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Development of a Pre- and Postnatal Bonding Scale (PPBS)

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Abstract

Objectives: Bonding is a major topic in the field of developmental psychology, due to its importance for adequate child's development. Studies investigating the relationship between prenatal and postnatal bonding show moderate correlations. However, an important limitation is that no similar instrument was used to measure bonding pre- and postnatally. For the current study, a user-friendly questionnaire was developed to assess maternal bonding during pregnancy and postpartum. Psychometric properties were investigated.

Methods: In a large sample of 1,050 pregnant women, 14 positive items, based on the literature, were used to construct a pre- and postnatal bonding questionnaire. The sample was randomly split into two equal subsamples: group I was used for reliability and Exploratory Factor Analysis, group II for Confirmatory Factor Analysis. The bonding scale was assessed at 32 weeks' pregnancy and at eight and 12 months postpartum. The Edinburgh Depression Scale (EDS) and the subscale Partner Involvement of the Tilburg Pregnancy Distress Scale (TPDS) were used to assess construct validity.

Results: After CFA, a five-item bonding scale remained with excellent model fit (CFI: 0.97, TLI: 0.97, NFI: 0.98; RMSEA: 0.06, lower bound 0.03. Cronbach alpha's at 32 weeks' gestation and at eight and 12 months postpartum were: 0.87, 0.80 and 0.79, respectively. Test-retest correlations of the PPBS at 32 weeks' gestation and at eight and 12 months postpartum were high: 0.42 and 0.41, and 0.67 between eight and 12 months postpartum, respectively. At 32 weeks' gestation, the PPBS correlated significantly with partner support (TPDS): 0.38. and depression (EDS): -0.24. Similar correlations with depression were found at eight and 12 months postpartum.

Conclusion: The five-item PPBS seems to be a user-friendly self-rating scale with good psychometric properties and construct validity, both pre- and postnatally.

Keywords: Maternal bonding; Prenatal; Postnatal; Screening instrument; Construct validation; Depression; Partner support

Introduction

The formation of the bond between mother and child, described in terms of bonding and attachment, is a major topic in the field of psychology as it is an elementary part of child's development. John Bowlby and Mary Ainsworth led the research into the history of this topic by respectively developing the biological basis of the attachment theory and introducing the affective domain [1,2]. Secure attachment is known to be beneficial in childhood development [3]. There is confusion between maternal-infant bonding and attachment, both being defined in equal terms and used interchangeably in the literature [4]. In general, attachment, has a reciprocal aspect [5] or refers to the emotional tie from infant to parent [4]. A principle-based concept analysis of the concept of maternal-infant bonding [4] states that maternal-infant bonding describes 'maternal feelings and emotions towards the infant'. Operationalization takes place in the affective domain; up until now there is limited evidence that it encompasses behavioural or biological components.

The development of the bond between mother and child already starts during pregnancy [6], called antenatal, prenatal, maternal-fetal attachment or bonding. Prenatal attachment is defined by Condon and Corkindale [7] as 'the emotional tie or the bond which normally develops between the pregnant parent and her unborn child'. During the second half of pregnancy in particular, the fetus becomes more human to the mother [2] and in the third trimester of pregnancy, mothers are able to picture their maternal identity and their baby [8]. They have stronger feelings of attachment to their child when their realization of actual life inside them increases [9]. Prenatal attachment is an abstract concept representing the affiliative relationship between a parent and fetus, containing the core experience of love [2]. Love, as a neurophysiological construct, makes phylogenetic changes in the autonomic nervous system, which promote the establishment of enduring bonds [10]. It is known that mothers associate their (unborn) child with positive feelings, such as love, warmth, joy, and happiness [11]. Higher prenatal attachment is associated with more optimal childhood development [12].

The given definition of prenatal attachment is also applicable for the postnatal period and it embodies the affective domain. It suggests the direction the relationship takes; from parent to infant, not requiring a response of any kind from the child, which actually makes it the definition of bonding. For that reason, in the current study, the term bonding is used to describe and measure the mother's feelings and emotions towards her (unborn) baby. However, as the terms bonding and attachment are interwoven and used interchangeably in the

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literature, in the following part of the introduction, factors associated to both attachment and bonding will be discussed.

Studies investigating the predictors of prenatal bonding often found that maternal depression and bonding are negatively related, showing depression to be a significant predictor of poor prenatal bonding [6,13,14]. Moreover, an inverse relationship was found between severity of depression and prenatal bonding [13] and the closer the prenatal bonding, the less symptoms of depression mothers report during the last term of pregnancy and postpartum [15]. Poor prenatal bonding seems to predict postpartum anxiety and depression even more than prenatal anxiety or depression [16]. On the other hand, social support and marital relationship are positively related to prenatal bonding [17]. Mothers with a partner report higher levels of prenatal bonding than single mothers [14] and married women with low prenatal bonding scores have low levels of social support outside the partner relationship and high levels of control, domination and criticism within the partner relationship [7]. A meta-analysis showed that social support is the most powerful theoretical predictor studied in relation to prenatal bonding, but that this effect is moderate [18].

In contrast to studies investigating the correlates of prenatal bonding, there a fewer studies on the correlates of postnatal bonding, and a number of factors have been clearly identified to be negatively correlated with postnatal bonding. Maternal postnatal depression has a strong negative association with postnatal bonding [19,20-24]. On the other hand, social and partner support were found to be positively correlated to postnatal bonding [19,21]. Postnatal bonding is known to be the best predictor of bonding later on in life [23].

Moreover, it is assumed that pre- and postnatal bonding are interrelated. This relationship has been investigated in several studies, with results showing modest to moderate correlations; women with low prenatal bonding scores tend to remain in this category for postpartum bonding [12,24-27]. However, bonding across pre- and postnatal periods has not been well researched, with bonding typically only being assessed at one time point during pregnancy or after birth. And therefore, the important limitation in all these studies is that, when measuring bonding pre- and postnatally, different instruments are used during pregnancy compared to postpartum. This makes it impossible to examine mean changes in bonding scores over time. In pregnancy, the mostly used instruments are the Prenatal Attachment Inventory (PAI), Maternal Fetal Attachment Scale (MFAS) and the Maternal Antenatal Attachment Scale (MAAS). These all have multifactorial structures and show good reliability, but not for all subscales. Moreover, several studies that used one of the questionnaires found different factor structures within the scales [28]. Several postpartum instruments have been developed, the most commonly used being the Postpartum Bonding Questionnaire (PBQ), Maternal-to-Infant Bonding Scale (MIBS), Parent-to-infant Attachment questionnaire (PAQ), Maternal Attachment Inventory (MAI) and Maternal Postpartum Attachment Questionnaire (MPAS) [28,29]. All these questionnaires have multifactorial structures with good reliability [28]. However, no factor structure is known with regard to the MIBS [30].

Apart from the fact that different instruments were used to measure pre- and postnatal bonding, another limitation of earlier studies is the relatively small sample size investigated in most studies [25-27,31]. Therefore, researchers from previous studies point out that more longitudinal research is needed in a larger study population [2,6,26]. But firstly, the development of an instrument for measuring bonding both pre- and postnatally is necessary [24,26,32]. This could provide more insight in the mother-child relationship over time and could be helpful in detecting mothers with higher risk for developing problems in bonding [12]. According to reviews, early postnatal interventions that enhance bonding, especially those focusing on behaviour, range between marginally successful and quite successful in improving the mother-child relation [33,34]. According to the review of Bakermans et al. [33] the best time for improving bonding is six months after birth or later. However, studies show contradictory results and more research is needed. A review on the effectiveness of prenatal interventions also yielded contradictory results [35] and, to the best of our knowledge, the question whether early preventive interventions that enhance bonding during pregnancy can be successfully implemented to develop an optimal mother-child relation after birth, has not yet been answered. A single instrument for measuring pre- and postnatal bonding is needed in order to eventually be able to measure effects of preventive interventions.

Therefore, the aim of the current study was to develop, and investigate the psychometric properties, of a user-friendly questionnaire for assessing maternal bonding during pregnancy as well as postpartum. We hypothesized that prenatal and postnatal bonding scores were highly correlated, if measured with the same instrument. Moreover, we also hypothesized that bonding scores correlated negatively with depression and positively with partner support (construct validity).

Methods

Participants and procedure

From January 2013 to September 2014, pregnant women who had their first antenatal appointment in the first trimester at the offices of the 17 participating community midwife offices in the South-East of The Netherlands, were invited to participate to the HAPPY study (Holistic Approach to Pregnancy and the first Postpartum Year), the design of which has been described in detail elsewhere [36]. During the 19-month recruitment period 3,160 Dutch-speaking Caucasian pregnant women who visited the participating midwifes and who met the inclusion criteria (i.e. singleton pregnancy, no diagnosis of severe psychiatric illness or endocrine disorder) were approached. Written informed consent to participate was signed by 2,275 (72%) of the eligible women. The women filled in online questionnaires at several moments during pregnancy and postpartum. We later decided to measure bonding during the HAPPY project, and since this was not included in the original planning, only 1,292 women are included in this study, 1,163 women (90%) of who returned the questionnaires. During pregnancy, 113 women failed to return complete data, resulting in a final sample of 1,050 women for data-analysis of whom the characteristics are shown in Table 1. These were similar to those of the total HAPPY cohort of 2,275 women (data not shown). The characteristics of the sample participating in this study were similar to those known in the 2013 national obstetric register [37]. However, 64% of the women in the current study were highly educated. This is a somewhat higher percentage than Statistics Netherlands report about women between 25 and 35 years of age; 53% [38].

The 1,050 participants were randomly divided by SPSS into two subsamples. Data from sample I (n=521) were used to conduct an exploratory factor analysis (EFA) and reliability analysis, while sample II (n=529) was used to perform a confirmatory factor analysis (CFA). The characteristics of these samples are shown in Table 1.

As can be seen, the two samples showed similar characteristics. Women had a mean age of 30, almost all of them were living with a partner, and 64% of them were highly educated. Only with regard

Characteristics	Sample I (*n*=521)				Sample II (*n*=529)			
	N	%	Mean (SD)	Range	*N*	%	Mean (SD)	Range
Demographics								
Age			30.5 (3.9)	19-42			30.5 (3.6)	21-40
Living with partner	500	99.6			508	98.6		
High educational level	323	64.3			329	63.9		
Paid job	467	93			493	96.1		
Pregnancy related								
Primiparous	228	45.4			236	46.2		
Planned pregnancy	477	94.3			480	94.3		
Previous history of miscarriage	139	27.7			152	29.6		
Psychiatric life-history								
Previous episode of depression	81	16.2			79	15.4		
Previous episode of other mental problems (anxiety, surmenage)	126	25.1			138	27		

Table 1: Characteristics of two samples of women participating in the HAPPY study (n=1050).

to paid jobs, χ^2 (1, n=1015) = 4.7, p=0.031, φ= 0.07, did the samples differ. However, a phi of -0.07 showed low effect size with little if any clinical relevance. Both samples met the criteria of four to ten subjects per item with a minimum of 100 subjects to conduct factor analyses [39,40]. Of this sample of 1,050 women, 774 and 629 completed the questionnaires at respectively eight and 12 months postpartum, respectively. The characteristics of these two postpartum samples were similar to the pregnancy sample (data not shown). These samples were used for test-retest analysis. The study was approved by the Medical Ethics Committee of the Máxima Medical Centre Veldhoven, The Netherlands.

Measures

Pre- and postnatal bonding scale (PPBS)

Based on the literature, we decided to use only positive items describing bonding. It is known that mothers associate their (unborn) child with positive feelings [11] and love is presumed to be the core experience of bonding [2]. Research and clinical practice usually focusses on the lack of positive, warm and caregiving maternal feelings towards the (unborn) baby and it was found that especially low scores on positive statements signal a lack of bonding or a disordered relationship [41]. Moreover, in order to avoid the 'acceptability influence' or 'social desirability' in the mothers' answers, no negative items were included [42]. Our society does not accept negative feelings in early mother-child relationships, which results in women consciously avoiding negative answers on those kinds of statements, thereby making negative items less discriminating and reliable. Therefore, we developed a bonding scale consisting of 14 items describing positive feelings of bonding (Appendix). During pregnancy, the women were asked to complete the following statement: 'We have a number of statements that reflect the feelings a pregnant woman may experience toward her unborn baby, especially when she is aware of the fetal movements. Would you kindly complete the following: During the last four weeks, I could describe my feeling towards my baby the best as:….'. Thereafter, the women were asked to complete the items using a four-point Likert answer scale, ranging from very much (1), much (2), hardly (3), not at all (4). This 14-item self-rating scale was completed at 32 weeks' gestation. Moreover, the women in the subsample who completed the entire HAPPY study, completed the scale at eight and 12 months postpartum. During these postpartum assessments, and using the same items, the introduction to the questionnaire was adapted into: 'We have a number of statements that reflect the feelings a mother may experience towards her baby. Can you please, answer the following question: During the last four weeks, I could describe my feeling towards my baby the best as:…' Total scores ranged from 14 to 56, with higher scores indicating more positive feelings of bonding.

Depressive symptoms

Depressive symptoms were assessed several times during pregnancy and the first year postpartum, including 32 weeks' gestation and at eight and 12 months postpartum, using the Edinburgh (Postnatal) Depression scale. This ten-item questionnaire has previously been validated for use during the postpartum period [43] and pregnancy [44]. During gestation a cut-off of ten at the third trimester has been described [44] and postpartum also a cut-off of ten [45]. The EDS has extensively been used in perinatal research in over 40 countries showing good psychometric properties. Total score range from 0 to 30, with higher scores indicating more depressive symptoms. The EDS was used for construct validity analysis with the bonding scale.

Partner support

The Tilburg Pregnancy Distress Scale (TPDS) has been previously developed and validated for use during pregnancy and contains a domain 'partner involvement' [46]. This subscale measures the extent of perceived partner involvement in pregnancy using four items on a four-point Likert scale, with higher scores indicating more involvement. This subscale was used for construct validity analysis with the bonding scale.

Baseline characteristics

Several baseline parameters were evaluated at 12 weeks gestation, including demographic, pregnancy-related and psychological characteristics (Table 1).

Statistical methods

Statistical analyses were performed using the Statistical Package for Social Sciences (SPSS version 22, IBM, Chicago, IL, USA). Parallel Analysis was performed using the MonteCarlo PA program [47]. Confirmatory factor analysis was carried out using AMOS (version 18, IBM, Chicago, IL, USA).

Factor analyses

An exploratory factor analysis (EFA) using principal component analysis (PCA) in sample I was performed using the 14-item bonding scale for testing psychometric properties. Due to the multifactorial structures of existing bonding scales, we used rigorous criteria for

multifactorial factor analysis, although the use of positive items only increased the likelihood of the scale having a one dimensional structure. Since all items related to positive feelings, we expected that all potential factors would be correlated, and chose to use oblimin rotation. A Catell scree plot was used to select factors for retention. Moreover, a Parallel Analysis was performed to randomly generate a data matrix with criterion values corresponding with the Eigenvalues from the EFA. Only Eigenvalues that exceeded the corresponding criterion values were retained [48]. As explained by Pallant [48], a subscale of less than three items is not advisable. Internal consistency analyses were conducted using Cronbach's alpha for the total scale and possible subscales derived from factor analysis. A Cronbach alpha reliability statistic of ≥ 0.70 is considered as the minimum acceptable criterion of an instrument's internal reliability [39]. In sample II, CFA was performed on the remaining items of the bonding scale. CFA was used to test the model fit of the factor structures found with EFA, assessing the comparative fit index (CFI), normed fit index (NFI), Tucker-Lewis Index (TLI), and the root mean square error of approximation (RMSEA). Adequate model fit can be assumed with a CFI ≥.80, combined with a NFI ≥ 0.80, TLI ≥ 0.80, and a RMSEA ≤ 0.05 for good and ≤ 0.08 for adequate fit [49,50]. Finally, EFA was repeated in sample II to verify the factor structure found after CFA.

Construct validity

To test for differences of characteristics between the two subsamples, χ^2 analyses were used for all dichotomous data. Differences in mean scores between sample I and II were analyzed using the t-test (two-tailed). Since the two subsamples showed similar characteristics, the two samples were merged to determine construct validity. Construct validity of the bonding scale was tested by correlating this scale with the EDS and the partner involvement subscale of the TPDS (Pearson's r correlations, two-tailed). For analysis with the subscale of the TPDS, women without a partner (0.9%) were excluded. Test-retest reliability of the bonding scale was analyzed by correlating the prenatal and postnatal scores. Differences in mean bonding scores of different measurement occasions were analyzed using one-way repeated measures ANOVA with post-hoc analysis.

Results

Exploratory and confirmatory factor analysis

Skewness and kurtosis statistics showed that the scores on all 14 items were distributed normally. All assumptions for conducting principal components analysis were met. The Kaiser-Meyer-Oklin value was greater than 0.60 (0.93) and the Bartlett's test of sphericity value was significant ($p < 0.001$). EFA with oblimin rotation of the 14-item scale in sample I, suggested two dimensions with Eigenvalues of 6.4 and 1.2, respectively 42.9% and 9.1% of variance explained, with 54.5% total explained variance. The Cattel scree plot clearly suggested a one-factor solution, since there was only one factor above the break in the plot, and retaining all factors above the break in the plot is recommmended [48].

For item loadings a cut-off score of .40 was used and a minimum difference of 0.20 if an item had two loadings. Items 7, 9, 13 and 14 did not discriminate and were omitted. This resulted in a two-dimension scale with Eigenvalues of 4.9 and 1.1, respectively, explaining 60.6% of total variance. The remaining ten items consisted of one factor with seven items and the one factor with only three items. Parallel Analysis showed two components with Eigenvalues exceeding the corresponding criterion values for a randomly generated data matrix of the same sample size (ten variables x 521). When this two-factor structure was tested in a CFA in sample II, a poor model fit was found: CFI 0.69, a NFI of 0.70, a TLI of 0.73, and an RMSEA of 0.15 with lower bound of 0.09. Therefore and according to the Cattel scree plot, in sample I, the EFA was repeated on the ten-item scale using a one-factor solution. This resulted in one dimension with an Eigenvalue of 4.9, explaining 49.4% of variance. This ten-item one factor scale was again tested by a CFA in sample II and showed a better but still inadequate model fit (CFI = 0.82, NFI= 0.86, TLI= 0.84 and RMSEA = 0.09, lower bound= 0.08). However, a closer look at the model estimates revealed that items 3, 4, 6, 11 and 12 showed poor standardized residual co-variances. Therefore, these items were omitted from the model, which resulted in a five item scale with excellent model fit: a CFI of 0.97, a NFI of 0.98, a TLI of 0.97, and a RMSEA of 0.06, with a lower bound of 0.03 and a Cronbach's alpha of 0.87. When this five-item model was tested again with an EFA with varimax rotation in sample II, a one factor structure was found with an Eigenvalue of 3.4, explaining 67.1% of total variance (Table 2).

The items were recoded from 1-4 into 0-3 in order to have a total score range from 0 – 15. We repeated the EFA and found similar results for both eight and 12 months postpartum with Eigenvalues of respectively 2.8 and 2.7, explained variance of respectively 56.8% and 53.5% (Table 2). At 8 and 12 months postpartum the Cronbach alpha's were respectively 0.80 and 0.79.

Construct validity

Since the characteristics of both subsamples (Table 1) were similar, we merged these two samples for construct validity analysis (n = 1.050). In Table 3, mean scores (SD) and range of the five-item PPBS, the EDS and the subscale partner involvement of the TPDS are shown, including the Pearson correlations between these scales.

Table 3 shows highly significant correlations between bonding scores, with medium effect sizes for prenatal and both postnatal measurement occasions. The postnatal bonding scores at eight and 12 months postpartum correlated also highly significant with a large

	32 weeks gestation	8 months postpartum	12 months postpartum
	Factor I	Factor I	Factor I
Eigenvalue	3.4	2.8	2.7
Percentage of variance explained (%)	67.1%	56.8%	53.5%
Item loadings			
1. Loving	0.83	0.66	0.56
2. Happy	0.83	0.81	0.72
3. The most beautiful thing that ever happened to me	0.78	0.76	0.77
4. Extraordinary	0.81	0.72	0.77
5. Blissful	0.85	0.80	0.81

Table 2: Final five-item bonding scale with one-factor solution from factor analysis with varimax rotation in 529 (sample II) pregnant women with an appropriate model fit in CFA. (CFI: 0.97, NFI: 0.98, TLI: 0.97, RMSEA: 0.06, lower bound: 0.03).

	PPBS32wks	PPBS 8 mPP	PPBS 12 mPP	TPDS32wks	EDS32wks	EDS 8 mPP	EDS 12 mPP	Mean (SD)	Range
PPBS32wks	1.00	0.42*	0.41*	0.38*	-0.24*			12.4 (2.4)	0-15
PPBS8mPP		1.00	0.67*			-0.23*		13.7 (1.8)	5-15
PPBS12mPP			1.00				-0.25*	13.7 (1.7)	6-15
TPDS32wks				1.00				8.2 (2.5)	0-12
EDS32wks					1.00			5.1 (4.3)	0-24
EDS8mPP						1.00		4.7 (4.6)	0-25
EDS12mPP							1.00	4.5 (4.2)	0-23

Establishment of concurrent validity of the PPBS, by comparing it to the EDS and the TPDS at 32 weeks' gestation, and the EDS at 8 and 12 months' postpartum, two-tailed, *p<0,05, PPBS: Pre- and Post-natal Bonding Scale; EDS: Edinburgh Depression Scale, TPDS: Tilburg Pregnancy Depression Scale

Table 3: Correlation matrix including mean scores (SD) and range of PPBS, EDS and TPDS scales assessed at each trimester (n=1050).

effect size (Cohen's d = 2.43). There was a significant inverse correlation between the PPBS and EDS scores at 32 weeks' gestation as well as at 8 and 12 months postpartum with medium effect sizes. Moreover, the PPBS scores and scores of the subscale partner involvement of the TPDS were significantly positively correlated with a medium effect size.

One-way repeated measures ANOVA was conducted to compare bonding scores at 32 weeks' gestation, eight months postpartum and 12 months postpartum. The means and standard deviations are presented in Table 3. There was a significant difference between the mean scores at 32 weeks' gestation and at eight and 12 months postpartum, respectively, $F(2,578) = 119$, $p<0.001$, partial eta squared = 0.29, but no significant difference between the scores at eight and 12 months postpartum.

Discussion

Since there is currently no instrument in existence to measure both pre- and postnatal bonding, this study aimed to develop a user-friendly questionnaire for assessing maternal bonding during pregnancy and postpartum. Our results showed that a five-item bonding scale, the Pre- and Postnatal Bonding Scale (PPBS), had good psychometric properties; a one-factor structure with good internal consistency and excellent model fit in the CFA, for assessing bonding pre- as well as postnatally. With regard to the structure analyses of PPBS, all the assumptions for appropriate factor analyses were met: both in sample I and II, the sample size was large (>10 subjects per item), Cronbach's alphas were ≥ 0.70 and the factor loadings of the retaining items were high (> 0.40). CFA showed an excellent model fit. The content of each of the five remaining items of the bonding scale interfaces the concept of love; a feeling to a person that arises among other things from natural ties and reveals itself in warm affection and attachment [51]. This corresponds to the only explanation of bonding to be found in all literature about bonding, stating that bonding contains the core experience of love [2]. Thereby, all five items have an affective character, in line with all past research that operationalized bonding only in the affective domain. It would seem that the excluded items had different characters and measure individual theoretical constructs, such as, for example, patience and optimism. Our results show significant correlations with medium effect sizes between pre- and postnatal bonding scores, and with a high effect size between both postnatal bonding scores (test-retest properties). Earlier research found a relationship between pre- and postnatal bonding, but in that research, bonding was measured with different instruments and small sample sizes were used [24-26]. To the best of our knowledge, the current study is the first that has developed an instrument for measuring bonding both pre- and postnatally, using a large sample size. This creates the opportunity to make a reliable comparison between pre- and postnatal bonding, by examining mean changes in bonding scores over time. We found that bonding scores at eight and 12 months postpartum were significantly higher than bonding scores at 32 weeks' gestation. However, there was no significant difference between the scores at eight and 12 months postpartum. The prenatal process of bonding that grows with the increasing 'realization of actual life inside them' [9], proceeds after birth. Possibly, the increasingly active role that the baby plays in the interaction with the mother after birth, and the growing trust in the co-regulation capacities in the mother-baby dyad, stimulate feelings of maternal bonding and then stabilize in the postnatal period.

Previous research suggested that bonding scores correlate negatively with depression and positively with partner support [12,18]. Firstly, in the current study, at all measurements an identical significant negative correlation between bonding and depression was found with a medium effect size, indicating a relationship between bonding and depression in the expected direction. However, the effect size was modest, confirming that the PPBS and the EDS measure different concepts. The negative association between depression and bonding may be explained by the less emotional availability depressed mothers experience [52], both during pregnancy and after birth and therefore be less able to bond well. Moreover, it is assumed that depression during pregnancy compromises a women's ability to feel confident in her new role as an expectant mother [12]. Postnatal bonding may also be impaired because depression has selective effects on different aspects of mother-infant interaction [53]. Women suffering from depressive symptoms show less positive interaction overall, with reduction in affective involvement, responsivity and sensitivity [53,54], which is important for infant-attachment [55,56]. Also, during pregnancy partner support and bonding were positively and significantly correlated, with a medium effect size. Earlier studies found that secure romantic attachment, which often results in higher partner involvement, is related to a better quality of attachment between mother and baby [57,58]. Thereby, the partner's reaction and attitude make a powerful contribution to the mother's adjustment to pregnancy and relationship to her unborn child [7,59]. The association between partner relationship and bonding implies that involvement in relationships is important in enabling the mother to bond with her (unborn) child [58,60]. The importance of emotional support for the mother was also recognized by Stern [61], who described both the healthy primary preoccupation with forming a bond with the baby, and the ability of the mother to gain emotional support, as one of the four basic themes of motherhood. Both the relation with depression and partner involvement confirm the idea that a woman's emotional state and availability may have a significant impact on her ability to form a healthy bond with her infant [21].

This study has its strengths and limitations. Its key strength is that it is the first to measure pre- and postnatal bonding with one and the same instrument, by means of which a large sample size – 1,050 women (more than double that of any previous studies) – could be screened. This enabled us to use different samples for the EFA and CFA, respectively 521 and 529 women in sample I and II. Another strength is the longitudinal

use of the EDS to assess the construct validity of our newly developed scale, which enabled us to determine the relationship between bonding and depression at different time-points. However, several limitations should be mentioned. In general, in this field of research, it is hard to determine the abstract concept of bonding clearly and unequivocally. A standard definition is lacking, and the interchangeable using of both the terms 'bonding' and 'attachment' is widespread [4]. Consequently, no gold standard, such as a diagnostic interview, to measure bonding exists, and thus could be used in developing the PPBS. Moreover, the current study only included Caucasian women, while in The Netherlands up to 10-15% of the women come from other ethnic groups. This means that the psychometric properties of the scale should be re-evaluated in women of other ethnic origins.

Using the PPBS will provide more insight in the mother-child relationship over time. It can be used as a screening instrument, because of its short duration and user-friendly setup. Such a reliable and validated scale for measuring pre- as well as postnatal bonding, makes it possible to investigate the predictive value of low prenatal bonding scores on postnatal bonding scores and, possibly, on infant attachment [23]. In clinical practice, it can be helpful in detecting mothers with higher risk for developing problems in bonding. As we already know, depression has a negative relation towards bonding, and it is of great importance to further investigate the relation between depression, as well as other psychological problems of the mother may have, and bonding over time. Moreover, studies testing interventions to enhance bonding can be conducted, and changes in bonding scores can be measured in the pre- and postnatal phase. Postnatal interventions that enhance bonding appear to be somehow effective, but more research is needed, also with regard to the best time to improve bonding [33,34]. Since the review of Mercer et al. [35] only included studies carried out before 1991, there is very little current knowledge about the effectiveness of preventive prenatal interventions, such as education on fetal behaviors, maternal-fetal interactive activities, awareness of fetal activity, and massage. The PPBS can also contribute to the investigation of the effectiveness of these kind of early preventive interventions for enhancing bonding during pregnancy, with the aim of developing an optimal mother-child relation after birth.

Conclusion

In conclusion, the five-item Pre- and Postnatal Bonding Scale (PPBS) scale is a short user-friendly instrument with good psychometric properties; good factor structure, internal consistency, and construct validity. Future research should further elucidate the validity and use of the PPBS in clinical practice. The PPBS can be used pre- and postnatally for detecting risk-groups of women with poor bonding. In the future, bonding scores can be related to infant attachment and child development. It may also be possible to implement preventive interventions to enhance bonding, in order to improve a child's development.

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