the Six-Minute Walk Test for cardiopulmonary endurance, and the timed up and go test for fall risk. Blood sugar estimation was carried out using the GOD-PAP enzymatic colorimetric method. HbA1c levels were analyzed on Cobas® C311 using the turbidimetric inhibition immunoassay (TINIA) method on hemolyzed whole blood. Triglyceride levels were also recorded.

Data were analyzed using SPSS version 22. Descriptive statistics (frequencies and percentages for categorical variables; means and standard deviations for continuous variables) were calculated. The Shapiro-Wilk test was used to assess normality. Parametric tests were applied to normally distributed data, while non-parametric tests were used for skewed data. Correlation and regression analyses were performed to explore associations among the study variables

RESULTS

A total of 226 participants were enrolled, with a mean age of 61.23± 10.19 years (range: 45-85 years). The mean BMI was 24.8±5.26 kg/m², ranging from 15.50 to 35.60 kg/m². The study population comprised slightly more females (54.0%) than males (46.0%). According to BMI categories, 17.3% of participants were underweight, 35.4% had a normal BMI, 27.0% were overweight, and 20.4% were obese.

Correlation analysis: The correlation of serum triglycerides with study outcomes revealed weak and statistically non-significant associations. A weak positive correlation was observed with risk of fall ®= 0.088, p= 0.18) and kinesiophobia (r=0.098, p= 0.14), while cardiopulmonary endurance showed a weak negative correlation (r=–0.09, p=0.89) [Table I].

Blood sugar random (BSR) demonstrated variable associations. There was a weak positive correlation with risk of fall (r=0.147, p=0.27) and a negligible correlation with kinesiophobia (r=0.040, p=0.547), both statistically non-significant. However, a moderate negative correlation with cardiopulmonary endurance (r=–0.32, p=0.02) was statistically significant, suggesting that higher BSR levels were associated with reduced cardiopulmonary endurance (Table I).

Analysis of HbA1c showed more notable findings. HbA1c exhibited a weak positive but non-significant correlation with risk of fall (r=0.195, p =0.070). A weak positive yet statistically significant correlation was found with kinesiophobia (r=0.121, p =0.030). Additionally, a moderate negative and significant correlation was observed between HbA1c and cardiopulmonary endurance (r = –0.50, p = 0.04), indicating that higher HbA1c levels were associated with lower endurance (Table I).

Regression analysis: Multiple regression analysis was conducted to identify predictors of fall risk, kinesiophobia, and cardiopulmonary endurance (Table II). HbA1c consistently emerged as a significant predictor across all outcomes. For risk of fall, HbA1c demonstrated a significant direct association (β=0.224, p=0.001). In relation to kinesiophobia, both BSR (β=0.148, p=0.009) and HbA1c (β=0.234, p=0.02) were significant predictors, indicating higher levels of both variables were associated with increased kinesiophobia. Regarding cardiopulmonary endurance, HbA1c showed a significant inverse association (β=–0.257, p=0.04), confirming its role in reduced endurance. Serum triglycerides and BSR, however, did not demonstrate significant predictive value for fall risk or cardiopulmonary endurance.

Table I: Correlation of serum triglycerides, blood sugar random, and HbA1c with risk of fall, kinesiophobia and cardiopulmonary endurance

Variable	Measure	Correlation (r)	p-value
Serum Triglyceride	Risk of Fall	0.088	0.18
	Kinesiophobia	0.098	0.14
	Cardiopulmonary Endurance	-0.09	0.89
Blood Sugar Random	Risk of Fall	0.147	0.27
	Kinesiophobia	0.040	0.547
	Cardiopulmonary Endurance	-0.32	0.02
HbA1c	Risk of	0.195	0.070
	Kinesiophobia	0.121	0.030
	Cardiopulmonary Endurance	-0.50	0.04

HbA1C: hemoglobin A1C

Table II: Multiple regression analysis of serum triglycerides, blood sugar random, and HbA1c as predictors of risk of fall, kinesiophobia and cardiopulmonary endurance

Dependent Variable	Independent Variable	Coefficient (β)	t-value	p-value
Risk of Fall	Serum Triglyceride	0.092	1.133	0.25
	BSR	-0.020	0.121	0.983
	HbA1c	0.224	3.21	0.001
Kinesiophobia	Serum Triglyceride	0.098	1.205	0.230
	BSR	0.148	1.946	0.009
	HbA1c	0.234	3.332	0.02
Cardiopulmonary Endurance	Serum Trigylceride	-0.04	-1.500	0.61
	BSR	-0.199	1.128	0.261
	HbA1c	-0.257	-0.790	0.04

HbA1C: hemoglobin A1C; BSR: Blood Sugar Random

DISCUSSION

This study aimed to examine the relationship between serum triglycerides, BSR, and HbA1c with fall risk, kinesiophobia, and cardiopulmonary endurance in post-stroke diabetic patients. The findings provide important insights into how metabolic markers interact with functional outcomes that are crucial for long-term recovery, rehabilitation, and quality of life in this vulnerable population.

Our results demonstrated a significant association between HbA1c and fall risk, indicating that higher HbA1c levels were linked to an increased probability of falls. This finding is consistent with previous studies showing that poor glycemic control, reflected by elevated HbA1c, contributes to impaired balance, reduced lower limb function, and heightened fall risk among diabetic and pre-diabetic populations.[14,15] The excessive and irrational fear of movement (kinesiophobia), a well-recognized barrier to rehabilitation, was also significantly associated with glycemic indices. Chronic hyperglycaemia may lead to muscle weakness and peripheral neuropathy-factors that increase the likelihood of falls in older adults and those with metabolic disorders.[16,17] In contrast, serum triglycerides and BSR did not exhibit significant correlations with fall risk, suggesting that their impact on physical balance may be indirect or comparatively less pronounced than HbA1c.

With respect to kinesiophobia, both BSR and HbA1c emerged as significant predictors, highlighting the role of poor glycemic control in the development of movement-related fear.[18] This aligns with existing evidence that patients with elevated glucose levels and chronic hyperglycaemia may experience reduced physical confidence and greater psychological barriers to movement due to fatigue, muscle weakness, and fear of falling.[19] Although serum triglycerides were not significantly correlated with kinesiophobia in this study, it remains plausible that other lipid-related parameters contribute to physical inactivity and anxiety about movement, warranting further investigation.

In terms of cardiopulmonary endurance, a significant inverse association was observed with HbA1c, confirming that higher HbA1c levels were linked with reduced endurance capacity. This finding corroborates earlier reports associating poor glycemic control with lower aerobic capacity and impaired cardiorespiratory health.[20,21] Elevated HbA1c may contribute to increased fatigue, reduced oxygen utilization, and diminished exercise tolerance, ultimately compromising endurance and overall physical performance.[22,23] Conversely, BSR and serum triglycerides did not demonstrate significant associations with endurance, which suggests that their effects may be mediated through other metabolic or cardiovascular mechanisms.

The regression models showed relatively low R^2 values, indicating that serum triglycerides, BSR, and HbA1c accounted for only a limited proportion of variance in fall risk, kinesiophobia, and cardiopulmonary endurance. This underscores the multifactorial nature of these outcomes, where additional factors such as muscle strength, joint stability, physical activity, and psychological determinants may play more prominent roles.

Overall, HbA1c emerged as the most consistent predictor, highlighting the central role of glycemic control in influencing fall risk, fear of movement, and endurance capacity among post-stroke diabetic patients. Clinically, this emphasizes the importance of regular monitoring and optimization of glycemic status as part of co-mprehensive rehabilitation. Integrating physical activity, psychological support, and metabolic management may reduce kinesiophobia, improve endurance, and enhance quality of life.

The study has limitations, including purposive sampling, a single-center design, and the potential influence of unmeasured confounders, which may limit generalizability. Future multi-center studies using probabilistic sampling are warranted to strengthen external validity.

To our knowledge, this is among the first studies to assess the combined impact of glycemic control and serum triglycerides on functional outcomes in post-stroke diabetic patients. By linking metabolic markers to rehabilitation-relevant outcomes, these findings provide new insights into post-stroke recovery and support the integration of metabolic monitoring into individualized rehabilitation strategies.

CONCLUSION

Higher HbA1c levels were significantly associated with increased fall risk, reduced cardiopulmonary endurance, and greater fear of movement, highlighting their central role in functional outcomes among post-stroke diabetic patients. In contrast, BSR and serum triglycerides showed no significant associations, suggesting a limited contribution to physical

performance measures. These findings emphasize the importance of maintaining optimal glycemic control to improve physical function, reduce fall risk, and enhance quality of life in this population. Future studies should investigate additional contributing factors and develop integrated interventions that combine metabolic management with structured rehabilitation strategies.

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AUTHORS' CONTRIBUTION

The Following authors have made substantial contributions to the manuscript as under:

SJ: Conception and study design, acquisition of data, drafting the manuscript, approval of the final version to be published

EI: Acquisition of data, drafting the manuscript, approval of the final version to be published

RF: Analysis and interpretation of data, critical review, approval of the final version to be published

RF: Conception and study design, critical review, approval of the final version to be published

EH: Conception and study design, drafting the manuscript, approval of the final version to be published

Authors agree to be accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved.

CONFLICT OF INTEREST

Authors declared no conflict of interest, whether financial or otherwise, that could influence the integrity, objectivity, or validity of their research work.

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DATA SHARING STATEMENT

The data that support the findings of this study are available from the corresponding author upon reasonable request

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