ANDROLOGY

Is There Really a Decrease in Sperm Parameters Among Healthy Young Men? A Survey of Sperm Donations During 15 Years

ABRAHAM BENSHUSHAN,^{1,3} ORLY SHOSHANI,¹ ORA PALTIEL,² JOSEPH G. SCHENKER,¹ and ABY LEWIN¹

Submitted: March 4, 1997

Accepted: March 12, 1997

Purpose: Our purpose was to measure changes in semen quality and quantity in young healthy sperm donors in Jerusalem over time.

Methods: A retrospective analysis of semen parameters over 15 years using linear regression analysis, in a single sperm bank in a tertiary university center. Study population consisted of 188 young, healthy medical students, aged 20 to 30 years, who donated sperm samples for Artificial insemination between 1980 and 1995.

Results: There were no statistically significant changes in semen concentration and motility during the study period. The mean semen volume increased by 0.1 ml (5.1%) per year ($P < 0.0001$), with a concomitant mean rise of 5.8×10^6 (7.7%) per year in total motile sperm count. The percentage normal morphology decreased by a mean of 1.04% per year during the entire period ($P < 0.0001$).

Conclusions: During the past 15 years, there has been an increase in total motile sperm count, secondary to an increase in semen volume, and a decline in normal morphology that are independent of the age and the duration of abstinence in fertile men.

KEY WORDS: geographic and time trend; semen concentration; semen morphology; sperm volume.

INTRODUCTION

In 1929, Macomber and Sanders reported the normal sperm density to be 100×10^6 sperm/ml, based on

the counts of 294 individuals with no regard to their fertility potential. Their conclusion was that men with sperm densities less than 60×10^6 were able to initiate pregnancies (1). Later, several reports confirmed their results. In 1951, MacLeod and Gold's study had set the minimal sperm count of 20×10^6 as a statistically significant important parameter for male fertility; the mean density for fertile man in their study was 107×10^6 (2). Since then, a number of studies have suggested an international decline in semen quality over the last several decades (3–12). Recently, in a meta-analysis of 61 studies worldwide, Carlesen *et al.* reported a trend toward decreasing sperm densities and volume of seminal fluid over the past 50 years (8). On the other hand, other studies (13–16) have shown no decrease in semen quality over the past 20 years. Since geographical and ethnic variations may have impact on the results, we reviewed semen samples obtained in our sperm bank from young, healthy Jewish donors in the years 1980 to 1995.

METHODS

Study Subjects

A retrospective review of 188 first ejaculate samples donated at our sperm bank between 1980 and 1995 was analyzed. Where more than one was donated, the first value for each characteristic was used. The sperm samples were collected by masturbation into wide-mouth plastic containers after 3 or 4 days of sexual abstinence. The donors were all healthy Jewish medical students participating in our AID program. Age at

¹ Department of Obstetrics and Gynecology, Hadassah Medical Center, Ein-Kerem, Jerusalem, Israel.

² Department of Social Medicine, Hadassah Medical Center, Ein-Kerem, Jerusalem, Israel.

³ To whom correspondence should be addressed at Hadassah Medical Center, P.O. Box 12000, 91120 Ein-Kerem, Jerusalem, Israel.

the time of donation ranged from 20 to 30 years. The donors underwent an interview to rule out health problems and genetic and other diseases in the family. A complete physical examination was done. Blood tests for transmissible diseases were done including HIV, VDRL, and hepatitis B and C, as well as blood count and determination of blood group and Rh factor.

Semen Analysis Techniques

In brief, the specimen was allowed to liquefy at room temperature for 30 min. Semen volume was determined using a graduated pipette. Five microliters of semen was placed in the center of a Makler Chamber (Sefi-Medical Instruments Ltd., Haifa, Israel) and covered with a cover glass. Sperm density, motility, and percentage of morphologically normal spermatozoa were evaluated as described previously.

During the 15 years of the study, all sperm analyses were performed by the same technician.

Statistical Analysis

The data were analyzed using SPSS statistical computer software (SPSS, Inc., Chicago, IL). Means and

standard errors were calculated for sperm concentration, semen volume, total motile sperm count, motility, and morphology. Linear regression analysis was used to assess the changes in semen characteristics. The narrow age range (20 to 30 years) and comparatively similar duration of abstinence (3 or 4 days) should eliminate the confounding effects of these parameters.

RESULTS

The mean volume of seminal fluid was 2.83 ± 1.02 ml and the volume increased by a mean of 0.1 ml (5.1%) per year (Fig. 1), from 1.95 ± 0.61 ml in 1982 to 3.312 ± 1.43 ml in 1995 ($P < 0.001$) (Table I) (since only two samples were donated in 1980 and none in 1981, we have combined the results with those of 1982). A concomitant mean rise of 5.8×10^6 (7.7%) per year (Fig. 2) in total motile sperm count, from $75.32 \times 10^6 \pm 40.27 \times 10^6$ to $119.79 \times 10^6 \pm 64.52 \times 10^6$, at the same time ($P < 0.0001$) was also noted. Motility rate increased every year by a mean of 0.27% ($P = 0.32$) (Fig. 3). On the other hand, the mean percentage normal morphology decreased by 1.04%

Fig. 1. Change in seminal fluid volume with time.

Table I. Mean and Time-Related Changes in Semen Characteristics

Variable	Mean $\pm$ SD	Range	N	Change per year (%)	β^a	P
n (millions/ml)	69.88 $\pm$ 28.44	12–180	188	3.43↓	−0.02	0.71
Volume	2.83 $\pm$ 1.02	0.8–7.0	187	5.1↑	0.34	<0.001
Motility (%)	60.5 $\pm$ 10.5	35–90	143	0.27↑	0.08	0.32
Normal morphology (%)	89.2 $\pm$ 8.9	20–100	132	1.04↓	−0.42	<0.001
Total motile (millions)	119.97 $\pm$ 60.53	24–336	143	7.7↑	0.31	<0.001

^a β = slope, the estimated mean change in semen parameter per year.

per year (Fig. 4) during the same period, from 93.38 ± 2.46 to $76.12 \pm 2.41\%$ ($P < 0.0001$). A nonsignificant decline in sperm density was noted, by a mean of 3.43% per year (Fig. 5), from $64.78 \times 10^6 \pm 28.52 \times 10^6$ to $67.5 \times 10^6 \pm 23.67 \times 10^6/\text{ml}$ ($P = 0.71$).

DISCUSSION

Analysis of our data reveals a statistically significant increase in total motile sperm count by a mean of 7.74% per year, mainly secondary to the increase in volume and also due to the slight increase in percentage

sperm motility. A nonsignificant decline in sperm concentration, 3.43% per year, was observed, as well as a significant decrease in the percentage normal sperm morphology, 1.04% per year. The semen donors were all in good physical health, confirmed by medical history, physical examination, and blood tests. The donors were within the narrow age range of 20 to 30 years and the duration of abstinence was short (3 to 4 days), thus eliminating the main reported confounding factors (17,18). Moreover, assay methods and equipment during the study period were consistent and all the examinations were done by the same technician.

Many studies in the literature have suggested a decline in semen quality and quantity over time (3–12).

Fig. 2. Change in total motile sperm count with time.

Fig. 3. Change in percentage motile sperm count with time.

Our data and other reports, however, do not support this conclusion (13,14,16,19–22). Suominen and Vierula (19) examined sperm counts from six studies of normal Finnish men from 1958 to 1992. Their data show no time-dependent decrease in sperm concentration. Recently, Paulsen *et al.* (14) reported their results of semen analysis of 510 healthy white males over 21 years from an urban population in the Seattle and Tacoma, Washington, area. They observed a small increase in sperm concentration, semen volume, total number of sperm, and percentage normal morphology with time that was statistically significant but not considered to be biologically important. In another report, Fisch *et al.* (13) reported the results of their study of 1283 men before vasectomy, during the years 1970 to 1994, at three geographically distinct U.S. sperm banks. They observed a statistically significant increase in sperm concentration and no change in sperm motility or semen volume. Bujan *et al.* (16) investigated semen concentration in 302 healthy fertile candidates for sperm donation in Toulouse, France, between 1977 and 1992. They reported a mean sperm

concentration of 83.12×10^6 that has not changed with time.

Our results do not agree with those of other investigators who have reported continuous decreases in semen quality over time. Leto and Frensilli (10) reported results on 275 men, potential sperm donors in the United States. In 1973, 77% met the criteria for artificial insemination donors, whereas only 37% of those who donated in 1980 met these criteria. Later, Carlesen *et al.* (8) reported a meta-analysis of 61 studies in 22 countries, from 1938 to 1990. With 14,947 fertile men included, they used linear regression alone and found a significant decrease with time in sperm concentration and a marginally significant decline in semen volume. However, Carlesen and co-workers' work, includes potential biases in confounding factors such as failing to consider age and duration of abstinence. Methodological inconsistencies, such as 61 different laboratories and varying sets of protocols and equipment, might also have influenced the quality of data. The studies were conducted in different countries for various reasons, with different eligibility criteria, and over

Fig. 4. Change in percentage normal spermatozoa with time.

a long time period. In fact, an analysis of the sperm concentration data for the time period from 1972 to 1992 shows no change or a slight increase in sperm concentration (14).

In a recent report, Auger *et al.* (11) studied 1351 fertile men from a single sperm bank in Paris, during 20 years. This study was similar to ours, in that all the men were fertile semen donors from an urban area, and all the tests were performed by one laboratory using standardized methods. However, their results showed a decline in mean concentration of sperm by 2.1% per year. During the same period the percentages of motile and normal spermatozoa decreased by 0.6 and 0.5% per year, respectively (both P 's < 0.001). They reported a significant increase in the age of sperm donors over time, and only 66% of the men adhered to the recommended abstinence time of 3 to 5 days. However, after taking these confounding factors into account, there were still significant declines in the semen parameters mentioned above.

Irvine *et al.* (12) reported a retrospective review of 577 volunteer semen donors, in Scotland, 171 of whom were born before 1959, 120 in 1960–1964, 171 in

1965–1969, and 115 in 1970–1974. The median sperm concentration fell from 98×10^6 among donors born before 1959 to 78×10^6 among donors born after 1970 ($P = 0.002$). The total number of sperm in the ejaculate fell from 301×10^6 to 214×10^6 ($P = 0.0005$). And the total number of motile sperm fell from 169.7×10^6 to 129×10^6 ($P = 0.0065$). They conclude that although the semen quality is deteriorating significantly in the United Kingdom, all the sperm parameters are well within the conventional criteria according to the World Health Organization guidelines. Moreover, the authors emphasize that there is, as yet, no evidence that male fertility, as opposed to semen quality, is declining.

Our data, based on a single sperm bank and a group of healthy young donors with a constant duration of abstinence, show a statistically significant increase in total motile sperm count with a decline in percentage sperm morphology during the study period.

We have no hard data to explain the differences in the results. Selection and methodological biases may have contributed to these differences. A combination of other factors such as geographic (15), ethnic, and

Fig. 5. Change in sperm concentration with time.

lifestyle including water supply (23) or environmental pollution (24) could account for it.

ACKNOWLEDGMENTS

We are grateful to Ms. Lois Gordon for her assistance in managing the data in this study.

REFERENCES

1. Macomber D, Sanders M: The spermatozoa count: Its value in the diagnosis, prognosis and treatment of sterility. *Engl J Med* 1929;200:981-984
2. MacLeod J, Gold RZ: The male factor in fertility and infertility II. Spermatozoon counts in 1,000 men of known fertility and in 1,000 cases of infertile marriage. *J Urol* 1951;66:436-448
3. Nelson CMK, Bunge RG: Semen analysis. Evidence for changing parameters of male fertility potential. *Fertil Steril* 1974;25:503-507
4. Naghma-E-Rehan, Sobrero AJ, Fertig JW: The semen of fertile men: statistical analysis of 1300 men. *Fertil Steril* 1975;26:492-502
5. Sheriff DS: Setting standards for male fertility. I. Semen analysis in 1500 patients—a report. *Andrologia* 1983;15:687-692
6. Wang C, Chan SYW, Leung A, Ng RP, Ng M, Tang LCH: Cross-sectional study of semen parameters in a large group of normal Chinese men. *Int J Androl* 1985;8:257-274
7. Kirei BR: Semen characteristics in 120 fertile Tanzanian men. *East Afr Med J* 1987;64:453-457
8. Carlesen E, Giwercman A, Keiding N, Skakkebaek NE: Evidence for decreasing quality of semen during the past 50 years. *BMJ* 1992;305:609-613
9. Bostofte E, Serup J, Rebbe H: Has the fertility of Danish men declined through the years in terms of semen quality? *Int J Fertil* 1983;28:91-95
10. Leto S, Frensilli FJ: Changing parameters of donor semen. *Fertil Steril* 1981;36:766-770
11. Auger J, Kuntzmann JM, Czyglik F, Jouannet P: Decline in semen quality among fertile men in Paris during the last 20 years. *Engl NJ Med* 1995;332:281-285
12. Irvine S, Cawood E, Richardson D, MacDonald E, Aitken J: Evidence of deteriorating semen quality in the United Kingdom: Birth cohort study in 577 men in Scotland over 11 years. *BMJ* 1996;312:467-470
13. Fish H, Goluboff ET, Olson JH, Feldshuh J, Broder SJ, Barad DH: Semen analysis in 1,283 men from the United States over a 25-year period: no decline in quality. *Fertil Steril* 1995;65:1009-1014

14. Paulsen CA, Berman NG, Wang C: Data from men in greater Seattle area reveals no downward trend in semen quality: Further evidence that deterioration in semen quality is not geographically uniform. *Fertil Steril* 1995;65:1015-1020
15. Fish H, Goluboff ER: Geographic variations in sperm count: A potential cause in bias in semen quality. *Fertil Steril* 1995;65:1044-1046
16. Bujan L, Mansat A, Pontonnier F, Miusset R: Time series analysis of sperm concentration in fertile men in Toulouse, France between 1977 and 1992. *BMJ* 1996;312:471-472
17. Schwartz D, Mayaux M-J, Spira A, Moscato M-L, Jouannet P, Czyglik E: Semen characteristics as a function of age in 833 fertile men. *Fertil Steril* 1983;39:530-535
18. Jouannet P, Czyglik E, David G, *et al.*: Study of a group of 484 men. Distribution of semen characteristics. *Int J Androl* 1981;4:440-449
19. Suominen J, Vierula M: Semen quality of Finnish men. *BMJ* 1993;306:1579
20. Tummon IS, Mortimer D: Decreasing quality of semen. *BMJ* 1992;305:1228-1229
21. Brake A, Krause W: Decreasing quality of semen. *BMJ* 1992;305:1498
22. Macleod J, Wang Y: Male fertility potential in terms of semen quality: A review of the past, a study of the present. *Fertil Steril* 1979;31:103-116
23. Ginsburg J, Okolo S, Prelevic G, Hardiman P: Residence in the London area and sperm density. *Lancet* 1994;343:230
24. Giwercman A, Carlesen E, Keiding N, Skakkebaek NE: Evidence for increasing incidence of abnormalities of the human testis: A review. *Environ Health Perspect* 1993;101 (Suppl 2):65-71