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The Effect Of Air Temperature On Quality Of Sperm In Diyarbakir: An Analysis Over Six Years

Diyarbakır'da Hava Sıcaklığının Sperm Parametrelerine Etkisi: Altı Yıllık Analiz

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Abstract

Introduction: There are many studies focusing on the effect of environmental conditions on human sperm quality. Therefore, we aimed to evaluate the possible effects of environmental factors such as air temperature, humidity, sun exposure time, and particulate matter 10 (PM_{10}), on semen parameters in Diyarbakır.

Materials and Methods: In this study, semen analysis data obtained from 7318 men with suspected infertility were analyzed retrospectively. Since spermatogenesis takes more than two months, retrospective data were adjusted to assess environmental exposure three months before semen retrieval. Semen samples taken from the participants were examined in conformity with WHO criteria after liquefaction.

Results: The mean age was 30.67± 7.21 years. The average air temperature was inversely related to sperm concentration, total sperm count, and total progressive motile sperm count (TPMSC). Sperm concentration, total sperm count, and TPMSC increased at low temperature (< 15°C) compared to high temperature (>15°C). TPMSC was higher in sun exposure for less than 8 hours than those exposed for more than 8 hours. Also, sperm concentration, and total sperm count, were higher when above relative humidity 50% than below 50% relative humidity. There was no significant difference between PM_{10} values (<40 µg/m³ and >40 µg/m³) and sperm parameters.

Conclusion: This study is the first to evaluate the association between parameters related to male fertility and environment with a big-data approach in Diyarbakır. Our results supported that environmental factors such as sun exposure, relative humidity, and air temperature have a negative effect on sperm parameters.

Keywords: Infertility; sperm analysis; environmental

Özet

Amaç: Çevre koşullarının insan sperm kalitesi üzerindeki etkisine odaklanan birçok çalışma bulunmaktadır. Bu nedenle Diyarbakır'da hava sıcaklığı ve nemi, güneşe maruz kalma süresi ve partikül madde 10 (PM10) gibi çevresel faktörlerin semen parametreleri üzerindeki olası etkilerini değerlendirmeyi amaçladık.

Gereç ve Yöntem: Bu çalışmada infertilite şüphesi bulunan 7318 erkekten elde edilen semen analizi verileri geriye dönük olarak incelendi. Spermatogenez iki aydan fazla sürdüğü için, semen alımından üç ay önce çevresel maruziyeti değerlendirmek için geriye dönük veriler ayarlandı. Katılımcılardan alınan semen örnekleri sıvılaştırma sonrası WHO kriterlerine uygun olarak incelendi.

Bulgular: Ortalama yaş 30,67±7,21 yıl idi. Ortalama hava sıcaklığı, sperm konsantrasyonu, toplam sperm sayısı ve toplam ilerleyici hareketli sperm sayısı (TPMSC) ile ters orantılıydı. Sperm konsantrasyonu, toplam sperm sayısı ve TPMSC düşük sıcaklıkta (< 15°C) yüksek sıcaklığa (>15°C) göre arttı. TPMSC, 8 saatten az güneşe maruz kalanlarda, 8 saatten fazla maruz kalanlara göre daha yüksekti. Ayrıca, sperm konsantrasyonu ve toplam sperm sayısı, bağıl nem %50'nin üzerindeyken %50 bağıl nemin altında olduğundan daha yüksekti. PM10 değerleri (<40 µg/m3 ve >40 µg/m3) ile sperm parametreleri arasında anlamlı fark yoktu.

Sonuç: Bu çalışma, Diyarbakır'da erkek doğurganlığı ve çevre ile ilgili parametreler arasındaki ilişkiyi büyük veri yaklaşımıyla değerlendiren ilk çalışmadır. Sonuçlarımız güneşe maruz kalma, bağıl nem ve hava sıcaklığı gibi çevresel faktörlerin sperm parametrelerini olumsuz etkilediğini destekledi.

Anahtar Kelimeler: İnfertilite; sperm analizi; çevresel

Introduction

About 40% of infertility cases are caused by male factors involved in infertility (1). The causes of male infertility are multiple and complex. Lifestyle, environmental exposures, and genetic factors affect male fertility and semen quality. The evident changes in semen quality show that genetic factors are not the only cause. Intrinsic factors such as age and extraneous factors such as nutrition, climate, and management practice affect sperm characteristics. There is a close relation between sperm maturation, spermatogenesis and environmental temperature, requiring a temperature slightly below the normal body temperature. The increase in air temperature is an important factor affecting semen quality and semen production. The lowest sperm count in

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summer (2), and a peak mean sperm concentration during the spring months (3) were reported in some published studies. Some researchers thought that the sperm count changes might be associated with temperature changes, and photoperiod is required for normal spermatogenesis as a temperature 2-3°C below the rectal temperature and increased temperature in the testes inhibited sperm production (4). Some studies in animal models show a reduction of sperm production and increase of abnormalities during spermiogenesis through a higher testis temperature of approximately 1.5 °C (5). Despite a retrospective cohort study performed in Italy suggesting the impact of environmental temperature on sperm quantity, some confounding variables, e.g., demographic characteristics, were not controlled well (6). Air pollution occurs when air pollutants are released into the atmosphere with different activities and factors. Air pollutants can be seen as liquid droplets, solid particles, or gases. Furthermore, they may be man-made or natural. It is widely known that air pollution adversely affects human health, including respiratory and cardiovascular diseases. Few animal toxicologic studies have given preliminary evidence showing the relationship between air pollutant exposure and semen quality outcomes. There have been an association between reduced daily sperm production and total air pollution among rats and mice receiving prenatal or *in utero* exposure to filtered exhaust and total diesel exhaust (7). As reported by Lao et al., every increment of 5 μg/m3 in 2-year average particulate matter (PM) PM2.5 was significantly related to the reduction of 1.29% in sperm normal morphology and a 26% higher risk of having the bottom 10% of sperm normal morphology (8). Therefore, we aimed to evaluate the possible effects of environmental factors such as air temperature and humidity, sun exposure time and PM10 on semen parameters in Diyarbakır.

Material and Methods

Study Population: This study was carried out in Diyarbakır governorship provincial health directorate health sciences üniversity Gazi Yaşarlıgil training and research hospital andrology laboratory, between September 2016 and October 2021. In this study, semen analysis data obtained from 7318 men (aged between 16 and 70 years; mean age ± SD: 30.67 ± 7.21) with suspected infertility living in Diyarbakır were analyzed and environmental conditions were evaluated, including air temperature, sun exposure time, relative humidity, and PM_{10}. The males with azoospermia were not included in the study. Since the time sperm cell took to reach its egg fertilization capacity from the primordial germ cell stage is 75-90 days, the exposure of the sperm cell to environmental factors in a 3-month development period was evaluated in the semen analysis taken from the males included in the study. The average temperature of the autumn and winter months is estimated to be 15^{o}C. We have taken the daily working time as the sun exposure time. Monthly average temperature (^{o}C), monthly average sunlight exposure (hours), monthly average humidity (%) data were obtained from Diyarbakır Meteorology Regional Directorate Station (station no: 17 281). PM consists of the complex liquid droplets and solid particles suspended in the atmosphere, varying in size, concentration, chemical composition, shape, acidity, surface area, reactivity, solubility, and origin (9). PM_{10} characterizes inhalable particles with 10 micrometers and smaller diameters. PM_{10} values were obtained from the air quality measurement station of the Provincial Directorate of Environment and Urbanization. Reference is made to the article of Wdowiak et al. for the PM10 value (10).

Semen Analysis: Sperm samples were taken from the participants who abstained for 2-7 days in sterile disposable plastic containers. Semen samples taken from the participants were examined in conformity with WHO criteria after liquefaction. The semen samples were first homogenized by pipetting with a Pasteur pipette. Approximately 10 μl of semen was pipetted and placed on the Makler camera (caunting chamber) and sealed with a lamella to determine the count and motility. Spermatozoa in 10 squares were counted through the x20 lens of the light microscope (Olympus CX31), and the result was expressed in millions. It was evaluated that sperm parameters including viscosity, leucocyte count, sperm concentration, total sperm count, motility, immotilty, and total progressive motile sperm count (TPMSC).

Table 1: Demographic characteristics of the study participants.

Characteristics	All Subjects (n= 7318)
Age (year), mean ± SD	30.67 ± 7.21
15-25, n %	1585 (21.6)
26-35, n %	4050 (55.3)
>36, n %	1683 (23.1)
BMI, mean ± SD	25.95 ± 3.20
< 18.5, n (%)	7 (0.09)
18.5-24.9, n (%)	464 (6.3)
25-29.9, n (%)	499 (6.8)
> 30, n (%)	81 (1.1)
Unknown	6 267 (85.6)
Education Level	
Primary School, n (%)	503 (6.8)
High School, n (%)	240 (3.3)
University, n (%)	309 (4.3)
Unknown, n (%)	6 266 (85.6)
Location	
Rural, n (%)	314 (4.3)
Urban n (%)	740 (10.1)
Unknown, n(%)	6 264 (85.6)
Current Smoking	
Yes, n (%)	619 (8.4)
No, n (%)	427 (5.8)
Unknown, n (%)	6 272 (85.8)
Infertility type	
Primary infertility, n (%)	632 (8.6)
Secondary infertility, n (%)	281 (3.8)
Unknown, n (%)	6405 (87.6)
Infertility period	
0-5 years, n (%)	815 (11.1)
>5 years, n (%)	232 (3.1)
Unknown, n(%)	6 271 (85,7)
Varicocele	
Yes, n(%)	313 (4.27)
No, n(%)	741 (10.12)
Unknown, n(%)	6 264 (85.61)
Chronic disease	
Yes, n (%)	125 (1.70)
No, n (%)	929 (12.69)
Unknown, n (%)	6 264 (85.61)

BMI: body mass index

Statistical Analysis: The normality of data distribution was tested with the Shapiro Wilk test. When the data did not fit the normal distribution, Mann Whitney U and Wilcoxon tests were used for pairwise comparison. Data were defined as mean and standard deviation. It was tested to see whether there was a significant difference between the means of pre-and post-treatment data. $p \leq 0.05$ was considered significant.

Ethical Approval: The study was conducted within the framework of the principles set out in the Declaration of Helsinki, after obtaining approval from the Human Research Local Ethics Committee (867/2021).

Results

In our study, sperm samples taken from 7318 male participants with suspected infertility were evaluated. The mean age of participants was 30.67± 7.21 years. The demographical findings of males are demonstrated in Table 1. We evaluated sperm parameters in males with suspected infertility, including sperm viscosity, leucocyte level, sperm examination years and semen examination seasons.

Table 2: Sperm features of participants

Sperm features	n (%)
Abstinence period (day), Mean ± SD	3.08 ± 0.05
Semen viscosity	
Negative,	5356 (73.2)
(+), n (%)	637 (8.7)
(++), n (%)	1282 (17.5)
(+++), n (%)	43 (0.6)
Leukocyte level of semen	
Negative,	7161 (97.85)
< 1, n (%)	89 (1.22)
1-5, n (%)	19 (0.26)
6-15, n (%)	42 (0.58)
>15, n (%)	7 (0.09)
Semen examination years	
2016, n (%)	418 (5.71)
2017, n (%)	824 (11.27)
2018, n(%)	1108 (15.15)
2019, n (%)	2204 (30.11)
2020, n(%)	1345 (18.37)
2021, n (%)	1419 (19.39)
Semen examination seasons	
Warm (April-September), n(%)	3823 (52.24)
Cool (October-March), n(%)	3495 (47.76)

Table 3: The relationship between sperm quality parameters and weather temperature

Semen quality parameters	Air temperature < 15 °C	Air temperature > 15 °C	p
Ejaculate volume, (ml), mean ± SD, median (Min-Max)	2.82 ± 1.39 2.7 (0.1-11)	2.8 ± 1.41 2.7 (0.1-13.6)	0.8
Sperm concentration (million/ml), mean ± SD, median (Min-Max)	59.25 ± 42.94 44 (0.01-300)	48.64 ± 41.36 43 (0.01-280)	**0.004**
Total sperm count (million), mean ± SD, median (Min-Max)	159.6 ± 126.5 106 (0.01-1050)	129.09 ± 127.5 104 (0.0035-1100)	**0.004**
Motility (%)			
Progressive (%), mean ± SD, median (Min-Max)	45.05 ± 19.55 50 (0-100)	46.13 ± 19.85 50 (0-100)	0.22
Nonprogressive (%), mean ± SD, median (Min-Max)	9.18 ± 4.8 6 (0-21)	8.79 ± 4.74 6 (0-20)	0.56
Immotility (n, %), mean ± SD, median (Min-Max)	45.65 ± 19.05 42 (0-100)	45.03 ± 18.87 42 (0-100)	0.51
TPMSC (million), Mean ± SD, median (Min-Max)	77.22 ± 78.17 49 (0-822.8)	67.51 ± 78.63 49 (0-840)	**0.02**

TPMSC: Total Progressive Motile Sperm Count; The results that are statistically significant are shown in boldface.

participants are shown in Table 2. The relationship between sperm quality parameters and air temperature are presented in Table 3. There was a significant difference between air temperature and TPMSC. TPMSC increased at low air temperature (< 15 °C) compared to high air temperature (> 15 °C) (*p=0.004, p=0.004, p=0.02,* respectively). Then, we compared sperm parameters with exposure hours to sunlight. TPMSC differed in sun exposure hours. TPMSC was higher in sun exposure for less than 8 hours than those exposed for more than 8 hours

Table 4: Association between sperm quality and sun exposure

Semen quality parameters	Sun exposure < 8 hours	Sun exposure > 8 hours	p
Ejaculate volume (ml), mean ± SD, median (Min-Max)	2.81 ± 1,39 2.7 (0.1-11)	2.8 ± 1.41 2.7 (0.1-13,6)	0.68
Sperm concentration (million/ml), mean ± SD, median (Min-Max)	57.28 ± 42.38 44 (0,01-300)	47.16 ± 41.18 43 (0,01-280)	**0.007**
Total sperm count (million), mean ± SD, median (Min-Max)	154.44 ± 122.4 106 (0.01-1050)	124.11 ± 125.5 104 (0.0035-1100)	**0.007**
Motility (%)			
Progressive (%), mean ± SD, median (Min-Max)	45.56 ± 19.74 50 (0-100)	45.86 ± 19.68 50 (0-100)	0.56
Nonprogressive (%), mean ± SD, median (Min-Max)	9.26 ± 4.91 6 (0-21)	8.52 ± 4.52 6 (0-20)	0.22
Immotility (%), mean ± SD, median (Min-Max)	45.09 ± 18.92 42 (0-100)	45,57 ± 19.21 42 (0-100)	0.74
TPMSC (million), mean ± SD, median (Min-Max)	76.34 ± 78.17 49 (0-822.8)	64.86 ± 76.13 49 (0-840)	**0.01**

TPMSC: Total Progressive Motile Sperm Count; The results that are statistically significant are shown in boldface.

Table 5: Association between sperm quality parameters and relative humidity

Semen quality parameters	Relative humidity < 50%	Relative humidity > 50%	p
Ejaculate volume (ml), Mean ± SD, median (min-max)	2.8 ± 1.39 2.7 (0.1-13.6)	2.81 ± 1.41 2.7 (0.1-11)	0.87
Sperm concentration (million/ml), Mean ± SD, median (min-max)	48.53 ± 41.34 43 (0.01-280)	57.60 ± 42.18 44 (0.01-300)	**0.01**
Total sperm count (million), Mean ± SD, median (min-max)	128.86 ± 127.4 104 (0.0035-1100)	154.75 ± 122.8 106 (0.01-1050)	**0.01**
Motility (%)			
Progressive (%), Mean ± SD, median (min-max)	46.22 ± 19.63 50 (0-100)	45.14 ± 19.35 50 (0-100)	0.26
Nonprogressive (%), Mean ± SD, median (min-max)	8.71 ± 4.36 6 (0-20)	9.2 ± 4.88 6 (0-21)	0.42
Immotility (%), Mean ± SD, median (Min-Max)	45.02 ± 19.13 42 (0-100)	45.56 ± 19.21 42 (0-100)	0.57
TPMSC (million), Mean ± SD, median (min-max)	67.50 ± 77.59 49 (0-840)	75.61 ± 75.28 49 (0-822.8)	0.07

TPMSC: Total Progressive Motile Sperm Count; The results that are statistically significant are shown in boldface.

(*p=0.01*). Data are shown in Table 4. When we compared relative humidity and sperm parameters, it was found that sperm concentration, total sperm count, and TPMSC differed in terms of relative humidity. Sperm concentration, and total sperm count, were higher when above relative humidity 50% than below 50% relative humidity (*p=0.01*, *p=0.01,* respectively). The relationship between sperm quality parameters and relative humidity is shown in Table 5. Additionally, we evaluated the relationship between sperm parameters and PM_{10} levels. There was no significant difference between PM_{10} values (<40 µg/m³ and >40 µg/m³) and sperm parameters (*p>0.05*). Results are presented in Table 6.

Discussion

The effect of the male factor in infertility has been studied widely in the last 20 years. Seasonal variations in birth rates and conception have shown the association between seasonal changes of sperm parameters. Different researchers showed temperature and photoperiod changes partially responsible for circannual variations found in sperm parameters (11). Both fertile and infertile men have shown seasonal variations in semen parameters (12).

Table 6. Association between sperm quality parameters and PM_{10}

Semen quality parameters	PM_{10} (µg/m³) <40	PM_{10} (µg/m³) > 40	p
Ejaculate Volume (ml), mean ± SD, median (Min-Max)	2.78 ± 1.43 2.7 (0.1-13.6)	2.83 ± 1.39 2.7 (0.1-11)	0.25
Sperm Concentration (million/ml), mean ± SD, median (Min-Max)	50.72 ± 41.73 43 (0.01-300)	55.41 ± 41.27 44 (0.01-280)	0.26
Total sperm count (million), mean ± SD, median (Min-Max)	134.2 ± 125.6 104 (0.001-1050)	149.41 ± 127.5 106 (0.0035-1100)	0.2
Motility (%)			
Progressive (%), Mean ± SD, median (Min-Max)	45.43 ± 19.27 (0-100)	45.94 ± 19.57 (0-100)	0.63
Nonprogressive (%), Mean ± SD, median (Min-Max)	8.67 ± 4.89 (0-21)	9.24 ± 4.65 (0-20)	0.52
Immotility (n, %), Mean ± SD, median (Min-Max)	45.84 ± 19.36 (0-100)	44.73 ± 18.83 (0-100)	0.37
TPMSC (million), Mean ± SD, median (Min-Max)	67.97 ± 73.38 49 (0-840)	75.14 ± 76.13 49 (0-822.8)	0.07

TPMSC: Total Progressive Motile Sperm Count; The results that are statistically significant are shown in boldface.

Also, North America, Africa, Europe, and Asia have shown significant geographic differences in sperm concentration (13). Different researchers show that temperature and photoperiod changes are partly responsible for the sperm parameters' periodic changes. Saint Pol et al. showed a significant seasonal change in sperm count, in which there were the highest sperm counts in late winter and early spring, and the lowest concentration was found in late summer (14) . Heat stress was associated with decreased sperm concentration, motility, and viability in bull (15), mice (16), and men (17). A study in Turkey, Kabukcu et al. found significantly lower total count and sperm concentration in July and August than in May, December, and June (18). The progressively motile sperm count in October was 23.6% less than in May. The temperature-humidity and temperature index had a negative correlation with semen parameters. Studies on rhesus monkeys implicitly showed that a mechanism associated with the length of daylight might cause seasonal variations in semen quality (19). Melatonin regulation is associated with the length of daylight variations and its positive impact on sperm motility (20). Hassan et al. reported significantly higher sperm motilities and concentrations and a significantly lower percentage of abnormal sperm form in non-exposed cases than those exposed to night light in the idiopathic oligoasthenoteratozoospermia group (21). Particulate matter (PM), polycyclic aromatic hydrocarbons (PAHs) and multiple trace elements in the respirable range have been studied as they affect testicular spermatogenesis and cause sperm changes (22). Several studies showed a significant reduction in sperm concentration (23, 24), and total sperm count (25) , through air pollution, but significant results were not shown in several studies. Twenty-two studies assessing the effect of air pollutants (PM2.5, PM10, SO2, NOx, O3, PAHs) on DNA fragmentation, the level hormones, and main semen parameters (sperm concentration, motility, morphology), computer-aided sperm analysis (CASA) parameters were evaluated (22). However, inconsistency in results across different studies made comparison difficult. Zhang et al. evaluated the results of 11 studies with 4562 males to examine the effect of air pollution on sperm quality (26). Higher levels of air pollution were related to a significant reduction of sperm concentration, progressive motility, semen volume, total motility, and normal sperm morphology rate. In addition, the DNA fragmentation index significantly increased. Also, it was found that PM10 and PM2.5 were inversely associated with progressive motility and abnormal forms (27). The testicles are organs highly vulnerable to environmental chemical and physical agents. This study evaluated a cohort of males with suspected infertility in Diyarbakir, Turkey to evaluate the relationship between high prevalence environmental risk factors and infertility-related outcomes. Considering the duration of spermatogenesis, we tested the data of 3 months before semen retrieval. Our results showed that environmental exposure, particularly air temperature, sun exposure, and relative humidity, are associated with sperm quality. Our observations are consistent with those found in previous cross-sectional studies. Sperm parameters were different at air temperature < 15^{o}C and >15^{o}C. Sperm concentration, total sperm count, and TPMSC were higher in < 15^{o}C air temperature than >15^{o}C (Table 3). Regarding the duration of sun exposure, we found that the TPMSC was higher in those exposed to the sun for less than 8 hours than those exposed to the sun for more than 8 hours (Table 4). Also, relative humidity was found to be associated with sperm quality. It was observed that when the relative humidity was above 50%, the sperm concentration and the total sperm count increased more than when the relative humidity was below 50% (Table 5). We did not find any significant difference between PM10 values and sperm parameters (Table 6).

Study Limitations: Our study has some limitations. First, seasonal classification could be made instead of air temperature. Secondly, fertile men were comparable to this group.

Conclusion

Diyarbakir is a province located in the Southeast Anatolian region. This study is the first to evaluate the association between parameters related to male fertility and environment with a big-data approach in Diyarbakır. Finally, we found the adverse effect of environmental factors, particularly sun exposure, relative humidity, and air temperature, in sperm parameters. It may be necessary to determine the seasonal variation of sperm in the treatment management of couples with male-induced infertility and long-term treatment failure.

Ethical Consent: Clinical Trials Local Ethics Committee approved this trial (867/2021)

Conflict of Interest: The authors declared no conflicts of interest with respect to the authorship and/or publication of this article.

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