



Body Mass Index and HbA1c Are Associated with Renal and Hepatic Function

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ABSTRACT

Hypertension and diabetes may have implications for damage to other organs such as the kidneys and liver which are evaluated by serum creatinine and ALT, respectively. This study aims to delineate the association between body mass index and hbA1c with renal and hepatic function, respectively. This is a cross-sectional study involving 32 subjects. The research subjects consisted of diabetics and hypertension who were registered in the Muhammadiyah Primary Health Care, Kebanaran, Purwokerto. It was found that in diabetics, there were significant results between serum creatinine and HbA1c values ($p < 0.01$, $r = 0.855$). Systolic blood pressure was correlated with body mass index (BMI) ($p < 0.01$, $r = 0.649$). In patients with hypertension, serum creatinine was correlated with the length of time a person has hypertension ($p < 0.01$, $r = 0.475$). Meanwhile, the ALT value was correlated with body mass index ($p < 0.05$, $r = 0.422$) and waist circumference ($p < 0.001$, $r = 0.528$). We found that a decreased HbA1c levels significantly reduces serum creatinine levels so it may also reduce kidney damage. A decrease in the value of BMI and waist circumference significantly reduces ALT enzyme levels which may have the potential for reducing liver damage.

Keywords : body mass index, diabetes, hbA1c, hypertension.

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INTRODUCTION

Non-communicable diseases have high mortality and morbidity in the world, especially hypertension (Mills, Stefanescu, & He, 2020) and diabetes mellitus (Ravindrarajah et al., 2020). Diabetes can have implications for damage to other organs such as the kidneys (Hamasaki & Morimitsu, 2020) and the liver (Teshome et al., 2019). Meanwhile, hypertension is closely related to decreased kidney function, especially in people with diabetes mellitus (Viazzi et al., 2020). Serum creatinine and ALT enzyme values are two markers that can describe renal (Ito, Matsue, & Minamino, 2020) and hepatic (Mangus et al., 2015) function, respectively.

Some non-communicable diseases are closely related to metabolic abnormalities. Hypertension, which is a disease that affects nearly a third of the world's population (Mills, Stefanescu, & He, 2020), is closely related to metabolic abnormalities (Zheng et al., 2015; Nistala & Savin, 2017). This could be due to kidney damage due to inflammation and oxidative stress in the nephrons (Zheng et al., 2015; Nistala & Savin, 2017). In addition, diabetes is also closely related to metabolic abnormalities because it is directly related to glucose homeostasis via the GLP-1 pathway and improvements in cell membrane insulin sensitivity (Deacon, 2019). Diabetes mellitus is a disease with high morbidity and mortality (Ministry of Health of the Republic of Indonesia, 2018) where prevention strategies are one of the priority programs of the Ministry of Health of the Republic of Indonesia (Ministry of Health of the Republic of Indonesia, 2015).

Therefore, the correlation between hypertension and diabetes, with metabolic abnormalities can be assumed to be the pathogenesis of insulin resistance which causes metabolic diseases such as diabetes which has implications for hypertension. Because of this, it is necessary to conduct research on the analysis of metabolic factors that affect the increased risk of morbidity for people with diabetes mellitus and hypertension.

METHODS

This study is an observational study with a cross-sectional design. The research sample was participants who were registered at the PKU Muhammadiyah Primary Health Care, Kebanaran, Purwokerto. The samples were patients who had agreed to participate in the study with informed consent according to ethical suitability issued by the ethical committee of the Faculty of Medicine, Jenderal Soedirman University. The number of samples taken was 32 people. Samples were taken by consecutive sampling method.

Anthropometric measurements are carried out by measuring height in meters (m) and body weight in kilograms (kg). Body mass index (BMI) obtained from the formula body weight (kg) divided by the square of height (m). The diagnosis of hypertension was determined if the participants had systolic blood pressure greater than 140 mmHg and/or diastole more than 90 mmHg at rest. If hypertension is controlled with drugs, the diagnosis is based on the doctor's decision at the beginning before administering the drug. Drug administration was recorded based on available medical records. The diagnosis of diabetes mellitus was given if the participants had fasting blood sugar > 126 mg / dL, or blood sugar 2 hours post prandial > 200mg / dL, or HbA1c > 6.5%, according to the diagnosis given by the previous doctor. Drug administration was recorded based on available medical records.

Peripheral blood samples were taken by aseptic venous puncture, at the location of the medial cubital vein. Blood samples were taken as much as 5 ml. The sample used was a sample from a non-EDTA vacutainer tube. Serum creatinine examination using the Jaffe Reaction Method.

SGPT/ ALT examination using the kinetic method. Mean-while, blood glucose using a spectrophotometer.

Data in the form of long-suffering from hypertension and diabetes, anthropometric status, vital signs, HbA1c, serum creatinine levels, ALT/ ALT levels, and fasting blood glucose were analyzed using the Pearson Correlation test. Data is significant if $p < 0.05$. Data processing using SPSS 20.0 for Windows software.

RESULTS AND DISCUSSION

Subject Characteristics

A total of 32 people who were participants of the PKU Muhammadiyah Primary Health Care Kebanaran Purwokerto became participants in this study. Participants consisted of 14 men and 18 women with a mean age of 58 ± 8.5 years. Patients consisted of 25 people with hypertension, 15 people with diabetes mellitus, and 8 people with hypertension and diabetes mellitus. Patients currently still routinely consume Sulfonylurea, Metformin, Insulin, Calcium channel blockers, and Angiotensin Receptor Blockers.

Correlative Analysis

Correlative analysis test results in diabetics showed significant results between serum creatinine and HbA1c values ($p < 0.01$) with a correlation coefficient of 0.855. Meanwhile, the variables of long-suffering from diabetes, body mass index, systolic blood pressure, diastolic blood pressure, and fasting glucose were not significant.

The results of the correlation test between the systolic and diastolic blood pressure values of diabetics show that systolic blood pressure is influenced by the body mass index (BMI) ($p < 0.01$) with a correlation coefficient of 0.649. Meanwhile, diastolic blood pressure was influenced by diabetes duration ($p < 0.05$) with a correlation coefficient of -0.593. Other variables, namely HbA1c, fasting glucose, Serum Creatinine, and ALT were not found to be significant.

The results of the correlation analysis test between serum creatinine and other variables showed that the serum creatinine value was influenced by the length of time a person had hypertension ($p < 0.01$) with a correlation coefficient of 0.475, parallel with previous studies (Sung et al., 2016; Yamout & Bakris, 2018). Meanwhile, the ALT value was influenced by body mass index ($p < 0.05$ with a correlation coefficient of 0.422) and waist circumference ($p < 0.001$ with a correlation coefficient of 0.528). The systolic and diastolic blood pressure variables did not find a significant relationship with serum creatinine and ALT values.

The data on the results of this study indicate that HbA1c is closely correlated with serum creatinine. Previous studies have also suggested that HbA1c has a strong correlation with serum

creatinine levels (Farasat et al., 2015; Zubair, Malik, & Ahmad, 2019). Increased creatinine levels are closely associated with increased morbidity and mortality due to decreased renal function (Colombo et al., 2020; Willey et al., 2020). High HbA1c levels indicate an uncontrolled diabetes condition and can be a marker of higher morbidity, so that low levels are a good prognosis for the prevention of organ damage due to diabetes (Schnell, Crocker, & Weng, 2017; Langholz et al., 2021). Therefore, a decrease in HbA1c levels is important to reduce the potential for kidney damage which is represented by elevated creatinine levels.

Table 1. Characteristics of Subjects

Characteristics	Nilai
Number of Subjects	32
Gender	
Male	14 (43,8%)
Women	18 (56,3%)
Age (years)	58 ± 8,5
Chronic Illness	
Hypertension	25
Diabetes mellitus	15
Hypertension and Diabetes Mellitus	8
Length of Suffering from Hypertension (years)	4,28 ± 6,11
Duration of Diabetes (years)	6,67 ± 5,15
Weight	68,36 ± 12,55
Height	158,18 ± 8,81
Body mass index	27,23 ± 4,05
Waist circumference	94 ± 9,16
Systolic Blood Pressure	151,19 ± 18,12
Diastolic Blood Pressure	87,81 ± 13,77
HbA1c (%)	8,9 ± 1,93
Fasting Glucose (mg/dl)	154,34 ± 83,81
Serum Creatinine (mg/dl)	1,36 ± 0,28
ALT (U/L)	18,12 ± 10,85
Treatment:	
Sulfonylureas	10 (31,25%)
Metformin	11 (34,37%)
Insulin	2 (6,25%)
Calcium channel blockers	16 (15%)
Angiotensin Receptor Blockers	3 (9,37%)

Table 2. Univariate Correlation Test between Serum Creatinine and Other Variables in Diabetes Patients

Variable	Correlation coefficient	P value
Time suffering from diabetes	0,093	0,742
Body mass index	0,301	0,276
Systolic Blood Pressure	0,274	0,323
Diastolic Blood Pressure	-0,241	0,386
HbA1c	0,855	0,002**
fasting glucose	-0,040	0,889
ALT	-0,395	0,145

* = significant ($p < 0.05$), ** = significant ($p < 0.01$)

Table 3. Univariate Correlation Test between Systolic Blood Pressure and Other Variables in Diabetes Patients

Variable	Correlation coefficient	P value
Time suffering from diabetes	-0,457	0,087
Body mass index	0,649	0,009**
HbA1c	-0,056	0,877
fasting glucose	-0,080	0,777
Serum Creatinine	0,274	0,323
ALT	-0,119	0,672

* = significant ($p < 0.05$), ** = significant ($p < 0.01$)

Table 4. Univariate Correlation Test between Diastolic Blood Pressure and Other Variables in Diabetes Patients

Variable	Correlation coefficient	P value
Time suffering from diabetes	-0,593	0,020*
Body mass index	0,039	0,892
HbA1c	0,035	0,923
fasting glucose	0,066	0,814
Serum Creatinine	-0,241	0,386
ALT	0,424	0,115

* = significant ($p < 0.05$), ** = significant ($p < 0.01$)

Table 5. Univariate Correlation Test between Serum Creatinine and Other Variables in Hypertension Patients

Variable	Correlation coefficient	P value
Time suffering from hypertension	0,475	0,017*
Body mass index	-0,044	0,834
Waist circumference	0,318	0,121
Systolic Blood Pressure	-0,162	0,438
Diastolic Blood Pressure	-0,215	0,301
ALT	-0,085	0,686

* = significant ($p < 0.05$), ** = significant ($p < 0.01$)

Table 6. Univariate Correlation Test between ALT and Other Variables in Hypertension Patients

Variable	Correlation coefficient	P value
Time suffering from hypertension	-0,021	0,922
Body mass index	0,422	0,036*
Waist circumference	0,528	0,007**
Systolic Blood Pressure	0,185	0,375
Diastolic Blood Pressure	0,332	0,105
Serum Creatinine	-0,085	0,686

* = significant ($p < 0.05$), ** = significant ($p < 0.01$)

A decrease in the value of body mass index (BMI) and waist circumference can reduce the potential for liver damage in hypertensive patients which is correlated with an increase in the ALT enzyme. The data from this study indicate that the lower the BMI will reduce the ALT level in the serum. Previous studies have shown the same thing, namely that there is a close relationship between BMI and ALT (Bilal et al., 2011; Wang, Guo, & Lu, 2016; Fan, Wang, & Du, 2018; Song et al., 2018). High ALT levels indicate liver damage (Mangus et al., 2015), so a decrease in BMI in people with hypertension can reduce the risk of liver damage.

Obesity is a risk factor for hypertension and cardiovascular disease. Obesity is characterized by a high BMI value (more than 25 kg/ m²). Previous studies have shown that reducing BMI can significantly reduce the incidence of hypertension and cardiovascular disease (Betz et al., 2018; Zhou et al., 2018; Vrettos et al., 2020). Our study data show the same thing, where BMI has a correlation with systolic blood pressure. A decrease in BMI is important to support blood pressure control because it plays a significant role in lowering systolic blood pressure.

CONCLUSION

We found that control of HbA1c and BMI are important to reduce the risk of organ damage in diabetics and hypertension. Decreased HbA1c levels significantly reduce serum creatinine levels so it may also reduce kidney damage. A decrease in the value of BMI and waist circumference significantly reduce ALT enzyme levels which may have potential for reducing liver damage. Besides that, a decrease in BMI is important to support blood pressure control because it significantly reduces systolic blood pressure.

REFERENCES

- Betz, H. H., Eisenmann, J. C., Laurson, K. R., DuBose, K. D., Reeves, M. J., Carlson, J. J., & Pfeiffer, K. A. 2018. Physical Activity, BMI, and Blood Pressure in US Youth: NHANES 2003-2006. *Pediatric exercise science*, 30: 418–425.
- Bilal, M., Tariq, A., Khan, S., Quratulain, Tariq, A., Shahid, M. F., Khan, M. W., Shah, A. R., & Naveed, A. K. 2011. Influence of gender, BMI, and ethnicity on serum ALT levels of healthy students of a medical school. *Journal of Ayub Medical College, Abbottabad: JAMC*, 23: 70–72.
- Colombo, M., McGurnaghan, S. J., Blackbourn, L. A. K., Dalton, R. N., Dunger, D., Bell, S., Petrie, J. R., Green, F., MacRury, S., McKnight, J. A., Chalmers, J., Collier, A., McKeigue, P. M., & Colhoun, H. M. 2020. Comparison of serum and urinary biomarker panels with albumin/creatinine ratio in the prediction of renal function decline in type 1 diabetes. *Diabetologia*, 63: 788–798.
- Deacon, C. F. 2019. Physiology and Pharmacology of DPP-4 in Glucose Homeostasis and the Treatment of Type 2 Diabetes. *Frontiers in Endocrinology*.
- Fan, R., Wang, J., & Du, J. 2018. Association between body mass index and fatty liver risk: A dose-response analysis. *Scientific reports*, 8: 15273.
- Farasat, T., Sharif, S., Naz, S., & Fazal, S. 2015. Significant association of serum creatinine with HbA1C in impaired glucose tolerant Pakistani subjects. *Pakistan journal of medical sciences*, 31: 991–994.
- Hamasaki, H., & Morimitsu, S. 2020. Association of Glucagon With Obesity, Glycemic Control and Renal Function in Adults With Type 2 Diabetes Mellitus. *Canadian journal of diabetes*.
- Ito, M., Matsue, Y., & Minamino, T. 2020, September. Worsening renal function during intensive blood pressure control: another example of not prognostically relevant creatinine rise? *European journal of heart failure*. England.
- Langholz, P. L., Wilsgaard, T., Njølstad, I., Jorde, R., & Hopstock, L. A. 2021. Trends in known and undiagnosed diabetes, HbA1c levels, cardiometabolic risk factors and diabetes treatment target achievement in repeated cross-sectional surveys: the population-based Tromsø Study 1994-2016. *BMJ open*, 11: e041846.

- Mangus, R. S., Fridell, J. A., Kubal, C. A., Davis, J. P., & Tector, A. J. 2015. Elevated alanine aminotransferase (ALT) in the deceased donor: impact on early post-transplant liver allograft function. *Liver international : official journal of the International Association for the Study of the Liver*, 35: 524–531.
- Menteri Kesehatan RI. 2015. Peraturan Menteri Kesehatan RI Nomor 71 Tahun 2015 Tentang Penanggulangan Penyakit Tidak Menular, 1–15.
- Menteri Kesehatan RI. 2018. *Indonesia Health Profile 2017*. Jakarta, Indonesia: Menteri Kesehatan RI.
- Mills, K. T., Stefanescu, A., & He, J. 2020. The global epidemiology of hypertension. *Nature Reviews Nephrology*, 16: 223–237.
- Nistala, R., & Savin, V. 2017. Diabetes, hypertension, and chronic kidney disease progression: role of DPP4. *American journal of physiology. Renal physiology*, 312: F661–F670.
- Ravindrarajah, R., Reeves, D., Howarth, E., Meacock, R., Soiland-Reyes, C., Cotterill, S., Whittaker, W., Heller, S., Sutton, M., Bower, P., & Kontopantelis, E. 2020. Epidemiology and determinants of non-diabetic hyperglycaemia and its conversion to type 2 diabetes mellitus, 2000-2015: cohort population study using UK electronic health records. *BMJ open*, 10: e040201.
- Schnell, O., Crocker, J. B., & Weng, J. 2017. Impact of HbA1c Testing at Point of Care on Diabetes Management. *Journal of diabetes science and technology*, 11: 611–617.
- Song, B. M., Kim, H. C., Kim, D. J., Ahn, S. V., Kim, K. M., Lee, J.-M., Koh, S.-B., & Suh, I. 2018. Aminotransferase levels, body mass index, and the risk of diabetes: a prospective cohort study. *Annals of epidemiology*, 28: 675-680.e6.
- Sung, K.-C., Ryu, S., Lee, J.-Y., Lee, S. H., Cheong, E., Hyun, Y.-Y., Lee, K.-B., Kim, H., & Byrne, C. D. 2016. Urine Albumin/Creatinine Ratio Below 30 mg/g is a Predictor of Incident Hypertension and Cardiovascular Mortality. *Journal of the American Heart Association*, 5.
- Teshome, G., Ambachew, S., Fasil, A., & Abebe, M. 2019. Prevalence of Liver Function Test Abnormality and Associated Factors in Type 2 Diabetes Mellitus: A Comparative Cross-Sectional Study. *EJIFCC*, 30: 303–316.
- Viazzi, F., Russo, E., Mirijello, A., Fioretto, P., Giorda, C., Ceriello, A., Copetti, M., Russo, G. T., Di Bartolo, P., Manicardi, V., Leoncini, G., De Cosmo, S., & Pontremoli, R. 2020. Long-term blood pressure variability, incidence of hypertension and changes in renal function in type 2 diabetes. *Journal of hypertension*, 38: 2279–2286.
- Vrettos, I., Voukelatou, P., Pappa, E., Beletsioti, C., Papadopoulos, A., & Niakas, D. 2020. Increased Body Mass Index and Hypertension: An Unbreakable Bond. *International journal of preventive medicine*, 11: 155.
- Wang, L., Guo, J., & Lu, J. 2016. Risk factor compositions of nonalcoholic fatty liver disease

- change with body mass index in males and females. *Oncotarget*, 7: 35632–35642.
- Willey, J. Z., Moon, Y. P., Husain, S. A., Elkind, M. S. V, Sacco, R. L., Wolf, M., Cheung, K., Wright, C. B., & Mohan, S. 2020. Creatinine versus cystatin C for renal function-based mortality prediction in an elderly cohort: The Northern Manhattan Study. *PLoS one*, 15: e0226509.
- Yamout, H., & Bakris, G. L. 2018, January. Consequences of Overinterpreting Serum Creatinine Increases when Achieving BP Reduction: Balancing Risks and Benefits of BP Reduction in Hypertension. *Clinical journal of the American Society of Nephrology : CJASN*.
- Zheng, T., Chen, T., Liu, Y., Gao, Y., & Tian, H. 2015. Increased plasma DPP4 activity predicts new-onset hypertension in Chinese over a 4-year period: possible associations with inflammation and oxidative stress. *Journal of human hypertension*, 29: 424–429.
- Zhou, W., Shi, Y., Li, Y.-Q., Ping, Z., Wang, C., Liu, X., Lu, J., Mao, Z.-X., Zhao, J., Yin, L., Zhang, D., Tian, Z., Zhang, L., & Li, L. 2018. Body mass index, abdominal fatness, and hypertension incidence: a dose-response meta-analysis of prospective studies. *Journal of human hypertension*, 32: 321–333.
- Zubair, M., Malik, A., & Ahmad, J. 2019. Correlation of HbA1c and S. creatinine along with microbiological profiling of infected ulcers; cases of diabetic patients. *Diabetes & metabolic syndrome*, 13: 30–34.