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# The Orgasmometer-m: validation in Mandarin and measurement of orgasmic intensity in the Han population affected by premature ejaculation

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This cross-sectional study aimed to validate the male version of the Orgasmometer in Mandarin and to examine whether Chinese men with premature ejaculation (PE) experience reduced orgasmic intensity. From September 2020 to January 2023, a group of 230 men with PE (mean age=28.2 ± 4.8) and 107 men without sexual dysfunction (mean age= 35.1 ± 6.7), who were seeking help from the Department of Infertility and Sexual Medicine, underwent a detailed assessment from the andrologist and completed a questionnaire that included the Mandarin Orgasmometer (Orgasmometer-m), the Premature Ejaculation Diagnostic Tool (PEDT), and the erectile function domain of the International Index of Erectile Function (IIEF-6). Orgasmometer-m scores were 5.0 (4.0) in the PE group and 8.0 (3.0) in the non-PE group; PEDT scores were 14.8 ± 2.5 and 3.3 ± 2.4, and IIEF-6 scores were 27.9 ± 1.6 and 29.1 ± 1.2, respectively ($p < 0.001$). The Orgasmometer demonstrated good discriminative validity, with an area under the curve (AUC) of 0.8296 (95% CI: 0.7873–0.8719, $p < 0.0001$). A score of ≤6 was identified as the optimal cutoff for distinguishing low from high orgasm intensity, yielding 66.1% sensitivity and 86.9% specificity. These findings support the reliability of the Orgasmometer-m and suggest that men with PE report diminished orgasmic experiences.

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## INTRODUCTION

Orgasm is widely recognized as a significant phase within the human sexual response cycle, characterized by intense physiological and psychological experiences [1]. Despite its centrality, reaching a universally accepted definition of orgasm remains challenging due to varying disciplinary perspectives [2], including psychology, neurobiology, urology, and endocrinology. Contemporary research suggests that, psychobiologically, orgasm involves similar mechanisms in both men and women, such as rhythmic muscular contractions, autonomic nervous system activation, and altered states of consciousness [3]. However, its subjective experience and social interpretation may differ by gender and cultural context [4].

In men, orgasm and ejaculation frequently occur together, but they are physiologically distinct phenomena [2]. Orgasm refers to the subjective sensation of climax, while ejaculation is a physical process involving semen expulsion [2]. Importantly, one may occur without the other. This distinction is particularly relevant when studying male sexual function, as orgasmic impairment may not always be reflected in ejaculatory dysfunction or vice versa [5].

Although orgasm is often perceived as the goal or reward of sexual activity [6], contemporary views on sexual health emphasize that pleasure and satisfaction can exist independently of orgasm. For individuals with orgasmic difficulties, framing orgasm as essential may pathologize otherwise healthy sexual experiences [7]. A more inclusive understanding of sexual well-being must recognize a diversity of sexual goals and expressions.

Nevertheless, the ability to measure orgasm remains clinically and scientifically important, particularly for diagnosing and managing conditions such as premature ejaculation (PE), anorgasmia, or post-surgical sexual dysfunction. Several instruments have been developed to assess orgasm, including the Orgasm Rating Scale [8–10], which evaluates the cognitive, sensory, and affective dimensions of the orgasm experience and has been validated in Spain [11]. However, such multi-item tools may be less feasible in clinical settings due to their length and complexity.

In contrast, the Orgasmometer, developed by Limoncin et al. [12], is a single-item, visual analogue scale specifically designed to measure orgasm intensity, ranging from 0 (no orgasmic sensation) to 10 (maximum intensity). It has shown good psychometric properties and has been used in studies to differentiate orgasmic function between clinical populations. For example, men with PE have reported significantly lower orgasm intensity using the Orgasmometer compared to healthy controls, suggesting its sensitivity to clinically relevant differences in orgasmic experience [12]. Mollaioli et al. [13] validated the Orgasmometer in a female population and found that women with sexual dysfunction reported significantly lower orgasmic intensity scores compared

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**Table 1.** Demographic characteristics.

| | All (N = 337) | PE (N = 230) | Non-PE (N = 107) | P value |
|---|---|---|---|---|
| Age (Y), mean ± SD | 30.4 ± 6.4 | 28.2 ± 4.8 | 35.1 ± 6.7 | <0.001 |
| BMI (Kg/m$^2$) | 23.0 ± 3.1 | 22.5 ± 3.2 | 24.0 ± 2.7 | <0.001 |
| Marital status, n (%) | | | | <0.001 |
| married | 164 (48.7%) | 75 (32.6%) | 89 (83.2%) | |
| unmarried | 173 (51.3%) | 155 (67.4%) | 18 (16.8%) | |
| Educational level, (n, %) | | | | <0.001 |
| High school and below | 73 (21.7%) | 63 (27.4%) | 10 (9.3%) | |
| University and above | 264 (78.3%) | 167 (72.6%) | 97 (90.7%) | |

*PE* premature ejaculation, *SD* standard deviation, *BMI* body mass index.
The independent samples t-test and the chi-square test were used.

to sexually healthy controls. The instrument demonstrated robust psychometric properties, supporting its clinical utility in assessing the orgasmic impact of female sexual dysfunction. In a sample of 1799 women, 40.7% reported primarily clitorally activated orgasms (CAO), 18% vaginally activated orgasms (VAO), and 41.2% both types (CaVAO) [14]. Women reporting CaVAO showed significantly higher sexual function (FSFI) and orgasmic intensity (Orgasmometer scores) compared to those with VAO or CAO [14].

Despite these promising findings, research using the Orgasmometer has so far been limited to a few Western populations [13, 14], and the instrument has not yet been validated in Chinese-speaking or East Asian populations. Given the influence of cultural norms on how individuals perceive and report orgasmic experiences, cross-cultural validation is essential before its wider use in non-English-speaking countries. Moreover, the Orgasmometer's brevity and ease of use make it a particularly attractive tool for both clinical and research contexts, especially when quick assessments are needed.

Therefore, the current study aims to evaluate the psychometric validity of the Orgasmometer in a Chinese male population, with a particular focus on its application among patients with PE.

## METHODS

### Linguistic validation

Two andrologists with extensive English skills translated the English version of the Orgasmometer into Chinese, and then an andrologist performed a backward translation. Other researchers reviewed and confirmed the preliminary Mandarin version of the Orgasmometer. Ten men with PE and ten men without sexual dysfunctions completed the preliminary version of the Orgasmometer and provided feedbacks. Ultimately, we finalized the Mandarin version of the Orgasmometer (Orgsmometer-m).

### Study population

From September 2020 to January 2023, patients presenting with PE at the Third Affiliated Hospital of Sun Yat-sen University, Guangzhou, China, and men without sexual dysfunction who underwent reproductive health counseling, along with healthy volunteers, were included in the study. The inclusion criteria for the PE group were as follows: i) PE as the patient's sole sexual primary complaint; ii) premature ejaculation diagnostic tool (PEDT) score ≥ 11 [15, 16]; iii) heterosexual orientation as measured by the XYGO tool [17]; iv) age equal or greater than 18 years; v) have experienced ejaculation within the past 6 months. The exclusion criteria for the PE group were: i) unable to understand the content of the questionnaire; ii) central and peripheral nervous system diseases; iii) severe psychiatric disorders (Given the close association between anxiety, depression, and PE [18], it is possible that PE may induce certain anxiety symptoms to varying degrees, especially considering that distress is one of the defining dimensions of PE. However, such symptoms may not reach the threshold of a diagnosable psychiatric disorder. Therefore, we did not exclude participants with subclinical levels of anxiety or depression.); iv) diabetes; v) erectile dysfunction (ED) (score of the erectile function domain of the International Index of Erectile Function (IIEF-6) < 25) [19, 20] and Loss of Control over Erection and Ejaculation (LCEE) [21]; vi) self-reported significant hyperactive or hypoactive sexual desire disorder; vii) use of medications that significantly affect orgasm intensity, such as silodosin, an alpha1A-adrenoceptor antagonist [5]; viii) belonging to a non-Han population. The inclusion and exclusion criteria for the control group were similar to those of the PE group, with the exception of significant differences in the presence of sexual dysfunction. The protocol approval was obtained from the Third Affiliated Hospital of Sun Yat-sen University, Guangzhou, China.

### Procedure

After participants gave their informed consent, they underwent a detailed assessment by the andrologist and completed a questionnaire that included the Orgasmometer-m, the PEDT, and the IIEF-6. The researchers strictly followed the inclusion and exclusion criteria to enroll the subjects included in the study.

### Statistical analyses

The determination of the sample size followed Altman's general guideline, which suggests including at least 50 to 100 participants to evaluate the reliability of a questionnaire [22]. Continuous variables were presented as mean ± standard deviation or median (interquartile range, IQR), depending on whether the data followed a normal distribution. Categorical variables were presented as frequencies (percentage). When comparing continuous variables between the two groups, either the independent samples t-test or the Mann-Whitney U test was used, depending on whether the data met the assumption of normality. Categorical variables between the two groups were compared using the chi-square test. The coefficient of variation was calculated to assess the relative dispersion of Orgasmometer scores within the PE and non-PE groups. Floor and ceiling effects were evaluated by determining the proportion of participants achieving the lowest and highest possible scores, respectively. According to commonly accepted criteria, floor or ceiling effects were considered present if more than 15% of participants achieved the minimum or maximum score [23]. The receiver operating characteristic (ROC) curve analysis was used to assess the predictive ability of the Orgasmometer for orgasm intensity, and the Youden Index was used to determine the optimal cutoff value. Age, body mass index (BMI), marital status, education level, frequency of intercourse, PEDT score, self-perceived intravaginal ejaculatory latency time (P-IELT), and the IIEF-6 were included as covariates. One-Way Analysis of Covariance (ANCOVA) was used to compare Orgasmometer scores between different groups (PE vs. Non-PE). Levene's Test indicated a significant violation of homogeneity of variance ($p < 0.001$). To address this, a General Linear Model with 1000 bootstrap samples was employed to obtain robust estimates of the ANCOVA parameters. Data were analyzed using SPSS version 26.0 (SPSS, Inc.) and Prism software (GraphPad), with a significance level set at $p < 0.05$.

## RESULTS

The demographic characteristics of the PE group and the non-PE group, along with the intravaginal intercourse-related indicators, are presented in Tables 1 and 2, respectively. A Mann-Whitney U

**Table 2.** Characteristics of sexual intercourse between two groups.

| | PE (N = 230) | Non-PE (N = 107) | P value |
|---|---|---|---|
| Frequency of sexual intercourse | 4.5 ± 3.2 | 6.5 ± 4.0 | <0.001 |
| PEDT score | 14.8 ± 2.5 | 3.3 ± 2.4 | <0.001 |
| P-IELT (min, median, IQR) | 1.0 (1.0) | 15 (10.0) | <0.001 |
| IIEF-6 (min, mean ± SD) | 27.9 ± 1.6 | 29.1 ± 1.2 | <0.001 |
| Orgasmometer-m score (median, IQR) | 5.0 (4.0) | 8.0 (3.0) | <0.001 |

*PE* premature ejaculation, *PEDT* premature ejaculation diagnostic tool, *P-IELT* patient-perceived intravaginal ejaculation latency time, IQR interquartile range, *IIEF* international index of erectile function, *SD* standard deviation.
The independent samples t-test and the Mann-Whitney U test were used.

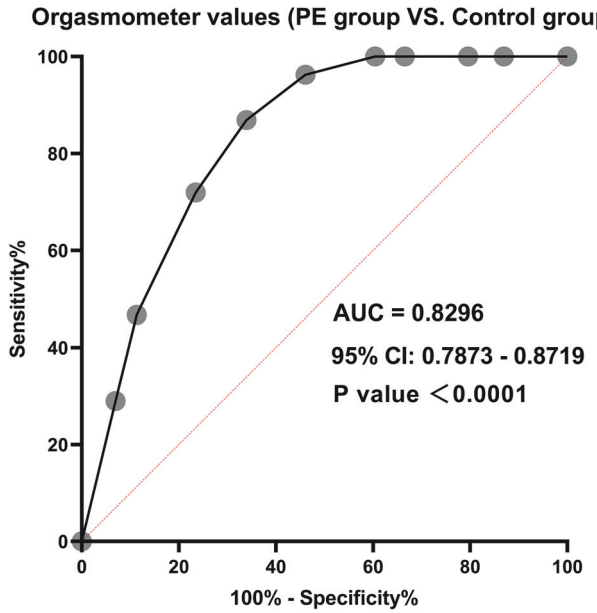


**Fig. 1** ROC curve analysis was conducted to assess the Orgasmometer's ability to predict the subjective perception of orgasm intensity.

**Table 3.** Results of ANCOVA for orgasm intensity, controlling for covariates.

| Predictor | F | p-value | Partial $\eta^2$ |
|---|---|---|---|
| Group (PE vs. Non-PE) | 10.98 | 0.001 | 0.032 |
| Age | 3.63 | 0.058 | 0.011 |
| BMI | 3.85 | 0.051 | 0.012 |
| Marital status | 0.14 | 0.710 | 0.000 |
| Educational level | 6.51 | 0.011 | 0.020 |
| Sexual frequency. | 0.72 | 0.396 | 0.002 |
| P-IELT | 1.21 | 0.273 | 0.004 |
| PEDT | 2.15 | 0.143 | 0.007 |
| IIEF-6 | 13.3 | <0.001 | 0.039 |

*PE* premature ejaculation, *BMI* body mass index, *P-IELT* patient-perceived intravaginal ejaculation latency time, *PEDT* premature ejaculation diagnostic tool, *IIEF* international index of erectile function.
One-Way Analysis of Covariance (ANCOVA) was used.

test was conducted to compare orgasmometer scores between the PE group (n = 230, median = 5.0, IQR = 4.0) and the non-PE group (n = 107, median = 8.0, IQR = 3.0). The results indicated a significant difference between the groups (U = 4193.000, p < 0.001), with the non-PE group demonstrating higher orgasmometer scores. The effect size, calculated as the rank-biserial correlation, was r = 0.66, suggesting a moderate to large difference between the groups. The sample sizes (n = 230 for PE, n = 107 for non-PE) provided sufficient power to detect this substantial effect, as evidenced by the highly significant result and the robust effect size.

**Table 4.** Estimated marginal means of Orgasmometer-m score by group.

| Group | Adjusted Mean (M) | Std. Error (SE) | 95% CI |
|---|---|---|---|
| PE group | 5.37 | 0.26 | 4.85, 5.85 |
| Non-PE group | 7.85 | 0.50 | 6.90, 8.89 |

*PE* premature ejaculation, *CI* confidence interval.

In the present study, the coefficients of variation for Orgasmometer-m scores were 52.85% in the PE group and 17.53% in the non-PE group. Floor and ceiling effect analysis showed that 0% of participants scored the lowest point (0) and 13.9% scored the highest point [10], both below the 15% threshold. The area under the curve (AUC) was 0.8296 (95% CI 0.7873–0.8719; p < 0.0001). A score of ≤6 serves as the optimal cutoff value for distinguishing between low and high orgasm intensity, with a sensitivity of 66.1% and a specificity of 86.9% (Fig. 1).

After adjusting for age, BMI, marital status, education level, sexual frequency, P-IELT, PEDT, and IIEF-6 scores, the effect of group was statistically significant, F(1, 327) = 10.98, p = 0.001, partial $\eta^2$ = 0.032 (Table 3). Among the covariates, educational level (p = 0.011), and IIEF-6 (p < 0.001) were significant predictors of orgasm intensity (Table 3). The estimated marginal means indicated that, after controlling for these covariates, participants in the PE group reported significantly lower orgasm intensity (M = 5.37, SE = 0.26, 95% CI [4.85, 5.85]) than those in the non-PE group (M = 7.85, SE = 0.50, 95% CI [6.90, 8.89]) (Table 4).

The ANCOVA analysis with robust standard errors confirmed that PE was significantly associated with reduced orgasm intensity, with men in the PE group scoring 2.48 points lower on average compared to the non-PE group (B = −2.478, p = 0.001) (Table 5). Furthermore, erectile function (IIEF-6, B = 0.320, p = 0.001), education level (B = 0.805, p = 0.020), and age (B = −0.053, p = 0.044) were significant predictors of orgasm intensity (Table 5).

## DISCUSSION

Orgasmic function – and, by consequence, orgasmic intensity – are among the least understood and studied parts of human sexual behavior. In general, most sexual health experts will have no issue with discussing ejaculatory function with their patients, investigating the domains of control, distress and timeliness

**Table 5.** Parameter estimates of ANCOVA model predicting orgasm intensity (Robust SE).

| Parameter | B | Robust Std. Error | p-value | 95% CI | Partial $\eta^2$ |
|---|---|---|---|---|---|
| Intercept | −1.165 | 3.008 | 0.699 | −7.082, 4.753 | <0.001 |
| Age | −0.053 | 0.026 | 0.044 | −0.105, −0.001 | 0.012 |
| BMI | 0.082 | 0.049 | 0.093 | −0.014, 0.179 | 0.009 |
| Marital status | −0.129 | 0.343 | 0.707 | −0.803, 0.546 | 0.000 |
| Educational level | 0.805 | 0.344 | 0.020 | 0.129, 1.482 | 0.016 |
| Sexual frequency | 0.031 | 0.036 | 0.391 | −0.040, 0.102 | 0.002 |
| P-IELT | −0.036 | 0.025 | 0.145 | −0.084, 0.012 | 0.006 |
| PEDT | −0.077 | 0.058 | 0.188 | −0.192, 0.038 | 0.005 |
| IIEF-6 | 0.320 | 0.092 | 0.001 | 0.139, 0.501 | 0.036 |
| PE group (ref: Non-PE) | −2.478 | 0.738 | 0.001 | −3.930, −1.026 | 0.033 |

*BMI* body mass index, *P-IELT* patient-perceived intravaginal ejaculation latency time, *PEDT* premature ejaculation diagnostic tool, *IIEF* international index of erectile function, *PE* premature ejaculation.

traditionally used for definition of PE [21, 24–26] – however, the issue of orgasmic intensity is rarely addressed in clinical practice, and even more rarely in research. The Orgasmometer aims to fill this gap, addressing an unmet need for men and women alike [12, 13].

Our findings provide robust psychometric support for the Mandarin version of the Orgasmometer. We observed acceptable score distribution, minimal floor and ceiling effects, and strong known-groups validity, as demonstrated by ANCOVA analyses comparing men with and without PE. Even after adjusting for key covariates (age, BMI, education, and erectile function), men with PE reported significantly lower orgasm intensity than those without. This supports the construct validity of the instrument, confirming its ability to detect clinically meaningful differences in orgasmic experience between theoretically distinct groups.

The discriminant validity of the scale was further confirmed via ROC curve analysis, which demonstrated excellent accuracy in distinguishing between low and high orgasm intensity. The cutoff identified by the Youden index balanced sensitivity and specificity, further validating the utility of the instrument in both research and clinical settings. These results align with previous validations in other studies [13, 14]. Its theoretical foundation rests on the need for brief yet valid instruments to capture subjective orgasmic experiences—a domain often neglected in structured interviews or conventional scales. In this sense, the Orgasmometer-m differs from an arbitrary single-question measure, as it has undergone translation, cross-cultural adaptation, and systematic validation procedures. Interestingly, despite cultural and demographic differences between the Italian and Mandarin-speaking populations, the optimal cutoff value for distinguishing between "functional" and "non-functional" orgasmic intensity in our study closely mirrors the threshold established in the original Italian validation of the Orgasmometer [12]. This cross-cultural consistency lends further support to the scale's discriminant validity and suggests that the subjective perception of orgasmic intensity may be comparable across different cultural contexts.

Importantly, our results reaffirm that men with PE not only report diminished ejaculatory control but also significantly lower orgasmic intensity, highlighting the broader impact of PE on sexual well-being. These findings extend earlier work by Limoncin et al. [12] and support the clinical relevance of assessing orgasm intensity in the diagnostic and therapeutic evaluation of PE.

In addition to group differences, we found that age, education level, and erectile function were significant predictors of orgasm intensity, supporting the multifactorial nature of orgasmic experience. Specifically, older age and lower educational attainment were associated with reduced orgasm intensity, while better erectile function predicted more intense orgasmic experiences. These findings are consistent with previous research showing that age-related declines in serum testosterone may impair orgasmic function [27, 28], and that sexual health literacy—which tends to be higher among individuals with more education—enhances self-awareness and communication about sexual experiences [29, 30]. For example, Banaei et al. [29] demonstrated that higher sexual health literacy improved regulation and understanding of one's sexual response, while Warshowsky et al. [30] found structured sexuality education led to enhanced orgasm quality and confidence in sexual communication.

Our data also support emerging evidence that erectile function is intricately linked to orgasm intensity. While traditional instruments such as the IIEF assess orgasm frequency, they do not capture the intensity of orgasm, which is a distinct and clinically relevant dimension. A recent 2024 study highlighted the potential for undiagnosed orgasmic dysfunction in men with ED [31], but formal measurement tools for orgasm intensity remain underused. Although Perelman first proposed assessing orgasm intensity in ED over a decade ago [32], our study is among the first to empirically evaluate this construct using a validated instrument. Future research should assess orgasm intensity in ED populations using tools such as the Orgasmometer-m to explore this overlap in greater depth.

The present study has some strengths worth considering, such as a very selected clinical population free from possible confounding bias. Particularly relevant is the exclusion of individuals with ED. As defined by the LCEE [21], some men might experience both ED and PE at the same time: in fact, each sexual symptom might "hide" the other, resulting in clinical scenario which might be easily mistaken by the clinician as well as by the patient himself. Diabetes, another possible confounding factor, has similarly been included among exclusion criteria. In fact, diabetes can affect orgasmic function by impairing sensitive nerve transmission in the genitals [33, 34].

Despite its strengths, several limitations should be acknowledged. First, test-retest reliability and responsiveness were not assessed. Due to the nature of the sample, we did not follow up with these participants, and many participants initiated pharmacological or behavioral interventions shortly after baseline assessment, which could significantly alter orgasm intensity over time. Therefore, conducting a follow-up assessment would have compromised the validity of evaluating temporal stability. We partially addressed this issue by analyzing score distribution, variability, and group discrimination, but future studies should include longitudinal designs to assess test-retest reliability in more stable populations.

Moreover, due to the single-item nature of the Orgasmometer-m, no psychometric assessment such as Cronbach's alpha or

confirmatory factor analysis was deemed necessary. While single-item scales offer simplicity and ease of administration, they may not capture the full complexity or multidimensional nature of subjective experiences such as orgasm intensity. This limitation could potentially reduce the sensitivity of the measure to subtle variations across individuals or contexts. Furthermore, single-item instruments are more vulnerable to measurement error and may be less reliable compared to multi-item scales.

Second, the study utilized a cross-sectional design, which limits causal inferences regarding factors influencing orgasm intensity. Relatedly, while we included the frequency of sexual intercourse as a covariate, we did not assess broader dimensions of sexual behavior, such as the quality of sexual relationships or solitary sexual activity (e.g., masturbation). These factors may also influence the experience and reporting of orgasm and should be considered in future studies to better capture the full scope of sexual functioning.

Third, the sample size, although adequate for the conducted analyses, was drawn from a single center only, which may potentially affect the external validity of the results. Cultural norms and attitudes toward sexual expression and reporting may significantly influence self-reported measures of orgasm intensity. These cultural factors may differ from those in Western populations, where the original Orgasmometer was developed and validated. Therefore, caution should be exercised when extrapolating our results to broader or more diverse populations. Future validation efforts should include gender- and sexual-minority populations, as well as diverse cultural groups, to assess the instrument's broader applicability.

Due to the cross-sectional and observational nature of our study, complete matching was not feasible. However, we attempted to control for these variables statistically by including age, BMI, and education as covariates in our ANCOVA models. Nevertheless, we acknowledge this as a limitation of our study. Residual confounding may still exist, and the demographic imbalance could impact the internal validity of our findings. Future research should aim to replicate these findings in larger, more diverse, and longitudinal cohorts to further confirm the psychometric properties of the Mandarin version of the Orgasmometer.

Another limitation of our study is the use of assessment tools, such as the XYGO, that have not been formally validated in the Mandarin language. We acknowledge that without proper validation, responses to these measures may not accurately reflect the constructs they intend to assess. Future studies should aim to use tools that have undergone standardized translation and validation processes for the target language and cultural context.

Furthermore, the study did not evaluate fertility status, which may be a relevant factor influencing sexual function. Existing research suggests that a diagnosis of infertility may negatively affect various aspects of male sexual function, including erectile confidence, ejaculatory control, and overall sexual satisfaction. It is plausible that men seeking fatherhood and facing fertility challenges may report lower orgasmic intensity. As such, future studies should include fertility-related variables to examine whether infertility is associated with differences in Orgasmometer-m scores. The present study did not collect behavioral data regarding pornography use and masturbation habits (such as frequency and technique). Previous research has shown that these factors may influence penile sensitivity and ejaculatory control, thereby affecting the orgasmic experience [35]. Future studies should include these variables to gain a more comprehensive understanding of their potential impact.

## CONCLUSION

Our study confirmed that the Mandarin version of the Orgasmometer is a valid instrument for assessing orgasm intensity well working in the Chinese population. Moreover, this study demonstrates that Chinese men with PE experience significantly lower orgasm intensity compared to those without PE, even after adjusting for relevant demographic and sexual function variables. The findings also highlight the multifactorial nature of orgasmic experience, with age, education level, and erectile function emerging as significant contributors. These results underscore the need to consider orgasm intensity as a clinically relevant dimension in the assessment and management of PE, potentially guiding more holistic and patient-centered treatment strategies.

## DATA AVAILABILITY

The data produced in this study are available in the published article or can be obtained from the corresponding author upon reasonable request.

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## COMPETING INTERESTS

EAJ is or has been a consultant and/or paid speaker for Bayer, FQM, Ibsa, Kanna, Lundbeck, Menarini, Merck, Mia, Otsuka, Pfizer, Recordati, Shionogi, and Viatris. The other authors declare no competing interests.

## ETHICAL APPROVAL

The protocol approval was obtained from the Ethics Committee of the Third Affiliated Hospital of Sun Yat-sen University (II2024-064-01).

## ETHICS APPROVAL AND CONSENT TO PARTICIPATE

All methods in this study were performed in accordance with the Declaration of Helsinki and relevant national and institutional guidelines and regulations. The study protocol was reviewed and approved by the Ethics Committee of the Third Affiliated Hospital of Sun Yat-sen University, Guangzhou, China (approval number: II2024-064-01). Written informed consent was obtained from all participants prior to their inclusion in the study. No identifiable images or personal data of human participants are included in this article; therefore, consent for publication of images was not applicable.

## ADDITIONAL INFORMATION

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