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CENTRAL ADIPOSITY MARKERS: PREDICTING GLUCOSE METABOLISM DISORDERS AND ANDROLOGICAL HEALTH IMPLICATIONS IN YOUNG MEN BEYOND WEIGHT

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ABSTRACT

Objective: To examine the relationship between anthropometric indicators and fasting blood glucose (FBG) levels in young adult males and assess their potential impact on andrological health.

Methodology: This cross-sectional study was conducted from March 2024 to September 2024. One hundred ninety-six young males aged 18-40 years were recruited using convenient purposive sampling. Anthropometric measurements included body mass index (BMI), waist circumference, waist-to-height ratio (WHtR), waist-to-hip ratio (WHR), mid-upper arm circumference (MUAC), body fat percentage, and visceral fat levels. Fasting blood glucose was measured after an 8-hour overnight fast. Prediabetes was defined as FBG 100-125 mg/dL, and diabetes as FBG ≥126 mg/dL. Data were analyzed using SPSS version 25.0.

Results: The average age was 30.1 ± 5.8 years, with 63% living in urban areas. The overall prevalence of prediabetes was 20.4% (40 out of 196). The mean BMI was 23.9±3.5 kg/m², and the mean FBG was 94.8 ± 9.2 mg/dL. Significant correlations were found between FBG and age ($r=0.198$, $p<0.01$) and BMI ($r=0.175$, $p<0.05$). Overweight participants had significantly higher mean FBG compared to those with normal weight (97.3 vs. 93.2 mg/dL, difference=4.1 mg/dL, $p<0.05$).

Conclusion: The high prevalence of prediabetes (20.4%) in young males and its link to anthropometric indicators have important implications for andrological health. Given the established connections between glucose metabolism disorders, obesity, and testosterone deficiency, these findings highlight the need for early screening that addresses both metabolic and reproductive health in young men.

Key Words: Anthropometry, Body Mass Index, Fasting Blood Glucose, Diabetes, Male Hypogonadism, Testosterone, Metabolic Health.

INTRODUCTION

The worldwide epidemic of diabetes and metabolic syndrome has reached concerning levels, affecting over 537 million adults globally. [1] This issue is especially troubling considering emerging evidence showing bidirectional links between metabolic disorders and male reproductive health. Recent research has shown that diabetes and obesity greatly influence testosterone levels and male fertility, while testosterone deficiency may lead to metabolic problems.[2]

In Pakistan, the dual burden of malnutrition presents unique challenges, with 23% of the population being clinically obese while nutritional deficiencies remain widespread.[3] This coexistence of undernutrition and overnutrition creates complex pathophysiological scenarios that can differently affect andrological health.

The relationship between anthropometric indicators and glucose metabolism has significant implications for male reproductive health. Studies show that testosterone deficiency affects up to 25% of men with type 2 diabetes, while obesity-related hypogonadism is increasingly recognized as a distinct clinical condition.[4] Additionally, recent research has confirmed that components of metabolic syndrome, including central obesity and insulin resistance, are independently linked to lower testosterone levels and reduced spermatogenesis.[5]

Anthropometric measurements offer accessible, cost-effective screening tools that can identify individuals at risk for both metabolic and andrological disorders. Body mass index (BMI), waist circumference, and waist-to-height ratio accurately reflect body composition patterns that are closely associated with insulin resistance, inflammation, and hormonal dysfunction.[6] However, the relative importance of different anthropometric parameters in predicting glucose metabolism disorders and their potential impact on male reproductive health remains incompletely understood in South Asian populations.

This study was conducted to examine the relationship between anthropometric indicators and fasting blood glucose levels, considering potential implications for male andrological health and reproductive function.

METHODOLOGY

This cross-sectional study was conducted from March 2024 to September 2024 after receiving approval from the institutional ethical review committee. The sample size was calculated using the WHO sample size calculator, considering a diabetes prevalence of 25% among adults,[7] with a 95% confidence level and a 5% margin of error, resulting in a sample size of 196. Young adult males aged 18 to 40 years visiting the teaching hospital in Turbat were enrolled through a convenient purposive sampling method. The inclusion criteria included males aged 18 to 40 years, permanent residents of the area, willing to participate, and without known medical conditions. The exclusion criteria included known chronic diseases, active malignancy, current use of medications affecting glucose metabolism, known endocrine disorders, and any acute illness within the past two weeks. After obtaining written informed consent, demographic data such as age, education, residence, and family type were recorded on a pre-designed form. Body fat percentage and visceral fat levels were assessed using bioelectrical impedance analysis. Five milliliters of venous blood were collected after an 8-hour overnight fast under aseptic conditions. Fasting blood glucose was measured using the glucose oxidase method within two hours of collection with an automated analyzer. Glucose categories were classified based on WHO standards. A waist-to-height ratio above 0.5 was considered a sign of central obesity. Data were entered and analyzed using SPSS version 23.0.

RESULTS

The mean age was 30.1 ± 5.8 years, with 62.8% living in urban areas. The overall prediabetes prevalence was 20.4% (40/196). The BMI distribution was as follows: underweight 5.6% (11/196), normal weight 53.6% (105/196), overweight 34.7% (68/196), and obese 6.1% (12/196).

Table-I: Anthropometric and metabolic parameters across study population.

Parameters	Mean ± SD
Age (years)	30.1 ± 5.8
Height (cm)	165.3 ± 5.9
Weight (kg)	65.3 ± 10.9
BMI (kg/m²)	23.9 ± 3.5
Waist circumference (cm)	84.8 ± 5.9
Waist-to-height ratio	0.51 ± 0.04
Waist-to-hip ratio	0.83 ± 0.07
MUAC (cm)	27.0 ± 1.7
Body fat (%)	27.3 ± 4.4
Visceral fat level	14.0 ± 3.5
FBG (mg/dL)	94.8 ± 9.2

Table-II: Comparison of FBG and anthropometric parameters across BMI categories (ANOVA).

Parameters	Underweight (n=11)	Normal (n=105)	Overweight (n=68)	Obese (n=12)	F-value	p-value
FBG (mg/dL)	96.8 ± 10.2	93.2 ± 8.6	97.3 ± 9.8	98.1 ± 1.4	3.142	0.026*
Waist circumference (cm)	78.2 ± 4.1	83.1 ± 5.2	87.4 ± 6.1	92.3 ± 7.2	18.672	<0.001*
Waist-to-height ratio	0.47 ± 0.03	0.50 ± 0.04	0.53 ± 0.04	0.56 ± .05	12.984	<0.001*
Body fat (%)	22.1 ± 3.8	26.8 ± 4.2	28.9 ± 4.6	31.2 ± 5.1	9.741	<0.001*
Visceral fat level	11.2 ± 2.9	13.6 ± 3.2	15.1 ± 3.8	17.8 ± 4.2	6.823	<0.001*

DISCUSSION

Our study revealed a 20.4% prevalence of prediabetes in young adult males with no known comorbidities is concerning due to their young age and apparent health status. This finding has significant implications for future andrological health, given the established link between early glucose metabolism issues and later testosterone deficiency. The ANOVA analysis showed significant differences in FBG across BMI categories ($F=3.142$, $p=0.026$), confirming a U-shaped pattern. Both underweight (96.8±10.2 mg/dL) and obese (98.1±11.4 mg/dL) participants had higher average FBG levels compared to those with normal weight (93.2±8.6 mg/dL).

This pattern has significant andrological implications, as both ends of BMI can affect reproductive health through different mechanisms. A meta-analysis by Corona et al. showed that type 2 diabetes is linked to a considerable decrease in total testosterone levels, with hypogonadism found in about 25% of diabetic men.[8] Similarly, Dandona and Dhindsa reported that one-third of men with type 2 diabetes have low free testosterone levels, which relates to the level of insulin resistance.[9]

The increasing levels of central adiposity markers across BMI categories were highly significant: waist circumference ($F=18.672$, $p<0.001$), waist-to-height ratio ($F=12.984$, $p<0.001$), body fat percentage ($F=9.741$, $p<0.001$), and visceral fat levels ($F=6.823$, $p<0.001$). These findings are especially relevant to andrological health, as visceral adiposity is strongly associated with testosterone suppression due to the production of inflammatory cytokines. Zumoff et al. showed that obesity leads to decreased testosterone levels through multiple mechanisms, including increased aromatase activity in adipose tissue and suppression of the hypothalamic-pituitary-gonadal axis.

The prevalence of prediabetes varied across BMI categories, with underweight at 27.3% (3/11), normal weight at 17.1% (18/105), overweight at 23.5% (16/68), and obese at 25.0% (3/12). Although the chi-square test did not reach statistical significance ($p=0.248$), likely due to small sample sizes in extreme BMI groups, the trend suggests that deviations from normal BMI in young males may increase the risk of glucose metabolism issues. This finding is consistent with the work of Ding et al.,

who reported that both low and high BMI are linked to a higher risk of developing type 2 diabetes in men.

The mechanisms connecting early glucose problems and reproductive health are complex. Hyperinsulinemia lowers luteinizing hormone (LH) levels, which decreases testosterone production. Pitteloud et al. showed that insulin resistance is linked to reduced Leydig cell testosterone secretion in men.[12] Additionally, high levels of cytokines in metabolic syndrome directly harm Leydig cell function. Isidori et al. reported that inflammatory markers like TNF-α and IL-6 are inversely related to testosterone levels and directly inhibit Leydig cell steroidogenesis.[13]

The U-shaped relationship observed between BMI categories and glucose levels indicates that both underweight and overweight individuals might be at risk for hormonal problems. Underweight men often have nutritional deficiencies that can hinder testosterone production, while overweight men face obesity-related hypogonadism. This is supported by findings from Tajar et al. in the European Male Aging Study, which showed that both underweight and obese men had lower testosterone levels compared to normal-weight men.[14]

Our findings indicate that young men across the BMI range, especially those with elevated FBG, should undergo thorough andrological assessment. The notable differences in body measurements among BMI groups, particularly the steady rise in visceral fat levels (from 11.2±2.9 in underweight to 17.8±4.2 in obese participants), highlight the metabolic diversity even within this young group. Brand et al. demonstrated that even slight increases in fasting glucose within the normal range are linked to lower testosterone levels in men.

The 4.1 mg/dL difference in mean FBG between normal and overweight BMI groups in young males may indicate early metabolic issues that could affect reproductive health later on. This aligns with Laaksonen et al.'s findings, showing that even small increases in fasting glucose can predict future metabolic syndrome development and related testosterone deficiency.[16] Furthermore, Selvin et al. reported that glycemic control is a key factor influencing circulating testosterone levels in men with diabetes.[17]

The concerning 20.4% prevalence of prediabetes in young, apparently healthy males indicates early metabolic issues that could affect future andrological health. The urban dominance (62.8%) in our study reflects lifestyle changes contributing to metabolic disorders even among young populations. This is especially relevant in the Pakistani context, where rapid urbanization has increased the prevalence of metabolic disorders, as reported by Basit et al. in the National Diabetes Survey of Pakistan.[18]

Recent evidence from the TRAVERSE trial further highlights the two-way relationship between metabolic health and testosterone levels. The trial showed that testosterone replacement therapy not only improves metabolic parameters but also treats anemia in hypogonadal men, emphasizing the complex connection between endocrine and metabolic systems.[19] Additionally, Yassin et al. demonstrated that long-term testosterone therapy in hypogonadal men with type 2 diabetes mellitus significantly enhances glycemic control and lowers cardiovascular risk factors.[20]

Several limitations should be acknowledged. The cross-sectional design prevents establishing causality between anthropometric measures and glucose metabolism. The lack of testosterone measurements restricts direct evaluation of andrological effects. Moreover, lifestyle factors such as physical activity, dietary habits, smoking, and stress levels were not assessed, which could greatly influence both metabolic and reproductive health. Future studies should include longitudinal assessments of testosterone levels alongside glucose metabolism, evaluate sperm parameters and fertility outcomes, investigate inflammatory markers and oxidative stress, and examine the effects of lifestyle interventions on both metabolic and andrological outcomes.

CONCLUSION

This study reveals a concerning 20.4% prevalence of prediabetes among young adult males with no known comorbidities, showing significant links between anthropometric measures and fasting blood glucose levels. The U-shaped correlation between BMI and glucose metabolism, along with emerging

evidence connecting early metabolic dysfunction and testosterone levels, underscores the importance of preventive screening that targets both metabolic and andrological health.

Healthcare providers should consider conducting baseline andrological assessments in young men with glucose metabolism issues, even at prediabetic levels, due to the potential for early effects on andrological health. Public health efforts must emphasize lifestyle changes in young populations to prevent the progression of metabolic disorders and protect long-term andrological health. The findings highlight the importance of early detection and lifestyle modifications in young men to avoid metabolic and reproductive health problems. Early intervention during reproductive years may be crucial for maintaining proper andrological function throughout life.

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