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REVIEW ARTICLE

Body composition and reproductive outcomes: a scoping review

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Abstract

Objectives: Infertility affects more than 48 million couples worldwide. Body composition could interfere in fertility rates in Assisted Reproductive Techniques (ART). Our study aims to assess body composition and reproductive outcomes in women, men and couples undergoing ART. **Methods:** A scoping review was conducted under review registry https://osf.io/xthdr. Studies evaluating body composition and reproductive outcomes in ART by methods other than weight and Body Mass Index (BMI) in men, women and couples, published until February 2025, were included. The main review question was: "What is known in the literature about the relation between body composition and reproductive outcomes in women, men and couples undergoing ART?" **Results:** From 5,122 studies, only 17 (8.905 participants) addressed the main question. Studies included women (n=12), men (n=1), and couples (n=4). In women, Waist Circumference (WC) was associated with lower rates of implantation (4 studies) but not pregnancy (5 studies). Moreover, Percentage of Body Fat (%BF) was inversely related to pregnancy (3 studies). **Conclusions:** Central obesity, measured by WC, seems to be related to poorer ART outcomes. More studies are necessary to evaluate the effect of body composition on ART outcomes.

Keywords: body composition; infertility; assisted reproduction technologies; waist circumference; central obesity.

1.Introduction

Infertility is a defined as failure to achieve a clinical pregnancy (ultrasound visualization of one or more gestacional sacs or definitive clinical signs of pregnancy), after 12 months or more of regular unprotected sexual intercourse.[1] It affects more than 48 million couples in reproductive age worldwide[2] and Assisted Reproductive Technology (ART), which encompasses *in vitro* Fertilization (IVF) and Intracytoplasmic Sperm Injection (ICSI), is an alternative treatment for those who cannot conceive naturally. The rates of live births per cycle in ART range from 5% to 30% worldwide.[3] Increased maternal age, ovarian reserve, tobacco and substance use and sperm factors, are associated with poorer ART outcomes.[4-6] The role of nutrition and body composition in ART success is not clearly understood.

Both, underweight and high Body Mass Index (BMI) in men and women may adversely affect pregnancy.[7] Body weight reflects the combined weight of all the body's tissues, while body composition measures the relative proportions of fat and lean mass in the body. Lean mass refers to bones, tissues, organs, and muscle.[8] Individuals with the same BMI can have different body compositions.[9]

Most studies use anthropometric indicators like BMI and weight to estimate adiposity in this population.[10,11] In contrast, Waist Circumference (WC), is not commonly used.[9] BMI and isolated weight are unable to detect these differences in fat and lean mass and in fat location (subcutaneous or visceral), despite being commonly used in clinical practice.[12] Increasing central adiposity, measured by WC, is associated with an increased risk of morbidity and mortality, however the impact of different body compartments in the outcomes of ART is not clear.

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WC is a simple way to estimate central fat, but it is not able to evaluate lean mass. Bioelectric impedance analysis measurement is simple and widely used, however it is accuracy depends on several factors, such as hydratation, exercise, menstrual cycle phases. Dual-energy x-ray absorptiometry (DXA) is the preferred method in a clinical setting to provide a more rigorous determination of body composition. DXA provides information about lean and fat mass distribution both central and appendicular. Image techniques, such as computed tomography can also be used as an alternative to assess body composition, but the are more time-consuming, expensive and involve higher levels of radiation. Like magnetic resonance imaging, their use is limited to research settings.[8]

Adiposity can affect reproductive outcomes in both men and women. This scoping review aims to identify the studies that evaluated body composition reproductive outcomes in women, men and couples undergoing artificial reproduction technologies.

2. Materials and Methods

The *Joanna Briggs institute's scope review manual* was followed.[13] The protocol of this study was registered on the Open Science Framework registry platform and the registry code is *xthdr*. Question Review: What is known in the literature about the relation between body composition and reproductive outcomes in women, men and couples undergoing ART?

2.1 Search strategies:

A three-step search strategy was used for this review. PubMed, LILACS, Scopus, and Embase databases were searched. The first and initially limited search was performed on MEDLINE (PubMed) followed by the analysis of the titles and abstracts as well as the index terms used to describe the article. A full secondary search was performed on all included databases, using the keywords and index terms identified in the initial limited search. To help identify any additional studies, a tertiary literature search was performed examining reference lists of all literatures with the inclusion criteria for this review. Studies published in English, Spanish, or Portuguese were included. This review considered all relevant papers, not limiting publication dates.

2.2 Inclusion Criteria:

Inclusion criteria were selected according to the Participants, Concept, and Context (PCC) method for scope review. Studies with infertile men, women or couples (participants) subjected to assisted reproductive technology (context) and had associated body composition and reproductive outcomes (concept) were selected.

2.3 Exclusion criteria:

Studies with animals, assessing body composition only by weight and BMI and studies that only analyzed reproductive outcomes that precede the fertilization process—such as ovarian stimulation and sperm quality—were excluded.

2.4 Study selection process:

The study selection process was conducted by two independent reviewers and when there were discrepancies, a third reviewer was consulted. After identifying the studies in the different databases, the Mendeley reference manager was used, in which all identified references were grouped and loaded, and the duplicates were removed. After selecting the abstracts, a list of articles was prepared for in-full reading, and those that did not meet the previously established inclusion criteria were excluded. The survey results are detailed in the Preferred Report Items for Systematic Reviews and Meta-Analyses for Scope Review (PRISMA-ScR).[14] The results were described based on the PRISMA manual for Scoping Review.[15]

2.5 Data extraction process from the included studies:

Data were extracted from the articles included in this scoping review by two independent reviewers using a data extraction tool developed by the reviewers on the Google Forms platform. The pilot tool was tested for three studies. The pilot data extraction tool had been modified and revised for adjustments.

3. Results:

The search strategy identified 5,122 references, as Figure 1 - PRISMA Flow Diagram for the scoping review process shows. After removing duplicates, 3,936 references remained. In total, 3,877 articles were excluded based on title and abstract screening. During the full review process of the remaining 30 articles, studies were excluded for the following reasons: did not assess the outcome of interest (n=8), did not assess body composition (n=1), included only weight and BMI as body composition variables (n=6), ongoing study (n=1), did not include infertile participants (n=2). In a second moment, an update search was performed and a total of 17 relevant articles that evaluated the association of body composition with reproductive outcomes in participants undergoing ART were included.

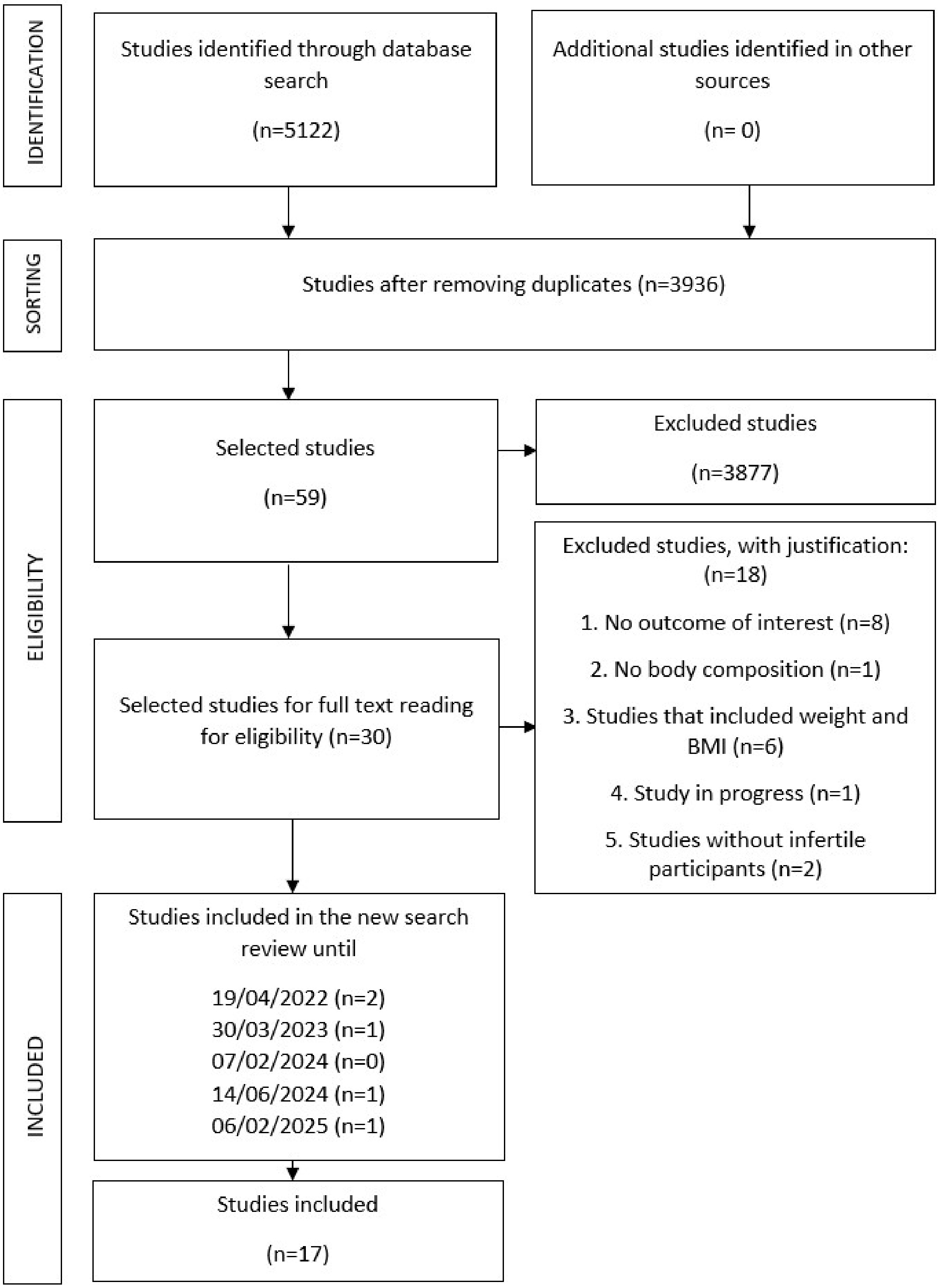

Figure 1. PRISMA Flow Diagram for the scoping review process.

Table 1 shows the characteristics of the articles included. In total, 17 studies included 8,905 participants, who were subjected to FIV (nine studies);[9,12,22-27,29] ICSI (two studies);[18,20] or both methods (six studies).[6,16,17,19,21,28] The sample size of the studies ranged from 70 to 1,889 participants. Six studies had been conducted in the United States;[12,17,21-23,26] three in Europe;[6,19,27] two in China,[16,28] two in Brazil,[9,18] one in the Middle East[25] and one in Turkiye.[29] Nine papers were prospective cohort studies,[12,17-23,26] six were retrospective[6,16,24,25,28,29] one was a transversal study[9] and one was a randomized controlled trial.[27]

Figure 2 shows the body composition variables available in the studies. 6 studies evaluated Body Fat Percentage (%BF)[9,12,21,23,24,28] and twelve measured WC.[6,9,16-20,22,25-27,29] The Novel Body Fat Index (BFI) and Visceral Adiposity Index (VAI) were evaluated by one study. They consist of multiplying the pre-peritoneal and subcutaneous fat (in mm) and dividing it by height (in cm).[20] Body composition parameters vary between: % BF < 24 - ≥40 and 17- ≥31;[12,21,28] WC 77-88 cm and > 94 cm;[16-20,22] Waist-to-hip ratio (WHR) 0.75 – 0.86 (6), in women and men, respectively.

Figure 3 describes the design of the study and the outcomes evaluated: Most studies evaluate clinical pregnancy (n=13),[6,9,12,16-20,22,26-29] live births (n=9),[6,16,17,19,21,22,24,26,27] implantation (n=9)[16-19,21,22,25,26,28] and fertilization (n=8).[12,17-21,23,26]

Table 2 shows the main outcomes of each study. Five studies reported that implantation was reduced in women who had larger WC;[16-18,22,26] five studies found no association between WC and pregnancy;[16,19,20,22,27] two studies found that %BF has an inverse association with pregnancy,[12,24] however, one of these studies is a summary of a provisory analysis with limited power.[12] Our review was inconclusive for the association of %BF, regarding WC, WHR, and WHtR with outcomes such as embryo quality, birth weight, preterm childbirth, fertilization, live births, miscarriages, oocytes retrieved and fertilized, cleaved embryos.

Table 1. Characteristics of included studies (n=17)

First Author	Population	Design	Country	Participants (N)	Age	Art
Kim et al.[12]	Infertile couples	Prospective cohort	United States	862		IVF
Li et al.[16]	Infertile women	Retrospective cohort	China	Central obesity group (70); No central obesity group (118)	29.5 – 30.2	IVF/ICSI
Li et al.[17]	Infertile women	Prospective cohort	United States	264	34.5 – 35.4	IVF/ICSI
Setti et al.[18]	Infertile couples	Prospective cohort	Brazil	201	35.9	ICSI
Ferreira et al.[19]	Infertile women	Prospective cohort	Portugal	578	35	IVF/ICSI
Makhlouf et al.[20]	Infertile women	Prospective cohort	Data not found	Central obesity group (40); No central obesity group (32)	Data not found	ICSI
Kim et al.[21]	Infertile couples	Prospective cohort	United States	1889	35.4	IVF/ICSI
Hansen et al.[22]	Infertile women	Prospective cohort	United States	899	18 – 40	IVF
Kim et al.[23]	Infertile couples	Prospective cohort	United States	395 women, 346 men	35.8 – 37.1	IVF
Amsiejiene et al.[6]	Infertile women	Retrospective cohort	Lithuania	597	33.4	IVF/ICSI
Bustillo et al.[24]	Infertile women	Retrospective cohort	Data not found	166	Data not found	IVF
Christofolini et al.[9]	Infertile women	Cross-sectional	Brazil	788	33.55	IVF
Hassab et al.[25]	Infertile women	Retrospective cohort	Iraq	70	19 – 45	IVF
Bian et al.[26]	Infertile men	Prospective cohort	United States	163	36.1	IVF
Svensson et al.[27]	Infertile Women	Randomized Controlled trial	Sweden/ Denmark/ Iceland	187	31.7 - 4.14	IVF
Yao et al.[28]	Infertile Women	Retrospective cohort	China	469	31.3	IVF/ICSI
Özelçi et al.[29]	Infertile Women	Retrospective cohort	Turquia	771	28.5 – 29.1	FIV

IVF=*In Vitro* Fertilization, ICSI=Intracytoplasmic Sperm Injection, Age is presented as mean ± years or median/range.

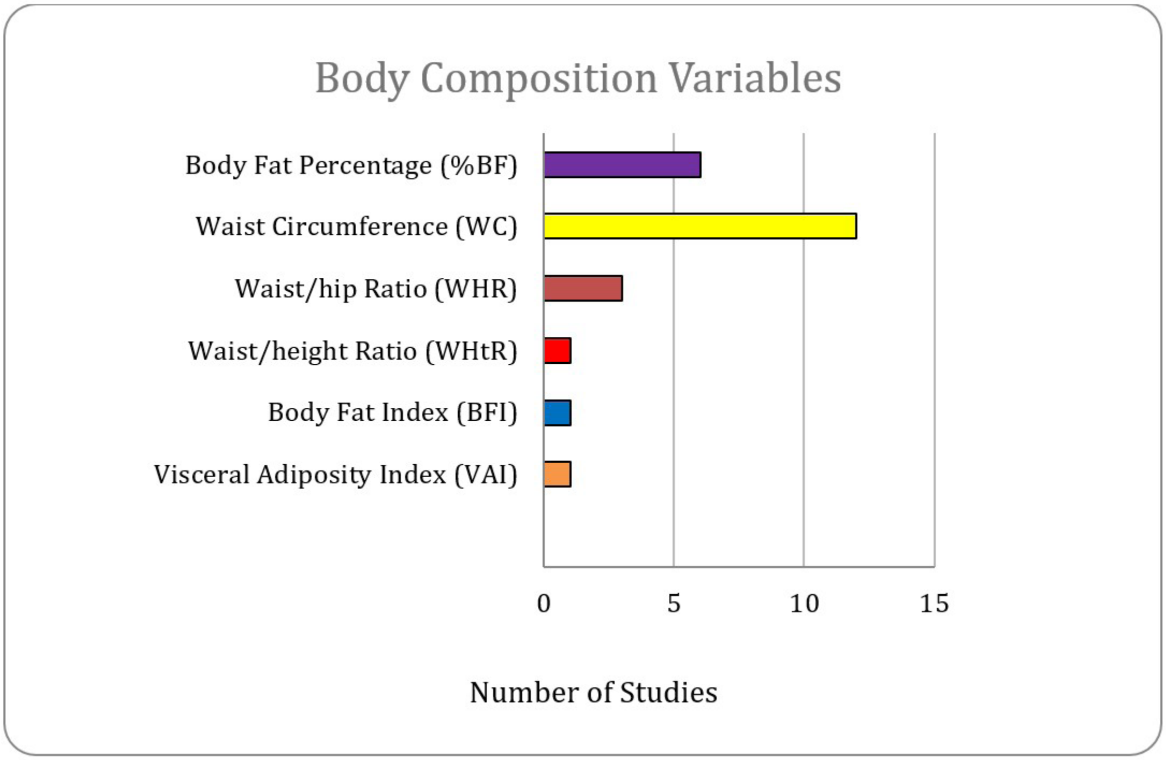

Figure 2. Shows the body composition variables available in the studies. Twelve studies measured WC.

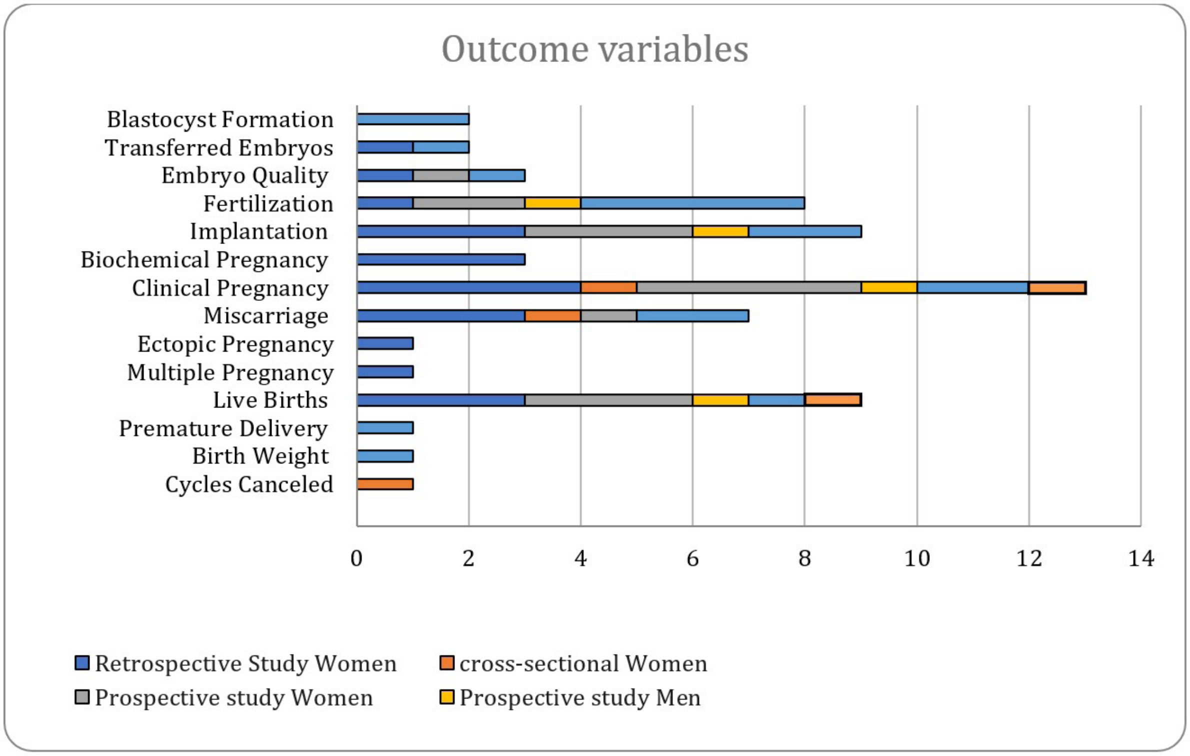

Figure 3. Describes the design of the study and the outcomes evaluated: Most studies evaluate clinical pregnancy (n=13), live births (n=9) and implantation (n=9).

Table 2. Summary of results (n=17)

First Author	Body Composition	Groups	Equipaments	Outcomes	Results
Kim et al.[12]	%BF	BF≥31% Women BF≥22% Men	InBody 770 bioelectrical impedance	Fertilization, Clinical Pregnancy (did not define the variables)	Men with BF<22% had a higher fertilization rate. Women with BF<31% had a higher chance of clinical pregnancy.
Li et al.[16]	WC	Women > 80 cm; ≤ 80 cm	Gullick II Plus tape measure recorded to millimeter accuracy	Implantation (gestational sac/no), live births (birth of a fetus at or after 24 weeks of gestation), early miscarriage (did not define the variables) biochemical pregnancy [defined as elevated serum b-HCG (≥25 IU/L) 14 days after embryo transfer], clinical pregnancy (the presence of gestational sacs by ultrasonography 4–5 weeks after embryo transferred), ectopic pregnancy, and multiple pregnancies.	The group with WC>80 cm had lower implantation and live births and a higher rate of early miscarriage. The two groups showed similar rates of biochemical, clinical, multiple, and ectopic pregnancy and number of embryos transferred.
Li et al.[17]	WC	Women: Tertile cm: < 77.0; 77.0 - 86.0; > 86.0	Tape-measure	Implantation (serum b-HCG>6 mIU/mL), fertilization rate (the number of oocytes with two pronuclei divided by the number of metaphase II oocytes at 17–20 hours after IVF or ICSI), clinical pregnancy (presence of intrauterine gestational sacs at six weeks), live births.	No associations were observed between WC and fertilization. The smaller the waist circumference, the bigger the implantation rate, clinical pregnancy, and live birth.
Setti et al.[18]	WC	WC cm (Women): ≤80 cm, >80 WC cm (Men): ≤94 cm, > 94 cm	Tape-measure	Implantation, fertilization, clinical pregnancy (the fetal heartbeat was detected Pregnancy), miscarriage (clinical pregnancy loss before 20 weeks), number of embryos, High-quality embryos (defined as those with four cells on day 2 or 8–10 cells on day 3, < 15% fragmentation, symmetric, and monunucleated blastomeres, and absence of cytoplasmic inclusions and/or dimorphisms in the perivitelline space and zona pellucida).	Women: WC≤80 were associated with fertilization, number of embryos, high quality embryos on day 2 and 3, blastocyst development and implantation. Men: WC≤94 were associated with high quality embryos at day 2 and 3, blastocyst development, implantation and pregnancy. Couples: Lower WC had higher fertilization, quality embryo on day 2 and 3, higher blastocyst development and implantation rate.
Ferreira et al.[19]	WC	Women: WC (cm) < 88, ≥88	Tape-measure	Implantation rates (considered per embryo transfer), fertilization, clinical pregnancy (presence of an intrauterine gestational sac on ultrasound examination), live births (when the fetus was born alive. beyond the 24th week of gestation), spontaneous abortion (pregnancy failing to reach the 24th week of gestation after detection of gestational sacs).	A direct association between WC>88cm and the occurrence of fertilization was found. No significant association between WC and pregnancy, live births, abortion, and implantation was found.

% BF=Body Fat Percentage (%BF), WC=Waist Circumference, WHR=Waist-to-Hip Ratio, WHtR=Waist- to-Height Ratio, VAI=Visceral Adiposity Index, BFI= Novel Body Fat Index, cm = Centimeter.

Table 2. Continued...

First Author	Body Composition	Groups	Equipaments	Outcomes	Results
Makhlouf et al.[20]	WC, VAI and BFI	WC (cm) ≥ 80 cm, <80 cm	Data not found	Fertilization, clinical pregnancy, embryo quality, ongoing pregnancy.	No difference in fertilization and pregnancy rates between the groups was found.
Kim et al.[21]	%BF	Women BF (%) < 25%, 25-30%, 31-31.9% e ≥ 40% Men BF (%) < 17%; 17-21.9%; 22-29.9%; ≥30%	InBody 770 bioelectrical impedance	Fertilization (defined as the presence of two pronuclei the morning after oocyte retrieval), live births, miscarriage, premature delivery (gestational age <37 weeks), birth weight [(<2,500 g), very low birth weight (<1,500 g), large for gestational age (>4,000 g)], blastocyst formation rate (determined by progression to the blastocyst stage on day 5, 6, or 7), implantation rate (measured as the number of embryos with ongoing implantation at time of discharged divided by the number of embryos transferred).	Greater blastocyst formation and small for gestation age in group with highest %BF in women. Implantation, live births and abortion rates were not statistically significant among the groups. Outcomes were not different among the groups in men.
Hansen et al.[22]	WC	WC (cm) ≤ 88; > 88	Data not found	Clinical pregnancy (defined as an intrauterine pregnancy with fetal heart motion as detected by transvaginal ultrasound), live births (defined as the delivery of a viable infant), conception (defined as having a rising serum level of human chorionic gonadotropin on two consecutive tests).	Higher WC was associated with higher conception/ implantation rate. When evaluated as a continuous variable, WC was not significantly associated with any pregnancy outcome.
Kim et al.[23]	%BF	Data not found	Bioelectrical impedance	Fertilization, blastulation rates.	%BF was not associated with outcomes.
Amsiejiene et al.[6]	WHR	0.75; 0.75–0.79; 0.80–0.86; ≥ 0.86	Tanita Body Composition Analyzer model TBF-410	Clinical pregnancy, live births.	No difference statistically significant among the groups
Bustillo et al.[24]	%BF	Data not found	Tanita body composition analyzer	Live births, biochemical pregnancy, miscarriage.	%BF was significantly lower in women who became pregnant than among those who did not.
Christofolini et al.[9]	%BF, WC, WHR	Data not found	BIA scale of 50 kHz, 500mA and inelastic anthropometric measure tape;	Clinical pregnancy, miscarriage, embryos obtained, cycles canceled.	An inverse correlation was observed among %BF, WC, and WHR and cycle and gestational cancellation rates, with no correspondence between anthropometric indicators and miscarriage.
Hassab et al.[25]	WC, WHR	Data not found	Data not found	Successful implantation.	Significant increase WC among the failed implantation group WHR was not associated with successful implantation.

% BF=Body Fat Percentage (%BF), WC=Waist Circumference, WHR=Waist-to-Hip Ratio, WHtR=Waist- to-Height Ratio, VAI=Visceral Adiposity Index, BFI= Novel Body Fat Index, cm = Centimeter.

Table 2. Continued...

First Author	Body Composition	Groups	Equipaments	Outcomes	Results
Bian et al.[26]	WC	Data not found	Gullick II Plus Measuring Tape	Fertilization rate, implantation, clinical pregnancy, live birth.	5 cm increase in male WC was associated with 14.2% lower odds of implantation, 12.1% lower odds of clinical pregnancy, and 9.0% lower odds of a live birth.
Svensson et al.[27]	WC and WHtR	Data not found	Data not found	Pregnancy and live birth.	WC and WHtR were not identified as a significant predictor of pregnancy or live birth.
Yao et al.[28]	%BF	Low %BF: <24%; Normal %BF: 24-30.9%; High BF: ≥ 31%	BIA	Number of oocytes retrieved, fertilized oocytes, cleaved embryos, good quality embryos on day 3, implantation (serum b-HCG ≥ 5 UI/L 12 days after embryo transfer), biochemical pregnancy (implantation confirmed with failure to achieve clinical pregnancy), clinical pregnancy (presence of gestacional sac on ultrasound 5 weeks after embryo transfer.	High %BF group had significantly lower antral follicle count (AFC) than those in the normal %BF group. The AFC tended to decrease as %BF increased across the three groups (P <0.001). Ovarian reserve parameters: the differences were not significant. There were no significant differences in IVF outcome parameters among the groups.
Özelçi et al.[29]	WC	WC (cm) ≥ 88	Data not found	Endometrial thickness, number of oocyte retrieved, number of inseminated oocyte, number of mature oocyte, clinical pregnancy rate, miscarriage rate	Metabolic syndrome parameters such as triglyceride, waist circumference and BMI were negatively associated with clinical pregnancy rate.

% BF=Body Fat Percentage (%BF), WC=Waist Circumference, WHR=Waist-to-Hip Ratio, WHtR=Waist- to-Height Ratio, VAI=Visceral Adiposity Index, BFI= Novel Body Fat Index, cm = Centimeter.

4. Discussion:

In our scoping review higher adiposity seemed to be related to lower fertile outcomes**.** The association between increased BMI and poorer reproductive outcomes, including lower implantation and live birth rates, and a higher risk of spontaneous abortion[30] is well described in literature.[31,32] However, a Brazilian study demonstrated that central obesity measured by WC is more reliable than BMI as a parameter for evaluating body composition in infertile couples.[9] Also a recent cross-sectional study with 3239 women found that for every 1cm increase in WC the risk of infertility increased by 3% and it can be considered a predictor of female infertility independent of BMI.[33]

However, until now, few studies tested the association between body compartments and reproductive outcomes in ART as demonstrated in our study. In a Brazilian study included in our review—including almost 800 women—using five different anthropometric indicators to assess the effect of patient's body composition on ART outcomes, all of them indicate a decrease in positive ART outcomes proportional to the increased adiposity. Moreover, fertility outcomes were worse even in women with normal weight and higher waist circumference compared to a waist circumference lower than 80 cm.[9]

Our results were mixed for women, men, and couples. However, our review reinforces that central obesity—measured by WC—is related to infertility outcomes.[16,17,19,22] However, these studies have some limitations. They all included only women, without considering the male part[19] for example, and the small number of participants included in the sample[16,17].

In fact, central obesity leads to insulin resistance and increases the sensitivity of gonadotroph cells to gonadotropin-releasing hormone[34] and modulation of the bioavailability of sex steroid by inhibiting sex hormone-binding globulin (SHBG) synthesis.[35] In women, lower levels of SHBG are associated with an increase in circulating-free testosterone, which leads to hyperandrogenism.[35,36] In turn, hyperandrogenism impairs follicular development and ovulation.

Since early embryonic development mainly depends on the oocyte, poor oocyte quality can be expected to affect embryo development, leading to a reduced implantation potential.[18] According to Hansen et al.,[22] among women with a higher WC, there may be a subgroup of women with obesity with subtle menstrual cycle abnormalities and assisted reproduction treatments can overcome these barriers reaching implantation, but metabolic abnormalities can interfere with the continuity of pregnancy, resulting in lower pregnancy rates.[37] Also, a retrospective cohort study of infertile Asian women with PCOS found that those with metabolic syndrome had significantly more ovulatory dysfunction and tubal factor infertility than those without metabolic syndrome.[38] In men, overweight and obesity were associated with reduced total sperm count and concentration and lower serum testosterone compared to normal weight men.[39]

Body composition measurements can differentiate fat and free-fat mass. Foucaut et al.[40] evaluate the association of body composition by bioelectrical impedance, sedentary behavior, and physical inactivity in infertile men and women. Sedentary behavior and fat-free mass were not related to infertility in men. However women with sedentary behavior and body fat and fat-free mass over and under reference values for their age, respectively, were associated with an increased risk of infertility. A previous study—evaluating body composition by DXA—also showed that infertile women of normal weight, with PCOS, and primary amenorrhea showed an extraordinarily high amount of fat tissue and a tendency toward android fat pattern.[41] Notably, no study evaluated body composition by DXA before ART among the included studies even though this method remains the standard to evaluate body compartments.

Body composition has a close relation with nutrition and physical activity. Most of the included studies have no description of lifestyle variables that could influence body composition and ART outcomes. Thus, nutritional information, physical exercise, infertility diagnosis, and inflammatory markers, which reflect on body composition and outcomes, may interfere with the outcomes and can be confounding factors in these group of patients. Although the results of our study remain incomplete due to lack of data, it seems reasonable to suggest that body composition can affect a couple's fecundity or fertility, and different body compartments can negatively affect and mitigate the results of assisted reproductive technologies. Furthermore, besides ART outcomes, couples should be encouraged to follow a healthy lifestyle and achieve a healthy body weight.[10,11]

5. Conclusion:

In conclusion, high adiposity, especially central fat distribution, seems to negatively affect ART outcomes according to the available studies included in this scoping review. Trials evaluating the effect of body compartments (fat and fat-free mass) in reproductive outcomes of patients subjected to assisted reproductive techniques need to be conducted.

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Authors contribution

All the authors contributed to the study conception and design. Material preparation, data collection and analysis were performed by Caroline de Oliveira Martini, Manoela Teixeira da Silva, Eduardo Pandolfi Passos, Luciana Verçoza Viana. The first draft of the manuscript was written by Caroline de Oliveira Martini and Manoela Teixeira da Silva, all the authors commented on previous versions of the manuscript. All authors read and approved the final manuscript. Idea for the article: Luciana Verçoza Viana, Literature search and data analysis: Caroline de Oliveira Martini and Manoela Teixeira da Silva, Revised the work: Luciana Verçoza Viana and Eduardo Pandolfi Passos.