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Can cardiometabolic index predict erectile and other sexual functions in men with metabolic syndrome?

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Abstract

Background: We aimed to examine the impact of the cardiometabolic index (CMI) on various aspects of male sexuality across different age groups, with a focus on the presence of metabolic syndrome (MetS). **Methods**: We included a total of 454 sexually active men, 127 with MetS and 327 without MetS. We assessed sexual function using the long form of the International Index of Erectile Function (IIEF) questionnaire. According to the IIEF guestionnaire, a total score <26 is defined as erectile dysfunction (ED). We calculated the CMI using the formula: (Triglyceride/High Density Lipoprotein-cholesterol) $\times$ (Waist circumference/Height). The relationship between sexual function scores and CMI was analyzed in men, using a 50-year age cut-off. We investigated the predictive power of the CMI for ED. **Results**: The mean CMI was higher in men with MetS than those without (p-value < 0.001). The MetS group had lower mean testosterone levels and erectile function scores than the non-MetS group (p-value < 0.05). Men under 50 with MetS had lower sexual function scores for erectile function, sexual satisfaction, orgasm, desire and overall satisfaction than their non-MetS counterparts (p-value < 0.05). Regardless of MetS grouping, at a CMI cut-off value of 0.50, sensitivity and specificity were 77% and 55%, respectively (p-value < 0.001). However, MetS group had low sensitivity and specificity at a CMI cut-off value of 1.46 (56% and 57%, respectively; p-value > 0.05). Logistic regression revealed that both CMI and age were significant risk factors for sexual dysfunction (Odds Ratio = 2.672 and 1.081, respectively; p-value = 0.001). **Conclusions**: The CMI predicted sexual dysfunction, including ED, in younger men. The presence of MetS increased the risk of sexual dysfunction. However, CMI did not predict male sexual dysfunction in older men, independent of MetS. Our findings suggest that CMI can be a predictor of various aspects of sexual functions, particularly in younger men.

Keywords

Cardiometabolic index; Desire; Erectile dysfunction; Metabolic syndrome; Orgasm

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¿Puede el índice cardiometabólico predecir la función eréctil y otras funciones sexuales en hombres con síndrome metabólico?

Resumen

Antecedentes: Nuestro objetivo fue examinar el impacto del índice cardiometabólico (ICM) en varios aspectos de la sexualidad masculina en diferentes grupos de edad, con un enfoque en la presencia del síndrome metabólico (MetS). **Métodos**: Incluimos un total de 454 hombres sexualmente activos, 127 con MetS y 327 sin MetS. Evaluamos la función sexual utilizando la versión larga de 15 ítems del cuestionario del Índice Internacional de Función Eréctil (IIEF). Según este cuestionario, una puntuación total de 1 a 5, o una puntuación inferior a 26 en las 15 preguntas, se define como disfunción eréctil (DE). Calculamos el ICM utilizando la fórmula: (Triglicéridos/Lipoproteína de alta densidad) × (Circunferencia de cintura/Altura). La relación entre las puntuaciones de la función sexual y el ICM se analizó en hombres, estableciendo un límite de edad de 50 años. Investigamos el poder predictivo del CMI para determinar la gravedad de la disfunción eréctil. **Resultados**: El CMI promedio fue mayor en hombres con MetS que en aquellos sin él ($p < 0.001$). El grupo con MetS presentó niveles medios de testosterona y puntuaciones de función eréctil más bajos que el grupo sin MetS ($p < 0.05$). En hombres menores de 50 años con MetS, las puntuaciones de función sexual, incluida la función eréctil, satisfacción sexual, orgasmo, deseo y satisfacción general, fueron significativamente más bajas que las de sus homólogos sin MetS ($p < 0.05$). Independientemente de la presencia de MetS, con un valor de corte de CMI de 0.50, la sensibilidad y la especificidad para predecir DE fueron del 77% y 55%, respectivamente ($p < 0.001$). Sin embargo, en hombres con MetS, la sensibilidad y la especificidad fueron bajas con un valor de corte del CMI de 1.46 (56% y 57%, respectivamente; $p > 0.05$). El análisis de regresión logística reveló que tanto el IMC como la edad eran factores de riesgo significativos para la disfunción sexual (Razón de probabilidades = 2.672 y 1.081, respectivamente; $p = 0.001$). **Conclusiones**: El ICM predijo disfunción sexual, incluida la disfunción eréctil, en hombres más jóvenes. La presencia de MetS aumentó el riesgo de disfunción sexual. No obstante, el CMI no predijo la disfunción sexual masculina en hombres mayores, independientemente del MetS. Nuestros hallazgos sugieren que el CMI puede ser un predictor útil de varios aspectos de la función sexual, particularmente en hombres más jóvenes.

Palabras Clave

Índice cardiometabólico; Deseo; Disfunción eréctil; Síndrome metabólico; Orgasmo

1. Introduction

Erectile dysfunction (ED) is the inability of the penis to achieve or maintain an erection sufficient for vaginal intercourse [1]. Adequate erection allowing vaginal penetration plays a crucial role in the physical and psychosocial well-being of both men and their partners [2]. Beginning in the fifth decade of life, half of men experience ED, and the majority will encounter it after the age of 70 [3]. Many conditions contribute to ED, including hypertension, lipid metabolism disorders and metabolic syndrome (MetS) that exert their effects over time, in particular through atherosclerosis and endothelial damage [4]. Studies have shown that men presenting with ED are at a higher risk of experiencing significant cardiovascular events within 3–5 years [5]. Therefore, ED can become a risk factor for potential cardiovascular events soon.

The cardiometabolic index (CMI) was initially introduced as a predictor of diabetes [6]. Over the past decade, many authors have explored the possible link between CMI and depression, chronic inflammation, chronic kidney disease, hematological diseases, stroke, premature birth and malignancies [7–12]. Studies have demonstrated that CMI influences the atherosclerotic process. Given that atherosclerosis and subsequent endothelial damage are important risk factors for ED, there has been an increase in studies examining the relationship between CMI and ED. However, the number of studies in this area remains limited [13]. The relationship between metabolic syndrome and sexual dysfunction is well known, but studies showing the relationship between CMI and sexual dysfunction are limited, and we conducted this study to reconfirm previous reports. We hypothesized that CMI, as a noninvasive method, could predict all forms of sexual dysfunction, including ED, in the presence of metabolic syndrome (MetS).

In this report, we aimed to investigate the impact of CMI on all aspects of male sexuality across different age groups regarding MetS.

2. Materials and methods

This cross-sectional study was conducted at an andrology center between 2021 and 2024. Clinical and demographic data such as age, body mass index (BMI), waist circumference, fasting serum glucose, HDL-cholesterol, triglyceride, fasting morning testosterone, prolactin, estradiol levels and habits were documented. We used the 15-item long form of the International Index of Erectile Function (IIEF) questionnaire to assess all the sexual functions: the erectile function (items IIEF 1–5 and 15), sexual satisfaction (items 6–8), orgasm (items 9–10 items), desire (items 11–12) and overall satisfaction scores (items 13–14). According to IIEF 1–5 and 15, patients were classified as severe ED (IIEF score: 0–10), moderate ED (IIEF score: 11–16), mild-moderate ED (IIEF score: 17–21), mild ED (IIEF score: 22–25) and no ED (IIEF score: 26–30). We measured the CMI using the following formula: (Triglyceride/HDL-cholesterol) × (Waist circumference/Height) [14].

We diagnosed the MetS according to the National Cholesterol Education Program (NCEP ATP3, 2005) in the presence of at least three of the following:

1. Waist circumference greater than 102 cm,
2. Serum triglyceride level of 150 mg/dL or greater or being treated for hypertriglyceridemia,
3. HDL cholesterol level less than 40 mg/dL,
4. Systolic blood pressure greater than 130 mmHg or diastolic blood pressure greater than 85 mmHg or being treated for antihypertension,
5. Fasting glucose level >100 mg/dL or being treated for hyperglycemia. We created two groups, according to the presence or absence of MetS (MetS and no MetS groups). Considering the association between the atherosclerotic process and aging, we also investigated the relationship between sexual function scores and CMI between two subgroups, considering the 50-year age cut-off. Finally, we investigated the ability of the CMI to predict the severity of the ED.

The ejaculatory function was assessed using the Turkish short form of the Male Sexual Health Questionnaire: questions 1, 2 and 3 assess ejaculatory function, frequency and force, respectively, with higher scores indicating better function, whereas the last question assesses ejaculatory discomfort, with lower scores indicating less discomfort [15]. We used the Statistical Package software for the Social Sciences (SPSS), version 26.0 (SPSS Inc., Chicago, IL, USA). We used mean ± standard deviation and frequency (percentage) to show quantitative and qualitative variables; the Analysis of variance (ANOVA) test to compare the means of more than two groups; the Bonferroni test for *post-hoc* analysis, and Spearman's correlation analysis to determine the strength and direction of the relationship between two variables. We also used binary logistic regression analysis to identify factors associated with sexual dysfunction. A p-value < 0.05 was considered statistically significant.

3. Results

The mean age, IIEF1-5 and 15 score and duration of ED were 43.9 ± 12.2 years, 17.0 ± 8.4 and 18.7 ± 29.5 months, respectively. Demographic, anthropometric, laboratory and clinical data such as the prevalence of diabetes, hypertension and coronary artery disease were 15.4%, 7.5% and 6.8%, respectively. Of the patients, 127 had MetS (28%) (Table 1). The CMI was significantly higher in patients with MetS than those without MetS ($p < 0.001$). The mean testosterone level was lower in MetS patients compared to non-MetS patients (9.4 ± 7.1 *vs.* 12.9 ± 9.2, $p = 0.002$).

The mean IIEF 1–5, 15 scores were lower in the MetS group compared to the non-MetS group (13.9 ± 7.4 *vs.* 18.2 ± 8.4) ($p < 0.001$). However, ejaculatory function scores were similar between the two groups ($p > 0.05$). Regardless of age, the mean CMI value in patients with MetS was significantly higher than in those without MetS ($p < 0.001$). The mean erectile function, sexual satisfaction, orgasm, desire and general satisfaction scores of patients younger than 50 were lower in the MetS group compared to those without MetS ($p < 0.05$). These scores were similar in patients over 50 years of age in both groups ($p > 0.05$) (Table 2).

Regardless of MetS grouping, a 77% sensitivity and 0.55% specificity were reached at a 0.50 cut-off value of CMI (Area under curve (AUC) = 0.650–0.761, 95% confidence interval (CI)) (Fig. 1A) ($p < 0.01$). For patients without MetS, 69% sensitivity and 0.55% specificity were found at a 0.48 cut-off value of CMI (AUC = 0.578–0.707, 95% CI) (Fig. 1B) ($p < 0.001$). Men with MetS had lower sensitivity and specificity rates (56% and 57%) at a 1.46 cut-off value of CMI (AUC = 0.314–0.696, 95% CI) ($p = 0.966$) (Fig. 1C) (Table 3).

We found a moderate, significantly negative relationship between erectile function scores and CMI values (r = -28.8; $p < 0.001$). *Post-hoc* analysis showed that the mean CMI in participants without ED was significantly lower than in all degrees of ED ($p < 0.001$), but no difference was found between the ED groups ($p > 0.05$) (Table 3). In binary logistic regression analysis, BMI scores did not show a significant effect ($p = 0.432$). The CMI and age were significant risk factors for sexual dysfunction (OR = 2.672, 95% CI = 1.472–4.850 ($p < 0.001$) and OR = 1.081, 95% CI = 1.054–1.108 ($p = 0.001$), respectively (Table 3).

4. Discussion

Regardless of age, the presence of MetS was associated with increased CMI levels, which is unsurprising given that the anthropometric and clinical data used in the CMI formula are similar to the components of MetS. It is well known that MetS increases the risk of cardiac events [16]. Given the limited number of studies in this area, the present study contributes further evidence and demonstrated an odds ratio of 2.672 between CMI and ED. For the first time in the literature, a 2019 study reported that CMI could be an index for evaluating ED risk [12]. However, the authors did not provide an odds ratio for the relationship between CMI and ED risk.

Men presenting with sexual dysfunction are at risk of future cardiovascular events, making it essential for men with ED to undergo careful cardiovascular evaluation [17]. However, some urologists may hesitate to perform such assessments and overlook the patient's cardiovascular status. Madani *et al.* [18] found that urologists who identified as andrologists were more likely to recognize the clinical significance of the relationships between cardiovascular disease (CVD) and ED than non-andrologists. That study showed that urologists are aware of the risk of CVD in patients with ED, but the clinical assessment of CVD in those patients was lower than expected. We believe that urologists should be more vigilant in the cardiovascular assessment of ED patients with CVD. Contrary to these reports, Madani *et al.* [18] reported no correlation between CMI and ED, possibly due to a low number of participants.

Our findings indicated a stronger association between CMI and sexual dysfunction in younger participants compared to those older than 50. In men over the age of 50, whether they had MetS or not, CMI did not predict sexual function scores, including erectile function, orgasm, desire, and satisfaction. Therefore, it is reasonable to suggest that lower CMI levels are associated with better sexual function scores in the younger age group without MetS. Our results showed that age is another predicting factor for ED, which is consistent with previous reports [19]. The progressive nature of the atherosclerotic

TABLE 1. Demographic, clinical and anthropometric data of the patients.

Variable	Number of patients	Mean ± standard deviation/%
Age (yr)	454	43.9 ± 12.2
Body mass index (kg/m^2)	454	28.5 ± 4.0
Waist circumference (cm)	454	103.2 ± 10.8
Fasting glucose level (mg/dL)	454	114.2 ± 47.7
High density lipoprotein-cholesterol (mg/dL)	454	48.5 ± 10.8
Triglyceride (mg/dL)	454	203.1 ± 126.2
International Index of Erectile Function	454	17.0 ± 8.4
Duration of erectile dysfunction (mon)	364	18.7 ± 29.5
Sexual satisfaction	447	7.4 ± 3.9
Orgasm	446	6.5 ± 3.2
Desire	447	6.2 ± 2.5
General satisfaction	443	5.7 ± 2.6
Testosterone (nmol/L)	231	11.8 ± 8.7
Prolactin	200	11.9 ± 7.7
Estradiol	134	28.9 ± 11.3
Cardiometabolic index (CMI)	454	1.07 ± 0.9
Male Sexual Health Quality-1 score	141	3.8 ± 1.5
Male Sexual Health Quality-2 score	139	2.9 ± 1.6
Male Sexual Health Quality-3 score	141	3.6 ± 1.5
Male Sexual Health Quality-4 score	140	1.6 ± 1.7
Diabetes mellitus	70	15.4
Hypertension	34	7.5
Coronary artery disease	31	6.8
Smoking		
Smoker	259	57.0
Ex-smoker	70	15.4
Alcohol	30	6.6
Metabolic Syndrome	127	28.0
Number of comorbidity		
1	68	15.0
2	14	3.1
3	5	1.1
ED*		
No ED	94	20.7
Mild	52	11.5
Mild-to-moderate	99	21.8
Moderate	99	21.8
Severe	110	24.2

**According to International Index of Erectile Function qustionnaire (IIEF). ED: erectile dysfunction; HDL: High density lipoprotein.*

TABLE 2. Cardiometabolic index (CMI) and sexual function scores and other laboratory findings in patients with and without metabolic syndrome under and over 50 years of age.

	Patients with MetS (n = 127, 28.0%)	Patients with no MetS (n = 327, 72.0%)	*p*
Body mass index (kg/m^2)	30.1 ± 3.9	27.9 ± 0.3	<0.001
Waist Circumference (cm)	108.5 ± 9.3	101.1 ± 10.7	<0.001
Fasting morning glucose (mgdL)	151.1 ± 67.0	99.9 ± 26.4	<0.001
HDL-cholesterol (mg/dL)	42.8 ± 8.7	50.7 ± 10.8	<0.001
Trglyceride (mg/dL)	279.9 ± 147.8	173.2 ± 102.4	<0.001
Cardiometabolic index	1.81 ± 1.0	0.77 ± 0.6	<0.001
Testosterone (ng/mL)	9.4 ± 7.1	12.9 ± 9.2	0.002
Prolactin	11.9 ± 9.4	11.9 ± 6.7	0.976
Estradiol	27.9 ± 12.9	29.5 ± 10.3	0.469
International Index of Erectile Function (IIEF) score	13.9 ± 7.4	18.2 ± 8.4	<0.001
MSHQ*-1	3.7 ± 1.8	3.8 ± 1.4	0.792
MSHQ-2	2.5 ± 1.8	3.1 ± 1.6	0.093
MSHQ-3	3.4 ± 1.7	3.6 ± 1.5	0.484
MSHQ-4	2.1 ± 1.8	1.5 ± 1.7	0.068
<50 years	(n = 63)	(n = 229)	
CMI	1.92 ± 1.2	0.79 ± 0.6	<0.001
Erectile function	14.8 ± 7.3	19.8 ± 8.2	<0.001
Duration of erectile dysfunction	19.4 ± 27.6	14.1 ± 26.1	0.247
Sexual satisfacttion	6.7 ± 4.0	8.4 ± 3.8	0.004
Orgasm	6.2 ± 3.4	7.4 ± 2.8	0.013
Desire	5.9 ± 2.4	6.9 ± 2.4	0.008
General satisfaction	5.0 ± 2.5	6.4 ± 2.6	<0.001
50 years and older	(n = 64)	(n = 98)	
CMI	1.70 ± 0.8	0.75 ± 0.7	<0.001
Erectile function	13.1 ± 7.4	14.4 ± 7.8	0.312
Duration of erectile dysfunction	22.5 ± 27.4	24.3 ± 36.2	0.731
Sexual satisfacttion	6.2 ± 3.6	6.2 ± 3.7	0.996
Orgasm	4.9 ± 3.3	5.6 ± 3.3	0.163
Desire	5.0 ± 2.5	5.2 ± 2.5	0.309
General satisfaction	4.9 ± 2.6	5.0 ± 2.3	0.843

**Male sexual health questionnaire. MetS: metabolic syndrome; CMI: cardiometabolic index; HDL: high density lipoprotein; MSHQ: male sexual health questionnaire.*

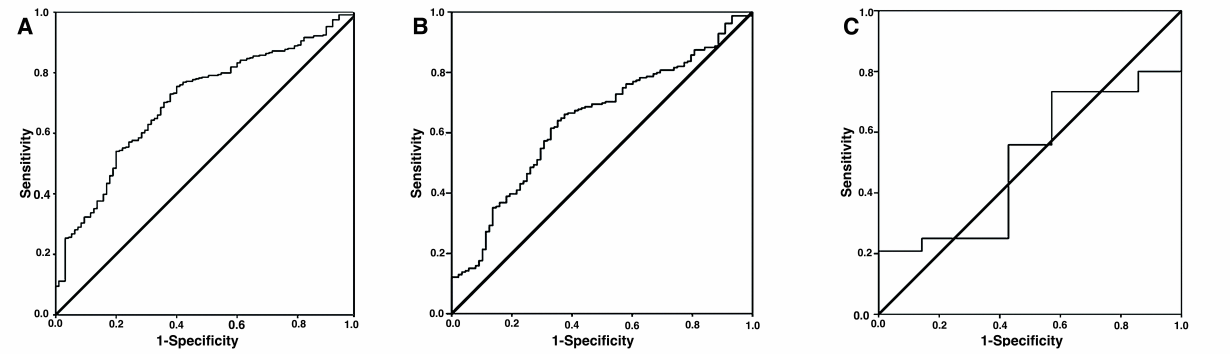

FIGURE 1. Receiver Operating Curves (ROC) diagrams for cardiometabolic index for predicting erectile dysfunction. (A) For patients regardless of the presence of metabolic syndrome. (B) For patients with metabolic syndrome. (C) For patients without metabolic syndrome.

TABLE 3. Cut-off values of Cardiometabolic index (CMI) to predict sexual dysfunction; relationship between the CMI and severity of erectile dysfunction; and odds ratios of variables predict erectile dysfunction in men.

Study Group	Sensitivity-specificity	Cut-off value	Area under curve	95% Confidence Interval		*p*
All men	0.77–0.55	0.50	0.706	0.650–0.761		<0.001
Men with no MetS	0.69–0.55	0.48	0.642	0.578–0.707		<0.001
Men with MetS	0.56–0.57	1.46	0.505	0.314–0.696		0.966
					95% CI	
Variable	B	S.E.	Significance	Odds Ratio	Lower	Upper
Age	0.078	0.013	0.001	1.081	1.054	1.108
Body mass index	0.028	0.036	0.432	1.029	0.959	1.103
Cardiometabolic index	0.983	0.304	0.001	2.672	1.472	4.850
Metabolic syndrome	0.568	0.476	0.232	1.766	0.695	4.485
Constant	−3.534	1.007	0.001	0.029		
Degree of erectile dysfunction (ED)		Number of patients, (%)		Cardiometabolic index		
Non-ED		95 (20.93)		0.65 ± 0.5		
Mild		51 (11.23)		1.16 ± 0.9		
Mild-to-moderate		99 (21.81)		1.15 ± 0.9		
Moderate		99 (21.81)		1.24 ± 1.0		
Severe		110 (24.22)		1.15 ± 0.9		
p		454 (100.00)		<0.001		

MetS: metabolic syndrome; AUC: area under curve; CI: confidence interval; B: unstandardized regression weight; S.E.: standard error.

process in small and medium-sized vascular structures is linked to endothelial dysfunction and associated ischemic changes, which lead to end-organ failure. Obesity-related metabolic conditions and chronic diseases such as diabetes, hypertension and dyslipidemia accelerate ischemic changes and negatively affect male sexual function [20, 21]. According to Guay *et al.* [21], endothelial dysfunction can be seen early in insulin-resistance conditions. Endothelial dysfunction and atherosclerosis are followed by plaque formation, and plaques of the same size affects penile function earlier, since the penile arteries are 1–2 mm in diameter while the coronary arteries are 3–4 mm in diameter.

Hypoandrogenemia symptoms may occur in response to decreased circulating testosterone levels. Low testosterone levels are associated with increased centrally located adiposity [22]. The most common reasons for hypoandrogenemia in men over 40–50 years are diabetes, cardiac disease and MetS [23]. Excessive adipose tissue has a dual effect on metabolism: (1) increased aromatase activity that converts testosterone to estrogen, and (2) increased release of pro-inflammatory cytokines such as interleukin-1-beta, tumor necrosis factor-alpha and interleukin-6 which inhibits testosterone production through to the hypothalamic-pituitary-gonadal axis [24, 25]. According to the current literature, increased leves of inflammatory cytokine lead to hypoandrogenemia. However, the extent of the impact of testosterone replacement on preventing inflammation remains debatable [22]. Normal testosterone levels are required for normal sexual desire and satisfaction, and a decrease in testosterone is one of the reasons for loss of libido [26]. According to the European Association of Urology Guidelines in Male Hypogonadism, testosterone levels below 12 nmol/L is accepted as a reasonable cut-off in symptomatic men [27]. Our results showed that patients without MetS had a mean testosterone level greater than 12 nmol/L, consistent with the literature. According to the reasons mentioned above, in younger men, decreased sexual functions other than ED may be related to mean androgen insufficiency in men with MetS. Contrary to this finding, although all sexual function scores were slightly decreased in older men, whether or not they had MetS, CMI did not predict sexual functions, possibly due to lower testosterone levels (10.47 nmol/L).

Wei *et al.* [27] investigated the effect of ED on arteriosclerosis, and they showed that each mmol/liter increase in serum cholesterol increased the risk of ED by 1.32 times, while each mmol/liter increase in HDL-cholesterol was associated with a 0.38-fold increase of ED. Increased waist circumference and visceral adiposity are associated with ED. Waist circumference greater than 102 cm is one of the criteria for metabolic syndrome and is associated with visceral adiposity. Increased visceral adiposity leads to increased insulin resistance and release of inflammatory cytokines, resulting in consequent vascular endothelial dysfunction. Insulin resistance negatively affects glucose metabolism, causing chronic hyperinsulinemia, which in turn triggers oxidative stress and inflammatory responses [28]. Leptin levels increase in obese individuals. Leptin plays a role in homeostasis and nutrition, but increased serum leptin levels inhibit the stimulatory effects of gonadotropins on Leydig cells, causing hypoandrogenemia [29]. Although we did not measure leptin level, partial androgen deficiency secondary to increased leptin in men with metabolic syndrome

may add to ED.

CMI can predict not only male sexual dysfunction but also various other conditions. Therefore, we believe that all men with sexual dysfunction should be systematically evaluated from a multidisciplinary perspective. Our findings suggest that CMI may be used as a noninvasive marker to predict vascular endothelial function, especially in men with metabolic syndrome.

5. Limitation of the study

Lack of assessment of proinflammatory cytokines, cross-sectional design of the study, identification of sexual function scores using international questionnaires, missing of some hormonal data and relatively low number of participants are the limiting factors.

6. Conclusions

The CMI predicted all forms of sexual dysfunction, including ED, especially in young patients, and the presence of metabolic syndrome (MetS) increased the risk of sexual dysfunction. CMI did not predict male sexual dysfunction in older individuals, independent of MetS. The progression of the atherosclerotic process leads to hypoandrogenemia and endothelial damage, and these changes become irreversible with aging. Therefore, we believe that CMI can predict all aspects of sexual function, including erectile function, orgasm, desire and sexual satisfaction in young men, and the presence of metabolic syndrome may complicate outcomes. To support our findings, further prospective multicenter clinical studies with larger sample sizes are needed.

AVAILABILITY OF DATA AND MATERIALS

The data presented in this study are available on reasonable request from the corresponding author.

AUTHOR CONTRIBUTIONS

MSB and RA—designed the research study. MSB, CD and RA—performed the research; wrote the manuscript. All authors contributed to editorial changes in the manuscript. RA—provided help and advice on providing research articles. MSB and CD—analyzed the data. All authors read and approved the final manuscript.

ETHICS APPROVAL AND CONSENT TO PARTICIPATE

After receiving institutional review board approval (Ethical approval: Medicana International Samsun Hospital/28.08.2024/31). We provided informed written consent and recruited 454 participants presenting with sexual dysfunction.

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CONFLICT OF INTEREST

The authors declare no conflict of interest.

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