DOI: *10.4081/aiua.2025.14069*

ORIGINAL PAPER

Nocturnal Penile Tumescencetest, revaluation of its utility after 1587 exams recorded from 1986 to 2024

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Summary ***Introduction: The Authors report their 38-year experience with the use of nocturnal penile tumescence (NPT) testing.***
Methods: Among over 46,000 patients evaluated for andrological issues since 1980, the NPT test was selectively proposed in cases of suspected psychogenic erectile dysfunction, as part of a standardized diagnostic workup, which included medical history, physical and genital examination, blood tests, and hormonal evaluation. The test aimed to assess nocturnal erectile function and support differential diagnosis.
Results: From June 20, 1986, to December 31, 2024, a total of 1,587 NPT recordings were performed in patients aged 16 to 90 years. Among these, 992 tests were conducted over three nights, 486 over two nights, and 109 for a single night. The majority of tests were completed without major issues and provided interpretable data. Overall, the test was well tolerated, with good patient compliance and minimal technical difficulties. In many cases, the recordings allowed useful diagnostic insights into the nature of erectile dysfunction. In nearly all cases, patients exhibited varying degrees of anxiety concerning their ED, often interpreted as a consequence rather than the cause of an underlying organic condition.
Conclusions: After nearly four decades of clinical use, NPT testing has proven to be a reliable and informative component of the diagnostic approach to erectile dysfunction. Its ability to offer objective data in a home setting, with minimal discomfort and high patient compliance, makes it a useful adjunct in distinguishing psychogenic from etiologies.

KEY WORDS: *NPT test; Erectile dysfunction; Nocturnal erections; RigiScan.*

Submitted 11 June 2025; Accepted 14 June 2025

INTRODUCTION

The *Nocturnal Penile Tumescence* (NPT) test, also known as RigiScan, a computerized instrument capable of monitoring the variations in penile circumference and consistency that occur in all men during the REM phases of sleep, has represented a great step forward in the diagnostic approach of *Erectile Dysfunction* (ED).
Karacan et al. (1-3) were the first to report that penile erections naturally occur 3 to 5 times during sleep, typically coinciding with the *rapid eye movement* (REM) phase. Since then, the assessment of nocturnal penile tumescence has become a valuable diagnostic tool in evaluating ED. This method was first implemented by *Karacan* in 1970 (4). Building on previous techniques, Timm et al and *Bradley et al.* (5-7) introduced the use of NPT test software to monitor nocturnal erections. Subsequently, *Levine* (8) developed a new approach in which the data were analysed and presented both graphically and numerically. NPT test consists of a small, computerized device, equipped with two small cables with loops capable of measuring the circumference of the penis and the degree of tumescence-rigidity obtained over a period of 10 hours (one night) for 3 nights (Figure 1).
The NPT test is user friendly, and can be comfortably used by patients, during the physiological periods of sleep, at home and in bed, without interfering with sleep and it is capable of effectively distinguishing whether nocturnal erections exhibit normal characteristics or are altered. In this way, the presence of an organic dysfunction within the erectile system can be identified and graphically differentiated from a condition primarily of psychogenic origin.
In men presenting with ED, it is essential to distinguish between a possible psycho-emotional or anxiety-related component that may inhibit adequate erections during sexual activity, and an underlying neurovascular impairment.
Penile erections during sleep are a physiological phenomenon observed in all males from childhood onward. These erections occur during a specific phase of sleep known as REM sleep, which is characterized by elevated blood levels of the neurotransmitter acetylcholine and a marked reduction in histamine, serotonin, and norepinephrine (9). This phase is also associated with distinctive physiological changes: heart rate and respiration slow down, muscle tone decreases, skin temperature drops, and brain waves become slower. During REM sleep, the penile arteries dilate, leading to increased blood flow, penile enlargement, tumescence, and often sufficient rigidity for penetration.
In practical terms, if the penis becomes and remains rigid for some minutes during sleep, it can be inferred that the vascular structures of the corpora cavernosa, including arteries and veins, are functioning properly in response to neurogenic stimuli originating from the brain (a normal physiological condition). Conversely, irregular REM sleep

cycles associated with inadequate erectile responses, such as insufficient rigidity, poor maintenance, or abnormal duration may indicate an underlying organic cause of ED. The NPT test is relatively simple to use. It is first initialized with the patient's data and then provided to the patient, who must follow specific instructions to ensure accurate results. These include abstaining from sexual activity on the days of recording, avoiding strenuous physical activity, refraining from the use of tranquilizers and phosphodiesterase-5 inhibitors, limiting the intake of caffeine, tea, and alcohol, urinating before going to bed, and maintaining typical daily habits without engaging in unusual physical or discretionary activities. The goal is to capture the patient's normal nocturnal physiological patterns.

Material and methods

Since 1980, our andrological center has evaluated over 46,000 male patients, aged 12 to 90 years, for a wide range of concerns, including urological disorders, infertility, ED, hypogonadism, pubertal development issues, testicular pain and preventive andrological check-ups. All patients underwent clinical examination by the same physician (DP), who consistently applied a standardized diagnostic approach. This included a thorough medical history, physical and genital examination, blood tests, and hormonal assessments. When indicated, further investigations such as X-rays, basal and duplex ultrasound, or MRI were performed. Among the various reasons for consultation, ED represented one of the most common and complex issues. In most cases, patients reported some degree of anxiety related to their ED, often perceived as consequence of an underlying organic condition. When a psychological or anxiety-related component was suspected, NPT testing was recommended to better characterize the nature of the dysfunction.

The Nocturnal Penile Tumescence test

Our first NPT test device (*RigiScan*) utilized since in 1986, is still in operation. Over the years, we have used one device for 28 years, two devices for 18 years, and three devices for the past 9 years (10-11). Maintenance is relatively straightforward: recalibration is recommended every 2-3 years, and the tension guides (*Base and Tip*) typically require replacement every 50-60 uses. The cover rings, although designed as disposable components, can be washed, sterilized, and reused for multiple nocturnal recordings. Multipurpose elastic bands are used to secure the device to the patient's thigh, allowing for freedom of movement during sleep (Figure 1). The NPT test is initialized with the patient's data using Windows-compatible software, which enables data from each night's recording to be downloaded and converted into numerical values and graphs that are easily interpretable by both physician and patient. Initially, the NPT test operated using the DOS 3.2 system, with data stored on floppy disks (Figure 2). Later, the system was upgraded to a Windows-based platform, which significantly improved data management and usability. In addition to monitoring nocturnal erections, the NPT test can be employed to assess erectile responses during diagnostic procedures such as the *Audio-Visual Sexual Stimulation Test* (AVSST) or following intracavernosal drug injections, helping to clarify the nature of the erectile response to various stimuli (12-18) (Figure 3). Whenever possible, we prefer to deliver the NPT test to the patient in person, providing detailed instructions and troubleshooting guidance for

Figure 1.
The Nocturnal Penile Tumescence Test Device.

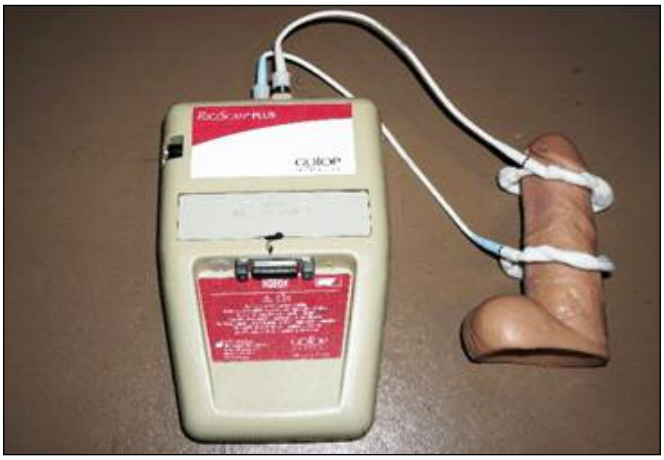
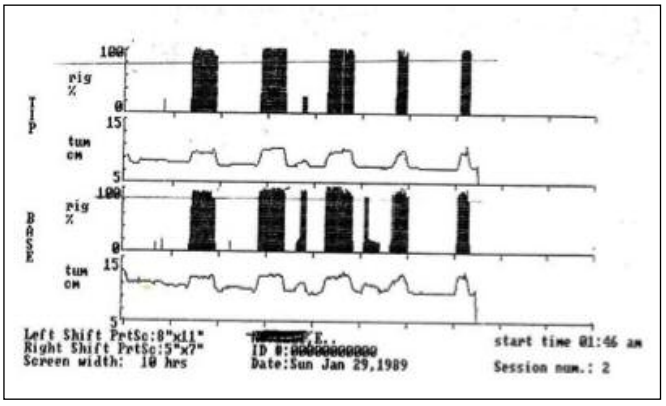


Figure 2.
Examples of original NPT test software boot and data diskettes from the Dacomed Corporation, dating back to the system's introduction in 1986.

Figure 3.
Nocturnal NPT test recording. The pattern shows preserved erectile episodes with both tip and base rigidity exceeding 60% and tumescence exceeding 3 cm, consistent with normal erectile physiology.



common issues that may arise during the recordings (e.g., replacing cover rings, delayed activation, or battery problems). Alternatively, the device can be shipped to the patient's home, pre-initialized with their data, along with instructions to view an instructional YouTube Video. After completing three nights of recording, the patient returns the device either in person or via courier which typically ensures return within 1-2 days. The results, including graphs, numerical data, and interpretation, are processed the day after return and sent to the patient and their referring physician via email (Figures 4-7).

Figure 4.
Audio Visual Sexual Stimulation Test (AVSST). Representative recordings from 1998 demonstrating poor erectile response (A, B), partial rigidity without full tumescence (C), and complete erectile cycles (D, E) as recorded by early NPT test software. Screen width: 1 hour.

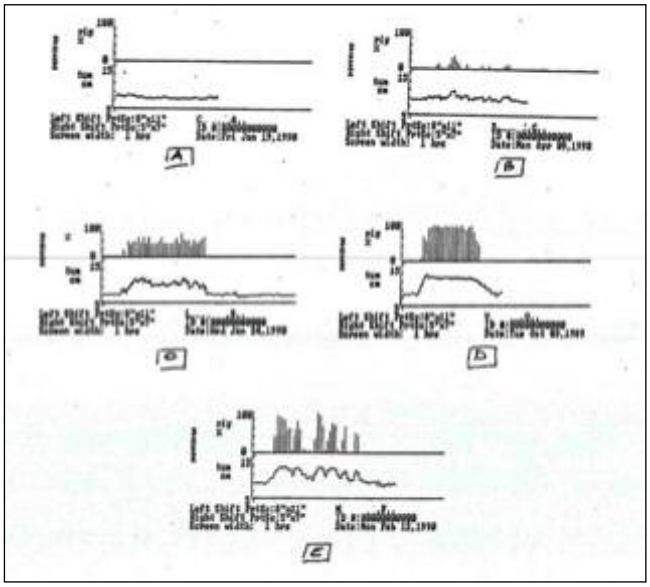


Figure 5.
Nocturnal penile tumescence and rigidity tracing form. The trace shows multiple erectile events with sustained rigidity and tumescence, indicating preserved neurovascular function.

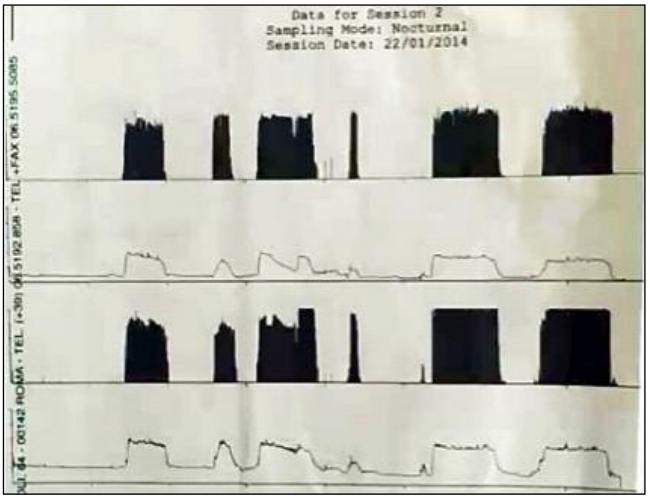


Figure 6.
Example of a modern Nocturnal Penile Tumescence test PLUS recording (2020), showing nocturnal erectile activity. The graphs display tip rigidity (%), tip tumescence (cm), base rigidity (%), and base tumescence (cm) over a 10-hour recording window.

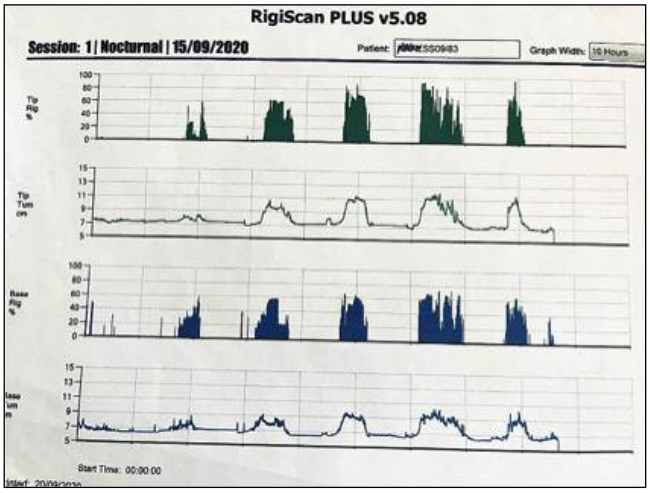
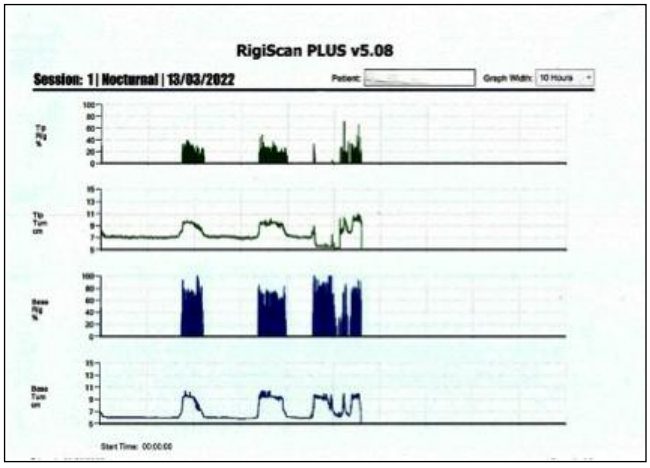


Figure 7.
Recent NPT PLUS output illustrating three distinct erectile events with sufficient rigidity and tumescence, interpreted as physiologically normal responses.



Real time NPT test monitoring with AVSST

Real-Time NPT test monitoring can be performed along with an AVSST in a private setting (14-16). During the procedure, patients wear headphones that deliver audio from a sequence of erotic audiovisual stimuli while the NPT test device is active. A baseline penile duplex ultrasound is performed prior to stimulation. The stimulation protocol consists of six explicit erotic contents of increasing intensity (each lasting 3 minutes), interspersed with 30-second neutral segments (nature or landscape scenes), for a total of 12 clips (24 minutes). In openly homosexual patients, same-sex content is provided. Following the audiovisual stimulation, penile Doppler ultrasound is repeated, both immediately after the test and after intracavernosal administration of PGE1, to evaluate the vascular response of cavernous vessels, in a setting that stimulates physiological conditions. This approach may help identification of arte-

riogenic erectile dysfunction in patients with borderline or inconclusive RigiScan results, or in those who do not respond adequately to standard NPT monitoring.

Use of NPT

Before the recording night, two 9-volt batteries must be inserted into the device. Fabric bands are attached to secure the instrument to the inner thigh. The measuring rings are gently expanded and positioned around the base of the penis (Base ring) and just below the glans (Tip ring). Once the device is activated using the side button, the rings automatically adjust to their correct positions. Importantly, even if one of the rings shifts or opens during the night, the recording is still considered valid. In the morning, the patient presses the side button to stop the recording and removes the rings. The used batteries should be discarded, and new ones inserted before the next session. The same rings and bands can be reused for subsequent nights.

Special problems

During the night, the patient may need to get up to urinate, defecate, drink, or answer the phone. These actions can be performed while the NPT test remains securely attached to the thigh, without interrupting the recording. Alternatively, the patient may pause the recording by pressing the side button, gently remove the rings and release the bands to leave the bed and then reapply the device. It is important that the NPT test, rings, and bands are correctly repositioned, and the recording restarted within 15 minutes to ensure data validity. In some cases, a ring may come undone. If this occurs, the patient is instructed on how to reconnect it using a silicone guide that allows the metal cable to be reinserted into the cover ring, thus enabling the continuation of the recording. The NPT test can be used for up to three nights, which do not need to be consecutive. After completing the recordings, the device, along with the rings and bands, should be returned to the Studio, either by the patient or another person, or shipped via courier (e.g., DHL or UPS) with delivery expected within 2-3 days. Once the device is returned, the data are downloaded, and graphs, numerical recordings, and a final report are generated. These can be provided directly to the patient or sent to the referring physician via email.

Results

Between June 20, 1986, and December 31, 2024, we performed a total of 1,587 NPT test recordings in patients aged 16 to 90 years (Tables 1, 2).

Of these, 992 were conducted over three nights, 486 over two nights, and 109 for a single night only. In the initial phase of our experience, local patients were asked to return after the first night of recording to allow early evaluation of the erectile activity recorded. If enough adequate erections were observed, further testing on subsequent nights was deemed unnecessary. However, to ensure diagnostic reliability, the NPT test was repeated in 78 cases: 52 patients underwent a second night of recording, and 26 proceeded to a third night. In 123 cases, we encountered complications during nocturnal recordings. Among these, 32 patients reported being unable to sleep with the device applied to the penis. In 36 cases, the tip ring, and in 42 cases, the base ring, detached during the night, and the patients were unable to reconnect them. Additionally, 46 recordings were repeated due to irregularities in the output graphs, while in 29 cases, the discomfort caused by the rings led to premature interruption of the recording (Table 3).

Sleep duration was assessed in a subgroup of 200 patients. On average, sleep lasted:

- 5 hours and 32 minutes during the first night (range: 45 minutes to 10 hours);
- 5 hours and 45 minutes during the second night (range: 137 minutes to 10 hours);
- 6 hours and 45 minutes during the third night (range: 224 minutes to 10 hours).

The mean sleep duration across all nights was 6 hours and 25 minutes.

Patients generally slept longer on the third night, likely due to increased adaptation to the device. Erections were considered "*valid for penetration*" when rigidity exceeded 80% and was sustained for more than 5 minutes. The number of erectile episodes recorded per night ranged from 1 to 9, regardless of their intensity.

Valid erections (> 80% rigidity) were observed in 23% of the patients.

All patients evaluated in our outpatient clinic completed vascular investigations to determine the aetiology of their

Table 1.
Distribution of NPT test recordings performed since 1986, categorized by number of recording nights.

Number of nights	N. of patients
3	992
2	486
1	109

Table 2.
Number of NPT test recording nights and corresponding number of patients, grouped by period (1986–2024).

Period	Number of nights	N. of patients
1986-1999	612	247
2000-2009	934	467
2010-2019	1498	548
2020-2024	852	325
1986-2024	3896	1587

Table 3.
Age range of patients who performed NPT test since 1986.

Age (years)	N. of patients
< 20	92
21-40	615
41-60	436
61-90	444

ED. An additional 350 patients were referred by other specialists and underwent diagnostic workups externally; therefore, final diagnoses for these individuals are not available.
In 48 cases, NPT test was repeated after a course of therapy to assess treatment efficacy.
A subset of 176 patients underwent Real-Time NPT test Monitoring, performing a AVSST in a private room (14-16).
Based on the erectile response obtained during the test, we categorized patients into five groups (Figure 3):

A. Absent response
   a) the patient reported discomfort with the stimuli or didn't enjoy porn
   b) the patient engaged with the content but showed no response due to severe vasculopathy
B. Mild response with confirmed vascular impairment
C. Mild response with good arterial inflow but insufficient rigidity
D. Consistent and lasting erectile response during stimulation.
   indicating normal vascular function
E. Initial erectile response during erotic videos followed by detumescence during neutral segments, suggestive of *Corporal Veno Occlusive Dysfunction* (CVOD).

Discussion

In many cases, the RigiScan can differentiate ED primarily caused by organic factors from that arising due to psycho-emotional components. While the device cannot replace the role of a psychologist (16), it offers unique advantages: it can be performed at home, during sleep, in complete privacy, and without interfering with daily activities or requiring the involvement of others. The resulting data, presented as easily interpretable graphs, allow the patient to understand potential alterations in erectile function, even without medical or psychological expertise. Moreover, the cost of a NPT test assessment is significantly lower than that of multiple psychodiagnostics sessions, making it a cost-effective option in the initial diagnostic workup. Patients often seek specialist consultation for ED in clinical contexts where no overt psychological factors, such as emotional distress, uncertainty, or performance anxiety, are initially apparent. In these cases, organic causes are presumed to be predominant or exclusive (17, 18). However, some patients do exhibit psychological comorbidities, including anxiety, depression, or even manic features, making it difficult to determine whether these are the cause or the consequence of ED. When psycho-emotional factors are clearly present, a psychological assessment is advisable.
Psychological counselling and psychotherapy can be often difficult to access in everyday clinical practice. Patients may struggle to find a trusted therapist, to attend sessions regularly around work and personal obligations, and may face the additional burden of cost, especially when only private care is available.
Furthermore, the duration of psychological assessment and treatment can be lengthy, and the final reports sent to the referring andrologist are often not easily understood by patients, particularly those without a medical background. Based on our long-standing experience, we believe that collaboration between the andrologist and psychologist is essential in both diagnostic and therapeutic phases. However, it is not uncommon for patients to abandon the psychological path if they perceive slow or unclear progress, especially after having waited a considerable time before seeking medical help. Many patients expect a clear diagnosis and a concrete therapeutic plan in a short time frame.

Conclusions

In the diagnostic workup of ED, some tests offer more diagnostic value than others. A comprehensive assessment, including physical, metabolic, and hormonal evaluation, is essential to define an accurate diagnosis and initiate appropriate treatment. Within this framework, NPT testing has confirmed to be a particularly useful tool. It is typically proposed by the andrologist after the initial clinical assessment and is often well accepted even by the patient's partner, who tends to appreciate the patient's proactive engagement in addressing the issue. In our experience, partner refusal to the examination is rare, except in a few cases where the patient had not engaged in sexual activity within the relationship for an extended period and was experiencing ED only in extramarital encounters unknown to the partner. Even in such situations, many men have justified undergoing testing as a step toward restoring intimacy within the relationship, often citing fatigue, relational difficulties, or long-standing ED as contributing factors to the sexual distance.

Declarations

Ethical approval: *This study is a retrospective collection of case reports from our clinical practice. All procedures were performed in accordance with the ethical standards of the Declaration of Helsinki. Informed consent for the procedure and for the use of anonymized data for publication was obtained from each patient prior to testing.*

Availability of data and material: *The datasets generated and analyzed during the current study are not publicly available due to the inclusion of sensitive patient information and privacy regulations.*

Competing interests: *The authors declare that they have no competing interests.*

Funding: *This research received no external funding.*

Authors' contributions: *Diego Pozza: conceptualization and design of the study, clinical evaluation and management of all patients, interpretation of NPT results, and final approval of the manuscript; Andrea Marcantonio and Gabriele Savarese: data collection; Mariangela Pozza: statistical analysis; Carlotta Pozza: study supervision, critical revision of the manuscript, and contribution to data interpretation and discussion. All authors have read and approved the final version of the manuscript.*

Acknowledgments: *The authors would like to thank all patients who participated in the diagnostic process and acknowledge the support of the entire clinical team in data management over the years.*

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