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OCCUPATIONAL AND ENVIRONMENTAL FACTORS AFFECT SEMEN QUALITY: HOW EXPOSURE TO MECHANICAL VIBERATION IMPACTS REPRODUCTIVE INDICES

Abstract*: it is well known that sperm is a unique cell with a function to be done by itself outside the body and this function is second to none for species' continuity. The sperm mission of reaching the ova and is affected by both chemical and physical factors influence its ability to survive, move and fertilize the ova.*

Vibration as an environmental external physical stressor that affect semen viscosity and accordingly semen velocity, is reported to be prevalent among drivers occupied in industrial jobs whose inability to produce natural sperm compared to other occupation will be reviewed in this paper. We will also review the effects of mechanical vibrations with a special attention to shaking semen samples in assisted reproductive technologies in vitro. The effects of whole body exposure to vibrations on reproductive indices will also be investigated.

Keywords*: whole body vibration, sperm motility, car drivers, sperm activation in vitro, environmental factors.*

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ПРОФЕССИОНАЛЬНЫЕ ФАКТОРЫ И ФАКТОРЫ ОКРУЖАЮЩЕЙ СРЕДЫ ВЛИЯЮТ НА КАЧЕСТВО СПЕРМЫ: КАК ВОЗДЕЙСТВИЕ МЕХАНИЧЕСКОЙ ВИБРАЦИИ ВЛИЯЕТ НА РЕПРОДУКТИВНЫЕ ПОКАЗАТЕЛИ

***Аннотация**: хорошо известно, что сперматозоид – это уникальная клетка, выполняющая функцию самостоятельно вне организма, и эта функция не имеет себе равных для продолжения рода. Задача сперматозоида – достичь яйцеклетки, и на его способность выживать, перемещаться и оплодотворять яйцеклетку влияют как химические, так и физические факторы.*

Сообщается, что вибрация как внешний физический стрессор окружающей среды, влияющий на вязкость спермы и, соответственно, на скорость сперматозоидов, распространена среди водителей, занятых на промышленных работах, чья неспособность производить естественную сперму по сравнению с другими видами деятельности будет рассмотрена в статье. Рассмотрено воздействие механических вибраций, уделив особое внимание встряхиванию образцов спермы при вспомогательных репродуктивных технологиях in vitro, а также исследовано влияние воздействия вибраций на все тело на репродуктивные показатели.

***Ключевые слова**: вибрация всего тела, подвижность сперматозоидов, водители автомобилей, активация сперматозоидов в пробирке, факторы окружающей среды.*

1. Introduction

According to the WHO in 2010, a normal semen analysis sample has to contain at least a volume of 2ml, with a pH above or equal to 7.2, the sperm concentration must be equal to or higher than 15 million/ml, total sperm count must be higher than 39 million per ejaculation, a minimum of 40% of which has to have movement until 1 hour after ejaculation, not less than 32% of sperm must have rapid progressive movement and 4% has to have normal morphology as per Kruger’s criteria [17].

Sperm motility is an essential predictor of male fertility potential and it directly correlated with fertilization success in both natural and some types of assisted reproduction. It can however be impaired by both genetic and environmental factors.

All bodies with mass and elasticity like humans are capable of vibrating. Resonance occurs If the excitation frequency of the external vibration coincides with the natural frequency of the system [1], resulting in large oscillations within in structure creating potentially harmful stress.

Whole body vibration is used in physiotherapy to improve muscle function [3] but Continues vibration is however, uncommon force to affect semen samples in vitro although the human genitalia are sometimes being vibrated as a part of some types of jobs [2] or in cases of impotence due to spinal cord injury where a pineal vibrator is used to induce ejaculation [4].

Asthenospermia

Asthenozoospermia being widely spread clinical presentation is an infertility condition in which a person experiences defects in sperm motility whether it be slow, non-directed, or even immotile but viable according to severity [5]. and It imposes heavy costs for infertile individuals and couples [12; 13].

ART is an important treatment of this problem by using (ISCI) or (IVF) (IUI) the outcome of which is directly affected by the sperm [6–8] Assisted reproductive techniques are likely to have a greater impact on the infertile couple [18].

Vibration has a high effect potential when it comes to the reproductive system [14, 15]. The aim of this review is to highlight the positive and negative impacts of mechanical vibration on semen quality and other reproductive indices.

2. Effect of Vibration on semen Quality

Vibration influences the body in a variety of ways. The response to a vibration exposure is primarily dependent on the frequency, amplitude, and duration of exposure besides other factors like the direction of vibration input, location and mass of different body segments, level of fatigue and presence of external support [9]. Therefore the energy is absorbed by the tissue and organs that had medical significance when vibrations are attenuated in the body.

Sperm preparation processes in vitro include centrifugation pipate aspiration, shaking are forms of mechanical vibration

2.1. Shaking:

By using shakers for 20 minutes [1] consisting of a M540 DC motor equipped with PWM controller to control the rotational speed from 5–2400 rpm, a significant increase ($P < 0.05$) found by Saeed et al. in percentage of sperm active directed motility (grade A) with a non-significant increase in sluggish motility and a non-significant decrease in percentage of immotile sperms percentage. No significant changes were found regarding sperm morphology and count. It was concluded that vibrating seminal sample for 20min increases the overall sperms activity with significant increase in percentage of highly active directed sperms[1]. As shown in *Table 1 below*.

Table 1. Certain parameters of standard seminal fluid examination before and after 20 min Vibration at 37C

	Certain sperm function parameters	Before Vibration	After 20 min. Vibration	P – Value
	Count (sperm/ml)	42.82 ± 19.52	42.25 ± 19.15	P > 0.05
Motility (%)	Grade A (%)	3.37 ± 5.92	7.12 ± 9.66	P < 0.05
Motility(%)	Grade B (%)	39.12 ± 16.44	41.25 ± 16.86	P > 0.05
Motility(%)	Grade C (%)	23.37 ± 11.62	21.25 ± 11.07	P > 0.05
Motility(%)	Grade D (%)	34.37 ± 19.38	31 ± 20.19	P > 0.05
	Morphology (%)	34 ± 11.72	38.87 ± 14.60	P > 0.05

Values are expressed as Means ± SD.
Patients No. = 40.

Altavista al (2018) in a different study found no signifcant change in sperm morphology and total sperm count and concluded that simple vibration of the semen sample for 20minutes increases overall sperm activity with a considerable increase in the percentage of highly active fast progressive sperm [29].

2.2. Whole body vibration WBV

In a study conducted by Zarei et al. (2022) among taxi drivers in Tehran to determine the efect of exposureto WBV on sperm parameters. A statistically signifcant diference in total sperm count, progressive motility, non-progressive motility and total motility was observed between the taxi drivers and the office employees.According to

the univariate analysis of variance, exposure to WBV had a decremental efect on the most of sperm parameters, but these efects were not statistically signifcant [18] as it *Table 2* bellow

Table 2

Effect of WBV on sperm parameters

Variable		Sperm Concentration			
		P-value	95% Confidence Interval		Exp (B)
			Lower Bound	Upper Bound	
Age		0.162	−0.552	3.244	−1.346
BMI		0.758	−5.862	4.285	−0.789
Whole Body Vibration		0.249	−56.597	32.214	−49.376
Smoking Habit	Yes, Routinely	0.290	−16.597	41.652	−14.528
	No	0.835	−20.146	24.873	2.363
Physical Exercise	No Exercise/Light Activity	0.551	−50.402	27.075	−11.664
	Medium	0.721	−47.847	33.244	−7.302
Group	Taxi drivers	0.102	−103.783	9.501	−47.141
Variable		Progressive Motility			
		P-value	95% Confidence Interval		Exp (B)
			Lower Bound	Upper Bound	
Age		0.399	−0.483	0.981	−0.399
BMI		0.914	−1.456	1.624	−0.084
Whole Body Vibration		0.314	−14.620	38.853	−13.117
Smoking Habit	Yes, Routinely	0.581	−10.581	5.964	−2.308
	No	0.285	−3.185	10.688	3.751
Physical Exercise	No Exercise/Light Activity	0.197	−8.087	19.514	−7.713
	Medium	0.186	−8.047	20.585	−7.302
Group	Taxi drivers	0.071	−33.104	1.441	−15.846
Variable		Immotile Sperm			
		P-value	95% Confidence Interval		Exp (B)
			Lower Bound	Upper Bound	
Age		0.745	−0.831	1.157	0.163
BMI		0.745	−4.197	1.064	1.567
Whole Body Vibration		0.894	−46.908	40.984	2.962
Smoking Habit	Yes, Routinely	0.894	−15.191	13.060	1.066
	No	0.333	−17.650	6.039	−5.805
Physical Exercise	No Exercise/Light Activity	0.620	−25.202	15.098	5.052
	Medium	0.973	−24.388	20.673	7.302
Group	Taxi drivers	0.724	−24.207	34.728	5.261
Variable		Normal Morphology			
		P-value	95% Confidence Interval		Exp (B)
			Lower Bound	Upper Bound	
Age		0.006	0.028	0.164	−0.096
BMI		0.135	−0.316	0.043	−0.136
Whole Body Vibration		0.121	−3.638	5.631	−2.631
Smoking Habit	Yes, Routinely	0.237	−1.542	0.387	−0.577
	No	0.638	−0.616	1.000	0.192
Physical Exercise	No Exercise/Light Activity	0.441	−0.839	1.911	−0.536
	Medium	0.495	−0.940	1.931	0.495
Group	Taxi drivers	0.442	−3.570	0.452	−1.559

2.3. Centerfugation

Centrifugation of human spermatozoa induces sub lethal damage; separation of human spermatozoa from seminal plasma by a dextran swim-up procedure without centrifugation extends their motile lifetime [19].

Centrifuging dog sperm for 5 min at 720 x g proved to be the best strategy to remove prostatic fluid because the loss of sperm cells is acceptable and the functional parameters of the spermatozoa are well preserved, even after 3 days of storage [20].

3. Enenvironmental factors.

It is a well documented fact that environmental pollution unfavorably impacts semen quality by impairing spermatogenesis, steroidogenesis, and sperm functions and Sertoli cell, hence leading to decreased male fertility [36; 37].

In spite of the adverse influence of environmental chemicals such as iherbicides,industrial waste, insecticides,,pesticides, food additives, etc. on spermatogenesis men, there still insufficient data on the direct impact of these chemicals in humans. since the studies available are all but conducted in an occupational setting, where the population is exposed to these substances at very high concentrations [38, 39]. *Figure* 1 below summarizes the effects of environmental factors on semen quality. All these factors are modifiable and can therefore provide opportunities for the treatment of male fertility.

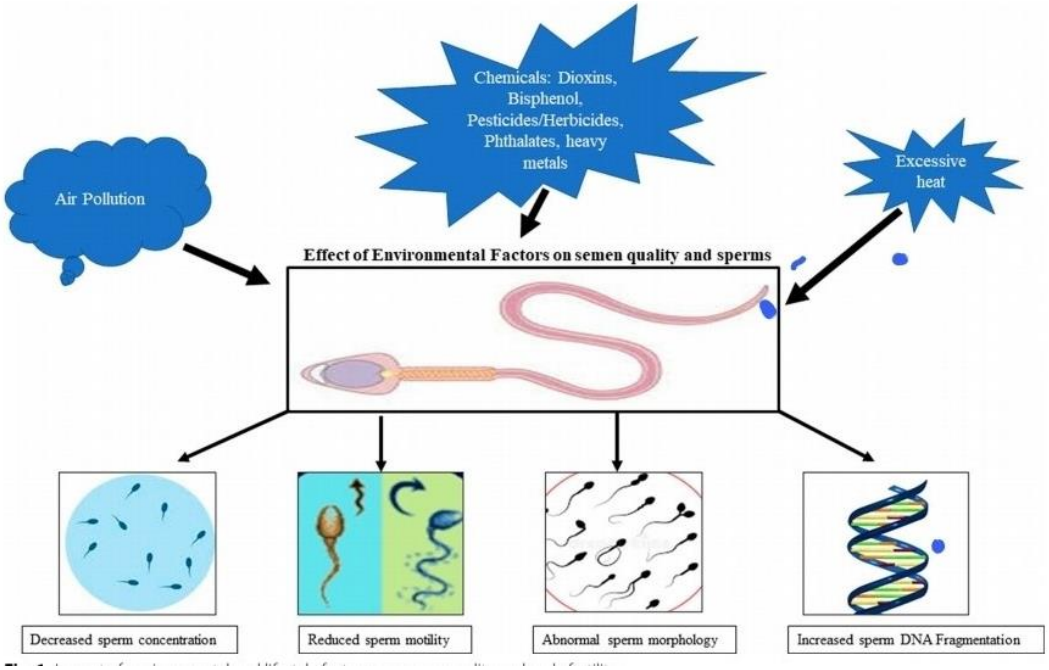

Fig. 1. Environmental factors affecting sperm quality

These environmental factors and their impact on semen quality and overall male fertility are discussed in detail as under.

3.1. Air Pollution.

Caused mainly by automobile exhaust, factories, fire, household, agriculture, waste treatment, oil refineries, natural sources, such as volcanic eruptions, wind, etc. Presence of PM 2.5 particles in the air is directly associated with total sperm number

and concentration [40; 41] PM 10 is however, related to semen volume and typical forms and inversely related to atypical forms [40; 42] while SO 2 exposure at the time of sperm development results in sperm oxidaticoncentration [43]. Air pollution may also affect testosterone levels [42].

3.2. Dioxins/Furans

Causing Pro-oxidative/apoptotic mitochondrial dysfunction [44] Dioxins are produced as a by-product of industrial and natural processes, such as biomedical and plastic waste incineration, smelting, chlorine bleaching of paper and pulp, production of pesticides.

3.3. Bisphenol A (*BPA*)

Believed to reduce sperm motility, sperm count, concentration, and increased sperm morphological abnormalities [45, 46], Bisphenol is released during use, production, or disposal of plastics and breakdown of industrial plastic-related wastes

3.4. Pesticides/ Herbicides

Cause Reduction in total sperm counts, sperm concentration, larger sperm head sizes, an increased number of morphologically abnormalities [47; 48], pesticides and Herbicides are used in agriculture, to control insects found in numerous consumer products, such as medications, personal care products, toys, pharmaceuticals, cosmetic products, building and construction materials and scent retainers

3.5. Heat exposure

Drivers and people working in furnaces, jakuzzi and hot bath laudable bakeries, welding, ceramic factories, laundries, dry cleaning shops, hot climate, excessive use of hot tubs, experience extremes of temperature the thing that resuls t in decreased semen quality [49] Reduced sperm concentration and total amount per ejaculate in summers compared to winters [50]

4. Discussion

According to a study conducted by Saeed et al[1] an overall increase in sperm motility obtained post 20 minutes shaking of semen sample disagreed with the other studies of sperm samples shaking (21) and centrifuging [22] so more investigation need to be conducted to validate the results.

As far as WBV is concerned, results showed that those with a history of exposure to WBV had altered sperm parameters, although vibration was not associated with semen quality [23]. Figà-Talamanca et al. assessed the association between the exposures of professional drivers to WBV and their reproductive health, by studying a group of 201 drivers in Rome Italy. The results showed that taxi drivers, compared to the controls, had a significantly lower prevalence of normal sperm forms (45.8% vs. 64.0% [23; 24].

It is worth mentioning that the effect of WVB on the organ being vibrated is not destructive in the short term and only causes reduced performance in the individual. People who are subjected to high amplitude vibrations for extended periods of time each day [19] will suffer adverse effects in the long run. The effect of low amplitude vibration on the human body is not thoroughly understood. The threshold of adverse effects due to vibration also differs among individuals which makes it impossible to define threshold limits and sensitivity to vibration [18; 26; 28].

Vaziri et al. (2011), also claim a relationship between type of occupation and quality of sperm and stated that the lowest mean sperm motility they observed was among those working in the transportation industry [26] having investigated the effects of mechanical vibration on sperm activity in humans in laboratory conditions Al-Azzawi et al. (2018) found that vibration had led to a significant increase in the rate of fast progressive motility (grade A), a maginal increase in slow progressive motility and an insignificant reduction in the number of immotile sperm [27]. In another study, Jurewicz et al. (2014) looked at the relationship between exposure to occupational factors and semen quality parameters and concluded that occupational factors may affect the quality of semen. A signifcant inverse relationship between occupational exposure to vibration and reduced sperm motility and increased DNA fragmentation was also found [30].

Mechanisms

Hormone and enzyme levels disruption in blood circulation in the testicular tissue is highly likely to be the potential mechanism of effect involved in the impact of vi-

bration on the reproductive system primary asthenospermia. And secondary asthenospermia manifest when motility is affected by the structure of the sperm flagella and when white blood cells are present in semen, respectively 33]. Asthenospermia could also happen due morphologically abnormal sperms in the semen [34] as these abnormal cells cause liberation of factors that increase the oxidative stress in seminal plasma [35] but no clear chemical could be suggested to explain it. But the explanation could be physical as high frequency movements cause activation of the structure of sperm flagella or mitochondria that synthesis energy [1].

5. Conclusion

Vibration along with other Environmental factors and vibration affect semen viscosity and accordingly semen velocity. Vibration is reported to be prevalent among drivers occupied in industrial jobs whose inability to produce natural sperm compared to other occupation was reviewed in this paper. Shaking affects the vicosity of the semen and consequently sperm motility will increase. Shaking and centrifugation for small duration and acceleration are negligible and higher rates of acceleration and velocity will also be of no advantage for sperm motility and it may even cause harmful side effects [1].

The effect of WVB on the organ being vibrated is not destructive in the short term and only causes reduced performance in the individual. People who are subjected to high amplitude vibrations for extended periods of time each day like drivers will suffer adverse effects in the long run.

Environmental factors be it air pollution or other chemicals unfavorably impact semen quality by impairing spermatogenesis, steroidogenesis, and sperm functions and Sertoli cell, hence leading to decreased male fertility.

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