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The association of impaired semen quality and pregnancy rates in assisted reproduction technology cycles: Systematic review and meta-analysis

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Abstract

Some studies suggest a relationship between semen quality and pregnancy rates of assisted reproduction technologies (ART). Others have questioned the utility of semen quality as proxy for fertility in couples attempting to conceive with or without assistance. We aimed to investigate the current body of evidence which correlates semen parameters and clinical pregnancy among couples utilizing ART (i.e. in vitro fertilization [IVF], intracytoplasmic sperm injection [ICSI]) through a systematic review and meta-analysis of cross-sectional and retrospective cohort studies. Pooled Odd Ratio (OR) for oligo-, astheno- and teratospermic compared to normospermic number of ART cycles were calculated among. Meta-regression and sub-group analysis were implemented to model the contribution of clinical/demographic and laboratory standards differences among the studies. Overall, 17 studies were analysed representing 17,348 cycles were analysed. Pooled OR for impaired sperm concentration, motility and morphology was 1 (95%Confidence Interval [CI]: 0.97–1.03), 0.88 (95%CI: 0.73–1.03) and 0.88 (95%CI: 0.75–1) respectively. Further analysis on sperm morphology showed no differences with regard of IVF versus ICSI ($p = 0.14$) nor a significant correlation with rising reference thresholds (Coeff: −0.02, $p = 0.38$). A temporal trend towards a null association between semen parameters and clinical pregnancy was observed over the 20-year observation period (Coeff: 0.01, $p = 0.014$). The current analysis found no association between semen quality (as measured by concentration, motility or morphology) and clinical pregnancy rates utilizing ART. Future investigations are necessary to explore the association between semen parameters and other ART outcomes (e.g. fertilization, implantation, birth and perinatal health).

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Francesco Del Giudice and Federico Belladelli have equally contributed to this study.

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KEYWORDS
ART cycles, assisted reproductive technologies, ICSI, IVF, semen parameters

1 | INTRODUCTION

Infertility, defined as attempting to conceive for 12 months without success, affects about 15% of couples. Within these couples, a contributing male factor can be identified in 30%–50% of cases (Del Giudice, Busetto, et al., 2020; Kasman et al., 2020; Thoma et al., 2013; Del Giudice, Kasman, et al., 2020). Assisted reproductive technology (ART) is commonly utilized in overcoming male factor infertility. One of the most common methods of fertilization is intracytoplasmic sperm injection (ICSI), initially used in managing male factor infertility with severely impaired spermatogenesis (Palermo et al., 1992). Over time, ICSI has been employed in treating aetiologies beyond male factors (Hollingsworth et al., 2007; Ola et al., 2001). However, it has been suggested that semen quality may be associated with IVF success given that spermatogenic success may be associated with gamete quality (Farquhar & Marjoribanks, 2018).

Threshold values of semen parameters are conventionally based on the guidelines set by World Health Organization (World Health Organization, 2010) and are used to stratify men into fertile or subfertile categories (Verheyen et al., 1999). While some studies suggest a correlation between semen quality and pregnancy rates, others have questioned the utility of semen quality as proxy for fertility in couples attempting to conceive (Akanji Tijani & Bhattacharya, 2010; Boeri et al., 2021; van der Steeg et al., 2011; van Weert et al., 2004).

While oocyte quality is a major driver of ART outcomes (Del Giudice, Busetto, et al., 2020; Lopes et al., 1998; Sousa & Tesarik, 1994; Tesarik et al., 2002), the relationship between semen quality and ART outcomes also remains uncertain. The aim of the meta-analysis and systematic review is to investigate the association of semen parameters and ART pregnancy rates.

2 | MATERIALS AND METHODS

We followed previously established guidelines in designing this systematic review and meta-analysis (Stroup et al., 2000). PICO criteria were used to establish a research question in the following fashion: what is the association of impaired semen quality and clinical pregnancy achieved by ART? Additionally, we sought to compare the current evidence within available cohort studies. More specifically, pooled OR were determined for oligo-, astheno or teratospermic features in comparison with normospermic features among infertile couples undergoing ART.

2.1 | Evidence acquisition

A systematic literature review was performed in the Embase, Cochrane and PubMed from the dates of inception to December 2020, without language restriction, in order to identify studies that have investigated sperm parameters and success rates among ART cycles for clinical pregnancy among infertile couples. The reference lists of these studies were also screened for additional relevant articles. We included and critically evaluated original observational retrospective or prospective cohort studies (Level of Evidence: III 1–2). Abstracts, meeting reports and case reports were excluded from the analysis. Search terms included but were not limited to assisted reproductive techniques or technologies or ART AND in vitro fertilization or IVF, AND intracytoplasmic sperm injection or ICSI AND male factor infertility AND semen quality or parameters AND fertility status or fertility impairment AND pregnancy rate or clinical pregnancy; secondary fields: sperm concentration; sperm motility; sperm morphology; normospermic; number ART cycles. Table S1 provides a comprehensive list of search terms used.

2.2 | Study selection and inclusion criteria

Data included in the analysis were sourced original articles that examined infertile couples undergoing ART reporting clinical pregnancy outcomes, defined by detectable foetal heartbeat per number of cycles of IVF or ICSI. Only studies reporting descriptive statistics of subjects with oligo- or astheno- or teratozoospermia compared to control groups were further evaluated. Studies were considered eligible if no significant differences in the male and female demographics was relevant when assessing cases versus controls, and if results presented were controlled for female factors. Articles were excluded if the data on cycles from control group were not assessed or were not available from the article. The titles and abstracts of all articles were independently screened by three authors (FDG, AMK and TC) using predefined inclusion criteria. Three authors (FDG, FB and MLE) then independently examined the full manuscript of the articles to assess if inclusion criteria was met. All investigators agreed upon the decision for final inclusion.

Data were obtained from included studies using a standardized form: origin/year of study (institution and period of enrolment), study population size, mean/median age (± SD/range) of the participants and controls, semen parameters threshold references, sample size (impaired semen quality subgroups – total, impaired semen quality subgroups with clinical pregnancy; control group totals, controls with clinical pregnancy) and reference standards used to determine fertile matched control groups.

2.3 | Study quality assessment and statistical analysis

The "Quality Assessment Tool for Observational Cohort and Cross-Sectional Studies," provided by the National Institute of Health (NIH) was used to assess the risk of bias (RoB). Biases screened for included selection bias, information bias, measurement bias or confounding bias (including cointerventions, differences at baseline in patient characteristics and other factors are presented in Table S2). Studies were rated as poor quality, fair or good, with higher risk of bias leading to poor quality ("-") ratings and low risk of bias leading to good quality ("+") ratings (NIH Guidelines, 2015). Publication bias was tested for by both the determination of a *p* value using the Deeks' asymmetry test and the visual assessment of the Deeks' funnel plot (DerSimonian & Laird, 1986). The potential nature of studies "missed" in our review was explored using the Trim and Fill method (Duval & Tweedie, 2000). Pooled odds ratio (OR) and 95% Confidence Intervals (CI) were used to compare treatments. Evaluation for presence of heterogeneity (Higgins et al., 2003) was done using the following: (1) Higgins I^2 test with inconsistency indexes (I^2): 0%–40%, minimal heterogeneity; 30%–60%, moderate heterogeneity; 50%–90%, substantial heterogeneity; and 75%–100%, considerable heterogeneity and (2) Cochran's Q-test with $p < 0.05$ suggesting heterogeneity. Pooled OR estimates were calculated using a random-effects model (Mantel & Haenszel, 1959). We graphically displayed our results as forest plots, with pooled ORs indicating overall odds in favour of infertile couples with or without at least one semen parameter impairment to achieve clinical pregnancy. Subgroup analysis was performed looking at differences in ART techniques (i.e. IVF vs. ICSI). Meta-regression analysis was performed using available quantitative variables extracted from the studies to model the contribution of possible confounders to the aim of interest as well as to examine further potential sources of heterogeneity. ORs were charted against the following variables: publication year, mean paternal age at baseline and values of reference thresholds for sperm parameters. After generic OR estimates were obtained, they were plotted with the area of the circles proportional to the inverse of the squared standard errors of the studies included. Calculations were performed using Stata version 16.1 (Stata Corporation, College Station, TX, USA), and all tests were two-sided, with $p < 0.05$ set as threshold for statistical significance.

3 | RESULTS

3.1 | Search results

The initial search yielded 256 articles (PubMed: 117; Web of Science: 33; Embase: 16; Cochrane: 9; and Scopus: 81). A total of 142 articles were excluded because they contained overlapping data or were that appeared in multiple databases. Of the remaining 114, 95 were subsequently excluded since they did not examine couple infertility and ART (n = 64), were not reporting information on semen parameters (n = 8), were focused on animal experiments (n = 17) or were editorials or review papers (n = 5). The remaining 20 journal references were then critically analysed and evaluated. After this in-depth review, a further three did not meet the inclusion criteria due to missing exactable information. The remaining 17 studies were eligible for inclusion in our review (Fig. S1). No study was considered to be seriously flawed as per the "Quality Assessment Tool for Observational Cohort and Cross-Sectional Studies." There was moderately low risk to performance bias across all included studies. There was no risk of attrition bias due to incomplete outcome data in the included studies. Table S2 and Figure S1 illustrate the Individual RoB as well as visual assessment of the Deeks' funnel plots.

3.2 | Study location, types and sample size cohort

Table 1 summarizes the main findings, patient description and study characteristics of each article. Of the 17 studies included (Kruger et al., 1986; Grow et al., 1994; Nagy et al., 1995; Oehninger et al., 1995; Palermo et al., 1995; Ben-Chetrit et al., 1995; Mansour et al., 1995; Lundin et al., 1997; Mercan et al., 1998; Osawa et al., 1999; Keegan et al., 2007; Dubey et al. 2007; Capelouto et al., 2018; Schachter-Safrai et al. Mariappen et al., 2018; Chen et al., 2020; Kasman et al., 2021), eight took place within the United States, two in Europe (Belgium and Sweden), one in South Africa, one in Egypt, one in Japan, one in Israel, one in Australia, one in Canada and one in China (Table 1). Four studies investigated only the association of semen parameters and pregnancy rates in IVF. Ten studies investigated only semen parameters associations pregnancy rates in ICSI, while three studies investigated both techniques. Three papers included were cross-sectional cohort studies, while the remaining 14 were retrospective cohort studies (Table 1).

3.3 | Study sample sizes and participant ages

In total, 17,348 cycles were analysed, with individual studies ranging from 190 cycles and 4,517. Mean ages of the men ranged from 30.2 to 41.3 years old. Some of the studies did not report subject ages. Three papers (Ben-Chetrit et al., 1995; Mansour et al., 1995; Oehninger et al., 1995) included couples presenting with only male factor infertility, while two allowed only inclusion of couples with female factor infertility (Kasman et al., 2021; Kruger et al., 1986). The remaining studies included couples treated for both conditions.

3.4 | Teratozoospermia and pregnancy rates

Thirteen studies (Capelouto et al., 2018; Chen et al., 2020; Grow et al., 1994; Keegan et al., 2007; Kruger et al., 1986; Lundin et al., 1997; Mansour et al., 1995; Mariappen et al., 2018; Mercan et al., 1998; Nagy et al., 1995; Oehninger et al., 1995; Osawa et al., 1999; Schachter-Safrai et al., 2019) included in the cumulative synthesis reported outcomes on the association of teratozoospermia and pregnancy rates with a reference threshold for teratozoospermia which was 4% in eight studies (Capelouto et al., 2018; Chen et al., 2020; Grow et al., 1994; Mariappen et al., 2018; Mercan et al., 1998; Oehninger et al., 1995; Osawa et al., 1999; Schachter-Safrai et al.,

TABLE 1 Demographics and clinical characteristics of the 17 studies included in the systematic review and meta-analysis

Author	Year	Country	Study design (Level of Evidence)	Sample size (n. of cycles)	Average age (Years)	Technique	Population Description	Main findings
Kruger et al	1986	South Africa	Cross-sectional cohort study (III-2)	190	–	IVF	Women with bilateral tubal damage and their partners	Higher fertilization and pregnancy rate in men with normal sperm morphology >14%.
Grow et al	1994	USA	Retrospective cohort study (III-2)	316	–	IVF	Patients with previous total failure of fertilization or <7.5 × 105 total motile sperm	Severe teratozoospermia yields a lower implantation rate and ongoing pregnancy rate.
Nagy et al	1995	Belgium	Cross-sectional cohort study (III-2)	965	34.9	ICSI	Patients with failed or very low (<10%) fertilization rate in the previous standard IVF cycle(s) or unsuitable sperm parameters for conventional IVF	ICSI can provide high normal fertilization, cleavage.
Oehninger et al	1995	USA	Retrospective cohort study (III-2)	1163	35.4	ICSI	Couples with male factor infertility associated with total failed fertilization in at least one previous attempt or unsuitable sperm parameters for conventional IVF	None of the sperm parameters of the original sperm analysis correlated with ICSI outcome.
Palermo et al	1995	USA	Retrospective cohort study (III-2)	227	36.2	ICSI	From 29 September 1993 to 14 March 1994, assisted fertilization was in couples with long-standing infertility	Sperm parameters do not clearly affect the outcome of ICSI.
Ben-Chetrit et al	1995	Canada	Retrospective cohort study (III-2)	672	-	IVF	cycles of successful oocyte retrieval performed from 10 August 1992 to 31 December 1993 from couple with male factor infertility	Couples with severe male factor infertility should be considered for standard IVF, as long as adequate total motile sperm can be recovered.
Mansour et al	1995	Egypt	Retrospective cohort study (III-2)	1433	–	ICSI	ICSI cycles was performed for the treatment of infertility due to male factor with different degrees of severity.	The fertilization and pregnancy rates are not affected by different semen parameters as long as morphologically well-shaped live sperms could be used.
Lundin et al	1997	Sweden	Retrospective cohort study (III-2)	622	32.8	IVF +ICSI	Patients who participated in an IVF or ICSI programme during a 2-year period.	Poor sperm morphology (<5% normal forms) is a factor that results in impaired fertilization.
Mercan et al	1998	USA	Cross-sectional cohort study (III-2)	715	34.9	ICSI	ICSI cycles and conventional IVF cycles performed between April 1994 and March 1996	Couples undergoing ICSI with severe male infertility have a reduced fertilization rate than patients undergoing clinical ICSI and IVF with non-male infertility.
Osawa et al	1999	Japan	Retrospective cohort study (III-2)	398	33.9	IVF +ICSI	cycles of IVF and ICSI between July 1995 and May 1997. Couples who underwent ICSI had previously failed standard IVF and/or had extremely low-sperm parameters (<500,000 progressive motile spermatozoa/ml).	The predominant abnormal form affects the ICSI outcome in the case of <4% normal forms.

TABLE 1 (Continued)

Author	Year	Country	Study design (Level of Evidence)	Sample size (n. of cycles)	Average age (Years)	Technique	Population Description	Main findings
Keegan et al	2007	USA	Retrospective cohort study (III-2)	518	37.7	IVF +ICSI	Couples were selected who experienced their first and/or second IVF cycle between 01 January 2002 and 21 December 2004, with at least one oocyte retrieved per cycle, semen analysis performed, and >2 million motile	Isolated teratozoospermia generally does not impact on the major indices of IVF.
Dubey et al	2008	USA	Retrospective cohort study (III-2)	52	36.7	IVF	Patients undergoing their first IVF–PGD cycle for idiopathic recurrent pregnancy loss or multiple failed IVF implantations between 01 January 2004 and 30 September 2006	Results suggest that sperm morphology plays an important role in the outcome of IVF–PGD cycles.
Capelouto et al	2018	USA	Retrospective cohort study (III-2)	845	41.3	ICSI	Patients undergoing IVF cycles from a private fertility clinic between 2008 and 2015.	Neither advancing male age, elevated BMI nor poor sperm quality were associated with outcomes in frozen donor oocyte IVF cycles in this study.
Schachter-Safrai et al	2018	Israel	Retrospective cohort study (III–2)	332	34.8	ICSI	Included couples after embryo transfer using fertilization by IMSI between January 2008 and May 2017.	IMSI procedure may be more efficient in severe compound sperm pathologies than in patients with one abnormal sperm parameter.
Mariappen et al	2018	Australia	Retrospective cohort study (III–2)	1280	-	ICSI	Patients undergoing IVF treatment cycles from 1 April 2008 to 30 November 2017 conducted at one facility	The outcomes were not significantly influenced by semen parameters or male age with respect to the likelihood of clinical pregnancy or live birth.
Chen et al	2019	China	Retrospective cohort study (III-2)	3155	30.2	ICSI	Patients undergoing c-IVF, early rescue ICSI (RICSI) treatment and follow-up from January 2015 to May 2017	Normal sperm morphology rate <4% significantly increased the total fertilization failure rate but did not affect the clinical or neonatal outcomes.
Kasman et al	2020	USA	Retrospective cohort study (III-2)	4517	37.7	ICSI	Any female undergoing ART from January 2012 to December 2018 who had Available demographic and semen parameters	Sperm motility is associated with pregnancy rates, while other semen parameters are not.

Abbreviations: ICSI, intracytoplasmic sperm injection; IVF, in vitro fertilization.

2019), 5% in three (Keegan et al., 2007; Lundin et al., 1997; Mansour et al., 1995) and 14% in two remaining studies (Kruger et al., 1986; Nagy et al., 1995). Odds ratio estimates ranged from 0.08 to 1.41 with OR <1 indicating lower pregnancy with teratospermia while >1 represents higher odds of pregnancy with teratospermia. The pooled OR estimate was equivalent under a fixed- or random-effect model: 0.88 (95%CI: 0.75–1) Figure 1a. There was no evidence to support any meaningful heterogeneity between the studies: $Q = 23.4$ (d.f. = 12), $p = 0.02$; $I^2 = 48.7\%$ and the findings from the two models were not materially different. Because of this finding, we chose to present random-effects models for all analyses. No single study was found to significantly affect the heterogeneity statistic when excluded from analysis. Furthermore, the funnel plot suggests that there was no small-study effect (Egger test, $p = 0.78$), which supports the absence of publication bias. The "Trim and Fill" method suggests that no "missing" studies need to be included to remove any asymmetry from the funnel plot Figure S2a. At subgroup analysis of ART technique (i.e. IVF vs. IVF/ICSI), there was an association with semen morphology in case of IVF studies (OR, 0.59, 95%CI: 0.25–0.93; lower morphology associated with lower pregnancy rate) but not for ICSI (OR, 0.87, 95%CI: 0.73–1.02) (Figure 1b) in presence of a non-significant test of groups differences ($p = 0.14$). On meta-regression analysis, we found a positive correlation among more recent year of publication and decreasing effect size (Coeff: 0.01, SE: 0.004, $p = 0.014$) suggesting modern studies showing no association between morphology and pregnancy rate while older studies favoured a negative association (Fig. S3). In contrast, there were no significant trends between baseline men's age, the total number of cycles per study nor the reference threshold for teratozoospermia (Fig. S3).

3.5 | Oligospermia and pregnancy rates

Of the 17 studies included, only seven (Capelouto et al., 2018; Kasman et al., 2021; Mariappen et al., 2018; Mercan et al., 1998; Nagy et al., 1995; Oehninger et al., 1995; Schachter-Safrai et al., 2019) reported data regarding the association of sperm concentration and ART outcomes. All the studies (Capelouto et al., 2018; Kasman et al., 2021; Mariappen et al., 2018; Mercan et al., 1998; Nagy et al., 1995; Oehninger et al., 1995; Schachter-Safrai et al., 2019) reported outcomes from IVF/ICSI. The reference threshold for defining normospermic patients ranged from 10×10^6/ml to 20×10^6/ml across the studies. Odds ratio estimates varied from 0.75 to 1.20 with OR <1 indicating lower probability of pregnancy with oligospermia. The pooled OR estimate was similar under a fixed or random effect model: 0.88 (95% CI: 0.75–1; Figure 2) in absence of study heterogeneity ($Q = 6.09$, d.f. = 6, $p = 0.41$; $I^2 = 1.46\%$). No single study was found to significantly affect the heterogeneity statistic when excluded from analysis. Furthermore, the funnel plot suggests that there was no small-study effect (Egger test, p=0.63), which supports the absence of publication bias. The "Trim and Fill" method suggested that two "missing" studies would be necessary to adjust asymmetry from the funnel plot Figure S2b. On meta-regression analysis, there were no significant trends between patient age, number of cycles per study as well as year of publication (Fig. S4). There was a modest negative association between normal concentration threshold and clinical pregnant rate (Coeff: −0.04, SE: 0.02, $p = 0.039$; Fig. S4) suggesting that lower sperm concentrations were associated with lower pregnancy rates.

3.6 | Asthenospermia and pregnancy rates

Of the 17 studies included, nine studies reported data regarding the effect of impaired motility on ART outcomes. Eight studies (Capelouto et al., 2018; Kasman et al., 2021; Mariappen et al., 2018; Mercan et al., 1998; Nagy et al., 1995; Oehninger et al., 1995; Palermo et al., 1995; Schachter-Safrai et al., 2019) reported outcomes from IVF/ICSI technique while only one experience (Ben-Chetrit et al., 1995) from IVF alone. The reference threshold for defining normal proportion of motile spermatozoa ranged from 20% to 40% across the studies analysed. Odds ratio estimates varied from 0.61 to 1.22 with OR <1 indicating lower probability of pregnancy rate with asthenospermia. The pooled OR estimate was the same both under a fixed- or random-effect model: 0.88 (95%CI: 0.73–1.03; Figure 3) acknowledging the existence of substantial study heterogeneity ($Q = 19.1$, d.f. = 8, $p = 0.01$; $I^2 = 58\%$). No single study was found to significantly affect the heterogeneity statistic when excluded from analysis. Furthermore, the funnel plot suggests that there was no small-study effect (Egger test, $p = 0.72$), which supports the absence of publication bias. The "Trim and Fill" method suggested that there were no "missing" studies necessary for inclusion to remove potential asymmetry from the funnel plot Figure S2c. Similar to the meta-regression analysis of concentration, higher motility thresholds were associated with effect sizes closer to the null effect point (Coeff: −0.04, SE: 0.02, $p = 0.039$; Fig. S5) suggesting that more severe asthenospermia may be associated with lower pregnancy rates.

4 | DISCUSSION

Overall, the current report failed to identify an association between semen parameters (i.e. sperm motility, concentration and morphology) and pregnancy rates with ART. While early studies suggested a possible relationship between sperm morphology and clinical pregnancy rate, later studies in the meta-analysis did not find any relationship. Importantly, some secondary analyses suggested that lower sperm concentration and motility levels are associated with lower pregnancy rates. However, the current metanalysis suggests that current ART techniques are able to overcome impairments in semen quality.

To date, more than 8 million children have been born with the assistance of IVF, and over 2.5 million cycles are being performed annually, resulting in over 500,000 deliveries, with continued

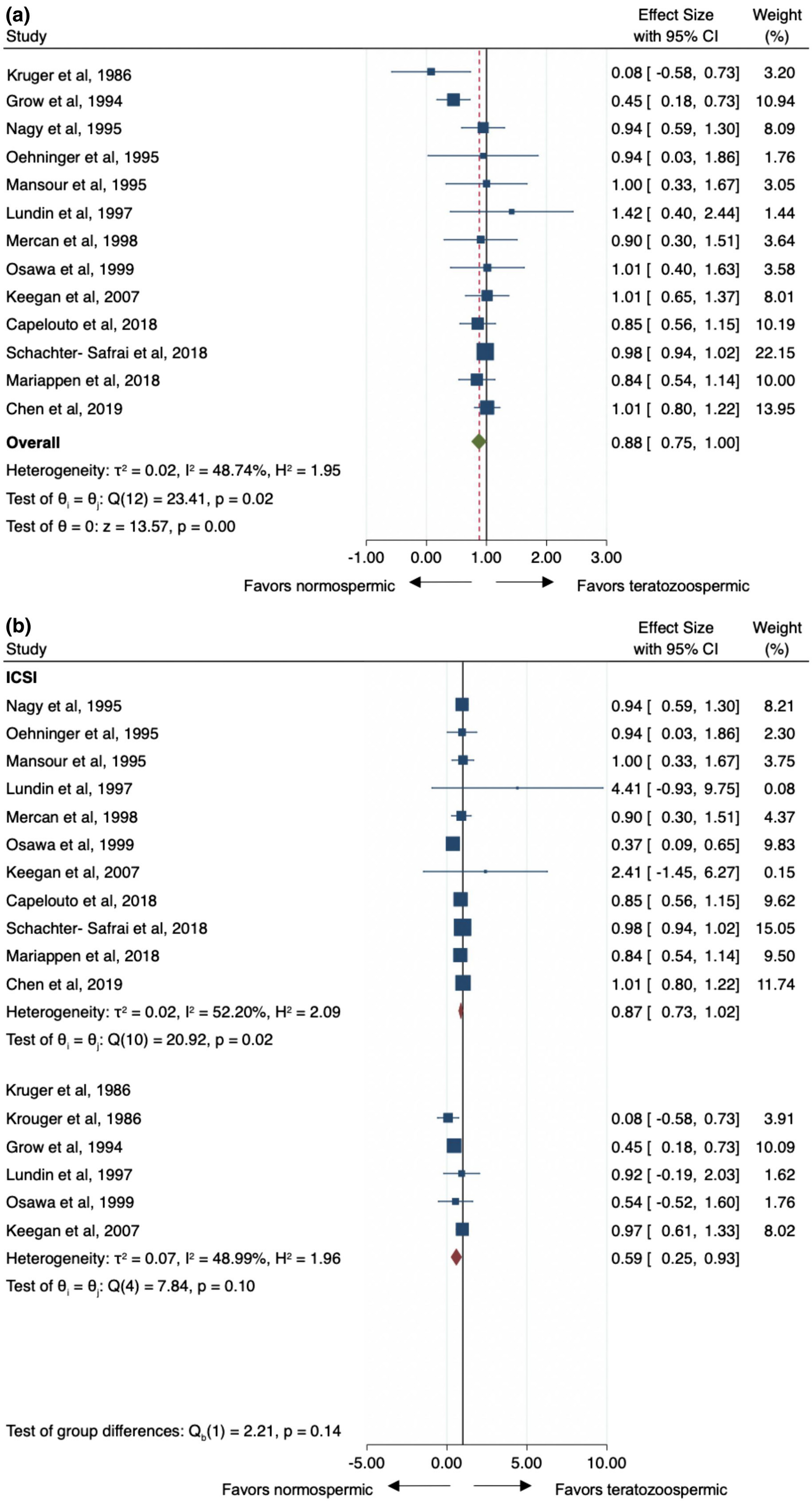

FIGURE 1 (a) Pooled odds ratio for teratozoospermic men compared to normozoospermic controls for pregnancy rate outcome at assisted reproductive techniques. (b) Subgroup analysis of IVF versus ICSI approach in teratozoospermic men compared to normozoospermic controls for pregnancy rate outcome CI, confidence interval; IVF, in vitro fertilization; ICSI, intracytoplasmic sperm injection

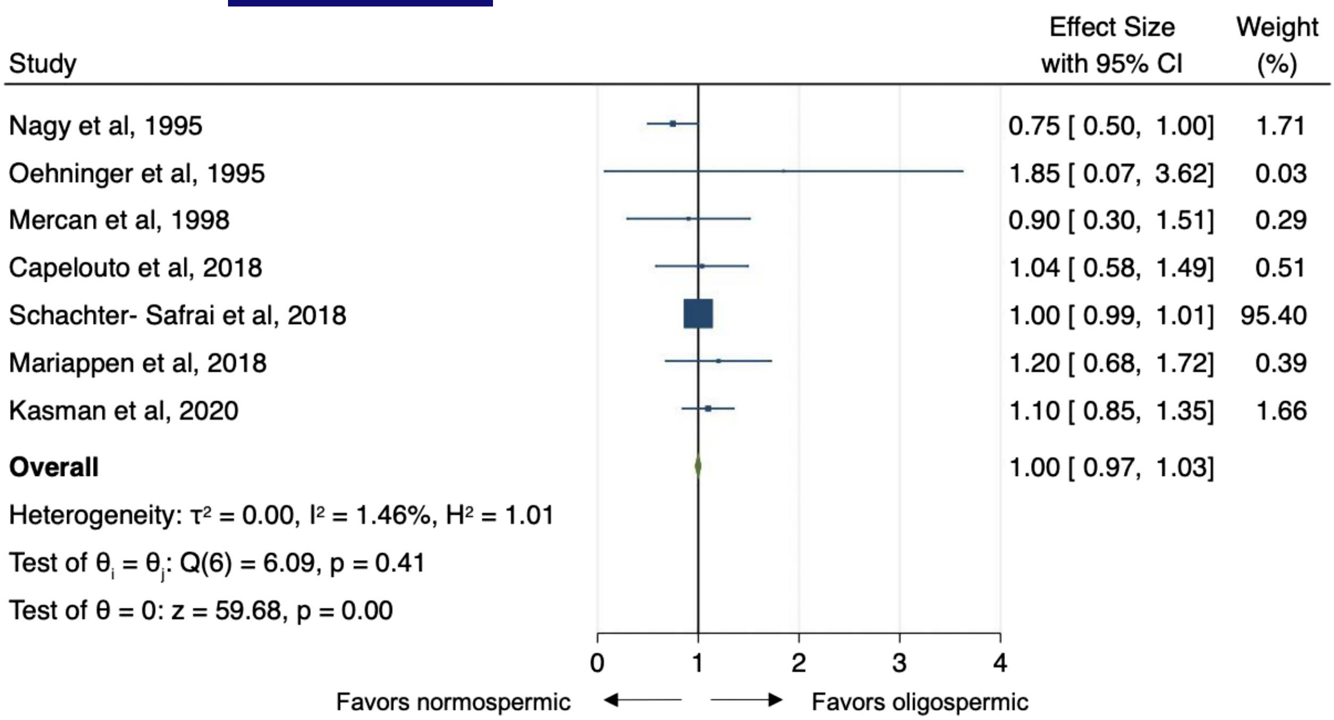

FIGURE 2 Pooled odds ratio for oligospermic men compared to normospermic controls for pregnancy rate outcome at assisted reproductive techniques. CI, confidence interval

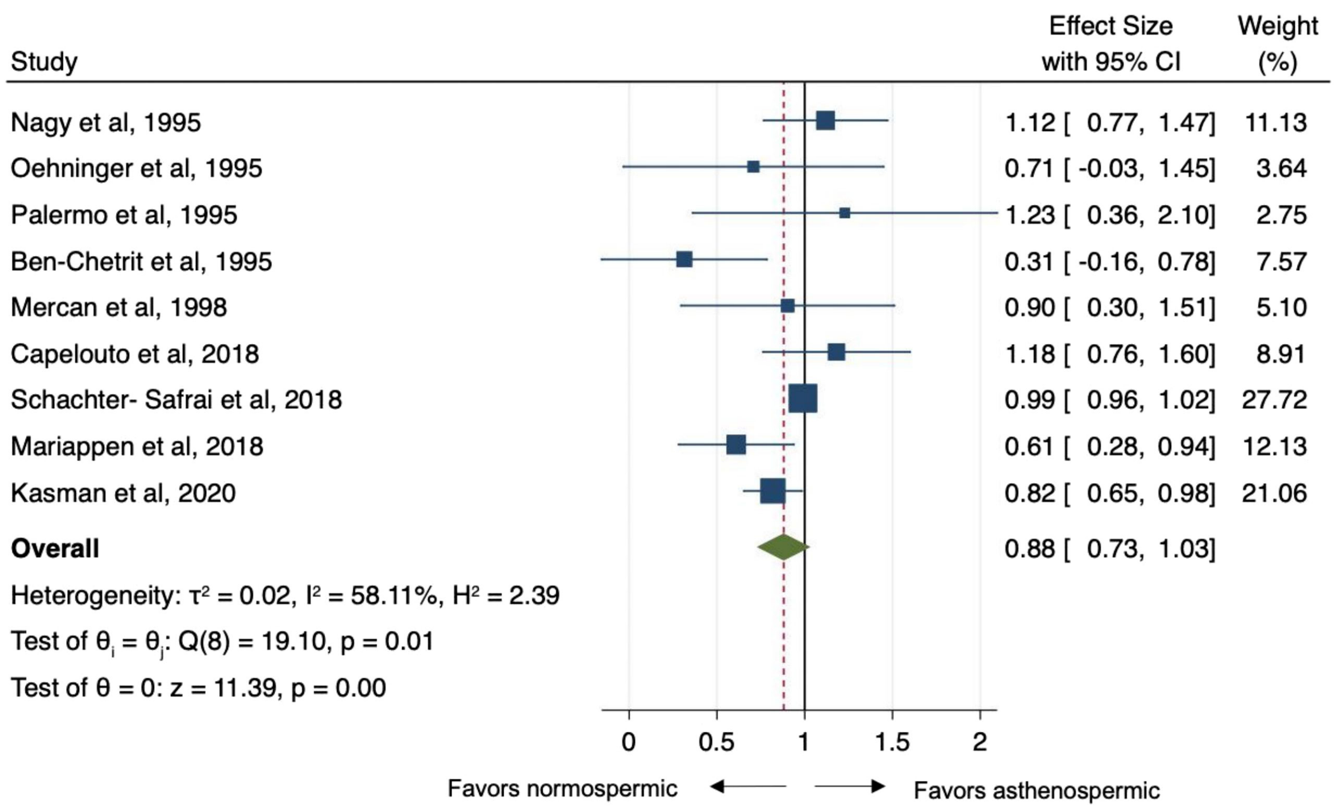

FIGURE 3 Pooled odds ratio for asthenospermic men compared to normospermic controls for pregnancy rate outcome at assisted reproductive techniques. CI, confidence interval

studies examining factors associated with outcomes (Fauser, 2019). Oocyte quality is a well-known predictor of IVF success with a recent meta-analysis highlighting the association between intra- and/or extra-cytoplasmatic oocyte morphologies and IVF outcomes (Setti et al., 2011). On the other hand, the influence of the male gamete on IVF success is less certain. Previously, a meta-analysis by Hotaling et al.

(2011) reported that isolated teratozoospermia was not correlated with clinical pregnancy (OR 1.18, 95% CI, 0.83–1.67). However, other semen parameters have not been rigorously examined.

A major strength of this present study is the comprehensive assessment of the different semen parameters over a long time period of observation and evolution of the practice of ART (i.e. 1986–2020). While early studies suggested that lower sperm morphology led to impaired pregnancy rates, current studies displayed to association between sperm morphology and pregnancy rate. The current report was limited to conventional semen parameters (i.e. sperm concentration, motility and morphology). However, Ribas-Maynou et al. (2021) recently demonstrated an inverse relationship between sperm DNA fragmentation, implantation and clinical pregnancy rate. In their meta-analysis, the authors reported a 32% and 28% lower implantation and clinical pregnancy rate for cycles with abnormal sperm DNA fragmentation. Moreover, the association was stronger for IVF compared to ICSI suggesting ICSI may be able to overcome sperm damage.

It is important to highlight that the current analysis identified a temporal effect on the outcomes from ART and semen quality. There was a trend over the years where the more recent experiences did not identify an association between semen quality and PR which may reflect continued quality control and improvements in ART. In addition, granular data on semen parameters were not available in the majority of the reports. However, an analysis comparing bounds of semen parameter reference ranges suggested lower quality may be associated with lower pregnancy rates for both concentration and motility. As a secondary analysis, the results should be interpreted with caution. Nevertheless, it is possible that men with the most severely impaired semen quality may display compromised ART outcomes.

Our study has limitations that warrant discussion. First, despite the fact that the experiences included cover a long time period and different geographical regions of the world, the overall number of studies analysed is relatively small. Second, it was not possible to explore the isolated effect of each semen abnormality as most studies did not report abnormalities in isolation. Next, we were limited by specific thresholds of semen quality that were reported. It is conceivable that lower parameters (e.g. <1 M sperm/mL, <5% motility, 0% morphology) or a combination of impaired parameters (e.g. Oligo–Astheno–Teratospermic [OAT] syndrome) may be associated with ART outcomes. Finally, the outcome analysed was clinical pregnancy rate rather than the ultimate goal of a couple utilizing ART which is a live birth.

5 | CONCLUSION

The current analysis found no association between semen quality (as measured by concentration, motility or morphology) and clinical pregnancy rates utilizing ART. While future investigations are necessary to explore the association between semen parameters and other ART outcomes (e.g. fertilization, implantation, birth and perinatal health), our study suggests that ART is able to overcome modest impairments in semen quality.

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CONFLICT OF INTEREST

Authors have no conflict of interest to disclose.

RELEVANT DISCLOSURES

Authors have nothing to disclose.

DATA AVAILABILITY STATEMENT

Research data are not shared.

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