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Evaluating Fasting Glucose, Insulin, and HOMA-IR in Metabolic Disorders

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ABSTRACT

Objective: *Insulin resistance is a metabolic complaint related to the progression of type 2 diabetes and cardiovascular disease, as well as a range of other chronic conditions. The Homeostatic Insulin Resistant Assessment Model (HOMA-IR) is widely used as an indicator of this condition, based on measurements of fasting blood glucose sugar and insulin concentrations. However, the nature of the relationship between these indicators can vary depending on different physiological factors and underlying medical condition.* ***Method:*** *A cross-sectional study was conducted with 18 participants, including individuals with difficulty losing weight and patients with type 2 diabetes. Fasting blood glucose levels were estimated by an automated biochemical analyzer, while fasting insulin concentrations were measured using an automated immunoassay system. The HOMA-IR insulin resistance index was calculated using a standardized formula. To assess the strong point and the route of the relationship among the studied variables, with a p-value < 0.05 considered statistically significant, Pearson's correlation coefficient was used.* ***Results:*** *This results showed a strong positive correlation between fasting insulin and the HOMA-IR index ($r = 0.945$, $p < 0.001$), indicating a highly statistically significant relationship. In contrast, fasting blood glucose did not show a statistically significant correlation with either fasting insulin ($r = 0.145$, $p = 0.566$) or the HOMA-IR index ($r = 0.351$, $p = 0.153$).* ***Novelty:*** *The results indicate that fasting insulin concentration is a crucial factor in determining HOMA-IR values and may be a more sensitive indicator for assessing insulin resistance than fasting glucose concentration alone. The lack of a statistically significant correlation between fasting glucose concentration and other variables highlights its limitations as a sole indicator for the early detection of insulin resistance. However, the small size of sample and the nature of cross-sectional in this study limit the broad applicability of these outcomes, necessitating future studies with more samples also more comprehensive analytical approaches. Adding some necessary and complementary tests to the study, such as lipid profile, vitamin D levels, and body mass index, for example.*

INTRODUCTION

Insulin resistance is a widespread disorder affecting several vital tissues such as the heart, skeletal muscles, liver, and adipose tissue, and over time it produces latent negative effects despite their lack of early manifestation [[1], [2], [3]]. For example, individuals with insulin resistance exhibit higher susceptibility to several types of cancer, such as ovarian, breast, endometrial, liver, colon, and pancreatic cancer, compared to healthy individuals. This is often attributed to elevated blood insulin levels, a hallmark of this condition, which has been shown to contribute to tumor initiation and development [[4], [5], [6]]. Although a precise understanding of the underlying mechanisms of insulin resistance is still incomplete, which is reflected in the limited optimal treatment options, it can be controlled pharmacologically and even reversed by creating a severe negative energy balance [7,8]. Therefore, research aimed at reducing insulin resistance can contribute new scientific insights into strategies for preventing the development of associated or co-occurring disorders, such as type 2 diabetes, cardiovascular disease, age-related cognitive decline, and dementia. This is particularly important because these conditions often have a gradual and inevitable progression that can lead to irreversible changes. [2,9,10].

The resistance of insulin considers as major agent related to the progress of several metabolic disorders, such as type 2 diabetes and cardiovascular disease. The HOMA-IR which mean (Homeostatic Model Assessment of Insulin Resistance) is broadly used as an indirect way for assessing insulin resistance based on insulin levels fasting and blood glucose (FBS). While fasting blood glucose (FBS) and fasting insulin are important biomarkers for assessing metabolic homeostasis, the relationship between these variables can vary depending on an individual's physiological or pathological status. Despite the widespread use of these biomarkers, understanding the nature of their statistical correlations remains crucial for accurately interpreting the mechanisms underlying insulin resistance [11]. Evidence has shown that regular physical activity contributes to reduced insulin secretion from the pancreas, while simultaneously improving the sensitivity of insulin receptors at the cellular level, particularly in muscle cells. Consequently, less insulin is required to promote glucose uptake into the muscles, leading to increased glucose absorption from the bloodstream and contributing to a reduction in insulin resistance in skeletal muscle [12].

On the other hand, establishing a precise clinical definition of insulin resistance is complex due to the lack of standardised and agreed-upon diagnostic criteria. Clinically, this condition is indicated by a range of associated metabolic manifestations, including hyperglycemia, hypertension, dyslipidemia, and endothelial dysfunction. This cluster of disorders is collectively called insulin resistance syndrome or Syndrome X. Insulin resistance is also related to raised thrombophilia and elevated uric acid levels. These metabolic changes combine to raise the danger of type 2 diabetes and cardiovascular disease [13].

Aims of the study

This study aims to explore the bond among fasting blood glucose, fasting insulin, and the insulin resistance index (HOMA-IR), by using Pearson correlation analysis to determine the strength and direction of the relations among them.

RESEARCH METHOD

This study relied on cross-sectional data analysis of 18 samples, Venous blood samples were collected using tubes without clotting factors to obtain serum, of individuals experiencing difficulty losing weight and others with type 2 diabetes. It included three main biochemical variables: fasting blood glucose (FBS), measured to assess basal glucose levels, fasting insulin, measured to assess pancreatic response, and the HOMA-IR index. Fasting blood glucose concentrations were measured using a fully automated Mendry BS-230 chemistry analyzer, and fasting insulin levels were measured using a fully automated Maglumi 800 analyzer. The HOMA-IR index calculated using the standard equation:

$$\text{HOMA-IR} = \frac{\text{FBS (mg/dL)} \times \text{Insulin (mIU/L)}}{405}$$

or using equivalent international units. Also used Pearson correlation analysis to assess linear relationships among variable quantity, also considered statistically significant with a $p < 0.05$.

RESULTS AND DISCUSSION

Pearson correlation analysis demonstrated a strong positive association between fasting insulin and HOMA-IR ($r = 0.945$, $P < 0.001$). In contrast, fasting blood sugar revealed statistically significant correlation with fasting insulin ($r = 0.145$, $P = 0.566$) or with HOMA-IR ($r = 0.351$, $P = 0.153$). The very high correlation ($r = 0.945$) reflects that fasting insulin is the dominant factor in the HOMA-IR calculation in this sample. This is consistent with what Son & Lee (2022) stated: that HOMA-IR is consider as an indirect pointer of IR and is often more influenced by insulin levels than glucose, especially in the early stages of insulin resistance [14].

Insulin resistance often begins with elevated insulin (hyperinsulinemia), while glucose remains normal for a long period (pancreatic compensation), This explains why insulin HOMA-IR ratios are elevated but FBS does not change significantly [15].

Table (1-1) shows that insulin resistance may precede high blood sugar for many years, making the HOMA-IR index and fasting insulin level more sensitive tools for detecting insulin resistance in its early stages before it affects blood sugar levels [16].

Table 1. Correlation coefficients and P-values.

Variable pair	Pearson r	P-value	Interpretation
FBS vs FI	0.145	0.566	Non-significant
FBS vs HOMA-IR	0.351	0.153	Non-significant
Fasting insulin versus HOMA-IR	0.945	<0.001	Highly significant

Table 2. Correlation matrix.

Variable	FBS	Fasting insulin	HOMA-IR
FBS	1.000	0.145	0.351
Fasting insulin	0.145	1.000	0.945
HOMA-IR	0.351	0.945	1.000

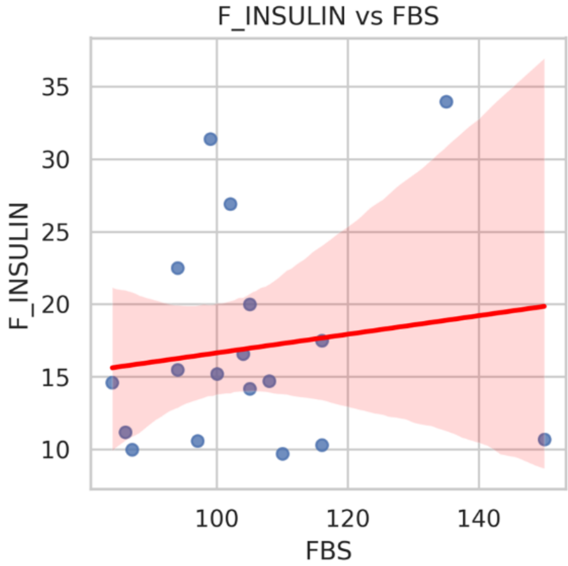

Figure 1. Scatter plot illustrates the relationship between fasting insulin levels and fasting blood sugar (FBS).

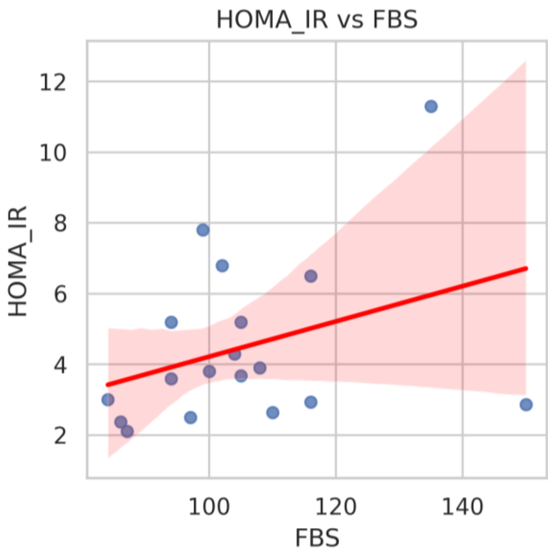

Figure 2. Scatter plot viewing the connection between HOMA-IR also FBS.

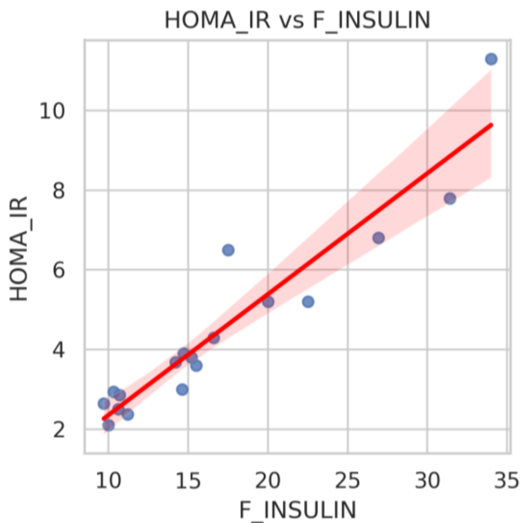

Figure 3. Scatter plot shows the relationship between HOMA-IR and fasting insulin.

CONCLUSION

Fundamental Finding : The article examines the relationship between fasting glucose concentrations, fasting insulin concentrations, and the insulin resistance index (HOMA-IR) in individuals with metabolic disorders. The study highlights that fasting insulin plays a crucial role in determining HOMA-IR values and is a more sensitive indicator for assessing insulin resistance than fasting glucose levels. Pearson's correlation analysis reveals a strong positive correlation between fasting insulin and HOMA-IR, indicating that insulin is the primary factor influencing HOMA-IR calculations. Conversely, fasting glucose did not show a significant correlation with either fasting insulin or HOMA-IR, suggesting its limitations as a sole marker for insulin resistance. **Implication :** The findings imply that fasting insulin levels could be a more reliable biomarker for detecting insulin resistance, particularly in its early stages, compared to fasting glucose levels. This insight can inform clinical practices, suggesting that insulin measurements should be prioritized over glucose levels for assessing insulin resistance and its associated risks. Furthermore, the study underscores the need to consider insulin concentration as a key factor in metabolic health assessments, which could potentially lead to more accurate diagnoses and better-targeted interventions. **Limitation :** Despite the important contributions of this study, it is limited by the small sample size and the cross-sectional nature of the design. These factors may affect the generalizability of the findings, as the results may not reflect the broader population or account for long-term trends in insulin resistance development. Additionally, the study does not explore the potential influence of other factors that could affect insulin resistance, such as genetic predisposition, lifestyle, or comorbid conditions. **Future Research :** Future research should aim to validate these findings with larger sample sizes and longitudinal designs to strengthen the evidence on the role of fasting insulin in insulin resistance assessment. Studies incorporating diverse populations and exploring additional variables influencing insulin resistance will help provide a more comprehensive understanding of its pathophysiology. Furthermore, research should investigate the potential of combining insulin and glucose measurements with other biomarkers to improve early detection and prevention strategies for metabolic disorders like type 2 diabetes and cardiovascular diseases.

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