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ORIGINAL ARTICLE

Erectile Dysfunction

Consecutive nightly measurements are needed for accurate evaluation of nocturnal erectile capacity when the first-night laboratory recording is abnormal

Zi-Jun Zou*, Shi-Tao Chen*, Gong-Chao Ma, Yu-Fen Lai, Xiao-Jian Yang, Jia-Rong Feng, Zhi-Jun Zang, Tao Qi, Bo Wang, Lei Ye, Yan Zhang

Multiple measurements of nocturnal penile tumescence and rigidity (NPTR) are widely accepted as a method to differentiate psychogenic erectile dysfunction (ED) from organic ED. However, direct evidence remains limited regarding the first-night effect on NPTR measurement using the RigiScan. Here, we evaluated the first-night effect on the results of NPTR measurement to validate the necessity of NPTR measurement for two consecutive nights, particularly when abnormal first-night measurements are recorded in a laboratory setting. We retrospectively reviewed 105 patients with a complaint of ED, who underwent NPTR measurement using the RigiScan in the Department of Infertility and Sexual Medicine, the Third Affiliated Hospital of Sun Yat-sen University (Guangzhou, China), for two consecutive nights, during the period from November 2015 to May 2016. NPTR parameters were collected and analyzed. We found that more effective nocturnal erections were detected during the second night than during the first night ($P < 0.001$). Twenty percent of all patients had no effective erection during the first night, but exhibited at least one effective erection during the second night. The negative predictive value of NPTR measurement during the first night was 43.2%; this was significantly lower than that on the second night (84.2%; $P = 0.003$). Most NPTR parameters were better on the second night than on the first night. The first-night effect might be greater among patients younger than 40 years of age. In conclusion, two consecutive nightly measurements of NPTR can avoid a false-abnormal result caused by the first-night effect; moreover, these measurements more accurately reflect erectile capacity, especially when the first-night record is abnormal in a laboratory setting.
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INTRODUCTION

Nocturnal penile tumescence (NPT) is a normal physiological phenomenon that occurs spontaneously 3–5 times per night during nighttime sleep in healthy males 3–79 years of age.[1] Ohlmeyer *et al.*[2] first recorded the phenomenon in the scientific literature in 1944. In 1977, Karacan and colleagues first recognized the diagnostic value of NPT assessment in distinguishing among etiologies of erectile dysfunction (ED).[3] Differentiation of psychogenic ED from organic ED was performed based on the presumption that normal NPT verified the integrity of local penile tissues, as well as neural and vascular pathways used for sexually stimulated erections in the absence of anxiety, stress, and apprehension during sleep.[4] In 1985, the RigiScan prototype for continuously recording nocturnal penile tumescence and rigidity (NPTR) was introduced.[5] Currently, this device records data at the tip and base of the penis regarding the number of erectile events, increments of penile tumescence and rigidity, erectile duration, tumescence activated units (TAUs), and rigidity activated units (RAUs). A widely accepted criterion for a normal nocturnal erection is an erectile event with penile tip rigidity ≥60% and duration of at least 10 min.[6,7] Although the role of NPTR monitoring by the RigiScan in differentiating psychogenic ED from organic ED has been questioned in recent years,[8] it remains a valuable diagnostic method for this purpose[9] and is recommended by both the EAU[7] and AUA guidelines[10] in 2018.

NPT is closely associated with rapid eye movement (REM) sleep;[8,11,12] therefore, the accuracy of NPTR monitoring by the RigiScan is affected by the quality of sleep. When a patient is measured for the first time in a laboratory setting, discomfort and movement restriction caused by gauges and cables, as well as potential psychological effects of medical scrutiny and changes in the sleep environment, likely contribute to reductions in sleep time and efficiency, decreases in slow-wave sleep and REM sleep, and increases in intermittent wake times and REM latency.[13,14] These phenomena are collectively known as the first-night effect. To avoid misdiagnosis caused by this effect, measurements are recommended during at least two separate nights.[7,10] Although this principle is widely accepted, there have been remarkably few studies regarding the influence of the first-night effect on NPTR monitoring results when using the RigiScan device in a laboratory setting. Therefore, we performed a retrospective review of data collected in our clinic, to evaluate the first-night effects and to validate

Department of Infertility and Sexual Medicine, The Third Affiliated Hospital, Sun Yat-sen University, Guangzhou 510630, China.
*These authors contributed equally to this work.
Correspondence: Dr. Y Zhang (zhangyan_sys3h@21cn.com)
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the reliability and necessity of obtaining NPTR data from consecutive nights of monitoring in a laboratory setting.

MATERIALS AND METHODS

Patients selection

Patients who were referred to the Department of Infertility and Sexual Medicine, the Third Affiliated Hospital of Sun Yat-sen University (Guangzhou, China), for the evaluation and treatment of ED from November 2015 to May 2016 were enrolled in this study. Two consecutive nightly measurements of NPTR were routinely performed during the study period. We excluded patients who had abnormal results for hormonal tests (*e.g.*, testosterone deficiency and hyperprolactinemia), a medication history of phosphodiesterase-5 inhibitors (PDE5I), pelvic surgery and radiotherapy, pelvic trauma, neurological diseases, and/or severe psychogenic disorders. We retrospectively reviewed the NPTR monitoring records of all enrolled patients. This study was approved by the institutional review board of our hospital. Informed consent was obtained from all patients before treatment.

NPTR measurements

All patients underwent NPTR measurement from 10 p.m. to 7 a.m. for two consecutive nights in the sleep unit of our clinic. Patients were prohibited from any activities that could interfere with sleep, including smoking, as well as intake of tea, caffeine, alcohol, and hypnotics. The RigiScan plus device (GOTOP Medical, Inc., St. Paul, MN, USA) was used. The device was strapped to the patient's thigh. Two self-calibrating loops were attached to the penis, with one loop at the tip and the other at the base. Data collected included the number of effective erectile events (EEEs), total erection time (TET), RAUs, TAUs, average event rigidity (AER), and the duration of erectile episodes with rigidity ≥60% (D60%) and maximal tumescence (MT) at both sites. RAUs and TAUs represent the products of time spent at a given rigidity or tumescence level, respectively.[15] In accordance with the EAU guidelines regarding male sexual dysfunction, an effective erectile event was defined as an erectile episode with penile tip rigidity ≥60% and a duration of no less than 10 min.[6] Moreover, a patient was considered to have normal erectile function when at least one effective erectile event was recorded in two consecutive nights of measurements. If a patient exhibited mechanical problems or sleep disorder, or if monitoring time was <6 h, the patient was retested and excluded from the study.

Statistical analysis

The data of all included patients were initially analyzed as a single group. Next, patients were divided into three groups for further analysis: Group A included patients with effective nocturnal erections recorded during both nights; Group B included patients with at least one effective nocturnal erection on the second night, but not on the first night; Group C included patients without any effective nocturnal erections during either night. We compared all NPTR parameters between first- and second-night measurements among the patient groups. Then, the entire patient cohort and the patients in Group A were stratified by age. Parameters of two consecutive nights were compared among patients of different ages. Data were expressed as mean ± standard deviation (s.d.). For comparisons, paired-sample *t*-test or Wilcoxon signed-rank test was used as appropriate on the basis of sample normality, as determined by the Kolmogorov–Smirnov test. The negative predictive value (NPV) of NPTR measurement was calculated, and the differences between NPV of the first and second nights were compared using the Chi-squared test. All NPTR parameters were compared with each other among age-stratified subgroups using one-way ANOVA. $P < 0.05$ was considered statistically significant. All statistical analyses were conducted using IBM SPSS software version 19 (SPSS, Inc., Chicago, IL, USA).

RESULTS

Patient characteristics

A total of 105 patients were included in this study; the mean age of the patients was 32.0 ± 8.1 years. Twenty-one (20.0%) patients showed no spontaneous effective erections during the first night, but exhibited at least one effective erection during the second night. Sixty-five patients had at least one effective nocturnal erection on both nights. Sixteen patients did not exhibit any effective erections during either night of monitoring. The remaining three patients had effective nocturnal erections detected during the first night, but no spontaneous effective erection on the following night. There were no statistically significant differences in age and test time among these groups ($P > 0.05$ for all). The test time of the first and second nights were also not significantly different in all groups ($P > 0.05$ for all). Details are shown in **Table 1**.

NPV of NPTR measurements using the RigiScan

The NPV of NPTR measurements using the RigiScan on the first night was 43.2% (16/37); this was significantly lower than the NPV of 84.2% (16/19) on the second night ($P = 0.003$). These data are shown in **Table 2**.

Number of effective nocturnal erectile events

The mean number of EEEs in all patients was 1.4 ± 1.4 on the first night; this was significantly less than that recorded on the second night (2.1 ± 1.5; $P < 0.001$). In Group A, a significantly greater number of EEEs was recorded on the second night than on the first night (2.6 ± 1.3 *vs* 2.2 ± 1.1; $P = 0.013$). In Group B, patients who did not exhibit an EEE during the first-night measurement had approximately 2.4 ± 1.0 EEEs during the second-night measurement (median: 2.0 EEEs; $Z = -4.06$; $P < 0.001$). No EEEs were detected during two consecutive nights of measurement in Group C.

Other NPTR parameters

Among all patients, in addition to the number of EEEs, all other parameters were also better on the second night than those on the first night; TET, number of RAUs, and D60% at both sites, number of tip TAUs, and base MT were significantly different between the two nights ($P < 0.05$ for all). In Group A, all parameters except tip MT were better on the second night than those on the first night; number of tip RAUs and D60% at both sites were significantly different between the

Table 1: Characteristics of patients with different nocturnal penile tumescence and rigidity records monitored by RigiScan for two consecutive nights

	Total	*1st-night erection*	*2nd-night erection*	*Both-night erection*	*No erection*	*P*
Patients, *n* (%)	105	3 (2.9)	21 (20.0)	65 (61.9)	16 (15.2)	NA
Age (year), mean±s.d.	32.0±8.1	27.7±4.0	30.5±7.3	32.5±8.9	32.8±6.6	NS
Test time of the 1st night (h), mean±s.d.	9.0±0.5	8.9±0.0	8.8±0.9	9.1±0.3	8.9±0.7	NS
Test time of the 2nd night (h)*, mean±s.d.	9.1±0.6	9.2±0.1	9.2±0.5	9.1±0.7	9.0±0.4	NS

*No significant difference in test time between the first and second night. NA: not applicable; NS: no significance; s.d.: standard deviation

two nights ($P < 0.05$ for all). In Group B, all parameters except base MT were significantly better on the second night than on the first night ($P < 0.05$ for all). In Group C, patients did not have a normal NPT on either of the two consecutive nights, indicating that they likely exhibited organic ED. For these patients, all parameters except tip and base AER were also numerically better on the second night than those on the first night; TET and tip MT were significantly different between the two nights ($P = 0.001$ and $P = 0.048$, respectively). Detailed data are shown in **Table 3**.

Impact of age

Because of limited sample size, we performed stratified analysis solely in the entire patient cohort and among patients in Group A, to assess the effect of age on NPTR parameters. Number of EEEs, TET, number of tip RAUs, and tip AER were all better on the second night than those on the first night in all age groups. Differences in TET, as well as numbers of EEEs and tip RAUs, were significantly different between the two nights in patients <40 years of age ($P < 0.05$ for all), but not in patients more than 40 years of age. Numbers of base RAUs and tip TAUs, as well as D60% at both sites in patients <40 years of age, were significantly better on the second night than those on the first night ($P < 0.05$ for all); however, variations in these parameters were not consistent in patients more than 40 years of age. Variation in number of base TAUs with age was similar to that observed in number of tip TAUs. Tip and base MT did not show consistent variation between the two nights among different age groups. Similar tendencies for changes in NPTR parameters with age between the two nights were observed in Group A. Detailed data are shown in **Table 4** and **5**.

DISCUSSION

Our study, with a larger sample than prior studies,[16,17] directly demonstrated that the results of NPTR measurement, using the RigiScan device in a laboratory setting, were negatively impacted by the first-night effect. In comparison with single-night monitoring, NPTR monitoring for at least two consecutive nights provided physicians with more reliable data for differentiating among etiologies of ED, especially when NPTR monitoring in a laboratory setting showed abnormal results on the first night. Our results also indicated that the first-night effect might be greater in patients younger than 40 years of age.

A nocturnal erectile event of at least 60% rigidity recorded on the tip of the penis, which lasts for more than 10 min, is the most widely accepted criterion for a functional erectile mechanism.[7] According to this criterion, a significant reduction in effective NPT was recorded on the first night of measurement, compared with the second night of measurement, in our study. Among patients who had no normal NPT on the first night, 56.8% had at least one normal NPT on the second night of measurement. This indicates that abnormal outcomes on the first night of NPTR monitoring should be cautiously interpreted.

A recent study compared NPTR parameters of the first and second nights within groups of patients who had normal or abnormal erections.[16] Contrary to our results, the prior study showed that multiple parameters (*e.g.*, the number of effective erections, erection time, tip and base rigidity, and maximal tip and base tumescence) were significantly better on the first night than those on the second night in both groups; moreover, patients without normal erections during the first night also all failed to exhibit normal erections during the second night. However, that study used a longer total test time of the first-night measurement, compared with that of the second-night measurement ($P < 0.002$).[16] The use of extended test time on the first night may have impacted the detection of the first-night effect. In a separate study, Hirshkowitz and colleagues showed that the number of NPT episodes at the coronal sulcus, as well as the tumescence time and increase in size, when detected by other testing devices (*i.e.*, NPT monitors from either American Medical Systems or Texas Medical Electronics), were numerically better on the second night than those on the first night; however, the statistical significance of those findings was ambiguous.[18] The positive change between the first and second night was speculated to be associated with increased REM time during the second night, relative to that experienced during the first night.[18,19] These outcomes supported our conclusion.

For patients with organic ED, the impairment of local penile tissues, vessels, and nerves can negatively affect the quality of nocturnal erection. Severe organic impairment can indeed result in loss of nocturnal erection. Currently, no EEEs on at least two separate nights of examination is considered to indicate an organic etiology.[7,10,15]

Table 2: Negative predictive value of nocturnal penile tumescence and rigidity monitoring by RigiScan on the first and second nights

Time	*NPV, n (%)*	*P*
The 1st night	16/37 (43.2)	0.003
The 2nd night	16/19 (84.2)	

NPV: negative predictive value

Table 3: Comparison of nocturnal penile tumescence and rigidity parameters of the first and second nights in all included patients and in patients with both-night erection (Group A), second-night erection (Group B), and no erection (Group C)

	EEEs (n)	*TET (h)*	*Tip RAUs*	*Base RAUs*	*Tip TAUs*	*Base TAUs*	*Tip AER*	*Base AER*	*Tip D60%*	*Base D60%*	*Tip MT*	*Base MT*
All patients												
N1	1.4±1.4	1.2±1.1	35.8±28.2	42.8±32.6	23.1±24.4	27.4±27.2	49.3±25.8	56.6±25.1	36.3±33.6	47.5±39.0	8.0±1.2	7.8±1.2
N2	2.1±1.5*	1.7±1.0*	52.3±29.2*	57.9±33.7*	30.6±21.9*	32.8±23.8	55.6±21.0	60.9±21.2	51.8±34.1*	63.0±41.1*	8.2±1.0	8.1±1.1*
Group A												
N1	2.2±1.1	1.6±1.1	49.2±25.0	55.7±29.8	30.1±25.5	34.0±26.7	59.9±17.0	64.8±16.6	53.2±31.3	63.3±36.8	8.2±0.9	7.9±1.1
N2	2.6±1.3*	1.7±1.0	63.3±26.0*	63.3±26.0	36.8±23.0	40.3±25.1	60.9±16.3	66.4±16.2	64.7±31.1*	78.8±39.2*	8.1±0.9	8.0±1.0
Group B												
N1	0	0.7±0.7	13.9±17.8	23.1±25.5	14.0±21.5	21.2±30.7	33.7±31.6	45.7±32.0	7.9±8.7	22.8±26.1	7.5±1.4	7.9±1.4
N2	2.4±1.0*	1.7±0.8*	52.3±17.1*	52.7±20.6*	31.5±11.8*	29.5±12.0*	63.4±14.0*	65.4±13.0*	51.6±22.3*	55.8±23.9*	8.5±1.2*	8.4±1.3
Group C												
N1	0	0.4±0.7	8.2±10.4	12.9±19.3	5.9±8.2	7.8±12.2	26.8±26.4	35.8±29.7	4.8±6.5	11.3±14.4	7.2±1.4	7.1±1.6
N2	0	1.4±1.0*	10.0±12.6	13.4±16.5	6.1±7.8	8.0±9.8	25.3±21.2	32.9±27.8	5.8±6.6	12.4±15.1	8.1±1.0*	8.0±1.2

Data are expressed as mean±s.d. *$P<0.05$ when measurement on the second night was compared with that on the first night. AER: average event rigidity; D60%: duration of erectile episodes with rigidity ≥60%; EEEs: effective erectile events; MT: maximal tumescence; N1: the first night; N2: the second night; RAUs: rigidity activated units; TAUs: tumescence activated units; TET: total erection time; s.d.: standard deviation

Table 4: Comparison of nocturnal penile tumescence and rigidity parameters of the first and second nights when all patients were stratified by age

Parameters	*18-29 years*	*30-39 years*	*40-49 years*	*50-60 years*
Patients (*n*)	46	40	15	4
EEEs (*n*)				
N1	1.3±1.4	1.4±1.4	1.5±1.5	2.0±2.2
N2	2.2±1.3*	2.1±1.8*	1.7±1.3	2.2±0.5
TET (h)				
N1	1.4±1.2	1.1±0.8	1.2±1.3	1.0±1.0
N2	1.8±0.7*	1.4±0.9*	1.9±1.5	1.9±0.7
Tip RAUs				
N1	36.9±29.7	33.2±23.4	38.1±33.3	39.3±43.7
N2	58.7±25.7*	50.4±33.3*	39.7±24.8	44.0±28.3
Base RAUs				
N1	43.9±33.7	41.3±29.6	42.2±37.4	46.8±44.1
N2	64.9±32.7*	55.3±36.0*	46.3±30.6	45.8±23.1
Tip TAUs				
N1	22.9±21.5	20.3±15.5	31.1±45.2	23.0±25.4
N2	35.6±21.2*	29.7±25.0*	20.7±12.4	21.0±10.0
Base TAUs				
N1	30.6±33.4	24.1±18.7	27.9±28.5	22.8±18.8
N2	37.7±23.6	31.5±26.4	24.3±15.9	23.0±11.6
Tip AER (%)				
N1	46.0±26.6	53.1±22.3	50.3±31.4	44.8±31.1
N2	55.6±21.2*	55.5±20.3	51.9±22.4	72.0±19.2
Base AER (%)				
N1	52.6±24.6	61.0±19.0	56.9±36.0	58.5±39.1
N2	60.1±21.5*	60.8±20.0	59.0±25.5	77.5±11.0
Tip D60% (min)				
N1	34.3±32.2	33.5±27.0	47.1±46. 3	46.2±56.5
N2	56.0±30.0*	50.7±39.7*	43.5±31.8	45.6±28.6
Base D60% (min)				
N1	47.6±39.5	45.4±33.3	50.8±50.2	55.4±54.3
N2	71.5±39.2*	58.1±42.2*	53.0±44.9	51.5±27.4
Tip MT (cm)				
N1	8.0±1.2	7.9±1.2	7.8±1.2	8.4±1.1
N2	8.5±1.0*	7.8±0.9	8.4±0.9	8.3±1.1
Base MT (cm)				
N1	7.8±1.3	7.8±1.1	7.6±1.4	8.0±1.5
N2	8.4±1.2	7.7±1.0	8.3±0.7	8.4±0.8

Data are expressed as mean±standard deviation. *P<0.05, when measurement on the second night was compared with that on the first night. AER: average event rigidity; D60%: duration of erectile episodes with rigidity ≥60%; EEEs: effective erectile events; MT: maximal tumescence; N1: the first night; N2: the second night; RAUs: rigidity activated units; TAUs: tumescence activated units; TET: total erection time; s.d.: standard deviation

Among patients with no EEEs on both nights in our study, the first-night effect on impaired measurement of NPTR parameters was not significant, except for TET and tip MT. This indicated that extent of the negative impact of the first-night effect on NPTR parameters was likely limited because these parameters were already impaired by organic diseases. Thus, the first-night effect may be greater in patients with nonorganic ED.

Because the first-night effect can negatively affect NPTR parameters, and may lead to false abnormal outcomes, consecutive nightly NPTR monitoring is considered necessary, particularly when first-night measurements are abnormal. Hatzichristou *et al.*[17] demonstrated that the accuracy of at least two consecutive nightly measurements reached 100%. Greenstein *et al.*[16] suggested that consecutive nightly assessments should be reserved for patients whose recorded data during the first night did not fulfill the criteria for normal erection; however, no patients had false-abnormal results during the first night in their study. In our study, the NPV of first-night NPTR monitoring was 43.2%; this increased to 84.2% on the second night of measurement. Consecutive nightly NPTR measurements can thus significantly reduce false-abnormal results of first-night measurements, thereby avoiding misdiagnosis.

Some studies have shown that the quality of NPT is associated with age. In a study of 353 patients with normal NPTR parameters, Yaman and colleagues showed that, after 50 years of age, increased age negatively influenced the quality of nocturnal erections.[20] Some older studies consistently showed that subjects <40–50 years of age had greater total tumescence time and an increased number of erectile episodes, compared with older subjects.[21–24] In our study, NPTR parameters did not significantly differ among age groups for patients <50 years of age. Because only four patients were more than 50 years

Table 5: Comparison of nocturnal penile tumescence and rigidity parameters of the first and second nights when patients in Group A (both-night erections) were stratified by age

Parameters	*Years*			
	18-29	*30-39*	*40-49*	*50-60*
Patients (*n*)	28	24	10	3
EEEs (*n*)				
N1	2.1±1.1	2.2±1.0	2.3±1.2	2.7±2.1
N2	2.6±1.0*	2.9±1.6*	2.1±1.2	2.3±0.6
TET (h)				
N1	1.6±1.3	1.4±0.8	1.8±1.2	1.4±0.9
N2	1.8±0.6	1.4±0.8	2.1±1.9	1.8±0.8
Tip RAUs				
N1	49.2±29.1	45.8±17.5	56.4±24.5	52.3±42.9
N2	67.7±22.8*	66.4±28.8*	48.4±21.2	47.0±33.9
Base RAUs				
N1	53.2±34.0	54.9±25.3	62.4±28.4	62.3±38.2
N2	76.0±30.8*	73.5±31.8*	57.4±28.1	50.3±26.0
Tip TAUs				
N1	26.3±20.7	27.6±13.4	46.4±48.9	30.7±24.8
N2	40.6±22.5*	39.4±26.4*	23.8±11.0	22.7±11.6
Base TAUs				
N1	34.1±34.4	31.3±17.0	41.5±25.4	30.3±13.5
N2	43.8±25.7	42.4±28.0	29.8±15.3	26.7±11.1
Tip AER (%)				
N1	57.8±18.5	61.2±14.2	62.8±21.2	59.7±10.7
N2	60.5±15.9	60.5±18.4	60.0±10.2	71.3±23.5
Base AER (%)				
N1	60.6±16.2	66.7±13.1	68.1±24.2	78.0±3.5
N2	64.6±15.9	65.6±17.5	68.9±14.9	81.0±10.4
Tip D60% (min)				
N1	50.0±31.6	49.1±21.8	69.8±40.2	61.7±57.9
N2	67.1±26.2*	68.6±36.2*	53.5±30.3	48.1±34.5
Base D60% (min)				
N1	61.2±40.4	59.5±28.1	75.2±43.9	73.8±48.8
N2	85.4±38.6*	78.4±38.3*	67.6±46.3	58.2±29.2
Tip MT (cm)				
N1	8.2±1.0	8.3±1.0	8.2±0.6	8.9±0.5
N2	8.5±0.7	7.7±0.9*	8.2±0.9	7.8±0.5
Base MT (cm)				
N1	7.7±1.2	8.0±1.0	7.8±0.6	8.6±1.0
N2	8.3±1.0	7.6±1.1	8.2±0.8	8.3±1.0

Data are expressed as mean±s.d. *$P<0.05$, when measurement on the second night was compared with that on the first night. AER: average event rigidity; D60%: duration of erectile episodes with rigidity ≥60%; EEEs: effective erectile events; MT: maximal tumescence; N1: the first night; N2: the second night; RAUs: rigidity activated units; TAUs: tumescence activated units; TET: total erection time; s.d.: standard deviation

of age in our study, the overall status of NPTR parameters could not be evaluated accurately in these patients. Interestingly, in our study, age seemed to be associated with the first-night effect: this effect was greater in patients <40 years of age. However, this association should be further evaluated in a larger sample.

The first-night effect is linked to the anxiety of the testing situation,[19] which is typically difficult to avoid in a laboratory setting. This linkage suggests that NPTR monitoring at home may ameliorate the first-night effect by relieving the anxiety caused by strange hospital environment. However, studies regarding this approach have produced conflicting results. Reid and colleagues found no significant difference in the number of NPT episodes between the first night of home NPT monitoring and the second night of home monitoring.[25] Similarly, Greenstein and colleagues found that NPTR parameters recorded at patients' homes during the first night were no worse than those recorded during the second night;[16] however, significantly greater test time during the first night than during the second night made their results less convincing. Contrary to the findings of those two studies, a comparative study using laboratory-based and home-based NPTR monitoring with the RigiScan demonstrated that recordings at home were significantly shorter and involved a greater number of interruptions, compared with laboratory-based recordings, irrespective of diagnosis, incidence of waking erections, and age of the patient.[26] Therefore, at-home NPTR monitoring should be performed with diagnostic caution. Further well-designed studies are needed to validate the necessity of consecutive nightly measurements at home.

The study had several limitations. First, the study exhibited the typical weaknesses of a retrospective study. Second, the sample size of the study was small, particularly among patients over 50 years of age; this may have made the results inconsistent when stratified analysis was conducted by age (*e.g.*, TET, tip AER, and base AER among 30–39-year-old patients in Group A). Moreover, this could lead to an indefinite conclusion regarding the associations between age and the first-night effect or NPTR results. Therefore, these results should be interpreted with caution. However, the sample size in this study is relatively large compared with that of similar studies.[16,17] Third, some basic information was not assessed in all patients, including weight, height, blood glucose level, serum testosterone level, and medication history. Furthermore, glucose and testosterone levels were detected only when clinically indicated. In our practice, PDE5I, smoking, tea, caffeine, alcohol, and hypnotics were prohibited for 3 days before an NPTR measurement, to ensure the greatest accuracy. Therefore, our results are unlikely to be influenced by medication history. Fourth, concurrent sleep monitoring was not performed; notably, we did not demonstrate a first-night effect on NPTR monitoring by performing sleep monitoring. Finally, not all parameters were consistently better on the second night than those on the first night; this included tip MT, which differed from base MT in Group A. Importantly, parameters at the base are often dissimilar from those at the tip; this lack of similarity between the two sites is regarded as a common fact that is thus far difficult to explain.[27] For AER in Group C, we suspect that the impaired erectile ability likely interfered with detection of the first-night effect. Despite such limitations, our results demonstrate that the first-night effect is an important factor that impacts the accuracy of NPTR monitoring by the RigiScan; this effect cannot be disregarded, particularly in a laboratory setting.

CONCLUSION

We observed a significant improvement in NPTR parameters recorded during the second night, compared with those recorded during the first night. These results support the use of monitoring for at least two consecutive nights, to avoid the first-night effect and obtain more accurate NPTR data; this approach will ensure clarity when differentiating among different etiologies of ED, particularly when abnormal first-night measurements are recorded in a laboratory setting.

AUTHOR CONTRIBUTIONS

YZ and ZJ Zou designed the study. ZJ Zou, STC and GCM collected, analyzed and interpreted the clinical data. ZJ Zou, YZ and STC wrote and revised the manuscript. GCM, XJY, and LY conducted NPTR assessments. YFL, JRF, ZJ Zang, TQ, BW, and YZ evaluated patients and collected patients' clinical data. All authors confirmed the integrity

of the respective data and analysis. All authors read and approved the final manuscript.

COMPETING INTERESTS

All authors declared no competing interests.

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