No evidence of deteriorating semen quality among men in infertile relationships during the last decade: a study of males from Southern Sweden

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The aim of this study was to investigate whether the quality of semen has deteriorated during the last decade. Laboratory records containing semen analysis results were reviewed. The records, arranged according to date of birth, are kept in shelves. Every fifth record for analyses performed between 1985 and 1995, and only those of men in infertile relationships, were included. The data were abstracted in a data base, and time-related changes in semen characteristics were studied using linear regression analyses. During the study period, there was a slight, but significant increase in sperm concentration, percentage of motile spermatozoa, percentage of spermatozoa with normal morphology, and the base-value of the penetration test. The seminal volumes decreased slightly, but significantly. Sperm characteristics were not associated with age or date of birth of the men. In conclusion, these data show no evidence of deterioration in sperm quality during the last decade among men in infertile relationships.

Key words: infertility/sperm quality

Introduction

Conflicting evidence is available as to trends in sperm quality during the past decades. Some studies have suggested decreasing semen volume and sperm count (Carlsen et al., 1992; Ginsburg and Hardiman, 1992; Irvine, 1994; Auger et al., 1995; Adamopoulos et al., 1996) or decreasing proportion of spermatozoa with normal morphology and progressive motility (Van Waeleghem et al., 1996). Intrauterine exposure to environmental toxins, including oestrogens, has been postulated to be the cause of this trend (Sharpe and Skakkebaek, 1993). Fukuda et al. (1996) demonstrated acute decline in sperm motility among 10 men exposed to heavy stress during the Kobe earthquake in 1995. Other studies were unable to confirm any decline in semen quality, even among men referred for infertility investigation (MacLeod and Wang, 1979; Fisch et al., 1996; Paulsen et al., 1996). Two recent studies reported results from different areas of the USA and included pre-vasectomy examinations and examinations of specimens from healthy donors (Fisch et al., 1996; Paulsen et al., 1996) These studies showed slight improvements in various sperm characteristics. One explanation for the controversial findings of Carlsen et al. (1992) is the strong geographic variations of semen quality. In that study, a meta-analysis of 61 published studies from different areas of the world from different time periods was performed. The authors themselves pointed out the possibility of selection bias due to geographical differences. In a recent consensus meeting at Baylor College of Medicine, an international panel pointed out several limitations of the available literature on this topic, including use of mean values for skewed distributions, design flaws, methodological variations, choice of statistical models, selection bias, variations in sample collection, and potential regional variations (Lipshultz, 1996). Without claiming that we have avoided all the pitfalls mentioned by the panel, we initiated this study to explore whether the sperm quality has changed among men in infertile relationships referred to our fertility laboratory during the last decade. Laboratory records for semen specimens from 718 men, who had provided us with at least one specimen during the last decade, were studied.

Materials and methods

Subjects were men who, as a part of infertility investigation, had a sperm specimen examined in the Infertility Laboratory of the University Hospital of Lund. The Hospital is a tertiary centre serving the general population of Malmöhus County and referral patients from several other counties of Southern Sweden.

The study was based on a retrospective review of patient records. The records were stored according to date of birth. Every fifth patient record was selected. Only those patients who had provided us with a specimen between 1985 and 1995 for infertility purposes were included. When a selected record belonged to an ineligible patient, it was replaced by the next record with the same or later date of birth. For patients who had delivered sperm specimens more than once, only the first specimen was considered for the study. Altogether, the data for 718 eligible men were abstracted from the data base. Replicate semen samples were not available.

All patients had received written instructions not to ejaculate within 3 days before delivering the specimen. The specimens had been produced by masturbation either at home (for patients living in the vicinity of the hospital), or in a specially equipped room close to the laboratory. The patients had collected the specimens in standard cups supplied by the laboratory. The World Health Organization (WHO, 1992) criteria were used for processing and evaluation of the specimens. During the entire study period, the spermatozoa were counted using a Makler Counting Chamber (Sefi Medical Instruments, Haifa, Israel). For morphology, spermatozoa were fixed on a microscopy slide and stained with haematoxylin and eosin. For the penetration test, glass capillaries filled with 10 µl of a hyaluronic acid-based viscous fluid (Healon®, Pharmacia-Upjohn, Stockholm, Sweden) were used. One end of the capillary was kept in a container with 0.1 ml of sperm fluid. The capillary and the container were...
incubated for 60 min at 37°C in a chamber kept moist by a wet paper strip on the bottom. The distance from the immersed end of the capillary to the front of the main group of spermatozoa was designated the ‘base value’. The farthest distance a spermatozoon had migrated after 60 min was the ‘top value’. All specimens had been examined by one of the three same laboratory workers. Data on variations between different assessors were not available.

Data were entered into Microsoft EXCEL© spreadsheets (Microsoft Corporation, Redmond, WA, USA). Abstracted data included age, year of examination, sperm concentration (10⁶/ml), the total sperm count, semen volume, morphology (% spermatozoa with normal morphology), % abnormal tails, % motile spermatozoa and penetration through capillaries filled with Healon® (mm/h).

The data were analysed using SPSS© statistical computer software (SPSS Inc., Chicago, IL, USA). Linear regression analyses were used to assess changes in semen characteristics over time, and in relation to age or date of birth.

Results

Altogether, 718 specimens were included in the study. The number of specimens included per year ranged from 42 (1995) to 86 (1985). The mean (±SD) age of the men varied from 32.8 ± 4.6 years in 1985 to 33.6 ± 5.3 years in 1993 (range 21–54 years). Linear regression analysis by examination year showed no significant change in age of the men over the study period ($R^2 = 0.003$, $F = 2.85$, $P = 0.09$).

The sperm concentration by year of examination is shown in Figure 1. Between 1985 and 1995 there was a slight but significant increase in sperm concentration from a mean of $45.95 ± 29.2 \times 10^6$/ml in 1985 to a mean of $64.2 ± 38.5 \times 10^6$/ml in 1995 ($R^2 = 0.03$, $F = 24.3$, $P < 0.001$). However, the linear regression analysis of the total sperm count by year showed no significant trend ($R^2 = 0.004$, $F = 2.59$, $P = 0.1$). This discrepancy might be explained by the fact that the seminal volume decreased significantly during the study period ($R^2 = 0.01$, $F = 9.4$, $P = 0.002$) from a mean of $3.56 ± 1.86$ ml in 1985 to a mean of $2.6 ± 1.0$ ml in 1995 (Figure 2). As shown in Figure 3, the decline in sperm volume was not a steady downward trend, but the volumes underwent periodic fluctuations over the years.

Figure 4 depicts the percentage of spermatozoa with normal morphology (WHO, 1992) by year. This percentage increased significantly from $57.8 ± 13.1%$ in 1985 to $66.4 ± 13.6%$ in 1995 ($R^2 = 0.03$, $F = 20.4$, $P < 0.001$). As shown in Figure 5, the percentages of abnormal tails decreased significantly during the study period ($F = 192.1$, $P < 0.001$), with a noteworthy $R^2 = 0.3$. 

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**Figure 1.** Sperm concentration by year of examination ($R^2 = 0.03$, $P < 0.001$).

**Figure 2.** Seminal volume by year of examination (each plot represents several values, $R^2 = 0.01$, $P = 0.002$).

**Figure 3.** Changes in mean (±2 SD) seminal volume between 1985 and 1995.

**Figure 4.** Percentage of semen specimens containing normal-looking spermatozoa by year of examination ($R^2 = 0.03$, $P < 0.001$). It is not known why data collected in 1989 showed an unusually high percentage of spermatozoa with abnormal morphology. When these data were excluded from analysis, no perceptible change occurred in the overall trend.
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Discussion

This study showed no evidence of deteriorating sperm quality among men evaluated for infertility during the past decade. By contrast, statistically significant improvements of several sperm characteristics were observed. These changes were probably not clinically significant, the $R^2$-values generally being small. The only deteriorating characteristic was sperm volume, which declined from a mean of 3.6 ± 1.86 ml in 1985 to a mean of 2.6 ± 1.0 ml in 1995. The apparent periodic fluctuations of sperm volume over the years and the fact that we started our study during a ‘peak year’ (Figure 3) and ended it close to a ‘bottom year’ does not support a belief of a periodic pattern.

Dynamic tests showed improvements over the years. The percentage of motile spermatozoa by year of examination is shown in Figure 6. A significant increase from 50.7 ± 15.1% in 1985 to 69.3 ± 16.5% in 1995 was found ($R^2 = 0.07, F = 53.2, P < 0.0001$). There is a close correlation between the capillary penetration test and the conception rate (Edvinsson et al., 1983). In our laboratory, the top-value only was recorded until 1989; later, the base-value was also recorded. Figure 7 shows the base-value of the penetration test by year of examination. A significant increase was noted between 1989 and 1995 from 5.0 ± 3.6 to 12.6 ± 7.0 mm/h ($R^2 = 0.05, F = 21.0, P < 0.0001$).

We also looked at the relationships between dates of birth of the men delivering the specimens and various sperm variables. No significant associations were found between date of birth and seminal volume ($R^2 = 0.002$), total sperm number ($R^2 < 0.001$), concentration of spermatozoa ($R^2 < 0.001$), percentage of motile spermatozoa ($R^2 < 0.001$), base value of penetration tests ($R^2 < 0.001$), or percentage of normal-looking spermatozoa with normal morphology ($R^2 < 0.001$).

Some studies have shown associations between age and various semen characteristics (Irvine, 1994). In this study, no such associations were found, whether we looked at semen volume ($R^2 = 0.004$), total sperm number ($R^2 = 0.001$), concentration of spermatozoa ($R^2 < 0.001$), percentage of motile spermatozoa ($R^2 = 0.002$), base-value of penetration tests ($R^2 = 0.006$), or percentage of normal-looking spermatozoa with normal morphology ($R^2 < 0.001$).

These findings are in agreement with those of Fisch et al. (1996), who studied spermatozoa from men from different areas of the USA who had banked the semen before vasectomy between 1970 and 1994. A statistically significant increase in sperm concentration and motility was observed. Paulsen et al. (1996) studied sperm specimens from healthy volunteers in the state of Washington, USA that had been produced between 1972 and 1993. These investigators also found a slight improvement of sperm concentration and sperm morphology during the study period. McLeod and Wang (1979) reported on 9000 men from the New York area who had delivered sperm specimens for infertility investigations between 1966 and 1977. No deterioration of sperm concentration was seen during that period.

By contrast, other investigators have suggested a decline in sperm characteristics over recent decades (Carlsen et al., 1992; Ginsburg and Hardiman, 1992; Irvine, 1994; Auger et al., 1995; Adamopoulos et al., 1996; Van Waeleghem et al., 1996). Carlsen et al. (1992) analysed 61 published studies of fertile
Men. They found a decrease in mean sperm count and in seminal volume between 1938 and 1990. The authors postulated that increased oestrogen exposure in utero was responsible for the decline in semen quality (Sharpe and Skakkebaek, 1993). The study of Carlsen et al. (1992) has been criticised for having a number of limitations. Olsen et al. (1995), for example, pointed out that during the last 20 years of the data collection, containing 88.1% of the total number of subjects, no decrease in sperm counts was observed. Fisch and Goluboff (1996) re-analysed the Carlsen data, and pointed out that only 20 of the 61 studies had ≥100 men each and that these studies comprised 91% of the total men studied. From 1938 to 1970 there were only five studies including >100 men, all from the USA. After 1970 there were 15 equally large studies, only three of them from the USA. Of the seven studies from this period with the lowest sperm counts, five were from Third World countries. The authors concluded that the difference in semen quality over time may reflect clustering of significant geographic variations rather than decline over time. Bromwich et al. (1994), using mathematical models, concluded that the 'reported decline in concentration of spermatozoa may have been accounted for entirely or in part by the change in lower reference value'. Auger et al. (1995), in a study of 1351 samples collected in Paris from healthy fertile men, showed a decrease in sperm concentration of 2.1% annually between 1973 and 1992. The percentage of motile spermatozoa of spermatozoa with normal morphology decreased annually by 0.6 and 0.5% respectively. That study was criticised for containing a serious selection bias, i.e. only fertile men accepted as donors were included in the study (Fisch et al., 1996). Irvine (1994), also reporting data from semen donors, showed a significant decline in sperm concentration with increasing year of birth. He felt this finding supported the Sharpe and Skakkebaek (1993) hypothesis of declining semen quality due to intrauterine oestrogen exposure. However, in the present study, no associations were found between year of birth and various sperm characteristics.

The present study has several limitations. Firstly, the observation period of 10 years may be too short to detect trends in sperm quality. However, longer observation periods may be hampered by variations in methods and by involvement of different laboratory workers over time. Secondly, the selection of men in infertile relationships precludes any prediction about the general population, even when many couples were childless due to a female factor. Even among men in infertile relationships, the studied group is self-selected. Nothing is known about the men of infertile couples not consulting a physician for infertility investigation, and this may have introduced a selection bias. Also, men developing testicular cancer, hypospadias, or cryptorchism, all conditions believed to be a result of in-utero exposure to oestrogens (Sharpe and Skakkebaek, 1993), might have been under-represented among the studied patients. For example, semen samples delivered to be frozen prior to treatment for malignant disease were not included in the analyses. If these patients tend to have low sperm quality and their relative numbers among infertile men has increased during recent years, the exclusion of the group might have resulted in over-representation of higher quality semen specimens. Thirdly, even when the men received written instructions not to ejaculate within 3 days before the test, we have not recorded the actual days of abstinence. Shorter abstinence time than 3 days might result in altered quality of the specimen. However, there is no reason to believe that men have tended to abstain for different periods of time during recent years in a way that could compensate for otherwise deteriorating sperm quality.

In conclusion, during the last decade, there is no evidence of deteriorating sperm quality among men in infertile relationships living in this area of Sweden.

References


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