

Relationship of glycaemic control with endurance and fall risk in diabetics with and without cardiovascular diseases

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Abstract

Objective: To determine the relationship of blood glucose random and glycosylated haemoglobin with cardiopulmonary endurance and risk of fall in diabetic patients with and without cardiovascular disease.

Method: The correlational study was conducted at the Riphah College of Rehabilitation and Allied Health Sciences, Riphah International University (RIU), Islamabad, Pakistan, from September 2022 to August 2023. The sample was raised from The Diabetic Centre, Islamabad, and the Pakistan Ordnance Factories, Wah Cantonment, and comprised diabetic patients of either gender aged 45-65 years who were divided into group 1 with cardiovascular diseases and group 2 without cardiovascular diseases. To assess glycaemic control, blood glucose random and glycosylated haemoglobin levels were checked. The Berg balance scale was used for balance assessment, and the 6 minutes' walk test was used for cardiopulmonary endurance. Data was analysed using SPSS 23.

Results: Of the 204 patients with mean age 53.56 ± 6.39 years, 102(50%) were in group 1; 72(70.6%) females and 30(29.4%) males with mean age 54.50 ± 6.42 years. The remaining 102(50%) patients were in group 2; 61(59.8%) females and 41(40.2%) males with mean age 52.63 ± 6.25 years. There were statistically significant results in both groups regarding glycosylated haemoglobin, blood glucose random, risk of fall and cardiopulmonary endurance ($p < 0.05$), but correlational analysis in each group showed negligible correlation with ($p > 0.05$)

Conclusion: Increased blood glucose level was associated with increased risk of fall and reduced cardiopulmonary endurance.

Keywords: Balance, Cardiopulmonary endurance, Cardiovascular disease, Glycaemic control, Risk of fall, Type 2 diabetes. (JPMA 75: 1091; 2025) DOI: <https://doi.org/10.47391/JPMA.20005>

Introduction

Diabetes mellitus (DM) is one of the most prevalent non-communicable diseases (NCDs) as well as a predominant cause of morbidity and mortality worldwide.¹ DM is a chronic hyperglycaemic multisystem disorder that can be due to either genetic or metabolic dysfunction that leads to insulin resistance (IR) or insulin deficiency (ID).² Diabetes, aside from its immediate impact on glycaemic control, is associated with a multitude of consequences, including cardiovascular diseases (CVDs) and an increased risk of fall.^{3,4} CVDs are the leading cause of morbidity and mortality in DM patients, making the management of blood glucose levels a critical aspect of DM care.⁵ Furthermore, DM patients are more prone to falling due to multiple factors involved, such as neuropathy, muscle weakness and impaired proprioception.⁶ Blood glucose random (BSR) and glycosylated haemoglobin (HbA1c) have frequently been used as important indices of assessing glycaemic control for DM management. These factors must

be monitored to prevent DM-related complications.⁷ In recent years, there has been a rising interest in exploring the complex relationship of glycaemic control with other health-related outcomes in DM patients, such as cardiopulmonary endurance and risk of fall. However, the specific relationship of glycaemic control with the cardiopulmonary and musculoskeletal aspects of health is still being researched and investigated.

Cardiopulmonary endurance, which is frequently measured using maximal oxygen consumption (VO₂ max) as the marker, represents the circulatory and respiratory systems' ability to supply oxygen to working muscles during physical activity. It is an important indicator of total physical fitness and an important element in the treatment of CVDs.⁸ DM can interrupt the intricate sensory feedback system that assists the individuals in keeping their balance, resulting in impaired proprioception, neuromuscular derangement and an increased risk of fall.⁴ Establishing the relationship of glycaemic control with the risk of fall is essential for prescribing effective medication, exercises and preventive strategies to the diabetics. A study with 2,049 DM patients reported that there was an association between frailty and the risk of fall, with a noteworthy intensification of risk in susceptible groups, such as the elderly, those living in rural areas, and those with poor

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physical balance. The findings highlighted the need of fall prevention strategies, predominantly for at-risk individuals.⁹ Another study comparing type 2 DM (T2DM) patients to a control group showed a significant association of blood glucose levels with cardiopulmonary endurance. The study found that fasting plasma glucose (FPG) and postprandial plasma glucose (PPG) levels increased in the DM group, and cardiopulmonary functions decreased significantly.⁸

According to one study, DM prevalence in Pakistan is 15.8% and that of ischaemic heart disease is 17%. In T2DM, mitochondrial dysfunction and chronic inflammation contribute to reduced muscle endurance and increased fatigue. Elevated cytokines, like tumour necrosis factor- α (TNF- α) and interleukin-6 (IL-6) further exacerbate muscle weakness, while cardiovascular changes include decreased cardiac output, and limited oxygen delivery to the muscles. IR impairs glucose uptake, reducing energy availability and leading to early fatigue.¹⁰ Additionally, peripheral neuropathy affects balance by damaging sensory nerves, autonomic dysfunction causes instability, and musculoskeletal changes reduce strength and flexibility, all of which increase the risk of fall. Visual impairments from diabetic retinopathy (DR) further compromise stability.¹¹

The current study was planned to determine the relationship of BSR and HbA1c with cardiopulmonary endurance and risk of fall in DM patients with and without CVDs.

Patients and Methods

The cross-sectional, correlational study was conducted at the Riphah College of Rehabilitation and Allied Health Sciences, Riphah International University (RIU), Islamabad, Pakistan, from September 2022 to August 2023. The sample was raised from The Diabetic Centre, Islamabad, and the Pakistan Ordinance Factories, Wah Cantonment, and comprised DM patients who were divided into group 1 with CVDs and group 2 without CVD.

After approval from the ethics review committee of the Riphah College of Rehabilitation and Allied Health Sciences, Riphah International University (RIU), Islamabad, the sample size was calculated using the University of California, San Francisco (UCSF) calculator¹² with $\alpha=0.05$, $\beta(\beta)=0.20$ and $r=0.274$ in line with literature.¹³ The sample was raised using non-probability purposive sampling technique. Those included were DM patients of either gender aged 45-65 years with DM having been diagnosed at least 7 years ago, and, for group 1, a CVD diagnosis for at least 5 years. Those with neurological

complications or balance issues were excluded. Informed consent was taken from the participants prior to sample collection. Venous blood 5ml was aseptically drawn into sodium fluoride tubes (NaF) for assessing blood glucose level of all the subjects. After centrifugation at 3,000 revolutions per minute (rpm) for 5 minutes, glycaemic control was evaluated on the basis of HbA1c and RBS. Plasma glucose levels were determined via the glucose oxidase method using an automated analyser and relevant reagents (Selectra Pro M analyser, ELITechGroup, Puteaux, France using the reagent Merck, Darmstadt, Germany). HbA1c analysis was conducted on another automated analyser named (Roche Cobas C311), employing the turbidimetric inhibition immunoassay (TINIA) technique for haemolysed whole blood, ensuring standardised and precise assessments of HbA1c levels. The 6 Minute Walk Test (6MWT)¹⁴ for cardiopulmonary endurance, and the Berg Balance Scale (BBS)¹⁵ for assessing the risk of fall were used.

Data was analysed using SPSS 22. Data was expressed as frequencies and percentages. The relationship among the variables was assessed, and binary logistic regression was used to assess the variability between dichotomous dependant and independent variables. $P<0.05$ was considered significant.

Results

Of the 204 patients with mean age 53.56 ± 6.39 years, 102(50%) were I group 1; 72(70.6%) females and 30(29.4%) males with mean age 54.50 ± 6.42 years. The remaining 102(50%) patients were in group 2; 61(59.8%) females and 41(40.2%) males with mean age 52.63 ± 6.25 years (Table 1).

In group 1, HbA1c had negligible correlation with the risk of fall ($p=0.69$, $r=0.04$) and cardiopulmonary endurance ($p=0.01$, $r=-0.25$). In group 2, lower HbA1c levels were associated with improved balance ($p=0.12$, $r=-0.15$) and cardiopulmonary endurance ($p=0.18$, $r=-0.13$). BSR had non-significant correlation with cardiopulmonary endurance in group 1 ($p=0.78$, $r=0.028$) and group 2 ($p=0.81$, $r=0.023$). BSR's correlation with the risk of fall in both the groups was also noted (Table 2).

Table-1: Demographic data (n=204).

Variable		Mean \pm SD	
Total Population	Age of the diabetic participants with CVD	Total Population	54.50 \pm 6.42
Age (years)	Age of the diabetic participants without CVD	53.56 \pm 6.39	52.63 \pm 6.25
Gender		n (%)	
Males	With CVD	71 (34.8)	30 (29.4)
	Without CVD		41 (40.2)
Females	With CVD	133 (65.2)	72 (70.6)
	Without CVD	61 (59.8)	

SD: Standard Deviation; CVD: Cardiovascular disease.

Table-2: Correlation of HbA1c and BSR with the risk of fall and cardiopulmonary endurance in diabetic patients with and without CVD.

	Groups	Correlation Coefficient (r)	p-value
Correlation of HbA1c with risk of fall in diabetic patients	With CVD	0.040	0.691
	Without CVD	-0.153	0.124
Correlation of HbA1c with Cardiopulmonary endurance in diabetic patients	With CVD	-0.255	0.010
	Without CVD	-0.132	0.186
Correlation of BSR with Cardiopulmonary endurance in diabetic patients	With CVD	0.028	0.782
	Without CVD	0.023	0.817
Correlational of BSR with risk of fall in diabetic patients	With CVD	-0.269	0.006
	Without CVD	0.008	0.937

HbA1c: Glycosylated haemoglobin, BSR: Blood sugar random, CVD: Cardiovascular disease.

Table-3: Regression analysis of HbA1c, BSR, Berg Balance Scale (BBS) and cardiopulmonary endurance.

Step 1	B	S.E	Wald	p-value	Odds ratio	95%CI for EXP(B)	
						Lower	Upper
HbA1c	0.256	1.08	5.594	0.018	1.29	1.04	1.59
BSR	0.012	0.002	23.405	<0.001	1.01	1.00	1.01
BBS	-0.086	0.029	8.630	0.003	0.91	0.86	0.97
VO _{2max}	-0.090	0.045	4.058	0.044	0.91	0.83	0.99
Distance Covered (m)	-0.035	0.017	4.589	0.032	0.96	0.93	0.99
Distance predicted (m)	0.022	0.013	2.808	0.094	1.02	0.99	1.04

HbA1c: Glycosylated haemoglobin, BGR: Blood glucose random, VO_{2max}: Maximal oxygen consumption.

Logistic regression analysis showed that for every unit increase in HbA1c, the odds of poor outcomes increased by 29% in group 1 compared to group 2, and for every unit increase in BGR, the odds of poor outcomes increased significantly in group 1, while patients in group 1 were less likely to have better balance and cardiopulmonary endurance compared to group 2 (Table 3).

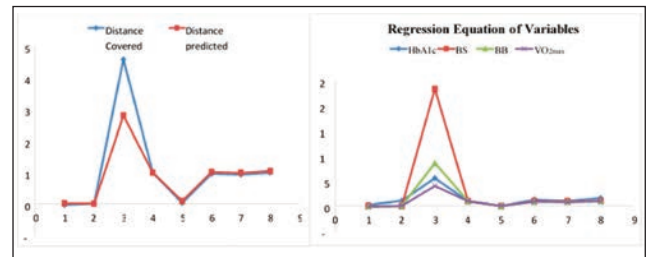
Discussion

Literature shows that cardiopulmonary endurance is inversely related to T2DM^{8,16} which supports the current findings. CVD patients with high BGR carry an increased risk of fall¹⁷ In the current study, the correlation of serum BGR with the risk of fall in CVD patients showed a negligible correlation with significant relationship ($p=0.006$).

According to a 2022 study, those with hypoglycaemia also had a high risk of fall (OR 6.64, $p < 0.001$)¹⁵ but in the current study, patients with hyperglycaemia had a higher risk of fall.

A study suggested that there was a significant correlation between HbA1c levels and VO_{2max}, which supports the current findings. Another study, in support of the current results, reported that CVDs and other micro- and macro-vascular problems are brought on by elevated blood glucose levels in T2DM, and that aerobic exercise training had substantial effects on HbA1c levels.¹⁸

The current study found the correlation between HbA1c

**Figure:** Graphical representation of regression equation of variables.

and the risk of fall in CVD patients to be negligible and non-significant relationship. A study in 2021 noted that HbA1c and BBS were significantly correlated ($p < 0.05$).¹⁹

In the current study the correlation of HbA1C with cardiopulmonary endurance in group 2 patients was negligible and non-significant, while the correlation of cardiopulmonary endurance with the risk of fall was also negligible and non-significant. In Figure, Regression analysis showed that those without CVD will have significantly improved balance and cardiopulmonary endurance. A 2021 study also reported that cardiopulmonary endurance was directly correlated with the risk of fall.²

The current findings should be interpreted with caution because of the observational design of the study. A primary limitation was the lack of control over confounding variables that could have affected the relationship involving glycaemic control, endurance and the risk of fall. Besides, the impact of age, an important factor in balance and endurance, was not directly addressed. Other possible confounders, such as medication adherence, physical activity and comorbid conditions, were also not assessed, and that might have influenced the results. Besides, the study used only two biomarkers, and was conducted in a specific geographical location.

Conclusion

Diabetic patients with increased BGR and HbA1c were more likely to have the risk of fall and reduced cardiopulmonary endurance, with those additionally having CVDs were at a significantly higher risk than those without CVD.

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References

1. Ramesh S, Kosalram K. The burden of non-communicable diseases: A scoping review focus on the context of India. *J Educ Health Promot* 2023;12:171. doi: 10.4103/jehp.jehp_1053_22.

2. Galicia-Garcia U, Benito-Vicente A, Jebari S, Larrea-Sebal A, Siddiqui H, Uribe KB, et al. Pathophysiology of type 2 diabetes mellitus. *Int J Mol Sci* 2020;21:6275. doi: 10.3390/ijms21176275.
3. Kiyani MM, Jahan S, Kiyani SK, Rehman H, Khan LG, Iqbal U. Erythrocyte sedimentation rate in diabetic and non-diabetic patients of cardiovascular disease. *J Teknol* 2019;8:18–22. doi: 10.29238/teknoljournal.v8i1.159.
4. Cheng Z, Li X, Xu H, Bao D, Mu C, Xing Q. Incidence of accidental falls and development of a fall risk prediction model among elderly patients with diabetes mellitus: A prospective cohort study. *J Clin Nurs* 2023;32:1398–409. doi: 10.1111/jocn.16371.
5. Jyotsna F, Ahmed A, Kumar K, Kaur P, Chaudhary MH, Kumar S, et al. Exploring the complex connection between diabetes and cardiovascular disease: Analyzing approaches to mitigate cardiovascular risk in patients with diabetes. *Cureus* 2023;15:e43567. doi: 10.7759/cureus.43567.
6. Rasmussen NH-H, Dal J, Jensen MH, Kvist AV, van den Bergh J, Hirata RP, et al. Impaired postural control in diabetes—a predictor of falls? *Arch Osteoporos* 2022;18:6. doi: 10.1007/s11657-022-01188-5.
7. Yuan Y, Zhou X, Jia W, Zhou J, Zhang F, Du J, et al. The association between self-monitoring of blood glucose and HbA1c in type 2 diabetes. *Front Endocrinol (Lausanne)* 2023;14:1056828. doi: 10.3389/fendo.2023.1056828.
8. Liu B-B, Niu Z-R, Jia X-J, Liu X-L, Lu Q. A correlational study on cardiopulmonary endurance in male patients with new-onset type 2 diabetes. *Diabetes Metab Syndr Obes* 2022;15:1365–73. doi: 10.2147/DMSO.S360317.
9. Wang X, Chen Z, Li Z, Chen B, Qi Y, Li G, et al. Association between frailty and risk of fall among diabetic patients. *Endocr Connect* 2020;9:1057–64. doi: 10.1530/EC-20-0362.
10. Sanches JM, Zhao LN, Salehi A, Wollheim CB, Kaldis PJ. Pathophysiology of type 2 diabetes and the impact of altered metabolic interorgan crosstalk. *FEBS J* 2023;290:620–48. doi: 10.1111/febs.16306.
11. Reeves ND, Orlando G, Brown SJ. Sensory-motor mechanisms increasing falls risk in diabetic peripheral neuropathy. *Medicina (Kaunas)* 2021;57:457. doi: 10.3390/medicina57050457.
12. Kohn M, Senyak J, Jarrett M. Sample size calculators for designing clinical research. UCSF CTSI. [Online] 2021 [Cited 2025 May 28]. Available from URL: <https://sample-size.net/>.
13. Stankute I, Dobrovolskiene R, Danyte E, Razanskaite-Virbickiene D, Jasinskiene E, Mockeviciene G, et al. Factors affecting cardiovascular risk in children, adolescents, and young adults with type 1 diabetes. *J Diabetes Res* 2019;2019:6742570. doi: 10.1155/2019/6742570.
14. Kammin EJ. The 6-minute walk test: Indications and guidelines for use in outpatient practices. *J Nurse Pract* 2022;18:608–10. doi: 10.1016/j.nurpra.2022.04.013.
15. Miranda N, Tiu TK. *Berg Balance Testing*. Treasure Island, FL: StatPearls Publishing; 2025.
16. Tarp J, Støle AP, Blond K, Grøntved A. Cardiorespiratory fitness, muscular strength and risk of type 2 diabetes: A systematic review and meta-analysis. *Diabetologia* 2019;62:1129–42. doi: 10.1007/s00125-019-4867-4.
17. Manemann SM, Chamberlain AM, Boyd CM, Miller DM, Poe KL, Chevillat A, et al. Fall risk and outcomes among patients hospitalized with cardiovascular disease in the community. *Circ Cardiovasc Qual Outcomes* 2018;11:e004199. doi: 10.1161/CIRCOUTCOMES.117.004199.
18. Kaur N, Singh S. Role of physiotherapy in managing type 2 diabetes mellitus: A systematic review. *J Diabetol* 2022;13:210–26. doi: 10.4103/jod.jod_61_22.
19. Yümin ET, Şimşek TT, Bakar Y. Plantar sensation and balance in patients with type 2 diabetes mellitus with and without peripheral neuropathy. *Acta Clin Croat* 2021;60:191–7. doi: 10.20471/acc.2021.60.02.06.
20. Ho H-H, Fang I-Y, Yu Y-C, Huang Y-P, Kuo I, Wang L-T, et al. Is functional fitness performance a useful predictor of risk of falls among community-dwelling older adults? *Arch Public Health* 2021;79:1–9. doi: 10.1186/s13690-021-00587-2.

Author Contribution:

SJ: Concept, data analysis, interpretation, drafting, revision, final approval and agreement to be accountable for all aspects of the work.

SF & AA: Design, data collection, analysis, drafting, final approval and agreement to be accountable for all aspects of the work.

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