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ORIGINAL RESEARCH

Erectile Dysfunction and Low Serum Testosterone in Indian Diabetic Men: Prevalence and Risk factors

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Abstract: **Introduction:** Diabetic male patients are more likely to have ED and subnormal testosterone levels than non-diabetic men. We aimed to estimate the prevalence of ED and low serum testosterone level in diabetic men, and to study the patient's age, duration of diabetes, body mass index (BMI), glycosylated hemoglobin (HbA1c) and spot urine albumin to urine creatinine ratio (uACR) as risk factors for ED, and their correlation with serum total testosterone level.

Methods: This was a cross-sectional observational study, including 103 male patients aged 30-60 years, diagnosed with type 2 diabetes mellitus (T2DM). Patients with score less than 22 on the abridged 5-item version of the International Index of Erectile Function (IIEF-5) questionnaire were diagnosed to have ED, and patients with serum total testosterone level less than 2.3ng/ml (8nmol/L) were considered to have low serum testosterone.

Results: The prevalence of ED was 46.6%, and that of low testosterone level was 18.4%. Men with ED had significantly higher prevalence of testosterone deficiency than those without ED (31.3% vs 7.3%, P=0.004). Mean age of the patient (50.73±7.22 vs 47.51±8.67 years, P=0.045), mean duration of diabetes (10.66±5.56 vs 8.53±5.60 years, P<0.001), mean BMI (28.51±4.05 vs 24.51±3.32 kg/m2, P<0.001), and mean HbA1c (8.49±1.15 vs 7.70±1.05 %, P<0.001) were higher, while mean total testosterone level (3.18±1.65 vs 4.61±1.92 ng/ml, P<0.001) was lower in patients with ED, compared with those without ED. Total testosterone level negatively correlated with BMI (R=-0.682, P<0.001), HbA1c (R=-0.279, P=0.004), and uACR (R=-0.241, P=0.014); and positively correlated with IIEF-5 questionnaire score (R=0.519, P<0.001). BMI (P<0.001) and uACR (P=0.048) independently and negatively correlated with total testosterone level.

Conclusions: ED is a common complication in Indian men with T2DM. Excess weight is a risk factor for ED as well as low testosterone level. Older age, longer duration of DM and poor glycemic control are risk factors for ED, and presence of microalbuminuria is associated with low testosterone level. Serum testosterone levels should be measured in diabetic men suffering from ED.

Keywords: Erectile Dysfunction, Diabetes Mellitus, Testosterone Deficiency, Abridged IIEF-5 Questionnaire, Hypogonadism

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1. Introduction

The long-term complications of diabetes mellitus (DM) include dysfunction of different organs, including sexual dysfunction. There are neglected aspects of diabetes and its complications, such as psychological issues, skin and dental problems, overall quality of life etc., and sexual health is one of them. These issues are often not addressed due to physician inertia and their 'non-life-threatening' nature; however, with advancement in medical science and increase in longevity, these neglected aspects are gaining importance. Erectile dysfunction (ED) is defined as the persistent inability to achieve or maintain penile erection sufficient for satisfactory sexual performance (1). Type 2 DM (T2DM) is strongly associated with the development of ED, and the reported prevalence of ED and low testosterone levels are 57-79% and 15-60%, respectively, in different populations of Indian men with DM (2-5). However, since many men are too embar-

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rassed to admit having ED or to talk to a doctor about the issue, it is difficult to know the precise estimates.

The pathophysiology of ED in DM is multifactorial, and can develop due to interaction between neuropathy, vasculopathy, hypogonadism, vascular endothelial dysfunction, psychological factors and pharmacotherapy. Subnormal testosterone levels were found more commonly in diabetic than non-diabetic men, and may contribute to ED (5,6). T2DM and metabolic syndrome can be risk factors for hypogonadism via certain mechanisms, such as excessive body weight, decrease in the levels of the sex hormone–binding globulin (SHBG), direct suppression of gonadotropin release or Leydig cell testosterone secretion, cytokine-mediated inhibition of the release of gonadotropins or testosterone, and a rise in the aromatase activity leading to a relative estrogen excess (7). DM associated hypogonadism might also affect mood and libido, and worsen the sexual function further (8). The incidence of DM is steadily rising in all the age groups and a notable number will most probably be in their prime reproductive years.

Research on erectile dysfunction and hypogonadism in India is sparse, especially when compared to studies done on other complications of DM such as cardiovascular and cerebrovascular events, nephropathy, peripheral neuropathy and retinopathy.

Through this study, we aimed to estimate the prevalence of erectile dysfunction and low serum testosterone level in male patients with T2DM, and their correlation with various clinical and laboratory parameters. This study was designed to evaluate the patient's age, duration of DM, body mass index (BMI), glycosylated hemoglobin (HbA1c) and spot urine albumin to urine creatinine ratio (uACR) as risk factors for ED in male patients with T2DM, and their correlation to serum total testosterone level.

2. Material and Methods

The study was conducted as per the Helsinki Declaration of 1975 (revised in 2000), and the study protocol received approval from the institutional research Ethics Committee (IRB/1226/AL/18/42). Patients were enrolled after giving them complete relevant information and obtaining a written consent. The participants were reassured that their data would remain confidential.

This was a cross-sectional observational study, including adult male patients aged 30- 60 years, diagnosed with T2DM, attending the clinic of the Department of Endocrinology, at a tertiary care centre in Western India. Considering the standard normal variate as 1.96 for a type I error of 5%, with 56.5% prevalence of ED from a reference study (2), and an absolute error of 10%, the sample size for the study was determined to be 94. Seriously ill and debilitated patients, patients with known malignancy or suffering from chronic liver, kidney or psychiatric disease, and patients with history of trauma, surgery or radiation to the head or pelvis were excluded.

Patients with history of thyroid disease, hyperprolactinemia, primary pituitary pathology or primary testicular-penile pathology were also excluded from the study. Patients who were receiving testosterone, anabolic steroids, glucocorticoids or any drugs causing hypogonadism were not considered for the study. 103 diabetic men were eventually enrolled in the study.

Patients were subjected to thorough history taking with special emphasis on the age, duration of DM and detailed drug and treatment history. Complete physical examination was done including weight and height to calculate BMI. Investigations including HbA1c, spot uACR and serum total testosterone (morning 8am to 9am, after an overnight fast of 8 to 12 hours) were done.

The patients were asked to answer the abridged 5–item version of the International Index of ED (IIEF-5) questionnaire (Figure 1) (9).

This questionnaire consists of 5 questions addressing the pertinent disciplines of male sexual function, namely ED, orgasmic function, sexual desire, intercourse satisfaction, and overall satisfaction. Each of them is scored on a 5–point ordinal scale, where the lower values represent poorer function. Patients with scores less than 22 were considered to have ED. The sensitivity and specificity of the Abridged IIEF-5 questionnaire in diagnosing ED is 98% and 88%, respectively (9). All patients filled the English, Hindi or Marathi language version of IIEF-5 questionnaire themselves.

As per the Abridged IIEF-5 questionnaire score, the patients were divided into two groups, ED (score < 22) and no ED (score ≥ 22).

Patients with serum total testosterone level less than 2.3 ng/ml (8 nmol/L) were considered to be having low serum testosterone and diagnosed as testosterone deficient. Quantitative titres for serum total testosterone levels were run on automated Seimens® Immulite® 1000, using chemiluminescent immunoassay method (solid-phase, enzyme labelled, competitive chemiluminescent immunoassay using polyclonal rabbit antibody specific for testosterone), with analytical sensitivity of 0.15 ng/ml, and inter-assay and intra-assay precision of 7.4 to 13% and 9.1 to 16.4%, respectively.

The data was recorded in MS Excel and analysed in SPSS software, version 22. Results for descriptive qualitative data (age groups, BMI groups etc.) were represented with percentages and results for quantitative data (age, HbA1c, serum testosterone level etc.) were represented with mean ± standard deviation (SD). Nominal categorical data between the groups (ED/ No ED vs low testosterone present/ low testosterone absent etc.) were compared using the Chi-square test. The comparison of normally distributed quantitative vari-

ables between the two independent groups (ED/ No ED vs mean age, mean HbA1c etc.) was performed using Unpaired Student's 't' test. Spearman coefficient was applied to evaluate correlation between testosterone level and other continuous variables. Finally, multiple linear regression was applied for the correlating data. P<0.05 was considered as statistically significant.

3. Results

Demographic data of the participants are shown in Table 1. Mean age of the participants was 49.01±8.15 years. Nineteen (18.4%) and 32 (31.1%) patients were 31-40 and 41-50 years, respectively; while more than half (52, 50.5%) were 51-60 years old. Around one-fourth (25, 24.3%) of the patients had DM for 5 years or less. Thirty-six (35%) patients had DM for 6-10 years, 24 (23.2%) had DM for 11 to 15 years, and 18 (17.5%) had DM for 16 years or more. The patients' mean±SD BMI was 26.37±4.17 kg/m2. Forty-five (43.7%) patients had a BMI <25 kg/m2, 35 (34%) were overweight with a BMI between 25 kg/m2 to 30 kg/m2, and the rest (n=23, 22.3%) were obese (BMI >30 kg/m2). Most patients (57, 55.34%) had an acceptable HbA1c of 8% or less, while 19 (18.45%) had good glycemic control with HbA1c of less than 7%. Only four (3.88%) patients had HbA1c of more than 10%. In the study, we had excluded subjects with uACR >300 mg/g (diagnosed as diabetic kidney disease). The mean±SD uACR in the study group was 43.40±57.33 mg/g.

The prevalence of ED in our study cohort was 46.6% (48 of the 103 subjects), as diagnosed by the abridged IIEF-5 questionnaire.

Prevalence of testosterone deficiency, as defined by serum total testosterone level less than 2.3 ng/ml, was 18.4% (19 of 103 patients). Of all the patients with ED, 31.3% (15 of 48) had low testosterone level and 68.7% (33 of 48) had normal testosterone level. 78.9% (15 of 19) patients with testosterone deficiency had ED. Men with ED had significantly higher prevalence of testosterone deficiency than those without ED (P=0.004) (Table 2).

The mean age of the patient (50.73±7.22 vs. 47.51±8.67 years, P=0.045), mean duration of DM (10.66±5.56 vs. 8.53±5.60 years, P<0.001), mean BMI (28.51±4.05 vs. 24.51±3.32 kg/m2, P<0.001), and mean glycosylated hemoglobin (8.49±1.15 vs. 7.70±1.05 %, P<0.001) were significantly higher, while total testosterone level (3.18±1.65 vs. 4.61±1.92 ng/ml, P<0.001) was significantly lower, in the ED group compared with the No ED group. Though the mean uACR was higher in the ED group than that in the No ED group, there was no statistically significant correlation between presence of ED and value of spot urinary albumin to urinary creatinine ratio (P=0.63) (Table 3).

Serum total testosterone level negatively correlated with BMI (R=-0.682, P<0.001), HbA1c (R=-0.279, P=0.004) and uACR (R=-0.241, P=0.014); while there was no significant correlation between serum total testosterone level and age and duration of DM (Table 4). Serum total testosterone level positively correlated with IIEF-5 questionnaire score (R=0.519, P<0.001). By applying linear regression for the studied parameters, only BMI and uACR independently and negatively correlated with total serum testosterone level (Table 5).

4. Discussion

4.1. Prevalence of ED and Low serum Testosterone level

In our study, the prevalence of ED, as diagnosed by the abridged IIEF-5 questionnaire, in men with DM aged 30-60 years, was 46.6%. Reported prevalence of ED in other studies from various parts of the world as 33-90% (10-14). Indian studies have reported a prevalence of ED to be 57-79%, which was higher than our study (2-4). In a study by Martin-Morales and colleagues, the prevalence of ED by direct questioning on history was 12.1%, and IIEF defined ED was 18.9% (15). Sondhi and co-workers from New Delhi reported the prevalence of ED as determined by Sexual Health Inventory for Men (SHIM) score to be 78.7% in the group with DM, which was higher than that in the non-DM (46%) group (3). The difference in prevalence in various studies may be because of different inclusion criteria with regards to age, different definitions used for diagnosis of ED, varying demographics, differing duration of DM and diabetic control, and use of other drugs which may influence erectile function.

Prevalence of low serum total testosterone levels (testosterone deficiency, hypogonadism) in our study was 18.4%. Other similar studies have shown prevalence of 23 to 40% (16-20). The prevalence of hypogonadism in a study done by Ganesh and colleagues was 15% among the patients with DM (25 to 50 years old) and 10% among non-diabetic control group (5). In a study by Dhindsa and colleagues, hypogonadism was prevalent in 33% of men with DM aged 28-80 years (21). The prevalence of hypogonadism in our study is comparable to the study by Ganesh and colleagues, but is lower than most others. This is probably because of the younger age of our study cohort, lesser mean BMI, and a better HbA1c profile.

4.2. ED and the studied parameters

In our study, the mean age of the subjects was significantly higher in patients with ED than those without ED. Giuliano and colleagues demonstrated positive relation between advancing age and increasing prevalence of ED (22), while Mahbub and colleagues reported that the frequency of ED increased from 35.5% in men aged 28-39 years, to 100% in those aged 60 years or more (23). Though several other studies are

consistent with our findings (12,24,25), a few studies did not report increasing age as a risk factor for ED (18,26).

The results of the current study show that patients with DM with ED had significantly longer duration of DM when compared to those without ED. Mahbub and colleagues reported that duration of DM was associated with the increase in frequency of ED (20.2% in DM duration 0 to 5 years vs 100% in DM duration >20 years) (23), while Yang and colleagues observed that men with longer duration of T2DM had increasing severity of ED (12).

In the present study, patients with ED had a significantly higher BMI than those without ED. The Health Professionals Follow up Study (HPF5) had concluded that BMI was inversely associated with the risk of ED development (11), while Zheng and colleagues observed an increasing risk of ED for older age (OR=1.10), longer duration of T2DM (OR=1.36) and higher BMI (OR=1.73) (25). A similar inverse association between BMI and ED was also reported by other studies (5,27).

We observed that patients with ED had a significantly higher mean HbA1c as compared to those without ED. Korani and co-workers also reported a similar outcome (ED vs No ED = 10.20±2.37 vs. 8.30±1.70, P<0.001) (24), while another study reported frequencies of 3.5% and 71.6% ED in patients with good and poor glycemic control, respectively (23). Though other studies also reported similar findings (3,12,21), one study by Ziaei-Rad and colleagues showed that glycemic control did not show a significant association with sexual dysfunction (28).

Though the mean uACR was higher in the ED group than that in the No ED group, there was no statistically significant correlation between presence of ED and level of uACR in our study. Other studies did not find a significant correlation between ED and uACR (12,23). Yu and co-workers reported significant correlation of IIEF defined ED with uACR, but not with NIH defined ED (29). Contrary to studies demonstrating significant correlation between ED and uACR, our study did not include subjects with uACR more than 300 mg/g, and those with CKD.

In the present study, patients with ED had significantly lower total serum testosterone levels than those without ED. Korani and colleagues reported a similar outcome with significantly lower total serum testosterone levels in ED group than in No ED group (4.53 ± 1.01 vs. 1.94 ± 1.07 ng/ml, P<0.001) (24). Of the 19 patients with testosterone deficiency in our study, 15 (78.9%) had ED; while 33 (39.3%) of 84 patients with normal testosterone had ED. Similarly, other researchers reported that patients with low serum testosterone had higher prevalence ED than those with normal testosterone level (85.7% vs. 31%, and 94% vs. 61%, respectively) (16,18).

4.3. Serum total testosterone level and the studied parameters

In our study, BMI, HbA1c and uACR negatively correlated with levels of serum total testosterone; while age of the patient and duration of DM did not correlate with serum total testosterone level. Other studies also reported a significantly negative correlation between age of patient and testosterone levels (16,24), while other studies demonstrated no such negative correlation (17,18). Similar to our study, most studies documented no significant correlation between hypogonadism and duration of DM (16,18,21,30), though a couple of studies reported that the prevalence of low testosterone was higher in patients with a longer duration of T2DM (17,20).

A study on obese men showed that total and free testosterone levels were inversely related to BMI (R=-0.48, P<0.001) (31). Similar to our study, multiple other studies published a strong significant negative correlation between hypogonadism and BMI in patients with DM (16,18,21,24). Overweight patients have low total testosterone chiefly due to insulin resistance-mediated decrease in SHBG.

Obesity additionally leads to reductions in free testosterone levels as well, mainly because of the inhibition of the hypothalamo-pituitary-testicular axis secondary to combination of multiple factors like cytokine-mediated suppression of the release of the gonadotropins, increase in the aromatase activity leading to relative hyperestrogenemia, subclinical hypercortisolemia etc (32).

Obesity-associated low testosterone level is a functional, reversible state (32).

Analysis of most studies showed a significant negative correlation between HbA1c and testosterone concentration in T2DM (16,19,21,24). Contrarily, other researchers reported no such correlation between HbA1c and testosterone levels (17,18). Chronic hyperglycemia causes accumulation of advanced glycated end products, vascular endothelial dysfunction, hemodynamic alteration, derangement in neuronal cell function, and activation of inflammatory cells, all of which can suppress release of gonadotropins, or may directly affect Leydig cells, leading to decreased testosterone levels (7,33).

In one study, uACR was significantly higher in the hypogonadal group compared with the eugonadal group (63.26±75.09 mg/g vs. 45.34±46.79 mg/g, P<0.05) (5). The correlation between hypogonadism and albuminuria is not well known. Albuminuria is regarded as a marker of vascular endothelial injury (34). It is theorized that albuminuria might represent microvascular injury to the hypothalamus in diabetic patients, leading to altered secretion of gonadotropin releasing hormones, and thereby causing secondary hypogonadism (19).

We acknowledge that the cross-sectional nature of the study, which does not enable inferences to be made on causality, is

a limitation of the study; and longitudinal randomized studies may be undertaken to clarify a causal relation between ED, hypogonadism and various clinical and laboratory parameters. Further endocrine evaluation of patients with low serum total testosterone (SHBG, free testosterone level, follicle stimulating hormone, luteinizing hormone etc) was not a part of the study. Additional interventional studies are needed to evaluate effect of testosterone therapy on ED in patients with low testosterone levels.

5. Conclusion

ED is common in Indian men with T2DM in the clinic at our institute, and is prevalent in almost half of the men aged 30-60 years.

Abridged IIEF-5 questionnaire is an easy, quick and handy tool to objectively evaluate and diagnose ED.

Diabetic male patients with ED had a higher prevalence of testosterone deficiency, than those without ED. Excess weight and poor glycemic control are the modifiable risk factors, while age and duration of DM are non-modifiable risk factors for ED in men with T2DM.

Excessive weight and microalbuminuria are the risk factors for low testosterone level in men with T2DM.

Men with DM should be counselled regarding these risk factors and high-risk individuals should be targeted for early interventions. Serum testosterone should be measured in diabetic men diagnosed with ED.

6. Appendix

6.1. Acknowledgment

None.

6.2. Conflict of interest

All authors certify that they have no affiliations with or involvement in any organization or entity with any financial interest or non-financial interest in the subject matter or materials discussed in this manuscript.

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6.4. Author's contributions

All the authors were involved in the conception and design of the work. Dr. Maldar was involved in investigations and acquiring the data, while Dr. Maldar and Dr. Shingare curated, analysed and interpreted the data. Original draft preparation was done by Dr. Maldar. Dr. Shingare, Dr. Chauhan, Dr. Shah and Dr. Chadha were involved in review, editing and supervision of the work. All the authors revised the work critically for important intellectual content. All authors are accountable for all sections of the manuscript and declare that it is written originally and there is no data fabrication or data falsification, including deceptive manipulation of images and plagiarism.

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lence of microalbuminuria in relation to glycemic control in type-2 diabetic patients in Mymensingh. Mymensingh Med J. 2015 Jan;24(1):18-24.

Table 1: Clinical and laboratory characteristics of evaluated parameters in the participants.

Variables	Mean ± SD
Age (years)	49.01 ± 8.15
Duration of diabetes (years)	9.51 ± 5.66
BMI (kg/m2)	26.37 ± 4.17
HbA1c (%)	8.07 ± 1.06
uACR (mg/g)	43.40 ± 57.33
Serum total testosterone (ng/ml)	3.95 ± 1.98

BMI: Body Mass Index, HbA1c: Glycosylated hemoglobin, uACR: urine Albumin to Creatinine Ratio

Table 2: Correlation between ED and low serum testosterone level.

Group	Low T level	Normal T level	Total	P-value
ED present	15	33	48	0.004
ED absent	4	51	55	
Total	19	84	103	

ED: Erectile Dysfunction, T: serum total testosterone.

Table 3: Correlation between ED and No ED groups, and studied parameters.

Variable	ED group (Mean ± SD)	No ED groups (Mean ± SD)	P-value
Age (years)	50.73 ± 7.22	47.51 ± 8.67	0.045
Duration of diabetes (years)	10.66 ± 5.56	8.53 ± 5.60	<0.001
BMI (kg/m2)	28.51 ± 4.05	24.51 ± 3.32	<0.001
HbA1c (%)	8.49 ± 1.15	7.70 ± 1.05	<0.001
uACR (mg/g)	47.91 ± 52.24	40.69 ± 61.88	0.63
Serum total testosterone (ng/ml)	3.18 ± 1.65	4.61 ± 1.92	<0.001

BMI: Body Mass Index, ED: Erectile Dysfunction, HbA1c: Glycosylated haemoglobin, uACR: urine Albumin to Creatinine Ratio.

Table 4: Correlation between serum total testosterone level and studied parameters.

Variable	Serum total testosterone (ng/ml)	
	R	P-value
Age (years)	-0.072	0.467
Duration of diabetes (years)	-0.101	0.312
BMI (kg/m2)	-0.682	<0.001
HbA1c (%)	-0.279	0.004
uACR (mg/g)	-0.241	0.014

BMI: Body Mass Index, HbA1c: Glycosylated haemoglobin, R: Spearman co-efficient, uACR: urine Albumin to Creatinine Ratio

Table 5: Linear regression for the studied parameters affecting total serum testosterone values.

Variable	Serum total testosterone (ng/ml)		
	B	SE	P-value
Age (years)	0.010	0.015	0.526
Duration of diabetes (years)	-0.005	0.022	0.817
BMI (kg/m2)	-0.230	0.026	<0.001
HbA1c (%)	-0.169	0.101	0.097
uACR (mg/g)	-0.004	0.002	0.048

B: Unstandardized co-efficient, BMI: Body Mass Index, HbA1c: Glycosylated hemoglobin, SE: Standard Error, uACR: urine Albumin to Creatinine Ratio.

The abridged 5 – item version of the International Index of Erectile Function (IIEF-5) questionnaire

Please √ the response that best describes you foe the following five questions

Over the past four months:

1: How do you rate your confidence that you could get and keep an erection?	Very low 1	Low 2	Moderate 3	High 4	Very high 5
2: When you had erections with sexual stimulation, how often were your erections hard enough for penetration?	Almost never or never 1	A few times (much less than half the time) 2	Sometimes (about half the times) 3	Most times (much more than half the time) 4	Almost always or always 5
3. During sexual intercourse, how often were you able to maintain your erection after you had penetrated your partner?	Almost never or never 1	A few times (much less than half the time) 2	Sometimes (about half the times) 3	Most times (much more than half the time) 4	Almost always or always 5
4. During sexual intercourse, how difficult was it to maintain your erection to completion of intercourse?	Extremely difficult 1	Very difficult 2	Difficult 3	Slightly difficult 4	Not difficult 5
5. When you attempted sexual intercourse, how often was it satisfactory for you?	Almost never or never 1	A few times (much less than half the time) 2	Sometimes (about half the times) 3	Most times (much more than half the time) 4	Almost always or always 5
Total score:					

Figure 1: The abridged 5 – item version of the International Index of Erectile Function (IIEF-5) questionnaire (English version).