The role of biofeedback in the rehabilitation of veno-occlusive erectile dysfunction

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Received 11 July 2014
Accepted 11 August 2014

Egyptian Rheumatology & Rehabilitation
2014, 41:179–186

Background
Pelviperineal muscles play a role in erection through the enhancement of blood flow to the penis. Hence, the reinforcement of the power of such muscles through noninvasive visual pressure biofeedback rehabilitation may be helpful in erectile function improvement.

Aim
The aim of this study was to assess the value of pelviperineal muscles' visual pressure biofeedback rehabilitation in the treatment of organic veno-occlusive erectile dysfunction (ED).

Materials and methods
This study included 30 patients with veno-occlusive ED. Exclusion criteria were neurological, psychological, endocrinal, and arterial insufficiency ED. Also, patients with malignancies, chronic renal failure, liver cell failure, urological congenital abnormalities, pelvic surgery, pelvic radiation, or trauma and patients on medications known to cause ED were excluded. All patients performed visual pressure biofeedback strengthening of the pelviperineal muscles three times weekly for 3 months. In addition to clinical and laboratory evaluations, patients were assessed by a self-administered questionnaire, a neurophysiological examination, a pharmacopenile duplex ultrasound, and the anal hold pressure.

Results
According to the self-administered questionnaire, 16/30 patients (53.3%) showed either partial or complete improvement (11 and five patients, respectively). On comparing prerehabilitation and postrehabilitation results of the pharmacopenile duplex ultrasound, 18/30 patients (60%) showed either partial or complete improvement (13 and five patients, respectively). The anal hold pressure improved from 120.7 to 189.9 after biofeedback rehabilitation.

Conclusion
Pelviperineal muscles' visual pressure biofeedback rehabilitation is effective, inexpensive, noninvasive, safe, and easily applicable in the treatment of venogenic ED and does not have as much side effects as medication.

Keywords:
cavernosal artery diameter, end-diastolic velocity, erectile dysfunction, pharmacopenile duplex ultrasound, peak systolic velocity, visual pressure biofeedback

Egypt Rheumatol Rehabil 41:179–186

1110-161X

Introduction

The penis is a highly vascular organ, and erection is primarily a vascular event [1]. Sexual stimulation causes the release of neurotransmitters from the corpus cavernosa (the two cylindrical chambers that run through the length of the penis) and cause endothelial cells of the penis to release nitric oxide, which is an essential vasodilator [2–4]. The neurotransmitters, together with nitric oxide, cause the corpus cavernosa to relax, allowing blood to flow into the penis helped by contraction of the pelviperineal muscles, causing the penis to expand [5]. Once erection has started, the contraction of pelviperineal muscles help in reaching and maintaining a rigid erection, whereas the contraction of the ischiocavernosus muscle and the bulbospongiosus muscle results in an increase in the intracavernous pressure above the systolic pressure, causing rigid erection in the fifth stage of the six phases of penile erection [6]. Also, bulbospongiosus muscle contraction compresses the deep dorsal vein of the penis to prevent the outflow of blood from an engorged penis, thus causing veno-occlusion, which helps in maintaining erection for the time sufficient to perform a satisfactory sexual intercourse [7].

Disturbance of such a physiological mechanism will lead to erectile dysfunction (ED), usually known as impotence, which is defined as a consistent or recurrent inability to attain or maintain a rigid erection sufficient for satisfactory sexual intercourse for at least 3 months' duration. It is an important health problem affecting patients' quality of life and ability to maintain intimate relationships [8–10]. Its incidence increases with age; the most severe form (defined as never being able to achieve an erection) occurs in 2% of men aged 20–39 years, increasing to 47% of men aged 75 years [11].

ED has two main etiological factors: psychogenic and organic. Previously, most EDs were considered to be psychogenic, but currently, it is suggested that up to 80% of the cases have an organic cause, with vascular insufficiency considered to be the most common cause of organic male sexual dysfunction [12,13].

The organic causes of ED are classified into vascular impairments (separate from diabetes mellitus) (40%), diabetes mellitus (30%), medications (15%), pelvic surgery, radiation and trauma (6%), neurogenic (5%), endocrinal (3%), others such as chronic renal failure, liver cell failure, and anatomic abnormalities (1%) [10,13–15]. Vasculogenic ED includes the inability of the penis to store blood during erection due to leak into the venous system, termed as venous leak or veno-occlusive ED [16].

The management of ED has evolved significantly as evidenced by the increased recognition of its organic etiologies. There are different treatment options including psychosexual counseling, medications, external vacuum devices, intracavernous injection therapy, vascular surgery, and the use of a penile prosthesis. The choice of intervention modality depends on the etiology and patients' acceptability for the treatment options [17–19].

As there is an active role of pelviperineal muscles in sexual activity, hence, pelviperineal muscle rehabilitation programs may be a possible alternative in the treatment of venogenic ED and may be considered as a first-line approach for men seeking resolution without pharmacological or surgical interventions. Also, men receiving other forms of therapy could be advised to strengthen the pelviperineal muscles in addition to the therapy prescribed [19].

Consequently, this study aims to assess the value of pelviperineal muscles' visual pressure biofeedback rehabilitation in the management of organic veno-occlusive ED.

Materials and methods

This was a prospective study that was approved by the research ethical committee of the Ain Shams Faculty of Medicine, and all patients provided a written informed consent before participation. This study included 30 patients recruited from the Andrology Clinic in Ain Shams University Hospitals.

Inclusion criteria were veno-occlusive ED for at least 3 months' duration, and it was confirmed by a pharmacopenile duplex ultrasound (PPDU).

Exclusion criteria included patients with ED due to causes other than a veno-occlusive etiology: for example, (a) neurological ED (excluded by a neurophysiological study), (b) psychological ED (excluded by nocturnal penile tumescence testing using RigiScan: patients achieving at least one erection with rigidity > 60% lasting for ≥10 min were considered as having psychological ED), (c) endocrinal ED (excluded by the assessment of serum levels of testosterone and prolactin), and (d) ED due to arterial insufficiency (excluded by a PPDU). Also, patients with malignancies, chronic renal failure, liver cell failure, cardiovascular diseases, urological congenital abnormalities, pelvic surgery, pelvic radiation or trauma, and patients on medications known to cause ED, such as antidepressants or anxiolytics, were excluded [20,21].

Baseline patient assessment

(1) Clinical, psychological, sexual, and laboratory evaluations were performed.
(2) *Nocturnal penile tumescence assessment*: To study erections during sleep, the RigiScan system (Laborie Medical Technologies, Inc., Mississauga, CA) was used to record the penile circumference and rigidity. In men without organic ED, three to five erections per night lasting up to 30 min may occur during sleep. Nocturnal penile tumescence is a valuable tool differentiating psychological from organic impotence [22].
(3) Neurophysiological assessment to exclude neurological ED:
    (a) The nerve conduction velocity of the dorsal nerve of the penis was determined [23,24].
    This test was performed while the patient was in the supine position. Two stimulating surface disk electrodes (0.5 cm in diameter) were placed 1 cm apart on the dorsum of the glans penis with the cathode electrode oriented proximally, whereas the two recording surface disk electrodes (1 cm in diameter) were placed on the dorsum of penile shaft at its base ~2 cm apart. The ground electrode was placed on the shaft between the stimulating and the recording electrodes. The impulse used was as follows: square-wave impulses with a duration of 0.1 ms were delivered at a rate of 1.7 pulses/s with a maximal strength of 19.9 mA. Neurological ED was excluded if the nerve conduction velocity measured to the peak was at least 21.4 m/s, the shape was biphasic or triphasic, and the amplitude 5.9–18.1 μV.
    (b) The penile sympathetic skin response [25,26].
    This test was performed while the patient was in the supine position. Two stimulating surface disk electrodes (0.5 cm in diameter) were placed 1 cm apart over the right median nerve at the wrist with the cathode electrode oriented proximally, whereas

the two recording surface disk electrodes (1 cm in diameter) were placed on the lateral aspect of the shaft of the penis to avoid vascular artifacts (ECG) and the reference electrode was placed on the dorsum of the glans penis. The ground electrode was placed around the right thigh. The impulse used was as follows: a painful single square-wave impulse with a duration of 0.1 ms and an intensity of 40–100 mA was used to evoke the response. Neurological ED was excluded if the latency was 1600 ms or less (baseline to first deflection), the amplitude was at least 235 μV (baseline to peak), and the shape was triphasic, biphasic, or monophasic, either the P or the N type.

(4) Subjective self-administered questionnaire (SAQ) of ED [27]:
Patients were assessed and scored according to the five-item version of the International Index of Erectile Function (IIEF-5), which consists of five questions. Its score ranges from 1 to 25 and classifies ED severity with the following breakpoints: severe (1–7/25), moderate (8–11/25), mild to moderate (12–16/25), mild (17–21/25), and no ED (22–25/25).

(5) Anal hold pressure measurement [28,29]:
The Enraf Nonius 'Myomed 932' (Enraf Nonius, Amsterdam, Netherlands) apparatus was used to evaluate the pelviperineal muscle strength.
Technique: The air-filled, sheathed, and lubricated anal probe was inserted into the anal canal to a depth of 4 cm, and then each patient was asked to voluntarily tighten the pelviperineal muscles with maximum strength (as if preventing the flow of urine and flatus) and hold the contraction for 10 s. This contraction was performed three times with a 10-s rest in between. In each anal-holding trial, the lowest pressure was recorded. The best of the three readings was considered as the anal hold pressure in hPa.

(6) Objective PPDU was performed for the quantitative diagnosis of veno-occlusive dysfunction using a high-resolution ultrasound apparatus (Voluson 730 Expert; GE Medical System, Buckinghamshire, UK) after intracavernosal injection of 1 ml trimix vasoactive agents (15 mg papaverine, 5 μg PGE1, and 0.5 mg phentolamine). Then, assessment of the cavernosal artery diameter (CAD), the peak systolic velocity (PSV), and the end-diastolic velocity (EDV) was performed.

Pharmacopenile duplex ultrasound result interpretation [30]

Normal values: CAD > 75%, PSV ≥ 25 cm/s, EDV < 5 cm/s.

Arteriogenic ED: CAD < 75%, PSV < 25 cm/s.

Venogenic ED: CAD > 75%, PSV ≥ 25 cm/s, EDV > 5 cm/s.

Rehabilitation program

The rehabilitation program was performed at the Department of Physical Medicine & Rehabilitation of Ain Shams University Hospital in the form of visual pressure biofeedback muscle strengthening (using Enraf Nonius 'Myomed 932') for the pelviperineal muscles (levator ani, external anal sphincter, ischiocavernosus muscle, bulbospongiosus muscle, superficial transverses perineal muscles, deep transverses perineal muscles, and sphincter urethrae). The patient performed 10 maximal muscle contractions: each lasted for 10 s with a 5-s rest in between. The patient was able to visualize and quantify his muscle contractions. The sessions were performed three times weekly for 3 months.

Outcome assessment

Patients were re-evaluated at the end of the rehabilitation program (3 months) by the subjective SAQ (IIEF-5), anal hold pressure, and objective quantitative PPDU.

Categorization for improvement after rehabilitation

(1) Complete improvement:
   (a) *By Doppler*: If the EDV returned to normal, that is less than 5 cm/s regardless of the results of SAQ.
   (b) *By SAQ*: If the IIEF-5 score became 22–25 regardless of the results of duplex.
   (c) *By both duplex and SAQ*: If the patient showed complete improvement by both of them at the same time.

(2) Partial improvement:
   (a) *By Doppler*: If the EDV decreased but was still greater than 5 cm/s regardless of the results of SAQ.
   (b) *By SAQ*: If the IIEF-5 score increased and the patient moved to a better category (e.g. from severe ED to moderate ED) regardless of the results of duplex.
   (c) *By both duplex and SAQ*: If the patient showed partial improvement by both of them at the same time.

(3) No improvement:
   (a) *By Doppler*: If the EDV was still greater than 5 cm/s and did not decrease more than its value before rehabilitation regardless of the results of SAQ.
   (b) *By SAQ*: If the IIEF-5 score did not increase or increased but the patient did not move to a better category regardless of the results of duplex.

(c) *By both duplex and SAQ*: If the patient did not show any improvement by both of them at the same time.

Results

Patients' age ranged from 29 to 56 years (43.8 ± 9.1 years), and the disease duration was 6–60 months (24.3 ± 16.4 months). None of the patients were hypertensive or diabetic. Laboratory data are shown in Table 1. Nocturnal penile tumescence testing using RigiScan for two successive nights showed that the best duration of erection was less than 5 min and tip rigidity was greater than 32% in all included patients.

The neurophysiological study

Nerve conduction velocities of the dorsal nerve of the penis and the penile sympathetic skin response of all included patients were within the average reference range (Figs. 1 and 2) [23,26].

Self-administered questionnaire

It ranges from 2 to 16 (8.1 ± 4.3) before rehabilitation and became 5–24 (13.4 ± 7.7) at the end of the rehabilitation program. By SAQ, 16 patients (53.3%) showed either partial or complete improvement (11 and five patients, respectively) (Table 2).

Pharmacopenile duplex ultrasound

On comparing prerehabilitation and postrehabilitation results of PPDU, 18 patients (60%) showed either partial or complete improvement (13 and five patients, respectively) (Table 2, Fig. 3).

The total number of patients showing complete, partial, and no improvement are shown in Fig. 4.

Table 1 Laboratory data of the patients

Laboratory data	Range	Mean ± SD
Fasting blood sugar (mg/dl)	75–110	85.3 ± 24.2
Hemoglobin (g/dl)	12–16	13.3 ± 0.6
BUN (mg/dl)	7–18	12.3 ± 3.2
Serum creatinine (mg/dl)	0.4–1.1	0.8 ± 0.3
ALT (U/l)	11–22	17.2 ± 3.6
AST (U/l)	12–29	16.3 ± 6.4
Serum albumin (g/dl)	3.6–5	4.3 ± 0.4
Serum prolactin (ng/ml)	3.1–16	7.6 ± 3.7
Serum testosterone (ng/dl)	300–685	465 ± 49
Triglycerides (mg/dl)	63–160	109.9 ± 25.2
Total cholesterol (mg/dl)	140–231	183.2 ± 0.7
LDL	101–165	132.2 ± 17.8
HDL	35–60	42.1 ± 7.9

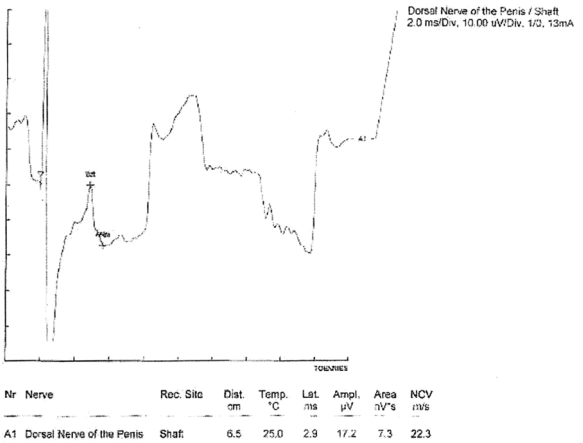
ALT, alanine transaminase; AST, aspartate aminotransferase; BUN, blood urea nitrogen; HDL, high-density lipoprotein; LDL, low-density lipoprotein.

Table 2 Improvement of patients according to SAQs and PPDU

Variables	*n* (%)
Failure	
No improvement by any assessment	9/30 (30)
Complete improvement	
Total complete improvement	7/30 (23.3)
Complete improvement by both PPDU and SAQ	3/30 (10)
Complete improvement by PPDU only	2/30 (6.6)
Complete improvement by SAQ only	2/30 (6.6)
Partial improvement	
Total partial improvement	14/30 (46.6)
Partial improvement by both PPDU and SAQ	10/30 (33.3)
Partial improvement by PPDU only	3/30 (10)
Partial improvement by SAQ only	1/30 (3.3)
Overall improvement	
Complete or partial	21/30 (70)

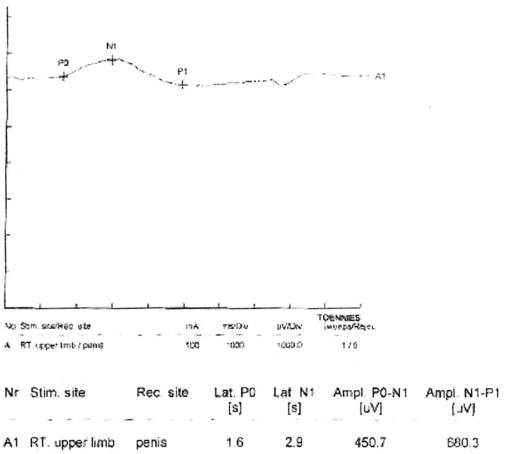
PPDU, pharmacopenile duplex ultrasound; SAQ, self-administered questionnaire.

Figure 1



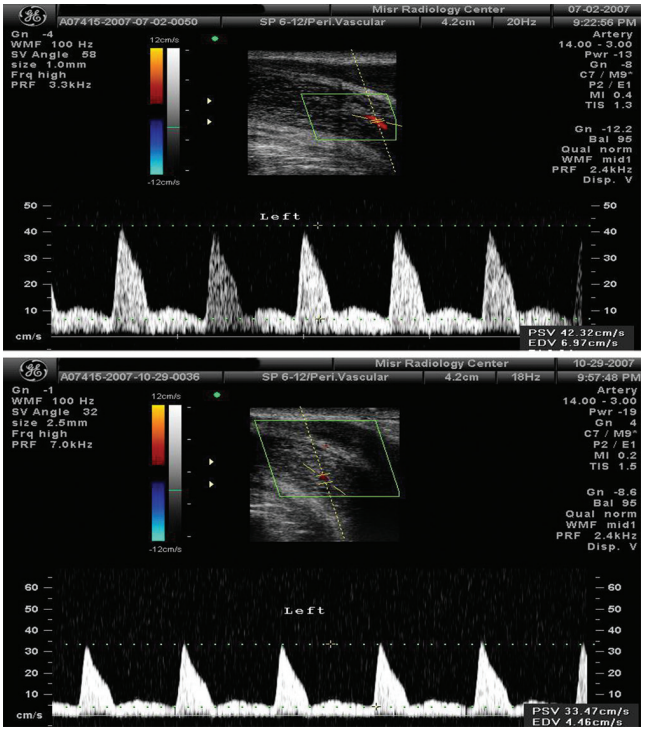
Normal nerve conduction study of the dorsal nerve of the penis.

Figure 2



Normal penile sympathetic skin response.

Figure 3



PPDU in one of the patients before and after rehabilitation showing improvement [(a) and (b), respectively]. (a) PPDU of a patient before rehabilitation showing evidence of ED (PSV = 42.3 cm/s, EDV = 6.97 cm/s). (b) PPDU of the same patient after rehabilitation showing evidence of improvement (PSV = 33.5 cm/s, EDV = 4.46 cm/s). ED, erectile dysfunction; EDV, end-diastolic velocity; PPDU, pharmacopenile duplex ultrasound; PSV, peak systolic velocity.

The baseline anal hold pressure ranges from 39 to 175 hPa and it improved to 50–270 hPa after therapy, whereas the mean anal hold pressure increased from 120.7 hPa (53.1) to 189.9 hPa (67.9) after rehabilitation.

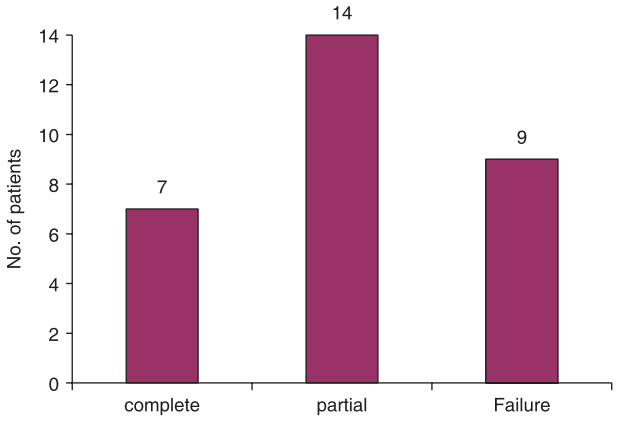
There was a statistically significant positive correlation of the EDV difference (post–pre therapy difference) with that of anal hold pressure and IIEF-5, with *P* value less than 0.001 and less than 0.05, respectively.

Discussion

ED affects millions of men throughout the world. Although it does not alter the life expectancy, it has a negative effect on the individual's well-being and quality of life [8].

Various methods are used to assess patients' response to treatment in erectile disorders. They include questionnaires such as the Erection Hardness Score, the IIEF, the Erectile Dysfunction Effect on the Quality of Life, the Sexual Life Quality Questionnaire (subject and partner), Partner's IIEF, and the validated German questionnaire of ED (KEED) [28,31–36].

Figure 4



The number of patients showing complete, partial, and no improvement after biofeedback rehabilitation.

Although questionnaires are important, it still remains a subjective method for assessment. Also, the anal hold pressure was used, but it had limitations as it needs patient education and cooperation. In contrast, some investigators used objective methods such as cavernosometry for patient evaluation, but it is an invasive method [36].

To the best of our knowledge, PPDU was not used previously in the assessment of erectile function in patients with venogenic ED after pelviperineal muscle rehabilitation; hence, in our study, in addition to the traditional subjective SAQ (IIEF-5 questionnaire) and anal holding pressure, the PPDU was used as an objective noninvasive method for evaluating the value of visual pressure biofeedback strengthening of pelviperineal muscles in venogenic ED.

Various modalities are used in the management of ED including medications, exercise, intracavernosal pharmacotherapy, inflatable penile prosthesis, vacuum erection device, and revascularization surgery [37–40]. An important noninvasive approach that helps patient education and performance of muscle exercises is the clinical biofeedback, which is not yet tested in the management of ED due to venous leak (veno-occlusive ED). Clinical biofeedback is a self-regulation technique through which patients can view their own muscle contractions on a screen such as a computer monitor [41]. Hence, in our study, visual pressure biofeedback was used to convert patient's pelviperineal muscle contractions from physiological signals into meaningful visual cues seen by the patient who was trained to voluntarily control and improve his muscle contractions.

On using the SAQ, 16.6% of our patients regained normal erectile function (complete response), whereas

36.6% showed partial improvement, that is, 53.2% showed variable degrees of either partial or complete improvement.

A previous study performed by Dorey and colleagues revealed subjective total improvement of erection in 40% of patients following pelvic muscles exercise. Our results are in line with that of Dorey, although they included all types ED and used the IIEF while in our study only venous leak ED were included and were assessed by the five-item version of the IIEF (IIEF-5) in addition to PPDU [42].

In contrast, our questionnaire results were lower than those of Van Kampen *et al*. [19], Dorey *et al*. [28], and Sommer *et al*. [36], who reported a subjective total improvement in 71.5, 75, and 74% of their patients, respectively. This may be due to the variations in the subjective method used for patient evaluation in each study, wherein we used the IIEF-5 questionnaire, whereas no questionnaires were used by Van Kampen, who relied on interviewing the patients and asking them directly to evaluate whether there was any improvement in the rigidity or the duration of the erection, whereas Sommer and colleagues depended on the KEED questionnaire and Dorey used the erectile function domain of IIEF. Also, Dorey and Van Kampen included patients with ED of different etiologies, whereas we included only venogenic ED in our study.

Hence, variations in the results between different studies may be attributed to the difference in the number of patients, the type of ED, the rehabilitation program performed, and the evaluation method used in the assessment.

Objective methods for the evaluation of erectile function include cavernosometry, which is an invasive procedure [36]. Another objective method was described by Virag and Paul [43], who diagnosed and classified venous leakage using multidetector computed tomography cavernography, after contrast media intracavernous injection, but it is still an invasive method and carries the risk of intracavernous dye injection. Also, Penile color-Doppler ultrasonography was used by Chung *et al.* [44] to evaluate patients with Peyronie's disease and/or ED, and they concluded that penile color-Doppler ultrasonography continues to be a valuable clinical tool in the management of men with ED.

Hence, PPDU was used in our study as it is a valuable objective method in excluding arteriogenic ED and also in evaluating venogenic ED, and helps in its categorization according to the severity. PPDU revealed that 16.66 and 43.33% of our patients showed complete and partial improvement, respectively, with a total improvement of 60%. These results were better than those of Sommer *et al*. [36], who reported an objective improvement in 46% of the patients with venous leak after pelvic floor exercise. This may be due to the variation in the rehabilitation program used where they used pelvic floor exercises only, whereas our patients performed clinical electromyography biofeedback. In addition, the method of assessment was different as we used PPDU, whereas they used cavernosometry, which is an invasive procedure.

Two of our patients (6.6%) showed complete improvement by SAQ, whereas they showed partial improvement by PPDU; this may be due to the psychological satisfaction of patients by their improvement in comparison with their prerehabilitation condition. Also, one patient (3.3%) showed a partial response by SAQ, whereas showed no improvement by PPDU, and this may be due to the placebo effect of the rehabilitation program.

On using the anal hold pressure as a method for the evaluation of pelviperineal muscle strength, there was a marked increase in anal hold pressure values after rehabilitation (189.9 ± 67.9 hPa), compared with the values before rehabilitation (120.7 ± 53.1 hPa), indicating the improvement in pelviperineal muscles strength after the rehabilitation program.

In our study, there was a significant positive correlation ($P < 0.001$) between changes in EDV and the anal hold pressure before and after rehabilitation, indicating the strong positive relation between the increased strength of the pelviperineal muscles (indicated by an increased anal hold pressure) and the decreased penile venous return (indicated by the decreased EDV) after rehabilitation due to the role of the bulbospongiosus muscle and the ischiocavernosus muscle.

Improvement of the pelviperineal muscle strength and its correlation with erectile improvement is supported by the study of Prota *et al*. [45] and Sighinolfi *et al*. [46], who observed an association between potency and continence after biofeedback training in postprostatectomy patients.

In addition, there was a significant positive correlation ($P < 0.05$) between changes in EDV and that of IIEF-5 before and after rehabilitation, indicating the strong positive relation between decreased penile venous return (indicated by decreased EDV) after rehabilitation and the improved erectile function (indicated by increased IIEF-5) after rehabilitation, and this could be explained by the fact that in pure

venogenic ED, the more the EDV, the more severe the condition and vice versa.

Also, there was a significant positive correlation ($P < 0.05$) between changes in the anal hold pressure and changes in IIEF-5 values before and after rehabilitation, which indicate the strong positive correlation between the increased strength of the pelviperineal muscles (indicated by increased anal hold pressure values) after rehabilitation and the improved erectile function (indicated by increased IIEF-5 values) after rehabilitation, and this may be due to the important role of the bulbospongiosus muscle and the ischiocavernosus muscle in erection.

From our results, it can be concluded that visual pressure biofeedback strengthening of pelviperineal muscles is an effective, inexpensive, noninvasive, safe, and easily applicable method for the treatment of venogenic ED and it does not have as much side effects as medications. Also, our results highlight the importance of PPDU in the diagnosis, the categorization, and the assessment of improvement in patients with venogenic ED. In addition, the anal hold pressure is a valuable method for the assessment of the strength of pelviperineal muscles in patients with venous leak ED.

Acknowledgements

Conflicts of interests

There are no conflicts of interest.

References

1 Billups KL, Bank AJ, Padma-Nathan H, Katz SD, Williams RA. Erectile dysfunction as a harbinger for increased cardiometabolic risk. Int J Impot Res 2008; **20**:236–242.

2 Solomon H, Man JW, Jackson G. Erectile dysfunction and the cardiovascular patient: endothelial dysfunction is the common denominator. Heart 2003; **89**:251–253.

3 Meldrum DR, Gambone JC, Morris MA, Meldrum DA, Esposito K, Ignarro LJ. The link between erectile and cardiovascular health: the canary in the coal mine. Am J Cardiol 2011; **108**:599–606.

4 Bird IM. Endothelial nitric oxide synthase activation and nitric oxide function: new light through old windows. J Endocrinol 2011; **210**:239–241.

5 Giuliano F. Neurophysiology of erection and ejaculation. J Sex Med 2011; **8**:310–5.

6 Han WR, Chuang CY, Li PC, Chen KK, Young ST. Intracavernosal pressure characteristics analyzed by power spectral density for identifying the phase of penile erection. Int J Impot Res 2009; 21:336–42.

7 Dorey G. Pelvic floor exercises as a treatment for men with erectile dysfunction. Nurs Times 2004; **100**:65–67.

8 Caretta N, Foresta C. Clinical diagnostic approach to erectile dysfunction. Minerva Ginecol 2007; **59**:51–61.

9 Broderick GA, Lue TF. In: Walsh PC, Retik AB, Vaughan ED, Wein AJ, Kavoussi LR, Novick AC, Partin AW, Peters CA editors.. Evaluation and non surgical management of erectile dysfunction and priapism. Vol. 2, section 8, chapter 46. *Campbell's urology*. 8th ed.. Pennsylvania, USA: Saunders, an imprint of Elsevier; 2002. 1619–1671.

10 Burnett AL. Erectile dysfunction. J Urol 2006; **175**:S25–S31.

11 Saigal CS, Wessells H, Pace J, Schonlau M, Wilt TJUrologic Diseases in America Project. Predictors and prevalence of erectile dysfunction in a racially diverse population. Arch Intern Med 2006; **166**:207–212.

12 Kandeel FR, Koussa VK, Swerdloff RS. Male sexual function and its disorders: physiology, pathophysiology, clinical investigation, and treatment. Endocr Rev 2001; **22**:342–388.

13 Kloner RA. Erectile dysfunction and cardiovascular risk factors. Urol Clin North Am 2005; **32**:397–402.

14 Valles Antuña C, Fernández Gómez JM, Escaf S, Fernández-González F. Neurogenic etiology in patients with erectile dysfunction. Arch Esp Urol 2008; **61**:403–411.

15 Goyal A, Singh P, Ahuja A. Prevalence and severity of erectile dysfunction as assessed by IIEF-5 in North Indian type 2 diabetic males and its correlation with variables. J Clin Diagn Res 2013; **7**:2936–2938.

16 Mulhall JP, Damaser MS. Development of a mathematical model for the prediction of the area of venous leak. Int J Impot Res 2001; **13**:236–239.

17 Gareri P, Castagna A, Francomano D, Cerminara G, De Fazio P. Erectile dysfunction in the elderly: an old widespread issue with novel treatment perspectives. Int J Endocrinol 2014; **2014**:878670.

18 Stein MJ, Lin H, Wang R. New advances in erectile technology. Ther Adv Urol 2014; **6**:15–24.

19 Van Kampen M, De Weerdt W, Claes H, Feys H, De Maeyer M, Van Poppel H. Treatment of erectile dysfunction by perineal exercise, electromyographic biofeedback, and electrical stimulation. Phys Ther 2003; **83**:536–543.

20 Madeo B, Bettica P, Milleri S, Balestrieri A, Granata AR, Carani C, Rochira V. The effects of citalopram and fluoxetine on sexual behavior in healthy men: evidence of delayed ejaculation and unaffected sexual desire. A randomized, placebo-controlled, double-blind, double-dummy, parallel group study. J Sex Med 2008; **5**:2431–2441.

21 Yang C, Tang K, Wang B. Clinical value of serum 5-HT level in diagnosis and treatment of premature ejaculation. Urol Int 2013; **90**:214–218.

22 Elhanbly S, Elkholy A. Nocturnal penile erections: the role of RigiScan in the diagnosis of vascular erectile dysfunction. J Sex Med 2012; **9**: 3219–3226.

23 Amarenco G, Sheikh Ismaël S, Verollet D, Le Breton F, Lacroix P, Fahed M. Clinical and electrophysiological study of sensory penile alterations. A prospective study of 44 cases. Prog Urol 2013; **23**:946–950.

24 Hamdan FB, Al-Matubsi HY. Assessment of erectile dysfunction in diabetic patients. Int J Androl 2009; **32**:176–185.

25 Xia JD, Han YF, Zhou LH, Xu ZP, Chen Y, Dai YT. Sympathetic skin response in patients with primary premature ejaculation. Int J Impot Res 2014; **26**:31–34.

26 Valles-Antuña C, Fernandez-Gomez J, Escaf S, Fernandez-Gonzalez F. Sympathetic skin response in patients with erectile dysfunction. BJU Int 2009; **104**:1709–1712.

27 Rosen RC, Cappelleri JC, Smith MD, Lipsky J, Peña BM. Development and evaluation of an abridged, 5-item version of the International Index of Erectile Function (IIEF-5) as a diagnostic tool for erectile dysfunction. Int J Impot Res 1999; **11**:319–326.

28 Dorey G, Speakman M, Feneley R, Swinkels A, Dunn C, Ewings P. Randomised controlled trial of pelvic floor muscle exercises and manometric biofeedback for erectile dysfunction. Br J Gen Pract 2004; **54**:819–825.

29 Sun X, Wang R, Zhang L, Li D, Li Y. Efficacy of pelvic floor muscle training for the treatment of fecal incontinence after Soave procedure for Hirschsprung disease. Eur J Pediatr Surg 2012; **22**:300–304.

30 Golijanin D, Singer E, Davis R, Bhatt S, Seftel A, Dogra V. Doppler evaluation of erectile dysfunction – part 2. Int J Impot Res 2007; **19**:43–48.

31 Rubio-Aurioles E, Kim ED, Rosen RC, Porst H, Burns P, Zeigler H, Wong DG. Impact on erectile function and sexual quality of life of couples: a double-blind, randomized, placebo-controlled trial of tadalafil taken once daily. J Sex Med 2009; **6**:1314–1323.

32 Yang M, Ni X, Sontag A, Litman HJ, Rosen RC. Nonresponders, partial responders, and complete responders to PDE5 inhibitors therapy according to IIEF criteria: validation of an anchor-based treatment responder classification. J Sex Med 2013; **10**:3029–3037.

33 Gorgel SN, Gorgel A, Sefik E. Sexual function in male patients with metabolic syndrome and effective parameters on erectile dysfunction. Int Braz J Urol 2014; **40**:56–61.

34 Zhang K, Xu B, Liu D, Wang X, Zhu J, Deng C, et al. Sildenafil improves erectile hardness in Chinese men with erectile dysfunction: a real-life study analyzed on age stratification. Urology 2014; **83**:831–836.

35 MacDonagh RP, Porter T, Pontin D, Ewings P. The ED-EQoL: the development of a new quality of life measure for patients with erectile dysfunction. Qual Life Res 2004; **13**:361–368.

36 Sommer F, Axel R, Bondarenko B, Caspers H, Esders K, Bartsch G. A conservative treatment option of curing venous leakage in impotent men. Eur Urol Suppl 2002; **1**:153.

37 Hsiao W, Shrewsberry AB, Moses KA, Johnson TV, Cai AW, Stuhldreher P, *et al*. Exercise is associated with better erectile function in men under 40 as evaluated by the International Index of Erectile Function. J Sex Med 2012; **9**:524–530.

38 Hellstrom WJ, Montague DK, Moncada I, Carson C, Minhas S, Faria G, Krishnamurti S. Implants, mechanical devices, and vascular surgery for erectile dysfunction. J Sex Med 2010; 7:501–523.

39 Blute M, Hakimian P, Kashanian J, Shteynshluyger A, Lee M, Shabsigh R. Erectile dysfunction and testosterone deficiency. Front Horm Res 2009; **37**:108–122.

40 Jakubczyk T. Intracavernosal injections in the diagnosis and treatment of PDE-5 resistant erectile dysfunction. Cent European J Urol 2013; **66**:215–216.

41 Frank DL, Khorshid L, Kiffer JF, Moravec CS, McKee MG Biofeedback in medicine: who, when, why and how?. Ment Health Fam Med 2010; **7**:85–91.

42 Dorey G, Speakman MJ, Feneley RC, Swinkels A, Dunn CD. Pelvic floor exercises for erectile dysfunction. BJU Int 2005; **96**:595–597.

43 Virag R, Paul JF. New classification of anomalous venous drainage using caverno-computed tomography in men with erectile dysfunction. J Sex Med 2011; **8**:1439–1444.

44 Chung E, Yan H, De Young L, Brock GB. Penile Doppler sonographic and clinical characteristics in Peyronie's disease and/or erectile dysfunction: an analysis of 1500 men with male sexual dysfunction. BJU Int 2012; **110**:1201–1205.

45 Prota C, Gomes CM, Ribeiro LH, de Bessa J Jr, Nakano E, Dall'Oglio M, *et al*. Early postoperative pelvic-floor biofeedback improves erectile function in men undergoing radical prostatectomy: a prospective, randomized, controlled trial. Int J Impot Res 2012; **24**:174–178.

46 Sighinolfi MC, Rivalta M, Mofferdin A, Micali S, De Stefani S, Bianchi G. Potential effectiveness of pelvic floor rehabilitation treatment for postradical prostatectomy incontinence, climacturia, and erectile dysfunction: a case series. J Sex Med 2009; **6**:3496–3499.