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# *Association between the Dysfunctional Adiposity Index (DAI) and Metabolic Risk in University Students*

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## Abstract

***Introduction:*** *Dysfunctional adiposity plays a key role in the early development of cardiometabolic disturbances, particularly in young adults. The Dysfunctional Adiposity Index (DAI) has been proposed as an alternative marker integrating anthropometric and biochemical parameters to identify metabolic risk at early stages. This study aimed to evaluate the association between DAI and multiple cardiometabolic risk factors in university students.*

***Methodology:*** *A cross-sectional study was conducted in 253 individuals aged 18-25 years from the Guadalajara Metropolitan Area. Anthropometric, clinical, and biochemical measurements were obtained following standardized procedures. The DAI was calculated using sex-specific formulas and classified using a cutoff value of 1.065. Insulin resistance was assessed using HOMA-IR. Student's t-tests, Chi-square tests, and logistic regression analyses were performed, with significance set at $p < 0.05$.*

***Results:*** *Participants with elevated DAI showed higher waist circumference, triglycerides, total cholesterol, diastolic blood pressure, and HOMA-IR, along with lower HDL-c levels compared with those with normal DAI ($p < 0.05$). The prevalence of abdominal obesity, hypertriglyceridemia, and low HDL-c was markedly higher among individuals with elevated DAI. Elevated DAI was strongly associated with increased odds of obesity (OR=5.63), dyslipidemias (OR 4.41–5.08), hypertension (OR=9.51), and insulin resistance (OR=3.44).*

***Conclusion:*** *The DAI emerges as a practical, low-cost marker for early detection of cardiometabolic alterations in young adults. Its use in screening strategies may support timely preventive interventions*

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## Introduction

Cardiovascular disease (CVD) remains the leading cause of premature morbidity and mortality worldwide. Since the mid-20th century, extensive research has identified major modifiable risk factors such as smoking, hypertension, diabetes, and dyslipidemia demonstrating that reducing these conditions can significantly lower disease incidence [1]. National dietary and prevention guidelines have incorporated these findings since the 1960s, though they require ongoing revision.

Obesity plays a central role in the development of cardiometabolic risk. However, beyond Body Mass Index (BMI), indicators that assess fat mass distribution and metabolic alterations may provide better predictive value for disease than BMI alone [2]. Several markers such as waist circumference, body fat percentage, and waist-to-height ratio have been used to improve risk stratification in youth populations [3,4].

The Dysfunctional Adiposity Index (DAI) has recently emerged as a novel, integrative marker of adipose tissue dysfunction that considers both anthropometric and biochemical parameters. In apparently healthy individuals, especially young adults, DAI has shown associations with early-stage metabolic alterations, allowing detection of risk before clinical symptoms appear [5].

Compared to traditional measures like BMI or waist circumference, DAI evaluates both the morphological and functional quality of adipose tissue, offering greater predictive accuracy for metabolic disorders [5]. It incorporates practical, non-invasive data waist circumference, BMI, triglycerides, and HDL cholesterol making it suitable for use in routine clinical and screening settings [6].

Evidence from occupational cohorts, including a study involving over 400,000 Spanish workers, has demonstrated DAI's diagnostic utility for identifying metabolic syndrome [7]. Furthermore, sex-specific differences have been observed, with DAI showing higher predictive capacity in women for cardiovascular and metabolic abnormalities [8,9].

The pathophysiological basis of DAI aligns with insulin resistance and lipotoxicity, which are central components of metabolic syndrome [10]. Although DAI and HOMA-IR are distinct, their overlapping biological mechanisms suggest potential interrelations that merit further exploration.

University life can expose students to lifestyle changes such as poor diet, reduced physical activity, and increased stress that contribute to the early onset of metabolic risk factors [11,12]. These factors may not only increase the risk of long-term chronic disease but also hinder academic performance and well-being.

Such alterations may impact metabolism by promoting the emergence of cardiometabolic risk factors that, over time, could increase the likelihood of developing non-communicable chronic diseases. However, there is still limited knowledge regarding the prevalence of these risk factors in the university student population. For this reason, the aim of this study is to analyze the association between the Dysfunctional Adiposity Index (DAI) and metabolic risk markers including insulin resistance and related cardiometabolic factors in a population of university students, to evaluate its predictive utility and potential application in early risk screening.

## Materials and Methods

### Participants

This cross-sectional study included 252 university-aged individuals from the Guadalajara Metropolitan Area (ZMG), Mexico, ranging from 18 to 25 years old. Participants were recruited through public announcements and selected based on the inclusion criterion of age. Individuals with known conditions that could interfere with insulin metabolism (e.g., polycystic ovary syndrome) were excluded. Ethical approval was obtained, and all procedures complied with the Mexican General Health Law on health research and the 2008 Declaration of Helsinki.

### Anthropometric and Clinical Measurements

All enrolled individuals completed a standardized health history form and underwent a physical examination. Anthropometric data included body weight,

height, and waist circumference. Weight and height were recorded using a TANITA30A electronic scale, which also provided the BMI. Waist circumference was measured with a flexible, non-stretchable tape, and abdominal obesity was defined according to the Adult Treatment Panel III (ATP III) guidelines [13].

Blood pressure was measured in a seated position using an aneroid sphygmomanometer, following the procedures described in the Mexican Official Standard [14].

## Biochemical Analysis

Venous blood samples were collected after a fasting period of 8 to 12 hours and processed immediately. Samples were divided into two aliquots:

The first aliquot was analyzed using a wet chemistry method on an A15 Biosystems analyzer to determine serum levels of glucose, total cholesterol, triglycerides (TG), and high-density lipoprotein cholesterol (HDL-c).

The Dysfunctional Adiposity Index (DAI) was computed using sex-specific formulas proposed by [15], which incorporate waist circumference (WC), BMI, triglycerides, and HDL-c:

$$DAI\ female = \left(\frac{WC}{24.02+(2.37*BMI)}\right)\left(\frac{TG}{1.32}\right)\left(\frac{1.43}{HDL-c}\right)$$

[1]

$$DAI\ male = \left(\frac{WC}{22.79+(2.68*BMI)}\right)\left(\frac{TG}{1.37}\right)\left(\frac{1.19}{HDL-c}\right)$$

[2]

A cut off point of 1.065 was used to classify individuals as having metabolic alterations.

The second aliquot was used to determine insulin concentrations through an enzyme-linked immunosorbent assay (ELISA). Insulin resistance was assessed using the Homeostasis Model Assessment of Insulin Resistance (HOMA-IR), calculated as:

$$HOMA-IR = \frac{Glucose\left(\frac{mg}{dl}\right)*Insulin\left(\frac{\mu U}{mL}\right)}{405}$$

[3]

A cut-off value of >2.5 was applied to identify insulin-resistant individuals [16].

## Data Analysis

Descriptive statistics were generated for all variables and expressed as frequencies, percentages, or mean ± standard deviation, as appropriate. Differences between groups were assessed using Student's t-tests for continuous variables and Chi-square tests for categorical data. The association between metabolic risk and DAI was estimated using Odds Ratios (ORs). All statistical analyses were carried out using Statgraphics Centurion 19, with significance set at $p < 0.05$.

## Results.

A total of 252 university students were included, classified into DAI–Elevated (n = 56) and DAI–Normal (n = 196). Table 1 summarizes the comparison of metabolic and anthropometric variables between groups.

Participants with elevated DAI showed significantly higher values of waist circumference (WC), triglycerides (TG), total cholesterol, diastolic blood pressure (DBP), and HOMA-IR, along with significantly lower HDL-cholesterol levels compared with participants with normal DAI ($p < 0.05$ for all). Body mass index (BMI) was also slightly higher in the elevated DAI group (27.03 ± 5.27 vs. 23.39 ± 4.05, $p < 0.000$). No significant differences were observed in systolic blood pressure (SBP) ($p = 0.0608$).

**Table 1:** Metabolic Risk Factors Differences Between Normal and elevated Dysfunctional Adiposity Index

| | **DAI – Elevated n = 56** | **DAI-Normal n = 196** | **p – value** |
|---|---|---|---|
| BMI | 27.03 ± 5.27 | 23.39 ± 4.05 | < 0.000 * |
| WC | 94.66 ± 12.07 | 83.00 ± 4.72 | < 0.000 * |
| TG | 151.44 ± 53.41 | 72.23 ± 23.08 | < 0.000 * |
| HDL | 45.76 ± 6.43 | 54.35 ± 9.73 | < 0.000 * |
| CHOL | 185. 98 ± 35.67 | 159.83 ± 27.55 | < 0.000 * |
| SBP | 117.83 ± 14.06 | 114.06 ± 12.21 | < 0.0608 |
| DBP | 79.25 ± 12.02 | 74.07 ± 9.64 | < 0.0023 * |
| HOMA-IR | 2.98 ± 3.36 | 1.68 ± 1.56 | < 0.0008 * |

Mean ± standard deviation. Student's t test, a p value <0.05 was considered significant.

*Statistical differences. SBP (systolic blood pressure), DBP (diastolic blood pressure), WC (waist circumference), HDL (high density lipoprotein), HOMA (homeostatic model assessment). DAI (dysfunctional adiposity index). DAI (dysfunctional adiposity index), BMI (Body Mass Index).

We illustrate the prevalence of several metabolic risk factors stratified by the Dysfunctional Adiposity Index (DAI) in figure 1. Consistently, the group with elevated DAI showed a significantly higher frequency of metabolic alterations compared with the group with normal DAI. Abdominal obesity was the most prevalent condition in the elevated-DAI group (69.5%), followed by hypertriglyceridemia (55.4%), low HDL cholesterol (55.5%), and hypercholesterolemia (33.8%). In contrast, the normal-DAI group exhibited considerably lower prevalences across all assessed conditions, with abdominal obesity (28.4%) and low HDL (21.9%) being the most frequent. These findings indicate a clear clustering of cardiometabolic risk factors among individuals with elevated DAI.

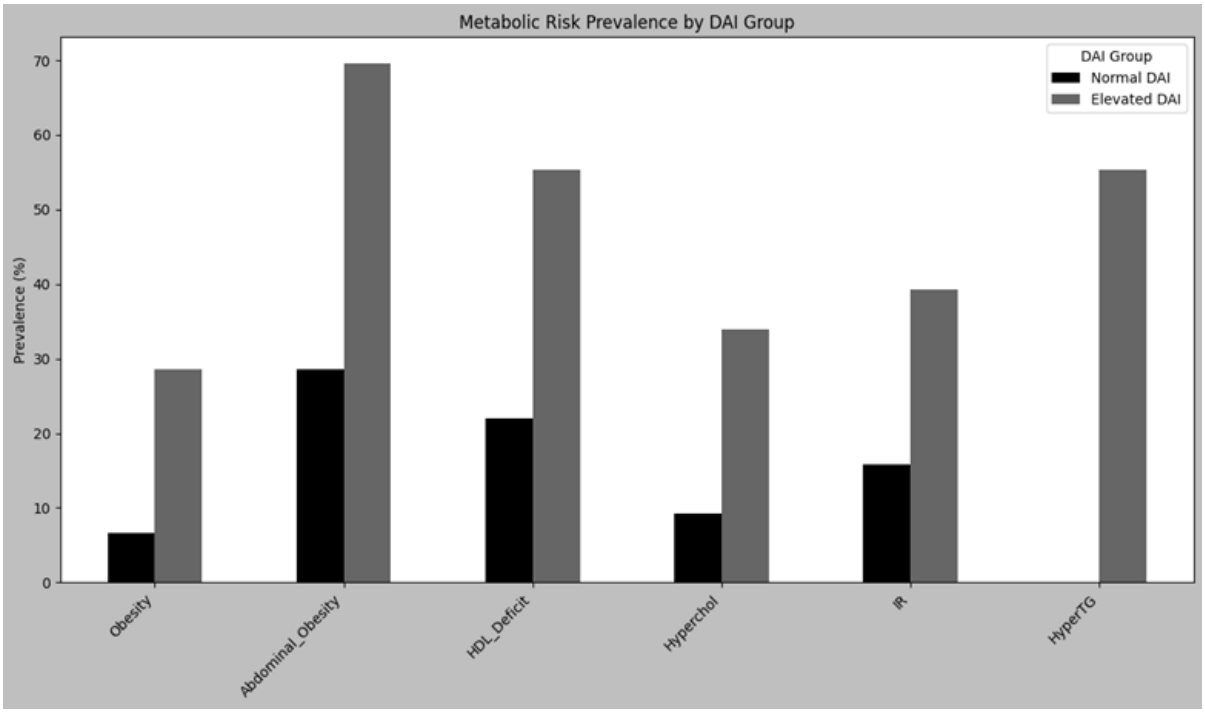


**Figure 1:** Metabolic risk factors by DAI Group.

In figure 2, depicts the relationship between DAI and three continuous metabolic parameters: body mass index (BMI) (A), triglycerides (TG) (B), and waist circumference (WC) (C). In all cases, a positive association was observed between DAI and the variables analyzed. The association was particularly strong for DAI and triglycerides, where higher DAI values were accompanied by marked increases in serum TG levels. Similarly, both BMI and waist circumference showed ascending trends as DAI increased, indicating that a higher DAI is linked to greater overall and central adiposity. The confidence bands emphasize the consistency of these associations, suggesting that DAI functions as a robust indicator of metabolic disturbances related to excessive adiposity and dyslipidemia.

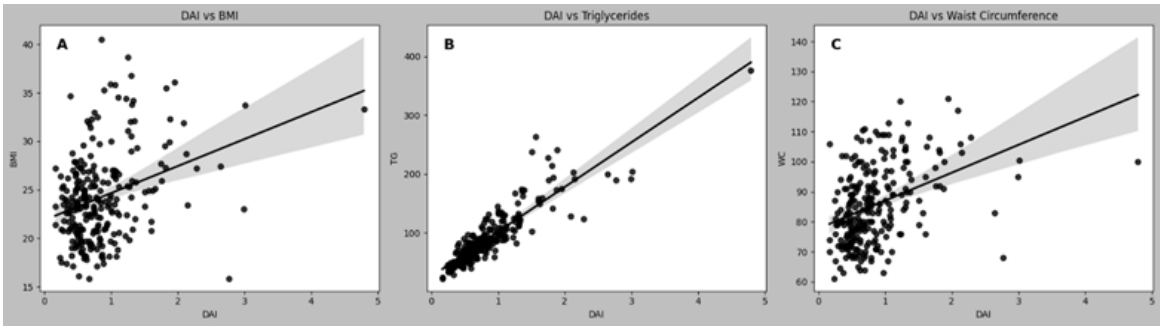


**Figure 2:** Correlation between DAI and BMI (A), TG (B) and WC (C).

Finally, to further explore the metabolic implications of elevated DAI, odds ratios (OR) were calculated for key cardiometabolic risk factors (Table 2). Students with elevated DAI exhibited 5.63-fold higher odds of obesity (95% CI: 2.51–12.63, $p < 0.0001$) and 3.10-fold higher odds of abdominal obesity (95% CI: 2.70–9.61, $p < 0.0001$). Altered lipid parameters were also strongly associated with elevated DAI, including 4.41-fold higher odds of HDL-cholesterol deficit (95% CI: 2.36–8.25, $p < 0.0001$) and 5.08-fold higher odds of hypercholesterolemia (95% CI: 2.43–10.59, $p < 0.001$). Elevated DAI was further associated with 9.51-fold increased odds of hypertension (95% CI: 1.79–30.44, $p = 0.0082$) and 3.44-fold increased odds of insulin resistance (95% CI: 1.78–6.66, $p = 0.0002$).

**Table 2:** Association of DAI with Metabolic Risk Factors.

| | Odds Ratio | p value | Confidence interval (CI) |
|---|---|---|---|
| Obesity (BMI) | 5.6308 | < 0.0001 | 2.5103 – 12.6304 |
| Abdominal Obesity (WC) | 3.100 | < 0.0001 | 2.7069 – 9.6090 |
| HDL Deficit | 4.4121 | < 0.0001 | 2.3590 – 8.2522 |
| Hyper cholesterol | 5.0781 | < 0.001 | 2.4336 – 10.5960 |
| Hypertension | 9.5098 | 0.0082 | 1.7927 – 30.4473 |
| Insulin resistance | 3.4440 | 0.0002 | 1.7811 – 6.6595 |

Chi square test. $p < 0.05$ was considered significant.

Overall, these data indicate that elevated DAI is strongly associated with multiple components of metabolic risk, including adiposity, dyslipidemia, blood pressure alterations, and insulin resistance. The consistency and magnitude of these associations suggest that the DAI may serve as a useful marker for early identification of metabolic risk among young adults.

## Discussion

This study evaluated the associations between the Dysfunctional Adiposity Index (DAI) and multiple metabolic risk factors in a population of young university students. Our findings demonstrate that elevated DAI is consistently linked to an adverse metabolic profile, supporting its relevance as an early indicator of cardiometabolic risk.

Consistent with our results, participants with elevated DAI showed significantly higher levels of triglycerides, total cholesterol, waist circumference, and HOMA-IR, along with lower HDL cholesterol concentrations. These parameters reflect well-established components of metabolic dysfunction and are strongly associated with impaired adipose tissue regulation [17,18]. Like previous reports, our findings suggest that DAI captures underlying adipose tissue dysfunction, particularly visceral and ectopic fat accumulation which may occur even in young adults without clinically manifest disease [19].

The marked differences in the prevalence of metabolic alterations between the elevated and normal DAI groups are aligned with evidence suggesting that dysfunctional adiposity often co-occurs with dyslipidemia and central obesity. Prior studies have shown that individuals with visceral adiposity exhibit a higher frequency of hypertriglyceridemia, low HDL cholesterol, and insulin resistance, even when BMI remains within non-obese ranges [20,21]. Our results reinforce this pattern and extend it to university students, highlighting the early onset of cardiometabolic clustering.

The positive linear associations observed between DAI and continuous measures including BMI, triglycerides, and waist circumference further support the biological plausibility of the index. DAI increased in parallel with general and central adiposity markers, consistent with findings that adipose tissue dysfunction reflects both excess fat mass and impaired metabolic flexibility [22]. The particularly strong relationship between DAI and triglycerides aligns with previous evidence demonstrating that dysfunctional adiposity promotes hepatic fat flux and reduced clearance of triglyceride-rich lipoproteins.

Additionally, the odds ratios calculated for several cardiometabolic risk factors underscore the clinical relevance of elevated DAI. The increased odds of obesity, abdominal obesity, low HDL, hypercholesterolemia, hypertension, and insulin resistance mirror patterns reported in studies examining early cardiometabolic risk in youth and young adults. The magnitude of these associations suggests that DAI not only reflects excess adiposity but also captures multisystem metabolic vulnerability, likely involving inflammatory and endocrine pathways.

Taken together, these results position the DAI as a promising early screening tool for metabolic risk among young adults. Identifying individuals with dysfunctional adiposity at this stage is critical, given that early metabolic disturbances strongly predict long-term cardiometabolic outcomes [23,24]. While our findings provide substantial support for the utility of the DAI, longitudinal studies are needed to determine whether elevated DAI predicts incident metabolic disease and whether its incorporation into routine screening improves early detection strategies. In conclusion, elevated DAI was strongly associated with multiple metabolic risk components in young individuals. This study contributes to the growing body of evidence highlighting the importance of adipose tissue function beyond body mass alone in understanding and identifying cardiometabolic risk. The consistency between our findings and existing literature supports the DAI as a potentially valuable marker for early risk stratification in university populations.

## Conclusions

This study demonstrated a strong and consistent association of DAI with multiple metabolic risk factors. Individuals with elevated DAI exhibited higher levels of adiposity, dyslipidemia, blood pressure alterations, and insulin resistance, as well as a greater prevalence of key cardiometabolic abnormalities. The magnitude and coherence of these associations indicate that DAI captures early metabolic dysregulation that is not fully reflected by traditional anthropometric measures alone. These findings highlight the potential of DAI as a practical and informative tool for early identification of metabolic risk in young adults, a population in which cardiometabolic disturbances often go unrecognized. Incorporating DAI into screening strategies may improve the detection of individuals at elevated risk and support timely interventions aimed at

preventing the progression of metabolic disease.

Future longitudinal studies are needed to determine whether elevated DAI predicts incident cardiometabolic outcomes and to evaluate its applicability across diverse populations and clinical settings

## References


1. Teo K K, Rafiq T (2021) Cardiovascular risk factors and prevention: A perspective from developing countries. Canadian Journal of Cardiology 37: 733-743.
2. Elagizi A, Kachur S, Lavie C J, Carbone S, Pandey A, et al. (2018) An overview and update on obesity and the obesity paradox in cardiovascular diseases. Progress in Cardiovascular Diseases 61: 142-150.
3. Carvalho W R C, França A K T D C, Santos A M D, Padilha L L, Bogea E. G (2023) Appropriate neck circumference and waist-to-height ratio cut-off points as predictors of obesity and cardiovascular risk in adolescents. Revista de Saúde Pública 57: 24.
4. Megchún Hernández M, Espinosa Raya J, García Parra E, Gómez Pliego R, Castellanos Pérez M (2022) Comparative analysis of anthropometric indicators for diagnosing obesity and predicting cardiometabolic risk in Mexican adolescents. Nutrición Hospitalaria 39: 513-519.
5. Teófila Vicente-Herreroa, Mónica Egea Sanchob (2023) Revista Colombiana de Medicina Familiar.
6. Archivos de la Sociedad Española de Medicina Interna (2024)
7. Advances in Preventive Research and Lifestyle (2022)
8. Samuel V T, Shulman G I (2016) The pathogenesis of insulin resistance: Integrating signaling pathways and substrate flux. The Journal of Clinical Investigation 126: 12-22.
9. Kahn C R, Wang G, Lee K Y (2019) Altered adipose tissue and adipocyte function in the pathogenesis of metabolic syndrome. The Journal of Clinical Investigation 129: 3990-4000.
10. Bays H E (2011) Adiposopathy is “sick fat” a cardiovascular disease? Journal of the American College of Cardiology 57: 2461-2473.
11. Giménez L, Degiorgio L, Diaz Zechin M, Balbi M I, Villani M, et al. (2019) Factores de riesgo de enfermedad cardiovascular en estudiantes universitarios. Revista Argentina de Cardiología 87: 203-209.
12. Kubová P, Smolová H, Urbancová H (2018) Adherence to healthy lifestyle principles among college students: A case study. Acta Universitatis Agriculturae et.
13. Diguay-Clavijo S E, Rosendo Chalma P, Prieto Fuenmayor C F (2022) Comparación de criterios diagnósticos del síndrome metabólico en un Centro de Atención Primario Rural. Revista Arbitrada Interdisciplinaria De Ciencias De La Salud. Salud Y Vida 6: 790-811.
14. NOM-030-SSA2-2009 (2009) Para la prevención, detección, diagnóstico, tratamiento y control de la hipertensión arterial sistémica. Secretaría de Salud. Diario Oficial de la Federación, México.
15. Reyes Barrera J, Sainz Escárrega V H, Medina Urritia A X, Jorge Galarza E, Osorio Alonso, et al. (2021) Dysfunctional adiposity index as a marker of adipose tissue morpho functional abnormalities and metabolic disorders in apparently healthy subjects. Adipocyte 10: 142-152.
16. Vega-Ponce et al. (2023) Diagnostic performance of eleven indicators of insulin resistance in a sample of Peruvian. Med. Clín. Soc. 7: 168-176
17. Després J P (2012) Body fat distribution and risk of cardiovascular disease: An update. Circulation 126: 1301-1313.
18. Neeland I J, Ross R, Després J P, Matsuzawa Y, Yamashita S, et al. (2019) Visceral and ectopic fat, atherosclerosis, and cardiometabolic disease: A position statement. The Lancet Diabetes & Endocrinology 7: 715-725.
19. Stefan N (2020) Causes, consequences, and treatment of metabolically unhealthy fat distribution. The Lancet Diabetes & Endocrinology 8: 616-627.
20. Karelis A D, St Pierre D H, Conus F, Rabasa Lhoret R, Poehlman E T (2005) Metabolic and body composition factors in subgroups of obesity: What do we know? The Journal of Clinical Endocrinology & Metabolism 90: 2569-2575.
21. Gastaldelli A (2019) Insulin resistance and reduced metabolic flexibility: Cause or consequence of NAFLD? Clinical Science 133: 7-10.
22. Blüher M (2021) Metabolically healthy obesity. Endocrine Reviews 42: 405-446.
23. Reaven G (2011) Insulin resistance: The link between obesity and cardiovascular disease. Medical Clinics of North America 95: 875-892.

24. Twig G, et al. (2016) BMI in adolescence and risk of cardiovascular mortality in adulthood. The New England Journal of Medicine 374: 2430-2440.