Nonpharmacologic Approaches for Pain Management During Labor Compared with Usual Care: A Meta-Analysis

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ABSTRACT: Objectives: *To assess the effects of nonpharmacologic approaches to pain relief during labor, according to their endogenous mechanism of action, on obstetric interventions, maternal, and neonatal outcomes.* **Data source:** *Cochrane library, Medline, Embase, CINAHL and the MRCT databases were used to screen studies from January 1990 to December 2012.* **Study selection:** *According to Cochrane criteria, we selected randomized controlled trials that compared nonpharmacologic approaches for pain relief during labor to usual care, using intention-to-treat method.* **Results:** *Nonpharmacologic approaches, based on Gate Control (water immersion, massage, ambulation, positions) and Diffuse Noxious Inhibitory Control (acupressure, acupuncture, electrical stimulation, water injections), are associated with a reduction in epidural analgesia and a higher maternal satisfaction with childbirth. When compared with nonpharmacologic approaches based on Central Nervous System Control (education, attention deviation, support), usual care is associated with increased odds of epidural OR 1.13 (95% CI 1.05–1.23), cesarean delivery OR 1.60 (95% CI 1.18–2.18), instrumental delivery OR 1.21 (95% CI 1.03–1.44), use of oxytocin OR 1.20 (95% CI 1.01–1.43), labor duration (29.7 min, 95% CI 4.5–54.8), and a lesser satisfaction with childbirth. Tailored nonpharmacologic approaches, based on continuous support, were the most effective for reducing obstetric interventions.* **Conclusion:** *Nonpharmacologic approaches to relieve pain during labor, when used as a part of hospital pain relief strategies, provide significant benefits to women and their infants without causing additional harm. (BIRTH 41:2 June 2014)*

Key words: *Central Nervous System Control, diffuse noxious inhibitory control, epidural analgesia, gate control theory, maternal outcomes, meta-analysis, neonatal outcomes, non-pharmacologic approaches, obstetric intervention, pain relief in labor*

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Background

Relieving pain during childbirth represents an important challenge for both health care professionals and pregnant women. Pain relief strategies include nonpharmacologic and pharmacologic approaches. In obstetrics, pharmacologic methods such as epidural analgesia have proven to be efficient in reducing pain during labor and are now routinely used, and even expected, to manage pain (1–6). Some authors have suggested that this process may contribute to an overmedicalization of women's childbirth experiences (7–10). Nonpharmacologic approaches to pain relief may enhance women's satisfaction, competence, and feeling of control in labor, reducing the need for obstetric interventions (9). Numerous studies and systematic reviews suggest the use of nonpharmacologic approaches to pain management either as a primary method, or as a complement to pharmacologic approaches (1,2,7–15). However, the effectiveness of nonpharmacologic approaches on obstetric interventions and outcomes remains unclear, and there is still no consensus for the use of nonpharmacologic approaches to pain relief in hospital settings. The difficulty to translate these approaches into practices may be explained by the lack of systematic review assessing the impact of nonpharmacologic approaches on obstetric interventions and outcomes; further, it may be explained by an inappropriate pooling or classification of these approaches, leading to a lack of statistical power or a potential dilution of results when too specific or too large nonpharmacologic approaches with different mechanisms of action are included in meta-analyses (8,16–20).

To overcome these limits, Bonapace proposed to organize nonpharmacologic approaches to pain relief according to three endogenous mechanisms activated during labor (Table 1), based on the Marchand classification, to assess their impact and effectiveness according to their mode of action rather than by type of approach (10,21–27). The International Association for the Study of Pain defines pain as "an unpleasant sensory and emotional experience associated with actual or potential tissue damage" (23). According to Melzack and Casey, pain is composed of at least two components described as sensory-discriminative (intensity) and motivational-affective (unpleasantness) supported by two separate neurophysiological pathways (24). According to these definitions, the first endogenous mechanism (Gate Control Theory) consists of applying nonpainful massages on the painful areas. This mechanism acts mainly on the sensory-discriminative component of pain, by blocking part of the nociceptive message in the spine (28,29). The second mechanism, Diffuse Noxious Inhibitory Control (DNIC), involves the creation of a second pain anywhere on the body during a contraction and acts on both components of pain but mainly on the sensory-discriminative component of pain (30,31), through a release of endorphins in the spine and brain (30–33). The third mechanism, the Central Nervous System Control (CNSC), consists of controlling the mind through attention deviation (10,21). The CNSC acts mainly on the motivational-affective component of pain, although it also has an effect on the sensory-discriminative component of pain (34,35), by releasing endorphins through the amygdala and the limbic system in the entire body (22).

The primary objective was to assess, in women with normal singleton pregnancy, the effects of nonpharmacologic approaches to pain relief during labor on obstetric interventions, based on their respective endogenous mechanism of action and compared with usual care. Secondary objectives were to determine their respective effects on labor, maternal satisfaction, and maternal and neonatal outcomes.

Data Sources

Together with a medical librarian, three investigators (LB, MW, JB) conducted multiple searches in the Cochrane library, in the Cochrane Central Register of Controlled Trials, EMBASE and MEDLINE databases, EBM reviews, CINAHL, ACP Journal club, DARE and the MRCT database in publication type category screening studies ranging from January 1990 to December 2012, using MeSH terms: "cesarean," "caesarean," "c-section," "assisted delivery," "instrumental delivery," "forceps," "vacuum," "oxytocin," "labor or labour length," "breastfeeding," "pain," "epidural," "anaesthesia," "analgesia," "labour," and "labor." Studies before 1990 were not considered in this review because of the important changes in clinical practice and usual care over time. These terms were then combined with the following texts words: "gate control theory," "alternative therapies," "massage," "position," "mobility," "TENS," "bathing," "DNIC," "acupuncture," "acupressure," "sterile water injection," "higher center," "control mind," "breathing," "relaxation," "mental imagery," "visualization," "mind focusing," "hypnosis," "sophrology," "music," "odors," "prenatal training," "haptonomy," "transcutaneous electrical stimulation," "antenatal education," "support," "companion," "intrapartum care," "nurse," "midwife(ves)," "father," "doula," and "caregiver." Additional studies were identified by screening reference lists from selected studies and from expert suggestions. No language restrictions were applied.

Methods of Study Selection

Inclusion Criteria

Based on PICOS (Population, Intervention, Comparator, Outcome, Study design) (36), both nulliparous and multiparous women with normal singleton pregnancy in labor (spontaneous or induced) at the first or second stage of labor were considered for inclusion. Studies including only women with an elective cesarean delivery or only women at risk of obstetric complications/diseases before labor (preeclampsia, obesity, hypertension) were excluded. All randomized controlled trials that compared a nonpharmacologic approach to pain relief during labor with usual care using intention-to-treat method, where women were randomly allocated to treatment and control groups, were considered for inclusion in the review. No exclusion criteria have been considered for outcomes. A nonpharmacologic approach to pain relief has been defined in this review as a method allowing women to cope with labor pain without the use of medical drugs. Women assigned to the nonpharmacologic intervention group could receive pharmacologic interventions if requested by the women when nonpharmacologic approaches became insufficient to manage pain. Usual care did not involve nonpharmacologic approaches as routine care, but could involve other measures, specific to each trial, such as intermittent presence of a nurse, episodic nonpharmacologic approaches, pharmacological analgesia, routine epidural analgesia or other pharmacologic pain relief, to help women to cope with labor.

To enhance internal validity of the analysis, three authors (NC, LB, JB) independently assessed for inclusion all potentially eligible studies with respect to design according to the Cochrane and the Effective Practice and Organization of Care inclusion criteria (36,37). Discordances were resolved through discussion and consensus. Minimum inclusion criteria for randomized controlled trials were: assignment of participants in each group using a process of random allocation, objective measurement of performance, and relevant and interpretable data presented or obtainable (37). Each criterion was assessed as "done," "not

Table 1. Bonapace and Marchand Classification

Theoretical model	*Type of stimulation*	*Activated mechanism*	*Effects*	*Nonpharmacologic approaches*
Gate Control theory	Nonpainful stimulation of the pain site	Fibers which do not transmit pain messages are activated during non-painful stimulation and block part of those that transmit pain	Acts only on the stimulated area. Modulates the sensory-discriminative component of pain (intensity)	Light massage Water immersion (bathing) Positions/ambulation Birth ball Warm packs Vibration Conventional TENS (high frequency - low intensity)
Diffuse Noxious Inhibitory Control (DNIC)	Painful stimulation of any site of the body	Painful stimulation triggers an endorphinergic system, which reduces pain everywhere, except in the stimulated area. This scheme allows the brain to address the second source of pain	Acts on all painful areas of the body, except the one that is stimulated. Modulates the sensory-discriminative component of pain (intensity)	Painful massage Reflexology Sterile water injections Acupressure Acupuncture TENS (high intensity – low frequency) Ice
Control of the higher centers of the central nervous system (CNSC)	Activated by thought and mental processes (Attention deviation)	The brain modulates the potentially painful stimulations by conditioning the areas which are responsible for memory, emotions, and reaction to pain	Acts on all painful areas of the body. Modulates the motivational-affective component of pain (unpleasantness)	Antenatal education Continuous support Relaxation/Breathing Mental imagery Meditation/Yoga Hypnosis/Self-hypnosis Music Aromatherapy Biofeedback Placebo

Adapted from: Bonapace J. Accoucher sans stress avec la méthode Bonapace. *Éditions de l'Homme, Montréal, 2009; and Marchand S.* Le phénomène de la douleur. *2e edition. Chenelière Éducation, Montréal, 2009.*

done," or "unclear." When a study was assessed as "unclear," authors were contacted for further information.

Risk of Bias and Quality Assessment

Two authors (LB, JB) independently assessed the quality of each study, using the Risk of Bias (ROB) tool according to the Cochrane and Effective Practice and Organization of Care quality scale (36,37). The six criteria from the Risk of Bias tool were assessed for each included study: sequence generation and allocation concealment (selection bias), blinding (performance bias), incomplete outcome data (attrition bias), selective reporting bias (i.e., missing prespecified outcomes of interests or missing expected outcomes that are of interest), and other source of bias (i.e., potential contamination) (36). As women and care providers cannot be blinded to the nonpharmacologic approach provided, studies were considered properly blinded if outcomes were collected and assessed without regard to the woman's group assignment. The risk of attrition was considered as "low" if at least 80 percent of data initially randomized were available for analysis (9). Each criterion was assessed as adequate, inadequate, or unclear. Authors from studies assessed as "unclear" were contacted for further information. Discordances were resolved through discussion and consensus together with a third assessor (NC). Each study was rated as having a "low," "unclear," or "potential" risk of bias. Quality, implementation, and comparability of each nonpharmacologic approach to pain relief were assessed using the Bonapace and Marchand standardized form, and rated "Poor," "Fair," or "Good" according to the degree of activation of each mechanism (10,21,22). Each approach was then classified by endogenous mechanisms activated during labor to relieve pain, according to the Bonapace and Marchand classification: (1) Gate Control, (2) DNIC, and (3) CNSC (10,21,22). Interventions targeting several mechanisms (tailored intervention) were classified according to the main mechanism activated. Finally, studies with potential risk of bias, poor implementation of nonpharmacologic approaches, and tailored interventions were considered in the meta-analysis through sensitivity analyses for primary outcomes, according to the Cochrane and Effective Practice and Organization of Care quality criteria (36,37).

Data Extraction and Statistical Analysis

Three reviewers (LB, NC, JB) independently abstracted specific information from full-text studies according to standardized data extraction checklist items derived from Cochrane and Effective Practice and Organization of Care checklist (36,37). Authors were contacted when data from the original report were unclear. Discordances between reviewers were resolved by consensus. Data were then entered into the Cochrane Review Manager software (Review Manager (RevMan), Version 5.2. The Nordic Cochrane Centre, The Cochrane Collaboration, Copenhagen, Denmark.) and checked for accuracy. Main maternal outcomes were: mode of delivery and need for epidural analgesia. Secondary maternal outcomes were: use of oxytocin in labor, labor duration, maternal morbidity, satisfaction, experience of childbirth and breastfeeding. For newborns, admission to neonatal intensive care, resuscitation, and neonatal morbidity such as trauma, Apgar scores at 1 and 5 minutes, and neurobehavioral assessment were considered in the review.

Dichotomous data were meta-analyzed using OR with 95 percent CI as measures of effect size, or Peto OR if the number of events in a group was equal to 0. Weighted mean difference (WMD) with 95 percent CI was used in the meta-analysis as a measure of effect size for similar continuous data. Inter study variation was incorporated with the assumption of a random effects model for the treatment effect using DerSimonian and Laird and inverse variance method for both dichotomous and continuous data when heterogeneity between trials was significant or superior to 50 percent (36,37). A fixed effect model was used in absence of significant heterogeneity using Mantel-Haenszel's method for dichotomous data, and inverse variance method for continuous data. Outcomes were directly compared between the control and the intervention group on an intention-to-treat basis. Begg's funnel plots were computed for assessed publication bias according to Cochrane procedures (36,37). Q and I^2 tests were used for addressing heterogeneity (36,37). If significant heterogeneity was detected, subgroups analysis were carried out by study period, geographic zone, parity, type of nonpharmacologic approach or other pertinent confounders. Meta-analyses were computed using RevMan 5 from the Cochrane Collaboration (36).

Results

A total of 1,561 studies corresponding to our search strategy were identified from January 1990 to December 2012. Of these, 1,446 were excluded based on eligibility criteria outlined in the Methods section and Fig. 1. The full-text articles for the remaining 115 citations were retrieved. Four additional articles were obtained from reference lists and expert suggestions, bringing the total number of identified studies to 119.

After review of the full-text articles using eligibility criteria, 66 studies remained and were further evaluated for quality. Studies were mainly excluded because the intervention group was not compared with usual care. Nine were excluded because minimum Effective Practice and Organization of Care inclusion criteria were not reached (i.e., assignment of participants with no random or a quasi-random allocation process, or a non-objective measurement of performance) (38–46). In all, 57 randomized controlled trials met all the inclusion criteria (12,13,15,47–100).

Description of Studies and Risk of Bias

Tables 2–4 present information about the characteristics of each included study. There were 21 trials assessing the Gate Control mechanism (13,52–59,71,89–99), 10 assessing the DNIC mechanism (15,51,60–66,100), and 26 assessing the CNSC mechanism (12,47–50,67–70,72–88). Included interventions were: water immersion during labor and/or birth, light massage, warm packs, ambulation, labor positions, and birth ball (Gate Control mechanism); acupuncture, acupressure, high intensity, low frequency Transcutaneous Electrical Nerve Stimulation, and sterile water injections (DNIC mechanism); psychosocial preparation for childbirth (antenatal education), aromatherapy, and continuous or discontinuous labor support provided by professionals or nonprofessionals (CNSC mechanism). The total number of included women was 34,300, with 6,029 for the Gate Control mechanism, 3,671 for the DNIC, and 24,600 for the CNSC mechanism. Risk of bias was "low" for 36 trials and "unclear" for 16 trials. Five trials presented a potential risk of bias (Fig. 2). Main reasons for the presence of bias were: allocation of participant not adequately concealed (allocation concealment); outcomes assessed with regard to the woman's group assignment (blinding); more than 20 percent of the data initially randomized were not available for analysis (attrition bias); and presence of a potential contamination bias between the intervention and the control group (60,77,82,90,93).

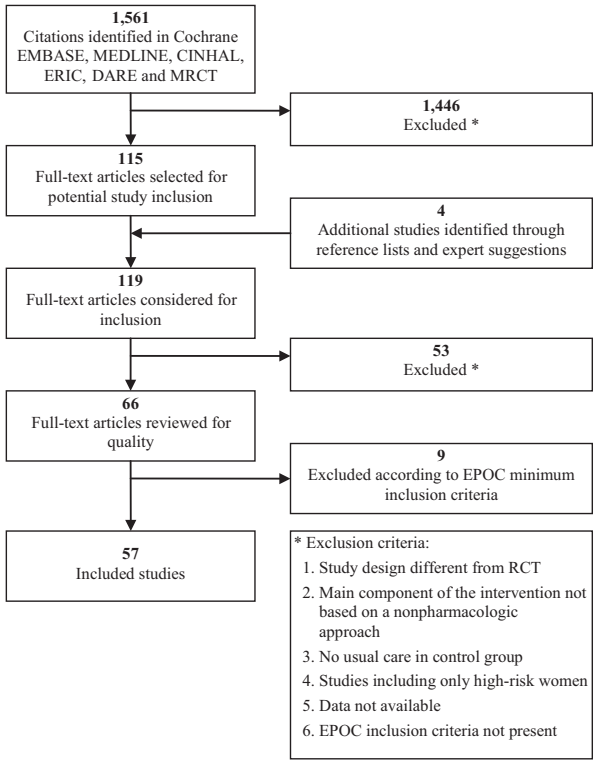

*Fig. 1. Study eligibility flow chart. *Effective Practice and Organization of Care (EPOC) Group. RCT = Randomized controlled trial.*

Effectiveness of the Gate Control, DNIC, and CNSC Mechanisms

Mode of delivery, obstetric interventions during labor, labor outcomes, and maternal and neonatal morbidity were considered for meta-analysis in this review. For all analyses, usual care group was compared with the intervention group (i.e., Gate Control mechanism, DNIC mechanism, and CNSC mechanism). Between 2 to 27 trials contributed to each meta-analysis. When only one study was identified for an outcome, the result from this trial has been reported without doing a meta-analysis. For each meta-analysis, including trials with a potential risk of bias, sensitivity analyses were performed removing these trials (60,77,82,90,93). In each case, sensitivity analyses did not change the interpretation of the results. No evidence of publication bias was observed through the Begg's funnel plot for the primary outcomes of the three nonpharmacologic mechanisms compared with usual care.

The three proposed mechanisms (Gate Control, DNIC, and CNSC) showed a gradient of effects on obstetric interventions. All mechanisms were found to significantly reduce the need for epidural, while only the CNSC mechanism showed an effect on other obstetric interventions (Tables 5–7). When compared with nonpharmacologic approaches based on the Gate Control mechanism (water immersion, light massage, ambulation, positions, and birth ball), usual care is associated with an increased odds of epidural analgesia OR 1.22 (95% CI 1.04–1.43), labor pain (VAS score 0–10, mean difference = 1.1, 95% CI 0.3–1.9), and use of oxytocin during labor OR 1.25 (95% CI 1.04–1.50) (Table 5). Among these approaches, only those based on ambulation during labor showed a significant reduction in cesarean delivery compared with the usual care

group OR 1.64 (95% CI 1.05–2.54). When compared with nonpharmacologic approaches based on the DNIC mechanism (acupressure, acupuncture, high intensity, and low frequency Transcutaneous Electrical Nerve Stimulation, sterile water injections), usual care is associated with an augmentation of epidural analgesia OR 1.62 (95% CI 1.18–2.21), labor pain (VAS score 0–100, mean difference = 10.3, 95% CI 4.7–15.9), and a lesser maternal satisfaction with childbirth (Table 6). Two other trials found that women reported themselves to feel safer, more relaxed, or more in control in the DNIC group compared with usual care. These findings are supported by several meta-analyses with respect to specific Gate Control or DNIC approaches, such as

Table 2. Studies Comparing Nonpharmacologic Approaches Addressing the Gate Control Mechanism versus Usual Care

Study	*Country*	*Design*	n	*Intervention group*	*Quality**	*Risk of bias*†
Barbosa et al (53)	Brazil	RCT	114	Water immersion	Good	Low
Eckert et al (54)	Australia	RCT	274	Water immersion	Good	Low
Ohlsson et al (56)	Sweden	RCT	1,247	Water immersion	Good	Unclear
Rush et al (59)	Canada	RCT	785	Water immersion	Good	Low
Cammu et al (13)	Belgium	RCT	109	Water immersion	Good	Low
Schorn (55)	USA	RCT	96	Water immersion	Good	Unclear
Woodward, Kelly (52)	UK	RCT	60	Water immersion	Good	Low
Da Silva et al (95)	Brazil	RCT	114	Water immersion	Good	Low
Nikodem (96)	South Africa	RCT	120	Water immersion	Good	Low
Taha (97)	South Africa	RCT	120	Water immersion	Good	Low
Hur, Hye (58)	South Korea	RCT	48	Massage (Back)	Fair	Unclear
Dahlen (57)	Australia	RCT	1,077	Massage (Warm packs)	Good	Low
Taavoni et al (71)	Iran	RCT	52	Massage (Birth ball)	Good	Low
Chang et al (98)	Taïwan	RCT	60	Massage	Good	Unclear
Karami et al (99)	Iran	RCT	60	Massage	Good	Low
Ben Regaya et al (89)	Tunisia	RCT	200	Ambulation	Good	Low
Bloom et al (91)	UK	RCT	1,067	Ambulation	Poor	Unclear
MacLennan et al (92)	Australia	RCT	196	Ambulation	Poor	Low
Phumdoung et al (93)	Thaliand	RCT	83	Position (Cat)‡	Fair	Potential
Andrews, Chrzanowski (90)	USA	RCT	40	Position (Upright)	Good	Potential
Miqueluti et al (94)	Brazil	RCT	107	Position (Upright)	Good	Unclear

**Quality of the implementation of interventions, with respect to the activation of one of the three endogenous mechanisms. †Risk of Bias criteria according to the Cochrane and Effective Practice and Organization of Care Risk of Bias Tool. RCT = Randomized controlled trial. ‡The position whereby women lean on the inclined head of the bed and the knee is bent on the bed.*

Table 3. Studies Comparing Nonpharmacologic Approaches Addressing the DNIC Mechanism versus Usual Care

Study	*Country*	*Design*	n	*Intervention group*	*Quality* *	*Risk of bias*†
Borup et al (15)	Denmark	RCT	607	Acupuncture	Good	Low
Ramnero et al (64)	Sweden	RCT	100	Acupuncture	Good	Low
Mac Kenzie et al (62)	UK	RCT	52	Acupuncture	Good	Low
Nesheim et al (100)	Norway	RCT	198	Acupuncture	Good	Unclear
Ziaei, Hajipour (63)	Iran	RCT	60	Acupuncture	Good	Unclear
Ma et al (61)	China	RCT	133	Acupuncture (Electro)	Good	Low
Hjelmstedt et al (66)	India	RCT	2,313	Acupressure	Fair	Low
Chung et al (65)	Taiwan	RCT	127	Acupressure	Good	Low
Labrecque et al (51)	Canada	RCT	22	Sterile water injections	Fair	Low
Van Der Spark (60)	Germany	RCT	59	TENS (High intensity)	Fair	Potential

**Quality of the implementation of interventions, with respect to the activation of one of the three endogenous mechanisms. †Risk of Bias criteria according to the Cochrane and Effective Practice and Organization of Care Risk of Bias Tool. RCT = Randomized controlled trial; DNIC = Diffuse noxious inhibitory control; TENS = Transcutaneous electrical nerve stimulation.*

Table 4. Studies Comparing Nonpharmacologic Approaches Addressing the CNSC Mechanism versus Usual Care

Study (Reference No.)	*Country*	*Design*	n	*Intervention group*	*Quality**	*Risk of bias†*
Maimburg et al (72)	USA	RCT	1,193	Antenatal education	Good	Unclear
Ip et al (69)	China	RCT	192	Antenatal education	Good	Low
Bergstrom et al (12)	Sweden	RCT	1,083	Antenatal education	Good	Unclear
Kimber et al (81)	UK	RCT	60	Antenatal education	Good	Unclear
Chuntaparat et al (49)	Thailand	RCT	66	Antenatal education	Good	Low
Bastani et al (67)	Iran	RCT	110	Antenatal education	Good	Low
Burns et al (70)	Italy	RCT	513	Aromatherapy	Poor	Low
McGrath, Kennell (75)	USA	RCT	420	Continuous doula support‡	Good	Low
Gordon et al (82)	USA	RCT	314	Continuous doula support‡	Good	Potential
Langer et al (83)	Mexico	RCT	713	Continuous doula support‡	Good	Low
Kennell et al (74)	USA	RCT	416	Continuous doula support‡	Good	Low
Campbell et al (68)	USA	RCT	600	Continuous doula support‡	Good	Unclear
Campbell et al (88)	USA	RCT	600	Continuous doula support‡	Good	Unclear
Gagnon, Waghorn (84)	Canada	RCT	100	One to one support from nurse	Good	Low
Gagnon et al (48)	Canada	RCT	413	One to one support from nurse	Good	Low
Hodnett et al (73)	Canada	RCT	6,915	Continuous support from nurse	Good	Low
Kashanian et al (87)	Iran	RCT	100	Continuous midwife support‡	Good	Low
Huang et al (85)	China	RCT	6,758	Continuous midwife support‡	Fair	Unclear
Harvey et al (78)	Canada	RCT	194	Continuous midwife support‡	Good	Unclear
Bréart et al (86)	Europe	RCT	2,153	Continuous midwife support	Fair	Unclear
Hemminki et al (77)	Finland	RCT	140	Continuous midwife support‡	Good	Potential
Hofmeyr (76)	South Africa	RCT	188	Laywoman as companionship	Good	Low
Torres et al (50)	Chile	RCT	435	Laywoman as companionship	Good	Low
Madi et al (79)	Bostwana	RCT	109	Female relative as companionship	Good	Low
Morhason-Bello et al (80)	Nigeria	RCT	603	Companion as labor support‡	Good	Low
Bruggemann et al (47)	Brazil	RCT	212	Companion as labor support	Good	Low

**Quality of the implementation of interventions, with respect to the activation of one of the three endogenous mechanisms. †Risk of Bias criteria according to the Cochrane and Effective Practice and Organization of Care Risk of Bias Tool. ‡Tailored intervention: nonpharmacologic interventions activating at least two mechanisms during labor targeting both sensory-discriminative and motivational-affective components of pain. RCT = Randomized controlled trial; CNSC = Central nervous system control.*

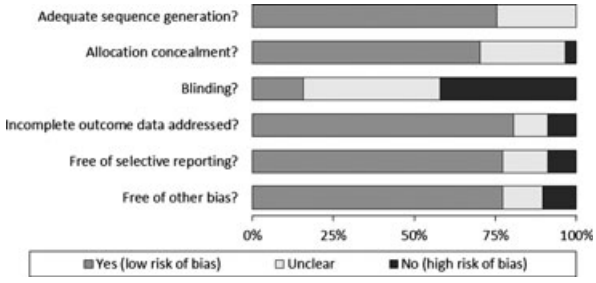

Fig. 2. Summary of the Risk of Bias among the 57 included studies.

water immersion, positions, light massage, and acupuncture (7,17,18,101), where they have been found to play a significant role in improving women's satisfaction with labor, reducing labor pain, and the need for pharmacologic management, but do not seem to be associated with a reduction in other obstetric interventions nor have an effect on neonatal outcomes (7,17,18,101).

The CNSC was the most effective mechanism to reduce obstetric interventions. When compared with nonpharmacologic approaches based on the CNSC mechanism (antenatal education, attention deviation, continuous support), usual care is associated with an augmentation of epidural analgesia OR 1.13 (95% CI 1.05–1.23), cesarean delivery OR 1.60 (95% CI 1.18–2.18), instrumental delivery OR 1.21 (95% CI 1.03–1.44), use of oxytocin OR 1.20 (95% CI 1.01–1.43), duration of labor (29.7 min, 95% CI 4.5–54.8), neonatal resuscitation OR 1.11 (95% CI 1.01–1.23), and a lesser satisfaction with childbirth (Table 7). These findings support the results of Hodnett's meta-analysis on the effectiveness of labor support for reducing obstetric interventions (9).

Heterogeneity and Subgroups Analysis

A significant heterogeneity for primary outcomes was mainly detected among studies assessing nonpharmacologic pain relief approaches based on the CNSC mechanism (Table 7). For cesarean section, all subgroup analysis for study time period and parity showed a significant risk of cesarean section in the usual care group compared with CNSC mechanism group. Analyses also showed that continuous support was the most effective intervention to reduce cesarean section rates, while antenatal education did not show a significant effect.

Finally, subgroup analyses also suggested that nonpharmacologic approaches based on continuous support and activating at least one more mechanism (tailored interventions) were most effective for reducing cesarean delivery OR 2.17 (95% CI 1.30–3.61), instrumental delivery OR 1.78 (95% CI 1.06–2.98), epidural analgesia OR 1.42 (95% CI 1.15–1.76), need of oxytocin OR

Table 5. Gate Control: Usual Care versus Nonpharmacologic Pain Relief

Outcomes - Gate control	*RCT*	n	*Statistical method*	I^2	*Overall effect*†	*GRADE score*†
Primary outcomes						
Cesarean delivery	13	5,039	OR (M-H, Fixed, 95% CI)	16%	1.04 [0.80–1.35]	Moderate
Ambulation	3	1,463	OR (M-H, Fixed, 95% CI)	33%	1.64 [1.05–2.54]*	Moderate
Water immersion	8	2,799	OR (M-H, Fixed, 95% CI)	0%	0.81 [0.57–1.16]	Moderate
Massage	2	777	OR (M-H, Fixed, 95% CI)	0%	0.76 [0.32–1.79]	Low
Instrumental delivery	12	4,946	OR (M-H, Fixed, 95% CI)	14%	1.15 [0.96–1.38]	Moderate
Epidural analgesia	6	3,369	OR (M-H, Fixed, 95% CI)	4%	1.22 [1.04–1.43]**	Moderate
Secondary outcomes						
Labor outcomes						
1st stage of labor duration (min)	9	2,677	WMD (IV, Random, 95% CI)	55%	28.29 [−8.17–64.75]	Low
2nd stage of labor duration (min)	11	3,605	WMD (IV, Random, 95% CI)	79%	3.00 [−4.99–11.00]	Low
Use of oxytocin during labor	10	2,672	OR (M-H, Fixed, 95% CI)	24%	1.25 [1.04–1.50]**	Moderate
1990–1999	5	2,095	OR (M-H, Fixed, 95% CI)	0%	1.15 [0.93–1.43]	Moderate
2000–2010	5	577	OR (M-H, Fixed, 95% CI)	35%	1.59 [1.11–2.27]**	Moderate
Maternal outcomes						
Episiotomy	11	3,602	OR (M-H, Fixed, 95% CI)	9%	1.13 [0.96–1.32]	Moderate
Labor pain (VAS score 0–10)	3	278	WMD (IV, Random, 95% CI)	77%	1.09 [0.33–1.85]*	Low
Perineal tear (III and IV)	6	3,184	OR (M-H, Fixed, 95% CI)	38%	1.14 [0.79–1.66]	Moderate
Urinary incontinence at 3 mo	1	530	OR (95% CI)	NA	2.68 [1.63–4.41]**	Low
Feeling in control	1	232	MD (95% CI)	NA	−3.55 [−10.41–3.31]	Low
Anxiety (1st stage of labor)	1	60	MD (95% CI)	NA	16.27 [5.28–27.25]*	Very low
Anxiety (2nd stage of labor)	1	60	MD (95% CI)	NA	8.93 [−3.14–21.01]	Very low
Overall experience of childbirth	1	232	MD (95% CI)	NA	−5.88 [−11.85–0.09]	Low
No breastfeeding at discharge	3	430	OR (M-H, Fixed, 95% CI)	0%	0.71 [0.38–1.34]	Low
Neonatal outcomes						
Apgar score < 7 (1 min)	5	860	OR (M-H, Fixed, 95% CI)	0%	0.73 [0.47–1.11]	Moderate
Apgar score < 7 (5 min)	8	2,349	OR (M-H, Fixed, 95% CI)	0%	0.66 [0.36–1.24]	Moderate
ICU admission	7	2,197	OR (M-H, Fixed, 95% CI)	23%	1.07 [0.75–1.54]	Moderate
Resuscitation	2	474	OR (M-H, Random, 95% CI)	81%	2.06 [0.68–6.21]	Low
Fractured clavicle	1	1,237	OR (95% CI)	NA	1.31 [0.45–3.80]	Low
Tachypnea	1	1,237	OR (95% CI)	NA	0.98 [0.34–2.81]	Low
Neonatal seizures	1	1,237	OR (95% CI)	NA	0.98 [0.06–15.69]	Low

**Significant < 0.05; **Highly significant < 0.01. †Dichotomous overall effect < 1.00 (More events in Gate Control group) and ≥ 1.00 (More events in usual care group). Continuous overall effect < 0 (Mean higher in Gate Control group) and ≥ 0 (Mean higher in usual care group. ‡Grading of Recommendations, Assessment, Development and Evaluations (GRADE): scoring system used for Clinical Evidence reviews (high, moderate, low, and very low), and assessing design, quality, consistency, directness, and effect size of studies for each outcome, according to the GRADE Working Group (129). RCT = Randomized Controlled Trial; WMD = Weighted mean difference; MD = Mean difference; I^2 = Heterogeneity assessment; M-H = Mantel-Haenszel method; IV = Inverse variance method; ICU = Intensive care unit.*

Table 6. Diffuse Noxious Inhibitory Control (DNIC): Usual Care versus Nonpharmacologic Pain Relief

Outcomes - DNIC	*RCT*	n	*Statistical method*	I^2	*Overall effect*[†]	*GRADE score*[‡]
Primary outcomes						
Cesarean delivery	6	866	OR (M-H, Fixed, 95% CI)	36%	1.52 [0.98–2.35]	Moderate
Instrumental delivery	5	981	OR (M-H, Fixed, 95% CI)	24%	1.20 [0.83–1.74]	Moderate
Epidural analgesia	6	920	OR (M-H, Fixed, 95% CI)	20%	1.62 [1.18–2.21]*	Moderate
Secondary outcomes						
Labor outcomes						
1st stage of labor duration (min)	3	374	WMD (IV, Random, 95% CI)	78%	23.5 [−53.6–100.7]	Low
2nd stage of labor duration (min)	2	293	WMD (IV, Fixed, 95% CI)	0%	0.34 [−4.37–5.04]	Low
Use of oxytocin during labor	5	824	OR (95% CI)	0%	1.14 [0.85–1.52]	Moderate
Failure to progress in the 1st stage	1	78	OR (95% CI)	NA	2.24 [0.58–8.57]	Very low
Failure to advance in the 2nd stage	1	78	Peto OR (95% CI)	NA	21.76 [1.91–247.71]*	Very low
Maternal outcomes						
Episiotomy	1	142	OR (95% CI)	NA	0.62 [0.24–1.63]	Very low
Labor Pain (VAS score 0–100)	1	142	MD (95% CI)	NA	10.30 [4.69–15.91]**	Very low
Felt safe	1	463	OR (95% CI)	NA	0.63 [0.41–0.97]*	Low
Felt relaxed	1	463	OR (95% CI)	NA	0.56 [0.34–0.92]*	Low
Felt in control with the situation	1	463	OR (95% CI)	NA	0.56 [0.36–0.87]*	Low
Experience of childbirth	1	142	MD (95% CI)	NA	−8.80 [−17.06 – −0.54]*	Very low
Neonatal outcomes						
Apgar score < 7 (1 min)	1	100	OR (95% CI)	NA	5.42 [0.25–115.83]	Very low
Apgar score < 7 (5 min)	1	198	Peto OR (95% CI)	NA	0.38 [0.02–9.45]	Very low
Fetal heart rate altered	1	78	OR (95% CI)	NA	0.38 [0.04–3.40]	Very low

**Significant < 0.05; **Highly significant < 0.01. †Dichotomous overall effect < 1.00 (More events in DNIC control group) and ≥ 1.00 (More events in usual care group). Continuous overall effect < 0 (Mean higher in DNIC control group) and ≥ 0 (Mean higher in usual care group). ‡Grading of Recommendations, Assessment, Development and Evaluations (GRADE): scoring system used for Clinical Evidence reviews (high, moderate, low, and very low), and assessing design, quality, consistency, directness, and effect size of studies for each outcome, according to the GRADE Working Group (129). RCT = Randomized Controlled Trial; WMD = Weighted mean difference; MD = Mean difference; I^2 = Heterogeneity assessment; M-H = Mantel-Haenszel method; IV = Inverse variance method; Peto = Peto method for hazard ratio; VAS = Visual analog scale.*

1.57 (95% CI 1.01–2.43), and total duration of labor (WMD = 73.8 min, 95% CI 42.6–105.0) (Table 7). These tailored interventions (Table 4) were mainly based on interventions activating at least two mechanisms, including the CNSC, and targeting both the sensory-discriminative and motivational-affective components of pain. The CNSC mechanism creates a favorable environment for women to feel encouraged and cared for, significantly modulating the affective component of pain, while the addition of another physical mechanism (Gate Control or DNIC) helps reduce the intensity of pain. According to Niven 1996, the more pain-coping strategies a woman had, the less likely she was to experience pain (102). Anxiety and suffering may be experienced when women have insufficient resources or support during labor and are unable to cope (103,104). Feeling alone, fearful, or stressed can lead to suffering. The use of tailored interventions, as a primary method to relieve pain, may decrease maternal anxiety and have the potential to ameliorate or even prevent suffering (103), increasing maternal satisfaction with childbirth.

Discussion

Nonpharmacologic approaches to relieve pain during labor can provide significant benefits to women and their infants depending on the activated mechanism. Nonpharmacologic approaches based on the Gate Control and DNIC mechanism, which modulate mainly the intensity of pain, are associated with a reduction in intrapartum epidural analgesia, and a better experience of childbirth. Nonpharmacologic approaches based on the CNSC mechanism, which mainly modulate the pain unpleasantness, are associated with a reduction in epidural rate and a significant reduction in cesarean and instrumental delivery, use of oxytocin, and duration of labor, and contribute to improved maternal satisfaction with childbirth and neonatal outcomes. Moreover, tailored

Table 7. Central Nervous System Control (CNSC): Usual Care versus Nonpharmacologic Pain Relief

Outcomes - CNSC	*RCT*	n	*Statistical method*	I^2	*Overall effect*†	*GRADE score*‡
Primary outcomes						
Cesarean delivery	27	23,860	OR (M-H, Random, 95% CI)	91%	1.60 [1.18–2.18]*	Moderate
1990–1999	14	5,249	OR (M-H, Random, 95% CI)	41%	1.31 [1.03–1.67]*	Moderate
2000–2010	13	18,611	OR (M-H, Random, 95% CI)	95%	1.76 [1.09–2.85]*	Moderate
Nulliparous	17	7,822	OR (M-H, Random, 95% CI)	48%	1.31 [1.08–1.60]*	Moderate
Continuous support	21	20,837	OR (M-H, Random, 95% CI)	93%	1.63 [1.12–2.37]**	Moderate
Antenatal education	4	2,510	OR (M-H, Random, 95% CI)	42%	1.40 [0.98–2.02]	Moderate
Tailored intervention	11	10,338	OR (M-H, Random, 95% CI)	91%	2.17 [1.30–3.61]**	High
Instrumental delivery	21	15,591	OR (M-H, Random, 95% CI)	50%	1.21 [1.03–1.44]*	Moderate
1990–1999	13	5,055	OR (M-H, Random, 95% CI)	59%	1.35 [1.03–1.77]*	Moderate
2000–2010	8	10,536	OR (M-H, Random, 95% CI)	0%	1.03 [0.92–1.15]	Moderate
Nulliparous	14	7,090	OR (M-H, Random, 95% CI)	63%	1.30 [1.03–1.63]*	Moderate
Continuous support	15	12,568	OR (M-H, Random, 95% CI)	62%	1.32 [1.06–1.64]*	Moderate
Antenatal education	4	2,510	OR (M-H, Random, 95% CI)	0%	0.95 [0.76–1.19]	Moderate
Tailored intervention	6	2,281	OR (M-H, Random, 95% CI)	56%	1.78 [1.06–2.98]*	Moderate
Epidural analgesia	11	11,957	OR (M-H, Fixed, 95% CI)	41%	1.13 [1.05–1.23]**	High
Tailored intervention	5	2,207	OR (M-H, Fixed, 95% CI)	29%	1.42 [1.15–1.76]**	High
Secondary outcomes						
Labor outcomes						
1st stage of labor duration (min)	5	799	WMD (IV, Random, 95% CI)	84%	20.2 [−41.2–81.5]	Moderate
2nd stage of labor duration (min)	6	1,397	WMD (IV, Random, 95% CI)	73%	2.7 [−5.1–10.5]	Moderate
Total Duration of labor (min)	13	4,276	WMD (IV, Random, 95% CI)	54%	29.7 [4.5–54.8]*	Moderate
Nulliparous	9	3,916	WMD (IV, Random, 95% CI)	51%	32.8 [8.7–56.9]*	Moderate
Continuous support	10	4,090	WMD (IV, Random, 95% CI)	45%	32.9 [10.2–55.7]*	Moderate
Antenatal education	3	186	WMD (IV, Random, 95% CI)	76%	−16.5 [−157.8–124.8]	Low
Tailored intervention	4	1,254	WMD (IV, Random, 95% CI)	0%	73.8 [42.6–105.0]**	Moderate
Use of oxytocin during labor	19	14,293	OR (M-H, Random, 95% CI)	72%	1.20 [1.01–1.43]*	Moderate
Nulliparous	13	5,966	OR (M-H, Random, 95% CI)	75%	1.31 [1.03–1.67]*	Moderate
Continuous support	14	12,401	OR (M-H, Random, 95% CI)	79%	1.27 [1.02–1.58]*	Moderate
Antenatal education	4	1,379	OR (M-H, Random, 95% CI)	0%	1.05 [0.85–1.31]	Moderate
Tailored intervention	6	2,207	OR (M-H, Random, 95% CI)	79%	1.57 [1.01–2.43]*	Moderate
Maternal outcomes						
Episiotomy	3	8,302	OR (M-H, Random, 95% CI)	70%	1.09 [0.72–1.64]	Moderate
Abnormal bleeding	2	13,673	OR (M-H, Fixed, 95% CI)	48%	1.69 [1.18–2.42]*	Moderate
Perineal tear (III and IV)	1	6,915	OR (95% CI)	NA	1.12 [0.91–1.37]	Low
Transfusion	1	6,915	OR (95% CI)	NA	1.42 [0.68–2.97]	Low
Hemorrhage	2	7,109	OR (M-H, Fixed, 95% CI)	0%	0.95 [0.71–1.26]	Moderate
Fever	3	7,525	OR (M-H, Random, 95% CI)	84%	1.59 [0.29–8.79]	Moderate
Antibiotics	1	6,915	OR (95% CI)	NA	1.01 [0.87–1.17]	Low
Labor pain (VAS score 0–100)	2	120	WMD (IV, Fixed, 95% CI)	0%	3.25 [−2.94–9.45]	Low
Birth pain (VAS score 0–100)	2	120	WMD (IV, Fixed, 95% CI)	12%	7.94 [−3.77–19.64]	Low
Severe labor pain	4	2,457	OR (M-H, Random, 95% CI)	75%	1.02 [0.69–1.53]	Low
Positive experience of childbirth	3	1,993	OR (M-H, Fixed, 95% CI)	33%	0.29 [0.23–0.37]**	High
Negative experience of childbirth	10	10,246	OR (M-H, Random, 95% CI)	84%	2.00 [1.43–2.80]**	Moderate

(continued)

Table 7. ***Continued***

Outcomes - CNSC	*RCT*	n	*Statistical method*	I^2	*Overall effect*†	*GRADE score*‡
Anxiety (1st stage of labor), VAS 10	1	133	MD (95% CI)	NA	1.72 [2.82–6.10]**	Very low
Anxiety (2nd stage of labor), VAS 10	1	133	MD (95% CI)	NA	1.25 [0.20–2.30]*	Very low
Described labor as very easy	5	1,117	OR (M-H, Fixed, 95% CI)	11%	0.39 [0.30–0.50]**	High
Breastfeeding at 1–2 mo	4	5,677	OR (M-H, Fixed, 95% CI)	31%	1.03 [0.92–1.15]	Moderate
Exclusive breastfeeding at 1 mo	1	655	OR (95% CI)	NA	0.58 [0.34–0.98]*	Low
Neonatal outcomes						
Apgar score < 7 (1 min)	6	8,718	OR (M-H, Fixed, 95% CI)	14%	1.16 [1.00–1.34]*	High
Apgar score < 7 (5 min)	12	12,349	OR (M-H, Fixed, 95% CI)	0%	1.28 [0.93–1.76]	Moderate
ICU admission	9	9,151	OR (M-H, Random, 95% CI)	56%	1.15 [0.72–1.83]	Moderate
Resuscitation	3	7,069	OR (M-H, Fixed, 95% CI)	38%	1.11 [1.01–1.23]*	Moderate
Seizures	1	6,949	OR (95% CI)	NA	1.25 [0.34–4.62]	Low
Major birth trauma	1	6,949	OR (95% CI)	NA	0.77 [0.34–1.76]	Low
Respiratory distress	2	13,707	OR (M-H, Fixed, 95% CI)	0%	1.13 [0.98–1.30]	Low
Fetal heart altered	2	7,127	OR (M-H, Fixed, 95% CI)	0%	1.25 [1.00–1.58]*	Low

*Tailored intervention: nonpharmacologic interventions activating at least two mechanisms during labor. *Significant < 0.05; **Highly significant < 0.01. †Dichotomous overall effect < 1.00 (More events in CNSC group) and ≥ 1.00 (More events in usual care group). Continuous overall effect < 0 (Mean higher in CNSC group) and ≥ 0 (Mean higher in usual care group). ‡Grading of Recommendations, Assessment, Development and Evaluations (GRADE): scoring system used for Clinical Evidence reviews (high, moderate, low, and very low), and assessing design, quality, consistency, directness, and effect size of studies for each outcome, according to the GRADE Working Group (129). RCT = Randomized Controlled Trial; M-H = Mantel-Haenszel method; IV = Inverse variance method; I^2 = Heterogeneity assessment.*

nonpharmacologic approaches that modulate both components of labor pain and include continuous support have been found to be the most effective strategy for reducing obstetric interventions when compared with usual care.

Intensity and Unpleasantness of Pain

The Gate Control and the DNIC mechanisms have been found to mainly reduce the intensity or the sensory-discriminative (objective) component of pain (29–33), which primarily assesses the physical aspect of pain and is relatively stable (105). This effect is shown in a reduction in the epidural rate and not in the obstetric interventions rate. On the other hand, the CNSC mechanism mainly reduces the unpleasant or motivational-affective (subjective) component of pain, which is easily modulated and gives us information on how well a woman is coping with her pain (34,35). The CNSC mechanism (antenatal education, attention deviation mindfulness, and support) acts on a woman's experience with labor pain and on her ability to deal with it (34), which is reflected in a reduction in obstetric interventions and in a small reduction in the need for epidural. This last finding may be explained by the main action of the CNSC mechanism on pain unpleasantness, enhancing the woman's ability to deal with labor pain without substantially decreasing the intensity of the sensory component of pain (103). An epidural may then be necessary to assist women in coping with labor pain, in addition to nonpharmacologic approaches. It has been demonstrated that emotions play an important role in the perception of pain (103–115). According to Lowe 2002: "*Anxiety is commonly associated with increased pain during labor and may modify labor pain through psychologic and physiologic mechanisms. Although some anxiety is considered normal for women during labor, excessive anxiety produces increased catecholamine secretion that may actually augment nociceptive stimuli from the pelvis and magnify the perception of nociceptive stimuli at the cortical level*" (103). A positive outlook on childbirth coupled with continuous active support during all phases of labor and delivery contribute to increase women's confidence in their ability to give birth. Through the use of the CNSC mechanism and a *teamwork* approach, health professionals and birth supporters help increase the woman's ability to deal with her anxiety and fears, enhancing her confidence in the birthing process (103). While remaining calm, confident, and satisfied throughout the birthing process, women may also, more readily accept the use of pharmacology as a complement to nonpharmacologic approaches when the latter become insufficient. The

combination of nonpharmacologic and pharmacologic approaches, grounded in a continuum of care, seems to be an important key factor explaining the findings on obstetric interventions and clinical outcomes observed with the CNSC mechanism.

Working with Pain and Pain Relief

Leap and Anderson introduced the paradigm of "*working with pain*" versus "*pain relief*" to illustrate the different approaches to pain management (116). The *pain relief* paradigm is based on a set of beliefs including the conviction that labor pain is unnecessary in a modern society; that the benefits of analgesia outweigh the risks; and that women should not be made to feel guilty if they choose pain relief (116). The *working with pain* paradigm is based on the view that pain is an important part of the physiology of normal labor and that, given an optimal support, a woman can cope with levels of pain because of the production of the body's natural pain-relieving opiates and endorphins (117–124). During labor, pain plays an important role in the production of natural pain relief hormones, such as endogenous oxytocin and endorphins, which also contribute to regulate uterine contractions (117,125–128). Anxiety may disrupt this production, disturbing uterine contractions which may lead to increasing medical interventions. A key role for the caregivers is then to reduce stimulation to the woman's senses so as to create the optimal environment for the release of the endogenous hormones by making women feel safe, unobserved, and private (116,127). This paradigm allows caregivers and birth supporters to assist women in working with both components of labor pain rather than only address the intensity of labor pain.

Our findings showed that pharmacologic pain relieving interventions, used in addition to nonpharmacologic approaches, can contribute to reducing medical interventions, and thus represent an important part of *intrapartum* care, if not used routinely as the first method for pain relief. Women can feel intense pain during labor and be able to cope with it because of the pain modulating effect provided by nonpharmacologic approaches. However, in some situations, nonpharmacologic approaches may become insufficient, and suffering may be experienced, increasing maternal anxiety and the risk of obstetric interventions. The use of pharmacologic approaches could then be beneficial to reduce pain intensity to prevent suffering and help women cope with labor pain.

With respect to these results, it appears reasonable to suggest that nonpharmacologic approaches, that modulate both components of labor pain, should be considered as primary methods of pain management by women and health professionals; and that pharmacologic approaches should be used in addition to nonpharmacologic approaches if the latter become insufficient to help women work with labor pain. In all cases, pain modulation through the CNSC (emotional and physical support) should be used in addition to at least one other pain modulating mechanism (DNIC or Gate Control). In addition, birth settings and hospital policies related to childbirth should facilitate a supportive birthing environment and should make readily available a broad spectrum of nonpharmacologic and pharmacologic pain relief approaches to allow caregivers to efficiently counsel and guide women and birth supporters in a team work approach, increasing the women's ability to deal with their anxiety and fears, and enhancing their confidence in the birthing process.

Limitations of the Study

The definition of usual care varies among included studies. In some studies, usual care includes formal pharmacologic care for pain relief, while in others, nonpharmacologic care for pain relief may be a part of usual care, even if not used routinely. The presence of nonpharmacologic care in usual care may reduce power to observe a significant difference among these two approaches. Nonetheless, this bias does not influence the validity of results when significant differences are observed between the two groups. Birth settings were also different between studies making the interpretation of results difficult. Subgroup analysis and exploration of heterogeneity were conducted to minimize these biases and to strengthen the conclusion of this study.

Conclusion

Nonpharmacologic approaches to relieve pain during labor, when used as a part of hospital pain relief strategies, provide significant benefits to women and their infants without causing additional harm. The challenge is now to help caregivers gain expertise in the use of nonpharmacologic approaches, as in the integration of these approaches in clinical practices, to help women work with labor pain.

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Supporting Information

Additional Supporting Information may be found in the online version of this article:

Figure S3 (a): References for meta-analyses related to the Gate Control mechanism.

Figure S3 (b): References for meta-analyses related to the Diffuse Noxious Inhibitory Control (DNIC) mechanism.

Figure S3 (c): References for meta-analyses related to the Central Nervous System Control (CNSC) mechanism.