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Original Article

The prevalence of erectile dysfunction among subjects with late-onset hypogonadism: a population-based study in China

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Abstract: *Introduction*: The concurrence of chronic diseases and some well-defined risk factors significantly impacts the prevalence of erectile dysfunction (ED). *Aim*: To determine whether late-onset hypogonadism (LOH) impacts the prevalence of ED using investigation reproductive health data of middle-aged and aging males in China. Methods: The reproductive health status of 1498 males, aged 40-69 years, was evaluated using questionnaires of LOH based on the Androgen Deficiency in Aging Males (ADAM) and Aging Male Symptoms scale (AMS), as well as the International Index of Erectile Function-5 (IIEF-5) assessment. The 10th percentile of serum total testosterone (TT) and calculated free testosterone (cFT) levels of controls were set as cut-off levels of AD. The main outcome measures were used to assess the prevalence of LOH and ED according to different subject characteristics. Results: Of the 1472 subjects who completed the questionnaires who supplied hormone measurements, the prevalence of self-reported ED and identified by the IIEF-5 assessment were 11.28% and 77.85%, respectively. The IIEF-5 assessment revealed a prevalence of ED of 55.34%, 88.20%, and 91.77%, respectively, among those aged 40-49, 50-59, and 60-69 years. AD rates of ED subjects were 13.73% and 40.69% according to the TT and cFT cut-off levels. The prevalence of ED among subjects positive for LOH (ADAM+ and AMS+) were 88.81% and 95.80%, respectively. The prevalence of ED among the AD subjects (TT and cFT cut-off levels) with LOH (ADAM+ and AMS+) were 86.67%/81.82%. And the prevalence of ED among clinical LOH subjects (ADAM+ and AMS+) were 89.51%/98.48%. *Conclusions*: We found that middle-aged and aging Chinese males were at a relatively high risk of ED. The prevalence of ED among subjects with LOH symptoms was greater than in all recruited subjects. The effect of LOH on the prevalence of ED far outweighed the risk of decreased testosterone levels.

Keywords: Erectile dysfunction, late-onset hypogonadism in males, prevalence rate, aging male, community population

Introduction

According to the National Health and Social Life Survey, the prevalence of erectile dysfunction (ED) increases with age (7% among males aged 18-29 years, 9% for 30-39-year-olds, 11% for 40-49-year-olds, and 18% for 50-59-year-olds) [1]. Likewise, the Massachusetts Male Aging Study (MMAS) reported that between the ages of 40 and 70 years, the probability of complete ED increased from 5.1% to 15%, moderate ED increased from 17% to 34%, and mild ED remained constant at about 17% [2, 3]. Hence, there is a general consensus that the prevalence ED gradually increases beginning in middle age. In addition, the incidence of ED increases with the occurrence of several chronic diseases (e.g., cardiovascular disease, hypertension, cerebrovascular disease, diabetes mellitus, metabolic syndrome, and other genitouri-

nary diseases) and some well-defined risk factors (i.e., use of certain medications, hormone therapy, and smoking, etc.) [4]. Among middle-aged and aging males, the prevalence of late-onset hypogonadism (LOH), which is characterized by decreased libido and sexual function, also increases with age, as with ED.

In the present study, we assessed the reproductive health status of middle-aged and aging males living in the township and rural communities of Fucheng County, Hebei Province, China, between August 2007 and November 2008. The aim of this study was to use the collected investigative data to explore the prevalence of LOH and ED and to determine whether LOH influences the prevalence of ED.

Materials and methods

The study protocol was designed to assess the reproductive health of middle-aged and aging males and was approved by the academic committee and ethics committee of the National Research Institute for Family Planning of China (Beijing, China). The study subjects were recruited through the help of the Fucheng Family Planning Bureau and Technical Service Center (Hengshui, Hebei Province, China). This preliminary, experimental research was conducted at only one site in order to collect basic data in the preparation of a larger, multi-center, population-based study in China. All subjects submitted informed consent at the research site prior to participation in this study.

Subjects

Cluster and age-stratified sampling methods were used to assess the reproductive health status of middle-aged and aging males. The research site was located in Fucheng County, while cluster sampling was conducted in Gucheng Town. On the basis of census data and a 10:1 ratio of healthy 40-69-year-old males, a total of 1498 males (age, 40-69 years) were divided into three groups according to age (40-49, 50-59, and 60-69 years, respectively). In addition, 59 participants aged 20-39 years residing in the same region were recruited as control subjects. The township subjects were governmental employees, while the rural subjects were farmers residing near Gucheng Town.

Questionnaires and assessment criteria

Some of the study subjects did not adequately understand the questions in the survey. Therefore, in keeping with the survey criteria and the voluntary status of the subjects, each of the subjects was instructed to independently complete the self-assessment questionnaire to submit data regarding age, health status, and lifestyle habits, as well as LOH status [two questionnaires: Androgen Deficiency in Aging Males (ADAM) and Aging Male Symptoms scale (AMS)], and ED status (International Index of Erectile Function-5, IIEF-5). To the best of our knowledge, this is the first study to employ the Chinese versions of the ADAM and AMS scales to screen a cohort regarding LOH. Although no validation of the IIEF-5 Chinese version was found in the literature at the time of this report, this questionnaire has been widely employed for many years in China.

Completed questionnaires were collected and data were analyzed by our research group to assess the ADAM results (positive or negative), AMS score, and IIEF-5 score, as well as diagnosis and severity of ED. According to the findings of Heinemann et al. [5] and Moore et al. [6], an AMS score of 17-26 is considered negative and ≥ 27 as positive (maximum score, 27 points). Regarding IIEF-5 classification, a score of ≥ 22 points was considered as normal erectile function, while ED was classified as mild (score, 12-21 points), moderate (8-11 points), or severe (5-7 points) [7].

Unfortunately, data describing co-morbidities (i.e., diabetes, hypertension, and so on) were not reported because of the limitations imposed by the research site and funding.

Hormone measurements

Blood samples were collected in the morning (07:00-09:00 h) and centrifuged (1000 g, 10 min) to obtain serum samples, which were aliquoted and stored at -70°C until assayed. Of the 1498 subjects, serum concentrations of reproductive hormones were assessed in 434 individuals (198 from the township and 236 from rural areas; n = 62/70, 74/86, and 54/88 aged 40-49, 50-59, and 60-69 years, respectively) and 59 control subjects (n = 39 from the township and 20 from rural areas).

The serum concentrations of total testosterone (TT) and luteinizing hormone (LH) were mea-

Table 1. The screening positive rates of LOH by ADAM and AMSin different age brackets, n (%)

Questionnaire	ADAM+	AMS+
40-49 years (*n* = 515)	287 (55.73)	49 (9.51)
50-59 years (*n* = 483)	442 (91.51)	125 (25.88)
60-69 years (*n* = 474)	460 (97.05)	302 (63.71)
Mean (*n* = 1472)	1189 (80.77)	476 (32.34)

Table 2. Androgen deficiency rates by TT and cFT cut-off point in different age brackets, n (%)

Type of cut-off point	TT	cFT
40-49 years (*n* = 132)	17 (12.88)	40 (30.30)
50-59 years (*n* = 160)	24 (15.00)	69 (43.13)
60-69 years (*n* = 136)	19 (13.97)	78 (57.35)
Mean (*n* = 428)	60 (14.02)	187 (43.69)

Table 3. Clinical prevalence rates of LOH with ADAM+ and AMS+in different age brackets, n (%)

Subjects	ADAM+ (cFT cut-off)	AMS+ (cFT cut-off)
40-49 years (*n* = 132)	25 (18.94)	6 (4.55)
50-59 years (*n* = 160)	61 (38.13)	11 (6.88)
60-69 years (*n* = 136)	76 (55.88)	49 (36.03)
Mean (*n* = 428)	162 (37.85)	66 (15.42)

sured using magnetic-separation enzyme-linked immunosorbent assay kits (Beijing Bio-Ekon Biotechnology Co., Ltd., Beijing, China). Sex hormone binding globulin (SHBG) was measured using an enzyme-linked immunosorbent kit (Diagnostic Systems Laboratories, Inc., Webster, TX, USA). TT, LH, and SHBG interassay coefficients of variation were 6.5%, 4.9% and 9.8%, respectively. The proportion of serum free testosterone (cFT) and bio-available testosterone (Bio-T) were calculated using the calculator available at http://www.issam.ch/, in accordance with the equations reported by Vermeulen [8].

Statistical analyses

All statistical analyses were performed using SPSS statistical software (ver. 13.0; IBM-SPSS, Inc., Chicago, IL, USA). Because of the skewed distributions of hormone levels, we analyzed the data using nonparametric statistics. The mean hormone levels were reported as medians (50th percentile) with 10th and 90th percentiles representing the upper and lower reference limits. Hormone levels among different age groups were compared using the Kruskal-Wallis H and Mann-Whitney U tests. The rates of ED and LOH among the different age groups were compared using the chi-square (χ^2) test. Correlations between IIEF-5 scores and age, hormone levels, ADAM results, and AMS scores were analyzed using the Spearman's rank-order correlation coefficient. Logistic regression analysis was used to identify risk factors associated with ED. A probability (*p*) value of < 0.05 was considered statistically significant.

Results

Serum reproductive hormone levels and the cut-off level for androgen deficiency (AD)

Serum reproductive hormone levels, variation status, and prevalence of LOH in middle-aged and aging subjects were assessed according to recent methods reported in 2009 and 2010 [9, 10]. The 10th percentile of hormone levels of the controls was set as the cut-off level of AD. Serum TT and cFT cut-off levels were 9.13 nM and 0.169 nM, respectively.

Retrieval of questionnaires

A total of 1472 completed questionnaires were collected and used to evaluate the related data. The effective response rate was 98.26%. Completed questionnaires were retrieved from 731 township subjects and 741 rural subjects (n = 260/255, 234/249, and 237/237 aged 40-49, 50-59, and 60-69 years, respectively). Serum samples for hormone measurements were collected from 434 subjects from whom 428 completed questionnaires were collected, which was 29.08% of all completed questionnaires.

Positive LOH rates

After combining the data from the completed questionnaires submitted from township and rural subjects, the positive LOH rates were calculated according to the ADAM and AMS scores (ADAM+ and AMS+) [10] (**Table 1**).

AD rates

Based on the described diagnostic cut-off level for AD, without consideration of LOH-related symptoms, the prevalence of AD was assessed among subjects with hormone levels lower than

Table 4. ED prevalence rates of three age brackets, n (%)

	Mild	Moderate	Severe	Total
40-49 yeas (*n* = 515)	180 (34.95)	42 (8.16)	63 (12.23)	285 (55.34)
50-59 years (*n* = 483)	121 (25.05)	63 (13.04)	242 (50.10)	426 (88.20)
60-69 years (n = 474)	112 (23.63)	46 (9.70)	277 (58.44)	435 (91.77)
Mean (*n* = 1472)	413 (28.06)	151 (10.26)	582 (39.54)	1146 (77.85)

the cut-off point [10] (**Table 2**). Reproductive hormone levels from AD subjects are presented in **Table 5**.

Prevalence of LOH

The prevalence of LOH was assessed among subjects exhibiting symptoms of LOH (i.e., ADAM+ or AMS+) with serum cFT levels lower than the established cut-off value [10] (**Table 3**). Reproductive hormone levels of subjects with clinical symptoms of LOH are shown in **Table 5**.

Self-reported prevalence of ED according to the IIEF-5 assessment

In response to the question "Do you consider yourself having ED now? (YES or NO)", the self-reported prevalence of ED was 11.28% (166/1472). According to the IIEF-5 assessment, the prevalence of mild, moderate, and severe ED was 28.06% (413/1472), 10.26% (151/1472), and 39.54% (582/1472), respectively. The total prevalence of ED among all subjects aged 40-69 years was 77.85% (1146/1472) (**Table 4**).

There were obvious significant differences between the self-reported prevalence of ED and the overall ED prevalence rate among all subjects ($P < 0.001$, χ^2 test). Thus, the self-reported ED prevalence rate was significantly lower than that estimated by the IIEF-5 assessment.

Prevalence of ED according to subject age

The prevalence of mild, moderate, and severe ED in subjects aged 40-49, 50-59, and 60-69 years, according to the IIEF-5 assessment, are shown in **Table 4**. The χ^2 test revealed significant differences in the prevalence of ED among these three age groups ($P < 0.001$). These findings showed that the prevalence of ED and severe ED gradually increased with age (**Table 4**).

Serum reproductive hormone levels and AD rates in subjects with ED

Using the IIEF-5 to assess the prevalence of ED among 428 subjects who completed the questionnaires and serum reproductive hormone levels were available, the 10th, 50th, and 90th percentiles of hormone levels of 204 ED subjects (IIEF-5 score ≤ 21 points) are listed in **Table 5**. AD rates of ED subjects according to TT and cFT cut-off levels were 13.73% (28/204) and 40.69% (83/204), respectively. χ^2 test results revealed no significant differences in AD rates between ED subjects and the 428 subjects who underwent hormone screening, regardless of the TT or cFT cut-off levels (both, $P > 0.05$).

The Kruskal-Wallis H test revealed significant differences in serum TT, cFT, Bio-T, and SHBG levels among subjects with ED, AD, or clinical LOH ($P < 0.001$, < 0.001, < 0.001, and < 0.01, respectively). However, there were no significant differences in LH levels among these subgroups (all, $P > 0.05$).

The Mann-Whitney U test indicated significant differences in serum TT, cFT, Bio-T, and SHBG levels between subjects with ED and those with AD ($P < 0.001$) or clinical LOH ($P < 0.001$). However, there were no significant differences in LH levels in subjects with ED ($P > 0.05$) or in LH, TT, cFT, Bio-T, and SHBG levels between subjects with AD and those with LOH (all, $P > 0.05$).

In accordance with the 50th percentile, serum TT, cFT, and Bio-T levels were greater in subjects with ED, while SHBG levels were lower, than in subjects with AD and/or LOH.

Prevalence of ED among LOH-positive subjects

The prevalence of LOH-positive (ADAM+ or AMS+) subjects with ED and IIEF-5 scores ≤ 21 points is shown in **Table 6**. We found that the prevalence of severe ED was greater than that of mild ED in both ADAM+ and AMS+ subjects. The χ^2 test revealed significant differences in the prevalence and severity (severe, moderate, and mild) of disease among subjects with ED and those with LOH (ADAM+ or AMS+; both, $P < 0.001$), as well as between all 1472 subjects who submitted completed surveys and those that were ADAM+ or AMS+ (both, $P < 0.001$).

Table 5. Serum reproductive hormone levels of ED subjects, androgen deficiency subjects and subjects with clinical prevalence of LOH

	ED subjects (*n* = 204)			Androgen deficiency subjects (cFT cut-off) (*n* = 187)			Subjects with clinical prevalence of LOH (ADAM+/cFT cut-off) (*n* = 162)		
	10% percentile	50% percentile	90% percentile	10% percentile	50% percentile	90% percentile	10% percentile	50% percentile	90% percentile
LH (IU/L)	1.86	4.28	8.36	1.62	4.38	9.60	1.77	4.65	9.71
TT (nmol/L)	8.47	13.01	24.50	7.02	11.15	18.69	7.01	11.04	18.67
cFT (nmol/L)	0.100	0.179	0.325	0.086	0.131	0.160	0.086	0.131	0.160
Bio-T (nmol/L)	2.35	4.20	7.61	2.02	3.07	3.75	2.02	3.08	3.75
SHBG (nmol/L)	29.40	59.35	122.51	39.10	72.66	137.36	39.02	71.98	137.52

Table 6. ED prevalence rates of subjects with screening positive results of LOH, n (%)

	Prevalence rates of ED			
	Mild n (%)	Moderate n (%)	Severe n (%)	Total prevalence rate n (%)
ADAM+ (*n* = 1189)	406 (34.15)	143 (12.03)	507 (42.64)	1056 (88.81)
AMS+ (*n* = 476)	131 (27.52)	66 (13.87)	259 (54.41)	456 (95.80)

Table 7. ED prevalence rates of androgen deficiency subjects, n (%)

	Prevalence rates of ED			
	Mild n (%)	Moderate n (%)	Severe n (%)	Total prevalence rate n (%)
AD, TT cut-off (*n* = 60)	23 (38.33)	14 (23.33)	15 (25.00)	52 (86.67)
AD, cFT cut-off (*n* = 187)	75 (40.11)	30 (16.04)	48 (25.67)	153 (81.82)

Note: AD: androgen deficiency.

Table 8. ED prevalence rates of subjects with clinical prevalence of LOH (cFT cut-off point), n (%)

	Prevalence rates of ED			
	Mild n (%)	Moderate n (%)	Severe n (%)	Total prevalence rate n (%)
ADAM+ (*n* = 162)	73 (45.06)	24 (14.81)	48 (29.63)	145 (89.51)
AMS+ (*n* = 66)	26 (39.39)	15 (22.73)	24 (36.36)	65 (98.48)

Note: ADAM+: ADAM+ subjects with clinical prevalence of LOH; AMS+: AMS+ subjects with clinical prevalence of LOH.

Prevalence of AD among subjects with ED

The prevalence of AD, as assessed by serum TT and cFT cut-off levels, and IIEF-5 scores of ≤ 21 points, among subjects with ED is shown in **Table 7**. These results indicated a lower incidence of severe ED, as compared to mild, in subjects with AD, as assessed by serum TT or cFT cut-off levels.

There was no significant difference in the prevalence of AD in subjects with ED or all 1472 subjects who submitted completed surveys according to the TT and cFT cut-off levels (both, $P > 0.05$; χ^2 test). Also, there was no significant difference in the prevalence of ED between ADAM+ subjects and those with AD, according to the TT cut-off level ($P > 0.05$). However, there were obvious significant differences in the prevalence of ED between AMS+ subjects with AD, according to the TT cut-off level ($P < 0.01$) and ADAM+ or AMS+ subjects with AD, according to the cFT cut-off level ($P < 0.01$ and < 0.001, respectively).

Prevalence of ED with LOH according to the cFT cut-off level

Table 8 lists the ED cases according to subjects with LOH, who had positive screening results for LOH (ADAM+ or AMS+), serum cFT levels lower than the cFT cut-off level (0.169 nM), and IIEF-5 scores ≤ 21 points. We found that the prevalence of ED and severe ED was lower than that of mild ED in both ADAM+ and AMS+ subjects with LOH.

There were significant differences in the prevalence of ED between both ADAM+ and AMS+ subjects with LOH ($P < 0.05$), and in ED severity (severe, moderate, and mild) between these

subgroups (both, $P > 0.05$; χ^2 test). Also, there were obvious significant differences in the prevalence of ED among all 1472 subjects who submitted completed surveys and those with LOH (ADAM+ or AMS+) ($P < 0.01$ and < 0.001, respectively). In addition, there were significant differences in the prevalence of ED between subjects with AD (cFT cut-off) and those with LOH (ADAM+ or AMS+) ($P < 0.05$ and < 0.01, respectively).

Correlations between IIEF-5 score, age, and serum reproductive hormone levels

Spearman's rank-order correlation analysis indicated notable significant correlations between IIEF-5 score and age, ADAM-positive results, and AMS scores, as well as LH, cFT, and Bio-T concentrations (all, $P < 0.001$), but not TT or SHBG concentrations (both, $P > 0.05$). Also, there were significant correlations between ED severity and ADAM-positive results and AMS score (both, $P < 0.001$).

Risk factors for ED

Logistic regression analysis showed that the risk factors for ED included age, occupation (physical, semi-physical, or mental labor), educational background, health status (very good, no disease; good, normal chance of disease; common, one chronic disease; bad, two or more chronic diseases); drug use (none, long-term with one drug, long-term with two drugs, long-term with three or more drugs), smoking duration (5, 10, 15, or ≥ 20 years), drinking frequency, and the incidence of genitourinary diseases. Marriage age and smoking frequency (10, 20, or ≥ 30 cigarettes/day) were not risk factors.

Discussion

ED is a common disease that severely impacts reproductive health and the quality of life of middle-aged and aging males. In China, the majority of men with ED are undiagnosed or receive inadequate treatment because many do not consider the importance of reproductive health or may rely on traditional Chinese medicines or are dissuaded by various socioeconomic factors. The data acquired in this study strongly suggest that ED remains an underdiagnosed and undertreated condition in China [11].

The present study of middle-aged and aging males according to the ADAM/AMS questionnaires to screen 40-69-year-old subjects revealed that the mean positive rates of LOH were 80.77% and 32.34%, the mean AD rates were 14.02% and 43.69% (according to the TT and cFT cut-off levels), and the mean clinical prevalence rates of LOH were 37.85% and 15.42% for ADAM+ and AMS+ subjects, respectively. In comparison, a study conducted in the Shanghai metropolitan area [12] reported that the LOH-positive rates, as screened with the ADAM and AMS scales, were 84.65% and 59.88% among 40-70-year-old males, respectively, while a Korean study [13] found that 10.2% of the study participants had LOH. Moreover, a 2012 Chinese study [14] found that the incidence of LOH among 40-80-year-old males (mean age, 56.22 ± 8.82 years) in a rural community of Zhejiang Province was 62.86% and 23.05% based on ADAM and AMS scales, respectively, and the incidence of ED was 68.83%. Another Chinese study [14] reported that the incidence of LOH in rural communities of Zhejiang Province was lower than that in urban areas, but there was no significant difference in the incidence of ED. The positive rates of LOH in the present study were similar to those reported in these previous studies conducted in China [12, 14], although the incidence of AD and LOH were higher than in other reports [15-19].

According to the European Male Ageing Study (EMAS), when only hormonal criteria were considered (TT level < 10 nM), the prevalence of "biochemical hypogonadism" was 23.3% in 40-79-year-old men [20]. In addition, the EMAS recently defined strict diagnostic criteria for LOH to include the simultaneous presence of reproducibly low serum testosterone (TT < 11 nM and FT < 220 pM) and three sexual symptoms (ED, reduced frequency of sexual thoughts, and morning erections). By these criteria, only 2% of 40-80-year-old men have LOH [21]. Compared with overseas reports, middle-aged and aging Chinese males had a relatively high prevalence of LOH symptoms as well as variations and deficiencies in reproductive hormone levels.

There have been relatively few population-based studies on the prevalence of ED among subjects with late-onset hypogonadism. LOH symptoms are generally impacted by physical,

psychological, and sexual factors. ED is considered a relatively common disease that directly impacts male reproductive health. Moreover, LOH symptoms affect sexual function, thus it is inevitable that the prevalence of ED is increased in subjects with LOH.

Although the incidence of ED significantly increases with age, recent studies have indicated that 55%-70% of men aged 77-79 years remain sexually active, although only about half of those who self-reported ED are concerned about this condition [22]. Reportedly, one in every 20 young men aged 18-39 years across five European countries have experienced ED in the past 6 months. However, about half (52%, 2702/5184) of men with ED across all ages were reported to not discuss their condition with a physician. Furthermore, among those men who did discuss their condition with a physician, 68% (1668/2465) did not use medication at that time [23].

Our results demonstrated that the self-reported incidence of ED was significantly lower than as measured using the IIEF-5 (11.28% vs. 77.85%, respectively). We suspect that the relatively low self-cognition level of the subjects was a major reason for the low frequency of doctor visits. Compared to Europeans, the Chinese tend to not report ED or seek treatment.

The prevalence of ED among men aged 40-49, 50-59, and 60-69 years were 55.34%, 88.20% and 91.77%, respectively, indicating that the incidence of ED tends to increase with age.

The MMAS was a community-based, random-sample, observational survey [24] of noninstitutionalized men 40-70 years old that reported a combined prevalence of minimal, moderate, and complete impotence of 52%. Meanwhile, other studies have repeatedly confirmed that about 52% of men between the ages of 40 and 70 years have experienced ED to some degree [25]. Data from Australia, the US, and UK have reported similar results, estimating the prevalence of complete ED at approximately 5% among 40-year-olds, 10% among men in their 60 s, 15% among men in their 70s, and 30%-40% among men in their 80 s [22]. Hence, the prevalence of ED demonstrated by our results was clearly higher than reported in these three referenced studies.

We found AD rates among ED subjects of 13.73% and 40.69%, respectively, in accordance with the established TT and cFT cut-off levels. Our statistical results showed that serum TT, cFT, and Bio-T levels of ED patients were higher than for AD subjects or subjects with LOH. Although there were notable significant correlations between IIEF-5 scores and cFT concentrations or Bio-T concentrations ($P < 0.001$), thus the serum testosterone concentration may not necessarily be the only or crucial factor impacting the incidence of ED.

We determined that the prevalence of ED among subjects with LOH (ADAM+ and AMS+) was 88.81% and 95.80%, respectively, while that among the AD subjects, as assessed by serum TT and cFT cut-off levels, was 86.67% and 81.82%, respectively. The prevalence of ED of subjects with LOH (ADAM+ and AMS+) was 89.51% and 98.48%, respectively. Our results demonstrated that ADAM-positive status and AMS score were useful indicators of ED prevalence, more so than the occurrence of AD, and LOH was a stronger indicator of ED than responses to the screening questionnaires or the presence of AD. A possible explanation for these results may be that the IIEF-5, ADAM, and AMS scales were all correlated with symptoms, thus the three questionnaires displayed good concordance. A multicenter, cross-sectional study conducted in Spain among men aged ≥ 45 years with low testosterone (TT < 8 nM or < 12 nM and cFT < 250 nM) moderate/severe ED, and obesity were significantly higher in men with symptom of moderate/severe LOH [26].

There have been several recent reports of various genitourinary diseases associated with an increased risk for ED. For example, a recent study [27] (mean age, 52.3 years; age range, 21-77 years) indicated that ED, lower urinary tract symptoms (LUTS), and LOH symptoms were detected in 76.8%, 52.8%, and 59.9% of cases, respectively. ED ratio and LUTS severity significantly increases with age. Thus, LUTS seems to be an important risk factor for erectile function. Another study [28] reported that among 7372 men, aged 15 to 60 years, the prevalence of ED, as assessed by self-reporting and IIEF-5 score, was 12.0% and 17.1%, respectively. Moreover, among 771 men with prostatitis-like symptoms, the prevalence of ED, as assessed by self-reporting and IIEF-5 score,

was 39.3% and 30.1%, respectively, and among 370 men suffering from chronic prostatitis, the rates were 40.5% and 35.1%, respectively. A third study [29] that explored the incidence of ED in the general male population found that 13%-29% had moderate to severe LUTS and 8%-35% had moderate to severe ED. In studies using both the International Prostate Symptom Score and IIEF-5, the overall prevalence of coexistent LUTS and ED of any severity was 71%-80% among men seeking treatment for LUTS. Coexistence of LUTS and ED increased with age, ranging from 59%-86% among men aged 40-60 years in primary care to 79%-100% in treatment-seeking men with LUTS aged 50-70 years. A fourth study [30] of the general US population (men ≥ 40 years old) reported that the prevalence of ED only or coexisting with benign prostatic hyperplasia (BPH) (ED/DxBPH) was 24.6% and 4.9% (mean age, 60 and 68 years, respectively). Overall, 37.3% of men with ED only and 74.6% with ED/DxBPH reported moderate-to-severe urinary symptoms based on a score of ≥ 8 points according to the American Urological Association-Symptom Index. It seems that symptoms of LUTS, prostatitis, BPH, and LOH are closely related with the occurrence of ED and, moreover, they may be indicators of coexisting diseases or risk factors of future illnesses.

The results of a number of epidemiological studies support a relationship between sexual health and testosterone levels, and it is well accepted that testosterone deficiency is an accurate indicator of sexual and physical frailty. However, several other hormones, including LH, prolactin, thyroid stimulating hormone, and free thyroxine are involved in sexual function and should be investigated in a proper work-out of ED [31]. A Korean study purported that testosterone production was decidedly age-dependent, and most putative symptoms of LOH show significant age dependence, but yet are not affected by serum testosterone levels. Decreased libido increased significantly at serum testosterone levels of 550 ng/dL (odds ratio [OR] = 1.295; 95% confidence interval [CI] = 1.047-1.601), and erectile dysfunction was affected by serum testosterone levels at 250 ng/dL (OR = 1.369; 95% CI = 1.005-1.866) [13]. Our results indicated significant correlations between IIEF-5 score, age, ADAM-positivity, and AMS score, as well as LH, cFT, and Bio-T concentrations, but not IIEF-5 score or TT and SHBG concentrations. Furthermore, there were obvious significant correlations between ADAM positive results, AMS score, and ED severity.

The findings of this study demonstrated that many conditions are potential risk factors for ED. Predictors of incident ED identified in this study were advanced age, lower income, abdominal fat mass, low alcohol intake, higher obstructive sleep apnea (OSA) risk, and avoiding LUTS, depression, and diabetes [32]. ED is highly prevalent, affecting up to half of men aged 50-70 years, and has been variably associated to a variety of causes, including unhealthy lifestyles, such as smoking and obesity, and associated comorbidities, such as hypertension, diabetes mellitus, and neurological disorders [31]. Our results demonstrated that the risk factors for ED included age, occupation, educational background, health status, drug use, smoking duration, drinking frequency, and genitourinary system diseases, while marriage age and smoking dose were not risk factors.

There were some limitations to this study that may have led to a bias in the reporting of the prevalence of LOH and ED among the study cohort. First, there was significant subjectivity, as the study subjects personally answered the questionnaires. Second, Chinese traditions may have impeded the subjects from uninhibitedly discussing sexual dysfunction with the surveyors. Third, the conditions of the surveys, such as the number of questions, the limited number of research sites (one), and the limited funding, limited the scope of this research. Hence, further studies are warranted to improve laboratory testing and consultation of patients regarding concurrent chronic diseases and promotion of lifestyle changes. Finally, the use of only questionnaires to diagnose LOH and ED may have resulted in a slight increase in the prevalence of ED, thus the combined use of several diagnostic methods is recommended.

In conclusion, we found a relatively high incidence of ED among middle-aged and aging Chinese men, regardless of screening positive for LOH, AD, or LOH. The prevalence of ED among subjects with LOH symptoms was greater than all recruited subjects. The effect of LOH symptoms exerted by ED far outweighed a decrease in testosterone levels. In addition, compared with overseas reports, the preva-

lence of ED among the Chinese is obviously greater. The reason for the extraordinary prevalence of ED in China is closely correlated with low cognition and poor health status, as well as underdiagnosed and undertreated conditions among the Chinese population.

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Disclosure of conflict of interest

None.

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