

Decline in Human Sperm Counts during the Past 50 years?

Srinivasa Jayachandra, Maxim Pinto, Urban JAD Souza

Abstract

There is widespread concern that environmental pollutants acting as xenoestrogens may affect human fertility adversely. Whether this has already made an impact on human fertility worldwide remains debatable at the present stage. Ever since Carlsen's analysis reported that sperm concentrations have decreased over the last 50 years there has been renewed attention and curiosity amongst peer groups in different parts of the world. Though Carlsen's mode of data analysis was criticized on many fronts, a number of similar studies that appeared subsequently have contradicted each other. The article has reviewed the literature to determine whether semen counts have indeed changed in the past 50 years. We conclude that sperm counts vary enormously between different countries or regions of the world and also between individual men. There is even marked variation between counts on the same men. It is therefore not surprising that not all analyses of sperm counts find the same patterns. We suggest that a well-designed prospective study should be performed in several different regions of the world in order to extrapolate the results on sperm counts and to evaluate the potential effect of external factors on male reproductive health. It is hoped that the conclusions from these new studies might put an end to the controversy that surrounds this issue.

Key words

Sperm count, male infertility, sperm quality

Srinivasa Jayachandra MD*

Department of Medical Bioscience Monash University Malaysia,
Petaling Jaya, Malaysia
Email: sjayacha@monash.edu.my

Maxim Pinto MCA

Wipro Technologies, Bangalore, India

Urban JAD Souza PhD

School of Medicine, University of Malaysia Sabah, Malaysia

*corresponding author

Introduction

There is controversy in the scientific world regarding the possible decline in human sperm count during the past 50 years. Such decline was already suggested in the early seventies following studies in the US. In 1992, a meta-analysis of 61 articles published by Carlsen et al. concluded that the mean sperm count of healthy men had declined by 1% per year over the previous 50 years. From 1995 onwards, some retrospective, longitudinal analyses of sperm counts of fertile or infertile men contradicted Carlsen's findings while others did not.¹ Researchers have also hypothesized that the possible reason for such a decline in sperm count might be caused by xenoestrogens. Although xenoestrogens are chemicals unrelated to the female sex hormone estrogen, they exert similar chemical effects as estrogens. Some examples of these "estrogen mimics" are Polychlorinated Biphenyls (PCBs), DichloroDiphenylTrichloroethane (DDT), other pesticides and industrial pollutants. This article attempts to address the controversy surrounding the postulated decline in sperm counts over the past 50 years.

Supporting Evidence for a decline in sperm counts

The first widely publicised study regarding the trends in human sperm counts over the last half-century, was carried out by Elisabeth Carlsen and a team of Danish scientists. Carlsen and her colleagues performed a meta analysis of the results of over 61 studies of sperm counts published between 1938 and 1991. Using a model which assumed that sperm count changes over time in a linear way, the results of the meta-analysis indicated average sperm counts declined from 113 million per milliliter (ml) of semen to 66 million per ml during the half century for which they had data (Figure 1).² The results obtained suggested that if such a decline were to continue, then the propagation of the human race would be jeopardised in the next century.

Ever since Carlsen's study was published, three other studies have found similar declines in sperm counts in smaller groups of men. Researchers at the University Hospital in Ghent, Belgium, found that counts among their sperm donors had declined about 10 million per ml between 1977 and 1994.³ At Scotland's Centre for Reproductive Biology in Edinburgh, Stewart Irvine found that median sperm counts among its sperm donors had declined by about 40 percent when he compared

men born in the 1940s with men born in the late 1960s.⁴ At a sperm bank in Paris, France mean sperm counts among donors declined by about 2 percent per year from 1973 to 1992, with total decline of 32 percent.⁵ Older studies from different places have also shown a similar pattern: sperm counts in Washington D.C. dropped about 25 percent during the 1980s¹⁰ and sperm counts in Denmark dropped about 25 percent between 1952 and 1972.⁴

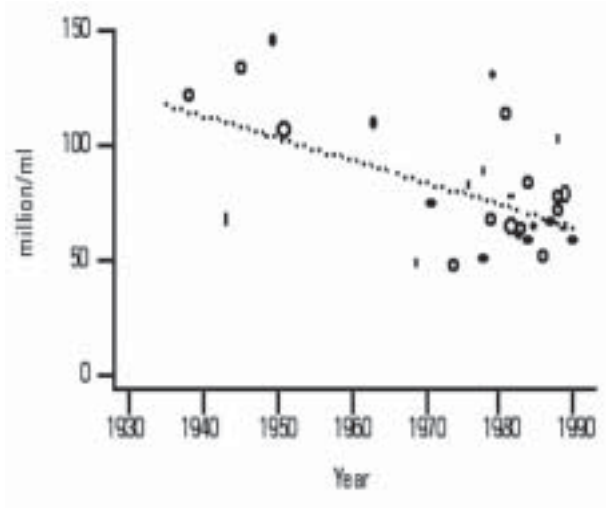
Perhaps of greater concern, was the fact that these studies found that other measures of sperm quality (such as sperm motility) deteriorated. Carlsen's study found that semen volume decreased by about 20 percent. In addition, the proportion of men with sperm counts below 20 million per ml tripled. The Belgian study found that both the proportion of abnormal sperm and their motility decreased during the last 20 years.³ The French study had similar results.⁵ Swan *et al* performed a reanalysis of the data from the 61 studies analysed by Carlsen. Multiple linear regression models (controlling for abstinence time, age, percent proven fertility, specimen collection method, study goal and location) were used to examine regional differences and the interaction between region (United States, Europe, and non-Western countries) and year. Results from this reanalysis showed that there was a decline in sperm density seen in the United States (studies from 1938-1988) and Europe (1971-1990), but not in non-Western countries(1978-1989).⁶

Again, older studies have shown similar results. In a Danish study, carried out between 1952 and 1972 the proportion of sperm with abnormal morphology increased (from 26 percent to 45 percent) and sperm motility decreased⁷ and in Oslo, Norway, the proportion of abnormal sperm rose from 40 percent to 59 percent between 1966 and 1986.¹¹ Further evidence of a large-scale problem comes from studies of other male reproductive disorders. The incidence of testicular cancer has increased as much as 3 or 4 times since the 1940s, whilst the incidence of undescended testes and other anatomical abnormalities of male genitals also seems to have increased.¹²

Evidence against a decline in sperm counts

In 1995 Olsen *GW et al*⁸ reanalyzed the data and the linear model that was used to predict a reduction in sperm counts of approximately 50% in the last 50 years. They argued that the published linear regression model was inappropriate. Potential pitfalls in using the linear regression model included (1) the potential selection biases that may have occurred with the 61 assembled studies such that they were not representative of their underlying populations; (2) the likely variability in collection methods, in particular, the lack of adherence to a minimum prescribed abstinence period, as has been stated for the largest study, which contained 29.7% of all the subjects included in the analysis; (3) the paucity of data in the first 30 years of the 50-year trend analysis; (4) the fact that if the last 20 years of data were examined, which contains 78.7% of all the studies and 88.1% of the total number of subjects, there was no decrease in sperm counts but in fact the sperm counts were observed to

Figure 1: Linear regression of mean sperm density reported in 61 publications (represented by circles whose area is proportional to the logarithm of the number of subjects in study), each weighted according to number of subjects, 1938 to 1990. Data from Carlsen *et al*²



have increased; (5) the conflicting data from a large individual laboratory, which was not subject to the variability in collection methods that occurred in the 61 studies. This large laboratory did not show a decline in mean sperm count or seminal volume during a comparable time period. It is interesting that this same laboratory generated the data that resulted in the high historical values in the linear model; and, most importantly, (6) the variety of other mathematical models that perform statistically better at describing the recent data than the linear model and thus offer substantially different hypotheses. A Japanese study also concluded that there was no evidence of deterioration in sperm counts of normal healthy men who lived in the Sapporo area of Japan over a 20 year period. However, they also mentioned that selection bias in the recruitment of volunteers and the issue of variable abstinence might have affected the results of these studies.⁹ Yet in another recent study in the United States, there was no reported decline in sperm density in men presenting for a screening of semen analysis.¹³

Jouannet *et al* have stated that the amplitude of the difference observed regarding the postulated decline in sperm count could be attributable to ethnic, genetic or environmental factors rather than methodological or confounding factors.¹ It is unfortunate that many of the published studies do not adequately describe population characteristics and different confounding factors. This together with study designs that did not apply standardized methodology and quality control makes it difficult to reach definite conclusions regarding changes in sperm counts around the world.

Conclusion

The significant variability in sperm counts in different countries or regions, as well as inter- and intra-individual

variability in counts in men from a particular region make studies related to changes in male fertility with time complicated. There is a need for well-designed prospective randomised studies in several different regions in order to determine changes on sperm counts and subsequently to evaluate the potential effect of external factors on male reproductive health. Sperm concentration, morphology and motility need to be assessed using a standardised method with the use of external and internal quality control indicators. Whether the decline in sperm counts observed by Carlsen and others is in fact a world wide phenomenon or whether it is restricted to only certain geographical areas remains to be confirmed.

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