

Review article/Pregledni znanstveni članek

The effects of increased body mass index on preconception health: A scoping literature review

Vpliv povišanega indeksa telesne mase na predkonceptijsko zdravje: pregled literature

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Key words: increased body weight; preconception period; family planning; fertility; health promotion

Ključne besede: povišana telesna teža; prednosečnostno obdobje; načrtovanje družine; plodnost; promocija zdravja

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ABSTRACT

Introduction: The growing proportion of overweight and obese people worldwide is of great concern as it affects the overall health of people and consequently also their reproductive health. The aim of this literature review is to examine how increased body mass index affects fertility and preconception health in men and women.

Methods: A scoping literature review was conducted in February 2021 using PubMed and Medline databases, as well as the Google Scholar search engine. Inclusion criteria consisted of scientific literature, regardless of methodology, and articles published in Slovene and English.

Results: The literature search yielded 9 reviews and 5 original quantitative studies published in English in the last 15 years. The results suggest that there is compelling evidence that obese individuals are at increased risk of various health problems in the pre-conception period that may affect their fertility and ability to conceive.

Discussion and conclusion: The rising prevalence of high body mass index is changing the reproductive health of men and women. Growing obesity rates, particularly in the Western world, call for greater awareness of this metabolic syndrome and its impact on female and male reproduction. Health professionals working with couples in the pre-conception period should have sufficient knowledge to address the impact of high body mass index on reproductive health and promote a healthy lifestyle.

IZVLEČEK

Uvod: Naraščajoča stopnja prekomerne telesne mase in debelosti po vsem svetu ovira zdravje moških in žensk ter posledično vpliva na njihovo reproduktivno zdravje. Namen tega pregleda literature je raziskati, kako povečan indeks telesne mase vpliva na plodnost in zdravje moških in žensk pred spočetjem.

Metode: Opravljen je bil pregled literature. Iskanje literature je potekalo februarja 2021 v podatkovnih bazah PubMed in Medline. Drugi iskalni zadetki so bili najdeni s pomočjo Google Učenjaka. Vključitveni kriteriji so zajemali znanstveno literaturo, ne glede na metodološki pristop, v slovenskem in angleškem jeziku.

Rezultati: V pregled literature je bilo vključenih devet preglednih in pet izvirnih člankov kvantitativne metodologije. Ugotovitve raziskav kažejo, da imajo posamezniki s povišano telesno težo v predkonceptijskem obdobju večje tveganje za številne zdravstvene težave, ki lahko vplivajo na njihovo plodnost in sposobnost zanositve.

Diskusija in zaključek: Povišanje indeksa telesne mase vpliva na reproduktivno zdravje moških in žensk. Naraščajoča stopnja debelosti predvsem v zahodnem svetu zahteva večjo ozaveščenost o tem presnovnem sindromu in njegovem vplivu na reprodukcijo žensk in moških. Zdravstveni delavci, ki delajo s pari s prekomerno telesno maso v obdobju pred spočetjem, morajo imeti ustrezno znanje za njihovo obravnavo ter spodbujati zdrav način življenja.



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Introduction

The global population is experiencing increased levels of overweight and obesity. This was first observed in Western countries, but now also affects other middle- and low-income countries (World Health Organization [WHO], 2021). Slovenia is no exception. It is estimated that in 2016, 1.9 billion adults were overweight and 650 million of them were obese (WHO, 2021). The Centers for Disease Control and Prevention (CDC, 2022) reported that in the last 20 years the prevalence of obesity in the United States has increased by over 10% (CDC, 2022). Rising levels of body mass index (BMI) are strongly associated with multiple risk factors that affect health, such as heart disease, stroke, type 2 diabetes and certain forms of cancer (CDC, 2022; Imterat, Agarwal, Esteves, Meyer, & Harlev, 2019; Stephenson et al., 2018).

As obesity is becoming a major global health problem, many risk factors associated with an elevated BMI also affect pregnant women, childbirth and/or the foetus/baby and should therefore be addressed before pregnancy. According to the Healthy Eating Index (HEI) (Tsigga, Filis, Hatzopoulou, Kotzamanidis, & Grammatikopoulou 2011), this could be due to the fact that women with a higher pre-pregnancy BMI have poorer diet quality during pregnancy. On the other hand, pregnancy is also the time when women are highly motivated to make healthy dietary and lifestyle changes (Lindqvist, Lindkvist, Eurenus, Persson, & Mogren, 2017), and it should therefore be used to promote healthy habits.

The nutritional status of adults can be measured with a predictive calculation tool, namely the body mass index (BMI). Although the calculation of BMI varies from country to country, in Slovenia it is calculated by dividing the person's weight (in kilograms) by the square of their height (in metres). According to the World Health Organization (WHO, 2019), it can be used for adults over 20 years of age and is divided into the categories listed in Table 1.

Obesity in pregnancy increases the risk of various health complications, such as gestational

hypertension, pre-eclampsia, and gestational diabetes (Poston, Harthoorn, & van der Beek, 2011). It also elevates the risk of induction of labour and prolonged labour (NICE, 2023), Caesarean section, postpartum haemorrhage, postpartum infections, and preterm birth (Creanga, Catalano, & Bateman, 2022). Obese women are more likely to suffer from depression and anxiety during pregnancy and after delivery (Dachew, Ayano, Betts, & Alati, 2021). In addition, as babies born to obese mothers are more likely to suffer from congenital anomalies, obesity affects the developing foetus and newborn. They often have macrosomia or are large for gestational age, which can lead to shoulder dystocia and other labour complications and potential morbidities for both mother and baby (Creanga, Catalano, & Bateman, 2022).

As far as we know, many studies and textbooks address the effects of obesity on pregnancy, delivery and the postpartum period. However, not much attention has been paid to maintaining a healthy body weight before planning pregnancy.

Aims and objectives

The aim of this literature review was to investigate how increased BMI affects preconception health and fertility in men and women.

Methods

A scoping review was conducted. According to Munn et al. (2018), scoping reviews present a relatively new form of literature review and should be used when identifying or discussing specific concepts and characteristics of articles or studies.

Review methods

The literature was searched in PubMed and Medline databases in February 2021. The search strategy also included a search in Google Scholar. We searched for articles published in Slovene and English in the last fifteen years using the following search terms including Boolean operators: *(BMI OR body mass index OR overweight OR obese) AND (preconception OR fertility) AND (health OR effect on health)*.

Results of the review

Our search results were screened using the Prisma flow diagram (Page et al., 2020), which initially yielded 2,252 records. In the first step of study identification and selection (Figure 1), duplicates and ineligible studies were excluded, resulting in 536 studies. All remaining studies were screened by title and aim. In total, 38 studies were eligible for full-text screening against the inclusion and exclusion criteria. Of these, 14 studies were selected and included in this review.

Table 1: *Body mass index classification (WHO, 2019)*
Tabela 1: *Klasifikacija indeksa telesne mase (WHO, 2019)*

<i>BMI/ ITM</i>	<i>Nutritional status/ Prehranski status</i>
Below 18.5	Underweight
18.5–24.9	Normal weight
25.0–29.9	Pre-obesity
30.0–34.9	Obesity class I
35.0–39.9	Obesity class II
Above 40	Obesity class III

Legend/Legenda: BMI – body mass index / indeks telesne mase

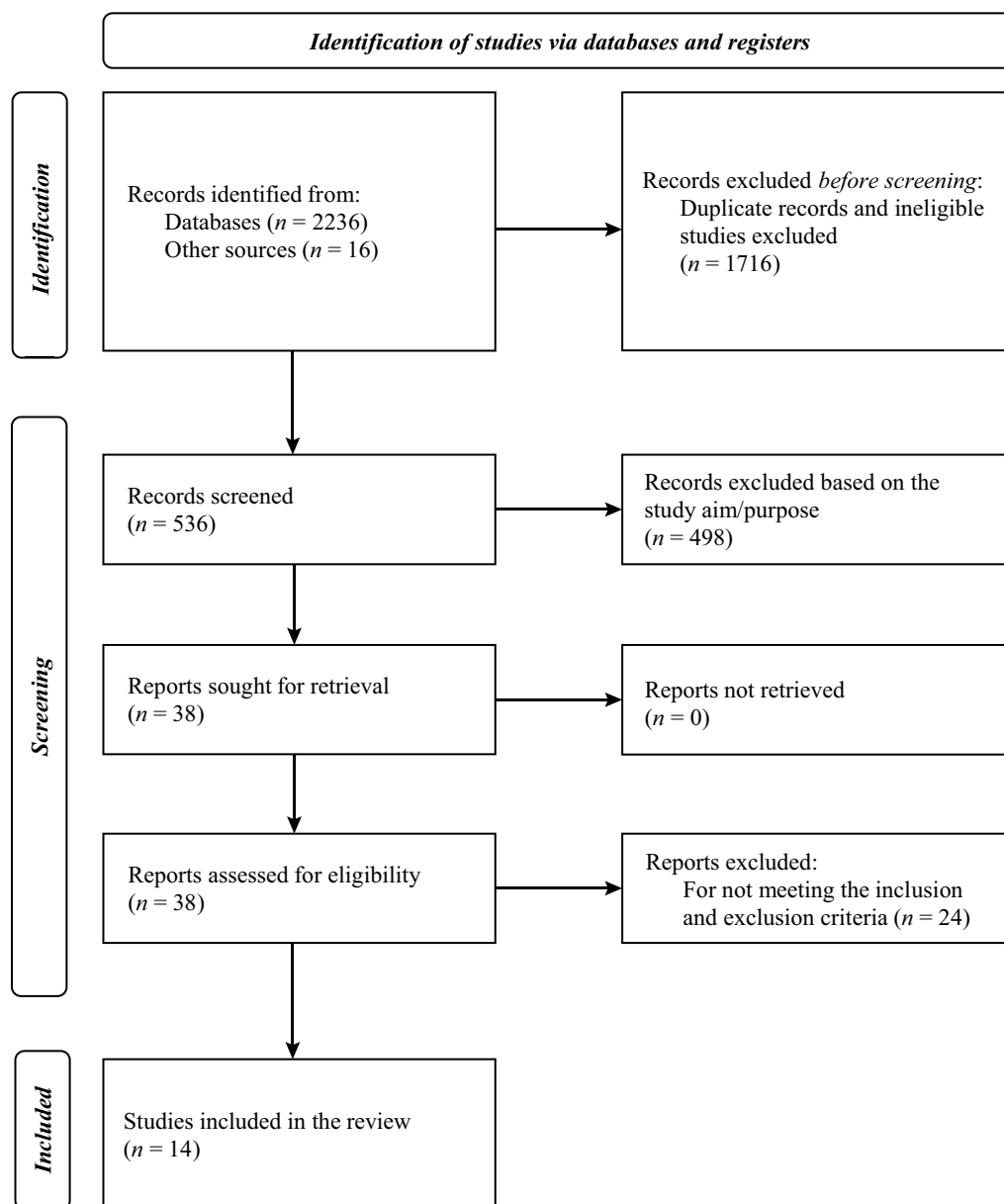


Figure 1: PRISMA flow chart diagram (Page et al.,2020)

Slika 1: PRISMA diagram poteka (Page et al.,2020)

Quality assessment of the review and description of data processing

Articles included in this review were published in peer-reviewed international journals and quality assessed using the Critical Appraisal Skills Programme (CASP) instrument (CASP, 2020). Review articles were screened using the CASP systematic review checklist, and other studies were screened using the CASP cohort study checklist. All studies included in this review were considered eligible. As this was a scoping review that included different types of study design, the results are reported thematically.

Results

Our literature search identified 9 review articles and 5 original research articles, the main characteristics of which are presented in Table 3. Results were extracted for overweight and obese women and men. The combination of an unhealthy diet and an increasingly sedentary lifestyle in the Western world has led to a growing number of obese people, which also applies to women and men in the preconception period (Du Plessis, Cabler, McAlister, Sabanegh, & Agarwal, 2010; Çekici, 2018).

Table 2: Inclusion and exclusion criteria**Tabela 2: Vključitveni in izključitveni kriteriji**

<i>Inclusion criteria/Vključitveni kriteriji</i>	<i>Exclusion criteria/Izključitveni kriteriji</i>
Type of studies: original and review articles	/
Studies published between 2006 and 2020	Studies published before 2006
Scientific articles	Other professional articles
Language of publication: English, Slovene	Other languages
Studies investigating or reviewing the impact of increased BMI on preconception health	Studies investigating the impact of BMI on other periods of reproductive age.

Table 3: Characteristics of studies included in the review**Tabela 3: Značilnosti študij vključenih v pregled literature**

<i>Authors, year, country/ Avtorji, leto, država</i>	<i>Research design/ Raziskovalni dizajn</i>	<i>Aim/ Namen</i>	<i>Main results/ Glavni rezultati</i>
Anifandis, Dafopoulos., Messini, Polyzos, & Messinis, 2013 Greece	Retrospective study, quantitative design	The primary aim of this study was to investigate the correlation between men's BMI and their sperm parameters (volume, concentration and motility) and to determine whether or not it affects embryo quality and IVF outcome. Its secondary aim was to investigate the influence of BMI of both men and women in combination with their age on IVF outcomes.	The overall ($n = 301$) BMI and age of men did not correlate with their sperm parameters. Group 1 and group 4 had the highest embryo quality and consequently the highest percentage of pregnancies regardless of the BMI of their partners. The BMI of men did not correlate with their sperm parameters, but did affect the quality of the embryos produced in a way that influenced the pregnancy rate.
Çekici, 2018 Turkey	Literature review	To outline various dietary factors affecting fertility or infertility in women and men.	The review article presents various dietary intakes affecting fertility or infertility in men and women.
Chambers & Anderson, 2015 UK	Literature review	To examine the factors of obesity that have an impact on male fertility.	It is important to emphasise that fertility is a complex, multifactorial process. Obesity affects male fertility through several mechanisms, including obesity-associated hypogonadism, its effects on sperm production and function, and its atherogenic effects on the peripheral vasculature, which may also cause erectile dysfunction. The article discusses the transgenerational impact of paternal obesity.
Du Plessis et al., 2010 South Africa & USA	Literature review	To present the effect of obesity on sperm disorders and male infertility, and provide an overview of the potential mechanisms and possible treatment options.	Population-based studies conducted over the past 5–10 years have indicated an increased likelihood of abnormal sperm parameters in overweight and obese men, and a potentially increased likelihood of subfertility in couples with an obese male partner. Additional characteristics associated with male obesity that could contribute to an increased risk of infertility include altered retention and metabolism of environmental toxins, unhealthy lifestyle factors and sexual dysfunction.
Hajshafiha, Ghareaghaji, Salemi, Sadegh-Asadi, & Sadeghi- Bazargani, 2013 Iran & Sweden	Clinical study, quantitative approach	The aim of this study was to investigate the role of BMI on certain laboratory indicators of male fertility in infertile and fertile men in an Iranian population.	The studied correlation between BMI and certain sex hormones and sperm characteristics, as well as the different patterns of this correlation between fertile and subfertile/infertile men, will contribute to our understanding of the impact of obesity on certain physiological characteristics of male reproduction in fertile and infertile men.

<i>Authors, year, country/ Avtorji, leto, država</i>	<i>Research design/ Raziskovalni dizajn</i>	<i>Aim/ Namen</i>	<i>Main results/ Glavni rezultati</i>
Imterat, Esteves, Meyer, Harlev, & Agarwal, 2019 Israel, Brazil & USA	Literature review	The aim of this study was to review information on the effects of BMI on female fertility and the outcomes of assisted reproductive technology (ART).	Imbalances along the hypothalamus-pituitary-ovarian axis may hinder couples' efforts to conceive. BMI and reproductive physiology are regulated by leptin and oestrogen. Lifestyle changes before and during have a positive impact on fertility.
Kort et al., 2006 USA	Clinical study, quantitative approach	The aim of the study was to determine the relationship between BMI and sperm parameters, including its chromatin integrity.	Men whose BMI is higher than 25 kg/m ² have fewer chromatin-intact normal-motile sperm cells per ejaculate. Patients may thus be advised to reduce their body weight so as to ensure maximum fertility potential.
Lash & Armstrong, 2009 USA	Literature review	The aim of the study was to review the effects of obesity on women's reproductive health and fertility.	Obesity is associated with early puberty, irregular menstrual patterns, reduced contraceptive effectiveness, ovulatory disorders, higher rates of miscarriage, and poorer outcomes of assisted reproductive technology. Many of these problems can be alleviated through weight loss.
Palmer, Bakos, Fullston, & Lane, 2012 Australia	Literature review	This review study focuses on the impact of male obesity on fertility and sperm quality, focusing on the proposed mechanisms and potential reversibility of these negative effects.	Over the last 30 years, obesity among men of reproductive age has almost tripled, coinciding with a global escalation in male infertility. Recent studies show that male obesity reduces sperm quality, and more importantly, alters the physical and molecular structure of germ cells in the testes and mature sperm, negatively impacting male reproductive potential. Obesity in men has also been shown to affect the metabolic and reproductive health of offspring, suggesting that paternal health traits are passed on to the next generation with the mediator likely being sperm.
Pandey, Pandey, Maheshwari, & Bhattacharya, 2010 UK	Literature review	To examine the effects of obesity on fertility and fertility treatment outcomes.	Obesity in women has implications for fertility and fertility treatment. A higher BMI lowers the likelihood of conception in ovulating women and negatively affects the results of ovulation induction treatments. Obese women undergoing IVF treatment require higher doses of gonadotropins, have less success in ovarian stimulation and fewer oocytes are harvested. Obesity is also associated with lower fertilisation rates, poorer quality embryos and a higher likelihood of miscarriage. While weight loss does improve women's reproductive outcomes, it must be gradual and consistent in order to be effective.
Sallmén, Sandler, Hoppin, Blair, & Baird, 2006 Finland	Retrospective study, quantitative approach	To investigate the association between male BMI and couple infertility in men participating in the Agricultural Health Study, a study conducted on male pesticide applicators and their partners.	Restriction of data to couples with the highest-quality infertility data showed a dose-response correlation, as well as a stronger effect of BMI. The correlation between BMI and infertility was similar in older and younger men, indicating that erectile dysfunction in older men does not account for the correlation.

<i>Authors, year, country/ Avtorji, leto, država</i>	<i>Research design/ Raziskovalni dizajn</i>	<i>Aim/ Namen</i>	<i>Main results/ Glavni rezultati</i>
Moussa, Alrais, Leon, & Abbas, Sibai, 2016 USA	Literature review	This literature review examines the impact of obesity on lives of women, describing complications from preconception to the postpartum period.	Increased BMI is correlated with poorer perinatal outcomes, including increased rates of gestational diabetes, pre-eclampsia (and other hypertension disorders), macrosomia, and neonatal morbidities. Isolated maternal obesity and maternal diabetes predispose the infant to potential diseases in adulthood through foetal programming.
Souter, Baltagi, Kuleta, Meeker, & Petrozza, 2011 USA	Retrospective study	To examine the fertility of overweight and obese infertile women undergoing gonadotropins treatment and intrauterine insemination (IUI).	While women with obesity need higher doses of medication and produce fewer follicles per dose, after adjustment for medication and response to overcome the weight effect, the success of the treatment cycle is comparable to that of normal weight women.
Zain & Norman, 2008 Australia & Malaysia	Literature review	To examine the impact of obesity on female fertility and fertility treatments.	This review article presents various factors of obesity that affect female fertility and fertility treatments.

Legend/Legenda: n – number/število; BMI – body mass index/indeks telesne mase; kg – kilogram/kilogram; m² – square meter/kvadratni meter; ART – assisted reproductive technology/asistirane reproduktivne tehnike; IVF – in vitro fertilization/in vitro fertilizacija; USA – United States of America/Združene države Amerike; UK – United Kingdom/Združeno Kraljevstvo

Overweight and obesity in women

Overweight and obesity may lead to several problems that affect preconception health and possibly women's ability to conceive. These include changes in the menstrual cycle, reduced effectiveness of contraceptive methods, reduced fertility, and reduced effectiveness of fertility treatments and assisted reproduction.

The pathophysiology of obesity leads to changes in metabolic and hormonal factors influencing obesity phenotypes (Zain & Norman, 2008). In obese girls, puberty usually begins at an earlier age. Girls who experience earlier sexual development may have psychosocial problems. In the physical sense, hormonal imbalances caused by obesity may disrupt the menstrual cycle and manifest in dysfunctional uterine bleeding (Lash & Armstrong, 2009; Souter, Baltagi, Kuleta, Meeker, & Petrozza, 2011).

In addition, steroid contraceptive methods such as oral contraceptive pills and progestin-only pills have been shown to be less effective in obese women. This reduced effectiveness of steroid contraceptives is mainly due to changes in steroid metabolism and distribution in obese women. As obese women are also at increased risk of thrombosis, they should be warned that this risk is even greater when taking oral contraceptives (Lash & Armstrong, 2009).

Studies show that, due to anovulation and subfecundity, obesity reduces fertility rates and prolongs the time to conception (Imterat et al., 2019; Lash & Armstrong, 2009; Pandey, Pandey, Maheshwari, & Bhattacharya, 2010). As obese women are often hyper-insulinemic, they are at increased risk

for an endocrine profile characteristic of polycystic ovarian syndrome (PCOS) (Imterat et al., 2019; Lash & Armstrong, 2009; Zain & Norman, 2008). PCOS is a heterogeneous condition characterised by alteration of the menstrual cycle, oligo- or anovulation and even hyperandrogenism (Pandey et al., 2010; Moussa, Alrais, Leon, Abbas, & Sibai, 2016). Obese women also face increased rates of infertility due to anovulation and hormonal changes alone (Imterat et al., 2019; Lash & Armstrong, 2009). Imterat et al. (2019) reported that obese women were found to have lower oocyte quality compared to normal weight women.

A high BMI also affects the ability to conceive using assisted reproduction techniques (ART). The higher a woman's BMI, the lower her chance of conceiving with ART (Lash & Armstrong, 2009). Women struggling with obesity and seeking fertility treatment should seriously consider weight loss, as this has a positive impact on ART techniques (Lash & Armstrong, 2009).

Overweight and obesity in men

Evidence suggests that male obesity also has a negative effect on the reproductive process. In addition, increased BMI in the male partner has been shown to prolong the time to conception, even when the female partner's BMI is within the normal range (Palmer, Bakos, Fullston, & Lane, 2012). Obesity in men is strongly associated with hypogonadism (Chambers & Anderson, 2015) and infertility (Sallmen et al., 2006). This is partly due to reduced sperm quality and sperm concentration, as well as altered physical and molecular structure of germ cells in the testes and

later mature sperm (Du Plessis et al., 2010; Hajshafiha, Ghareaghaji, Salemi, Sadegh-Asadi, & Sadeghi-Bazargani, 2013; Kort et al., 2006; Palmer et al., 2012). The altered hypothalamic-pituitary-gonadal axis in obesity deregulates the process of spermatogenesis itself. Obese men experience hormonal imbalances due to the elevated levels of white adipose tissue, which causes increased conversion of androgen hormones to oestrogens.

Another hormone produced by white adipose tissue is leptin, which plays an important role in regulating energy intake. In simple terms, the increased production of leptin significantly reduces the production of testosterone. Moreover, due to adiposity of scrotal tissue, obese men experience increased temperature in the gonads, which affects the process of spermatogenesis, which is very sensitive to increased heat (Chambers & Anderson, 2015; Du Plessis et al., 2010; Palmer et al., 2012). Research also shows that increased male BMI affects the quality of embryos produced during in vitro fertilisation (IVF), resulting in lower pregnancy rates (Anifandis et al., 2013).

Discussion

Although preconception care has been largely neglected in the past, there is a growing body of research stressing the importance of a healthy lifestyle in the preconception period (Stephenson et al., 2018). Not only can this influence an individual's future reproduction, but it can also have consequences that may affect future generations (Stephenson et al., 2018). This scoping review provides evidence from several studies highlighting multiple negative effects of increased BMI for women and men in the preconception period. Overweight or obese women often experience changes in their menstrual cycle (Souter et al., 2011). Obese girls are more prone to early puberty (Souter et al., 2011), and earlier sexual development may in turn lead to psychosocial distress. Given the increasing number of overweight and obese children (WHO, 2021), it is reasonable to assume that menarche and other signs of puberty will continue to occur earlier. Changes in the menstrual cycle (Lash & Armstrong, 2009; Souter et al., 2011), combined with reduced fertility rates due to anovulation, subfecundity and spontaneous abortion (Imterat et al., 2019; Lash & Armstrong, 2009), reduce women's chances of becoming pregnant. In view of increasing obesity among women, the number of infertile or subfertile women is expected to continue to rise. In the context of family planning methods, particular attention needs to be paid to obese women, as contraceptives are less effective for this group (Lash & Armstrong, 2009).

It must be emphasised that increased BMI also affects men's reproductive health, leading to negative consequences such as hypogonadism (Chambers &

Anderson, 2015) and infertility (Sallmen et al., 2006) due to lower sperm quality (Du Plessis et al., 2010; Hajshafiha et al., 2013; Palmer et al., 2012), changes in spermatogenesis, hormonal imbalance and increased heat in the gonads (Chambers & Anderson, 2015; Du Plessis et al., 2010; Palmer et al., 2012). It should not be underestimated that male obesity has negative effects on the metabolic and reproductive health of offspring (Chambers & Anderson, 2015; Palmer et al., 2012). This has been confirmed by the Lancet series which shows that the preconception nutritional status of parents can have a negative impact on the risk of future children for cardiovascular, immunological, neurological and metabolic morbidity (Barker et al., 2018; Fleming et al., 2018).

This scoping literature review sheds light on the importance of recognising the impact of increased body weight on preconception and subsequent health. This review could be structured in a more systematic manner. In terms of public health awareness, there is a need for a greater focus on the preconception period to improve the future health of mothers, fathers and their children. In the past, the preconception period has been of interest for family planning only in terms of preventing unwanted pregnancies and sexually transmitted infections. However, given the alarming trend of declining fertility rates among men and women around the world, we need to raise awareness and address the question of how to preserve the fertility of the population without delay. Health professionals, especially midwives and nurses, should emphasise the importance of the preconception health in a broader context to support preventive efforts related to maintaining a healthy body weight in the population. As suggested by Bizjak, Peršolja, & Zadnik Stirn (2016), nutrition counselling should be established at the primary care level, where individuals can access nutritional treatment.

Conclusion

It is evident that increased BMI levels have both short and long-term consequences for health, including in the preconception period. For this reason, health professionals should encourage both the young and adult population to maintain a healthy body weight. They should also provide appropriate methods for counselling overweight or obese individuals.

Preventive programmes promoting the maintenance of normal body weight should focus on healthy lifestyle habits, including healthy nutrition and regular physical activity. It is crucial that health professionals advocate for a healthy lifestyle and address the negative consequences of obesity, also in terms of future reproduction. Further research should focus on the factors associated with the effects of increased BMI on pregnancy, childbirth and the newborn baby.

Conflict of interest/Nasprotje interesov

The authors declare no conflict of interest./Avtorji izjavljajo, da ni nasprotja interesov.

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Ethical approval/Etika raziskovanja

This review was prepared in accordance with the Helsinki-Tokyo declaration (World Medical Association, 2013) and the Code of Ethics for Midwives in Slovenia (2014)./Pregled literature je bil pripravljen v skladu z načeli Helsinško-tokijske deklaracije (World Medical Association, 2013) in Kodeksa etike za babice Slovenije (2014).

Author contributions/Prispevek avtorjev

The first author conceptualised the study and conducted the literature search. The second and third authors reported on the results and interpreted them in the discussion section./Prva avtorica je zasnovala pregled literature in opravila iskanje literature. K temu sta se pridružila drugi avtor oziroma tretja avtorica, ki sta sodelovala pri poročanju rezultatov in v diskusiji.

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