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Sperm counts in Asian men: Reviewing the trend of past 50 years

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ABSTRACT

Objective: To reveal the trend in alterations of sperm counts in Asian men over the past 50 years. **Methods:** This study reviewed all the published reports to unveil the specific pattern of alterations of sperm concentrations in Asian men from 1965 till 2015. The time-related changes in sperm concentration were studied using linear regression analyses. **Results:** The present study elucidated the trend using the reports from Carlsen *et al* (1965-1990) and non-Carlsen studies published until 2015, on fertile Asian men. In the reports of Carlsen *et al.*, no overall declining trend in Asian men ($r = 0.509$, $P = 0.760$) was observed during this tenure, but non-Carlsen reports showed a significant time-dependent decline of sperm concentration ($r = -0.754$, $P = 0.005$) in Asian men. This present review also showed a mild time-dependant decline in sperm concentration ($-0.44 \times 10^6/\text{mL}/\text{year}$, 95% CI: -0.65 to -0.23 ; $r = -0.473$, $P = 0.040$) which accounted for an overall 22.17% decrease in past 50 years. **Conclusions:** This study brings to the forefront that sperm concentration among Asian men follows a mild declining trend over the period of 50 years, and further studies addressing the causes of this decline are required.

1. Introduction

The declining trend of semen quality over past few decades is one of the most concerned issues of men's health. This not only reflects upon male reproductive health but also indicates a threat to the mankind and upcoming generations as a whole. In 1974, Nelson and Bunge brought this alarming trend to the forefront for the first time[1]. Then in 1992, in a report of 61 studies, Carlsen *et al* found a global diminution in sperm counts by about 50% between 1938 and 1990[2]. In that study, they recorded significant declines in sperm count in the United States, Europe, and Australia with no such trend in non-Western countries. After this report, in 1997 Swan *et al* published a study where they reanalysed 56 studies confirming a significant deterioration in sperm density in the United States and Europe only[3]. Further in 2000, in an analysis of 101 studies, Swan *et al* had established the decline of sperm concentration in the phase

of 1934 to 1996[4]. Subsequently in 2013, Rolland *et al*[5] reported 32% diminution in sperm count between 1989 and 2005. A plentiful retrospective evaluations of laboratory semen records have indicated a decrease in semen quality as reported from Belgium[6], Canada[7], Finland[8], France[9], Greece[10], Norway[11], Scotland[12], the USA[13,14] and the UK[15], while no variations have been reported from regions such as Denmark[16], Israel[17] and Australia[18]. But, this is still unconvincing considering the global temporal trends.

The above discussed studies have helped to construct a portrait of the global trend of sperm concentration as well as the drift which research had been following to put forth such information. But whenever the orientation of the trend of sperm concentration among Asian men population comes to the forefront, it remains

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barely answerable as only a trivial number of such studies have been performed in non-Western countries including Asia. The first document regarding altered sperm concentration of Asian population after 1965 was put forth by Bhushan *et al* in 1978[19]. During 1965-1977, there was no study recounting altering sperm concentration in Asian men, however, after 1978, several research articles began to emerge with retrospective analysis of sperm concentration. The first duration analysis was published by Benshushan *et al* in 1997 reporting semen quality of 188 subjects for the duration of 1980-1995[17]. Followed by this report, Zhang *et al* in 1999 reported semen quality of 9 292 Chinese fertile men for the duration of 1983-1996[20], the report by Almagor *et al* in 2003 included 2 638 males from Jerusalem from the couples who attended infertility clinic for intrauterine insemination for the period of 1990-2000[21], Liang *et al* in 2008 reported semen quality of fertile 5 834 Chinese men for the duration of 1980-2005[22], the report by Haimov-Kochman *et al* in 2012 included the semen quality of 2 182 young, healthy, fertile Israeli men for the duration of 1995-2009[23] and very recently Huang *et al* in 2017 reported semen quality of 30 636 fertile Chinese men for the duration of 2001-2015[24]. In the report of Huang *et al*, they have indicated a decline of sperm concentration from $68 \times 10^6/\text{mL}$ to $47 \times 10^6/\text{mL}$ is past 15 years[24].

Thus, from these scanty and scattered studies regarding Asian trend of sperm count, it can be perceived that it has become crucial on scientific as well as social perspectives to have clear information regarding the trend of altering sperm count among Asian men. Thus, the objective of this report is to build-up a considerable idea concerning the trend in alterations of sperm concentration in fertile Asian men by picking all the available reports, of Carlsen *et al* (for studies before 1990) and non-Carlsen new studies (post-1990), over 50 years, moulding them in sequential pattern.

2. Methods and materials

Research articles on fertile men published in English-language from 1965 to 2015 had been considered. The data of Carlsen *et al*. *i.e.* reports from 1965 to 1990[2] and non-Carlsen new studies

(post-1990, until 2015) were included. The study opted randomized selection criteria for reports on sperm concentration, with predefined standards for inclusion and exclusion, as follows: (1) Non-Carlsen studies between 1990 and 2015 were identified in electronic databases including Medline, National Library of Medicine, Bathesda, MD with the Medical Subject Headings key words: semen quality, sperm concentration, sperm count, sperm density and semen analysis; (2) Relevant literatures on variations of the sperm concentration were retrieved; (3) Studies involving fertile men aged between 17 and 55 years were considered; (4) Data of the infertile patients were excluded; (5) Studies with sample size (n) of less than five ($n < 5$) were excluded. Following Meta-analyses of Observational Studies in Epidemiology guidelines[25] and Preferred Reporting Items for Systematic Reviews and Meta-analyses checklist[26], the present study extracted the data using the above mentioned electronic databases. The present study recorded a total of 38 studies published between 1965 and 2015 regarding semen quality in Asian men from the above-mentioned databases. From these reports, a total of 27 studies were excluded: (1) with infertile men ($n=6$); (2) not dealing with sperm count ($n=6$); (3) in non-English language ($n=2$); (4) with less sample size ($n=7$); (5) interval studies recorded alteration in sperm count ($n=6$, [17,20-24]). In addition, two studies[19,28] from Carlsen *et al*[2] were included. Thus, the present review was based on 13 Asian studies published between 1965 and 2015. In each case, the outcome of the report for sperm concentration was evaluated. The review applied univariate and multivariate linear regression analyses by weighted least squares method (for sample size) considering the entire data, and on studies from Carlsen *et al* and non-Carlsen separately. Statistical significance of trends, if any, was recorded[27].

3. Results

The outcome of the 13 studies on alterations of sperm concentration in Asian men over the past 50 years was represented in Table 1[19,28-39]. Most of the reports were grounded upon andrology laboratories (48.85%), and others included epidemiological studies (38.56%) and

Table 1
Studies on changes of sperm concentrations in Asia (1965-2015).

Country	Population	Sample size (n)	Male age definition (range/ mean/ group, in years)	Direction of effect with increasing age	Author	Reference No.
India	Small-scale study	66	17-21	↓ ($P < 0.001$)	Brushan <i>et al.</i> , 1978	[19]
Thailand	Andrology lab	307	19-50	↓ ($P < 0.050$)	Aribarg <i>et al.</i> , 1986	[28]
Israel	Sperm donors	1 283	34.3 (0.2)	↑ (NS)	Singer <i>et al.</i> , 1990	[29]
China	Andrology lab	19	20-45	↓ ($P < 0.010$)	Zhong <i>et al.</i> , 1990	[30]
Saudi Arabia	Andrology lab	50	No age data	↓ ($P < 0.050$)	El Shoura <i>et al.</i> , 1995	[31]
Israel	Sperm donors	188	18-53	↓ ($P < 0.000$)	Benshushan <i>et al.</i> , 1997	[32]
India	Cohort study	97	22-50	↓ ($P < 0.005$)	Marimuthu <i>et al.</i> , 2003	[33]
India	Andrology lab	368	25-50	↓	Pal <i>et al.</i> , 2006	[34]
Japan	Cohort study	324	25-40	↓ ($P < 0.000$)	Iwamoto <i>et al.</i> , 2006	[35]
India	Andrology lab	3 729	A. 33 B. 35 (of two decades)	↓ ($P < 0.005$)	Mukhopadhyay <i>et al.</i> , 2010	[36]
Korea	Andrology lab	1 139	A. 19-27; B. >54	↓	Bahk <i>et al.</i> , 2010	[37]
Japan	Cohort study	792	20-45	↓ ($P < 0.010$)	Iwamoto <i>et al.</i> , 2013	[38]
China	Cohort study	1 213	No age data	↓	Tang <i>et al.</i> , 2015	[39]

↓ =decrease; ↑ =increase; NS=not significant at $P < 0.05$; no P value indicates that no statistical testing was done.

data from healthy sperm donors (15.39%). Among the 13 published research studies discussed in this review article from 1965 to 2015, most were executed in India, China and Japan. Most of the studies had sample size of less than 500 men (61.54%) and four studies included sample size more than 1 000 men (30.76%). About 84.61% of these reports had data about age of the subjects; 92.30% had depicted significant decrease in sperm concentration from 1965 to 2015.

Separate evaluation of Carlsen and non-Carlsen studies by univariate linear regression there was no significant change in Carlsen data from 1965-1995 among Asian men ($r = 0.509$, $P = 0.760$), but non-Carlsen data revealed a significant decline with time ($r = -0.754$, $P = 0.005$) (Figure 1A). The study identified a time-dependent declining trend in sperm concentration of $-0.44 \times 10^6/\text{mL}/\text{year}$ (95% CI: -0.65 to -0.23 ; $r = -0.473$, $P = 0.040$) which accounted for an overall 22.17% decrease in mean sperm concentration in past 50 years (Figure 1B).

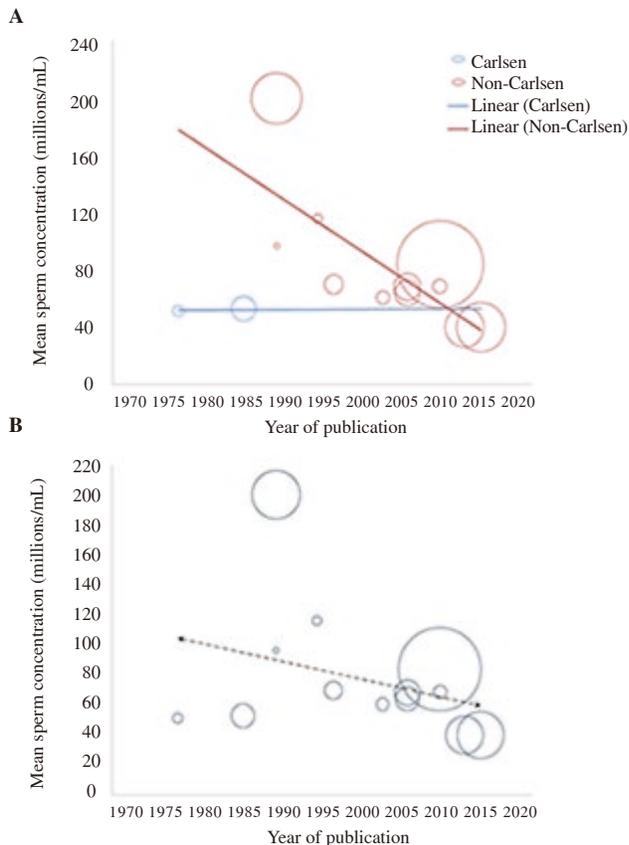


Figure 1. Sperm count.

(A) Sperm count in Asian men in Carlsen and Non-Carlsen studies; (B) Trend sperm count with time in past 50 years. Bubble size corresponds to the number of men in the study.

Figure 2 was describing the alterations in past five decades with the present World Health Organization (WHO) cut-off value of

sperm concentration. It revealed that despite being higher than the WHO range, this declining trend should be considered as a matter of concern of fertility among Asian men.

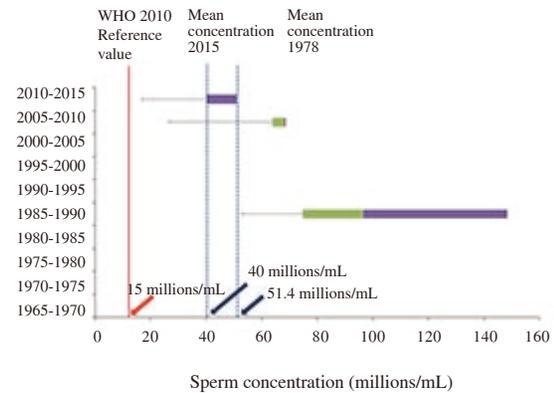


Figure 2. Changes in sperm concentrations ($\times 10^6/\text{mL}$) from 1965 to 2015 shown as box-and-Whisker plots.

4. Discussion

Review of the data of these studies suggests that the sperm concentration of Asian men is showing a mild declining trend in past 50 years, *i.e.*, 1965-2015. It is also similar with the trends in regional findings from India[19,33,34,36], China[30,39], Israel[29,32] and Japan[35,38]. Carlsen *et al*[2] reported the trend in all continents up to 1992, but there were very few studies on Asian population in that report within our selected range. These reports were not describing any significant trend in sperm concentration decline among Asian men. But while reviewing the non-Carlsen reports up to 2015, which were much higher in numbers, a very significant decline was observed. Most of these reports came up from India, China and Japan. Other studies, conducted in Thailand[28], Saudi Arabia[31], and Korea[37], also reported the same trend. Only one study from Israel failed to demonstrate a time-related decline in semen quality[29].

A very recent study on Chinese fertile men has shown that their sperm concentration has been decreasing over past 15 years. It declined from $68 \times 10^6/\text{mL}$ to $47 \times 10^6/\text{mL}$ from 2001 to 2015[24]. One more very recent large-scale cross-sectional update on sperm concentrations of Japanese men, Iwamoto *et al*[38] in 2013 reported a severe decline in sperm concentration in almost all provinces in Japan, including Sapporo, Osaka, Kanazawa and Fukuoka. They also reported that the present mean sperm concentration of Japanese was $18 \times 10^6/\text{mL}$ which was very near to WHO reference value of 2010 ($15 \times 10^6/\text{mL}$)[35]. Recently, one of the reports indicated a significant worldwide reduction in sperm concentration between 1980 and 2015 from $91.65 \times 10^6/\text{mL}$ to $39.34 \times 10^6/\text{mL}$ ($r = -0.313$, $P = 0.0002$). It has reflected almost 57% decline in sperm count worldwide from 1980. It also showed that recruitment of larger population for this

type of study has been increased predominantly after 1995, which is also found in this study[40]. The present study also reported declining trend of sperm count in Europe[41] and Africa[42], which suggested the biologically meaningful declining trend in global sperm counts. Conversely, a recent review from Cocuzza and Esteves revealed that evidences of confirmation of global decline in semen parameters are not enough[43]. Inquisitively, some analyses put forth that semen quality has neither declined nor remained steady, while slightly increased in the recent years[29,44]. Nonetheless, follow-up studies are essential to inspect whether the mentioned observation is an actual phenomenon or completely random variation. The possible causes of the decreasing sperm concentration were also mentioned[40]. The increased frequency of abnormalities in male reproductive may reflect adverse effects of environmental or lifestyle factors, like occupational and environmental exposures, sexually transmitted diseases and medications[45–48]. These factors play a key role in determining reproductive health and can influence fertility. Spanning the last few decades, progressive changes have been observed in aspects of diet, lifestyle and environment owing to which incident of male infertility has reportedly enhanced. Lifestyle factors such as alcohol intake, tobacco smoking, smokeless tobacco chewing, use of some modern electronic gadget *etc.* have heavily adverse effect on general health. These may interfere with spermatogenesis, spermiogenesis, sperm motility, integrity of sperm DNA and chromatin, hormonal regulation or by decreasing the fertilizing capability of spermatozoa. In previous reports, the root causes of this trend in declining semen quality were also indicated, highlighting on the effects of several lifestyle factors on male reproductive health[45–48]. In 2006 Iwamoto *et al*[35] specified that the low level of sperm concentration in fertile Japanese men may be the consequence of modifications in lifestyle or environmental factors. They also indicated the likelihood of ethnic differences owing to genetic variation or combinations[35].

The expansions and demanding agricultural and industrial activities worldwide, together with environmental abuse, are risk to the health of entire population. Recently, the effect of pollutants and occupational factors on reproductive health has been a matter of debate. Undeniably, environmental pollutants such as pesticides, lead, methylmercury, welding, endocrine-disrupting compounds, organic solvents, radiation, household glues, *etc.* may affect reproductive male function[49–51]. Alteration of the male reproductive health may due to effects on the endocrine control of reproductive system[52,53] or by direct effect on spermatogenesis[46,54]. However, a likely mechanism led to undesirable pregnancy outcomes owing to paternal susceptibility to organic solvents affecting sperm DNA directly, generating mutations and chromosomal abnormalities[45]. Mehta *et al*[55] in 2006 reported the cause of azoospermia and oligozoospermia in Indian male by analyzing the sperm count data from four major cities of India. They reported exposure of high concentration of fluoride and pesticides in some parts of India causing decreased serum testosterone level in men which resulted in low sperm production among Indian men[55].

As is known, Asia is the continent with wide cultural diversity; it is very difficult to find out a single possible cause of this trend. It is not clearly perceived how do ethnic and genetic backgrounds lay their influence upon semen quality. But, the correlations between prevalence of testicular cancer and ethnicity, as well as testicular cancer and altered germ cell formation were well known[56]. Though it has been published in a recent report that India and China has the lowest incidence of testicular cancer over last two decades[57], it is also known that other Asian countries are showing increasing trend of incidence of testicular cancer[58]. Lower testis parenchymal weight, lower sex steroid levels and lower testosterone production rate have been reported as the most common contributors of low sperm concentration in Asian men[54]. As testified by Iwamoto *et al* in 2013, Japanese men are suffering from low blood testosterone level and that is the major causative agent of low sperm concentration in Japanese men[38]. Age is also one of the contributing factors. A recent study has shown age-related changes in semen quality in Chinese men. It reported that men with age of more than 35 are having less sperm concentration than younger men[59].

The conceivable drawbacks of this study are: (1) since retrospective studies were carried out using sperm concentrations data, information on potential confounders, such as food habits, smoking, occupation of the subjects, and level of stress, could not be procured; (2) as per Velde and Bonde in 2013 on decreasing sperm counts and fertility in Europe[60], the present study is not claiming this decrease in sperm concentration in Asian men is the sole cause of declining fertility rate of them. There are innumerable factors which can contribute to reduced fertility rate[40,61–63]. Thus, from this present study, it cannot correlate the contributing factors of declining sperm concentration in Asia in past 50 years as well as cannot claim this is the cause of decreasing fertility in Asian countries. Following this review, future prospective studies including representative samples addressing life-style, occupational and other related factors from each region in general population are required to be sanguine that whether sperm concentration is still deteriorating in Asian countries.

In conclusion, this review has converged the dispersed data from the published articles to show a mild declining trend of sperm count in Asian countries, demonstrating an overall 22.17% decline in sperm concentration in Asian men over past 50 years. Sperm concentration has been found to be declined from $51.4 \times 10^6/\text{mL}$ to $40.0 \times 10^6/\text{mL}$. There are scarce evidences for the influence of environmental factors and life style on semen quality. This review implies the fertility status of Asian men and accentuates the necessity for further analytical reports focusing on life-style and other factors with the aim of finding the proper correlation of this declining trend of sperm count with the causative agents.

Conflict of interest statement

The authors declare that they have no conflict of interest.

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