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ANALYSIS OF DIURNAL VARIABILITY OF SPERM DONORS' SEMEN PARAMETERS

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Introduction. Diurnal variability of sperm parameters is controversial and should be considered during medical evaluation and solicitation of sperm donors. **Aim:** to evaluate diurnal variability of sperm parameters of anonymous sperm donors in reproductive medicine center. **Materials and methods.** Records of 1253 semen samples analysis of 39 sperm donors (mean age 27.1 ± 3.9 years) were retrospectively studied in reproductive medicine center in Saint Petersburg. Semen analysis was performed according to WHO 2010 recommendations. Diurnal variations of semen volume, sperm concentration, total sperm number, progressive motility and number of progressively motile sperm were analyzed. **Results.** Mean ejaculate volume, sperm total number and number of progressively motile sperm were higher after 3 p.m. ($t = 5.63$, $p < 0.0001$; $t = 3.66$, $p = 0.0003$ and $t = 1.76$, $p = 0.078$, respectively), while sperm concentration and percent of progressively motile sperm was lower ($t = 2.03$, $p = 0.043$ and $t = 4.63$, $p = 0.0003$, respectively).The lowest and the highest mean sperm numbers were registered in time slots between 12 a.m.–1 p.m. and 4 p.m.–5 p.m., respectively. **Conclusions.** The study suggests the diurnal variability of sperm donors' semen parameters. We might recommend a potential sperm donor preservation to be performed after 3 p.m., preferentially within 4 p.m.–5 p.m. interval.

Keywords: infertility; diurnal variation; semen; spermogram; sperm donor.

ИЗУЧЕНИЕ ДНЕВНЫХ КОЛЕБАНИЙ ПОКАЗАТЕЛЕЙ ЭЯКУЛЯТА У ДОНОРОВ СПЕРМЫ

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Актуальность. Известно, что показатели спермограммы у мужчин значительно варьируют. Закономерности изменчивости параметров эякулята в течение суток изучены недостаточно полно, полученные данные противоречивы. **Цель** — исследовать вариабельность количественных и качественных параметров эякулята, полученного в разное время у доноров спермы центра репродуктивной медицины. **Материалы и методы.** Ретроспективно проанализированы архивные материалы заготовки 1253 образцов спермы 39 мужчин-доноров в центре репродуктивной медицины в Санкт-Петербурге в 2015–2017 гг. Средний возраст доноров составил 27,1 ± 3,9 года, для сдачи спермы они неоднократно обращались в центр в разное время дня в интервале от 09:00 до 22:00 часов. Готовили эякулят и интерпретировали данные микроскопии в соответствии с рекомендациями ВОЗ 2010 г. Проанализированы результаты измерения объема эякулята, его концентрации и количества, а также доли и количества подвижных сперматозоидов в порциях спермы, полученных в разное время суток, проведено сравнение показателей, полученных во временных интервалах с 9:00 до 15:00 и с 15:00 до 22:00. **Результаты.** Порции эякулята, полученные после 15:00, по сравнению со сданными в более раннее время

дня в среднем имели большие объем (t = 5,63; p < 0,0001), количество сперматозоидов (t = 3,66; p = 0,0003) и количество прогрессивно подвижных сперматозоидов (t = 1,76; p = 0,078), а также меньшие концентрацию (t = 2,03; p = 0,043) и долю прогрессивно подвижных сперматозоидов (t = 4,63; p = 0,0003). Самые низкие средние значения количества сперматозоидов пришлись на интервал от 12:00 до 13:00, а самые высокие — от 16:00 до 17:00. **Заключение.** Выявлены закономерности вариабельности показателей эякулята доноров спермы, полученной в разные временные интервалы в течение дня. Их необходимо учитывать при интерпретации спермограмм при обследовании мужчин по поводу бесплодия в браке, а также при криоконсервации донорской спермы.

Ключевые слова: мужское бесплодие; суточные колебания; эякулят; спермограмма; доноры спермы.

INTRODUCTION

Semen parameters vary on the basis of many factors, such as the duration of sexual abstinence, the time of sexual stimulation prior to ejaculation, and the degree of sexual arousal [1–4]. Studies have been conducted worldwide to identify patterns of change in quantitative and qualitative semen parameters. These studies have been facilitated by the World Health Organization's (WHO) initiative for the standardization of approaches to examine and process human semen [5] and recommendations for compliance by professional communities [6, 7]. Results showed that sperm volume [8, 9], concentration [10, 11], number [12], motility [10, 12], and the rate of normal forms of spermatozoa [13–15] vary greatly in different samples from the same man, as well as over seasons. In addition, men from different countries exhibit specifics in these patterns [16]. Practitioners must consider seasonal variability when examining men for marital infertility and selecting candidates for participation in sperm donation programs. However, because of quantitative and qualitative variability in semen parameters over time of day, seasonal variability is not sufficient for comprehensive interpretation of spermatogenesis, and up-to-date data are controversial. This fact, in addition to a lack of Russian publications on this topic, prompted this study to evaluate daily variability in sperm parameters.

MATERIAL AND METHODS

We conducted a retrospective study on 1253 semen samples from 39 sperm donors (mean age 27.1 ± 3.9 years) in a reproductive medicine center in St. Petersburg, Russia. The semen samples were obtained consecutively during the period from October 1, 2015 to October 1, 2017 after 2 or 3 days of sexual abstinence; each sperm donor donated 2–91 samples (average 32 ± 29). The sperm donors were selected according to the requirements of the Order of the Russian Ministry of Health of 30.08.2012 No. 107n: "On the procedure for using assisted reproductive technologies, contraindications and restrictions on their use." Semen analysis was performed according to WHO 2010 recommendations [5], and the following parameters were analyzed: donation time, semen volume, sperm concentration, total sperm number, progressive motility, and number of progressively motile sperm. In addition, the significance of the differences in these parameters between semen samples obtained from 9:00 a.m. to 3:00 p.m. and from 3:00 p.m. to 10:00 p.m. was evaluated.

RESULTS

We observed an irregular distribution of the number of semen samples during the day. From 9:00 a.m. to 3:00 p.m., we registered 893 (71.3%) semen sample donations, with a peak of 320 (25.5%) semen samples from 10:00 to 11:00 a.m. In previous and subsequent intervals, fewer semen sample donations were registered, with a minimum value from 4:00 to 5:00 p.m. From 3:00 to 10:00 p.m., we registered 359 (28.7%) semen sample donations, with a peak from 6:00–8:00 p.m.: 88 (7%) and 89 (7.1%) of semen sample donations from 6:00 to 7:00 p.m. and from 7:00 to 8:00 p.m., respectively.

In 3 (0.2%) semen samples, quantitative and qualitative parameters did not meet the threshold values of normozoospermia recommended by WHO: 1 (0.08%) by number, 1 (0.08%) by concentration, and 1 (0.08%) by progressive motility.

The semen volume varied from 0.6 to 7.6 mL (average 3.0 ± 1.2 mL). In the first half of the day, the average semen volume after 9:00 a.m. and in every subsequent hour was lower compared with those of the previous one and reached a minimum immediately after noon. At other times, the average semen volume was high, with significantly larger values noted in samples provided after 3:00 p.m. compared with those donated earlier (t = 5.63; p < 0.0001). The maximum se-

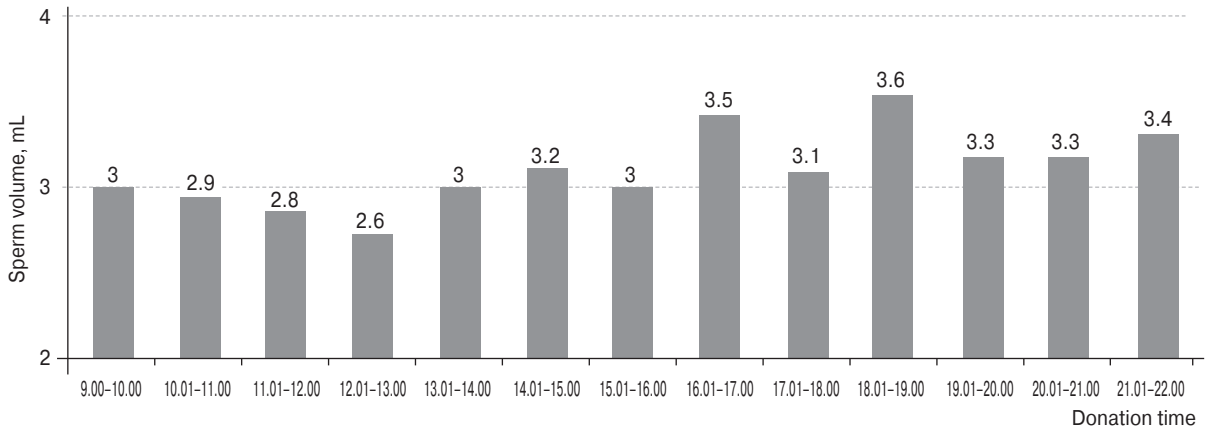

Fig. 1. Ejaculate volume of sperm donors depending on the time of its collection
Рис. 1. Объем эякулята доноров спермы в зависимости от времени его получения

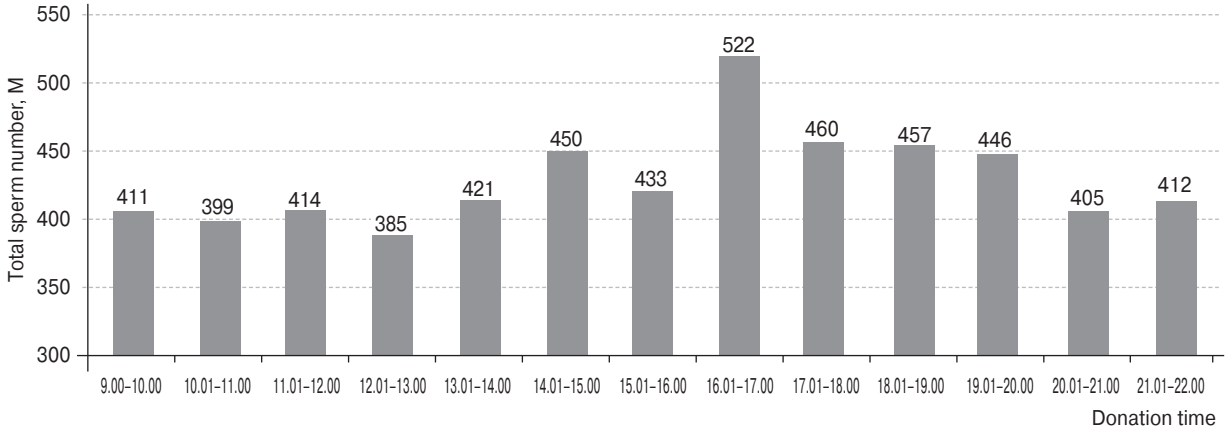

Fig. 2. The quantity (millions) of sperm cells in the ejaculate, depending on the time of its collection
Рис. 2. Количество (млн) сперматозоидов в эякуляте в зависимости от времени его получения

men volume (3.6 ± 1.0 mL) was observed from 6:00 to 7:00 p.m. (Fig. 1).

The sperm concentration ranged from 13 to 345 M/mL (average 144.1 ± 45.0 M/mL), which significantly exceeded the threshold values of normozoospermia recommended by WHO. The average sperm concentration in semen samples obtained before 3:00 p.m. was higher compared with that of the semen samples obtained later ($t = 2.03$; $p = 0.043$). However, the maximum sperm concentration (154 ± 6.8 M/mL) was observed from 4:00 to 5:00 p.m.

The average sperm number in semen samples obtained before 3:00 p.m. was less compared with that of the semen samples obtained later ($t = 3.66$; $p = 0.0003$). The lowest average sperm number and semen volume were observed at the first hour after noon, while the highest average sperm number and semen volume were observed from 4:00 to 5:00 p.m. (Fig. 2).

Progressive motility in semen samples was consistently high (average 64.6% ± 10.0%) in the morning and daytime. Lower average progressive motility was observed in semen samples obtained after 3:00 p.m. ($t = 4.63$; $p = 0.0003$): from 8:00 to 9:00 p.m. and from 9:00 to 10:00 p.m., the average progressive motility was 56.8% ± 9.5% and 57.0% ± 11.6%, respectively (Fig. 3). Daily variability in average progressive motility was approximately aligned with the total sperm number with a tendency ($t = 1.76$; $p = 0.078$) to large values after 3:00 p.m. and a maximum value (331 ± 134.6 M) from 4:00 to 5:00 p.m.

DISCUSSION

Studies of daily variability in semen parameters have not been conducted in Russia. A large number of semen samples, a single-center study conducted by certified personnel using equipment recommended by WHO, and the sperm donors' adherence to the period of sexual abstinence and the rules for sperm collection ensured high validity in this study.

Analysis of 2-year cryobank archival records in the reproductive medicine center confirmed the high variability in the quantity and quality of spermatozoa. Compliance with the normozoospermia criteria was found in the majority of cases, which was expected

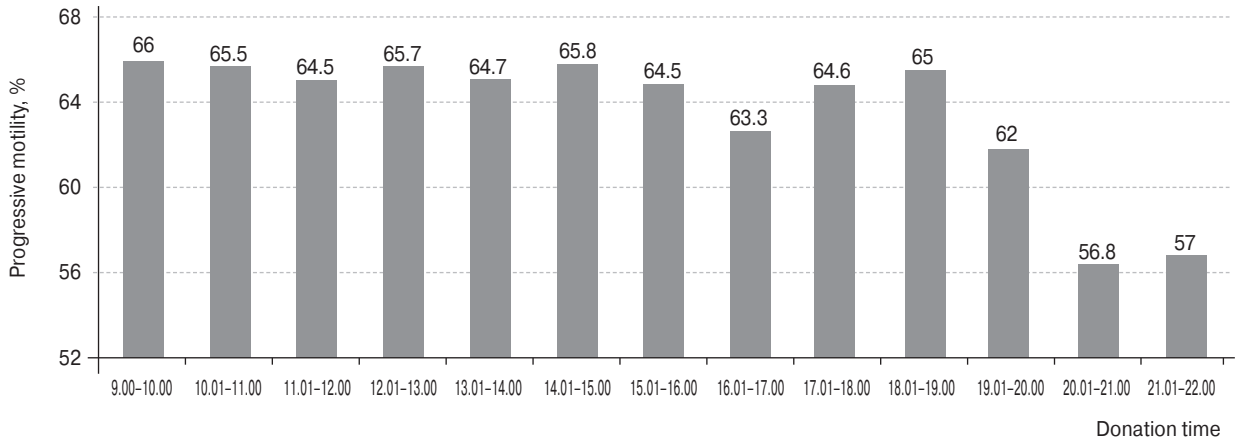

Fig. 3. Average values of the proportion of progressively motile sperm (%) in the ejaculate of sperm donors
Рис. 3. Средние значения доли прогрессивно подвижных сперматозоидов (%) в эякуляте доноров спермы

as the participants were selected for their high semen quality. However, our opinion did not always coincide with that of previous studies. There is no single point of view on the daily variability in semen parameters. According to the Laboratory of Andrology, University of Zurich [17], the best semen samples are collected in the early morning hours, which contradicts the conclusions of other researchers [18].

Biljan et al. [19] failed to identify any daily patterns in semen parameters. In contrast, in this study, sperm volume, total sperm count, and progressive motility were higher in semen samples collected after 3:00 p.m., which was consistent with the observations of Cagnacci et al. [18] but not with the observations of Xie et al. [17]. We also noted opposite tendencies between daily distributions of sperm count and sperm concentration, as well as the rate and number of progressively motile spermatozoa. The total sperm count and the number of progressively motile spermatozoa were higher in the second half of the day, while sperm concentration and the rate of the rapidly moving spermatozoa were lower because of differences in sperm volume between semen samples obtained in the first and second half of the day not described earlier. In addition, as Xie et al. [17] reported, we found no significant differences in the mean progressive motility in the morning and early afternoon hours.

The causes of daily variability in semen parameters have not been fully studied. One of the factors affecting sperm concentration may be a change in the level of hormones that regulate the function of the hypothalamic-pituitary-gonadal axis. Analysis of daily variability in follicle-stimulating hormone concentrations did not reveal significant changes, while in a survey of 1797 men from the European Union and the United States, serum inhibin B levels decreased by ~2% per hour from 8:00 a.m. to noon and by 3.25% per hour from noon to 4:00 p.m., accompanied by a significant decrease in sperm concentration and the number of spermatozoa [20, 21].

Daily variability in sperm parameters is believed to be associated with daily variability in the temperature of the scrotum, in turn related to a change in body position, especially apparent in men with low physical activity [22]. A study monitoring the temperature of the scrotum in 60 Danes who planned to have children showed that occupational hazards and lifestyle factors contribute to a decline in semen parameters.

Full maturation of the spermatozoid takes approximately 72–76 days [23], after which spermatozoa accumulate in the vas deferens and the tail of the epididymis before subsequent ejaculation. Daily variability in semen parameters may be related to functional specifics of the male reproductive system activity in emission and expulsion phases, which require further study. Differences in sperm motility during the day can be due to changes in the composition of seminal fluid, components of which are hormones, cytokines, amino acids, electrolytes, etc. [24], and further studies are required in order to investigate them.

Our study is of practical value. Its results indicated that semen samples should be taken after 3:00–4:00 p.m. However, further investigation is necessary.

Although in this study, we recorded good fertilizing ability for the vast majority of semen samples, regardless of the donation time, the study was based on the analysis of semen parameters in men with initially high levels of sperm concentration and progressive motility; therefore, these data should be extrapolated to other men with caution. The observed patterns may be due to

individual characteristics of a donor group, which could vary depending on living conditions and health status. In this regard, several spermograms are recommended for fertility analysis in men with marital infertility.

CONCLUSION

Although the results obtained in this and other studies do not allow us to finally formulate a general idea of the patterns in daily variability in semen parameters, they can be considered by reproductive health specialists when interpreting spermograms and preparing donor sperm samples for analysis.

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