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Research Article

Annual trends in semen parameters among men attending a fertility center between 2016 and 2022

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BACKGROUND: Multiple studies have shown sperm concentration and count decline in many countries, however, authors' conclusions were inconsistent. These types of studies were not conducted in Russia so far.

AIM: To evaluate and analyze semen parameters among men attending a fertility center in St. Petersburg between 2016 and 2022.

MATERIALS AND METHODS: In a retrospective study parameters of 14234 consequent semen analyses performed according to WHO guidelines (2010) were sorted, analyzed and compared by year.

RESULTS: The distribution parameters of the ejaculate volume did not have change over observation period. Azoospermia and cryptozoospermia were detected in 597 (4.2%) and 435 (3.1%) men respectively. A downward trends for sperm concentration of 1.6 million/ml (1.9%)/year and sperm count of 7 million (1.8%)/year were found, with simultaneous annual increase of 1.3% in the proportion of progressively motile spermatozoa. No noticeable changes in the number of motile spermatozoa and the proportion of spermatozoa with normal morphology were found.

CONCLUSIONS: Further research is needed to obtain final conclusions about the gradual decline in the semen quality and reproductive function of men, also in other centers of the Russian Federation.

Keywords: andrology; male infertility; male reproductive health; sperm quality; sperm count.

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Научная статья

Сравнительная характеристика параметров эякулята мужчин, обратившихся в центр репродуктивной медицины с 2016 по 2022 г.

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Актуальность. Концентрация и число сперматозоидов в эякуляте мужчин во многих странах мира постепенно снижаются, однако выводы авторов противоречивы, а исследований, основанных на результатах изучения параметров спермы российских мужчин, недостаточно.

Цель — провести сравнительный анализ показателей эякулята мужчин, обратившихся в центр репродуктивной медицины в период с 2016 по 2022 г.

Материалы и методы. Ретроспективно изучены показатели спермограмм 14 234 мужчин, последовательно обратившихся в Международный центр репродуктивной медицины (Санкт-Петербург), с 2016 по 2022 г. Всем мужчинам было выполнено стандартное исследование эякулята в соответствии с методическими указаниями Всемирной организации здравоохранения 2010 г. Проанализированы параметры распределения этих показателей за весь период и по годам наблюдения, произведена их сравнительная оценка.

Результаты. Параметры распределения объема эякулята не имели заметной динамики за весь период наблюдения. У 597 (4,2 %) мужчин была выявлена азооспермия, у 435 (3,1 %) — криптозооспермия, наблюдалась тенденция к снижению средней концентрации сперматозоидов на 1,6 млн/мл или 1,9 % в год и числа сперматозоидов на 4,7 млн, или 1,8 %, в год, а также увеличению доли прогрессивно-подвижных сперматозоидов на 1,3 % в год, что не сопровождалось существенным изменением числа подвижных сперматозоидов и доли сперматозоидов с нормальной морфологией.

Выводы. Для получения окончательных выводов о постепенном снижении репродуктивной функции мужчин целесообразно продолжение исследований, в том числе и в других медицинских центрах России.

Ключевые слова: андрология; мужское бесплодие; мужское репродуктивное здоровье; качество спермы; число сперматозоидов.

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BACKGROUND

According to modern concepts, sperm parameters allow us to determine the probability of natural conception, catch an idea of the functional state, identify diseases of male genital organs and components of the hypothalamus–pituitary–gonadal system and suspect the presence of genetic anomalies [1]. Besides, men with chronic diseases and shorter life expectancy were found to have poor sperm quality [2, 3], which gave grounds to consider spermogram parameters as health indicators in general. The relevance of these provisions is substantially supported by studies indicating a gradual decline in sperm quality, which began in the mid-20th century and has been found in men living in North, South and Central America, Australia, New Zealand, Asia, Africa and Central and Eastern Europe. Moreover, an increasing rate of decline was observed, from –1.16% to –2.64% annually before and after 2000, respectively [4–7], suggesting the urgent need to employ measures to preserve male fertility. Another point of view emerged [8], i.e. the data confirming the worldwide negative dynamics of ejaculate parameters have not reached the threshold of reliability, and such negative trends are observed only in specific countries and require further study. In this connection, national research groups have tried to obtain large datasets that would allow us to draw definitive conclusions about the trends in male reproductive health within a single country [9]. Given that no study in Russian literature has focused on the ejaculate parameters of Russians over time, this study intends to address this gap.

This study aimed to conduct a comparative analysis of male ejaculate values obtained between 2016 and 2022 at the Center for Reproductive Medicine.

MATERIALS AND METHODS

In this study, the spermograms of 14,234 men who consecutively applied to the International Center for Reproductive Medicine (Saint Petersburg) between 2016 and 2022 were retrospectively examined to clarify the state of reproductive function, determine possible participation in sperm donation programme or identify connection with the inability to conceive naturally. In accordance with the guidelines of the World Health Organization in 2010, the laboratory staff of the centre performed a standard examination of the ejaculate, including the evaluation of its volume, concentration, proportion (%) of progressive-active (categories A and B) and normal sperm, total number of sperm and number of progressive-active sperm. By using a package of applied programmes for statistical data analysis, the parameters of the distribution of these indicators for the entire period and for the years of observation were obtained and analysed. Further, they are presented as the mean and error of the mean ($M \pm SD$) and the 5th and 95th percentiles, and their comparative evaluation was made. The values of concentration, number, proportion of motile and normal spermatozoa and number of motile spermatozoa were calculated, and the data of men with azoospermia and cryptozoospermia were excluded from the sample.

RESULTS

Ejaculate volume. The ejaculate volume of the examined men ranged from 0.03 to 19 mL and averaged 3.5 ± 1.6 (1.3–6.5) mL. The distribution of this parameter did not show noticeable dynamics throughout the observation period (Table 1).

Sperm concentration. From 2016 to 2022, a trend was noted toward a gradual (1.6 million/mL, or 1.9%, annually) decrease in average sperm concentration from a level of 81.6 ± 60.9 million/mL, with minimum values of 64.1 ± 50 million/mL recorded from 2020 to 2021, and a subsequent reversal to a level of 71.3 ± 50.6 million/mL (Figure 1).

Azoospermia and cryptozoospermia were detected in 597 (4.2%) and 435 (3.1%) men, respectively. Of the total number of those examined annually, the proportions of men ranged from 3.2% to 6.9% and from 2% to 3.8%, respectively, with the maximum observed in 2016–2017 (Table 2).

Sperm count. The downward trend observed for the average sperm concentration after 2016 was also noted for the average total sperm count in the ejaculate (by 4.7 million, or 1.8%, annually): the maximum of 265 million was recorded at the beginning of the observation and the minimum in 2020 and 2021 (209.9 and 216.7 million, respectively), with a subsequent increase to 237 million in 2022 (Figure 2).

Proportion of progressively mobile spermatozoa (A + B). In contrast to the concentration and number of spermatozoa in the ejaculate, an opposite trend was observed for the proportion of progressively motile spermatozoa. The average values of this indicator increased in each subsequent year of observation (on average by 1.3% annually), i. e. from 47% in 2016 to 55% in 2022 with a ‘plateau’ period of 53% in 2019 and 2020 (Figure 3).

Number of progressively mobile spermatozoa (A + B). The value of this indicator in 2016 was 138.2 million. Two multidirectional trends, a decrease in the number of spermatozoa and an increase in the proportion of progressively mobile spermatozoa in the ejaculate, showed no significant changes over the years of observation, except for the decrease occurring in 2020 and 2021 (Fig. 4), i.e. to 122.7 million and 126 million, respectively (Fig. 4). In addition, men with motile sperm counts of <5 million and <1 million were predominant among those

Table 1. Sperm parameters of 14,234 men according to the year of sperm analysis, *M* ± *SD* [5th–95th percentile]

Таблица 1. Показатели эякулята 14 234 мужчин по годам проведения исследования, *M* ± *SD* [5-й – 95-й процентиль]

Ejaculate readings	Year of study and number of men surveyed							All time (2016–2022), *n* = 14234
	2016, *n* = 2136	2017, *n* = 2268	2018, *n* = 2015	2019, *n* = 2032	2020, *n* = 1800	2021, *n* = 2093	2022, *n* = 1890	
Volume, mL	3.5 ± 1.6 [1.3–6.6]	3.6 ± 2.6 [1.3–6.6]	3.4 ± 1.6 [1.3–6.3]	3.5 ± 1.6 [1.3–6.3]	3.5 ± 1.7 [1.3–6.6]	3.6 ± 1.6 [1.4–6.3]	3.5 ± 1.6 [1.4–6.4]	3.5 ± 1.6 [1.3–6.5]
Concentration of spermatozoa, mln/mL	81.6 ± 60.9 [6.3–193]	77 ± 56.1 [6.6–170]	72 ± 54.3 [5–169.4]	72.5 ± 56.3 [4–180.6]	64.1 ± 50.1 [3–164]	64.1 ± 50.3 [4–164]	71.3 ± 50.6 [4.6–165]	72 ± 54.7 [4.8–172]
Number of spermatozoa, mln	265 ± 212 [20.7–659.6]	256.8 ± 206 [17.9–670.7]	231.8 ± 189 [13.9–602.7]	235.6 ± 203.7 [12.1–628.2]	209.9 ± 177.8 [9.6–581.7]	216.7 ± 186.3 [13–603.2]	237 ± 188.8 [13.3–612.9]	236.8 ± 196.5 [14–624]
Proportion of progressively motile spermatozoa (A + B), %	47 ± 18 [14–74]	48 ± 19 [14–76]	51 ± 18 [18–77]	53 ± 18.2 [18–78]	52.8 ± 18.7 [16–78]	53.5 ± 17.9 [20–78]	55 ± 17.4 [22–79]	51.5 ± 18.3 [17–77]
Number of progressively mobile spermatozoa (A + B), mln	138.2 ± 126.9 [3.8–386.9]	132.3 ± 121.2 [3.7–370.3]	138.3±122.4 4.3–372.8	135.9 ± 124.9 [2.9–381.8]	122.7 ± 116 [1.7–356.2]	126 ± 120.5 [3.7–379.9]	139 ± 120.6 [4.1–385.3]	133.3 ± 122.1 [3.4–377.6]
Proportion of motile spermatozoa (A + B + C) %	53 ± 18 [21–79]	53 ± 19 [18–81]	56 ± 18 [22–80]	56 ± 18 [22–81]	56 ± 19 [20–81]	57.1±17.8 24–82	58.2 ± 17.2 [26–82]	55.8 ± 18.1 [21–81]
Share of spermatozoa with normal morphology %	5.4 ± 4.3 [0–14]	5 ± 3.5 [0–12]	5 ± 3.4 [0–11]	5 ± 3.3 [0–11]	5.9 ± 3.6 [0–12]	5.9 ± 3.5 [1–12]	6 ± 3.5 [1–12]	5.5 ± 3.6 [0–12]

Table 2. Numbers of men with azoospermia and cryptozoospermia according to the year of sperm analysis

Таблица 2. Число мужчин с азооспермией и криптозооспермией по годам проведения исследования

Indicator	Year of study and number of men surveyed							All time (2016–2022), *n* = 14234
	2016, *n* = 2136	2017, *n* = 2268	2018, *n* = 2015	2019, *n* = 2032	2020, *n* = 1800	2021, *n* = 2093	2022, *n* = 1890	
Number of men with azoospermia	82 (3.8%)	157 (6.9%)	83 (4.2%)	66 (3.2%)	65 (3.6%)	82 (3.9%)	62 (3.3%)	597 (4.2%)
Number of men with cryptozoospermia	82 (3.8%)	83 (3.7%)	59 (2.9%)	61 (3%)	57 (3.2%)	55 (2.6%)	38 (2%)	435 (3.1%)

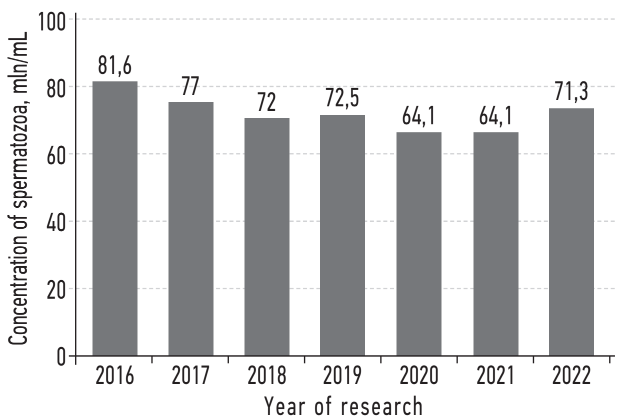

Fig. 1. Sperm concentration according to the year of sperm analysis
Рис. 1. Концентрация сперматозоидов у обследованных мужчин в зависимости от года проведения исследования

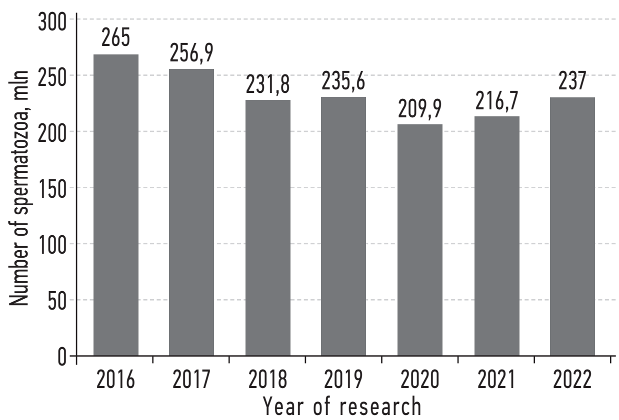

Fig. 2. Sperm counts according to the year of sperm analysis
Рис. 2. Число сперматозоидов у обследованных мужчин в зависимости от года проведения исследования

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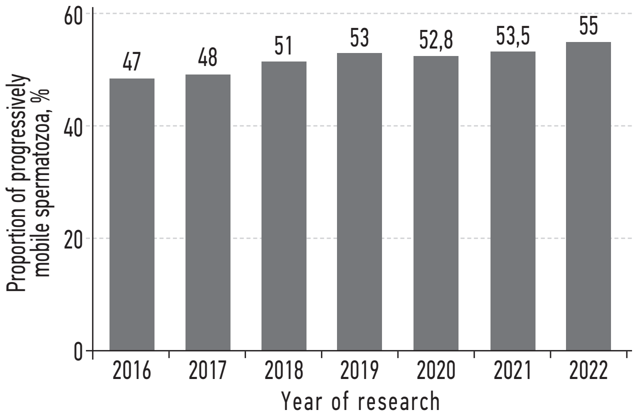

Fig. 3. Proportion of progressively motile sperm according to the year of sperm analysis
Рис. 3. Доля прогрессивно-подвижных сперматозоидов у обследованных мужчин в зависимости от года проведения исследования

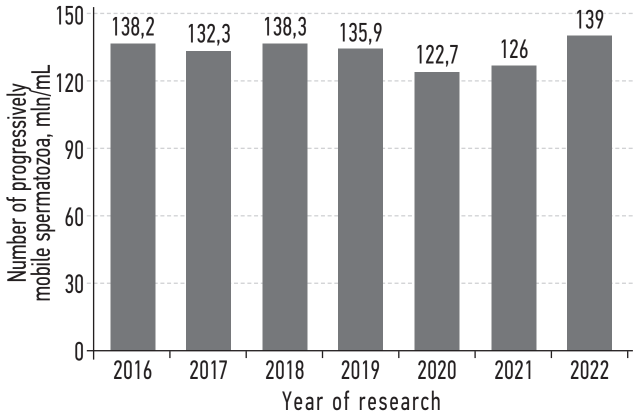

Fig. 4. Progressively motile sperm counts according to the year of sperm analysis
Рис. 4. Число прогрессивно-подвижных сперматозоидов у обследованных мужчин в зависимости от года проведения исследования

surveyed in 2020, accounting for 144 (8%) and 65 (3.6%), respectively.

Sperm morphology. Among the men examined, significant variability was noted in the proportion of spermatozoa with normal morphology; however, the mean values, which were 5.5% ± 3.6% (0%–12%), had no appreciable differences in different years of observation (Table 1).

DISCUSSION

This study presents the ejaculate parameters of 14,234 men who applied to the Center of Reproductive Medicine in Saint Petersburg between 2016 and 2022 for various reasons such as those unrelated to the inability to conceive naturally. In this study, 1032 (7.3%) of them had azoospermia or cryptozoospermia corresponding to the definition of male infertility according to the International Classification of Diseases, Revision 11 [10]. This value corresponds to the data on the prevalence of male infertility, from 2.5% to 12%, reported in population studies in other countries [11].

The group of men examined in this study, except for patients with cryptozoospermia and azoospermia, can be considered a cohort with unknown fertility. This allowed us to draw parallels with a similar cohort that was examined by researchers under the auspices of the World Health Organization [12] in 2009. As a result, the median and 5th and 95th percentile values of most spermogram parameters in these studies were comparable: ejaculate volume, 3.3 [1.3–6.5] and 3.2 [1.2–6.4] mL; sperm concentration, 61 [4.8–172] and 64 [9–192] ml/mL; total sperm count, 191.7 [14–624] and 196 [20–619] mL of motile sperm, 67% [21%–81%] and 62% [36%–85%]; proportion of progressively mobile spermatozoa, 50% [17%–77%] and 57% [31%–78%], respectively; only the differences in the proportion of spermatozoa with normal morphology, i. e. 5% [0%–12%] and 14% [4.7%–23.2%], respectively — the parameter with the greatest degree of subjective evaluation — were notable.

Similarly, Levine et al. [6, 7] confirmed that Russian men tended to have decreased concentration and number of sperm cells in the ejaculate over time of observation; we also found similar rates of such decrease. Markedly lower and overlapping spermogram values found in Russians examined in 2020–2021 could be due to the influence of SARS-CoV2 virus, which was widespread during this period [13]. An unexpected finding was the increase in the percentage of motile spermatozoa during the observation period, which ensured (except for 2020–2021) the stability of the number of motile spermatozoa, which is, according to modern concepts, the leading indicator of male reproductive function [14].

CONCLUSIONS

Thus, the data of the examined cohort of men reflect the contradictory nature of a possible global decrease in male reproductive function. Against the background of decreased sperm count, the proportion and preservation of the number of motile forms increased, whereas the values of this indicator in the overwhelming majority of men were high enough to expect the possibility of natural conception. Moreover, the results obtained should be extrapolated with caution because they were obtained retrospectively in a single medical centre specialising in infertility. On the contrary, there may be advantages, including the absence of differences in the technique of performing ejaculate analysis between different laboratories (15). To obtain definitive conclusions, further research in this direction is necessary, including at other centres in Russia. The timeliness of decision making for preserving male reproductive function is especially relevant given the prevalence of infertility and declining fertility in Russia.

ADDITIONAL INFORMATION

Author contribution. Thereby, all authors made a substantial contribution to the conception of the study, acquisition, analysis, interpretation of data for the work, drafting and revising the article, final approval of the version to be published and agree to be accountable for all aspects of the study.

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Competing interests. The authors declare that they have no competing interests.

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