



Original Article

Male infertility among bakers associated with exposure to high environmental temperature at the workplace

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المخلص

أهداف البحث: تهدف هذه الدراسة إلى معرفة معدل انتشار العقم لدى الذكور بين الخبازين المعرضين لدرجات حرارة بيئية عالية.

طرق البحث: أجريت دراسة مقطعية عرضية لجمع المعلومات باستخدام استبيان موثقة تدار من خلال مقابلة شخصية. حيث تم قياس مؤشر متوسط درجة حرارة الترمومتر المبلل في المخابز. واستخدمت صيغة إحصائية جديدة لتقدير انتشار العقم بين الخبازين.

النتائج: تطوع في هذه الدراسة عدد 137 خبازا يعملون في 20 مخبزا و107 مجموعة ضابطة مماثلة من حيث العمر، والعرق، والحالة الاجتماعية، والدخل، وتدخين السجائر. كان معدل انتشار العقم باستخدام الصيغة المحدثة بين المجموعة المعرضة 22.7٪، مقارنة مع 3.0٪ في المجموعة الضابطة. تم استبعاد جميع العوامل الخارجية المحتملة للعقم بين الخبازين مثل تدخين السجائر، والعمر والعرق. وجد أن هناك ظروف عمل بحرارة عالية غير ملائمة في المخابز حيث بلغ مؤشر متوسط درجة حرارة الترمومتر المبلل في المخابز 37.4 درجة مئوية، في حين بلغ مؤشر متوسط درجة حرارة الترمومتر المبلل للمكاتب 25.5 درجة مئوية.

الاستنتاجات: أظهرت هذه الدراسة معدلات مرتفعة للعقم بين الخبازين نتجت من التعرض لدرجات حرارة بيئية عالية في مكان العمل كما أظهر متوسط درجة حرارة الترمومتر المبلل. هذه النتائج ينبغي أن تنبه سلطات العمل الصحي لاتخاذ التدابير اللازمة بموجب قانون العمل للحد من العقم بين الخبازين.

الكلمات المفتاحية: الذكور؛ العقم؛ الخبازين؛ درجات حرارة عالية؛ مكان العمل

Abstract

Objective: This study aimed to evaluate the prevalence of male infertility among bakers exposed to high environmental temperature.

Methods: This cross-sectional study was conducted to obtain information using a validated questionnaire administered through an interview. The mean wet bulb globe temperature (WBGT) index in the bakeries was measured. A new statistical formula was used to estimate the prevalence of infertility among bakers.

Results: A total of 137 bakers working in 20 bakeries and 107 individuals included in the comparable control group with variations in age, race, marital status, and income and with history of cigarette smoking were recruited. Using a newly devised formula, the prevalence of infertility among the exposed group was 22.7%, compared with 3.0% in the control group ($p = 0.013$). All possible confounding factors associated with infertility among bakers were excluded such as cigarette smoking, age, and race. There were unfavorable hot working conditions in bakeries, with a WBGT index of 37.4 °C, while the average WBGT for offices was 25.5 °C ($p < 0.0001$).

Conclusion: Our study showed that the rate of infertility among bakers was high, which resulted from exposure to high environmental temperature at the workplace as evidenced by the WBGT index. This finding should alert the healthcare authorities to take necessary measures under the labor code to curtail infertility among bakers.

Keywords: Bakers; High temperature; Infertility; Male; Workplace

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Introduction

Elevation of scrotal temperature in relation to normal core body temperature results in failure of spermatogenesis in men. This phenomenon has been evaluated as a potential method of male contraception and shown to be clinically effective.^{1,2}

The effects of occupational and lifestyle exposures to heat on human sperm counts has been reported. From these studies, it is clear that constant exposure to any factor that compromises the ability of the scrotum to thermoregulate will result in an adverse effect on one or more aspects of semen quality. The risk of adverse reproductive outcome of male workers may range from loss of libido and potency to infertility, including impairment of fecundity as a result of disturbance in hormonal balance or nervous system.^{3,4} Male infertility primarily results from reduction in sperm count or defective sperm production. Infertility influences roughly 15% of all wedded couples. In around 33% of these couples, the essential issue dwells in the male accomplice and, in an extra third, issues in both the male and the female add to infertility. There is rising proof to recommend that presentation at the work environment for male infertility may exist in numerous men as of now named idiopathic. Occupational exposure to radiant heat (e.g., in bakers, workers in kitchens, welders, furnace workers, and ceramics workers) and other hazardous agents at workplace can induce such effects. Exposure to high environmental temperature at the workplace contributes to heat stress in males especially with exposure to a source of radiant heat over long working hours. Those working directly with sources of severe heat, such as bakers and ceramic oven operators, have a longer time to pregnancy with poorer sperm quality, which suggests that occupational heat exposure has an effect on fertility. Studies involving these workers demonstrate the decline in semen quality. They are more prone to having increased scrotal temperatures, which impair sperm production and function. The negative effect of long hours of work increases in severity with the number of years spent engaging in such activities. Men who work in close range to sources of intense heat seem to face infertility-related problems.⁵⁻¹⁰ An assortment of work-related exposures has been connected to weakened male fertility. However, studies have been constrained by limited sample sizes, unseemly review outlines, as well as choice inclination. Moreover, the utilization of semen measures as surrogates for male infertility has been risky, since there is extensive intra-individual changeability, generous cover between infertile and fertile men, and poor connection between fertility and decrements in semen measures within the "normal" range.^{11,12}

This study aimed to fill the gap of knowledge about male infertility in KSA by addressing the effects of heat exposure at the workplace where such a problem is amenable for prevention. Furthermore, this study aimed to evaluate the prevalence of infertility among bakers exposed to extreme heat at the workplace.

Materials and Methods

This cross-sectional study involved 137 male employees working in 20 bakeries in Al-Khobar area, KSA, with a

response rate of 100%. This high response rate would add considerable validity to the findings of this study.

This study was approved by the ethical review board of Imam Abdurrahman Bin Faisal University. The management of the bakeries was officially contacted, and their cooperation was requested. Verbal consent from all participants was obtained after explaining to them the aim of the study. Participants were informed that they are free to withdraw from the study at any time, and confidentiality of the recorded data was assured.

The control group (107 males) was selected based on the following criteria:

- a. Individuals who were not exposed to heat in their present jobs, like janitors, clerks and managers at offices, butchers, salesman at shops, and others.
- b. Individuals without previous history of work demanding exposure to high environmental temperature.

All bakers and control groups were interviewed using a pre-tested (through a pilot study) standard questionnaire. The questions were related to the demographic characteristics, smoking habit, number of children, and duration of work service in addition to drug and medical history.

For the purpose of this study, infertility was said to exist if the participant had been examined or treated for infertility for at least 1 year.⁵

The following is the newly devised formula used to find out and exclude from the analysis those who were infertile before taking their present job:

$$C = A - B$$

Where:

A = The age of the youngest child in months +9 (9 equal to duration of pregnancy in months) For an infertile participant with no children $A = 0 + 9$.

B = The duration of work in weeks divided by 4.2 (4.2 to convert weeks to months).

C = Time lapse between beginning work and conception of last child.

If the value of C is > 0 (i.e., $A > B$), this means that the participant was fertile before starting work; if he was infertile at the time of the study, the infertility must have happened after starting work. If C is < 0 , this means that the participant's infertility was doubtful (infertility might have happened before starting work). All respondents in the latter category were subsequently excluded from further analysis.

The natural wet bulb (NWB) temperature was measured in different locations in the bakeries and offices using a mercury-in-glass thermometer, which was shielded against radiant heat. Globe temperature (GT) was measured using a globe thermometer (hollow matt black sphere with a 15 cm diameter). The wet bulb globe temperature (WBGT) index was calculated as follows:

$$WBGT = 0.7 \text{ NWB} + 0.3 \text{ GT}$$

The data after being checked for accuracy were fed on a personal computer, and SPSS/PC+ program version 15 was used for analysis. The statistical tests used included Student's t-test, chi-square test, and Mantel-Haenszel chi-square test.

A p-value of less than 0.05 was considered as statistically significant.

Results

The mean age of the bakers was 32.3 (+standard deviation (SD) of 7.0) years and 30.5 (SD + 7.5) years for the control group. This difference was statistically insignificant ($p = 0.054$). Moreover, both groups were comparable in terms of nationality ($p = 0.2214$), marital status ($p = 0.1318$), income ($p = 0.076$), and duration of service ($p = 0.112$). A diagnosis of obesity was made if males have a body mass index (BMI) of >29 ; however, BMI was insignificant in both groups ($p = 0.5515$). Furthermore, since cigarette smoking is considered a risk factor affecting the health of workers especially those under heat stress¹³ and that smoking affects the reproductive outcomes,⁷ the differences in smoking habit were statistically tested. Table 1 shows that 63.5% of the bakers and 52.3% of the control group were current smokers, and 9.5% of the bakers and 14.0% of the control group were ex-smokers. The remaining participants had never smoked. These differences were statistically insignificant ($p = 0.1982$). Additionally, there was a statistically insignificant difference in the number of cigarettes smoked per day between the exposed and control group ($p = 0.5441$). It follows that any effect of cigarette smoking on the studied samples can be disregarded because both groups were comparable regarding this habit.

The estimation of infertility rate among the exposed and control groups was initially based on the participants' answers to the administered questionnaire. Three months after the field work, 10% of the total sample was randomly selected to test the reliability (stability) of the answers. Fortunately, all respondents gave the same answers as before. Table 2 depicts the distribution of the reasons for having no or no more children.

To comply with the objective of this study, all the single and newly married participants, in addition to those who were away from their wives or who had medical reasons other than heat-related illnesses, were excluded from both the exposed and the control group during the analysis. This left 152 participants (90 bakers and 62 controls). They were classified into two groups (Table 3):

1. Group I (fertile group) includes those whose reasons were as follows: youngest child is still a baby (less than 2 years), use of contraceptives, and reasons provided by the wife, including pregnancy.
2. Group II (infertile group) includes those who did not specify a reason (unknown) for their infertility.

According to this distribution, the rate of infertility among the exposed group (21.1%) was significantly higher

Table 1: Comparison of smoking habits in the study participants.

Smoking habit	Bakers		Control	
	Number	%	Number	%
Current smokers	87	63.5	56	52.3
Previous smokers	13	9.5	15	14.0
Never smoked	37	27.0	36	33.7
Total	137	100.0	107	100.0

Table 2: Distribution of the reasons for having no or no more children among the exposed and the control group.

Reason	Bakers	%	Control	%
Single (never married)	26	19.0	29	27.1
Newly married (less than 1 year)	5	3.7	3	2.8
Enough (on contraceptives)	27	19.7	18	16.8
Youngest is a baby (<2 years)	42	30.6	33	30.9
No contact with wife (>1 year)	16	11.7	12	11.2
Wife is pregnant now	1	0.7	5	4.7
Wife infertile	1	0.7	1	0.9
Medical reason (husbands' side)	0	0	1	0.9
Unknown	19	13.9	5	4.7
Total	137	100.0	107	100.0

Table 3: Prevalence of infertility between the exposed and the control groups.

Reason	Bakers		Controls	
	Number	%	Number	%
Fertile	71	78.9	57	91.9
Infertile	19	21.1	5	8.1
Total	90	100.0	62	100.0

than that in the comparison group (8.1%) ($p = 0.03$) (Table 3).

Based on the previously mentioned formula, the number to be analyzed was reduced to 77 instead of 152, as shown in Table 4. Of these, 44 were exposed bakers and the new (adjusted) prevalence rate of infertility was 22.7% compared with only 3.0% among the control group. The difference is now more statistically significant ($p = 0.013$). Although the investigator was certain about the accuracy of the above formula, further research is suggested to test its validity and applicability in this field using a larger sample size.

The following confounding factors were analyzed in relation to infertility:

- A. Age: After stratifying by age to remove the effect of the aging process as a possible confounding factor, the exposed group had a significantly higher rate of infertility than the control group (Mantel Haenszel Chi-Square = 7.8297, $p = 0.005$) (Table 5).
- B. Nationality: When the participants were grouped by nationality, the rate of infertility was still significantly higher in the bakers than that in the control group after discounting nationality as a confounding factor. Again, the difference was highly significant (Mantel-Haenszel chi-square = 6.8743, $p = 0.009$).

Table 4: Corrected infertility rate after beginning work in exposed and controls groups.

Reason	Bakers		Controls	
	Number	%	Number	%
Fertile	34	77.3	32	97.0
Infertile	10	22.7	1	3.0
Total	44	100.0	33	100.0

Table 5: Distribution of the fertile and infertile subjects by age groups.

Age		Bakers		Control		Total	
		Number	%	Number	%	Number	%
<30 years	Fertile	7	70.0	14	100.0	21	87.5
	Infertile	3	30.0	0	0	3	12.5
30-35 years	Fertile	8	57.1	10	90.9	18	72.0
	Infertile	6	42.9	1	9.1	7	28.0
>35 years	Fertile	19	95.0	8	100.0	27	96.4
	Infertile	1	5.0	0	0	1	3.6
Total		44		33		77	

Furthermore, the bakers had a surprising lack of knowledge, negative attitude, and practice regarding the preventive measures. These employees were exposed to heat for about 10 h each day, 7 days a week. The mean WBGT in the bakeries was 37.4 °C, while 25.5 °C for the offices ($p < 0.0001$), indicating that the bakery environment was unsuitable for work as evidenced by this index.

Discussion

Reproduction disorders and occupational hazards to male reproductive health have become prominent issues in recent decades after reports on the adverse effects of certain agents at the workplace on the male reproductive function. After adjusting the results for all possible confounding factors related to infertility, we found that men with infertility were more likely to be exposed to heat than fertile men. This finding is consistent with previous reports, which indicated that heat exposure is associated with male infertility.^{14–16}

Heat is an environmental and occupational hazard. Exposure to environmental heat is a significant but overlooked workplace hazard that has not been well characterized or studied. The working population is diverse; job function, age, fitness level, and risk factors to heat-related illnesses vary, while exposure to excessive heat threatens workers in addition to global climate change, which is a new challenge. Occupational contexts that involve hot and humid climatic conditions, heavy physical workloads, and/or protective clothing create a strenuous and potentially dangerous thermal load for a worker. Particularly in industrial applications, heat is generated during the manufacturing process. This heat transmits to the environment to make it hotter, as well as the community, especially affecting workers involved in the operation. The primary outcomes of working in such environment lead to major heat-related disorders, and male infertility is no exception. Exposure to occupational heat potentially induces effects on the human reproductive processes, specifically for male reproductive health. Yet few studies have examined or characterized the incidence of occupational heat-related male infertility. In men who were repeatedly exposed to high temperatures that affect testicular function, there may be thermoregulation that may result in changes in sperm characteristics.^{17–19} In humans, as in most mammals, testicular function is temperature dependent. Normal testicular function requires a temperature 2–4 °C below body temperature. Testicular temperature is regulated by two mechanisms. The scrotum is responsible for the first level of regulation: it has no subcutaneous fat, and the total surface area of its skin changes with temperature. Therefore,

it can dissipate heat to the exterior as appropriate. The second mechanism happens in the spermatic cord where there is a counter-current heat exchange between the incoming arterial blood and the outgoing venous blood, the temperature of which is lower than that of the arterial blood due to heat loss through the scrotal skin.^{20,21} Heat stress in the workplace has been researched extensively in the past; however, in the contemporary context of climate change, little is known about its extent and implications. The main factor found to be associated with male infertility in this study was excessive heat. Moreover, the effects of heat stress on the vulnerable groups such as bakers exposed to high indoor environmental temperature remain unclear. In this study, indoor exposures to heat exceeded the bakers' comfort temperature range and was estimated based on the characteristics of the workplace and surroundings. This method of estimating heat exposure can help improve heat exposure assessment for epidemiological investigations. Thermal stress is an important factor in many industrial situations including bakeries. It can seriously affect the productivity and the health of the individual and diminish tolerance to other environmental hazards. However, the assessment of the thermal stress and the translation of the stress in terms of physiological and psychological strain is complex.^{22,23}

Therefore, this study demonstrated that exposure to high environmental temperature among bakers is associated with high infertility rate. This finding is in agreement with those of other studies, which described reduced fertility as due to occupational exposure to heat as it inhibits sperm production when the testicular temperature exceeds the optimal temperature. In published studies, the evaluation of exposure to high environmental temperature at the workplace has been unacceptable: either self-announced or reasoned from job title.^{24–28} In our study, heat exposure was measured using the WBGT index.

There are several factors that can lead to a low sperm count, but one of the most preventable is exposure to extreme heat, which can cause male infertility. Therefore, exposure to high environmental temperature must be considered as a significant risk factor for male infertility. The working hours in bakeries should be reduced to comply with the stipulations in the Saudi Labor and Workmen law and Attached Procedures and Articles (147 and 148).^{29,30}

As with other cross-sectional studies, this study is susceptible to survivor bias because it assesses prevalent rather than incident cases and it did not take into account people who have left the job.

There is a possibility that individuals with symptoms were more willing to participate than those without symptoms; therefore, selection of participants is not truly random.

It was planned to have a control group as twice as the study group; unfortunately, great difficulties were encountered. Thus, a one-to-one ratio was studied instead.

The finding of this study was based on the participants' answers to the questionnaire, no medical file review.

A new statistical formula was used in this study, and we are confident about its accuracy.

Conclusion

The findings of this study indicated that there is a strong evidence that heat exposure in these bakeries based on the

WBGT index is a contributory of this high rate of male infertility.

Recommendation

A case control study is an alternative approach to investigate the findings of this study.

The improvement of the working condition inside these bakeries is highly recommended in order to minimize heat exposure. These measures should be directed to the triad: man-machine-environment with special medical surveillance and health education programs.

Conflict of interests

The author declared no conflict of interest.

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