

Decline in the Semen Quality of Students at Yamagata University Born in the 1970's

Taizo Iwasaki* and Kiyoshi Totsukawa

Section of Bioprocess Engineering, Faculty of Agriculture, Yamagata University, Wakaba-machi 1–23, Tsuruoka, Yamagata 997-8555, Japan

Abstract: The objective of this study was to determine the quality of semen in Japanese men born in the 1970's. When samples were compared among generations (1970–72, 1973–75 and 1976–78), significant differences were not seen in the volumes and the abnormality rates. But the sperm concentration of the 1970–72 generation ($114.8 \pm 52.5 \times 10^6$ sperms/mL $n=3$) was higher than these of other generations ($48.8 \pm 44.1 \times 10^6$ and $58.0 \pm 27.0 \times 10^6$ sperms/mL, respectively 1973–75 $n=17$ and 1976–78 $n=28$). There was no correlation between semen quality (sperm concentration and total sperm number) and the date of birth of the subjects. However their parents' date of birth had an influence on semen quality. Environmental chemicals began to increase around the time the subjects' parents were born, and it might be possible that parents' reproductive ability was connected with their children's semen quality.

Keywords: Semen quality, Parents' date of birth

In 1992, Carlsen et al. reported a significant decrease in the quality of human semen during the past 50 years, including reductions in mean semen volume and mean sperm concentration in volunteer sperm donors [1]. A number of investigators have also reported a decline in the quality of sperm of men living in industrialized countries [2, 3]. Furthermore, Auger et al. reported that sperm concentrations have dropped at a rate of 2.1% a year with year of birth among French men [2]. However, semen quality differs according to race, region and season [4–6]. Other investigators, on the other hand, have reported that there has been no decrease in the quality of semen [7–9].

Several environmental toxins and chemicals, such as alcohol [10], drugs [11], industrial solvents [12], and endogenous and exogenous estrogen-like compounds

[13], have been suggested as affecting the function of male reproductive organs via multiple mechanisms. Furthermore, Carlsen et al. suggested that the sperm count has been reduced by estrogens, compounds with estrogen-like activity or other environmental "endogenous" factors [1]. The basis for this speculation is that estrogen causes damage to the testis [14–16].

In the 1960's, the manufacture of persistent organic pollutants (e.g., PCB and DDT) was prohibited, and the use of such pollutants was restricted. These environmental pollutants reduced during the 1970's and 1980's. The objective of this study was to determine the quality of semen in men born in the 1970's.

Materials and Methods

Collection and evaluation of semen

We recruited 50 young students at Yamagata University, as healthy volunteer semen donors. Semen was collected 3 times from each volunteer (at 72 h intervals) at 08:00–10:00 by masturbation with a condom (Jex, Japan). All semen collections were conducted between the hours of 8:00 and 10:00.

The semen analyses were initiated at 30 minutes after ejaculation by one person only. Semen volume was determined using a plastic syringe. To determine the sperm motility, an aliquot of semen were placed on a clean glass cover slip with a Pt loop and the cover slip was overturned and placed on a hole slide glass. Sperm concentration was counted by Thoma hemacytometer, and sperm morphology was evaluated for at least 100 spermatozoa. Categories of abnormal sperm included coiled tails, double heads, cytoplasmic droplets, bent midpieces, pin heads, double tails, and immature forms. Total numbers of ejaculated spermatozoa and concentrations of normal spermatozoa were calculated.

Donors abstained from sexual intercourse and masturbation during the sampling period. Semen sampling was done from June to November in 1998. Normal

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*To whom correspondence should be addressed.

Table 1. Profiles of collected sperm from 48 men

	All samples (n=48)	(Range)	Abnormality	(WHO Normal value)
Volume (mL)	3.0 ± 1.0 ^{a)}	(0.9–6.2)	8.3%	(≥2.0 mL)
Concentration (× 10 ⁶ sperm/mL)	58.3 ± 36.4	(1.7–245)	8.3%	(≥20 × 10 ⁶ sperm/mL)
Motility (%)	56.7 ± 17.2	(1–90)	12.5%	(≥50% with forward progression)
Normal morphology (%)	92.4 ± 0.3	(76–98)	—	(≥30% normal morphology)

^{a)} mean ± SE.

Table 2. Semen qualities compared among generations

	Generation ^{a)}		
	1970–72	1973–75	1976–78
Sample size	3	17	28
Concentration (× 10 ⁶ sperm/mL)	114.8 ± 52.5	48.8 ± 44.1	58.0 ± 27.0
Volume (mL)	2.8 ± 0.7	3.0 ± 0.8	3.1 ± 0.5
Motility (%)	47.5 ± 12.1	58.4 ± 12.4	56.7 ± 12.2
Normal morphology (%)	93.4 ± 2.41	92.6 ± 2.51	92.1 ± 2.61

^{a)} mean ± SD.

values were based on World Health Organization criteria [17].

Questionnaire

Each subject was asked to fill in a questionnaire after sampling. The items in the questionnaire included 1) the subject's birthday and his parents' birthday, 2) the frequency of smoking, 3) the frequency of drinking, and 4) weight and height.

The Body Mass Index (BMI) was calculated by weight (kg) / height (m²), and the subjects' physiques were classified as "fat" (>25), "standard" (20–25) or "lean" (<20) on the basis of the BMI.

Statistical analysis

Statistical analysis was carried out using SAS® [18]. Semen was collected 3 times, but only the second and third samples were used for the analysis. The semen qualities were analyzed by LSMEAN followed by PROC GLM (P<0.05). The correlation between semen quality (sperm concentration and ejected sperm count) and the subject's birthday or his parents' birthday (January 1, 1900=1) was analyzed using PROC REG.

Results

All items in the questionnaires except for parents' birthdays were answered. Twenty-three subjects wrote both parents' birthdays, three subjects wrote only their mother's birthday and one subject wrote only his father's

birthday. Semen samples collected from 48 of the subjects were used for analysis. Semen samples from two subjects were excluded from analysis because the subjects were less than 20 years of age.

The results of analysis of the semen samples are shown in Table 1. Mean concentration was 56 ± 36.4 × 10⁶ sperms/mL, mean volume was 3.0 ± 1.0 mL, mean motility was 58.3 ± 17.2%, and mean percentage of sperm with normal morphology was 92.4 ± 0.3%. Twenty-seven percent of the subjects had at least one sperm abnormality: 8.3% had abnormalities in volume, 8.3% had abnormalities in concentration, and 12.5% had abnormalities in motility. However, none of the subjects had abnormalities in morphology.

When samples were compared among generations (Table 2), significant differences were not seen in the volumes and the normal morphology rates. But the sperm concentration of the 1970–72 semen (114.8 ± 52.5 × 10⁶ sperm/mL n=3) was higher than those from other generations (48.8 ± 44.1 × 10⁶ and 58.0 ± 27.0 × 10⁶ sperms/mL, respectively 1973–75's n=17 and 1976–78's n=28; Table 2).

The percentage of semen with normal morphology in "lean" subjects (90.9 ± 2.4% n=9) was lower than in "standard" subjects (92.9 ± 2.3% n=34, P<0.05). Moreover, the mean semen motility in subjects who smoked (53.0 ± 11.8% n=24) was lower than in subjects who did not smoke (60.5 ± 11.8% n=24, P<0.05). Other parameters were not significantly different.

There was no correlation between semen quality

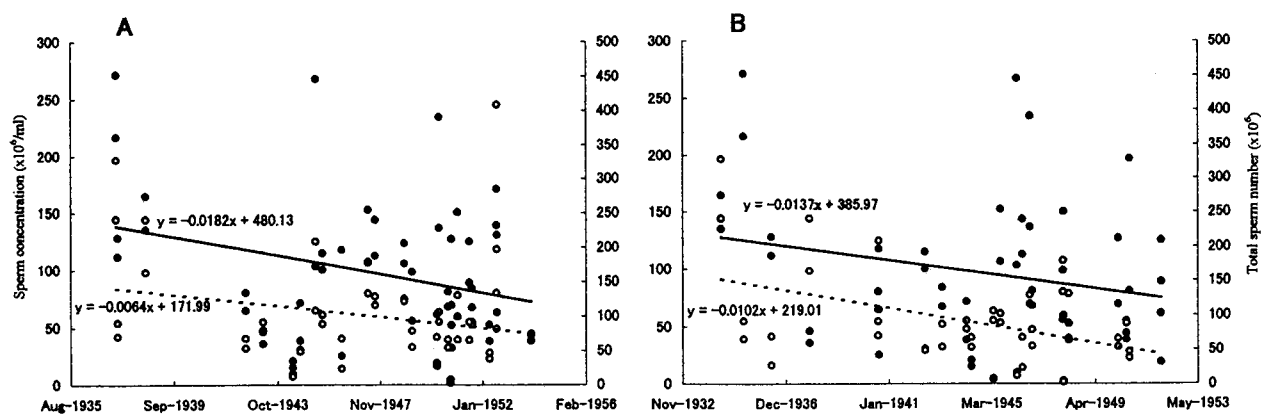


Fig. 1. Ejaculated sperm counts and concentrations were plotted by mothers' and fathers' date of birth (January 1st 1900=1). Right ordinate: ejaculated sperm counts (solid symbols, solid line), left ordinate: concentrations (open symbols, dotted line). (A) The correlation coefficient of ejaculated sperm counts and mothers' date of birth was 0.298 ($P=0.0356$), and the correlation coefficient of concentration and mothers' date of birth was 0.239 ($P=0.0946$). (B) The correlation coefficient of ejaculated sperm counts and fathers' date of birth was 0.263 ($P=0.0847$), and the correlation coefficient of concentration and fathers' date of birth was 0.396 ($P=0.0078$).

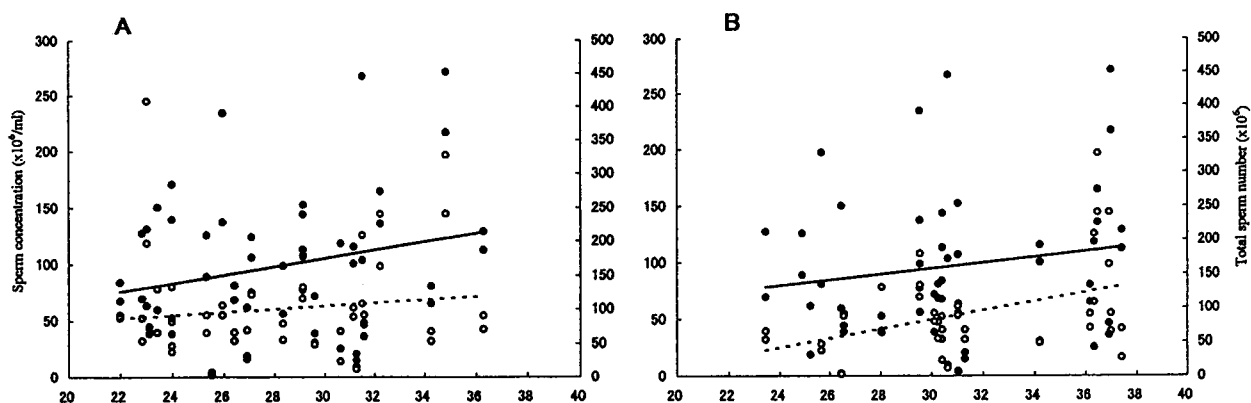


Fig. 2. Ejaculated sperm counts and concentrations were plotted by mothers' and fathers' parturient ages. Right ordinate: ejaculated sperm counts (solid symbols, solid line), left ordinate: concentrations (open symbols, dotted line). (A) The correlation coefficient of ejaculated sperm counts and mothers' ages was 0.227 ($P=0.1124$), and the correlation coefficient of concentration and mothers' ages was 0.117 ($P=0.4159$). (B) The correlation coefficient of ejaculated sperm counts and fathers' ages was 0.192 ($P=0.2122$) and the correlation coefficient of concentration and fathers' ages was 0.293 ($P=0.0534$).

(sperm concentration and total sperm number) and the date of birth of the subjects. On the other hand, a weak negative correlation was found between semen quality and parents' date of birth (Fig. 1).

Discussions

The quality of semen in older men (born in 1970–72) was higher than that in younger men (born in 1973–75 and 1976–78, Table 1). The period of birth covered corresponds to that in which dioxins and coplanar-PCBs

were on the increase. They had been around in the 1960's, increased rapidly in the 1970's, and a big peak was seen in 1980 from the results of analyzing sediments in Tokyo bay (1905–1998) [19]. Many environmental toxins and chemicals are passed on to the fetus through the female reproductive tract [20]. Furthermore, the half-lives of most environmental toxins and chemicals are long, and they accumulate inside the body. Since the protection functions of a fetus are not developed, the toxins and chemicals in a fetus metabolize slowly, and it is thought that the fetus is exposed to

danger from these factors.

A weak negative correlation was found between parents' date of birth and semen quality in the subject (Fig. 1). On the other hand, a correlation was not found between parents' parturient age and semen quality in the subject (Fig. 2). These results suggest that exogenous chemicals accumulated in daily life were not directly influencing the quality of their children's semen. The parents' date of birth had an influence on semen quality. In sediment from Lake Harina (1832–1998), dioxins and coplanar-PCBs have been detected since 1950 [19]. This means that unindustrialized areas of Japan have also been polluted since 1950. Parents of the younger subjects in this study were born after 1950. It might be possible that parents' reproductive ability was connected with their children's semen quality.

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