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THE RELATIONSHIP OF SPERM COUNTS TO BIRTH RATES: A POPULATION BASED STUDY

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ABSTRACT

Purpose: We determined if a statistical relationship exists between changes in sperm counts and birth rates by comparing data from a single geographic location for a 24-year period.

Materials and Methods: We retrospectively analyzed data from 660 men who banked 1,972 semen samples before vasectomy in Minnesota from 1971 to 1994. Using general linear models, annual variations in sperm count were determined after adjusting for age, duration of abstinence and seasonal (monthly) effects. Adjusted annual mean sperm count was then correlated with regional birth rate data obtained from The National Center for Health Statistics.

Results: Multiple regression analysis revealed a significant linear increase in mean annual sperm count at an estimated rate of 1.03×10^6 sperm per ml. per year ($b = 0.14$, $t = 5.641$, $p < 0.0001$). There was no effect of age ($t = -0.814$, $p = 0.4156$) but there were significant effects of abstinence ($b = 0.14$, $t = 8.808$, $p < 0.0001$) and month of sperm banking ($b = 0.025$, $t = 5.00$, $p < 0.0001$) on sperm counts. Using analysis of covariance there was a significant, nonlinear (year-to-year) fluctuation in mean sperm counts ($F = 8.63$, $p < 0.001$). For the study period mean birth rates in Minnesota (live births per 1,000 population) fluctuated yearly from 13.8 in 1973 to 16.7 in 1981. There was a strong correlation between adjusted mean yearly sperm count and annual birth rates ($r = 0.63$, $p = 0.001$).

Conclusions: We found a statistically significant correlation between yearly variations in mean sperm counts and birth rates. Our data suggest that variations in male reproductive function may affect population based birth rates and, therefore, may be more important than previously understood.

KEY WORDS: spermatozoa, semen, birth weight

Birth rate data have been collected in different regions of the world for centuries. Although the data show marked fluctuations with time,[1–6] to our knowledge the question of whether birth rates are directly affected by variations in sperm counts has not been previously addressed. We determined if a statistical relationship exists between sperm counts and birth rates by comparing data from a single geographic location for a 24-year period.

MATERIALS AND METHODS

A retrospective review of semen analysis data from men who banked semen before vasectomy between 1971 and 1994 at the oldest sperm bank in the United States (Cryogenic Laboratories, Inc., Roseville, Minnesota) was conducted. During this period 660 men banked semen and none was excluded from analysis. Age, sperm count (concentration) and duration of abstinence were recorded for each specimen. Before semen banking all men were asked whether they had ever fathered a child. The fertility status was recorded as proved (if they had fathered a child), unproved (if they had not fathered a child) or unknown (if they did not answer the question). A total of 1,972 specimens was available for study.

The sperm counting technique remained unchanged throughout the study period and was similar to World Health Organization guidelines.[7] Briefly, sperm count was determined by diluting semen 1:50. A 0.01 ml. aliquot of this mixture was placed in a hemacytometer and allowed to stand for 2 minutes. Under high power the number of sperm cells in 8 of the 16 large squares on the corners of the grid was counted. This count was repeated once on 8 different squares and the average of these 2 values was considered the sperm count in millions per ml.

The data were analyzed using statistical computer software. All analyses were conducted at the specimen level except when indicated. Means and standard errors were calculated for sperm counts, age and duration of abstinence before sample collection. To decrease skewness, sperm counts and abstinence periods were logarithmically transformed. Age, duration of abstinence and seasonal (monthly) variations in sperm count were controlled in all analyses at the specimen level. Seasonal fluctuations in sperm counts were adjusted by entering a variable representing month of semen banking, in which month was coded on a scale from highest to lowest mean sperm count. With year of semen banking entered as a continuous variable, multiple regression analysis was used to assess the linear change in sperm count for the 24-year period. A 1-way analysis of covariance, adjusting for the linear change in sperm count associated with year of banking, was used to determine the significance of nonlinear (year-to-year) fluctuations in sperm count.

Birth rate data from Minnesota and the United States as a whole from 1971 to 1994 were obtained from the National Center for Health Statistics.[8] A Pearson product-moment correlation coefficient (r) was used to evaluate the relationship between annual birth rates from Minnesota and the United States, and between annual birth rates and mean yearly sperm counts from Minnesota (adjusted for the effects of other variables in the model using multiple classification analysis).

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RESULTS

Of the 660 men studied 57% had proved fertility, 29% had never fathered a child and in 14% the fertility status was unknown. Mean age at sperm collection for the entire period plus or minus standard deviation was 33.0 ± 0.03 years, which increased from 29.7 years in 1971 to 36.5 years in 1994 ($r = 0.31$, $p < 0.0001$). Mean duration of abstinence at specimen collection was 4.4 ± 0.1 days, which did not change significantly during the study period ($r = 0.04$, $p = 0.34$). Mean sperm count for the entire population was 100.8 ± 0.11×10^6 per ml. After logarithmic transformation, mean sperm count for the 660 men studied was 76.7 ± 0.08×10^6 per ml. Mean sperm count varied greatly by month of banking. In general, mean sperm counts were lowest during the summer months (August and September) and highest during the winter months (February and March, fig. 1).

Multiple regression analysis adjusted for age, duration of abstinence and season (month) revealed a significant linear increase in the mean annual sperm count at an estimated rate of 1.03×10^6 sperm per ml. per year ($b = 0.014$, $t = 5.641$, $p < 0.0001$). There was no effect of age ($t = -0.814$, $p = 0.4156$) but there were significant effects of abstinence ($b = 0.082$, $t = 8.808$, $p < 0.0001$) and month of specimen banking ($b = 0.025$, $t = 5.00$, $p < 0.0001$). Using analysis of covariance, in which these effects were statistically controlled, there was a significant nonlinear (year-to-year) fluctuation in mean sperm counts ($F = 8.63$, $p < 0.001$).

Adjusted annual variation in mean sperm count and birth rate from 1971 to 1994 is illustrated in figure 2. Sperm counts varied markedly, with the highest mean sperm count in 1980 at 123.0×10^6 sperm per ml. and the lowest in 1974 at 46.5×10^6 sperm per ml. Mean birth rate in Minnesota ranged from 13.8 (in 1973) to 16.7 (in 1981) live births per 1,000 population (mean 15.3 for the 24 years). There was a strong correlation between adjusted mean yearly sperm counts in Minnesota and annual birth rates in Minnesota ($r = 0.63$, $p = 0.001$). There was also a strong correlation between mean birth rates from Minnesota and the United States for the study period ($r = 0.53$, $p = 0.007$, fig. 3). Mean birth rate from the United States for the 24-year period was 15.6 live births per 1,000 population.

Data regarding annual conception rates are not available from the National Center for Health Statistics. Therefore, an estimated conception rate was determined by subtracting 1 year from the annual birth rate. We found a statistically significant correlation between annual mean sperm counts and estimated annual conception rate in Minnesota ($r = 0.62$, $p = 0.002$).

To address the issue of independence of observation and to eliminate the influence of individuals banking multiple specimens, a separate analysis was performed in which mean sperm count was determined for each of the 660 men. Adjusting for the effects of age, duration of abstinence and month of banking, analysis of covariance revealed a significant nonlinear (year-to-year) fluctuation in annual mean sperm count ($F = 8.2$, $p < 0.001$). Again, there was a strong correlation between this mean sperm count, and annual birth rates ($r = 0.59$, $p = 0.002$) and estimated conception rates ($r = 0.61$, $p = 0.002$) in Minnesota.

DISCUSSION

We conducted a retrospective review of semen analysis data from all 660 men who banked semen before vasectomy from 1971 to 1994 at a Minnesota sperm bank, the oldest in the United States. To our knowledge this is the longest interval that semen analysis data were collected at a single location in the United States.

Our data revealed that the overall linear trend was an increase in sperm counts from 1971 to 1994. This increase is in contrast with the findings of Carlsen et al, who reported a dramatic worldwide decrease in sperm counts from presumably fertile men from 1938 to 1991.[9] Their study, a meta-analysis of 61 separate studies, has been sharply criticized for geographical and statistical biases.[10–13] When data from the meta-analysis were reanalyzed by Olsen et al, an increase in sperm counts was noted from 1970 to 1990,[10] consistent with our study. Auger et al also reported a decrease in sperm counts in fertile men from Paris from 1973 to 1992.[14] However, they evaluated data only from fertile men accepted as sperm donors, excluding data from fertile men rejected as sperm donors. This major exclusion bias, as well as the selection of sperm donors as study subjects, may account for the differences in results between their study and ours.

While we found an upward trend in sperm counts for the last 24 years, perhaps more significantly, our data revealed that mean sperm counts varied from year to year. In fact, the year-to-year variability was so great that it became apparent that the overall linear trend with time was strongly dependent on the year in which the study was initiated. For example, we initiated our study in 1971, when sperm counts were relatively low and they remained low until 1976. Had we initiated our study in 1977, 1980 or 1984, when mean sperm counts were high, we would have likely reported a decrease in sperm counts with time. Irvine et al recently evaluated sperm counts from Scottish men between 1984 and 1995, and reported decreased values.[15] Because of the potential for

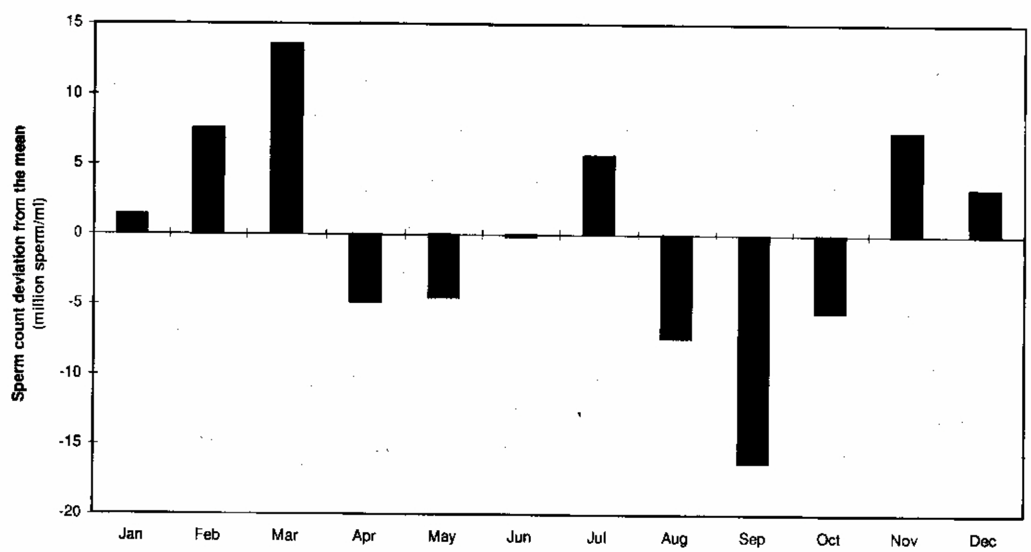

FIG. 1. Monthly variation in sperm count. Adjusted mean sperm count was 76.7 million sperm per ml.

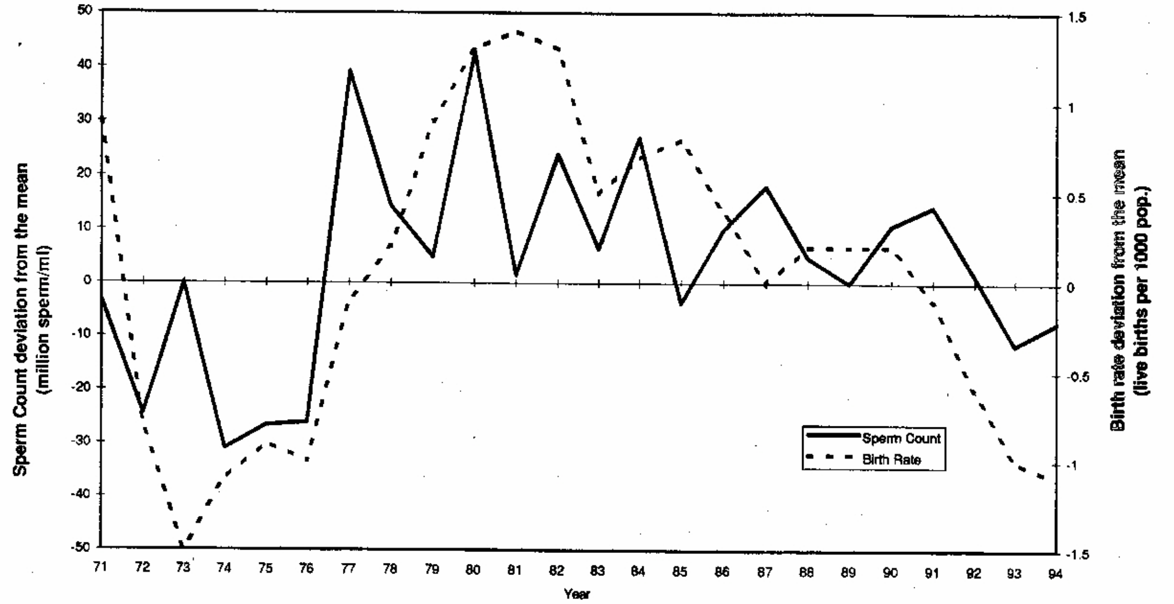

FIG. 2. Correlation of adjusted mean yearly sperm counts to birth rates in Minnesota from 1971 to 1994 (r = 0.63, p = 0.001). Adjusted mean sperm count was 76.7 million sperm per ml. Mean birth rate in Minnesota was 15.3 live births per 1,000 population (*pop.*).

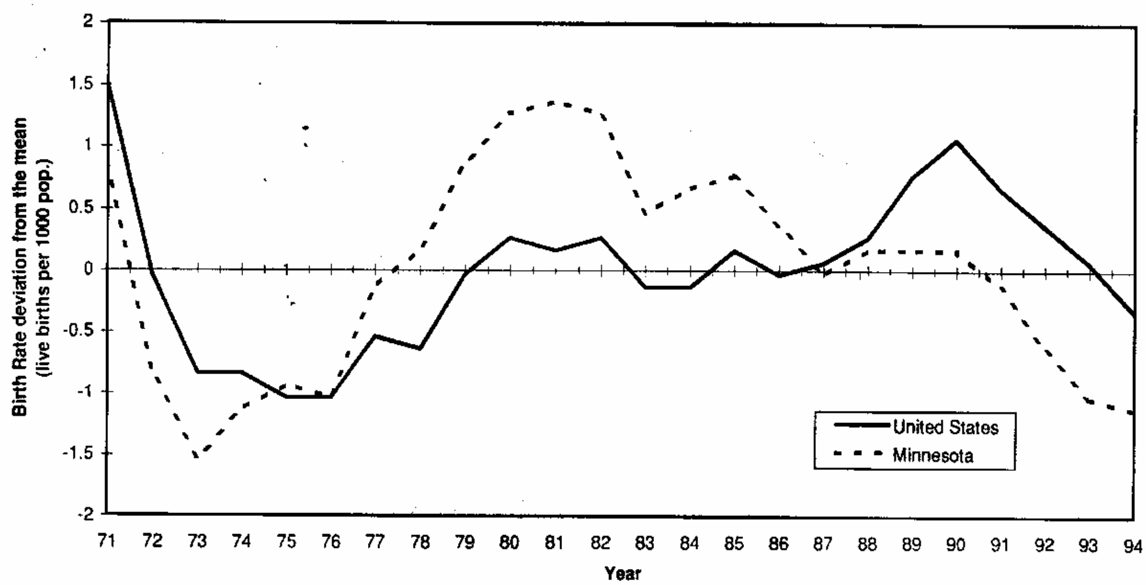

FIG. 3. Correlation of birth rates in Minnesota and United States from 1971 to 1994 (r = 0.53, p = 0.007). Mean birth rates in Minnesota and United States were 15.3 and 15.6 live births per 1,000 population (*pop.*), respectively.

significant yearly fluctuations in sperm counts, it is possible that different conclusions regarding changes in sperm counts with time would be made if more years were studied.

Why sperm counts fluctuate so dramatically from year to year is not known but heat may have a significant role. It is well known that mild changes in scrotal temperatures can decrease sperm counts.[16] Our data, consistent with other reports,[17–19] revealed that sperm counts fluctuate by season, with the highest sperm counts in the winter months and the lowest in the summer months. It is certainly possible that yearly temperature and climate changes may affect annual sperm counts in a similar manner as seasonal changes affect sperm counts.

Similar to sperm counts, fluctuations were also noted in annual birth rates. An analysis of data from the National Center for Health Statistics revealed that birth rates in Minnesota varied dramatically from 1971 to 1994. To determine if these fluctuations were unique to Minnesota, we also evaluated birth rate data from the United States overall and found the fluctuations to be similar. In fact, we found a statistically significant correlation between mean annual birth rates from Minnesota and the United States from 1971 to 1994, suggesting that factors that influence birth rates are not unique to a single location but probably affect different regions in a similar manner.

When we compared mean annual birth rates and sperm counts from Minnesota, we found a statistically significant correlation. It is possible that the changes in birth rates were influenced by changes in sperm counts. Steinberger et al evaluated the relationship between sperm counts and pregnancy in couples, and found that as sperm counts increased pregnancy occurrences increased and the length of time it took to initiate pregnancy decreased.[20] Since sperm counts can influence pregnancy in individuals, perhaps changes in population based sperm counts influence population based birth rates.

CONCLUSIONS

We evaluated the relationship between sperm counts and birth rates from a single geographic location for a 24-year period. Our data revealed that mean sperm counts were subject to marked yearly fluctuation and that yearly fluctuations could easily confound conclusions regarding overall linear trend with time. We also found a strong correlation between mean yearly sperm counts and annual birth rates, suggesting that changes in birth rates may be influenced at least partly by variations in the mean sperm count of a population. We conclude that temporal variations in male reproductive function may have an impact on population based rates of conception and birth. Further study of factors that affect male reproductive function is critical to understand the nature of these relationships.

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