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DECLINING SPERM COUNTS IN THE UNITED STATES? A CRITICAL REVIEW

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ABSTRACT

Purpose: Recent reports suggest declining sperm counts in the United States. These reports did not include all available data and did not account for geographic variations noted in prior studies. We examined all available data on U.S. sperm counts and evaluated whether geographic variations account for the decline suggested.

Materials and Methods: We reviewed all 29 U.S. studies from 1938 to 1996 reporting manually counted semen analyses of 9,612 fertile or presumably fertile men. We determined mean sperm concentrations by geographic location with weighted analysis of variance, and assessed any changes with time by linear regression analysis.

Results: Mean sperm concentrations from New York were significantly higher than from all other U.S. cities (98.6 versus 71.6×10^6 sperm per cc, respectively, $p = 0.006$). There has been no statistically significant change with time for mean sperm concentrations reported from New York ($p = 0.49$) or from U.S. cities other than New York ($p = 0.62$). Analysis without separating by location revealed a decline ($p = 0.047$).

Conclusions: Sperm concentrations are highest in New York compared to other U.S. cities. When accounting for this geographic difference and examining all available data, there appears to be no significant change in sperm counts in the U.S. during the last 60 years. Further studies addressing the causes of geographic variations are needed.

KEY WORDS: sperm count, regression analysis, geography

There has been recent controversy regarding changes in sperm counts during the last 60 years worldwide and within the United States. Carlsen et al reported a worldwide decline in sperm counts in a meta-analysis of 61 studies evaluating the semen analyses of 14,947 presumably fertile men from 23 countries.[1] Fisch and Goluboff noted that most of the early studies in that report were from New York where mean sperm concentrations were higher than the remaining worldwide locations, thus accounting for the presumed worldwide decline.[2] In addition, Fisch et al also reported new data collected from 3 American cities that revealed no decline in sperm concentrations during the last 25 years.[3]

Two recent reports reexamining only the data of Carlsen et al suggest that a decline in sperm counts exists from the U.S. studies alone, and cite that as the reason for the worldwide decline noted by Carlsen et al.[4,5] However, data from Fisch et al,[3] were omitted from both studies, which would have included all available U.S. data, and neither study considered geographic variations in sperm counts within the U.S. We reexamined all available data and determined whether geographic variations might account for perceived changes in sperm counts in the U.S.

MATERIALS AND METHODS

Of the original 61 studies reported by Carlsen et al we reviewed the 28 performed in the U.S.[1] Additionally, we included the study of semen analyses of 1,283 men from 3 U.S. sites published by Fisch et al.[3] Thus, a total of 9,612 fertile or presumable fertile men are included in this analysis. Semen analyses were performed manually in all studies. All available data from U.S. studies to date with the same inclusion criteria as in the meta-analysis by Carlsen et al[1] are included. Data are reported and analyzed by year of publication. We performed univariate and multivariate linear regression analyses using the weighted least squares method (weighted for number of men in each study) of the data as a whole, and on studies from New York and studies from cities other than New York separately. Any statistical significance of trends was assessed. The difference in mean sperm concentrations between the locations was determined by weighted analysis of variance (ANOVA). Analysis of data from New York separately is based on prior evidence that shows New York to have higher mean sperm concentrations than other U.S. cities.[2,3]

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RESULTS

Data from the 29 studies are shown in the table and figure. By weighted ANOVA, mean sperm concentration from New York studies was 98.6×10^6 sperm per cc and was significantly higher than mean sperm concentration of 71.6×10^6 sperm per cc from nonNew York studies ($p = 0.006$). By multivariate linear regression analysis with year and location (New York versus nonNew York) as variables, there was no statistically significant change in mean sperm concentrations with time ($p = 0.84$). Likewise, when separately analyzing New York and nonNew York studies by univariate linear regression there was no significant change in mean sperm concentration for either location with time ($p = 0.49$ and $p = 0.62$, respectively). Linear regression analysis of all studies without accounting for location revealed a decline in sperm concentrations with time ($r = -0.36$, $p = 0.047$).

DISCUSSION

In a meta-analysis of 61 studies Carlsen et al performed linear regression analysis and reported that from 1940 to

U.S. Studies from Carlsen[1] and Fisch[3] et al

Authors	Yr.	Location	No. Men	Mean Sperm Concentration ($\times 10^6$)
Hotchkiss et al	1938	New York	200	120.6
Hotchkiss et al	1941	New York	22	107
Weisman et al	1943	New York	25	66.9
MacLeod et al	1945	New York	100	134
Farris et al	1949	Philadelphia	49	145
Falk et al	1950	New York	100	100.7
MacLeod et al	1951	New York	1000	107
Lampe et al	1956	St. Louis	21	135
Rutherford et al	1963	Seattle	100	110
Zimmerman et al	1964	Houston	50	96.6
Freund et al	1969	New York	13	48.4
Santomauro et al	1972	New York	79	60
Nelson et al	1974	Iowa	386	48
Naghma-E-Rehan et al	1975	New York	1300	79
Glaub et al	1976	Berkeley	13	83.2
Tjoa et al	1977	St. Louis	7	52.7
Rehewy et al	1978	Detroit	33	100.2
Smith et al	1979	Tacoma	50	61.4
Meyer et al	1981	Cincinnati	89	115
Hamill et al	1982	Louisiana	90	76
Tjoa et al	1982	Houston	4435	66
Borghi et al	1983	San Antonio	22	60.3
Lewis et al	1984	Davis	9	58.9
Swanson et al	1984	Virginia	36	59
Heussner et al	1985	Indiana	20	65
Levin et al	1986	Philadelphia	12	68
Giblin et al	1988	Detroit	28	86.6
Welch et al	1988	Connecticut	40	78.6
Fisch et al	1996	Minnesota	662	100.8
		California	221	72.7
		New York	400	131.5

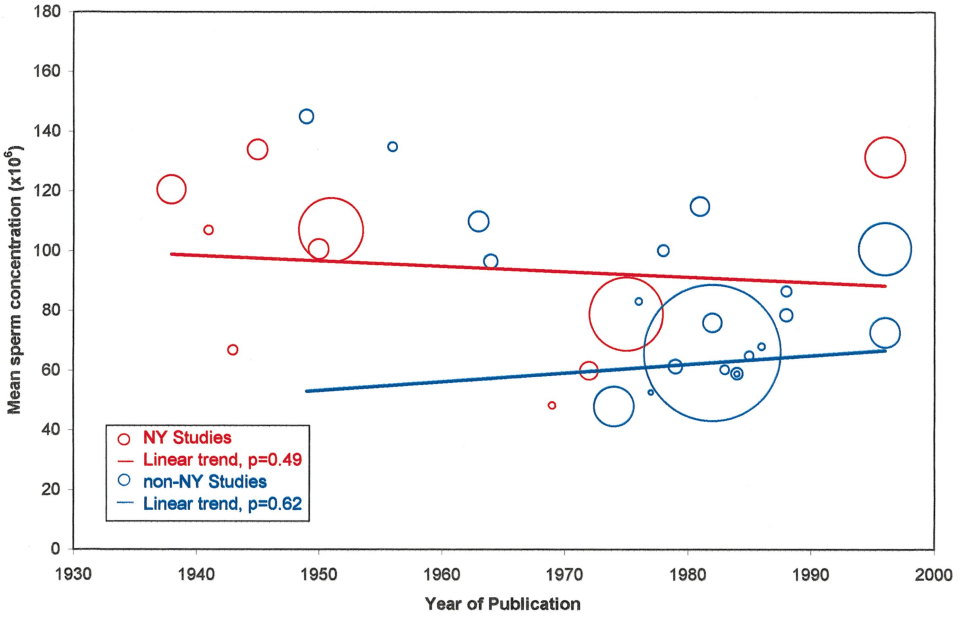
1990 sperm counts had decreased by almost 50% worldwide and implicated environmental factors as a reason for the decline.[1] Fisch and Goluboff noted that 94% of the men studied before 1970 were from the U.S. and that 87% of those men were from New York, whereas after 1970 only 50% of the studies were from the U.S. and only 25% were from New York, where sperm concentrations were noted to be higher than elsewhere in the U.S. and many of the foreign countries.[2] They concluded that worldwide geographic variations accounted for the claim of Carlsen et al.

There has been evidence for geographic variations within the U.S. dating back to the late 1970s. MacLeod and Wang,[6] and Smith and Steinberger[7] described variations within the U.S. with New York having the highest sperm counts compared to such locations as Houston, Iowa and Philadelphia. In 1996 Fisch et al also documented significantly higher mean sperm concentrations of men from New York in a study of 1,283 pre-vasectomy specimens during 25 years from sperm banks in New York, California and Minnesota.[3] No decline in sperm concentrations was found in this group of men.

A statistically significant decline in sperm concentrations is seen in the present analysis when examining all 29 studies without separating by geographic location. However, given the well-established increase in New York sperm counts compared to the rest of the U.S., this decline should be controlled for when analyzing U.S. sperm count data. When New York studies were separated from the others, there was a statistically significant difference in mean sperm concentrations between New York and other locations, and linear regression analysis failed to demonstrate a significant change with time for either group. As with the original meta-analysis of Carlsen et al, because most of the early studies originated from New York and because New York has higher mean sperm counts than the rest of the country, an apparent downward decline appears if the data are not separated.

If sperm counts were truly declining, the implications would be tremendous. The methodology involved in the analyses of nonstandardized sperm count data sets is severely flawed and drawing any conclusions should be viewed with caution. Some of the numerous confounders inherent in any study of sperm counts that might bias results include differences in selection criteria, patient age, abstinence duration, ejaculation frequency, lack of standardized methods of analysis, reporting years of publication rather than years of collection and choice of statistical analyses. Selection biases among the included studies are varied. Some studies included all potential donors to sperm banks, some only accepted donors, some only vasectomy candidates and some only populations of "normal" men at fertility clinics.

Our analysis reasserts the point that statistically significant geographic variations in sperm concentrations exist worldwide and within the U.S. alone, and geographic differences in sperm counts must also be considered as a significant confounder and controlled for in analyses. Studies addressing why sperm concentrations are significantly higher in select geographic populations should be the focus of future



Sperm counts in U.S. Bubble size corresponds to number of men in study

attention. Aside from differences in selection criteria and methodology, there may be differences due to climate, seasons, ethnicity, socioeconomic factors or other unknown reasons that merit further investigation. Our results, which contradict recent reports, reinforce the idea that any definitive claims regarding trends in sperm concentrations must be viewed critically. When including all available data and accounting for geographic differences in sperm concentrations, one cannot conclude that sperm counts are declining in the U.S.

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