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REVIEW

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Worldwide sperm quality variations between 2000 and 2020: a scoping review

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Abstract

There is a scarcity of research on male infertility and semen quality worldwide, notably in the Middle East and North Africa (MENA) region. This lack includes temporal comparisons of seminal parameters over decades. The aim of this scoping review is to summarize the articles, published between January 1, 2000, and December 31, 2020, which discuss and describe human semen quality and/or sperm quality in different countries, and/or their alternating patterns through time. The search was done on PubMed, using the following keywords: (((semen[Title/Abstract]) OR (SFA[Title/Abstract])) OR (sperm[Title/Abstract])) AND (country name[Title/Abstract]) with 195 world countries put in the "country name" field one by one along with other filters. The abstracts that fulfilled the inclusion criteria were read thoroughly and summarized. In conclusion, although some semen parameters appear to be stable, semen quality has deteriorated over time. Therefore, various countries must conduct research to characterize their semen quality and its altering patterns throughout time to reach a thorough conclusion.

Keywords Sperm quality, Semen quality, Semen volume, Sperm count, Motility, Viability, Sperm morphology

Introduction

One of the significant and widespread issues in public health today is infertility, which affects many couples. Despite this, worldwide epidemiological research on male infertility and semen quality, including temporal comparisons of seminal parameters through decades, is seriously lacking, particularly in the Middle East and North Africa (MENA) region [1].

The fluctuation of male fertility and semen parameters has sparked an intense debate in medical research and attracted a lot of scientific interest. Many reports of temporal variations in semen quality throughout the world have been published, yet the arguments about the semen quality and parameters still rage [2].

Although some literature reported a specific decline in sperm count [3], most available literature does not give an overall specific conclusion that the quality of human semen is deteriorating worldwide but shows a trend in some specific areas [4].

This scoping review was prepared to exam the scientific literature related to male fertility and reproductive health worldwide. The aim of this work was to summarize the articles, published between January 1, 2000, and December 31, 2020, which discussed and described human semen quality and/or sperm quality in different countries and/or their alternating patterns through time.

Methods

Searching method

Researchers searched the articles on PubMed, using the following keywords: (((semen[Title/Abstract]) OR (SFA[Title/Abstract])) OR (sperm[Title/Abstract])) AND (country name[Title/Abstract]) with the filter of January 1, 2000, to December 31, 2020. We added the filter "humans" to the searching platform when the original search result yielded more than 50 articles. In the

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"country name" field, researchers input 195 world countries one search at a time.

The number of searching results was recorded, and the research titles and/or abstracts were read to detect the articles that fulfill the inclusion criteria. These abstracts were read thoroughly (twice on different days) and summarized in this review article.

Inclusion and exclusion criteria

Inclusion criteria included all articles that discussed human semen quality and/or sperm quality and/or their alternating patterns through time. In addition, the data were gathered from a general population, sperm banks, sperm donors, or infertility clinics, retrospectively or prospectively. Also, the study period covered totally or partially the period between January 1, 2000, and December 31, 2020. If the study period was not mentioned in the articles, but it was published within the period January 1, 2000, and December 31, 2020, the article was still included in the study.

Exclusion criteria included all types of review articles and meta-analyses, articles that discussed non-human subjects, and articles that related the semen/sperm quality with other factors, such as seasonal, social, psychological, health, medical, or environmental conditions and chemical, pharmaceutical, and physical hazards and exposures. Any article that was published between January 1, 2000, and December 31, 2020, but covered data before or after the selected time frame was also excluded. Studies that were partially conducted beyond the inclusion dates were excluded unless they included more than ten years of the study period. Comparative studies without information about the semen quality were also excluded.

Search results

Only 150 counties out of 195 (76.9%) yielded one or more results using the original pre-established keywords. The total number of articles was 5781. That was reduced to 4224 after using the filter "humans" when applicable. After reading the titles and/or abstract, the articles that fulfilled the inclusion criteria were only 34. The abstracts of these 34 articles were read, reviewed, and summarized in the following paragraphs and in Table 1, where the articles are ordered from oldest to newest.

Results and discussion

Researchers investigated the articles, published between January 1, 2000, and December 31, 2020, which discussed and described human semen quality and/or sperm quality in different countries and/or their alternating patterns through time.

On 2002, Junqing and his research group recruited healthy normal young males from seven different regions in China. In their study, they reported that the geometric mean of sperm density was 55.45 million per mL, the median of semen viability was 79.0%, the mean percent of sperm with forward movement was 59.89% and the mean sperm volume was 2.61 mL. The percentage of participants who showed normal semen volume was 81.9%, liquefaction time was 91.1%, viscosity was 93.4%, pH was 90.8%, sperms with forward movement was 81.3%, sperm viability was 65.3%, semen density was 93.8%, normal sperm morphology was 98.8%, and total sperm count was 89.1%. Less than half of participants (42.3%) had sperms that complied with all World Health Organization (WHO) standards [5]. Nevertheless, after one year, the research group led by Li evaluated the sperm quality of 549 college students in the Chengdu area in China and concluded that the sperm concentration and sperm viability rate had declined [6].

On 2004, a scientist in Greenland studied the semen samples of 201 men in the country and reported that median sperm cell concentration was 53 million cells per mL, median sperm cell volume was 3.2 mL, median total sperm count was 185.6 million cells, and median motility was 60%. They concluded that total sperm count and sperm cell concentration in Greenland were lower compared to studies from Europe, Japan, and the USA [7].

In Abakaliki, on 2008, a research group revealed the deterioration of sperm quality in their study in Nigeria which showed a significantly high proportion (70%) of the study population had low sperm count. Also, asthenozoospermia and teratozoospermia were the major abnormal parameters recorded [8]. In 2007, a cross-sectional study was carried out to assess the semen quality of 1346 healthy men living in the southwest Chinese city of Chongqing. The medians for semen volume were 2.3 mL, semen concentration was 77.8 million per mL, total sperm count was 167.7 million, sperm quick progressive motility was 33%, sperm progressive motility was 52.6%, and overall motility was 70.9%. At least one semen parameter fell below the typical threshold values in 61.1% of healthy individuals [9].

Nonetheless, on the year 2010, in India, Mukhopadhyay reviewed the data of 3,729 men who sought treatment for infertility issues in two separate decades. The research results implied that sperm volume and motility had significantly changed and decreased between 1981–1985 and 2000–2006, but the overall sperm concentration did not alter [10]. However, Espinoza Navarro published an article where 102 healthy university students living in Arica, Chile between the ages of 18 and 30 volunteered for the study. The research group assessed the spermogram values in the sample of young males which had a

Table 1 Summary of the articles that fulfilled the inclusion criteria

Reference	Source of the sample	Country	Study period	Sperm concentration in million per mL	Total motility (%)	Progressive motility (%)	Semen volume (mL)	Count (×106 cells)	Morphology	Viability rate (%)	Normospermia (%) or normal semen tests	Abnormal forms/abnormal semen tests	Authors' final note
Junqing et al., 2002 [5]	Young men from seven geographical areas	China	Not mentioned	Geometric mean 55.45 million per mL 93.8% for semen density		Mean 59.89% 81.3% for sperm with forward progression	Mean 2.61 mL 81.9% normal semen volume	89.1% for total sperm count	98.8% for normal sperm morphology	Median 70.0% 65.3% for sperm viability	Participants whose sperm met all WHO standard parameters accounted for 42.3%		
Li et al., 2003 [6]	College students in Chengdu area	China	Not mentioned	50.90 ± 27.31 million per mL		Grade A and B sperm was 42.21 ± 15.38% Grade A sperm was 29.48 ± 13.71%	2.61			Sperm viability rate was 56.40 ± 14.77%	The volunteers with normal sperm accounted for 62.84%	Volunteers with abnormal sperms 37.16% (90.67% with abnormal motility, 19.21% with abnormal concentration, 10.78% with both abnormal concentration and abnormal motility)	Sperm concentration and sperm viability rate have a tendency to decrease
Toft et al., 2004 [7]	Recently proven fertile men from four regions	Greenland	Not mentioned	Median 53 million per mL	Median 60%		Median 3.2 mL	Median 185.6 million					Sperm cell concentration and total sperm count in Greenland seems to be in the lower range compared to studies from Europe, the USA, and Japan
Ugwuja et al., 2008 [8]	Male partners of the infertile couples	Nigeria	Not mentioned					70% of the study population had low sperm count				high defective parameters (64%), mainly asthenozoospermia and teratozoospermia	
Li et al., 2009 [9]	General healthy population	China	2007	Median 77.8 million per mL	Median 70.9%	Median 33% for sperm rapid progressive motility Median 52.6% for sperm progressive motility	Median 2.3 mL	Median 167.7 million				61.1% of healthy males had at least one semen parameter below normal threshold values	A high proportion of healthy males in Chongqing area of southwest China had abnormal semen parameters values according to WHO criteria
Mukhopadhyay et al., 2010 [10]	Andrology laboratory	India	Two periods: group 1: 1981–1985 group 2: 2000–2006	Did not change	Declined in the second group		Declined in the second group						Significant change in motility

Table 1 (continued)

Reference	Source of the sample	Country	Study period	Sperm concentration in million per mL	Total motility (%)	Progressive motility (%)	Semen volume (mL)	Count (×106 cells)	Morphology	Viability rate (%)	Normospermia (%) or normal semen tests	Abnormal forms/abnormal semen tests	Authors' final note
Espinoza Navarro, et al., 2010 [11]	Healthy young males	Chile	Not mentioned	Sperm concentration was 62.8 million per ml, 76% had normal sperm concentration	Total motility was 42.2 ± 23.2%, 38% had normal overall motility	Grade A motility 19.2 ± 18.6%, 26% had normal grade A motility	Volume was 2.9 ± 1.6ml, 72% had normal volume	82% normal total sperm count	Normal morphology 15.0 ± 7.9%, 57% had normal morphology	64% had normal vitality			
Ugboaja et al., 2010 [12]	Male partners of the infertile couples	Nigeria	January–December 2006									68.0% had semen fluid abnormalities 30.0% had single factor abnormalities 38.0% had combined factor anomalies 16.7% astheno-zoospermic 14.7% asthenooli-gozoospermic 13.2% asthenoo-ligoteratozoo-spermic 1.4% azospermic	High rate of semen fluid abnormalities among the male partners
Xu et al., 2011 [13]	Male infertility patients	China	Not mentioned			42.39% abnormal					27.35% were found normal in all seminal indexes	The incidences of asthenospermia 37.31% The incidences of oligospermia 8.94%	Mainly, decreased motility
Zou et al., 2011 [14]	Military personnel from different geographical areas	China	2007–2009	39.4 million per mL	0.439	15.8% for sperm rapid progressive motility 30.1% for sperm progressive motility	3.0 mL	120.1 million			62.5% according to WHO recommendations (2010)	88.3% had at least one semen parameter below normal values	Men had markedly lower mean sperm concentrations, sperm counts, and sperm motility

Table 1 (continued)

Reference	Source of the sample	Country	Study period	Sperm concentration in million per mL	Total motility (%)	Progressive motility (%)	Semen volume (mL)	Count (×106 cells)	Morphology	Viability rate (%)	Normospermia (%) or normal semen tests	Abnormal forms/abnormal semen tests	Authors' final note
Owolabi et al., 2013 [15]	Male partner of infertile couples	Nigeria	2004–2008									25.6% oligozoospermic 18.5% teratozoospermic 11.5% asthenozoospermic 6.2% azoospermic 3.2% oligoteratozoospermic 2.3% oligoasthenozoospermic 2.1% oligoasthenoteratozoospermic 0.9% asthenoteratozoospermic	
Mendiola et al., 2013 [16]	University students	Spain	Current study period 2010–2011 and the results were compared to a previous group 2001–2002	Declined Median declined from 51.0 million per mL to 44.0 million/mL				Declined median 149 million to 121 million					Total sperm count and sperm concentration may have declined in young Spanish men over the last decade
Jiang et al., 2014 [17]	Close to general population	China	2007–2012	Median was 62.0 million per mL Sperm concentration decreased from 66.0 million per mL to 49.0 million per mL		Median 39% progressive motility	Median 2.4 ml		Median 10.5% for normal morphology percentage of sperm normal morphology decreased from 13.5% to 4.5%			Incidence of azoospermia was increasing	There is a decline in semen quality of adult males in Sichuan, China
Mendiola et al., 2014 [18]	Unselected young men	New York, USA	Not mentioned	Median total sperm count was 158 million 23.1% sperm concentration below 20 million per mL 15.8% sperm concentration below 15 million per mL				Median total sperm count was 158 million					

Table 1 (continued)

Reference	Source of the sample	Country	Study period	Sperm concentration in million per mL	Total motility (%)	Progressive motility (%)	Semen volume (mL)	Count (×106 cells)	Morphology	Viability rate (%)	Normospermia (%) or normal semen tests	Abnormal forms/abnormal semen tests	Authors' final note
Li et al., 2014 [19]	From a hospital a control group from a sperm bank and another infertility group	China	Not mentioned									Asthenospermia Azoospermia Oligoasthenospermia	
Rao et al., 2015 [20]	University students	China	2010–2013	50.2 million per mL decrease in sperm concentration during the 4 years observation	0.586		3.0 ml	148.1 million			0.85		
Birdsall et al., 2015 [21]	Sperm donors	New Zealand	From 1987 to 2007 continued in the period 2008–2014	The declination did not continue	Declined in period 2008–2014								Semen quality has not changed in New Zealand men over the last decade
Ugwa et al., 2015 [22]	Male partner of couples presenting with inability to conceive	Nigeria	Not mentioned								52.38% normospermic	26.98% azoospermic 20.64% oligospermic 60.3% asthenospermic	
kim et al., 2015 [23]	Men presenting for reproductive issues	Korea	January 2002–December 2003, January 2007–December 2008, and January 2012–December 2013	40.1 ± 52.3 million/ml	28.2 ± 27.7 million/ml		2.8 ± 1.8 ml		46.1 ± 35.6 normal morphology				No significant changes in the semen parameters of Korean men from 2002 to 2013

Table 1 (continued)

Reference	Source of the sample	Country	Study period	Sperm concentration in million per mL	Total motility (%)	Progressive motility (%)	Semen volume (mL)	Count (×106 cells)	Morphology	Viability rate (%)	Normospermia (%) or normal semen tests	Abnormal forms/abnormal semen tests	Authors' final note
Borges Jr. et al., 2015 [24]	Males undergoing conventional seminal analysis	Brazil	Group1: years 2000 to 2002 Group2: 2010 to 2012	Decreased from 61.7 million to 26.7 million				Decreased significantly from 183.0 million to 82.8 million	Decreased significantly from 4.6% to 2.7%			The incidence of severe oligozoospermia significantly increased from 15.7% to 30.3% The incidence of azoospermia increased from 4.9% to 8.5%	A significant time-related decline in semen quality of infertile patients
Huang et al., 2016 [25]	Sperm donors	China	2001–2015	Decreased from 68 to 47 million/mL		Decreased from 34 to 21 million			Decreased from 31.8% to 10.8%				The semen quality among young Chinese men has declined over a period of 15 years
Centola et al., 2016 [26]	Sperm bank	USA	2003–2013	Decline	Decline		No change	Decline					Decline in semen quality
Erenpreiss et al., 2017 [27]	General population	Baltic countries (Estonia and Latvia) and Lithuania)	2003–2004	63									11–15% of men had low semen quality, 37–50% intermediate and 38–52% high semen quality
Ajayi et al., 2017 [28]	Fertility Centre	Nigeria	Group 1: 2003 Group 2: 2013	Decreased group 1: 34.6 group 2: 21.8	Decreased group 1: 47.9% group 2: 45.3%	Decreased group 1: 50% good, 44% fair, 2% poor, 4% no motility) group 2: (15% good, 81% fair, 4% poor)	Decreased Group 1:2.7 group 2: 2.6	Decreased	Increased				
Mahmud et al., 2018 [29]	Infertility clinic	Bangladesh	2000–2016		Declined by 20%	Total rapid motility: declined by 20%						Azoospermia increased by 18% between some ranges	
Karabulut et al., 2018 [30]	3 infertility clinics	Turkey	2011–2016									Azoospermia cases (5.85%) Cryptozoospermia (8.73%)	

Table 1 (continued)

Reference	Source of the sample	Country	Study period	Sperm concentration in million per mL	Total motility (%)	Progressive motility (%)	Semen volume (mL)	Count (×106 cells)	Morphology	Viability rate (%)	Normospermia (%) or normal semen tests	Abnormal forms/abnormal semen tests	Authors' final note
Elbardisi et al., 2018 [1]	48 different nationality from a hospital	Qatar	2012–2015	32.3	45.4	25.1						79.9% azoospermia (6.05%), oligospermia (23.3%), asthenospermia (30.5%), teratospermia (48.7%)	
Rahban et al., 2019 [31]	General population	Switzerland	1980–2014	48 17% of men had sperm concentration below 15 million/mL	25% had less than 40% motile spermatozoa,				43% had less than 4% normal forms				deterioration
Li et al., 2019 [32]	Hospital	China	2011–2017	increased 40.1–52.1	Progressive motility: increased 33.4–38.1			Increased 117.8–153.1					
Vahidi et al., 2020 [2]	Clinical center for infertility, comparison between two groups	Iran	Group 1: 1990–1992 Group 2: 2010–2012	Increase	Grade A: decreased Grade B: increased Grade C: constant Grade D: constant				Decrease		47.88% of infertile men showed normal semen parameters		No deterioration
Morey-León et al., 2020 [33]	An assisted reproduction center	Ecuador	2017–2018						A high percentage of patients presented sperm morphology and quality values below the reference limits		27.4% normospermic	27.9% teratozoospermia 8.8% oligoteratozoospermic	
Al-Kandari et al., 2020 [34]	One center study	Kuwait	Not mentioned								8.2% cases had normal semen tests	30.2% oligoasthenospermia	
Siqueira et al., 2020 [35]	Infertility clinic	Brazil	1995– 2018	Reduction of 0.24 million/mL each year	Reduction of 2.84 million/year				Reduction of 0.52% each year				
Barrera et al., 2020 [36]	Sperm bank: same subjects	Uruguay	1989– 2017	Declined in the 28 years			Increased in the 28 years						

normal sperm count when compared to reports from other countries. Sperm concentration was 62.8 million per mL, semen pH was 7.6 ± 0.5, volume was 2.9 ± 1.6 mL, normal morphology was 15.0 ± 7.9%, total motility was 42.2 ± 23.2%, and Grade A motility was 19.2 ± 18.6%. A percentage of 82% of the participants had normal total sperm count, 76% had normal sperm concentration, 72% had normal volume, 64% had normal vitality, 63% had normal pH, 57% had normal morphology, 38% had normal total motility, and 26% had normal Grade A motility [11]. These results were not consistent with the deterioration of semen quality that was found before publishing this article.

However, the retrospective study of all the semen samples of male partners of infertile couples submitted for analysis in Nnewi, Nigeria in 2006 revealed that the semen fluid analyses which were retrieved from the records department and supplemented with the laboratory register showed that 68.0% had semen fluid abnormalities, 30.0% had single factor abnormalities, and 38.0% had combined factor abnormalities. A percentage of 16.7% were asthenozoospermia, 14.7% were asthenooligozoospermic, 13.2% were oligoasthenoteratozoospermic, and only 1.4% were azoospermic [12]. Compatible with that was the research that studied the sperm motility of 2640 infertility patients in the Suzhou area and found that there was a decrease in sperm motility, particularly in the percentage of Grade A + B sperms. In fact, only 27.35% of the seminal indexes were found to be normal [13].

In addition, Zou and his colleagues studied a sample of 1194 soldiers from the armed forces of the People's Republic of China, who were aged 18 to 35 at the time of their inclusion in the study. The sample participated in a cross-sectional study to investigate the factors influencing semen quality between 2007 and 2009. The median sperm volume was determined to be 3.0 mL, the sperm concentration 39.4 million per mL, the total sperm count 120.1 million, the sperm quick progressive motility 15.8%, the sperm progressive motility 30.1%, and the total motility 43.9%. According to WHO standards from 2010, 62.5% of the servicemen had at least one semen parameter that was below normal limits. The mean sperm concentrations, numbers, and motility of the sample were significantly lower [14].

In accordance, the research group led by Owolabi, in their prospective study of the seminal fluid parameters in Nigeria between May 2004 and June 2008, documented the results of the semen analyses of 661 men. According to the results, 25.6% men were oligozoospermic, 18.5% teratozoospermic, 11.5% asthenozoospermic, 6.2% azoospermic, 3.2% oligoteratozoospermic, 2.3% oligoasthenozoospermic, 2.1% oligoasthenoteratozoospermic, and 0.9% asthenoteratozoospermic [15]. Also, Mendiola on 2013 studied young Spanish men over the last decade to discover that total sperm count declined (median 149 million to 121 million) and sperm concentration also declined (median from 51.0 million per mL to 44.0 million per mL) [16].

Later on 2014, Jiang's group examined semen parameters in a cohort of 28,213 adult in Sichuan, China, between July 2007 and June 2012 to detect the change in quality. The authors came to the conclusion that there was a deterioration in the quality of adult male semen in that area. According to WHO standards, the semen's pH, volume, concentration, motility, and morphology were all measured. Sperm concentration declined over the course of five years, falling from 66.0 million per mL to 49.0 million per mL, while the sperm with normal morphology fell from 13.5% to 4.5%. There was also an increase in azoospermia cases [17]. Next on 2014, Mendiola reported that the median sperm concentration for young men living in Rochester, New York, was 52 million per mL, the median total sperm count was 158 million per mL, while 23.1% of the participants had sperm concentrations below 20 million per mL, and 15.8% had sperm concentration below 15 million per mL [18].

On the other hand, a research group in China did a computer-assisted semen analysis to compare the semen parameters between two groups: an infertility group and a control group. They concluded that while oligozoospermia alone is not always associated with infertility, azoospermia, asthenospermia, and oligoasthenospermia are [19].

Then Rao and his lab members did a study from 1 March 2010 to 31 December 2013 where all student sperm donors who were listed in the Hubei Province Human Sperm Bank underwent screening. Their retrospective analysis was performed on a total of 3,616 semen samples from 1808 university student sperm donors. The WHO standards for each donor's semen parameters were averaged over two samples, and a generalized linear regression model was used to look at many semen quality factors. Semen volume mean was 3.0 mL, sperm concentration was 50.2 million per mL, total sperm count was 148.1 million, and total sperm motility was 58.6%. The parameters of about 85.0% of semen donors were within normal limits. During the four years of monitoring, the authors reported that there was a drop in sperm concentration, but this may not be solid enough evidence to support a trend of deteriorating semen quality [20].

Then, the retrospective study of Birdsall in New Zealand comparing semen test results from 2008 to 2014 to results from 1987 to 2007. They documented that the decline in semen volume and sperm concentration observed between 1987 and 2007 did not continue

in 2008 to 2014. Sperm concentration decreased from 1987 until the time between 1997 and 2001 and remained stable at an average of 62 million per mL between 2001 and 2014. Sperm motility declined (8%) in the period 2008–2014, but there was no significant change over the total period studied, between 1987 and 2014. They concluded that semen quality has not changed over the last decade after a decline between 1987 and during 1997–2001 [21]. Ugwa and his research group, in their retrospective study in Nigeria on semen parameters reported that 52.38% were normospermic, 26.98% were azoospermic, 20.64% were oligospermic, and 60.3% were asthenospermia. The mean volume was 2.8 ± 1.8 mL, sperm count was 40.1 ± 52.3 million per mL, 28.2 ± 27.7 million per mL were motile, 46.1 ± 35.6 showed normal morphology, and the pH was 8.3 ± 0.67 [22]. Also, it was concluded that the semen characteristics of Korean men did not alter significantly between 2002 and 2013 [23].

Alternatively, Borges Jr. and his lab members analyzed the sperm count, motility, and morphology of 2300 semen samples of infertile men who underwent a traditional seminal examination during the years 2000 and 2002 and 2010 and 2012 in Brazil. Their conclusion was that the overall sperm concentration declined from 183 million to 82.8 million, the mean sperm concentration per mL decreased dramatically from 61.7 million in 2000–2002 to 26.7 million in 2010–2012, and the percentage of normal forms decreased significantly from 4.6% to 2.7% over time. Additionally, the incidence of severe oligozoospermia significantly increased from 15.7% to 30.3%, and the incidence of azoospermia increased from 4.9% to 8.5% [24]. Moreover, in a retrospective cross-sectional study, 30,636 young Chinese men were shown to have lower sperm quality during a 15-year period (2001 to 2015), particularly in terms of sperm concentration, total sperm count, progressive motility, and normal morphology [25].

Also, it was shown on 2016, the semen parameters of young adult men from 2003 to 2013 at a USA urban sperm bank in the Boston area revealed a deterioration in the quality of semen and sperm concentration, while total motility, total count, and total motile count all significantly decreased, but semen volume did not significantly alter [26].

On 2017, a cross-sectional study was performed between 2003 and 2004 on 1165 men from the general population, ages 16–29, where they recruited men from Estonia ($N=573$), Latvia ($N=278$), and Lithuania ($N=314$). The median number of sperm per milliliter was 63 million. Percentages of 11–15% of the men had low, 37–50% had intermediate, and 38–52% had high semen quality [27].

Furthermore, Ajayi and colleagues also conducted a retrospective study at Nordica Fertility Centre, Lagos, Nigeria, in which semen parameters of two groups of men were compared, a group from 2003 and one from 2013. The mean sperm count was 34.6 million per mL and declined to 21.8 million per mL, respectively. The mean motility was 47.9% and declined to 45.3%, and the mean progressive motility in the 2003 group was predominantly graded as good (50%), while in the 2013 group, the predominant grade of mean progressive motility was fair (81%). Mean semen volume declined from 2.7 to 2.6 mL, and sperm counts have reduced in the last decade. Nevertheless, normal morphology was better in the 2013 group compared to 2003 one [28]. Mahmud and lab members on 2018 examined the semen data from men in Dhaka, Bangladesh, aged 18 to 64, between January 2000 and June 2016. Male Bangladeshis were found to have decreased overall motility and quick linear motility, as well as a higher incidence of azoospermia [29]. When a total of 9733 men, who were admitted to three infertility clinics in Turkey due to infertility between March 2011 and October 2016, were included in a study, azoospermia cases were observed in 5.85% of patients and cryptozoospermia in 8.73% [30]. Additionally, Elbardisi conducted a retrospective study in Qatar of 13,892 infertile men of 84 different nationalities between 2012 and 2015. They concluded that male infertility patients from the Middle East and North Africa (MENA) region had lower sperm counts, significantly higher semen volume, generally lower sperm total motility percentage, and generally lower quality sperm morphology [1].

In a cross-sectional research with 2523 young males from throughout Switzerland, sperm quantity, concentration, motility, and morphology were analyzed. The WHO semen reference requirements were only reached by 38% of men, and only 17% of males had sperm concentrations below 15 million per mL, 25% had spermatozoa that were less than 40% motile, and 43% had less than 4% normal forms [31]. In another retrospective cross-sectional study that was conducted from 2011 to 2017, they recruited 71,623 infertile men from Hunan, China. During the 7 years of observation, the researchers reported that there were erratic changes in the median semen parameters (sperm concentration 40.1–52.1 million per mL, total sperm count 117.8–153.1 million, and sperm progressive motility 33.4–38.1%), but there was no significant deterioration in semen quality, and 47.88% of infertile men had normal semen parameters according to the used WHO standards [32].

Vahidi on the year (2020) performed a retrospective cross-sectional investigation, in which the concentration, motility, and morphology of two groups of Iranian men, one from 1990 to 1992 and the other from 2010 to 2012,

were compared. Despite the latter group's higher sperm concentration, sperm with normal morphology considerably dropped, sperm with Grade A motility declined, Grade B motility increased, and Grade C and Grade D motile sperm stayed steady [2]. Also, Morey-León evaluated 204 samples of male semen from patients with reproductive issues aged 20 to 57 who were admitted between May 2017 and September 2018 in Guayaquil, Ecuador. Each sample was subjected to a fundamental spermogram in accordance with the manufacturer's guidelines for the evaluation and processing of human sperm. It was discovered that normozoospermia was present in 27.4% of the samples. Teratozoospermia was found to account for 27.9% of the diseases and oligoteratozoospermia for 8.8%. Also, a greater proportion of patients were discovered to be between 30 and 39 years old. Many patients had sperm morphology and quality readings that were below the WHO's reference ranges [33].

Likewise, Al-Kandari included 608 male patients between the ages of 22 and 56 in their study, and 8.2% of the cases had normal semen tests. Oligoasthenospermia showed the highest percentage of semen abnormality at 30.2% [34]. In addition to that, Siqueira et al. retrospectively analyzed the trends in seminal parameter values among Brazilian males between 1995 and 2018 and reported that Brazilian men who were visiting infertility clinics had decreased seminal parameters in the previous 23 years. They noticed that there was a considerable decline in sperm concentration (drop of 0.24 million/mL/year), normal morphology (decrease of 0.52%/year), and total motile sperm count (decrease of 2.84 million/year) [35]. Moreover, Barrera et al. concluded that sperm concentration declined while semen volume increased significantly over a 28-year period (1989–2017) in Uruguay [36].

Finally, yet importantly, from the results of the articles that reviewed, semen quality and semen stability throughout time are considered crucial issues since most of the studies concluded that a deterioration in seminal parameters was noticed. On the other hand, the semen quality exhibits conflicting tendencies, with published research findings exhibiting declining, rising, or stable characteristics in several parameters, in different populations, and in varied periods of time.

However, despite these findings, it is important to emphasize that confounding factors were not taken into consideration, and such factors like age, lifestyle characteristics, and medical issues might be related to the differences seen between countries. Accordingly, this study has a few limitations since we included neither seasonal, psychological, social, medical, health, nor environmental situations that might affect the seminal parameter. Researchers did not review, as well, potential risks that might result from pharmaceuticals, chemicals, and physical exposures. In addition, studies that provided comparisons between two nations without semen parameters were not reviewed.

Conclusion

Although some semen parameters appear to be stable, semen quality has deteriorated over time. All countries must consider conducting research to characterize the semen quality and its altering patterns throughout time in order to reach a thorough conclusion.

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