Penile Dimensions of Diabetic and Nondiabetic Men With Erectile Dysfunction: A Case–Control Study

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Abstract

This study aimed to report penile dimensions in diabetic and nondiabetic men with erectile dysfunction (ED) and correlate their dimensions with other study variables. A case–control study was designed through retrospective data analysis of diabetic and nondiabetic patients consulting for ED and a control group ($n = 105$, each group). Study data retrieved included history, clinical evaluation, and penile dimensions (pendulous length [PL], total length [TL], and circumference [CF]) at flaccid and erect states. Results identified that patients had lower values (mean, cm) for almost all penile dimensions. The diabetic patients identified significant differences in most dimensions, whether in flaccid (PL: 7.46 vs. 7.51 and 7.81, $p = .11$; TL: 11.8 vs. 12.77 and 12.88, $p = .000$; CF: 8.84 vs. 9.1 and 9.14, $p = .016$) or erect state (PL: 9.66 vs. 9.61 and 10, $p = .092$; TL: 13.96 vs. 14.88 and 15.04, $p = .000$; CF: 11.56 vs. 12.06 and 11.92, $p = .018$) as compared with the nondiabetic patients and controls, respectively. No significant correlation was detected between the dimensions and age, durations of diabetes and ED, or erectile function scores. In conclusion, diabetic and nondiabetic patients with ED presented, in varying degrees, significant decline in their penile dimensions, and this was more prevalent in diabetic patients. As changes in penile size could be a silent corollary of comorbidities, monitoring the changes in penile dimensions should be an important component of the clinical checkup of any patient with ED, especially a diabetic patient.

Keywords

penile dimensions, diabetes, erectile dysfunction

Introduction

Several epidemiological studies have recognized diabetes mellitus as the most frequent medical problem associated with erectile dysfunction (ED; Centers for Disease Control and Prevention, 2014; Selvin, Burnett, & Platz, 2007), and confirmed the high prevalence of ED among diabetic men (Malavige & Levy, 2009; Salama, 2013). Diabetes is notorious in its ability to induce several pathological changes of the penile corpora and tunica. These diabetic-associated changes may involve all components of penile tissues, including smooth muscle cells and extracellular matrix with its elastic fibers and collagen bundles. Beside being reported in diabetic ED, these penile pathological changes have also been documented in nondiabetic ED. Changes were demonstrated in both humans (Costa, Carrerete, Horta, & Sampaio, 2006; Sattar, Wespes, & Schulman, 1994; Yaman, Yilmaz, Bozlu, & Anafarta, 2003) and laboratory animals (Abidu-Figueiredo et al., 2011; Nehra et al., 1998; Salama & Kagawa, 1999), and were ascribed to represent important elements in the pathogenesis of ED.

Tunica albuginea (TA) is a key element in the mechanism of erection (Dean & Lue, 2005). It is a governing factor for penile extensibility (Bondil, Louis, Daures, Costa, & Navratil, 1990). The latter is defined as the difference between the penile length at the flaccid state and that under maximal stretch (Moreira de Goes et al., 1992). Penile extensibility could provide a good label for the mechanical quality of penile tunica. The existence of penile tunica in a healthy condition is essential not only for good penile erection but also for supple extensibility, and as a result, for a sound penile image (Bondil, Costa, Daures, Louis, & Navratil, 1992). It could be hypothesized that diabetic and nondiabetic ED may be associated with an altered penile size.

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Penile size, including penile length and girth, is an important issue during management of patients with ED. Many of ED patients have a well-established idea since their young ages that a large penis size is the only guarantee for better sexual and reproductive capabilities (Salama, 2015). Changes in penile size may worsen a man's self-esteem (Son, Lee, Huh, Kim, & Paick, 2003) which is already compromised during ED (Althof et al., 2006). Men with ED may also undergo penile prosthesis implantation, radical prostatectomy, or urethroplasty which may be associated with a decrease in penile length (Deveci, Martin, Parker, & Mulhall, 2007; Guralnick & Webster, 2001; Savoie, Kim, & Soloway, 2003). The use of a condom catheter in older men with ED, particularly those with diabetes, is not uncommon during the management of urinary incontinence, and its proper selection to fit penile girth should be kept in mind by the managing physician (Schneider, Sperling, Lümmer, Syllwasschy, & Rübber, 2001).

Penile measurements were extensively studied by many investigators. The data of these measures were recorded mostly from healthy men (Mondaini et al., 2002; Salama, 2015; Son et al., 2003). Studies assessing penile measurements in men with ED are scarce. Assessment of penile measurements in these men was not the main aim of most of these studies (Awwad et al., 2005; Kamel, Gadalla, Ghanem, & Oraby, 2009; Khan, Somani, Lam, & Donat, 2012). Moreover, a controversy, if ED could really affect penile dimensions, is existent in these reports.

The objective of this study was, therefore, to test the hypothesis that diabetic and nondiabetic ED may be associated with an altered penis size as represented by decline in the penile dimensions, to compare these dimensions under both types of ED, and to correlate them with other study variables.

Material and Method

Study Plan and Participants

The present study is a case-control study. It consisted of three age-matched groups: two patient (diabetic and nondiabetic) groups with ED and the controls. The data of the participants were retrieved through a retrospective checkup of consecutive patients' records who consulted the Andrology clinic at the Alexandria Faculty of Medicine in Alexandria for ED in the patient groups and for a premarital/postmarital checkup of fertility and potency in the control group. The presence of ED was based on the patient's self-reporting and the questionnaire of the International Index of Erectile Function-Abridged form (IIEF; score ≤ 21 ; Rosen, Cappelleri, Smith, Lipsky, & Peña, 1999). The ED should be present for a period of at least 3 months to be considered as a medical problem (Lewis et al., 2004). Each study group included 105

consecutive participants. All members in the three groups demonstrated Grade 4 (E4) artificial erection during intracorporal injection. This erection grade entailed a completely hard and fully rigid organ (Boolell, Gepi-Attee, Gingell, & Allen, 1996). All study members were collected during the same time period to keep the randomized selection. The protocol of the study was approved by the departmental review board. All study members gave informed consent. Exclusion criteria involved men with a history of endocrinopathy, testosterone replacement therapy, urethral intervention or disorder, like stricture, epispadias and hypospadias, and penile disease like Peyronie's disease and penile tumors.

Data Retrieval

Data retrieval included demographics as age, occupation, height, weight, and body mass index. Full history with special emphasis on any alcohol or drug intake, tobacco smoking or trying any erection-enhancing medications like phosphodiesterase inhibitors or aphrodisiacs, or tools like vacuum erection device (VED) was obtained. Patient's self-reporting response to these medications, whether good or not (the ability or inability of the treatment to induce a hard erection sufficient to perform a satisfactory penetration) was retrieved. The positive findings during general and local examinations together with the scores of the abridged five-item version of the IIEF (Rosen et al., 1999) were collected. Laboratory data, including a complete blood picture, serum total testosterone, serum prolactin, lipogram, and random blood sugar were interpreted. Glycosylated hemoglobin (HbA1c) was estimated routinely in cases of documented history of diabetes.

Penile Dimensions

These dimensions were collected from the files of the study participants. These were estimated as reported previously (Salama, 2015). In brief, a single physician who was unaware of the study estimated the penile dimensions. The estimation was done swiftly in a warm private room to avoid any effect of temperature or touch on penile measurements. The estimation began by measuring the penile dimensions at a flaccid state. A rigid ruler was used to estimate both *the pendulous and total flaccid penile lengths*, while a tap was used to assess *the mid-shaft penile circumference*. The calculations were taken to the nearest 0.5 cm. The penile length recorded on the dorsal surface of the penis and extending between peno-pubic skin junction and penile tip was *the pendulous flaccid penile length*, while the length extending from the penile tip to the edge of the pubic bone was *the total (peno-pubic) flaccid penile length*. After achievement of E4 artificial erection, the penile measures were reevaluated in

the same way to get the *pendulous and total erect penile lengths and erect penile circumference*. Penile extensibility was calculated by getting the difference between total erect and flaccid penile lengths (Moreira de Goes et al., 1992). The depth of the prepubic fat pad was also calculated while pushing it against the edge of the pubic bone (Salama, 2015; Savoie et al., 2003).

Statistical Analyses

The SPSS program for Windows Release 16 (SPSS Inc., Chicago, USA) was used to analyze the data. Descriptive statistics (mean, standard deviation, and range) for different study variables were prepared. As data distribution were not symmetrical, nonparametric tests were applied. Smoking incidence and good response to ED-enhancement medications were studied using chi-square tests. The correlation between the patients' penile measures and the different study variables was done using Spearman's rank correlation coefficient (r). p Value was significant when it was $<.05$.

Results

Patients with ED had smaller penile dimensions as compared with the potent controls, whether in flaccid or erect state. The reduction in most penile dimensions was significant when diabetes was associated but insignificant in its absence.

Study Participants

The age-matched study groups were 24 to 68 years old (controls), 28 to 70 years old (diabetic patients), and 25 to 68 years old (nondiabetic patients). All study participants reported well-developed secondary sexual characters, underwent circumcision, and were nonalcoholic. The number of smokers in the diabetic group was significantly less than those in the control (20 vs. 47, $p \leq .001$) and nondiabetic groups (Table 1). The difference in the rate of smoking was insignificant between the nondiabetic patients and the controls ($p = .12$). Body mass index in the three study groups seemed similar (27.8 ± 4.7 , 28.7 ± 5.6 , and 29.1 ± 4.6 ; $p = .48$, for the controls and diabetic and nondiabetic patients, respectively). All diabetic patients belonged to type 2 diabetes with HbA1c of $10.6\% \pm 2.8$ (17 patients had missing data) and disease duration of $9.17 \text{ years} \pm 6.22$ (14 patients had missing data). The missed data of these 14 patients could not be retrieved precisely as the patients could not decide for sure the exact duration of their diabetes. The etiological reasons of ED in the nondiabetic patient group included psychogenic (12 patients), organic (70 patients), and mixed (10 patients) ED, while the remaining 13 patients had undetermined etiologies. All members in the two patient

groups were married. In the diabetes group, the duration of ED and IIEF-5 were significantly shorter and lower, respectively, compared with the nondiabetic group (Table 1). Although more diabetic than nondiabetic patients tried some preparation of erection-enhancing medications (71 vs. 59), patients in the first group were less likely than those in the second group to report good response. The difference was insignificant (Table 1). No patient used the VED.

Penile Dimensions and Prepubic Fat Pad

The two patient groups had lower values for all penile dimensions as compared with the controls, except the erect circumference in the nondiabetic patients which was larger than the controls (Table 2). In the diabetic patients, the lower values identified significant differences with those of the controls and nondiabetic patients in all penile dimensions, except the apparent flaccid and erect lengths. In the nondiabetic patients, their smaller dimensions as compared with the controls did not reveal statistical differences, except the apparent erect length. The penile extensibility appeared similar in the three study groups. The depth of the prepubic fat pad was also significantly smaller in the diabetic group as compared with the controls and nondiabetic group whose fat pads were nearly alike in their depth (Table 2).

Correlation Between the Different Study Variables

No significant correlation could be appreciated between duration of diabetes and different penile dimensions or extensibility in the diabetes group (Table 3). It was also reported in Table 3 that no significant correlation was detected between any penile dimensions or extensibility and duration of ED or IIEF-5 in the two patient groups, except between total erect penile length and IIEF-5, where there was a positive correlation. The lack of significant correlation was also seen between the age of the study participants and their penile dimensions and extensibility. However, the estimated correlations identified inverse relationship between the study variables and one or more of penile dimensions and extensibility. It was the duration of diabetes followed by the duration of ED, which highlighted this negative relationship with most penile dimensions.

Discussion

Penile TA has several fundamental functions. Probably, the most important among these functions is its significant role in the veno-occlusive (VO) mechanism during erection (Lue & Tanagho, 1987). This happens through its compression on the emissary veins perforating it and subtunical venous plexus lying between it and the cavernous sinusoids leading to occlusion of both the veins and

Table 1. History Findings in the Two Patient Groups.

Study variable	Diabetic patient group	Nondiabetic patient group	<i>p</i>
Smoking	20 (19.1%) (<i>n</i> = 105)	36 (34.3%) (<i>n</i> = 105)	.013 ^a
IIEF-5	11.2 ± 4.7 (<i>n</i> = 64)	13.2 ± 3.9 (<i>n</i> = 89)	.004 ^b
Duration of ED	4.29 ± 5.66 (<i>n</i> = 100)	5.03 ± 5.14 (<i>n</i> = 99)	.043 ^b
Good response to ED-treatment	39 (24.8%) (<i>n</i> = 105)	41 (30.5%) (<i>n</i> = 105)	.35 ^a

Note. ED = erectile dysfunction; IIEF = International Index of Erectile Function; *n* = the number of patients with full available data which could be used for estimation.

^aChi-square test. ^bMann–Whitney test.

Table 2. Penile Dimensions and Extensibility and Prepubic Fat Pad in the Study Groups (*n* = 105, each).

Penile dimension/ prepubic fat pad	<i>p</i> ^a	Controls (<i>M</i> ± <i>SD</i> , cm)	<i>p</i> ^b (Control vs. Diabetic patients DM)	Diabetic patients (<i>M</i> ± <i>SD</i> , cm)	<i>p</i> ^b (DM vs. non-DM)	Nondiabetic patients (<i>M</i> ± <i>SD</i> , cm)	<i>p</i> ^b (Control vs. non-DM)
Apparent flaccid length	.11	7.81 ± 1.31	.097	7.46 ± 1.63	.88	7.51 ± 1.58	.053
Apparent erect length	.092	10 ± 1.56	.17	9.66 ± 1.66	.42	9.61 ± 1.75	.031
Flaccid circumference	.016	9.14 ± 0.89	.011	8.84 ± 0.82	.017	9.11 ± 0.79	.58
Total flaccid length	.000	12.88 ± 1.46	.000	11.8 ± 1.94	.001	12.77 ± 1.53	.51
Total erect length	.000	15.04 ± 1.51	.000	13.96 ± 2	.001	14.88 ± 1.48	.54
Erect circumference	.018	11.92 ± 1.06	.059	11.56 ± 1.17	.006	12.06 ± 1.02	.32
Penile extensibility	.91	2.16 ± 0.97	.97	2.16 ± 0.93	.69	2.11 ± 0.9	.73
Prepubic fatty pad	.000	4.99 ± 1.37	.001	4.34 ± 1.48	.000	5.24 ± 1.46	.14

Note. DM = diabetes mellitus.

^aKruskal–Wallis test. ^bMann–Whitney test.

Table 3. Correlation Between the Study Variables and Penile Dimensions of the Study Members.^a

Penile dimension	Age ^b (<i>n</i> = 315)		IIEF-5 (<i>n</i> = 153)		Duration of ED (<i>n</i> = 199)		Duration of diabetes (<i>n</i> = 91)	
	<i>p</i>	<i>r</i>	<i>p</i>	<i>r</i>	<i>p</i>	<i>r</i>	<i>p</i>	<i>r</i>
Apparent flaccid length	.9	-.007	.21	-.102	.87	-.011	.32	.105
Apparent erect length	.5	.038	.89	.011	.71	.027	.91	.013
Flaccid circumference	.85	.011	.46	.06	.91	.008	.49	-.073
Total flaccid length	.1	-.093	.19	.11	.28	-.077	.75	-.034
Total erect length	.17	-.078	.006	.22	.57	-.041	.38	-.093
Erect circumference	.47	.041	.1	.13	.87	-.011	.67	-.045
Penile extensibility	0.11	0.089	.07	.147	.29	.076	.33	-.103

Note. ED = erectile dysfunction; IIEF = International Index of Erectile Function.

^aSpearman correlation. ^bAge of all the study participants was correlated with their penile dimensions and extensibility.

plexus. This will trap the blood inside the penis and maintain the erection (Bitsch, Kromann-Andersen, Schou, & Sjøntoft, 1990; Brock, Hsu, Nunes, von Heyden, & Lue, 1997; Hsu, Hsieh, Wen, Kang, & Chiang, 2002; Lue & Tanagho, 1987). TA is also the main determining factor for penile extensibility (Bondil et al., 1990), which allows the increment in length and girth during erection and returning again to the original flaccid status with detumescence (Brock et al., 1997; Hsu et al., 1992; Simopoulos et al., 2001). These important functions of TA are essentially

related to its fine structure composed of collagen and elastic fibers (Iacono, Barra, Cafiero, & Lotti, 1995; Iacono, Barra, de Rosa, Boscaino, & Lotti, 1994; Iacono, Barra, & Lotti, 1995). The bearing of these fibers in healthy condition will guarantee against tunical subluxation and flabbiness and keep a competent “venous-leak proof” effect of TA (Shafik, Shafik, El-Sibai, & Shafik, 2007). In contrast, several pathological conditions were reported to affect TA with a reduction in its elastic fibers and concomitant disorders in the arrangement of the collagen fibers.

This eventually will end with the flabbiness of TA disturbing its VO mechanism with the development of ED (Akkus et al., 1997; El-Sibai, Shafik, & Shafik, 2011; Iacono, Barra, Cafiero, et al., 1995; Iacono, Barra, & Lotti, 1995; Iacono et al., 1994). It was, therefore, of a great interest to corroborate the existence of such penile structural changes in ED patients. This corroboration, in this study, took the form of estimating the penile dimensions in flaccid and erect states which depend on the integrity of the tunical fine structures (Bondil et al., 1992). This could give an answer to the hypothesis that the ultrastructural changes in TA, which are well indicated in patients with ED, may also lead to alterations in the penile size in these patients. This would mean two results of the same mechanism. Therefore, another aspect of functional characteristics of fine structure of penile TA, beside its pivotal role to maintain erection, could be highlighted.

The current study, through a case-control retrospective design, identified that the diabetic men with ED had significantly smaller penile size as compared with the controls and the nondiabetic men with ED. The latter individuals unveiled also penises with short measures compared with the controls in all dimensions, except the erect circumference which was larger. This interesting finding coincides with Savoie et al. (2003) who reported decrease in all penile dimensions after nerve-sparing radical prostatectomy except the girth which showed significant increase (9.4 cm vs. 9.8 cm, $p < .01$). All patients in the Savoie et al. study were potent before surgery, but the majority (63.8%) were unable to have intercourse after surgery. These authors could not explain this unique increase in penile girth in their patients. Therefore, the exact mechanism for the larger erect circumference in this current study remains to be elucidated. The current study could, therefore, confirm the tested hypothesis and identify another consequence of diabetes—the significant shrinkage of the penis. This is an important finding because loss of penile size might have an additional negative impact on quality of life (Son et al., 2003), particularly in patients with ED whose quality of life is already compromised (Althof et al., 2006). Penis size is still considered a prerequisite for better sexual performance by men in some communities (Salama, 2015). It may be also of special importance in ED men who may be subjected for penile prosthesis insertion, which is frequently associated with a decrease in penile length (Deveci et al., 2007) or in need for condom catheters, particularly those with diabetes, whose size should fit the penis (Schneider et al., 2001). The VED is a common choice for men wishing to enhance their penis size (Nugteren et al., 2010). However, the vacuum would probably not affect the study findings if they are irreversible due to organic comorbidities like diabetes (Cho et al., 2012; Wang et al., 2014).

In the present study, the reported decrease in penile measurements among the studied patients whether with or without diabetes were real as evidenced by: (a) the diabetic patients had the shortest reported penile dimensions among all the study participants, although they presented the smallest depth of prepubic fat pad. A prominent fatty pad is possible to mask few centimeters of the penile length giving a false measurement; (b) the study included an estimation of the total penile length, which bypassed the fat pad and went until the edge of pubic bone. This length was shorter in ED patients as compared with the controls; and (c) the decline in penile size included not only the length but also the girth measurement in all the patients. The current report of declined erect penile dimensions in ED patients was based on estimation of these dimensions after inducing artificial erection of E4 degree (Boolell et al., 1996) in these patients and controls. Some may argue that if it was hypothesized that these ED patients had altered structure in their TA which represented the basis of their declined penile dimensions, how did they achieve E4 erection? The answer could be that in the presence of abnormal TA and poor subalbugineal venous compression, the arterial inflow partially counterbalances the lack of TA-exerted venous compression (Aboseif et al., 1990). This eventually will increase the intracorporal pressure with more stretching of the abnormal TA which decreases the penile venous outflow (Iacono, Barra, Cafiero, et al., 1995).

Penile measurements have been reported by several studies. Information on almost all of these studies were retrieved from potent men to assure them in cases of concern for small-sized penis (Awwad et al., 2005; Mondaini et al., 2002; Salama, 2015) or establish nationally based nomograms for penile size (Khan et al., 2012; Ponchietti et al., 2001; Veale, Miles, Bramley, Muir, & Hodsoll, 2015). A recent systematic analysis involving 17 past studies reviewed penile dimensions in 15,521 males to create nomograms on flaccid and erect penile size measurements (Veale et al., 2015). Checking the reported dimensions in that study (Table 4) identified that both total flaccid and erect lengths and the erect circumference were smaller than the corresponding dimensions of the controls and patients in the current study, except the erect circumference in the diabetic patients. On the contrary, the flaccid circumference of men in that systematic analysis was larger than that reported in the three current study groups.

Studies investigating penile measurements in men with ED were exceptionally few and contradictory. As the assessment of penile measurements in men with ED was not the main objective of these studies, a cause-specific relationship with these measurements was neither investigated nor reported. Kamel et al. (2009) reported that his ED patients had significantly shorter fully stretched

Table 4. The Penile Dimensions in the Current and Veale et al. (2015) Studies.

Penile dimension	The current study (<i>n</i> = 105, each group)			Veale et al. study (2015; <i>M</i> ± <i>SD</i> , cm)
	Controls (<i>M</i> ± <i>SD</i> , cm)	Diabetic patients (<i>M</i> ± <i>SD</i> , cm)	Nondiabetic patients (<i>M</i> ± <i>SD</i> , cm)	
Total flaccid length	12.88 ± 1.46	11.8 ± 1.94	12.77 ± 1.53	9.16 ± 1.57 (<i>n</i> = 10,704)
Flaccid circumference	9.14 ± 0.89	8.84 ± 0.82	9.11 ± 0.79	9.31 ± 0.9 (<i>n</i> = 9,407)
Total erect length	15.04 ± 1.51	13.96 ± 2	14.88 ± 1.48	13.12 ± 1.66 (<i>n</i> = 692)
Erect circumference	11.92 ± 1.06	11.56 ± 1.17	12.06 ± 1.02	11.66 ± 1.1 (<i>n</i> = 381)

penile length than their controls (11.2 cm ± 1.5 vs. 12.9 cm ± 1.9). Awwad et al. (2005) claimed that there was a significant difference regarding the mean flaccid length (9.3 cm vs. 7.7 cm) and the mean stretched length (13.5 cm vs. 11.6 cm) of his normal and ED study members, respectively. Khan et al. (2012) on the other hand denied any significant differences of penile dimensions between his ED patients and their controls (8.62 cm vs. 8.7 cm, pendulous flaccid length, 10.38 cm vs. 10.2 cm, penopubic flaccid length and 14.36 cm vs. 14.3 cm, fully stretched length for ED patients vs. their controls, respectively). The sample size in these studies was relatively small (78, 109, and 114 patients, respectively) compared with that in the current study (210 patients). These previous studies did not report any additional penile dimensions like circumference or extensibility among their ED patients like the case in the currently studied patients. In contrast to these studies which assessed penile length during a maximal stretch, the current study replaced the stretched penile length by the penile length at full rigid erection. This assessment had several advantages. First, it avoided individual variations which represent a common problem during penile stretching (Bondil et al., 1992). Second, it avoided the significant difference between stretched and erect penile length, which was claimed by several researchers (Promodu, Shanmughadas, Bhat, & Nair, 2007; Sengezer, Ozturk, & Deveci, 2002) although others denied that (Awwad et al., 2005; Wessells, Lue, & McAninch, 1996). Third, it helped in estimating a new dimension that is the erect circumference, which cannot be assessed under a full stretch of the penis (Salama, 2015). This dimension has recently received special attention as it was claimed that penile circumference may be more important for sexual satisfaction than length (Francken, van de Wiel, van Driel, & Weijmar Schultz, 2002). Fourth, it could assure the patients who started to notice, in varying degrees, some alteration in their organ sizes (data not revealed). It was extremely hard to convince these patients that both stretched and erect penile lengths are comparable (Salama, 2015).

In the present study, the diabetic patients presented significantly shorter dimensions as compared with the

nondiabetic patients. Four lines of evidence are present, which may explain the significant difference. First, the average IIEF-5 scores of the diabetic patients were significantly lower (11.3 cm vs. 13.1 cm) than that of the nondiabetic patients. These low IIEF-5 scores entailed minimal penetration frequency (Rosen et al., 1999) and nonexistence of alternating stretch in the TA, substantiating the popular phrase (use it or you will lose it; Awwad et al., 2005). Several studies postulated that lack of erection for a long time may incite chronic hypoxia with subsequent tissue fibrosis and a decline in penile size (Savoie et al., 2003). Second, the hyperglycemia and advanced glycation end products in the diabetic patients could be a strong initiator of several systemic changes in extracellular matrix metabolism and increased production of transforming growth factor-B1 (Neves 2013; Salama, Tsuji, Tamura, & Kagawa, 2001). These changes in extracellular matrix and transforming growth factor-B1 may lead to increased production of collagen and fibrotic changes in the penile tissue which may hinder its compliance and extensibility. Third, the diabetic patients reported less good response on use of erection-enhancing medications than the nondiabetic patients (54% vs. 68%). Although this difference was insignificant, it might offer the nondiabetic patients more time periods to get a full erection. This can guard against penile ischemia, which was highlighted to initiate penile fibrosis as discussed above (Savoie et al., 2003). Fourth, hypercholesterolemia represented the commonest associated risk factors among the study patients with a higher incidence in diabetic patients (data not revealed). Recently, it was reported that hypercholesterolemia could induce several structural changes in the penile tissue, including marked decreases in its content of elastic fibers (Yesilli, Yaman, & Anafarta, 2001). It is known that diabetic patients have more medical problems than nondiabetic patients (Centers for Disease Control and Prevention, 2014). This may collectively affect the degree of ED and the associated ultrastructural changes of the penile tissues. The basis of the current results related to the evident changes in diabetic patients with ED agrees with previous investigators who identified that diabetic men with ED have more pronounced histological changes in penile tissue than

nondiabetic men with ED (Liu et al., 1993). This study, therefore, could suggest that men with small penis and ED may have undiagnosed diabetes or prediabetes. In fact, checking diabetes is usually done once a man with ED consults our institution.

Diabetes-associated pathological changes in the penis are strictly related to the duration of the diabetes (Bacon et al., 2002). However, in this study there was no significant correlation between this duration and penile dimensions. This may be related to the variation in the level of glycemic control among the diabetic patients in the current study. Previous reports have identified that the progress of poorly controlled diabetes is strictly associated with severe pathological alterations in penile tissues (Cho et al., 2012; Wang et al., 2014). Duration of ED and IIEF-5, in the current study, were also not correlated with the penile measures, except the total erect length which had positive correlation with IIEF-5 score. This is similarly reported by Kamel et al. (2009). The lack of correlation in the current study between duration of ED and penile measures may be attributed to the disparity in the frequency of intake of and degree of response to the erection-enhancing medications by the different patients. This disparity could lead to an obvious difference in the chance to have satisfactory erection which may stop, even temporary, the negative impact of penile hypoxia associated with diabetes and other ED-associated morbidities (Savoie et al., 2003). However, the correlations in the current study identified the negative trend between the study variables and one or more of penile dimensions. It was the duration of diabetes mellitus followed by the duration of ED, which highlighted this negative trend with most penile dimensions. The current data analysis has not identified a significant correlation between penile extensibility and IIEF-5 ($p = .07$). Previous researchers claimed a positive correlation between extensibility and erectile function (Bondil et al., 1990). These researchers did not use IIEF-5, which was not yet introduced at that time. In addition, their sample size was bigger than that of the current study (422 vs. 210 patients). This study did not reveal a significant correlation between penile dimensions or extensibility and participants' ages. This is similarly reported by other studies (Awwad et al., 2005; Khan et al., 2012).

In the present study, the incidence of smoking in the control group was higher than that in the two patient groups. A midline review did not show published studies investigating the relationship between smoking and penis size. Only one abstract from Boston University (Bliss, 2013) was found which revealed that smokers' penises are significantly shorter than nonsmokers' at erection. The researchers attributed this to the harmful effect of smoking on the penile tissue, making it less elastic and stopping it from stretching. However, this was not the

case in the current study. It is generally believed that smoking amplified the risk of ED associated with other risk factors like dyslipidemia and diabetes (Feldman, Goldstein, Hatzichristou, Krane, & McKinlay, 1994).

The present study has some limitations. The main limitation is related to the retrospective nature of this study. This could alter the specific report made by the patient questionnaire about his insight into the image of his penis. This point may be of a special interest to assess if the patient considered his altered penile dimensions as a problem. However, some patients in this study noticed changes in their penile dimensions and reported it by themselves (data not revealed). A second limitation is related to the relatively small size of this study. The material of this study was limited due to the current number of the participants in the three groups. The researcher aimed to collect all data during the same period of time and in a consecutive manner. This was to ensure as much as possible the level of randomness of the study. However, it is thought that increasing the number of participants in an extended study will increase the statistical power of the current hypothesis test giving a clear clue about the real relationship between the penile dimensions and the different study variables. Another limitation was connected to the inclusion criteria of the study participants who were selected based on their response to the artificial erection giving E4 degree (Boolell et al., 1996). Patients responding with Grade 3 (E3) erection (increased hardness sufficient for intercourse, but not fully rigid) were not, therefore, included. These E3 patients are supposed to have more advanced degrees of VO dysfunction and tunical structural changes. This may augment the alteration happening in the penile dimensions and corroborate the current study findings. In addition, data retrieved from E3 patients could probably predict response to ED medications. The E3 patients were not included in this study because it was expected that the controls, who were potent, would respond to the artificial erection with E4 degree. In order to accomplish this study, all members should have the same criteria of erection (E4) to assess precisely the erect penile dimensions. This could guarantee symmetrical inclusion criteria among all the study members.

Conclusion

The current study represents the first report on the changes in penile size, whether in flaccid or erect state in diabetic and nondiabetic men with ED. These changes included decline in all penile dimensions. The reduction in penile dimensions was significant when diabetes mellitus was associated, but insignificant in its absence. These changes could be a silent corollary of associated comorbidities, and in particular diabetes. Monitoring the

changes in penile size should be an important component of the clinical checkup of any patient with ED, especially diabetic patient. This can provide an indirect but useful and simple way to evaluate the status of fine structural components of penile TA, which would help improve the management of ED. The current reported results could identify another aspect of the functional characteristics of these tunical structures which may change under different diseases with its direct implications on erection. Accordingly, discussion about the future possibility of shortening of their organs should also be discussed with patients with ED.

An extension of the current study to follow up with these ED patients is highly recommended to check if the reported penile size alterations will continue with worsening the condition. This would imply an early diagnosis of problems related to erection in these men to initiate appropriate treatment in an early phase. Further studies are also needed to clarify precisely the relationship between different comorbidities and penile measurements.

Author's Note

A master table of the current study containing the retrieved data is documented, certified, and saved at the Department of Urology, Alexandria Faculty of Medicine, Alexandria, Egypt.

Declaration of Conflicting Interests

The author(s) declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

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