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Glycemic control and its associated factors in hypertensive patients with type 2 diabetes

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Abstract. – OBJECTIVE: Inadequate glycemic control among patients with type 2 diabetes is growing worldwide. Earlier research studies investigated the predictors of poor glycemic control among patients with diabetes, but not among hypertensive patients who have type 2 diabetes as a comorbid disease. The aim of this study was to explore the factors associated with poor glycemic control in patients with type 2 diabetes and hypertension.

PATIENTS AND METHODS: In the present retrospective study, the medical records of two major hospitals were used to collect sociodemographic, biomedical, disease and medication-related information about patients with hypertension and type 2 diabetes. Binary regression analysis was conducted to find the predictors of the study outcome.

RESULTS: The data from 522 patients were collected. High physical activity (OR=2.232; 95% CI: 1.368-3.640; $p<0.01$), receiving insulin (OR=5.094; 95% CI: 3.213-8.076; $p<0.01$) or GLP1 receptor agonist (OR=2.057; 95% CI: 1.309-3.231; $p<0.01$) increased the odds of having controlled blood glucose. Increased age (OR=1.041; 95% CI: 1.013-1.070; $p<0.01$), elevated high-density lipoprotein (HDL) levels (OR=3.727; 95% CI: 1.959-7.092; $p<0.01$), and lower triglycerides (TGs) levels (OR=0.918; 95% CI: 0.874-0.965; $p<0.01$) were also associated with improved glycemic control among the study participants.

CONCLUSIONS: Most of the current study participants showed uncontrolled type 2 diabetes. Low physical activity, not receiving insulin or GLP1 receptor agonist, younger age, low HDL and high TG levels were independently associated with poor glycemic control. Future interventions should place a strong emphasis on the value of consistent physical activity and a stable lipid profile in enhancing glycemic control, particularly in younger patients and those who are not receiving insulin or GLP1 receptor agonist therapy.

Key Words:
Hypertension, Type 2 diabetes, Glycemic control, Intervention, Jordan.

Introduction

Glycemic control has a significant impact on patient's health outcomes and has a role in lowering the risk of microvascular and macrovascular complications of diabetes[1]. According to the United Kingdom Prospective Diabetes Study[1,2], each 1% decrease in glycosylated hemoglobin (HbA1c) was associated with 12-43% decrease in macrovascular complications, 14% reduction in myocardial infarction, 12% reduction in stroke, and 14% reduction in all-cause mortality in patients with type 2 diabetes[1], and 10% reduction in the risk for diabetes-related death[2]. Inadequate glycemic control has been recognized as a worldwide growing issue for patients with diabetes, with more than 60% of the patients are failing to achieve the desired glycemic target[3]. Previous research[4-6] emphasized on the importance of implementing interventions that enhance glycemic control in order to reduce healthcare expenses associated with worsening blood glucose control. An earlier cohort study reported that better glycemic control resulted in annual cost savings of $685-$950 per patient per year in the total healthcare costs of diabetes management[7].

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The literature reported inconsistent findings regarding the factors associated with poor glycemic control in diabetic patients. Age was identified as one of the significant predictors of poor glycemic control in multiple studies[8-10]. Lack of physical activity was significantly associated with poor glycemic control in other studies[10,11]. Furthermore, earlier studies[8,9,12,13] conducted in Malaysia[9], USA[8], Ethiopia[12], and Brazil[13] found that diabetic patients who had longer disease duration had significantly poorer glycemic control than those with shorter disease duration. A systematic review[14] revealed that longer duration of diabetes, low education level, poor medication adherence, poor attitude towards diabetes, and the existence of comorbid conditions were the main factors influencing glycemic control in patients with type 2 diabetes. The diversity in the determinants of glycemic control necessitates the need for additional research that recruit patients from various nations and cultures. Furthermore, in contrast with earlier research studies, the present study aimed to explore the factors associated with blood glucose control in hypertensive patients who have type 2 diabetes comorbidity. Findings of the present study should provide insight for diabetes management interventions, which aim at improving glycemic control and hence health outcomes among patients with hypertension and type 2 diabetes.

Patients and Methods

Study Design and Participants

The current retrospective study utilized the medical data of hypertensive patients who had type 2 diabetes as a comorbid disease in the period between November 2021 and May 2022. The study was conducted at two major Hospitals named King Abdullah University Hospital and the Royal Medical Services Hospital. Patients were included in the study if they were 18 years old or older, diagnosed with hypertension according to the 2017 ACC/AHA guidelines[15], diagnosed with type 2 diabetes according to the American Diabetes Association (ADA) diagnostic criteria (available at: https://diabetes.org/diabetes/a1c/diagnosis), received at least one antidiabetic medication, and had at least one glucose checkup visit in the last year. Patients who had type 1 diabetes, had hypertension urgency or emergency, pregnant women, and those who were taking medications, which may increase the blood pressure, were excluded from the study.

Data Collection

A custom-designed questionnaire and hospital data were used to collect sociodemographic information including age, gender, employment status, educational level, marital status, body weight, smoking, area of residency and physical activity. In addition to the prescribed medications, the medical data included HbA1c, fasting blood glucose, systolic blood pressure (SBP) total cholesterol, triglycerides (TG), high-density lipoprotein (HDL), low-density lipoprotein (LDL), glomerular filtration rate (GFR), family history of heart disease and family history of type 2 diabetes. The data also included the presence of comorbid diseases such as dyslipidemia, retinopathy, neuropath, nephropathy, peripheral artery disease, heart failure, cerebrovascular disease, ischemic heart disease, renal failure, foot damage, anxiety, depression, asthma, COPD, and the presence of proteinuria. The patients were considered to have uncontrolled hypertension if they had BP readings of ≥130/80[15], whereas those with HbA1c >7% were deemed to have uncontrolled blood glucose[16].

Statistical Analysis

Data was analyzed using the Statistical Package for Social Sciences (SPSS) version 26 (IBM Corp., Armonk, NY, USA). Continuous variables were presented as means and standard deviations, while categorical variables were presented as frequencies and percentages. Chi-square and Mann-Whitney U tests were used to determine the variables associated with blood glucose control. Variables with $p<0.2$ in the univariate analysis were included in the multivariate analysis. Binary regression model was conducted to explore the variables that are significantly and independently associated with the study outcome. Statistical significance was determined at $p<0.05$.

Results

Data were collected for 522 patients. The mean age was 62 (±10) years. Most of the participants were males (51.2%), retired/non-employed (67.1%), had low educational level (72.6%), married (78.2%), non-obese (68.6%), former/non-smokers (68.0%), living in urban areas (69.6%) and were not physically active (60.5%). The sample characteristics are presented in Table I.

As shown in Table II, the means of the systolic and diastolic BP were 134 (± 17) and 79 (± 9) respectively. Fasting serum glucose was elevated in many patients with a total sample mean of 170.14

Table I. Socio-demographic characteristics of the study participants (n=522).

		Frequency (%) or Mean (± SD)
Age		62 (± 10)
Gender	Female	255 (48.8%)
	Male	267 (51.2%)
Marital status	Married	408 (78.2%)
	Other	114 (21.8%)
Educational level	High	143 (27.4%)
	Low	379 (72.6%)
Employment status	Employees	172 (32.9%)
	Retired/non-employees	350 (67.1%)
Area of residency	Rural area	159 (30.4%)
	Urban area	363 (69.6%)
Smoking	Current smoker	167 (32.0%)
	Former/non-smoking	355 (68.0%)
Physical activity	No	316 (60.5%)
	Yes	206 (39.5%)
Obesity	Non-obese	358 (68.6%)
	Obese/overweight	164 (31.4%)

Table II. Biomedical variables and the prescribed medications for the study participants.

	Frequency (%) or Mean (± SD)	
Lab tests		
HbA1c	10.31% (±49.32)	
Fasting serum glucose (Mg/dL)	170.14 (±74.40)	
Systolic BP	134 (± 17)	
Diastolic BP	79 (± 9)	
Total cholesterol (Mmol/L)	4.76 (±8.21)	
TG (Mmol/L)	3.46 (±25.64)	
HDL (Mmol/L)	1.13 (±1.83)	
LDL (Mmol/L)	2.58 (±2.82)	
GFR	69.85 (±26.58)	
Medications	**No**	**Yes**
Receiving ACEI	391 (74.9%)	131 (25.1%)
Receiving ARBs	224 (42.9%)	298 (57.1%)
Receiving BB	238 (45.6%)	284 (54.4%)
Receiving CCB	303 (58.0%)	219 (42.0%)
Receiving Metformin	68 (13.0%)	454 (87.0%)
Receiving Insulin	237 (45.4%)	285 (54.6%)
Receiving Thiazide diuretics	330 (63.2%)	192 (36.8%)
Receiving DPP4 inhibitors	359 (68.8%)	163 (31.2%)
Receiving GLP1 receptor agonist	269 (51.5%)	253 (48.5%)
Receiving Meglitinides	519 (99.4%)	3 (0.6%)
Receiving SU	328 (62.8%)	194 (37.2%)
Receiving SGLT2 inhibitors	490 (93.9%)	32 (6.1%)

BP: Blood pressure, ACEI: angiotensin-converting enzyme inhibitor, ARB: angiotensin receptor blocker, BB: beta-blocker, CCB: calcium channel blocker, DPP4: dipeptidyl-peptidase 4, GLP1: glucagon-like peptide 1, SU: sulfonylurea, SGLT2: sodium-glucose cotransporter-2, TG: triglycerides, HDL: high-density lipoprotein, LDL: low-density lipoprotein, GFR: glomerular filtration rate.

mg/dl (±74.40). HbA1c mean was estimated as 10.31% (±49.32). The sample had low GFR with a mean of 69.85 (±26.58). The most prescribed medications were metformin (87.0%) and angiotensin receptor blockers (57.1%), followed by beta-blockers (54.4%). More details about laboratory tests and the prescribed medications are presented in Table II. As shown in Table III, the most common comorbid disease was dyslipidemia (72.0%). Most of the patients had microvascular complications (50.6%) and 45.2% had retinopathy. Most of the patients had uncontrolled BP (63.4%) and 51.3% had uncontrolled type 2 diabetes.

Univariate analysis results showed that age, HDL, TG, gender, employment status, educational level, material status, physical activity, microvascular complications, receiving CCB, receiving insulin, receiving metformin, receiving GLP1 receptor agonist, and BP control were significantly associated with type 2 diabetes control.

Table III. Medical characteristics of the study participants.

		Frequency (%) or Mean (± SD)
Family history of cardiac problems	No	463 (88.7%)
	Yes	59 (11.3%)
Family history of type 2 diabetes	No	438 (83.9%)
	Yes	84 (16.1%)
Having Dyslipidemia	No	146 (28.0%)
	Yes	376 (72.0%)
Having Microvascular complications	No	258 (49.4%)
	Yes	264 (50.6%)
Having Peripheral artery disease	No	504 (96.6%)
	Yes	18 (3.4%)
Having Heart failure	No	490 (93.9%)
	Yes	32 (6.1%)
Having cerebrovascular disease	No	454 (87.0%)
	Yes	68 (13.0%)
Having Ischemic heart disease	No	308 (59.0%)
	Yes	214 (41.0%)
Having Renal failure	No	460 (88.1%)
	Yes	62 (11.9%)
Presence of proteinuria on UA	No	375 (71.8%)
	Yes	147 (28.2%)
Having Retinopathy	No	286 (54.8%)
	Yes	236 (45.2%)
Having Neuropathy	No	428 (82.0%)
	Yes	94 (18.0%)
Having Foot damage	No	455 (87.2%)
	Yes	67 (12.8%)
Having Anxiety	No	407 (78.0%)
	Yes	115 (22.0%)
Having Depression	No	466 (89.3%)
	Yes	56 (10.7%)
Having Asthma	No	499 (95.6%)
	Yes	23 (4.4%)
Having COPD	No	510 (97.7%)
	Yes	12 (2.3%)
Blood glucose control	Controlled	254 (48.7%)
	Uncontrolled	268 (51.3%)
Blood pressure control	Controlled	191 (36.6%)
	Uncontrolled	331 (63.4%)

Table IV. Multivariate analysis results of the variables associated with glycemic control.

Variables	*p*-value	EXP(B)-OR	95% CI	
			Lower	Upper
Gender *Female vs. male*	0.806	0.943	0.589	1.508
Employment states *Employed vs. unemployed/retired*	0.571	1.181	0.665	2.098
Educational level *High vs. low*	0.250	0.722	0.414	1.258
Material status *Married vs. other statuses*	0.898	0.965	0.559	1.666
Physical activity** *high vs. low*	0.001	2.232	1.368	3.640
Microvascular complications *No vs. yes*	0.239	0.754	0.471	1.207
CCB *No vs. yes*	0.764	1.068	0.693	1.647
Insulin** *No vs. yes*	0.000	5.094	3.213	8.076
Metformin *No vs. yes*	0.126	0.573	0.281	1.168
GLP1 receptor agonist** *No vs. yes*	0.002	2.057	1.309	3.231
BP control *Controlled vs. uncontrolled*	0.175	1.348	0.876	2.074
Age*	0.004	1.041	1.013	1.070
HDL*	0.000	3.727	1.959	7.092
TG*	0.001	0.918	0.874	0.965

CCB: calcium channel blocker, GLP1: glucagon-like peptide 1, TG: triglycerides, HDL: high-density lipoprotein. *Significant at $p<0.05$. **Significant at $p<0.01$.

As shown in Table IV, results of the binary regression model showed that patients with high physical activity had higher odds of being in the controlled blood glucose group when compared with those who were not physically active (OR=2.232, 95% CI: 1.368-3.640, $p<0.01$). Patients who were receiving insulin (OR=5.094, 95% CI: 3.213-8.076, $p<0.01$) or GLP1 receptor agonist (OR=2.057, 95% CI: 1.309-3.231, $p<0.01$) had significantly higher odds to be in the controlled blood glucose group. Increased age (OR=1.041, 95% CI: 1.013-1.070, $p<0.01$) and elevated HDL (OR=3.727, 95% CI: 1.959-7.092, $p<0.01$) were also associated with increased odds of being in the controlled group, while elevated TG decreased the odds of being in the controlled blood glucose group (OR=0.918, 95% CI: 0.874-0.965, $p<0.01$).

Discussion

Poor glycemic control leads to several detrimental consequences, such as cognitive function impairment, increased healthcare expenses and prescription costs, and greater rates of hospitalization[6.17,18]. Investigating the factors that hinder approaching good glycemic control is crucial for improving health outcomes in patients with hypertension and type 2 diabetes.

Consistent with earlier research findings[9,12,19-22], the present study results showed poor glycemic control among the participating patients. However, the earlier studies focused solely on type 2 diabetes patients, whereas this study specifically targeted those with type 2 diabetes and hypertension as a comorbid disease. This, together with the paucity of research in the field, contributes to a deeper understanding of glycemic control in hypertensive patients with type 2 diabetes, and provides a broader picture of the key contributing variables that impede obtaining adequate glycemic control in this group of patients.

Low physical activity was significantly associated with poor glycemic control in the present study. Several studies[23-26] have confirmed the benefit of physical activity in terms of improving blood glucose control in patients with type 2 diabetes. Furthermore, a large multicenter study of over 18 thousand diabetic patients reported that physical activity was inversely associated with HbA1c, diabetic ketoacidosis, diabetes-related comorbidities, body mass index, dyslipidemia and hypertension[27]. Another study conducted in the United States reported that lowering physical activity impairs glycemic control even in healthy individuals[28]. Exercise helps boosting insulin sensitivity and increasing glucose uptake by skeletal cells[29], which make it a crucial non-pharmacologic therapy for diabetic patients[30,31].

The present study results showed that patients who were receiving insulin had significantly better glycemic control than those who were not. A study conducted in the United Kingdom[32] reported that adherence to insulin therapy was significantly associated with long-term metabolic control among patients with type 2 diabetes. Another study by Garvey et al[33] showed that using insulin partially reversed the post-binding defect in peripheral insulin action, produced near-normal basal hepatic glucose output and increased insulin secretion. Furthermore, insulin use has been also reported[34] to be associated with reduced frustration, improving mood and emotional well-being and quality of life in patients with type 2 diabetes. Insulin has also been reported[35] to exhibit anti-inflammatory effects that provide additional protection against the development of atherosclerosis. On the other hand, a cohort study of over 8,000 patients with type 2 diabetes showed that insulin initiation in patients with poorly controlled type 2 diabetes was safe and effective in achieving moderate glycemic control. However, it can increase resources utilization without achieving tight glycemic control, even in patients who were moderately controlled[36]. Therefore, clinicians should weigh the risks and advantages of insulin therapy in order to provide the most cost-effective therapeutic regimen that would tightly control glucose level and improve therapeutic outcomes on patients with type 2 diabetes.

The current study showed a significant association between GLP-1 receptor agonist use and glycemic control in patients with type 2 diabetes. GLP-1 receptor agonists represent a unique approach for lowering blood glucose by mimicking the action of endogenous GLP-1, which aids in glucose control by slowing gastric emptying, reducing appetite, improving satiety, reducing inappropriate glucagon secretion, and promoting beta-cells proliferation[37]. Additionally, the restoration of insulin secretory functions by GLP-1 receptor agonists has also been shown[38] to improve glycemic control in patients with type 2 diabetes. GLP-1 receptor agonists also help reducing body weight, lowering blood pressure, and improving endothelia in addition to blood glucose control, diabetes care should also focus on blood pressure control, weight loss, and avoiding hypoglycemia[40,41], which all can be met by using GLP-1 receptor agonists.

The present study showed that older patients were more likely to have better glycemic control than younger ones. Similarly, a retrospective cohort study[8], which enrolled over than 2,000 diabetic patients, reported that being under the age of 35 was associated with poor glycemic control. Another study[9] conducted in Malaysia found that each 1-year increase in age was associated with 3% increase in the likelihood of achieving good glycemic control among patients with type 2 diabetes. Other studies[19,42,43] showed that HbA1c levels were significantly higher in younger diabetic patients. On the other hand, contradictory results have been reported in other studies conducted in Brazil[20] and India[22]. Previous research[44] has indicated a strong correlation between young diabetics' high HbA1c values and their excessive consumption of fat and sugar, which highlights the need for improving the awareness about the negative impact of high fat and sugar intake on glycemic control and health outcomes in younger patients.

Elevated HDL levels have shown impressive effects on blood glucose level through different mechanisms including the stimulation of pancreatic β-cell insulin secretion and increasing glucose uptake by skeletal muscles[45], which is consistent with the current study and earlier research findings[46,47]. Furthermore, several epidemiologic studies[48,49] showed that low HDL level was associated with increased risk for type 2 diabetes. On the other hand, higher level of triglyceride was significantly associated with poor glycemic control in the present study, which is in line with the findings of other studies conducted in China[50] and USA[51].

Conclusions

The current study revealed a disappointing rate of poor glycemic control among hypertensive patients with type 2 diabetes. Low physical activity, nonuse of insulin or GLP-1 receptor agonist, younger age, lower HDL level, and elevated triglyceride level were associated with poor glycemic control in this study. Future intervention programs should place a strong emphasis on the value of consistent exercise and a stable lipid profile in enhancing glycemic control, especially in younger patients and those who are not receiving insulin or GLP1 agonist therapy.

Conflict of Interest

The authors declare that they have no conflict of interest.

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Authors' Contribution

All Authors contributed to the design if the study. ASJ conceived the study, validated instruments, wrote the initial draft of article, and supervised. WA validated instruments, organized, analyzed and interpreted data and reviewed the final draft of the article. SA designed the study, collected, organized, analyzed and interpreted data, and wrote initial and final draft of article. SRA designed the study, analyzed and interpreted data, wrote the initial and final draft of article. TLM conceived and designed the study, analyzed data, and reviewed the final draft of the article. RB conceived and designed the study, analyzed data, and reviewed the final draft of the article. SA Conceived and designed the study, supervised the project, reviewed the final draft of the article and provided logistic support. All authors have critically reviewed and approved the final draft of the study and agreed to be accountable for all aspects of the work.

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Data Availability Statement

The data generated and/or analyzed during the present study are available from the corresponding author on reasonable request.

Informed Consent

Not applicable, due to the retrospective nature of the study.

Ethics Approval

The study has been carried out in accordance with the Declaration of Helsinki (1964) for experiments involving human subjects. Ethical approval was obtained from the Institutional Review Board (IRB) of KAUH at Jordan University of Science and Technology (Ref. # 25/27/2021).

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References

1) Stratton IM, Adler AI, Neil HAW, Matthews DR, Manley SE, Cull CA, Hadden D, Turner RC, Holman RR. Association of glycaemia with macrovascular and microvascular complications of type 2 diabetes (UKPDS 35): prospective observational study. BMJ 2000; 321: 405-412.
2) Turner R. Intensive blood-glucose control with sulphonylureas or insulin compared with conventional treatment and risk of complications in patients with type 2 diabetes (UKPDS 33). Lancet 1998; 352: 837-853.
3) Del Prato S, Felton AM, Munro N, Nesto R, Zimmet P, Zinman B, Alberti G, Aschner P, Bailey C, Blonde L, Goldstein B, Gomis R, Horton E, LaSalle J, Lee HK, Leiter L, Matthaei S, McGill M. Improving glucose management: Ten steps to get more patients with type 2 diabetes to glycaemic goal. Int J Clin Pract 2005; 59: 1345-1355.
4) Bansal M, Shah M, Reilly B, Willman S, Gill M, Kaufman FR. Impact of Reducing Glycated Hemoglobin on Healthcare Costs Among a Population with Uncontrolled Diabetes. Appl Heal Econ Heal Policy 2018; 16: 675-684.
5) Banerji MA, Dunn JD. Impact of Glycemic Control on Healthcare Resource Utilization and Costs of Type 2 Diabetes: Current and Future Pharmacologic Approaches to Improving Outcomes. Am Heal Drug Benefits 2013; 6: 382-392.
6) Mata-Cases M, Rodríguez-Sánchez B, Mauricio D, Real J, Vlacho B, Franch-Nadal J, Oliva J. The Association Between Poor Glycemic Control and Health Care Costs in People With Diabetes: A Population-Based Study. Diabetes Care 2020; 43: 751-758.
7) Wagner EH, Sandhu N, Newton KM, McCulloch DK, Ramsey SD, Grothaus LC. Effect of improved glycemic control on health care costs and utilization. JAMA 2001; 285: 182-189.
8) Juarez DT, Sentell T, Tokumaru S, Goo R, Davis JW, Mau MM. Factors Associated With Poor Glycemic Control or Wide Glycemic Variability Among Diabetes Patients in Hawaii, 2006-2009. Prev Chronic Dis 2012; 9.

9) Ahmad NS, Islahudin F, Paraidathathu T. Factors associated with good glycemic control among patients with type 2 diabetes mellitus. J Diabetes Investig 2014; 5: 563-569.
10) Fekadu G, Bula K, Bayisa G, Turi E, Tolossa T, Kasaye HK. Challenges And Factors Associated With Poor Glycemic Control Among Type 2 Diabetes Mellitus Patients At Nekemte Referral Hospital, Western Ethiopia. J Multidiscip Healthc 2019; 12: 963-974.
11) Ahn J, Yang Y. Factors Associated with Poor Glycemic Control Amongst Rural Residents with Diabetes in Korea. Healthc 2021; 9: 391-401.
12) Fiseha T, Alemayehu E, Kassahun W, Adamu A, Gebreweld A. Factors associated with glycemic control among diabetic adult out-patients in Northeast Ethiopia. BMC Res Notes 2018; 11: 316-321.
13) Gonçalves da Silva D, Alberto Simeoni L, Amorim Amato A. Factors Associated with Poor Glycemic Control among Patients with Type 2 Diabetes in the Southeast Region of Brazil. Int J Diabetes Res 2018; 8: 36-40.
14) Alramadan MJ, Afroz A, Hussain SM, Batais MA, Almigbal TH, Al-Humrani HA, Albaloshi A, Romero L, Magliano DJ, Billah B. Patient-related determinants of glycaemic control in people with type 2 diabetes in the gulf cooperation council countries: A systematic review. J Diabetes Res 2018; 2018.
15) Flack JM, Calhoun D, Schiffrin EL. The New ACC/AHA Hypertension Guidelines for the Prevention, Detection, Evaluation, and Management of High Blood Pressure in Adults. Am J Hypertens 2018; 31: 133-135.
16) American Diabetes Association. 6. Glycemic Targets: Standards of Medical Care in Diabetes—2020. Diabetes Care 2020; 43: S66-76.
17) Hamarneh D, Alkhatib N, Denhaerynck K, Vancayzeele S, Brié H, MacDonald K, Abraham I. Gender-stratified hierarchical modeling of patient and physician determinants of antihypertensive treatment outcomes: pooled analysis of seven prospective real-world studies with 17,044 patients. Curr Med Res Opin 2021; 37: 367-375.
18) Maan HB, Meo SA, Rouq FA, Meo IMU. Impact of Glycated Hemoglobin (HbA1c) on cognitive functions in Type 2 diabetic patients. Eur Rev Med Pharmacol Sci 2021; 25: 5978-5985.
19) Badedi M, Solan Y, Darraj H, Sabai A, Mahfouz M, Alamodi S, Alsabaani A. Factors Associated with Long-Term Control of Type 2 Diabetes Mellitus. J Diabetes Res 2016; 2016: 1-8.
20) Rossaneis MA, De Andrade SM, Gvozd R, Pissinati P de SC, Haddad M do CL. Factors associated with glycemic control in people with diabetes mellitus. Cienc e Saude Coletiva 2019; 24: 997-1006.
21) Khattab M, Khader YS, Al-Khawaldeh A, Ajlouni K. Factors associated with poor glycemic control among patients with Type 2 diabetes. J Diabetes Complications 2010; 24: 84-89.
22) Kakade AA, Mohanty I, Rai S. Assessment of factors associated with poor glycemic control among patients with Type II Diabetes mellitus. Integr Obes Diabetes 2018; 4.
23) Zhu X, Zhao L, Chen J, Lin C, Lv F, Hu S, Cai X, Zhang L, Ji L. The Effect of Physical Activity on Glycemic Variability in Patients With Diabetes: A Systematic Review and Meta-Analysis of Randomized Controlled Trials. Front Endocrinol (Lausanne) 2021; 12: 767152.
24) Borror A, Zieff G, Battaglini C, Stoner L. The Effects of Postprandial Exercise on Glucose Control in Individuals with Type 2 Diabetes: A Systematic Review. Sport Med 2018; 48: 1479-1491.
25) Yao WY, Han MG, De Vito G, Fang H, Xia Q, Chen Y, Liu X, Wei Y, Rothman RL, Xu WH. Physical Activity and Glycemic Control Status in Chinese Patients with Type 2 Diabetes: A Secondary Analysis of a Randomized Controlled Trial. Int J Environ Res Public Health 2021; 18: 4292.
26) Dempsey PC, Larsen RN, Sethi P, Sacre JW, Straznicky NE, Cohen ND, Cerin E, Lambert GW, Owen N, Kingwell BA, Dunstan DW. Benefits for Type 2 Diabetes of Interrupting Prolonged Sitting With Brief Bouts of Light Walking or Simple Resistance Activities. Diabetes Care 2016; 39: 964-972.
27) Bohn B, Initiative for the D, Herbst A, Initiative for the D, Pfeifer M, Initiative for the D, Krakow D, Initiative for the D, Zimny S, Initiative for the D, Kopp F, Initiative for the D, Melmer A, Initiative for the D, Steinacker JM, Initiative for the D, Holl RW, Initiative for the D. Impact of Physical Activity on Glycemic Control and Prevalence of Cardiovascular Risk Factors in Adults With Type 1 Diabetes: A Cross-sectional Multicenter Study of 18,028 Patients. Diabetes Care 2015; 38: 1536-1543.
28) Mikus CR, Oberlin DJ, Libla JL, Taylor AM, Booth FW, Thyfault JP. Lowering Physical Activity Impairs Glycemic Control in Healthy Volunteers. Med Sci Sports Exerc 2012; 44: 225.
29) Holloszy JO. Exercise-induced increase in muscle insulin sensitivity. J Appl Physiol (1985) 2005; 99: 338-343.
30) Cosentino F, Grant PJ, Aboyans V, Bailey CJ, Ceriello A, Delgado V, Federici M, Filippatos G, Grobbee DE, Hansen TB, Huikuri H V., Johansson I, Juni P, Lettino M, Marx N, Mellbin LG, Ostgren CJ, Rocca B, Roffi M, Sattar N, Seferovic PM, Sousa-Uva M, Valensi P, Wheeler DC, Piepoli MF, Birkeland KI, Adamopoulos S, Ajjan R, Avogaro A, Baigent C, Brodmann M, Bueno H, Ceconi C, Chioncel O, Coats A, Collet JP, Collins P, Cosyns B, Di Mario C, Fisher M, Fitzsimons D, Halvorsen S, Hansen D, Hoes A, Holt RIG, Home P, Katus HA, Khunti K, Komajda M, Lambrinou E, Landmesser U, Lewis BS, Linde C, Lorusso R, Mach F, Mueller C, Neumann FJ, Persson F, Petersen SE, Petronio AS, Richter DJ, Rosano GMC, Rossing P, Rydén L, Shlyakhto E, Simpson IA, Touyz RM, Wijns W, Wilhelm M, Williams B, Windecker S, Dean V, Gale CP, Hindricks G, Iung B, Leclercq C, Merkely B, Zelveian PH, Scherr D, Jahangirov T, Lazareva I, Shivalkar B, Naser N, Gruev I, Milicic D, Petrou PM, Linhart A, Hildebrandt P, Hasan-Ali H, Marandi T, Lehto S, Mansourati J, Kurashvili R, Siasos G, Lengyel C, Thrainsdottir IS, Aronson D, Di Lenar-

da A, Raissova A, Ibrahimi P, Abilova S, Trusinskis K, Saade G, Benlamin H, Petrulioniene Z, Banu C, Magri CJ, David L, Boskovic A, Alami M, Liem AH, Bosevski M, Svingen GFT, Janion M, Gavina C, Vinereanu D, Nedogoda S, Mancini T, Ilic MD, Fabryova L, Fras Z, Jiménez-Navarro MF, Norhammar A, Lehmann R, Mourali MS, Ural D, Nesukay E, Chowdhury TA. 2019 ESC Guidelines on diabetes, pre-diabetes, and cardiovascular diseases developed in collaboration with the EASDThe Task Force for diabetes, pre-diabetes, and cardiovascular diseases of the European Society of Cardiology (ESC) and the European Association for the Study of Diabetes (EASD). Eur Heart J 2020; 41: 255-323.

31) American Diabetes Association. 5. Facilitating Behavior Change and Well-being to Improve Health Outcomes: Standards of Medical Care in Diabetes—2021. Diabetes Care 2021; 44: S53-72.
32) Donnelly LA, Morris AD, Evans JMM. Adherence to insulin and its association with glycaemic control in patients with type 2 diabetes. QJM 2007; 100: 345-350.
33) Garvey WT, Olefsky JM, Griffin J, Hamman RF, Kolterman OG. The Effect of Insulin Treatment on Insulin Secretion and Insulin Action in Type II Diabetes Mellitus. Diabetes 1985; 34: 222-234.
34) Vieira G. Using Insulin for Type 2 Diabetes: Benefits Beyond Your A1c - Beyond Type 2 [Internet]. 2022 [cited 2022 Aug 28]. Available from: https://beyondtype2.org/benefits-of-insulin-beyond-a1c/
35) Caballero AE. Long-term benefits of insulin therapy and glycemic control in overweight and obese adults with type 2 diabetes. J Diabetes Complications 2009; 23: 143-152.
36) Hayward RA, Manning WG, Kaplan SH, Wagner EH, Greenfield S. Starting Insulin Therapy in Patients With Type 2 Diabetes: Effectiveness, Complications, and Resource Utilization. JAMA 1997; 278: 1663-1669.
37) Lee YS, Jun HS. Anti-diabetic actions of glucagon-like peptide-1 on pancreatic beta-cells. Metabolism 2014; 63: 9-19.
38) Garber AJ. Long-acting glucagon-like peptide 1 receptor agonists: A review of their efficacy and tolerability. Diabetes Care 2011; 34: S279-S284.
39) Prasad-Reddy L, Isaacs D. A clinical review of GLP-1 receptor agonists: efficacy and safety in diabetes and beyond. Drugs Context 2015; 4: 212283.
40) Rodbard HW, Jellinger PS, Davidson JA, Einhorn D, Garber AJ, Grunberger G, Handelsman Y, Horton ES, Lebovitz H, Levy P, Moghissi ES, Schwartz SS. Statement by an American Association of Clinical Endocrinologists/American College of Endocrinology consensus panel on type 2 diabetes mellitus: an algorithm for glycemic control. Endocr Pract 2009; 15: 540-559.
41) Nathan DM, Buse JB, Davidson MB, Ferrannini E, Holman RR, Sherwin R, Zinman B. Medical management of hyperglycaemia in type 2 diabetes mellitus: a consensus algorithm for the initiation and adjustment of therapy: a consensus statement from the American Diabetes Association and the European Association for the Study of Diabetes. Diabetologia 2009; 52: 17-30.
42) Morkos M, Tahsin B, Fogelfeld L. Factors Associated with Diabetes Control in Predominately African American and Hispanic Population with Newly Diagnosed Type 2 Diabetes. J Racial Ethn Heal Disparities 2020; 8: 332-338.
43) Eid M, Mafauzy M, Faridah AR. Glycaemic Control of Type 2 Diabetic Patients on Follow Up at Hospital Universiti Sains Malaysia. Malays J Med Sci 2003; 10: 40-49.
44) Carter JS, Gilliland SS, Perez GE, Skipper B, Gilliland FD. Public health and clinical implications of high hemoglobin A1c levels and weight in younger adult Native American people with diabetes. Arch Intern Med 2000; 160: 3471-3476.
45) Fryirs MA, Barter PJ, Appavoo M, Tuch BE, Tabet F, Heather AK, Rye KA. Effects of high-density lipoproteins on pancreatic beta-cell insulin secretion. Arterioscler Thromb Vasc Biol 2010; 30: 1642-1648.
46) Huang R, Yan L, Lei Y. The relationship between high-density lipoprotein cholesterol (HDL-C) and glycosylated hemoglobin in diabetic patients aged 20 or above: a cross-sectional study. BMC Endocr Disord 2021; 21: 1-8.
47) Wang S, Ji X, Zhang Z, Xue F. Relationship between Lipid Profiles and Glycemic Control Among Patients with Type 2 Diabetes in Qingdao, China. Int J Environ Res Public Health 2020; 17: 1-11.
48) Hirano M, Nakanishi S, Kubota M, Maeda S, Yoneda M, Yamane K, Kira S, Sasaki H, Kohno N. Low high-density lipoprotein cholesterol level is a significant risk factor for development of type 2 diabetes: Data from the Hawaii-Los Angeles-Hiroshima study. J Diabetes Investig 2014; 5: 501-506.
49) Wilson PWF, Meigs JB, Sullivan L, Fox CS, Nathan DM, D'Agostino RB. Prediction of incident diabetes mellitus in middle-aged adults: the Framingham Offspring Study. Arch Intern Med 2007; 167: 1068-1074.
50) Zheng D, Dou J, Liu G, Pan Y, Yan Y, Liu F, Gaisano HY, Lu J, He Y. Association Between Triglyceride Level and Glycemic Control Among Insulin-Treated Patients With Type 2 Diabetes. J Clin Endocrinol Metab 2019; 104: 1211-1220.
51) Davidson MB, Hu T, Sain G, Hoar B, Stevenson C, Hoogwerf BJ. The relationship of glycaemic control and triglycerides in patients with diabetes mellitus: A PreCIS Database Study. Diabetes, Obes Metab 2009; 11: 118-122.