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# The relationship between depression, stress, anxiety, and postpartum weight retention: A systematic review

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## Abstract:

Postpartum weight retention (PPWR) is a factor that causes permanent obesity and subsequent chronic and noncommunicable diseases. The relationship between depression/stress/anxiety and PPWR has been studied in some articles, but there is no definitive conclusion in this regard. The present systematic review was conducted to investigate the relationship between depression/stress/anxiety and PPWR. An extensive search was performed in the PubMed, Scopus, Embase, Web of Science, Google Scholar, SID, and Magiran, Irandoc databases using Medical Subject Headings terms (or their Persian synonyms) from 2000 to 2020. Inclusion and exclusion criteria were used for articles selection. The quality of the selected articles was assessed using the Newcastle–Ottawa Scale. Out of 371 reviewed articles, 24 articles were selected. The total sample size was 51,613 (range: 49–37,127). The mean of PPWR ranged from 0.5 kg (standard deviation [SD] = 6.49) to 6.4 kg (SD = 8.5). There was a statistically significant relationship between depression/stress/anxiety and PPWR in 12 of 23, 4 of 6, and 3 of 8 studies. This review demonstrates the relationship between depression/stress/anxiety and PPWR. Time of depression/stress/anxiety assessment is an important issue, as well as different measurement tools. Prevention of the mothers' psychological problems through educational and supportive programs may help to limit PPWR.

## Keywords:

Anxiety, depression, depression postpartum, gestational weight gain, postpartum weight retention, stress psychological

## Introduction

Postpartum weight retention (PPWR) is defined as a difference between weight at some time after delivery and prepregnancy weight.<sup>[1,2]</sup> It has been suggested as a factor that causes permanent obesity and subsequent chronic and noncommunicable diseases.<sup>[3]</sup> Therefore, it can be a health problem for women of childbearing age. A systematic review showed that two-third of women 6 months postpartum were weight more than before pregnancy.<sup>[4]</sup> In the United Kingdom, 73% of women were overweight compared to before pregnancy,<sup>[5]</sup> as well as 75% in the United States.<sup>[6]</sup>

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Psychological factors can affect PPWR influencing maternal behaviors such as physical activity, diet quality, and breastfeeding behavior.<sup>[7]</sup> Poor mental health is likely to negatively affect women's ability to engage in healthy lifestyle behaviors that reduce PPWR.<sup>[8]</sup> Depression and anxiety during pregnancy and postpartum can lead to weight gain.<sup>[9]</sup> New-onset postpartum depression is associated with more than doubling the risk of retaining at least 5 kg.<sup>[10]</sup> Stress can be a barrier for postpartum weight loss by contributing to hormonal changes that increase obesity and behaviors such as overeating.<sup>[11]</sup> Conversely, 0.1 kg of weight loss was reported for each unit increase in stress score.<sup>[12]</sup>

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In a systematic review, the associations between depression/anxiety/body image and weight status 1 year after delivery were examined.<sup>[13]</sup> Another review has investigated the impact of sleep/stress/depression on PPWR.<sup>[14]</sup> The associations between anxiety and pregnancy obesity, excessive gestational weight gain, and PPWR were studied in another one.<sup>[15]</sup> Previous reviews<sup>[13-15]</sup> have some limitations, such as considering a time limitation for postpartum weight measurement as inclusion criteria and evaluation of only English-language articles. Furthermore, none of the previous systematic reviews evaluated the relationship between depression/stress/anxiety and PPWR at the same time. Several valuable studies have been conducted after these reviews.<sup>[9,12,16-18]</sup>

Given the importance of complications caused by PPWR, it is necessary to find the relationship between psychological factors and PPWR, which helps to design prevention programs of psychological problems during and after pregnancy to limit PPWR. The relationship between depression/stress/anxiety and PPWR has been studied in some articles, but there is no definitive conclusion in this regard. Conducting a systematic review investigating depression/stress/anxiety at the same time leads to achieve an overview of the relationship between these essential psychological factors and PPWR, cover the previous reviews gaps, and identify the latest definitive results. Therefore, the present systematic review, which includes Persian-language articles for the first time based on our extensive search, was designed to investigate the relationship between depression/stress/anxiety and PPWR.

## Materials and Methods

This systematic review was reported based on the Preferred Reporting Items for Systematic Reviews and Meta-Analyses statement.<sup>[19]</sup>

### Study design and search strategy

This systematic review was designed based on the PICO; Population: The population of postpartum women, Intervention: Depression/stress/anxiety, Comparison: Absence of depression/stress/anxiety, and Outcome: PPWR. To access all published articles in English and Persian, an extensive search was performed in the PubMed, Scopus, Embase, Web of Science, Google Scholar, SID, Magiran, Irandoc databases using an appropriate combination of keywords from the Medical Subject Headings related to: "Postpartum Weight Retention;" "Depression;" "Depression, Postpartum;" "Anxiety;" and "Stress, Psychological" (or the Persian equivalent) from 2000 until the end of June 2020 by two researchers

### Box 1: An example of PubMed search query

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((("Gestational Weight Gain"[Mesh] OR "Weight Gain, Gestational"[tiab] OR "Maternal Weight Gain"[tiab] OR "Weight Gain, Maternal"[tiab] OR "Pregnancy Weight Gain"[tiab] OR "Weight Gain, Pregnancy"[tiab] OR "Postpartum Weight Retention"[tiab] OR "Weight Retention, Postpartum"[tiab]) AND (("Anxiety"[Mesh] OR "Hypervigilance"[tiab] OR "Nervousness"[tiab] OR "Social Anxiety"[tiab] OR "Anxieties, Social"[tiab] OR "Anxiety, Social"[tiab] OR "Social Anxieties"[tiab])))
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separately. Furthermore, ProQuest was searched and references of articles were reviewed. Box 1 presents an example of the PubMed search query.

### Selection criteria

English and Persian observational articles (cohort study, cross-sectional, case-control) that examined the relationship between depression/anxiety/stress and PPWR in 2000-2020 were included. Articles were excluded if they were not using prepregnancy/early pregnancy weight for calculating PPWR.

### Data extraction

Two reviewers independently searched the databases. After removing duplication, the title and abstract of the articles were assessed in terms of inclusion and exclusion criteria. Then, the full text of the articles was reviewed, ensuring relevancy. Hence, the irrelevant articles, duplicate articles, and conference abstracts without sufficient evidence, such as presentations, were removed.

### Quality assessment

To avoid bias, two reviewers independently evaluated the quality of the included articles using the Newcastle–Ottawa Scale to evaluate the quality of nonrandomized studies (Newcastle–Ottawa Cohort Scale version and modified version of it for cross-sectional studies).<sup>[20,21]</sup>

According to the Newcastle–Ottawa Cohort Scale, the minimum score is 0, and the maximum is 9. Articles with a score of 6 or higher were considered low risk and good quality, and those with a score of <6 were considered high risk and low quality. This scale examines all stages of the study, including sample selection, comparison of the two groups, and outcomes.<sup>[21]</sup>

An appropriate follow-up period for the outcome is considered 6 months or more in cohort studies. One score is considered for articles with follow-up failure rates up to 25%.<sup>[22]</sup> Based on the Newcastle–Ottawa Scale adjusted for cross-sectional studies, articles with a score of <4 are considered low quality (ranged 0–10).<sup>[20,23]</sup> Disagreements between the two reviewers were resolved by discussion with the third researcher.

## Results

Out of 371 nonduplicate reviewed articles, 24 articles were selected<sup>[2,9,10,12,16-18,24-40]</sup> [Figure 1]. The characteristics of the included studies are presented in Table 1. The total sample size was 51,613 (ranging from 49 to 37,127). All of the 24 selected studies had good quality with a low risk of bias [Supplementary Tables 1 and 2]. PPWR was reported as a difference between pre/early pregnancy weight and postpartum weight at different times from 1 month<sup>[33]</sup> to 18 months<sup>[29]</sup> postpartum.

The mean PPWR was variable, ranged from 0.5 kg (standard deviation [SD] = 6.49)<sup>[16]</sup> at 12 months postpartum to 6.4 kg (SD = 8.5)<sup>[38]</sup> at the same time. There was considerable variation in the frequency of PPWR, which ranged from 83%<sup>[32]</sup> at 6 months postpartum to 24.1%<sup>[9]</sup> 1 year after delivery.

Most studies have defined substantial PPWR (SPPWR) as a weight retention of  $\geq 5$  kg. SPPWR ranged from 62.6% at 3 months<sup>[31]</sup> to 12.1%<sup>[29]</sup> at 18 months postpartum.

### Depression and postpartum weight retention

A total of 23 articles examined the relationship between depression and PPWR<sup>[2,9,10,12,16-18,24-34,36-40]</sup> [Table 2]. A total of 50,917 participants were studied in these articles.

Out of 23 studies, 12 studies (11 cohorts and one cross sectional) showed a significant relationship between

depression (at different times from pregnancy to 1 year after delivery) and PPWR. All of the cohort studies reported a positive relationship,<sup>[9,10,12,24-27,29,31,38,40]</sup> and the cross-sectional study indicated an inverse relationship between depression and PPWR ( $\beta = -0.10$ ,  $P < 0.01$ ).<sup>[28]</sup>

Three groups were found based on measurement time of the depression: during pregnancy (8 studies), during delivery (1 study), or immediately after delivery (1 study), at some time after delivery (23 studies). The highest number of studies evaluated depression at 6 months postpartum (14 studies). Two studies during pregnancy,<sup>[9,29]</sup> 11 studies after delivery,<sup>[9,10,24-29,31,38,40]</sup> and one study during delivery<sup>[12]</sup> reported a significant relationship between depression and PPWR.

### Stress and postpartum weight retention

Out of 24 selected studies, six studies investigated the relationship between stress and PPWR<sup>[12,16,30,31,35,38]</sup> [Table 3]. A total of 1710 participants were examined in these studies.

Out of the six studies, four studies reported a significant relationship between stress and PPWR.<sup>[12,31,35,38]</sup> Two of them showed a positive relationship,<sup>[31,38]</sup> and two others reported an inverse relationship.<sup>[12,35]</sup> None of the two studies that measured stress during pregnancy reported a significant association.<sup>[16,31]</sup>

One study reported a significant marginal relationship between cortisol slope as a biologic marker of stress and PPWR ( $r^2 = 0.07$ ,  $P = 0.06$ ). When PPWR was considered as a continuous variable, this relationship disappeared.<sup>[35]</sup>

### Anxiety and postpartum weight retention

Out of the 24 selected studies, eight studies examined the relationship between anxiety and PPWR<sup>[9,16,25,26,29-31,36]</sup> [Table 4]. A total of 42,548 participants were examined in these studies. In six studies, anxiety was measured both during pregnancy and after delivery.<sup>[9,16,26,29,31,36]</sup> Out of the eight studies, three studies reported a positive statistically significant relationship between anxiety during pregnancy and PPWR.<sup>[9,26,29]</sup> In one study, a significant relationship was only reported between first-trimester anxiety and SPPWR 1 year after delivery.<sup>[9]</sup> In another one, univariate analysis was reported a significant relationship between anxiety 6 months after delivery and PPWR, but in the final multivariate analysis, this relationship was not reported.<sup>[26]</sup> None of the other studies reported a significant relationship between postpartum anxiety and PPWR.

## Discussion

The present systematic review was conducted to investigate the relationship between depression/stress/

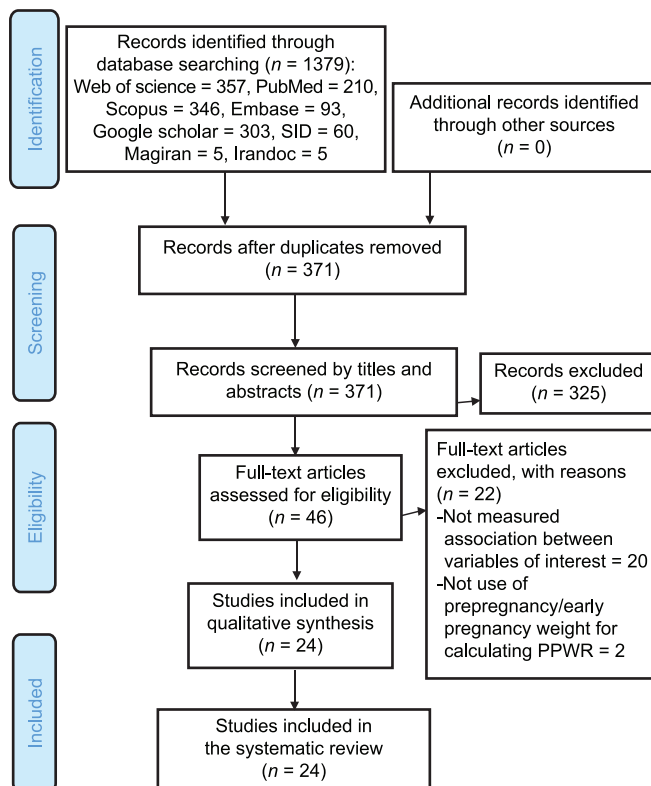


Figure 1: PRISMA flowchart of the present study

**Table 1: The characteristics of the included studies**

Author, year, country	Study design	Sample size	Predictor			Weight measures		Mean PPWR	Quality assessment
			Depression	Stress	Anxiety	Prepregnancy/early pregnancy	Postpartum		
Biesmans et al. (2013) Belgium <sup>[24]</sup>	Prospective cohort	75	✓		✓	S	S and M	12 months (m): 2.3 (SD=2.8) kg	7
Bogaerts et al. (2013) Belgium <sup>[26]</sup>	Prospective cohort	150	✓		✓	S	S	6 months: -1.28 (SD=6.05) (range: -17-19) kg	7
Bogaerts et al. (2017) Belgium <sup>[25]</sup>	Prospective cohort	220	✓			S	S	6 weeks (w): 3.3 (SD=4.1) (range: -7-16.2) kg	6
Collings et al. (2018) Australia <sup>[16]</sup>	Prospective cohort	178	✓	✓	✓	S	S and M	12 months: 0.5 (SD=6.49) kg	8
Ertel et al. (2017) USA <sup>[17]</sup>	Prospective cohort	2112	✓			S	M	6 month: 35% ≥5 kg (mean/SD not reported)	8
Goldstein et al. (2016) USA <sup>[12]</sup>	Prospective cohort	360	✓	✓		S	M	3 month: 4.6 (SD=7.4) kg	7
Gunderson et al. (2008) USA <sup>[27]</sup>	Prospective cohort	940	✓			S	S	12 month: 0.8 (SD=4.5) (range: -17.3-25.5) kg	7
Herring et al. (2008) USA <sup>[10]</sup>	Prospective cohort	850	✓			S	S	12 month: 0.6 (range: -16.4-25.5) kg	7
Huang et al. (2010) Taiwan <sup>[28]</sup>	Cross sectional	602	✓			MR	Not reported	6 month: 2.42 (SD=3.57) kg	9
Oken et al. (2007) USA <sup>[2]</sup>	Prospective cohort	902	✓			S	S	12 month: 0.6 (range: -17.3-25.5) kg	7
Pedersen et al. (2011) Denmark <sup>[29]</sup>	Prospective cohort	37,127	✓		✓	S	S	6 month: 1.4 (SD=4.7) kg 18 month: 0.00 (SD=4.8) kg	7
Phillips et al. (2014) Australia <sup>[30]</sup>	Prospective cohort	126	✓	✓	✓	S	S	9 month: 3.69 (SD=5.04) kg	7
Phillips et al. (2014) Australia <sup>[31]</sup>	Prospective cohort	227	✓	✓	✓	S	S	3 month: 6.10 (SD=5.56) kg	6
Riazi et al. (2017) Iran <sup>[32]</sup>	Cross-sectional	309	✓			MR	M	6 m: 4.04 (SD=3.99) kg	9
Rogers et al. (2016) UK <sup>[18]</sup>	Prospective cohort	49	✓			S	M	12 month: Mean retained BMI=1.5 kg/m <sup>2</sup> (SD=2.4)	8
Salehi-pourmehr et al. (2018) Iran <sup>[9]</sup>	Prospective cohort	307	✓		✓	MR	M	12 m in: Non-depressed: 1.70 (0.35) kg Depressed: 3.86 (0.98) kg Min/mild anxiety: 1.86 (0.36) kg Mod/severe anxiety: 3.88 (1.08) kg	8

Contd...

Table 1: Contd...

Author, year, country	Study design	Sample size	Predictor			Weight measures		Mean PPWR	Quality assessment
			Depression	Stress	Anxiety	Prepregnancy/ early pregnancy	Postpartum		
Sha et al. (2019) China <sup>[33]</sup>	Prospective cohort	924	✓			M	S and M	1 month: 5.91 (SD=4.78) kg 3 month: 4.18 (SD=4.81) kg 6 month: 3.25 (SD=4.64) kg 8 month: 2.24 (SD=4.66) kg	8
Siega-Riz et al. (2010) USA <sup>[34]</sup>	Prospective cohort	550	✓			S	M	3 month: 9.4 (SD±11.4) lb 12 month: 5.7 (SD±13.2) lb	8
Straub et al. (2016) USA <sup>[35]</sup>	Cross-sectional	696		✓		MR	M	6 month: 11.1±18.9 lbs	9
Van poppel et al. (2012) Netherlands <sup>[36]</sup>	Prospective cohort	4213	✓		✓	S	S	3-5 month: 3.56 (SD=4.58) kg	6
Walker (2009) USA <sup>[37]</sup>	Prospective cohort	247	✓			S	M	12 month: 6.2±8.2 kg	8
Wan Noor Fatehah et al. (2019) Malaysia <sup>[38]</sup>	Cross-sectional	226	✓			S	M	6 month: 2.6±5.3 kg	9
Whitaker et al. (2014) USA <sup>[38]</sup>	Prospective cohort	123	✓	✓		S	M	6 month: 5.8 (SD=7.4; range: -12.1-32.9) kg 12 month: 6.4 (SD=8.5; range: -9.7-35.9) kg	8
Zanotti et al. (2015) Brazil <sup>[40]</sup>	Prospective cohort	145	✓			S	M	6 month: 4.8 kg	7

SD=Standard deviation, MR=Medical records, S=Self-reported, S and M=Self-reported and measured, M=Measured

anxiety and PPWR. A total of 24 articles were selected. PPWR was measured at 6 or 12 months postpartum in most of the studies, which is similar to previous reviews.<sup>[41]</sup> The highest mean and the lowest mean of PPWR are similar to the Xiao et al.<sup>[14]</sup> review.

According to the present review, all of the positive relationships between depression and PPWR were found in prospective cohort design studies. It seems that a cohort study plan is more appropriate to measure the effect of psychological factors on overweight, which takes time.

Depression measurement time was different in studies. Most studies have assessed postpartum depression, which is probably why the most number of significant relationships between depression and PPWR are related to this period. The path of depression during and after pregnancy is an important issue in this regard. McCall-Hosenfeld et al. reported that women who suffer from depression during pregnancy remain depressed

or improve slightly during the 1<sup>st</sup> year after delivery. When the onset of depression is during 12 months after the first delivery, they become increasingly depressed.<sup>[42]</sup> The results of a meta-analysis showed that the severity of depression decreased over time.<sup>[43]</sup> These complex relationships make it difficult to determine the right time to measure depression. There should be an appropriate time interval between the onset of depression and the measurement of PPWR. In addition, biological and socioeconomic factors, lifestyle, obstetrical history, and history of mental illness were showed as risk factors for postpartum depression, suggesting to design of prevention programs.<sup>[44]</sup>

In this systematic review, most of the studies reported a significant relationship between stress and PPWR. A previous review reported different results.<sup>[14]</sup> Although studies of that review, which were published before 2000, are not included in the present review, some other reasons can explain this difference. Different times of stress measurement in the studies can be the reason for

**Table 2: Depression and postpartum weight retention**

Author, year	Measurement time	Measurement tool	Findings
Biesmans <i>et al.</i> (2013) <sup>[24]</sup>	3 MPP	EPDS	Positive association ( $P=0.042$ )
Bogaerts <i>et al.</i> <sup>[26]</sup> (2013)	Pregnancy, 6 MPP	EPDS	6 MPP: Association ( $P<0.20$ )
Bogaerts <i>et al.</i> <sup>[25]</sup> (2017)	4, 6 WPP	EPDS	4 WPP: Association ( $P<0.05$ ) Final analysis: NA
Collings <i>et al.</i> (2018) <sup>[16]</sup>	Pregnancy, 12 MPP	EPDS	NA
Ertel <i>et al.</i> (2017) <sup>[17]</sup>	Pregnancy, 6 MPP	EPDS	NA
Goldstein <i>et al.</i> (2016) <sup>[12]</sup>	Delivery, 3 MPP	PHQ2	Delivery: Positive association (0.88, 95% CI: 0.12-1.64, $P=0.02$ )
Gunderson <i>et al.</i> (2008) <sup>[27]</sup>	6 MPP	EPDS	6 MPP and SPPWR: Association (unadjusted OR=1.98, 95%CI: 1.06-3.71, $P=0.03$ ).
Herring <i>et al.</i> (2008) <sup>[10]</sup>	Pregnancy, 6 MPP	EPDS	6 MPP and SPPWR: Association (adjusted OR=2.54, 95%CI: 1.06-6.09) Antenatal: NA
Huang <i>et al.</i> (2010) <sup>[28]</sup>	6 MPP	BDI	Association ( $F=2.16$ , $P=0.001$ )
Oken <i>et al.</i> (2007) <sup>[2]</sup>	6 MPP	EPDS	NA
Pedersen <i>et al.</i> (2011) <sup>[29]</sup>	Pregnancy, 6 MPP	Taken from Symptoms checklist-92	Pregnancy and 6 month PPWR: Association (adjusted OR=1.35; 95% CI, 1.27-1.44, $P<0.01$ ) Pregnancy and 18 month PPWR: Association (adjusted OR=1.34; 95% CI: 1.24-1.45)
Phillips <i>et al.</i> (2014) <sup>[30]</sup>	3, 6 MPP	EPDS	NA
Phillips <i>et al.</i> (2014) <sup>[31]</sup>	Pregnancy, 3 MPP	EPDS	Pregnancy: NA 3 MPP: Positive association ( $r=0.15$ , $P<0.05$ )
Riazi <i>et al.</i> (2017) <sup>[32]</sup>	6 MPP	EPDS	NA
Rogers <i>et al.</i> (2016) <sup>[18]</sup>	1, 6, 12 MPP	EPDS	NA
Salehi-pourmehr <i>et al.</i> (2018) <sup>[9]</sup>	Pregnancy, 6-8 WPP, 12 MPP	EPDS	First trimester and 12 month PPWR: Association (aMD 3.416; 95% CI: 1.392-5.441, $P=0.001$ ) 6-8 WPP and 12 month PPWR: Association (aMD 3.042; 95% CI 0.538-5.547, $P=0.018$ )
Sha <i>et al.</i> (2019) <sup>[33]</sup>	1 MPP	EPDS	NA
Siega-Riz <i>et al.</i> (2010) <sup>[34]</sup>	3, 12 MPP	EPDS	NA
Van poppel <i>et al.</i> (2012) <sup>[36]</sup>	Pregnancy, 3-5 MPP	CES-D	NA
Walker (2009) <sup>[37]</sup>	Postdelivery, 6 WPP	CES-D	NA
	3, 6, 12 MPP		
Wan Noor Fatehah <i>et al.</i> (2019) <sup>[39]</sup>	6 MPP	EPDS	NA
Whitaker <i>et al.</i> (2014) <sup>[38]</sup>	2, 6, 12 MPP	PSI	6 MPP and 6 month PPWR: Positive association ( $t=2.122$ , $P=0.037$ )
Zanotti <i>et al.</i> (2015) <sup>[40]</sup>	1, 3, 6 MPP	BDI	Positive association

MPP=Months postpartum, EPDS=Edinburgh Postnatal Depression Scale, WPP=Weeks postpartum, PSI=Parenting stress index, CES-D=Center for Epidemiological Studies Depression Scale, BDI=Beck depression inventory, PHQ2=Patient Health Questionnaire-2, NA=No association, aMD=Adjusted mean difference

**Table 3: Stress and PPWR**

Author, year	Measurement time	Measurement tool	Findings
Collings <i>et al.</i> (2018) <sup>[16]</sup>	Pregnancy, 12 MPP	DASS-21	NA
Goldstein <i>et al.</i> 2016 <sup>[12]</sup>	Delivery, 3 MPP	PSS	3 MPP: Inverse relationship ( $-0.13$ , 95% CI: $-0.26$ -- $0.01$ , $P=0.04$ )
Phillips <i>et al.</i> (2014) <sup>[30]</sup>	3, 6 MPP	DASS-21	NA
Phillips <i>et al.</i> (2014) <sup>[31]</sup>	Pregnancy, 3 MPP	DASS-21	Pregnancy: NA 3 MPP: Positive association ( $r=0.27$ , $P<0.01$ ) 3 MPP and 3 month PPWR: cross-sectional relationships ( $B=7.41$ , $SEB=3.08$ , $\beta=0.26$ , $P<0.05$ )
Straub <i>et al.</i> 2016 <sup>[35]</sup>	6 MPP	Salivary cortisol slope	Inverse relationship ( $\beta=-1.90$ , 95% CI: 0.22-3.58)
Whitaker <i>et al.</i> 2014 <sup>[38]</sup>	2, 6, 12 MPP	PSI	2 MPP and 6 month PPWR: Inversely correlation ( $r=-0.230$ , $P=0.021$ ) 2 MPP and 12 month PPWR: NC 6 MPP and 6 month PPWR: NC 6 MPP and 12 month PPWR: Positive correlation ( $t=2.015$ , $P=0.048$ ) 12 MPP and 12 month PPWR: NC

DASS=Depression, anxiety, stress scale, PSS=Perceived Stress Scale, NC=Not correlation, MPP=Months postpartum, WPP=Weeks postpartum

**Table 4: Anxiety and postpartum weight retention**

Author, year	Measurement time	Measurement tool	Findings
Bogaerts <i>et al.</i> (2013) <sup>[26]</sup>	Pregnancy, 6 MPP	STAI	First trimester: Association ( $P<0.20$ ) 6 MPP: Association ( $P<0.20$ ) Final analysis: First trimester and 6 month PPWR: Positive predictor ( $\beta=0.255$ ; $P=0.001$ )
Bogaerts <i>et al.</i> (2017) <sup>[25]</sup>	4, 6 WPP	STAI	NA
Collings <i>et al.</i> (2018) <sup>[16]</sup>	Pregnancy, 12 MPP	DASS-21	NA
Pedersen <i>et al.</i> (2011) <sup>[29]</sup>	Pregnancy, 6 MPP	Taken from symptoms checklist-92	Pregnancy and 6 month PPWR: Association (adjusted OR=1.35; 95% CI, 1.27-1.44), $P<0.01$ ) Pregnancy and 18 month PPWR: Association (adjusted OR=1.34; 95% CI, 1.24-1.45)
Phillips <i>et al.</i> (2014) <sup>[30]</sup>	3, 6 MPP	DASS-21	NA (not shown)
Phillips <i>et al.</i> (2014) <sup>[31]</sup>	Pregnancy, 3 MPP	DASS-21	NA
Salehi-pourmehr <i>et al.</i> (2018) <sup>[9]</sup>	Pregnancy, 6-8 WPP, 12 MPP	BAI-II	First trimester and 12 month SPPWR: Association (aMD 3.050; 95% CI: 0.631-5.470; $P=0.014$ ).
Van poppel <i>et al.</i> (2012) <sup>[36]</sup>	Pregnancy, 3-5 MPP	STAI, Developed questionnaire	NA

BAI=Beck anxiety inventory, STAI=State-Trait Anxiety Inventory, OR=Odds ratio, CI=Confidence interval

this difference. Stress was measured 6, 12 months, and 2.5 years postpartum in the previous review studies, and it has measured during pregnancy in none of them.<sup>[14]</sup> These measurement times are different from the present review. Delay in stress measurement may be concurrent with expected postpartum weight loss, which could explain the nonsignificant relationship between stress and PPWR in the previous review studies. In addition, stress was measured using different tools, which may cause different results.

In the present systematic review, a significant relationship was reported between anxiety, mainly during pregnancy, and PPWR. Nagl *et al.*<sup>[15]</sup> reviewed three studies in this area, which included in the present systematic review. They achieved different results, probably due to fewer studies. Hartley *et al.* reported that there was no significant relationship between anxiety symptoms and postpartum weight status.<sup>[13]</sup> The smaller number of their reviewed studies may be the reason for the mentioned differences. It seems that anxiety during pregnancy can have a positive relationship with increasing PPWR, but this conclusion does not apply to the relationship between postpartum anxiety and PPWR.

### Strengths and limitations of the review

The present systematic review has some strengths, including conducting an extensive search in several databases, the high quality of the selected studies, and the selection of both Persian- and English-language articles. However, using different research methods, measurement tools/times in studies made it impossible to conduct a quantitative meta-analysis.

### Conclusion

The results of this systematic review indicate the relationship between depression/stress/anxiety and

PPWR. However, further researches are recommended for achieving a comprehensive conclusion. It seems that study design, time of depression/stress/anxiety assessment, and different measurement tools were important issues in different results. Faleschini *et al.* emphasized the protective role of social support in physical behaviors and mental health, which, in turn, affects PPWR.<sup>[45]</sup> Furthermore, relaxation could reduce stress, anxiety, and depression in pregnant women.<sup>[46]</sup> HBM model could be a suitable framework to design an educational intervention to improve weight control behaviors among pregnant women.<sup>[47]</sup> Therefore, educational, interventional, and supportive programs preventing psychological problems during pregnancy and postpartum are suggested reducing the psychological factors' impact on PPWR.

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### Conflicts of interest

There are no conflicts of interest.

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**Supplementary Table 1: Quality assessment of cohort studies based on Newcastle-Ottawa quality assessment scale**

Author, year	Selection			Demonstration that outcome of interest was not present at start of study	Comparability	Outcome			Total score
	Representativeness of the exposed cohort	Selection of the non exposed cohort	Ascertainment of exposure		Comparability of cohorts on the basis of the design or analysis	Assessment of outcome	Was follow-up long enough for outcomes to occur	Adequacy of follow up of cohorts	
Biesmans <i>et al.</i> (2013) <sup>[24]</sup>	*	*		*	**	*	*		7
Bogaerts <i>et al.</i> (2013) <sup>[26]</sup>	*	*		*	**		*	*	7
Bogaerts <i>et al.</i> (2017) <sup>[25]</sup>	*	*		*	**			*	6
Collings <i>et al.</i> (2018) <sup>[16]</sup>	*	*		*	**	*	*	*	8
Ertel <i>et al.</i> (2017) <sup>[17]</sup>	*	*		*	**	*	*	*	8
Goldstein <i>et al.</i> (2016) <sup>[12]</sup>	*	*		*	**	*		*	7
Gunderson <i>et al.</i> (2008) <sup>[27]</sup>	*	*		*	**		*	*	7
Herring <i>et al.</i> (2008) <sup>[10]</sup>	*	*		*	**		*	*	7
Oken <i>et al.</i> (2007) <sup>[2]</sup>	*	*		*	**		*	*	7
Pedersen <i>et al.</i> (2011) <sup>[29]</sup>	*	*		*	**		*	*	7
Phillips <i>et al.</i> (2014) <sup>[30]</sup>	*	*		*	**		*	*	7
Phillips <i>et al.</i> (2014) <sup>[31]</sup>	*	*		*	**			*	6
Rogers <i>et al.</i> (2016) <sup>[18]</sup>	*	*		*	**	*	*	*	8
Salehi -pourmehr <i>et al.</i> (2018) <sup>[9]</sup>									
Sha <i>et al.</i> (2019) <sup>[33]</sup>	*	*		*	**	*	*	*	8
Siega-Riz <i>et al.</i> (2010) <sup>[34]</sup>	*	*		*	**	*	*	*	8
Van poppel <i>et al.</i> (2012) <sup>[36]</sup>	*	*		*	**			*	6
Walker (2009) <sup>[37]</sup>	*	*		*	**	*	*	*	8
Whitaker <i>et al.</i> (2014) <sup>[38]</sup>	*	*		*	**	*	*	*	8
Zanotti <i>et al.</i> (2015) <sup>[40]</sup>	*	*		*	**	*	*		7

**Supplementary Table 2: Quality assessment of cross-sectional studies based on Newcastle-Ottawa quality assessment scale**

Author, year	Selection			Ascertainment of the exposure	Comparability	Outcome		Total score
	Representativeness of the sample	Sample size	Nonrespondents		The subjects in different outcome groups are comparable, based on the study design or analysis	Assessment of the outcome	Statistical test	
Huang <i>et al.</i> (2010) <sup>[28]</sup>	*	*	*	**	*	**	*	9
Riazi <i>et al.</i> (2017) <sup>[32]</sup>	*	*		**	**	**	*	9
Straub <i>et al.</i> (2016) <sup>[35]</sup>	*	*		**	**	**	*	9
Wan Noor Fatehah <i>et al.</i> (2019) <sup>[39]</sup>	*	*		**	**	**	*	9