Increased Levels of Glycated Hemoglobin (HbA1c) in Obese Adolescents

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ARTICLE INFO

Keywords:
HbA1c levels
Obesity
Adolescent

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All authors have reviewed and approved the final version of the manuscript.

https://doi.org/10.32539/BJI.v6i3.4

ABSTRACT

The Increment of Glycated Hemoglobin (HbA1c) in Obese Adolescent. Obesity in children and adolescents is a serious concern because the prevalence is increasing every year throughout the world. Obesity in children and adolescents is associated with an increased risk of impaired glucose tolerance, dyslipidemia and diabetes. Glycated hemoglobin (HbA1c) has been recommended as a diagnostic tool to identify diabetes. The purpose of this study was to determine differences in levels of glycated hemoglobin (HbA1c) in obese and non-obese adolescents aged 15-19 years. This study was an observational analytic study with a cross-sectional approach. The study was conducted in Palembang 1 Public High School and the Faculty of Medicine of Sriwijaya University and found 50 subjects consisting of obese adolescents and non-obese adolescent groups. Nutritional status was determined by measuring body mass index according to age and gender. Examination of HbA1c levels was carried out using a Nycocard Reader. The results of the study with Mann Whitney alternative test showed a p value of 0.000 (p <0.05) with an average HbA1c level in obese adolescents by 6.1% and an average HbA1c level in non-obese adolescents by 4.7%. In conclusion, HbA1c levels in obese adolescents aged 15-19 years are higher than non-obese adolescent.

1. Introduction

Obesity describes the high amount of fat accumulation that can cause various health problems.1 Obesity in childhood and adolescence is considered as a serious health problem in this 21 century. Globally, 1 in 6 children aged 5-17 years are overweight and obese. In 2016, the number of obese children reached 124 million. This number has increased 10 times from 11 million people in 1975.2 In Indonesia, based on data from Riskesdas 2010 and 2013, it shows that the prevalence of obesity and obesity in school children (6-12 years) has increased five times from 1.4 to 9.2% . South Sumatra is included in one of eleven provinces where the prevalence of obesity is above the national prevalence (11.6%).3,4

The increasing prevalence of obesity in children and adolescents has an impact on the onset of type 2 diabetes mellitus and the metabolic syndrome.5 Research shows that more than 85% of children with type 2 diabetes mellitus are overweight or obese at diagnosis.6 Most of the patients with diabetes initially experiencing impaired glucose tolerance (TGT), which is a developmental stage of the onset diabetes of type 2.7 Early diagnosis and intervention in a person with TGT has been shown to prevent the development of type 2 diabetes mellitus so it is important to screen children and adolescents who are at high risk.8 The American Diabetes Association in 2010 recommended checking
the level of glycated hemoglobin (HbA1c) as one of the variables for diagnosing diabetes.

HbA1c is a standard examination that describes glucose homeostasis in the form of fasting and postprandial blood glucose variations over a 3 month period.\textsuperscript{27} Thus, the HbA1c test is used to assess diabetes control and has a high predictive value for diabetes complications.\textsuperscript{10,11} The HbA1c test is very stable compared to plasma glucose assay because it has lower biological variability and preanalytic instability.\textsuperscript{12} However, in clinical situations such as pregnancy, hemoglobinopathy, anemia, blood transfusions and certain drugs can affect hemoglobin glycosylation or survival of certain erythrocytes. Likewise, the heterogeneity of ethnicity and age must also be considered.\textsuperscript{13}

Research conducted by Wijaya in 2015 found that HbA1C levels ≥ 5.55% were recommended as a screening tool in identifying impaired glucose tolerance (TGT) in obese children and adolescents with risk factors.\textsuperscript{14} Another study had an HbA1c level of 5.25% recommended as cut off points to identify impaired glucose tolerance in children and adolescents.\textsuperscript{15}

Several studies have been conducted regarding the association of HbA1c levels with obesity. However, research linking HbA1c levels with nutritional status in Indonesia is still limited. In addition, the high prevalence of obese children and adolescents with diabetes mellitus type 2 and the large risk posed by the increase in HbA1c, therefore this study was conducted to determine the differences in glycated hemoglobin (HbA1c) levels in obese and non-obese adolescents.

### 2. Research Methods

This study was an observational analytic study with a cross sectional design to determine the differences in HbA1c levels in obese and non-obese adolescents aged 15-19 years. This research was conducted in August - December 2019 at the Faculty of Medicine, Sriwijaya University and at SMA Negeri 1 Palembang.

The research sample was obtained using quota sampling and consecutive sampling techniques. The inclusion criteria in this study were adolescents aged 15-19 years who were willing to participate in the study and signed an informed consent. The exclusion criteria were adolescents who had transfusions in the last 3 months, adolescents who had been diagnosed with diabetes and were taking anti-diabetes drugs. There were 50 obese and non-obese adolescents aged 15-19 years of the Sriwijaya University Medical Faculty and students of SMA Negeri 1 Palembang as research subjects.

The dependent variable in this study is the HbA1C level obtained through venous blood sampling. Measurement of HbA1C levels using Affinity Binding Nycocard Reader products at the Sriwijaya University Clinical Laboratory. The independent variable in this study is the nutritional status which is known from the measurement of body mass index (BMI) as a quotient of body weight in kilograms with the square of the height in meters. Obesity was defined as BMI> +2 SD according to age and sex. Other variables that were also observed were age and sex which were known from filling out the questionnaire. Age is divided into 5 categories, namely 15 years, 16 years, 17 years, 18 years and 19 years. Gender is divided into 2 categories, namely men and women. Data analysis was performed descriptively and analytically using the Statistical Package for Social Science (SPSS) program version 24.0 for windows.

This research has received approval from the Health Research Ethics Committee of RSUP Mohammad Hoesin-FK UNSRI Palembang.

### 3. Result

The characteristics of the research respondents studied include nutritional status, age, and gender which can be seen in Table 1.

Respondents in this study were adolescents in the age group of 15 to 19 years with the largest number of respondents aged 18 years, namely 16 people (32%). Most of the respondents were female with 27 female respondents (54%).
The distribution of respondent characteristics in the form of gender and age based on their nutritional status can be seen in Table 2.

Based on Table 2, it is known that the nutritional status of obesity in this study was dominated by male respondents, namely 13 respondents (26%). And most of the respondents were in the obese group aged 17 years, as many as 8 respondents (16%).

The frequency distribution of respondents’ HbA1c based on nutritional status can be seen in Table 3. HbA1c levels were divided into 3 categories, namely categories with HbA1c levels ≥6.5%; 5.7% -6.4%; and <5.7% based on criteria published by the American Diabetes Association (ADA, 2010).

This study obtained data that all respondents who had HbA1c levels greater than or equal to 6.5% were respondents in the obese group, namely 9 respondents (18%); Likewise, all respondents with HbA1c levels of 5.7% to 6.4% were 6 respondents (12%) who were also in the obese group, while respondents who had HbA1c levels less than 5.7% were dominated by respondents who were in the non-obese group, namely 25 respondents (50%).

The Mann Whitney statistical test was performed to determine the difference in glycated hemoglobin (HbA1c) levels in the obese and non-obese adolescent groups and the results can be seen in Table 4.

Table 4 shows that statistically there is a difference in the mean HbA1c level in obese and non-obese adolescents where the HbA1c level in the obese group is higher than the non-obese group.

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**Table 1. General Characteristics of Research Respondents (N = 50)**

| Characteristics       | N  | %  |
|-----------------------|----|----|
| **Nutritional status (n)** |    |    |
| Obes                  | 25 | 50 |
| Non Obes              | 25 | 50 |
| **Sex [n]**           |    |    |
| Laki-laki             | 23 | 46 |
| Perempuan             | 27 | 54 |
| **Age [n]**           |    |    |
| 15 years              | 5  | 10 |
| 16 years              | 6  | 12 |
| 17 years              | 11 | 22 |
| 18 years              | 16 | 32 |
| 19 years              | 12 | 24 |
| **Total**             | 50 | 100 |

**Table 2. Frequency Distribution of Respondent Characteristics based on Nutritional Status (N = 50)**

| Characteristics | Nutritional status | Obes | Non obes |
|-----------------|--------------------|------|----------|
|                 | n     | %    | n   | %     |
| **Sex**         |       |      |     |       |
| Male            | 13    | 26   | 10  | 20    |
| Female          | 12    | 24   | 15  | 30    |
| **Age**         |       |      |     |       |
| 15 Years        | 4     | 8    | 1   | 2     |
| 16 Years        | 5     | 10   | 1   | 2     |
| 17 Years        | 8     | 16   | 3   | 6     |
| 18 Years        | 3     | 6    | 13  | 26    |
| 19 Years        | 5     | 10   | 7   | 14    |
| **Total**       | 25    | 50   | 25  | 50    |
Table 3. Frequency distribution of respondents' HbA1c based on nutritional status (N = 50)

| Category of HbA1c (ADA, 2010) | Nutritional Status | Total |
|-------------------------------|---------------------|-------|
|                               | Obes n | % | Non obes n | % | n | % |
| ≥6.5%                         | 9      | 18 | 0       | 0  | 9  | 18 |
| 5.7% - 6.4%                   | 6      | 12 | 0       | 0  | 6  | 12 |
| <5.7%                         | 10     | 20 | 25      | 50 | 35 | 70 |
| **Total**                     | 25     | 50 | 25      | 50 | 50 | 100 |

Table 4. Results of Difference Analysis of Mean HbA1c Levels for Obes and Non-Obes Groups

| Nutritional Status Category | HbA1c levels | P value |
|-----------------------------|--------------|---------|
| Obes                        | 6.1 ± 1.07   | 0.000   |
| Non Obes                    | 4.7 ± 0.40   |         |

4. Discussion

This study showed that there was a significant difference in the mean HbA1c levels in obese and non-obese adolescents. This study obtained an average HbA1c level of 6.1% in the obese adolescent group, while the non-obese group obtained an average HbA1c level of 4.7%. Based on research conducted on obese and overweight children by Lee, Park & Hwang in 2012, it was found that obesity is associated with an increase in the occurrence of impaired glucose tolerance, based on this study, the value of HbA1c levels can be used as a screening tool to identify children and adolescents with impaired glucose tolerance is 40 mmol / mol (5.8%) with a sensitivity of 64.7% and a specificity of 61.6%.16

Research conducted in Palembang, Indonesia in 2014 also stated that obesity is associated with an increase in the occurrence of impaired glucose tolerance and based on this study the HbA1c value which can be used as a screening tool in identifying children and adolescents with impaired glucose tolerance is 5.25% with sensitivity of 63% and specificity of 40%.15 Research conducted by Hasanuddin et al found that the mean HbA1c level in the obese group was 5.67%, in the overweight group was 5.49%, while in the normal weight group it was 5.33%. This study showed an increase in HbA1c levels along with an increase in body mass index with a significant difference in the mean HbA1c levels in adolescents with normal weight, overweight, and obesity.17

Research on adolescents in Brazil by de Cásia Lima Fernandes, et al in 2017 found that obese adolescents and adolescents with low or very low weight had a higher mean HbA1c levels than adolescents with normal weight or overweight / overweight18 strong association with insulin resistance and diabetes. An obese person has an increased amount of nonesterified fatty acids, glycerol, hormones, cytokines, proinflammatory markers, and other substances involved in the pathophysiology of insulin resistance19 Obesity also affects β-pancreatic cell dysfunction and leads to decreased glucose control. B-cell dysfunction and insulin resistance induce hyperglycemia and hence increase insulin demand. Dysfunction of pancreatic β cells results in inadequate secretion of insulin, resulting in higher circulating glucose concentrations. Increasingly elevated glucose concentrations over the physiological range result in manifestations of hyperglycemia and an increase in HbA1c levels.20

In this study, it was found that respondents in the obese group were dominated by male respondents compared to female respondents; Meanwhile, the non-obese group was dominated by female respondents.
compared to male respondents. This data is in line with the results of Mazidi’s research which states that obesity in adolescents is more common in boys (10.1%) than adolescent girls (6.2%) with p < 0.001. This result was also obtained by Sartika’s (2011) study, which shows that the proportion of overweight and obesity in boys is greater than girls. Research conducted by Wang, et al. (2018) also obtained data that the prevalence of overweight / obesity in male adolescents is higher than in female adolescents, according to him, this can be because adolescent girls are more likely to pay attention to their weight than adolescent boys. In his study, sex differences in the rate of obesity were significant in the adolescent group, but not in the younger group.

Boys and girls experience significant physical and psychological changes in adolescence and their identity as well as their bodies begin to mature. However, in some countries the cases of obesity and obesity in girls are higher than boys. Research by Lissau, et al., In 2004 showed no relationship between the incidence of obesity and gender.

Based on age characteristics, in this study, the highest number of respondents was 18 years old, namely 16 people, while the least respondents were 15 years old, namely 5 people. These results are consistent with research by Kranjac and Wagemiller in 2016, which used data for 2003-2004 from the NHANES, it was found that older children and adolescents were more likely to become obese than younger children and adolescents. However, for the 2011-2012 NHANES data Kranjac and Wagemiller found that older children and adolescents were not more likely to be obese than younger children and adolescents. Research conducted by Inchley et al., 2017 for the WHO region Europe using data from 2002-2014 found that in most countries and regions, the prevalence of obesity is higher in younger adolescents than in older adolescents and is generally higher in boys.

Research in Indonesia conducted by Sartika in 2011 found that the proportion of overweight and obesity in children aged less than 10 years is greater than those over or equal to 10 years of age. To obtain rapid growth, children aged 9-10 years need adequate nutrition. However, if food intake is not considered properly, the problem of obesity at this age is prone to occur. Growth and development in children aged 6-12 years are more stable than children aged <5 years (toddlers) as motor, cognitive, and social emotional development begins to mature. This period is marked by puberty in girls.

Given the morbidity associated with insulin resistance and type 2 diabetes, medical professionals and the general public face the challenge of preventing, not just treating, chronic metabolic and vascular complications in obese patients. Recent studies have shown that lifestyle interventions can reduce risk factors, and the incidence of impaired glucose tolerance and type-2 diabetes mellitus in children and adults. That people with prediabetes can also be converted back to normal sugar tolerance with appropriate lifestyle management. Measurement of HbA1c levels can be a useful measure to identify children who are screened for impaired glucose tolerance and should be treated with early lifestyle management.

5. CONCLUSION

HbA1c levels in adolescents aged 15-19 years in the obese group were higher than in the non-obese group.

6. REFERENCES

1. Garrow, J. S. Obesity and related diseases. Edinburgh, Churchill Livingstone; 1988 [diakses pada Juni 2019]; 1-16. Bottom of Form
2. World Health Organization. Adolescent obesity and related behaviors : trends and inequalities in the WHO European Region 2002-2014. Copenhagen, Denmark; 2017 [diakses pada Juni 2019]. Top of Form
3. Noer, E. R., Kustanti, E. R., & Fitriyanti, A. R. Perilaku gizi dan faktor psikososial remaja obes. Jurnal Gizi Indonesia (The Indonesian Journal of Nutrition); 2018 [diakses pada November 2019]; 6(2), 109-113
4. Kementerian Kesehatan Republik Indonesia. Pedoman Pencegahan dan Penanggulangan Obesitas pada Anak Sekolah 2012. Jakarta, Indonesia; 2012 [diakses pada Juni 2019]. Top of Form
5. Freedman, D.S. et al. Relation of body mass index and skinfold thicknesses to
cardiovascular disease risk factors in children: the Bogalusa Heart Study. Am. J. Clin. Nutr; 2009 [diakses pada Juni 2019]; 90(1), 210–216.
6. Rosenbloom AL, Silverstein JH, Amemiya S, Zeitler P, & Klingensmith G. ISPAD Clinical Practice Consensus Guidelines 2006-2007. Type 2 diabetes mellitus in the child and adolescent. Pediatr Diabetes; 2008 [diakses pada Juni 2019]; 9:512–26.
7. Polonsky, K.S., Sturis, J., & Bell, G.I. Seminars in Medicine of the Beth Israel Hospital, Boston. Non-insulin-dependent diabetes mellitus – a genetically programmed failure of the beta cell to compensate for insulin resistance. N Engl J Med; 1996 [diakses pada Juni 2019]; 334: 777–783.
8. Sinha, R., Fisch, G., Teague, B., Tamborlane, W., Banyas, B., Allen, K., Savoye, M., Rieger, V., Taksali, S., Barbeta, G., Sherwin, R. & Caprio, S. Prevalence of Impaired Glucose Tolerance among Children and Adolescents with Marked Obesity. New England Journal of Medicine; 2002 [diakses pada Juni 2019]; 346(11), hal.802-810.
9. American Diabetes Association. Standards of medical care in diabetes—2010. Diabetes Care; 2010 [diakses pada Juni 2019]; 33(suppl 1):S11–S61.
10. Nathan, D.M., Turgeon, H., & Regan, S. Relationship between glycated haemoglobin levels and mean glucose levels over time. Diabetologia; 2007 [diakses pada Juni 2019]; 50:2239-2244.
11. Brown, J. & Lechtenberg, E. Nutrition through the life cycle. Edisi ke-2. Belmont : Thomson Wadsorth; 2005 [diakses pada November 2019]
12. Bruns, D., Knowler, W.C. Stabilization of Glucose in Blood Samples: Why it matters. Clin Chem; 2009 [diakses pada Juni 2019]; (55): 850-2.
13. Galhardo, J. & Shield, J. The Role of Haemogoblin A1c in Screening Obese Children and Adolescents for Glucose Intolerance and Type 2 Diabetes. Acta Med Port ; 2015 [diakses pada November 2019]; 28(3): 307-15
14. Wijaya, A., Aditiawati, A & Saleh, I. Akurasi Pemeriksaan HbA1c dalam Mendeteksi Gangguan Toleransi Glukosa pada Anak dan Remaja Obes dengan Riwayat Orang Tua DM Tipe 2. Sari Pediatri; 2015 [diakses pada November 2019]; 17 (1), 17-20
15. Ginting, E., Aditiawati, A. & Irfanuddin, I. Utility of hemoglobin A1c to screen for impaired glucose tolerance. Paediatrica Indonesia; 2014 [diakses pada November 2019]; 54(4), 223.
16. Lee, H.S., Park, H.K & Hwang, J.S. HbA1c and Glucose Intolerance in Obese Children and Adolescents. Diabet.Med; 2012 [diakses pada November 2019]; 29, 102-5
17. Hasanuddin, Patellongi, I., Idris, I. & Rosdiana. HbA1c Levels in Adolescent Obesity, Overweight, and Normoweight Catholic High School Eagles in Makassar Rajawali. Universitas Islam Makassar; 2011 [diakses pada November 2019]; 1(1):257-61.
18. de Cäsia Lima Fernandes, R., Teló, G., Cureau, F., Barufaldi, L., Kuschnir, M., Schaan, B., Szko, M. and Bloch, K. Prevalence of high HbA1c levels in Brazilian adolescents: The Study of Cardiovascular Risk in Adolescents. Diabetes Research and Clinical Practice; 2017 [diakses pada November 2019]; 125 :1-9.
19. Al-Goblan, A. S., Al-Alfi, M. A., & Khan, M. Z. 2014. Mechanism linking diabetes mellitus and obesity. Dovepress; 2014 [diakses pada November 2019]; 587–91
20. Cerf, Marlon E. Beta Cell Dysfuntion and Insulin Resistance. Front Endocrinol; 2013 [diakses pada November 2019]; 4 : 37
21. Mazidi, M., Banach, M., & Kengne, A.. Prevalence of childhood and adolescent overweight and obesity in Asian countries: a systematic review and meta-analysis. Archives of Medical Science; 2018 [diakses pada November 2019]; 14(6), 1185-1203.
22. Wang, V., Min, J., Xue, H., Du, S., Xu, F., Wang, H. & Wang, Y. What factors may contribute to sex differences in childhood obesity prevalence in China?. Public Health Nutrition; 2018 [diakses pada November 2019]; 21(11), 2056-2064.
23. Lissau, I., Overpeck, M.D., Ruan, W.J., Due, P., Holstein, B.E., & Hediger, M.L. Body Mass Index and Overweight in Adolescents in 13 European Countries, Israel, and the United States. Arch Pediatri Adolesc Med; 2004 [diakses pada November 2019]; 158(1):27–33.
24. Kranjac, A. & Wagmiller, R. Association Between Age and Obesity Over Time. PEDIATRICS; 2016 [diakses pada November 2019]; 137(5), e20152096-e20152096.
25. Inchley, J., Currie, D., Jewell, J., Breda, J. & Barnekow, V. Adolescent obesity and related behaviours. Copenhagen: World Health Organization, Regional Office for europe; 2017 [diakses pada November 2019].
26. Sartika, R. Prevalensi dan Determinan Kelebihan Berat Badan dan Kegemukan pada Anak Berusia 5-15 Tahun. Kesmas: National Public Health Journal; 2011 [diakses pada
27. Indrawati, F.A., Moelyo, A.G.& Soebagyo, B. Hubungan HbA1c dengan Lingkar Pinggang, Rasio Lingkar Pinggang-Tinggi Badan, Indeks Massa Tubuh dan Lingkar Lengan Atas pada Remaja Perempuan Overweight / Obesitas. Sari Pediatri; 2019 [diakses pada November 2019]; 21(3) : 164-9