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Sperm quality and environment: A retrospective, cohort study in a Northern province of Italy

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ABSTRACT

Background: Several studies proposed a relationship between environmental factors and semen quality, as well as the negative effect of air pollution on spermatogenesis and gonadal function. No specific studies evaluated the environmental influence on semen quality in a specific geographical area.
Aim: to evaluate the environmental influence on male sperm parameters in a Northern Italian population referred for semen analysis in the National Health System. The objective of the study is the assessment of the relationship of both air pollution and environmental parameters with quality-related sperm variables, during the coldest months of the year when air is usually most polluted, due to low ventilation and poor rainfall.
Study design: A retrospective, observational, cohort study was carried out in the province of Modena, located in the Emilia-Romagna region of Northern Italy.
Methods: Semen analyses (n=406), environmental temperature, air humidity and air particulate matter (PM) measurements from the 1st of November 2014 to the 19th of February 2015 were acquired to the first database. Since spermatogenesis lasts over two months, a second, wider database was arranged, evaluating environmental exposure in the 3 months before semen collection (from August 1st 2014). All data included in the database were registered by geo-coding the residential address of the patients and the site of registration of environmental factors. The geo-codification of parameters was performed using Fusion Tables of Google available at https://www.google.com/fusiontables/data? dsrcid=implicit, considering the exact time of measurement.
Results: Average air temperature was inversely related to sperm concentration and to total sperm number ($p < 0.001$). Semen volume was inversely related only to the minimum ($p < 0.001$) and not to maximum recorded temperature ($p = 0.110$). Air humidity was not related to sperm quantity and quality. $PM_{2.5}$ was directly related to total sperm number ($p < 0.001$). PM_{10} was directly related to both semen volume ($0 < 0.001$), and typical forms ($p < 0.001$), inversely related to atypical forms ($p < 0.001$), but related neither to sperm concentration ($p = 0.430$) nor to sperm motility. The extended analyses considering environmental parameters in the 3 months before semen collection, confirmed the relationship between air temperature and sperm quantity, whereas no influence was found between PM and sperm quality.
Conclusion: An influence of environmental temperature on semen quantity is suggested, without a clear effect of air pollution, as assessed through PM_{10} levels, on sperm parameter variations.

1. Introduction

In the last decade some studies suggested that the mean value of human sperm concentration decreased of about 50% over the past 50 years, from 113 to 61 millions/mL (Joffe, 2003). Concomitantly, the incidence of male infertility has been increasing in

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industrial countries year after year, now affecting 25% of young men (Kumar and Singh, 2015; Thompson, 1993). The actual prevalence of male fertility leads to socio-economic changes in clinical management of infertile couples (Inhorn and Patrizio, 2015). The issue, however, is highly controversial (Kumar and Singh, 2015).

Several studies analysed the effect of environment on semen quality (Auger et al., 1995; Mendiola et al., 2014). In fact, substantial geographical variation in sperm concentrations were reported within both Europe and North America (Joffe, 2003). Sperm concentrations were described to be relatively high in New York and Finland and low in California and North-Western Europe including Denmark and Britain (Joffe, 2003). Specific factors, possibly affecting sperm quality, are present in specific geographic areas but not in others ones (Akre et al., 1999; Hauser and Sokol, 2008). Geographical variations in environmental temperature could be one of these risk factors. Although an increased temperature at the genital level reduces sperm quality, the relationship between ambient temperature and semen quality is not completely evaluated. Only few studies demonstrated that high environmental temperatures have negative effects on sperm quality in rats, leading to temporary or permanent sterility (Maya-Soriano et al., 2015).

The male reproductive system could be affected by gonadal endocrine disruption or by a direct damage on steroidogenesis (Hammoud et al., 2010). Endocrine disruptors and steroidotoxic agents are present in air pollution. However, although increased environmental chemical pollution was implicated in poor sperm quality, a correlation between pollution and fertility is far to be demonstrated (Carlsen et al., 1992; Forti and Serio, 1993; Jensen et al., 2002). Sperm development and testicular function could be affected by exposure to a wide variety of agents, including dioxins, poly-chlorinated biphenyls, phytoestrogens such as isoflavones, heavy metals, chlorination disinfection by-products in water, organic solvents, poly-aromatic hydrocarbons, particulate air pollution, substances emitted from landfill sites and caffeine (Carlsen et al., 1992; Forti and Serio, 1993; Jensen et al., 2002). Air pollution includes an increased air content of carbon monoxide, nitrous dioxide, sulphur dioxide, ozone, lead and particulate matter (PM). These toxins could affect semen quality and alter sperm DNA integrity, reducing sperm quality (Mendiola et al., 2014). However, only few studies have been able to consider comprehensively all possible air pollutants in infertile men (Joffe, 2003).

The effect of pollutants on sperm quality could be evaluated in humans or in laboratory animals. Watanabe et al. demonstrated that diesel engine exhaust stimulated hormonal secretion, depressed gonadotropin releasing hormone (GnRH) and inhibited spermatogenesis in the rat model (Watanabe and Oonuki, 1999). Similarly, the occupational exposure to heavy metal slightly reduces sperm production in men (Viskum et al., 1999). However, this decrease seems to be transient and partially reversible (Viskum et al., 1999). Similarly, De Rosa et al. found that all sperm parameters, except sperm count, were deranged in subjects continuously exposed to environmental pollutants (De Rosa et al., 2003). Mendiola et al. confirmed that air pollution is associated to reduction in sperm quality in the United States of America (Mendiola et al., 2014). On the contrary, Hovatta et al. did not find any correlation between the heavy metal and sperm quality (Hovatta et al., 1998).

The aim of this study is to evaluate the effect of environmental temperature and PM on semen analysis in a Northern Italy population, considering, for the first time, exact geographical parameters using a large set of data recorded in a specific time-interval, i.e. the winter months, characterized by the lowest temperatures and the highest presence of pollutants in the air.

2. Materials and methods

A retrospective, observational, cohort study was carried out in the province of Modena, located in the Emilia-Romagna region in Northern Italy. This area comprehends 2688 km^2 and 702,364 inhabitants (updated to 2014).

The institutional review board approved the study (protocol number: 0032791/15).

2.1. Subjects

All men undergoing a semen analysis from the 1st of November 2014 to the 19th of February 2015 at the Clinical Pathology of the Nuovo Ospedale Civile Sant'Agostino Estense (NOCSAE) of Modena were consecutively included in the study, irrespective of the reason of request and without any selection. Data concerning working exposure to contaminants was not available.

All sperm samples were collected and analysed in a single laboratory. This cohort is expected to be highly representative of the entire population of the province referred for semen analysis for any reason, mainly couple infertility. Ten other private laboratories are offering this analysis in the province. However, the NOCSAE represents the single laboratory approved by the National Health System for the province of Modena for semen analysis and patients do not obtain reimbursement if the test is performed in a private lab. For these reasons, the number of semen analyses included in the study is expected to be the vast majority of such analyses performed in the province of Modena in the mentioned time period. No previous historical population database on male infertility was available for the province of Modena. A computing database was created, registering sperm analyses performed for each enrolled patient. Moreover, the city of residence, the date of birth and the date of examination were registered for each man.

The population of the province of Modena is characterized by a mean age of 44.09 years with a birth rate of 8.4 per thousand inhabitants and a mortality rate of 9.7 per thousand inhabitants (old age index of 145.1 years) (www.urbistat.it/AdminStat/it/it/classifiche/). Interestingly, the migration rate in 2014 was only 3.2 of thousand inhabitants. Epidemiological data suggested that the percentage of obese subjects in the province of Modena is around 13%.

2.2. Semen analysis

Semen analyses were performed, according to parameters provided by the last guideline of the World Health Organization (WHO, 2010).

The samples were placed at 36 °C immediately after collection and sperm motility was assessed within one hour from semen collection.

To assess the validity of the measurements regarding sperm number, motility and morphology, the laboratory joins a program of external quality evaluation provided by the Reference Centre for Safety and Quality of Careggi Hospital, Florence, Italy.

Two times a year, three unknown samples, fixed with formalin 10%, are separately analysed by the three biologists of the laboratory for the evaluation of sperm number and morphology, while sperm motility is assessed by looking to some short movies.

Before sending back results to the Reference Centre, all disagreements between the biologists are discussed, and possibly samples are analysed again. Seminal parameters included in the database were: volume (mL), total sperm number (millions), sperm concentration (millions/mL), percentage of typical/atypical forms (%), percentage of motile sperms (%), and concentration of leucocytes (millions/mL). Sperm motility was registered as total, progressive and non-progressive motility.