# Correlation Between HbA1c and Body Mass Index Among Patients with High Lipid Profile Attending Johns Hopkins Aramco Healthcare Hospital in Saudi Arabia

Omer Kheir[1], Sheikha Dossary[1], Mohammad Dhalaan[1], Salman AlHajri[1], Ali Aljeshi[1], Raseel Wali Dawoud[1], Mohammad Ghamdi[1]

1 Johns Hopkins Aramco Healthcare

## Abstract

**Background:** Dyslipidemia is a modifiable risk factor for cardiovascular diseases, diabetes, and stroke. Obesity and elevated HbA1c levels are both risk factors for cardiovascular diseases.

**Objectives:** The main objective of this study was to examine the relationship between HbA1C and body mass index among patients with high lipid profiles.

**Methods:** This retrospective, hospital-based study was conducted at Johns Hopkins Aramco Healthcare Facilities. Data were extracted from medical health records and included demographics, lipid profiles, and HbA1c measurements. The study included 2368 non-diabetic participants, and DATAtab was used to analyze the data.

**Results:** The participants were 57.05% male and 78.42% Saudi. The mean age was $41.48\pm12.1$ years, and the mean body mass index was $28.44\pm5.53$. There was a statistically significant relationship between the use of lipid lowering medicine and HbA1c ($P<0.001$). There was a very weak positive but statistically significant relationship between HbA1c and body mass index ($r = 0.18$, $P<0.001$). HbA1c and systolic blood pressure appeared to have a statistically significant positive association ($r = 0.16$, $P< 0.001$). There was no correlation between HbA1c and low-density lipoprotein cholesterol, total cholesterol, or diastolic blood pressure. There was an inverse correlation between HbA1c and high-density lipoprotein cholesterol ($r = -0.11$, $P< 0.001$). Regression was performed using a linear multivariable analysis with HbA1c as the dependent variable and age (B 0.192, $P<0.001$), body mass index (B 0.119, $P<0.001$), high-density lipoprotein cholesterol (B -0.058, $P<0.005$), triglyceride (B 0.093, $P<0.001$), lipid-lowering medication (B 0.104, $P<0.001$), and systolic blood pressure (B 0.060, $P< 0.003$) as independent variables.

**Conclusion:** The results indicated that HbA1c is linked to body mass index, age, systolic blood pressure, triglycerides, and high-density lipoprotein cholesterol levels. There was no correlation between HbA1c and low-density lipoprotein cholesterol, total cholesterol, or diastolic blood pressure.

**Keywords:** Lipid Profile, HbA1c, BMI, Cross-sectional, Triglyceride, Saudi Arabia.

## Introduction

Elevated levels of total cholesterol (TC), triglycerides (TG), low-density lipoprotein cholesterol (LDL-C), and/or reduced levels of high-density lipoprotein cholesterol (HDL-C) are characteristics of the metabolic abnormality known as dyslipidaemia, which affects plasma lipids and lipoproteins. It is the main independent modifiable risk for cardiovascular disease (CVD), diabetes, and stroke and a leading source of morbidity and mortality [1][2][3][4][5]. Dyslipidemia causes 54% of the population's direct risk for myocardial infarction [6][7]. According to a study by the World Health Organization (WHO), high cholesterol levels cause 4.5% of worldwide deaths and 2% of disability-adjusted life years (DALYs) in people aged 18 years and over [8]. In a 2005 cross-sectional survey of the Saudi population aged 15-64 years, the prevalence of elevated total cholesterol was 20%, and the prevalence of dyslipidaemia ranged between 20 and 40% [9][10]. A study on the prevalence of dyslipidaemia among young people in all 13 districts of Saudi Arabia discovered that one in every four Saudi adolescents has dyslipidemia [11].

In patients with diabetes mellitus (DM), HbA1c predicts the likelihood of developing diabetic complications [12]. Elevated HbA1c is a risk factor for CVD and is distinct from conventional risk factors like dyslipidaemia [13]. According to estimates, the chance of CVD increases by 18% in the diabetic population for every 1% increase in absolute HbA1c levels. Even within the normal range of HbA1c, non-diabetic cases have shown this positive association between HbA1c and CVD [12][14][15]. Body Mass Index (BMI) is a valuable population-level indicator of overweight and obesity [16]. Being overweight or obese can lead to a variety of chronic conditions. Besides, multiple studies have found that a high BMI has been connected to increased mortality and morbidity in the elderly [17][18]. Obesity is a risk factor for the development of cardiovascular disease, although research shows that much of this influence is accounted for by obesity triggering dyslipidemia, diabetes, hypertension, inflammation, and a procoagulant condition. [19][20]

Therefore, the main aim of this study was to identify the correlation between HbA1c and body mass index (BMI) among patients with a high lipid profile, as well as to evaluate the importance of HbA1c as an indicator for dyslipidemia. It displays important information about an individual's overall metabolic health. This study will help in decision making, provide a baseline for evaluation, and help to develop a plan for recruiting patients for prevention and lifestyle-management programs. Also, allowing for early risk assessment and diagnosis of diabetes among individuals with a high lipid profile.

## Materials and Methods

### Study Design, Settings, and Participants

This retrospective, hospital-based study was conducted at Johns Hopkins Aramco Healthcare Facilities. This facility treats approximately 153,000 employees of ARAMCO and JHAH and their dependents. The majority of the study population

lived in the eastern region of Saudi Arabia in Dhahran, Al-Hasa, Ras Tanura, Abqaiq, and Udhailiyah. Eligible participants were had to meet one of the following requirements (all units are in mg/dl): TC ≥200, HDL-C <40 for men and <50 for women, LDL-C ≥ 100, TG ≥ 150, or age 20 years and over. Participants were excluded if they had been diagnosed by health care as having diabetes, hypertension, asthma, or any chronic disease (participants must not have received a previous diagnosis of diabetes mellitus, hypertension, asthma, or any chronic condition from a healthcare provider) or if they were taking medication (an individual who is currently prescribed and actively taking a drug for the management of a disease) other than dyslipidaemia medications. The sample size was calculated using EPI Info software [21]. The sample was determined to be 1128 patients, with a margin of error of 5% and a design effect of 3, assuming an average anticipated prevalence of dyslipidemia of 43%.[10]

## Data Extraction and Statistical Analysis

Data were extracted from medical health records (January 2022- September 2023). A data dictionary was used, and the following variables were included: HBA1c, age, sex, nationality, location, BMI, LDL-C, HDL-C, TC, TG, lipid lowering medication, blood pressure (BP) systolic, and BP (diastolic). All medical tests were performed on the same date. The data were validated by selecting 10% of the data randomly and comparing it with medical health records.

All incomplete or missing data were excluded from the analysis, and the remaining data were exported into a DATAtab (Graz, Austria). Descriptive analysis was carried out by computing frequencies and percentages for categorical variables and the mean and standard deviation for continuous variables. The normality assumption can hold; therefore, parametric tests were used. An independent t-test was used, as appropriate, to assess differences between groups. Pearson's correlation tests were performed to examine various correlations with the continuous outcome variable. Backward multivariate regression analysis was used to assess the impact of patient characteristics on HbA1c variations, with a significance level of $P < 0.05$.

## Ethical Considerations

Ethical clearance was obtained from the JHAH Institutional Review Board (IRB# 23- 49) as specified by the World Medical Association and Declaration of Helsinki.

## Results

The study included 2368 participants, including 660 (27.87%) aged 40-49 and 592 (25.1%) aged 30-39. The participants were 1351 (57.05%) male and 1857 (78.42%) Saudi. Regarding the BMI, the overweight group constitutes the highest group of participants; the overweight group has the most participants, 937 (39.5%). The mean age was 41.48±12.1 years, and the mean BMI was 28.44±5.53. Furthermore, 1625 (68.62%) of the study population were treated in Dharan, and 2195 (92.69%) were not taking lipid-lowering medications Table 1.

**Table 1.** Data distribution according to gender, Age, nationality, treatment location, BMI (Body Mass Index) and medication.

| Variable | Subgroup | Frequency | Percentage |
|---|---|---|---|
| *Gender* | *Male* | *1351* | *57.05%* |
| | *Female* | *1017* | *42.95%* |
| *Age    Mean & SD (41.48 ± 12.11)* | *20-29* | *468* | *19.76%* |
| | *30-39* | *592* | *25.1%* |
| | *40-49* | *660* | *27.87%* |
| | *50-59* | *486* | *20.52%* |
| | *over 60* | *162* | *6.84%* |
| *Country of Nationality* | *Saudi* | *1857* | *78.42%* |
| | *non-Saudi* | *511* | *21.58%* |
| *Treatment Location* | *Dharan* | *1625* | *68.62%* |
| | *RT* | *246* | *10.39%* |
| | *Abgig* | *218* | *9.21%* |
| | *Alhasa* | *184* | *7.77%* |
| | *UD* | *95* | *4.01%* |
| *BMI    Mean & SD (28.44±5.53)* | *Underweight* | *25* | *1.06%* |
| | *Healthy Weight* | *613* | *25.89%* |
| | *Overweight* | *937* | *39.57%* |
| | *class 1 obesity* | *517* | *21.83%* |
| | *class 2 obesity* | *207* | *8.74%* |
| | *class 3 obesity* | *69* | *2.91%* |
| *Is on lipid lowering Medications* | *No* | *2195* | *92.69%* |
| | *Yes* | *173* | *7.31%* |

The lipid profile and blood pressure are shown in Table 2.

**Table 2.** Data distribution according to, Hba1c (glycated haemoglobin), BP (blood pressure) and lipid profile (total cholesterol (TC), triglycerides (TG), low-density lipoprotein cholesterol (LDL-C), and/or reduced levels of high-density lipoprotein cholesterol (HDL-C)).

| Variable | N | Mean | Std. Deviation |
|---|---|---|---|
| HbA1c (%) | 2368 | 5.37 | 0.61 |
| LDL-C (mg/dl) | 2368 | 127.46 | 27.86 |
| HDL-C (mg/dl) | 2368 | 52.5 | 14.5 |
| TC (mg/dl) | 2368 | 201.87 | 33.01 |
| TG (mg/dl) | 2368 | 109.33 | 56.87 |
| BP (mmHg) (Systolic) | 2368 | 121.54 | 13 |
| BP (mmHg) (Diastolic) | 2368 | 76.89 | 8.09 |

The participant's country of origin and sex had no statistically significant relationship with HbA1c. There was a statistically significant relationship between the use of Lipid lowering-medication and HbA1c (P<0.001) (Table 3).

**Table 3.** Independent t test between HbA1c and country of origin, gender, and lipid lowering medication. P<0.05 was considered statistically significant.

| | variables | Sub-variable | M± SD | P- Value |
|---|---|---|---|---|
| HbA1c | Country of origin | Saudi (1857) | 5.37± 0.63 | >0.667 |
| | | non-Saudi(511) | 5.36± 0.52 | |
| | Gender | Male (1351) | 5.39± 0.53 | >0.53 |
| | | Female (1017) | 5.34± 0.7 | |
| | Lipid lowering Medication | Yes (173) | 5.77± 0.87 | <0.001 |
| | | No (2195) | 5.34 ± 0.57 | |

HbA1c and BMI had a very weak positive relationship that was statistically significant (r=0.18, P<0.001). HbA1c and systolic blood pressure showed a statistically significant positive connection (r=0.16, P< 0.001). There was no correlation between HbA1c and LDL-C, TC, and diastolic blood pressure. There was an inverse correlation between HbA1c and HDL-C (r = -0.11, P< 0.001). There was a slight positive relationship between age and HbA1c, which was statistically significant (r= 0.26, P<0.001). Also, there was a weak but statistically significant positive relationship between HbA1c and TG (r=0.2, P<0.001) Table 4.

**Table 4.** Pearson's Correlation between HbA1c and age, BMI, LDL, HDL, TC, TG.
BMI (body mass index), HbA1c (glycated hemoglobin), BP (blood pressure) and lipid profile (total cholesterol (TC), triglycerides (TG), low-density lipoprotein cholesterol (LDL-C), and high-density lipoprotein cholesterol (HDL-C)). P<0.05 was considered statistically significant.

| Variables | Correlation Coefficient | P- value |
|---|---|---|
| HbA1c and Age | 0.26 | <0.001 |
| HbA1c and BMI | 0.18 | <0.001 |
| HbA1c and LDL | 0.03 | >0.091 |
| HbA1c and HDL | -0.11 | <0.001 |
| HbA1c and Total Cholesterol | 0.05 | <0.02 |
| HbA1c and Triglycerides | 0.2 | <0.001 |
| HbA1c and BP (Systolic) | 0.16 | <0.001 |
| HbA1c and BP (Diastolic) | 0.09 | <0.001 |

Backward linear multivariate analysis with HbA1c as the dependent variable, and the age (B 0.192, P<0.001), BMI (B 0.119, P<0.001), HDL (B -0.058, P<0.005), Triglyceride (B 0.093, P<0.001), lipid lowering medication (B 0.104, P<0.001), systolic BP (B 0.060, P< 0.003), nationality ( B -0.045,  P<0.021) diastolic BP (P> 0.584), sex( B 0.007, P >0.308), LDL (B 0.018, P>0.961), cholesterol (B – 0.021, P>0.923) , and treatment location (B 0.001, P> 0.972) as all variables were significant determinant of HbA1c except for the sex, diastolic BP, cholesterol, and LDL Table 5.

**Table 5.** Backward multivariate analysis with HbA1c as the dependent variable
BMI (body mass index), HbA1c (glycated hemoglobin), BP (blood pressure) and lipid profile (total cholesterol (TC), triglycerides (TG), and high-density lipoprotein cholesterol (HDL-C).  Model R2 = 0.127. P<0.05 was considered statistically significant. Note: age and BMI, a quantitative form was used in the analysis.

| | Unadjusted B | Adjusted B | SE | P value | 95%CI | |
|---|---|---|---|---|---|---|
| | | | | | Lower Bound | Upper Bound |
| Intercept | | 4.252 | 0.136 | <0.001 | 3.984 | 4.519 |
| HDL-C | -0.002 | -.058 | 0.001 | <0.005 | -0.004 | -0.001 |
| TG | 0.002 | .093 | 0.001 | <0.001 | 0.001 | 0.001 |
| age | 0.010 | .192 | 0.001 | <0.001 | 0.008 | 0.012 |
| BMI | 0.013 | .119 | 0.002 | <0.001 | 0.009 | 0.017 |
| Lipid lowering medication | 0.242 | .104 | 0.047 | <0.001 | 0.151 | 0.336 |
| BP(systolic) | 0.003 | .060 | 0.001 | <0.003 | 0.001 | 0.005 |
| nationality | -0.67 | -0.045 | 0.029 | <0.021 | -0.125 | -0.010 |

## Discussion

Understanding the association between HbA1c and BMI in hyperlipidemia is vital for evaluating cardiovascular risk and making treatment options that enhance overall metabolic health. Our findings showed that HbA1c is related to BMI, age, systolic blood pressure, triglycerides, and HDL-C levels. HbA1c had no correlation with LDL-C, TC, or diastolic blood

pressure.

There was a significant correlation between HbA1c and age, which is consistent with a previous study conducted by Alzahrani et al. [22]. Our results showed a significant positive relationship between HbA1c and TG, which is also in agreement with previous studies [22][23][24]. Hussain et al. provided support for our finding of an inverse connection between HbA1C and HDL-C [25].

However, our findings showed no correlation between HbA1c, LDL-C, and TC, which is in disagreement with previous studies that showed a significant correlation with HbA1c [12][26][27]. This difference could be due to the fact that the previous studies included patients with DM, whereas in this study, such patients were excluded. However, one other study stated that HbA1c had no significant correlation with the LDL-C and TC, which agrees with our results [22]. HbA1c has been linked to elevated TG levels, suggesting that it may predict CVD and is a risk factor in type 2 DM [22].

There was no significant relationship between HbA1c and sex. However, previous studies showed that females had significantly higher HbA1c compared to males [22][28]. This difference may be due to population characteristics. The multivariable analysis found that non-Saudis have lower HbA1c than Saudis. This disparity could be attributed to the food culture. This conclusion contradicts the earlier study conducted by Alshahri et al. [29]. Our study found that 1% of participants were underweight, 25.8% were healthy, 39.5% were overweight, and 33.5% were obese. According to the KSAWHS survey, 39% of respondents had a normal BMI, whereas 3% were underweight, 38% were overweight, and 20% were obese. The normal weight was lower in our study, whereas the obese weight was higher. This could be attributable to age differences, as KSAWAHS comprises newborns, children, young adolescents, adults, and the elderly. [10]

There was a very slight positive relationship between the HbA1c and the BMI, which may indicate that high levels of HbA1c are related to a high BMI, leading to a higher risk of developing DM, CVD, and hypertension. This finding is supported by another study that also found that elevated levels of HbA1c and BMI are correlated and pose a risk of developing chronic diseases [30]. A Japanese study found a linear increase in HbA1c levels with increasing BMI[31]. In general, research has indicated that being overweight or obese increases the chances of being unable to achieve glycemic control [32].

A prior study discovered that dyslipidemia can cause obesity and that people with dyslipidemia are more likely to have hypertension [33][34]. Additionally, previous Saudi studies on adolescents found a significant frequency of unhealthy diets and sedentary lifestyles, which are likely to have an adverse effect on their health and wellbeing [35]. There was a very weak positive correlation between systolic and HbA1c. This means that higher levels of HbA1c could indicate higher levels of systolic blood pressure, which in turn increases the risk of hypertension.

Another study had similar results where high levels of systolic and diastolic blood pressure were associated with high levels of HbA1c [36]. In a previous study, higher HbA1c levels were associated with the occurrence of hypertension due to increased glucose flow across endothelial cell membranes [37].

Our study showed that individuals who are taking lipid-lowering therapy had lower HbA1c, which agrees with a previous study [38]. In a study conducted by Kosmas CE et al., some lipid-lowering medications may cause a lesser decline in LDL-

C but improve glucose metabolism and generate a decrease in HbA1c [39][40]. Another study conducted in Japan showed that statin use was related to a 1.9- to 2.6-fold increase in the incidence of new-onset diabetes [41]. An in-depth knowledge of these distinctions would enable the clinician to select the appropriate lipid-lowering drug for each individual patient.

Our results also suggested that controlling the level of HbA1c will lower TG levels and increase HDL.

The key to preventing dyslipidemia is to promote moderate exercise and a healthy diet [42]. A health education and promotion campaign would be very suitable for people with slightly HbA1c levels that are higher than normal. In addition, secondary prevention programs could be applied, such as screening for people aged 20 years and older, as well as high risk groups [43].

One of the limitations of this study was that it was a retrospective study. Furthermore, the results cannot be generalized for the population of Saudi Arabia. There was also no information on dietary choices, lifestyle behaviours, smoking, or the duration of regular physical exercise. However, the sample size was relatively large, and we eliminated selection and recall bias by retrieving information from medical records.

## Conclusion

Dyslipidemia is a risk factor for many diseases, including CVD and diabetes. This study found a correlation between BMI, systolic blood pressure, age, and TG. The results also showed that as HDL-C increases, HbA1c decreases. In addition, patients who were taking lipid-lowering medication had significantly lower levels of HbA1c than those who were not taking it. Therefore, health promotion campaigns and secondary prevention programs to lower HbA1c levels are essential to reduce the risk of multiple morbidities associated with high levels of HbA1c.

## References

1. ^Satoh M, Ohkubo T, Asayama K, Murakami Y, Sakurai M, Nakagawa H, et al. Combined Effect of Blood Pressure and Total Cholesterol Levels on Long-Term Risks of Subtypes of Cardiovascular Death. Hypertension. 2015 Mar;65(3):517–24. doi: 10.1161/HYPERTENSIONAHA.114.04639. Epub 2015 Jan 19. PMID: 25601929.

2. ^The Emerging Risk Factors Collaboration*. Lipid-Related Markers and Cardiovascular Disease Prediction. JAMA. 2012;307(23):2499–2506. doi:10.1001/jama.2012.6571

3. ^Turgeon RD, Anderson TJ, Grégoire J, Pearson GJ. 2016 Guidelines for the management of dyslipidemia and the prevention of cardiovascular disease in adults by pharmacists. Canadian Pharmacists Journal / Revue des Pharmaciens du Canada. 2017;150(4):243-250. doi:10.1177/1715163517713031

4. ^Katulanda P, Dissanayake HA, De Silva SDN, Katulanda GW, Liyanage IK, Constantine GR, et al. Prevalence, patterns, and associations of dyslipidemia among Sri Lankan adults—Sri Lanka Diabetes and Cardiovascular Study in 2005–2006. J Clin Lipidol. 2018 Mar;12(2):447–54. doi: 10.1016/j.jacl.2018.01.006. Epub 2018 Jan 31. PMID: 29429894.

5. ^Lee JS, Chang PY, Zhang Y, Kizer JR, Best LG, Howard BV. Triglyceride and HDL-C Dyslipidemia and Risks of Coronary Heart Disease and Ischemic Stroke by Glycemic Dysregulation Status: The Strong Heart Study. Diabetes Care. 2017 Apr;40(4):529-537. doi: 10.2337/dc16-1958. Epub 2017 Jan 25. PMID: 28122840; PMCID: PMC5360283.

6. ^Yusuf S, Hawken S, Ôunpuu S, Dans T, Avezum A, Lanas F, et al. Effect of potentially modifiable risk factors associated with myocardial infarction in 52 countries (the INTERHEART study): case-control study. The Lancet. 2004 Sep;364(9438):937–52. doi: 10.1016/S0140-6736(04)17018-9. PMID: 15364185.

7. ^Fruchart JC, Sacks FM, Hermans MP, Assmann G, Brown WV, Ceska R, et al. The Residual Risk Reduction Initiative: a call to action to reduce residual vascular risk in dyslipidaemic patients. Diab Vasc Dis Res. 2008 Nov 1;5(4):319–35. doi: 10.3132/dvdr.2008.046. PMID: 18958843.

8. ^"Indicator Metadata Registry Details." World Health Organization, www.who.int/data/gho/indicator-metadata-registry/imr-details. Accessed 25 DEC. 2023.

9. ^F. Al-Kaabba A, A. Al-Hamdan N, El Tahir A, M. Abdalla A, A. Saeed A, A. Hamza M. Prevalence and Correlates of Dyslipidemia among Adults in Saudi Arabia: Results from a National Survey. Open J Endocr Metab Dis. 2012;02(04):89–97.10.4236/ojemd.2012.24014.

10. a, b, c Biological Risk Factors. World Health Survey Saudi Arabia (SAUDI ARABIA WHS). 2021. https://www.moh.gov.sa/en/Ministry/Statistics/Indicator/Documents/Report-Biological-Risk-Factors.pdf

11. ^AlMuhaidib, S., AlBuhairan, F., Tamimi, W. et al. Prevalence and factors associated with dyslipidemia among adolescents in Saudi Arabia. Sci Rep 12, 16888 (2022). https://doi.org/10.1038/s41598-022-21262-9

12. a, b, c VinodMahato R, Gyawali P, Raut PP, Regmi P, Singh KP, Pandeya DR, et al. Association between glycaemic control and serum lipid profile in type 2 diabetic patients: glycated haemoglobin as a dual biomarker. Biomedical Research. 2011;22(3):375–380).

13. ^Syed IAA, Khan WA. Glycated haemoglobin--a marker and predictor of cardiovascular disease. J Pak Med Assoc. 2011 Jul;61(7):690–5. PMID: 22204248.

14. ^Yang CY, Su PF, Hung JY, Ou HT, Kuo S. Comparative predictive ability of visit-to-visit HbA1c variability measures for microvascular disease risk in type 2 diabetes. Cardiovasc Diabetol. 2020 Dec 6;19(1):105. https://doi.org/10.1186/s12933-020-01082-9

15. ^Nuttall FQ. Body Mass Index: Obesity, BMI, and Health: A Critical Review. Nutr Today. 2015 May;50(3):117-128. doi: 10.1097/NT.0000000000000092. Epub 2015 Apr 7. PMID: 27340299; PMCID: PMC4890841.

16. ^Nuttall FQ. Body Mass Index: Obesity, BMI, and Health: A Critical Review. Nutr Today. 2015 May;50(3):117-128. doi: 10.1097/NT.0000000000000092. Epub 2015 Apr 7. PMID: 27340299; PMCID: PMC4890841.

17. ^Ozturk GZ, Egici MT, Bukhari MH, Toprak D. Association between body mass index and activities of daily living in homecare patients. Pak J Med Sci. 2017 Nov-Dec;33(6):1479-1484. doi: 10.12669/pjms.336.13748. PMID: 29492082; PMCID: PMC5768848.

18. ^Kyrou I, Randeva HS, Tsigos C, Kaltsas G, Weickert MO. Clinical Problems Caused by Obesity. 2000. PMID: 25905207.

19. ^Kyrou I, Randeva HS, Tsigos C, Kaltsas G, Weickert MO. Clinical Problems Caused by Obesity. 2018 Jan 11. In: Feingold KR, Anawalt B, Blackman MR, Boyce A, Chrousos G, Corpas E, de Herder WW, Dhatariya K, Dungan K,

Hofland J, Kalra S, Kaltsas G, Kapoor N, Koch C, Kopp P, Korbonits M, Kovacs CS, Kuohung W, Laferrère B, Levy M, McGee EA, McLachlan R, New M, Purnell J, Sahay R, Shah AS, Singer F, Sperling MA, Stratakis CA, Trence DL, Wilson DP, editors. Endotext [Internet]. South Dartmouth (MA): MDText.com, Inc.; 2000–. PMID: 25905207.

20. ^Mandviwala T, Khalid U, Deswal A. Obesity and Cardiovascular Disease: a Risk Factor or a Risk Marker? Curr Atheroscler Rep. 2016 May;18(5):21. doi: 10.1007/s11883-016-0575-4. PMID: 26973130.

21. ^Dean AG, Arner TG, Sunki GG, Friedman R, Lantinga M, Sangam S, Zubieta JC, Sullivan KM, Brendel KA, Gao Z, Fontaine N, Shu M, Fuller G, Smith DC, Nitschke DA, and Fagan RF. Epi Info™, a database and statistics program for public health professionals. CDC, Atlanta, GA, USA, 2011

22. a, b, c, d, e Alzahrani SH, Baig M, Aashi MM, Al-Shaibi FK, Alqarni DA, Bakhamees WH. Association between glycated hemoglobin (HbA1c) and the lipid profile in patients with type 2 diabetes mellitus at a tertiary care hospital: a retrospective study. Diabetes Metab Syndr Obes. 2019 Aug 29;12:1639-1644. doi: 10.2147/DMSO.S222271. PMID: 31695459; PMCID: PMC6718241.

23. ^Ozder A. Lipid profile abnormalities seen in T2DM patients in primary healthcare in Turkey: a cross-sectional study. Lipids Health Dis. 2014 Dec 6;13:183. doi: 10.1186/1476-511X-13-183. PMID: 25481115; PMCID: PMC4271485

24. ^Ozder A. Lipid profile abnormalities seen in T2DM patients in primary healthcare in Turkey: a cross-sectional study. Lipids Health Dis. 2014 Dec 6;13:183. doi: 10.1186/1476-511X-13-183. PMID: 25481115; PMCID: PMC4271485

25. ^Hussain A, Ali I, Kaleem WA, Yasmeen F. Correlation between Body Mass Index and Lipid Profile in patients with Type 2 Diabetes attending a tertiary care hospital in Peshawar. Pak J Med Sci. 2019;35(3):591-597. doi: 10.12669/pjms.35.3.7. PMID: 31258559; PMCID: PMC6572993.

26. ^Andersen GE, Christiansen JS, Mortensen HB, Christiansen KM, Pedersen-Bjergaard L, Kastrup KW, Vestermark S. Serum lipids and lipoproteins in 157 insulin dependent diabetic children and adolescents in relation to metabolic regulation, obesity and genetic hyperlipoproteinemia. Acta Paediatr Scand. 1983 May;72(3):361-5. doi: 10.1111/j.1651-2227.1983.tb09729.x. PMID: 6349244.

27. ^Naeem, M., Khattak, R. M., Rehman, M. ur, & Khattak, M. N. K. (2016). The role of glycated hemoglobin (HbA1c) and serum lipid profile measurements to detect cardiovascular diseases in type 2 diabetic patients. South East Asia Journal of Public Health, 5(2), 30–34. https://doi.org/10.3329/seajph.v5i2.28310

28. ^Ahmad Khan H. Clinical significance of HbA1c as a marker of circulating lipids in male and female type 2 diabetic patients. Acta Diabetol. 2007 Dec;44(4):193-200. doi: 10.1007/s00592-007-0003-x. Epub 2007 Sep 1. PMID: 17786383.

29. ^Alshahri BK, Bamashmoos M, Alnaimi MI, Alsayil S, Basaqer S, Al-Hariri MT, Vallaba Doss CA Sr. Assessment of Self-Management Care and Glycated Hemoglobin Levels Among Type 2 Diabetes Mellitus Patients: A Cross-Sectional Study From the Kingdom of Saudi Arabia. Cureus. 2020 Dec 5;12(12):e11925. doi: 10.7759/cureus

30. ^Boye KS, Lage MJ, Shinde S, Thieu V, Bae JP. Trends in HbA1c and Body Mass Index Among Individuals with Type 2 Diabetes: Evidence from a US Database 2012-2019. Diabetes Ther. 2021 Jul;12(7):2077-2087. doi: 10.1007/s13300-021-01084-0. Epub 2021 Jun 2. PMID: 34076849; PMCID: PMC8266935

31. ^Nakajima K, Suwa K. Excess body weight affects HbA1c progression irrespective of baseline HbA1c levels in Japanese individuals: a longitudinal retrospective study. Endocr Res. 2015;40(2):63-9. doi:

10.3109/07435800.2014.934962. Epub 2014 Aug 11. PMID: 25111747.

32. ^Kennedy-Martin T, Robinson S, Boye K. PDB81 Literature review on the association between BMI and glycemic control in patients with type 2 diabetes across eight countries. Value Health. 2020;23:S519. doi: 10.1016/j.jval.2020.08.678.

33. ^Jia, X., Chen, Q., Wu, P. et al. Dynamic development of metabolic syndrome and its risk prediction in Chinese population: a longitudinal study using Markov model. Diabetol Metab Syndr 10, 24 (2018). https://doi.org/10.1186/s13098-018-0328-3

34. ^Baqal OJ, Saleheen H, AlBuhairan FS. Urgent Need for Adolescent Physical Activity Policies and Promotion: Lessons from "Jeeluna". Int J Environ Res Public Health. 2020 Jun 21;17(12):4464. doi: 10.3390/ijerph17124464. PMID: 32575900; PMCID: PMC7345490.

35. ^Abou Abbas O, AlBuhairan F. Predictors of adolescents' mental health problems in Saudi Arabia: findings from the Jeeluna® national study. Child Adolesc Psychiatry Ment Health. 2017 Sep 26;11:52. doi: 10.1186/s13034-017-0188-x. PMID: 28959356; PMCID: PMC5615485.

36. ^Huang X, Qin C, Guo X, Cao F, Tang C. Association of hemoglobin A1c with the incidence of hypertension: A large prospective study. Front Endocrinol (Lausanne). 2023 Jan 16;13:1098012. doi: 10.3389/fendo.2022.1098012. PMID: 36726461; PMCID: PMC9884972.

37. ^Cosentino F, Lüscher TF. Effects of blood pressure and glucose on endothelial function. Curr Hypertens Reports. 2001;3:79–88

38. ^Li J, Nie Z, Ge Z, Shi L, Gao B, Yang Y. Prevalence of dyslipidemia, treatment rate and its control among patients with type 2 diabetes mellitus in Northwest China: a cross-sectional study. Lipids Health Dis. 2022 Aug 25;21(1):77. doi: 10.1186/s12944-022-01691-1. PMID: 36002855; PMCID: PMC9404639.

39. ^Kosmas CE, Silverio D, Sourlas A, Garcia F, Montan PD, Guzman E. Impact of lipid-lowering therapy on glycemic control and the risk for new-onset diabetes mellitus. Drugs Context. 2018 Nov 28;7:212562. doi: 10.7573/dic.212562. PMID: 30515229; PMCID: PMC6267678.

40. ^Kosmas CE, Silverio D, Sourlas A, Garcia F, Montan PD, Guzman E. Impact of lipid-lowering therapy on glycemic control and the risk for new-onset diabetes mellitus. Drugs Context. 2018 Nov 28;7:212562. doi: 10.7573/dic.212562. PMID: 30515229; PMCID: PMC6267678.

41. ^Ooba N, Setoguchi S, Sato T, et al. Lipid-lowering drugs and risk of new-onset diabetes: a cohort study using Japanese healthcare data linked to clinical data for health screening. BMJ Open 2017;7:e015935. doi:10.1136/bmjopen-2017-015935

42. ^Handelsman Y, Jellinger PS, Guerin CK, Bloomgarden ZT, Brinton EA, Budoff MJ, Davidson MH, Einhorn D, Fazio S, Fonseca VA, Garber AJ, Grunberger G, Krauss RM, Mechanick JI, Rosenblit PD, Smith DA, Wyne KL. Consensus Statement by the American Association of Clinical Endocrinologists and American College of Endocrinology on the Management of Dyslipidemia and Prevention of Cardiovascular Disease Algorithm - 2020 Executive Summary. Endocr Pract. 2020 Oct;26(10):1196-1224. doi: 10.4158/CS-2020-0490. PMID: 33471721.

43. ^Chou R, Dana T, Blazina I, Daeges M, Bougatsos C, Jeanne TL. Screening for Dyslipidemia in Younger Adults: A Systematic Review for the U.S. Preventive Services Task Force. Ann Intern Med. 2016 Oct 18;165(8):560-564. doi:

*10.7326/M16-0946. Epub 2016 Aug 9. PMID: 27538032.*