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Geographic variations in sperm counts: a potential cause of bias in studies of semen quality

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Objective: To determine whether geographic variations in sperm counts might bias conclusions drawn from studies of semen quality.
Design: Reanalysis of published data from a meta-analysis of 61 studies from 1938 to 1990 that concluded a worldwide decline in semen quality over the last 50 years.
Main Outcome Measures: Influence of geographic location on sperm counts.
Results: Of 61 studies in the meta-analysis, only 20 included ≥100 men. These 20 studies collectively comprised 91% of the total men studied. We focused our reanalysis on these 20 studies. Of the studies before 1970, all were from the United States and 80% were from New York. These studies represented locations with the highest sperm counts. In contrast, after 1970, 80% of the studies were from locations not represented earlier, including five studies from third world countries, where sperm counts were low.
Conclusions: Sperm counts vary dramatically among different geographic locations. Geographic variations in sperm counts need to be considered when analyzing data from different locations. Fertil Steril 1996;65:1044–6

Key words: Sperm counts, geographic variation

In 1992, Carlsen et al. (1) presented evidence for a worldwide decline in semen quality in presumably fertile men over the last 50 years. The investigators performed a meta-analysis of 61 studies published between 1938 and 1991 comprising 14,947 men from 23 different countries. Using linear regression, they found that mean sperm counts had decreased almost 50% from 1940 to 1991, from 113 $\times$ 10^6/mL to 66 $\times$ 10^6/mL, respectively. This meta-analysis has been criticized in many ways. First, because each of the 61 publications used different protocols for semen analysis and had different inclusion criteria, there were methodological inconsistencies and patient selection biases (2, 3). Second, the use of linear regression analysis was criticized because there were relatively few data points from 1938 to 1970 and because the data did not fit well for this statistical method (3, 4). Finally, the authors were criticized for implicating an environmental toxin in the etiology of this decline without sufficient evidence for this effect (3). We suspected, however, that geographic variations in sperm counts may have played the most important role in causing these conclusions to be biased. To determine whether this hypothesis was accurate, a reanalysis of the data by Carlsen et al. (1) was performed.

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MATERIALS AND METHODS

The 61 studies included in the Carlsen et al. (1) meta-analysis were reviewed and geographic origin of the study, the number of men studied, and year

Table 1 Geographic Location, Number of Men Studied and Mean Sperm Counts Listed Chronologically*

Study no.	Reference from Carlsen (1)	Year of publication	Geographic location	No. of men	Mean sperm count
					$10^6/mL$
1	12	1938	United States—New York	200	120.6
2	10	1945	United States—New York	100	134.0
3	18	1950	United States—New York	100	100.7
4	19	1951	United States—New York	1,000	107.0
5	21	1963	United States—Washington State	100	110.0
6	25	1971	Germany	100	74.4
7	1	1974	United States—Iowa	386	48.0
8	27	1975	United States—New York	1,300	79.0
9	35	1979	Brazil	185	67.6
10	42	1982	United States—Texas	4,435	66.0
11	46	1983	France	809	102.9
12	47	1983	Libya	1,500	65.0
13	48	1984	Australia	119	83.9
14	49	1984	Greece	114	72.0
15	53	1985	Hong Kong	1,239	83.0
16	57	1986	Thailand	307	52.9
17	56	1986	Nigeria	100	54.7
18	58	1987	Tanzania	120	66.9
19	67	1989	United Kingdom	104	91.3
20	68	1989	France	1,222	77.7

* Adapted from Carlsen et al. (1), including only studies with ≥100 men.

of publication were noted. The number of men included in each individual study varied widely, from as few as 7 to as many as 4,435. The meta-analysis evaluated 14,947 men included in studies published from 1938 to 1990. Reanalysis of the data by Carlsen et al. (1) revealed that only 20 of 61 studies had ≥100 men each and, collectively, comprised 13,540 men, or 91% of the total studied. We focused our investigation on these larger 20 studies. The remaining 41 studies comprised only 9% of the total and, because they contained so few men each, were not included in our analysis of geographic variation of sperm counts.

RESULTS

Table 1 presents mean sperm counts, geographic location, and number of men studied, in chronological order. From 1938 to 1970, there were only five studies with ≥100 men. All of these studies were from the United States: four from New York and one from Washington State. Of the studies with the highest sperm counts, five of the top six were these studies from the United States.

In contrast, after 1970 there were 15 studies with ≥100 men. Only three were from the United States, and only one of these was from New York (study 8). Of the studies from the United States, sperm counts were lowest in Iowa and Texas. Of the studies with the lowest sperm counts, five of seven were from third world countries, all of which were published after 1970.

DISCUSSION

We are not the first to report a marked geographic variation in sperm counts. Mcleod and Wang (5), as well as Smith and Steinberger (6), have described variations in sperm counts from New York, Texas, Iowa, and Philadelphia, with New York values being highest and Iowa values being lowest.

Carlsen et al. (1) describe a meta-analysis of sperm counts from around the world over a 50-year period. In our reanalysis of this data, sperm counts varied dramatically among the different studies from a low of 48×10^6 sperm/mL to a high of 134 $\times 10^6$ sperm/mL. Why did sperm counts vary so much among the different studies? Is it that sperm counts truly have deteriorated over time, or is it that sperm counts vary widely among different geographic locations? Earlier studies were from the United States, particularly from New York, where sperm counts are highest. In contrast, later studies were from areas that were not represented earlier and included several studies from third world countries where sperm counts were low. In other words, studies from markedly different locations were compared over time. The differences in semen quality described among the different studies simply may reflect the clustering of significant geographic variations rather than a decline over time. Interestingly, Carlsen et al. (1) state in their Discussion: "Theoretically, selection bias due to geographical and racial differences could account for the decrease in sperm counts."

Why geographic variations in semen quality exist is unclear but may be due to environmental, nutritional, socioeconomic or other unknown causes. Our conclusions based on this reanalysis of the data by Carlsen et al. (1) could, of course, be criticized for the same reasons that the original meta-analysis was—namely, differences in methodologies for semen analysis and patient selection for each of the studies. However, those questions aside, differences in semen quality among the different studies described by Carlsen et al. (1) can be explained by inherent geographic variations in sperm counts. We found that substantial geographic differences in sperm counts are evident worldwide and therefore need to be considered when analyzing data from different locations over a finite period of time.

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