International Journal Of Occupational Health and Public Health Nursing, vol.2, no.3, 2015, 3-11
ISSN: 2053-2369 (print version), 2053-2377 (online)
Scienpress Ltd, 2015

Influence of Exogenous-Environmental or Occupational-Factors on Male Fertility

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Abstract

Sperm dysfunction is the single most common cause of worldwide infertility. The aim of this study was to investigate the influence of exogenous (environmental, lifestyle and occupational) factors on male fertility. Based on semen analysis, a retrospective case-control study was conducted among 140 males, 70 of them were dyspermic (cases) and 70 were classified as euspermic (controls). Cases were selected randomly among visitors to a specialized laboratory and controls among apparently healthy people from the general population. Ten exogenous risk factors/hazards were compared within the two groups. The odds ratios were calculated using logistic regression and were estimated as 1.7 for alcohol consumption, 1.65 for heavy tobacco smoking, 1.6 for extended driving, 1.55 for scrotal hyperthermia and 1.21 for prolonged sitting posture. The synergistic effect of multiple factors on male fertility was studied and the results were statistically significant. Selected exogenous factors can affect significantly male fertility and therefore preventive measures that can eliminate or reduce them could increase the fertilization capacity.

Keywords: Male infertility, occupational factors, environmental hazards.

1 Introduction

Infertility is a serious global problem that affects approximately 15% of married couples in reproductive age (meaning more than 80 million couples worldwide) and is defined as the absence of spontaneous pregnancy after one year of unprotected intercourse. As more than 40% of the affected cases can be attributed to male limited sperm capacity (dyspermia), sperm dysfunction is considered as the single most common cause of general

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Article Info: *Received* : February 25, 2015. *Revised online* : July 31, 2015
Published Online: December 31, 2015

infertility, in such degree that constitutes fertilization in these cases impossible without treatment [1,2].

Various forms of dyspermia include hypospermia (semen volume lower than 2 ml), azoospermia (no spermatozoa in the ejaculation), oligozoospermia (sperm concentration lower than 20.000.000 sp/ml), asthenozoospermia (spermatozoa motility lower than 50%) and teratozoospermia (normal spermatozoa morphology lower than 50%). These conditions are quantifiable in the laboratory with the analysis of semen volume, and spermatozoa count, motility and morphology [2,3].

Dyspermia, besides the individual anatomic and functional abnormalities, is also attributed to exogenous (environmental, lifestyle and occupational) factors. It is considered that during the last 40 years these factors increasingly contribute to male infertility [2].

Many studies, and some of them very recent, have proved this effect. Environmental or occupational exposure to agro or industrial chemicals, heavy metals (i.e. lead, cadmium etc.) and living in areas close to potential sources of pollution, has been associated with reduced sperm count, motility, viability and normal forms [4]. Current smoking also is associated with lower total seminal vesicles volume (before and after ejaculation) and lower ejaculate volume, despite higher testosterone levels, in male subjects of infertile couples [5].

Scrotal hyperthermia is another hazard highly related with reduced male fertility and (beside internal causes) there are occupational, lifestyle and environmental factors that can cause it, such as extended driving (and mainly of motorcycles), hot baths in genitalia, tight pants etc. Furthermore, a new factor has recently appeared, mainly in the last decade, consisting of laptop computer (LC) usage. Recent studies have shown that using an LC in sitting position with closely approximated legs is the major cause of scrotal hyperthermia. Even scrotal shielding with a lap pad can neither efficiently protect from scrotal temperature elevation, thus modified sitting position (legs apart) and shorter use of LC are recommended for effective protection [6].

Generally, the main occupations that appear significantly associated with a risk of reduced sperm parameters are workmen, patients, farmers, welders, plumbers and technicians. Similarly, the main occupational hazards are solvents, heavy metals, heat, vibrations and non-ionizing radiation [7].

The aim of this study was to investigate the relationship between male infertility and exogenous (environmental, lifestyle and occupational) risk factors by comparing euspermic and dyspermic male groups.

2 Material

A retrospective case control study was conducted on a group of 140 males, between 20 and 47 years old, varying economic and social status, as well as occupation, education and geographic origin within Greece. Out of 140 males, 70 were dyspermic and 70 were euspermic. The cases were randomly selected from visitors to a specialized outpatient's male sterility facility in Athens, Greece. For every dyspermic male, an euspermic male of similar age was selected from the general population. The average age of the dyspermic males was 35,6 (± 5,19) years while that of the euspermic was 34,2 (± 5,95).

Elimination criteria from the study group were: a) individuals with recent treatment and b) the testicle volume (subjects with individual testicle volume less than 10 ml) were eliminated. Subjects were categorized as euspermic or dyspermic based on the laboratory sperm analysis. Subjects were considered as normal (euspermic) with the following criteria [3]:

1] 14% or greater for the Kruger morphology criterion, a sperm quality indicator[2],
2] Semen volume greater than 2 ml,
3] Sperm concentration greater than 20.000.000 sp./ml,
4] High spermatozoa motility greater than 25% as well as the sum of high and moderate motility greater than 50%, and
5] Spermatozoa morphology greater than 50% for the normal forms.

Subjects that satisfied all the above five criteria were characterized as euspermic, while those that failed at least one of the five criteria were characterized as dyspermic [2,3].

All study participants were volunteers and consented to participate in the study in writing after being informed about its aim. All participants filled up the entry questionnaire by a face to face, direct interview. Information was collected regarding demographic data, occupational status, tobacco smoking, alcohol consumption, drug use, physical activity habits, exposure to chemicals, radiation, heat exposure (hyperthermia in the genitals), driving habits, and medical history. Testicle volumetric test and sperm analysis were conducted in detail for both cases and controls, following at least 48-hour ejaculation abstinence in order to safeguard sperm quality [2].

The two groups were compared for ten independent exogenous risk factors (qualifiers): prolonged sitting posture during work hours, exposure to occupational hazards, tobacco smoking, alcohol consumption, drug use, non-occupational heat exposure (hyperthermia of the genitals), daily driving duration, exposure to chemicals, exposure to radiation and physical activity.

3 Methods

Body posture during work hours was subdivided into three categories (standing or in-motion, sitting or kneeling and mixed). For tobacco smoking, the participants were first grouped in smokers and non-smokers. Smokers were subdivided in four categories in relation to tobacco use as mild (1-9 cigarette /day), moderate (10-19 cig/day), heavy (>20 cig/day, $\leq$400 cig.x years of smoking) and ultra-heavy (>20 cig/day, >400 cig.x years). For alcohol consumption, the participants were grouped as non-users, mild users (less than 100 ml of alcohol per week) and heavy users (greater than 100 ml of alcohol per week).

Non-occupational exposure (of the genitals) to high temperatures was qualified with regards to use of tight trousers or underwear and use of frequent hot baths. For daily driving duration, the participants were grouped into those driving up to two hours per day and those driving more than two hours per day.

Exposure to occupational and non-occupational hazards as well as exposure to chemicals was evaluated independently by three experts. Exposure to chemicals and radiation were evaluated as a lumped parameter for both occupational and non-occupational exposure, although the two were separate entries in the questionnaire.

For these factors, a statistical analysis was conducted for evaluating their effects on sperm quality, by using pearson's chi-square (x^2) test with statistical significance level at $p<0,05$. Multiple logistic regression was employed to estimate the odds ratio for multiple risk

factors at a 95% confidence interval.
The coexistence of different qualifiers (synergistic effect) in the same sample was studied by grouping participants to those with at least three or more risk factors and those with up to two risk factors. Multivariate logistic regression was used to estimate the odds ratio between euspermic and dyspermic individuals from exposure to each risk factor [8].

4 Results

Following table 1 shows the results of the multivariate analysis. A positive relationship was found for most factors although it was not statistically significant [8].

Table 1: Risk factor evaluation with univariate and multivariate analysis.

Qualifiers	OR*	Corr. OR	P	95% C.I.for corr. OR	
				lower	upper
Alcohol consum.	1,677	1,699	0,134	0,850	3,397
Heavy smoking	1,855	1,646	0,187	0,785	3,448
Extended driving	1,707	1,602	0,266	0,698	3,676
Hyperthermia	1,455	1,553	0,242	0,743	3,247
Sitting posture	1,414	1,214	0,594	0,596	2,474
Occupat.exposure	1,350	1,092	0,844	0,454	2,626

* OR=Odds Ratio

4.1 Tobacco Smoking

The odds ratio between smokers and non-smokers was 1.25 [CI:0,64-2,44/p:0,213]. The effect of heavy smoking was studied and the odds ratio for heavy and ultra-heavy smokers was quantified as 1.64 [CI:0,78-3,44/p:0,187]. Figure 1 shows the distribution of dyspermic and euspermic participants in relation to tobacco smoking.

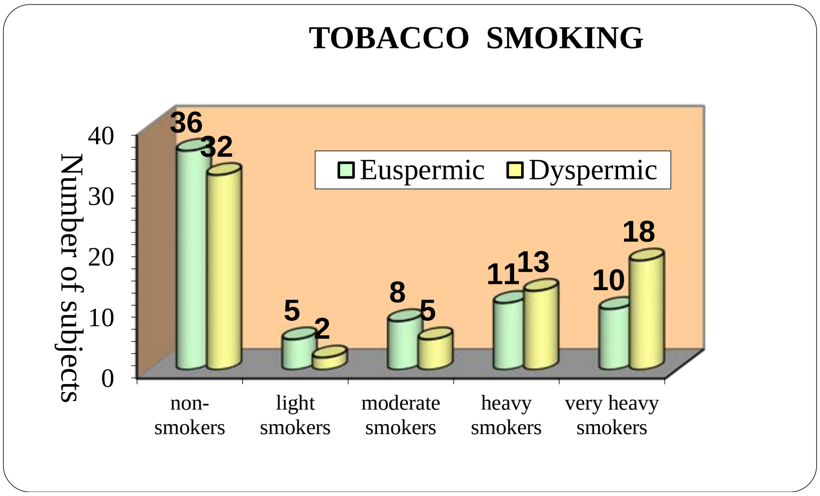

Figure 1: Distribution of euspermic and dyspermic according to smoking level.

4.2 Alcohol Consumption

The odds ratio between alcohol users and non-users was 1.69 [CI:0,85-3,39/p:0,134]. Figure 2 shows the distribution of dyspermic and euspermic participants according to alcohol consumption.

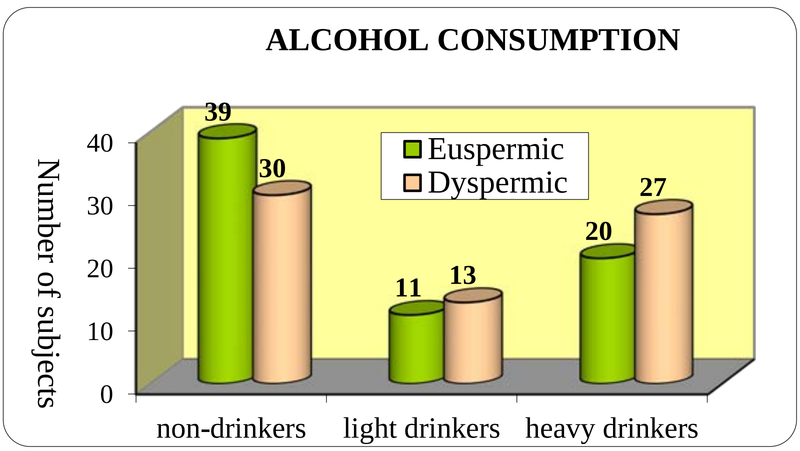

Figure 2: Distribution of euspermic and dyspermic subjects according to alcohol consumption level.

4.3 Other Factors

For non-occupational exposure of the genitals to high temperatures, the odds ratio was estimated at 1.55 [CI:0,74-3,24/p:0,242]. The odds ratio between the two groups of daily driving duration was 1.60 [CI:0,69-3,67/p:0,266]. The odds ratio for the sitting posture during work hours (compared to standing/in motion or mixed postures) was 1.21 [CI:0,59-2,47/p:0,594]. The odds ratio for the occupational exposure was estimated at

1.09 [CI:0,45-2,62/p:0,844].
For chemical exposure, the odds ratio was 1.85 [CI:0,74-4,56/p:0,178]. The odds ratio for those having radiation exposure history was found 0.82 [CI:0,23-2,82/p:0,753]. Factors such as drug use [0,65(CI:0,10-4,05)], and physical activity habits [1,06(CI:0,54-2,05)] were also studied and the results were not statistically significant.

4.4 General

All risk factors were not found to be statistically significant, even though the odds ratios were considerably greater than unity, since the sample population was not statistically large enough to affect the 95 % confidence interval. Table 2 shows the frequency of coexistence for multiple risk factors between euspermic and dyspermic participants [8].

Table 2: Number of qualifiers among the 2 groups

Number of qualifiers	FERTILITY		Total
	Dyspermic	Euspermic	
None	4	4	8
1	5	15	20
2	21	24	45
3	19	17	36
4	12	7	19
5	6	3	9
6	3	0	3
Number of subjects	70	70	140
Mean value	2,86	2,24	
Standard deviation	1,417	1,197	

The two groups differed significantly in respect to the number of risk factors (t=2.771, 138 d.f./ p=0.006]. The percentage of dyspermic that had three or more risk factors was greater than the euspermic (Pearson's x^2=4.837, p=0.028). The risk was 2.12 [CI:1,08-4,17] times greater and statistically significant. In addition, the respective percentage of dyspermic that had 4 or more risk factors was 2.57 [CI:1,10-5,97] time greater and also statistically significant [x^2=5,013, p:0,025].

5 Discussion

For most of the studied factors, a relationship to dyspermia was found, although the sample size did not allow a statistically significant documentation of it. Participants that were exposed to occupational hazards were found to be increasingly dyspermic, in comparison to the non-exposed. Numerous early and recent studies have concluded that the occupational risk factors affect male fertility [9]. Occupational groups exposed to heat (e.g. drivers, bakers), radiation or chemicals, have been found to be affected [4,5,9-16].

A positive correlation was found between dyspermic participants and those having a sitting posture during work hours, in relation to those having a standing or in-motion or mixed posture. The sitting posture helps maintain higher temperatures in genitalia, which affects normal testicle temperatures and seminal production. Other studies have shown a positive correlation with regards to sperm quality between sitting and standing postures during work hours [17,18] and leisure time [19].

Numerous studies have also examined the effects of hyperthermia in male fertility, by looking at risk factors such as occupational hyperthermia [11] temporal temperature variations [20], as well as more specialized factors such as hothouse occupations [21] and global warming [22]. In this study, non-occupational hyperthermia was examined, related to tight pants (mainly jeans), or frequent hot baths in genitalia and a positive correlation was found between those exposed and dyspermic participants. The same results were found in other studies that examined either one [19,23] or both of these risk factors.

High dyspermia was also found in those exposed in heavy driving (greater than two hours per day), and the risk is also attributed to elevated genitalia temperatures. In numerous studies the high risk of driving for extended hours, has been established for professional [24,25], semi-professional or recreational drivers [26].

A positive correlation between dyspermic participants and exposure to chemicals was found, but due to the small sample size, the groups were not further subdivided according to the exposure to specific chemicals. A lot of studies have examined the effect of exposure to hazardous chemicals in male sterility [4,14,18,27], either as a specific compound effect [13] or individually for groups of chemicals such as heavy metals [4,22,28] (lead [13,27], cadmium [4] etc.), pesticides [22,28,29], coatings [28], petroleum fuels [21,30], solvents [29,31], etc..

It has been proven in numerous studies that ionizing and non-ionizing radiation is harmful to male fertility [31], by either occupational [12,32] or environmental exposure [13,22].

Tobacco smoking, maybe the most widely studied risk factor [5,15], is proven to cause hormonal disorders and affect both sperm quantity and quality. In the present study, dyspermia was observed mainly in heavy smokers. Other studies examined the increased risk from heavy tobacco smoking [21,33], the correlation between hyperthermia and tobacco smoking [20] and the detrimental effect of cadmium in cigarettes [34].

Alcohol consumption has shown increased risk, between casual users and non-users, as well as between heavy users and moderate users. It has been proven that alcohol abuse and mainly chronic use can affect spermatogenesis in general. Although some studies have shown effects from casual alcohol consumption [35], most studies correlate dyspermia only with heavy alcohol use [36,37].

Physical exercise as a factor was not possible to be differentiated between euspermic and dyspermic participants, although it has been shown that has positive effects counterbalancing the negative ones of sitting lifestyle [19].

Numerous studies have shown the effect of multiple risk factors in male fertility [17,24,32]. The synergistic effect of different risk factors, can multiply the total risk. In the present study, the statistically significant correlation found for lumped qualifiers, is not certain, if it constitutes synergy, or just a correlation of individual qualifiers, since the small sample size becomes statistically significant after lumping.

Based on the findings of the present study, it can be concluded that the risk for male infertility is proportional to the size of the risk factors involved. Therefore, preventive measures that can eliminate some or most of the risk factors responsible for male infertility can increase the fertilization capacity.

References

[1] Barratt C, Mansell S, Beaton C, Tardif S, Oxenham S. Diagnostic tools in male infertility-the question of sperm dysfunction. Asian Journal of Andrology, **13**, (2011), 53-58.
[2] Milingos S. Male sterility. Greek company of gynecological endocrinology, Athens, 1994.
[3] WHO Laboratory Manual for the examination and processing of human semen (5thEdition). WHO Press, Switzerland, 2010.
[4] Wijesekara GUS, Fernando DMS, Wijerathna S, Bandara N. Environmental and occupational exposures as a cause of male infertility. Ceylon Medical Journey, **60**(2), (2015), 52-56.
[5] Lotti F et al. Current smoking is associated with lower seminal vesicles and ejaculate volumein male subjects of infertile couples. Hum Reprod, **30**(3), (2015), 590-602.
[6] Sheynkin Y, Welliver R, Winer A, Hajimirzaee F, Ann H, Lee K. Protection from scrotal hyperthermia in laptop computer users. Fertil Steril, **95**(2), (2011), 647-651.
[7] Hamouda O, Perrin J, Achard V, Courbiere B, Grillo JM, Sari-Minodier I. Association between sperm abnormalities and occupational environment among male consulting for couple infertility. Journal Gynecol Obstetr Biol Reprod, 2015 [Doi:10.1016/j.jgyn.2015.08.011].
[8] Lemeshow S, Hosmer DW. Logistic regression. In Armitage P. Colton T. Encyclopedia of biostatistics. John Wiley & Sons, New York,1998.
[9] Chia SE, Tay SK. Occupational risk for male infertility: A case-control study of 218 infertile and 227 fertile men. J Occup Envir Med, **43**(11), (2001), 946-951.
[10] Sharma R, Biederharn K, Fedor J, Agarwal A. Lifestyle factors and reproductive health:Taking control of your fertility. Reprod Biol Endocrinol, **11**, (2013), 66.
[11] Chia SE, Ong CN, Lee ST, Tsakok FH. Study of the effects of occupation and industry on sperm quality. Ann Acad Med Sing, **23**(5), (1994), 645-649.
[12] Gracia CR, Sammel MD, Coutifaris C, Guzick DS, Barnhart KT. Occupational exposures and male infertility. Am J Epidemio, **162**(8), (2005), 729-33.
[13] Osorio A.M. Male. Reproductive toxicology. Occupational & Environmental Medicine (2nd edition), chapter **26**, Appleton and Lange, Norwalk(CT), 1997.
[14] Bonde JP. Occupational risk for male infertility. Occup Environ Med, **71**, (2014), 596-597.
[15] Chia SE, Lim ST, Tay SK. Factors associated with male infertility: a case-control study of 218 infertile and 240 fertile men. BJOG, **107**(1), (2000), 55-61.
[16] Sheiner EK, Sheiner E, Carel R, Potashnik G, Shohan I. Potential association between male infertility and occupational psychological stress. J Occup Environ Med, **44**(12), (2002),1093-9.
[17] Stoy J, Hjollund NH, Mortensen JT, Burr H, Bonde JP. Semen quality and sedentary work position. Int J Androl, **27**(1). (2004), 5-11.

[18] Magnusdottir E, Thorsteinsson T, Thorsteinsdottir S, Heimisdottir M, Olafsdottir K. Persistent organochlorines, sedentary occupation, obesity and human male subfertility. Hum Reprod, **20**(1), (2005), 208-215.
[19] Jung A, Leonhardt F, Schill WB, Schuppe HC. Influence of the type of undertrousers and physical activity on scrotal temperature. Hum Reprod, **20**(4), (2005), 1022-7.
[20] Kunzle R, Mueller MD, Huber AW, Drescher H, Bersinger NA. Seasonality in human semen quality of smokers and non-smokers: effect of temperature. Asian J Androl, **6**(3), (2004). 243-7.
[21] Qin KG, Hou YX, Zhang LY, Li MH, Yang SX, Ma Y. A case control study on the risk factors of male infertility. Zhonghua Liu, **24**(1), (2003), 30-2.
[22] Sinawat S. The environmental impact on male fertility. J Med Assoc Thai, **83**(8), (2000), 880-885.
[23] De Kretser DM. Are sperm counts really falling? Reprod Fertil Dev, **10**(1), (1998), 93-5.
[24] Figa-Talamanca I, Cini C, Varricchio GC, Dondero F, Gandini L,Lenzi A. Effects of prolonged autovehicle driving on male reproduction function:a study among taxi drivers. Am J Ind Med, **30**(6), (1996), 750-758.
[25] Moskova P, Popov I. Changes in the fertility indices among professional drivers. Akush Ginekol, **32**(3), (1993), 36-8.
[26] Bujan L, Daudin M, Charlet JP, Thonneau P, Mieusset R. Increase in scrotal temperature in car drivers. Hum Reprod, **15**(6), (2000), 1355-7.
[27] Cherry N et al. Occupation exposures and sperm morphology: a case-referent analysis of a multi-centre study. Occup Environ Med, **71**(9), (2014), 598-604.
[28] Wong W, Zielhuis G, Thomas C, Merkus H, Steegers R. New evidence of the influence of exogenous and endogenous factors on sperm count in man. Eur J Obstet Gynecol Reprod Biol, **110**(1), (2003), 49-54.
[29] Oliva A, Spira A, Multinger L. Contribution of environmental factors to the risk of male infertility. Hum Reprod, **16**(8), (2001), 1768-76.
[30] Bonde JP. Occupational causes of male infertility. Current opinion in endocrinology, diabetes & obesity, **20**(3), (2013), 234-239.
[31] Bonde JP. Male reproductive organs are at risk from environmental hazards. Asian Journal of Andrology, **12**, (2010), 152-156.
[32] Oldereid NB, Rui H , Purvis K. Male infertility. Significance of life and occupation. TNL, **114**(28), (1994), 3308-11.
[33] Gaur D, Talekar M, Pathak V. Effect of cigarette smoking on semen quality of infertile men. Singapore Med J, **48**(2), (2007), 119-123.
[34] Chia SE, Xu B, Ong CN, Lee ST, Tsakok FM. Effect of cadmium and cigarette smoking on human semen quality. Int J Menop. Stud, **39**(5), (1994), 292-8.
[35] Tsujimura A, Matsumiya K, Takahashi T, Yamanaka M, Koga M, Miura H. Effect of lifestyle factors on infertility in men. Arch Androl, **50**(1), (2004),15-7.
[36] Okonofua F, Menakaya U, Onemu SO, Omo LO, Bergstrom S. A case-control study of risk factors for male infertility in Nigeria. Asian J Androl, **7**(4), (2005), 351-61.
[37] Muthusami K, Chinnaswamy P. Effect of chronic alcoholism on male fertility hormones and semen quality. Fertil Steril, **84**(4), (2005), 919-24.