

# Swaddling: A Systematic Review

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## ABSTRACT

Swaddling was an almost universal child-care practice before the 18th century. It is still tradition in certain parts of the Middle East and is gaining popularity in the United Kingdom, the United States, and the Netherlands to curb excessive crying. We have systematically reviewed all articles on swaddling to evaluate its possible benefits and disadvantages. In general, swaddled infants arouse less and sleep longer. Preterm infants have shown improved neuromuscular development, less physiologic distress, better motor organization, and more self-regulatory ability when they are swaddled. When compared with massage, excessively crying infants cried less when swaddled, and swaddling can soothe pain in infants. It is supportive in cases of neonatal abstinence syndrome and infants with neonatal cerebral lesions. It can be helpful in regulating temperature but can also cause hyperthermia when misapplied. Another possible adverse effect is an increased risk of the development of hip dysplasia, which is related to swaddling with the legs in extension and adduction. Although swaddling promotes the favorable supine position, the combination of swaddling with prone position increases the risk of sudden infant death syndrome, which makes it necessary to warn parents to stop swaddling if infants attempt to turn. There is some evidence that there is a higher risk of respiratory infections related to the tightness of swaddling. Furthermore, swaddling does not influence rickets onset or bone properties. Swaddling immediately after birth can cause delayed postnatal weight gain under certain conditions, but does not seem to influence breastfeeding parameters.

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### Key Words

swaddling, systematic review, traditional care, sudden infant death syndrome, developmental dysplasia of the hip

### Abbreviations

SIDS—sudden infant death syndrome  
DDH—developmental dysplasia of the hip  
RCT—randomized, controlled trial  
HR—heart rate  
QS—quiet sleep  
REM—rapid eye movement  
SpO<sub>2</sub>—pulse oxygen saturation  
VLBW—very low birth weight

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SOME DEGREE OF infant restraint, known as swaddling (also called binding or bundling), with or without the use of a cradleboard was an almost universal child-care practice before the 18th century.<sup>1</sup> Swaddling is still common in some countries in the Middle East and South America and is gaining popularity in the United Kingdom, the United States, and the Netherlands.<sup>2-4</sup>

In this review, all known studies of swaddling were included. Most studies were descriptive and not randomized, uncontrolled, or comparative. Many results, therefore, comprised opinions and perceptions. The 9 randomized comparative studies of good quality will be discussed separately.

A historical overview of swaddling and its practice in relation to sleep state and arousal, temperature control, motor development, sudden infant death syndrome (SIDS), respiratory infections, bone development, developmental dysplasia of the hip (DDH), pain control, crying behavior, breastfeeding, and weight gain after birth and the duration of swaddling will be described.

## HISTORICAL REVIEW

The technique of swaddling varies from wrapping the infant in bands (the European way) to tightly folding blankets or sheets around the child (as practiced for example in South America and in countries of the former Soviet Union). Swaddling is of considerable interest, because the use of this practice is widely spread in many different societies. The Holy Bible describes infants winded in cloths, and one of the earliest illustrations of swaddling is of the infant Jesus.<sup>5</sup> A few centuries ago swaddling was used in most societies of the north temperate and subarctic regions, in the Mediterranean and Middle East areas, in Asia and South America, and many other parts of the world.<sup>4,6</sup> In 1971 almost 52% of 139 societies still used some form of infant restraint.<sup>7</sup> In 2003 swaddling was still common in the Middle East.<sup>8</sup>

In parts of the world where humidity and temperature are high, such as Africa, swaddling can promote skin infections; as an alternative, children are carried in a sling, often with a minimum of clothing.<sup>9</sup>

Swaddling already began to disappear in Europe before industrialization. One of the reasons for the decrease of swaddling is that in the 20th century it was confined to a few rural societies in eastern Europe.<sup>1</sup> Rousseau's enormously successful book *Emile*,<sup>10</sup> in which he described swaddling as "unnatural," could have contributed to this decrease.

In the 19th and 20th centuries, more "liberal" ideas concerning child rearing started to dominate. Another influence could be the "swaddling hypothesis."<sup>11-14</sup> According to this hypothesis, the restraint of swaddling leads to an adult personality structure that inclines people to alternate meek submission and ambivalently regarded authority, with explosive, excessive expression of emotion. "Adult Russians and Eastern Europeans who

were swaddled, learned that passivity and restraint are necessary to secure milk, love and freedom, which can then only be enjoyed in excessive outbursts of emotion which are ambivalent nonetheless, for the mother is both the cause of 'imprisonment' and the release from it."<sup>11,13</sup> This hypothesis was never really defined or tested but probably reflects the sentiments concerning swaddling in European society at the time.

Swaddling is still applied in various traditional societies, sometimes using a board or cradle.<sup>6</sup> However, in societies where it was virtually abandoned, there seems to be a revival of swaddling practices because of presumed favorable effects on infant behavior, especially its soothing effect on infants' crying.<sup>2,3</sup>

One should realize that there is not one method of swaddling but many variations both in start and duration of swaddling and type and tightness of wrappings used. Apart from its presumed benefits, there are serious considerations to be addressed concerning its possible detrimental effects, specifically in relation to the congenital dislocation of the hip, the development of acute respiratory infections, and the combination of swaddling with prone position for the risk of SIDS.<sup>15-17</sup> In the Netherlands, swaddling has rapidly gained popularity in the last 10 years, mainly because it is presumed that this traditional method curbs excessive crying in infants. Nowadays, ~8% of Dutch parents place their infants in the prone position to sleep.<sup>18</sup> Half of these parents do so because their infant cries excessively or sleeps poorly. It was shown in 1 study that in 80% of the cases of child battering, excessive crying preceded the violence.<sup>19</sup> Because in the last few years many reports were published on the effects of swaddling, we decided to conduct a systematic review on the effects of swaddling infants.

## METHODS

### Search Strategy

Electronic searches were conducted in PubMed (1966 to February 2007), PsycINFO (1887 to February 2007), Embase (1974 to February 2007), the Cochrane library (2007, Issue 1), and Blackwell Synergy (1990 to February 2007). We used the Medical Subject Headings (MeSH) heading swaddling. Manually searched reference lists were used also.

### Selection of Eligible Trials

All published randomized, controlled trials (RCTs) that evaluated the intervention of swaddling were included, as were all other studies on swaddling in relation to sleep state and arousal, temperature control, motor development, SIDS, (acute) respiratory infections, bone development, DDH, pain control, the effect on crying behavior, and breastfeeding and neonatal weight loss.

## RESULTS

Among the 78 articles reviewed, we identified 9 RCTs that met the criteria of the Cochrane Central Register of Controlled Trials (Table 1).<sup>20–28</sup> Of all articles reviewed, 9 were articles on swaddling in relation to sleep state and arousal, 8 articles described the effect of swaddling on temperature control, 6 articles discussed the effect of swaddling on motor development, 12 articles evaluated the risk of SIDS related to swaddling, 5 set out the relation between swaddling and the risk for (acute) respiratory infections, 1 article was on the relation between swaddling and rickets and bone properties, 14 articles involved swaddling-related DDH, 4 articles set out the effects of swaddling on pain control, and the effect on crying behavior was discussed in 4 articles. The effect on breastfeeding and neonatal weight loss was discussed in 1 article, and the mean duration of swaddling in different cultures was described in 5 articles. All articles reviewed, including the Cochrane RCTs, will be described according to subject.

### Effects on Sleep and Arousal

It is widely held that swaddling calms infants and induces sleep.<sup>6</sup> Several studies have been conducted on the effect of swaddling on sleep state and arousal.

Swaddling above the waist seems to increase daytime sleep periods and the total daytime sleep.<sup>29</sup> Lipton et al described in their case-control study<sup>1</sup> an increase in sleep, reduced levels of motor activity, fewer startles, and lower heart rate (HR) variability compared with nonswaddled infants. There was no decrease in the capacity to respond to stimulation; there was only a decrease in frequency of response to stimulation.

A large ethnological observational study among Navajo infants revealed a definite correlation between cradleboard use and lowered behavioral states.<sup>30</sup> Being swaddled on a cradleboard completely immobilizes an infant and presumably regulates the infant's level of physiologic arousal or responsiveness.

In a short-term laboratory nap study (Cochrane, clinical trial), swaddled infants had less startles during quiet sleep (QS) and rapid eye movement (REM) sleep, and a decrease in behavioral arousals during QS but not during REM sleep (Table 1).<sup>20</sup> Swaddling decreased the progression of sighs to startles in both QS and REM sleep, but the progression from startles to full arousal was decreased in QS but not in REM sleep. The percentage of brief arousals was increased in REM sleep during swaddled periods, whereas the average sleep duration when swaddled was increased. In QS, however, there was no difference in either brief arousals or average sleep duration.

Several case-control studies were conducted on swaddling and arousal. Swaddling and sleeping supine promotes a better efficiency of sleep, more QS, and fewer spontaneous awakenings compared with sleeping supine

but unswaddled.<sup>31</sup> However, when sleeping swaddled or restrained, less-intense auditory stimuli are needed to arouse the infants compared with the infants who were not swaddled.<sup>32</sup> This may explain the increase in brief arousals during REM sleep reported in the previously mentioned study. When sleeping supine, restrained infants have a significant greater and earlier decrease in HR to white-noise challenges than nonswaddled supine infants during REM sleep.<sup>33</sup> During QS, the respiratory rate increases slightly with swaddle tightness, whereas HR, inspiratory tidal volumes, relative minute volume, and pulse oxygen saturation (SpO<sub>2</sub>) do not change.<sup>34</sup> On the other hand, during REM sleep, there is a slight decrease in HR after tightening, whereas the respiratory rate, inspiratory tidal volume, volume, and SpO<sub>2</sub> did not show a significant difference. In a study in which swaddling was compared with a free condition, swaddling resulted in less arousal, less alert activity, more drowsiness, and more sleep.<sup>35</sup>

Overall, it is clear that swaddling stimulates sleep continuity, as shown under laboratory conditions and in descriptive studies. The effect is most consistent in periods of QS but not always consistent during REM sleep. Swaddling seems to inhibit each step from sighs through startles to full arousal in the arousal pathway. The restraint of the arms may inhibit the movements that are associated with a full extensor startle response. Prone sleeping probably also has this effect; it is associated with fewer arousals and better sleep than those in the supine position.<sup>20</sup> Swaddling a supine infant, therefore, seems to mitigate these differences. The difference in the physiologic effect of swaddling in QS and REM sleep need more research, however.

### Temperature Control

Many different populations have used swaddling to keep infants warm and comfortable.<sup>1,27,36–38</sup> Preliminary results of an RCT (Cochrane RCT) that compared the effects of swaddling (within 48 hours of birth) with use of an infant sleeping bag of equal thermal resistance suggested that infant core, peripheral, and microenvironmental temperature were no different in Gers (traditional circular single-room tents) or apartments, and no differences were found between swaddled and nonswaddled infants.<sup>27</sup> A case-control study (Cochrane RCT) showed that in very low birth weight (VLBW) infants in a heated double-walled incubator, abdominal temperature rose 0.2°C higher during swaddling, and infants required a lower incubator temperature.<sup>25</sup> Hyperthermia, however, could be a possible adverse effect of swaddling, especially when the head is also covered or in case of infection.<sup>37–40</sup>

In summary, there is evidence that swaddling can be favorable for temperature control, but there is a risk for hyperthermia when misapplied.

**TABLE 1 Characteristics of Cochrane RCTs**

	Gerard et al <sup>20</sup> (2002)	Short <sup>25</sup> (1998)	Neu and Browne <sup>22</sup> (1997)	Short et al <sup>21</sup> (1996)	Campos <sup>24</sup> (1989)	Ohgi et al <sup>23</sup> (2004)	Huang et al <sup>26</sup> (2004)	Tsoigt et al <sup>27</sup> (2006)
Interventions	Swaddled vs unswaddled	Swaddled vs unswaddled	Swaddled vs unswaddled	Swaddling vs standard positioning	Swaddling vs pacifier	Swaddling vs massage	Swaddling vs containment	Swaddling vs infant sleeping bag
No. of infants	26 (16 female, 10 male)	15 (VLBW)	14 (preterm)	50 (VLBW; 25 female, 25 male)	64 (32 at 2 wk, 32 at 2 mo)	25 (13 swaddled, 12 massaged)	32 (preterm)	80 (40 swaddled, 40 in infant sleeping bag)
Study duration	107 ± 7 min, single event during daytime nap	—	—	21.1 h/d (swaddling) and 1.6 h/d (control group)	Single event at 2 wk and 2 mo of age	3 wk (swaddling 3.4 times per day, massage 3.3 times per day)	5 min before to 11 min after heel stick	Periods of 24 h at ages 1 and 3 mo
Mean age	80 ± 7 d	29.1 ± 1.5 wk	32 wk gestational age	28 wk gestational age	2 wk and 2 mo	11 wk	37 wk gestational age	1 and 3 mo
Effect size	No change in sighs (in QS or REM sleep); less startles during QS ( $P < .02$ ) and REM sleep ( $P < .005$ ); decrease in behavioral arousals during QS ( $P < .001$ ); decrease of progressing sighs to startles in QS and REM sleep ( $P < .003$ and $0.0004$ ); decrease of progression startles to full arousal in QS ( $P < .006$ ); increase in brief arousals during REM sleep ( $P < .05$ ); increase in duration in REM sleep ( $P < .0005$ )	When swaddled: abdominal temperature 0.2°C higher and lower incubator temperature needed (mean: 26.9 ± 0.4) than when unswaddled (mean: 29.8 ± 0.5)	When swaddled: less physiologic distress ( $P < .002$ ), better motor organization ( $P < .001$ ), and more effective self-regulatory ability ( $P < .037$ )	When swaddled: higher score on tone and motor subscale ( $P = .03$ ), higher score on response subscale ( $P = .04$ ), and higher total score ( $P = .007$ )	At 2 wk, HR levels and crying declined more rapidly with pacifier; at 2 mo: similar rates of decline in HR and crying; at both ages: in pacifier group more time in alert state, and HR and crying tended to rebound more in pacifier group	When swaddled: significant decrease in amount of crying, significant postintervention improvement in infant behavioral profiles and maternal anxiety level, and parents more satisfied with the effectiveness of intervention	When swaddled: significant shorter time periods to return to baseline HR and SpO <sub>2</sub>	No differences in infant core, peripheral, or microenvironmental temperature
Level of evidence <sup>a</sup>	2b	2b	2b	2b	2b	2b	2b	2b

<sup>a</sup> Level of evidence is as defined by the Oxford Centre for Evidence-Based Medicine Levels of Evidence. 2001. Available at: [www.cebm.net/levels\\_of\\_evidence.asp](http://www.cebm.net/levels_of_evidence.asp).

## Motor Development

All different techniques of swaddling have in common that they restrict the movement of the body and limbs.<sup>6</sup> In VLBW infants, 1 case-control study (Cochrane RCT) showed that swaddling might have a positive effect on neuromuscular development,<sup>21</sup> and another case-control study (Cochrane RCT) showed that if preterm infants are weighed when swaddled, they show better motor organization.<sup>22</sup> While swaddled, the level of motor activity is reduced.<sup>1</sup> No evidence that swaddling has short-term or long-term effects on the attainment of motor milestones has been found.<sup>6,39,40</sup> Dennis and Dennis<sup>41</sup> found that Hopi infants reared on a cradleboard walked as early as unrestrained Hopi infants.<sup>41-43</sup> Next to the variation in the tightness of swaddling, especially of the lower limbs, most studies have not reported the exact duration of swaddling, which makes it difficult to draw firm conclusions about the effect of swaddling on motor development.

## Sudden Infant Death Syndrome

Six articles evaluated swaddling and the risk of SIDS. A large nationwide case-control study (New Zealand) and a prospective cohort study both indicated that firm tucking, wrapping, or swaddling contributes to a reduced risk of SIDS.<sup>17,44</sup> Swaddled infants in the supine position have a lower risk for SIDS.<sup>17,45,46</sup> Immobilization of infant arms and legs by swaddling might reduce the chances that an infant will cover his or her head and face with bedding, which is a well-established risk factor for SIDS in which overheating and asphyxia may be causal factors.<sup>34</sup> It can be assumed that infants, when swaddled, are placed supine, as Nelson et al<sup>47</sup> stated in a retrospective descriptive study. The "Back to Sleep" campaign has been successful in decreasing the rate of SIDS, but some infants seem to sleep poorly when they are placed supine. Most infants, however, tolerate the supine position when swaddled, even a considerable number of infants who are accustomed to sleeping prone.<sup>34,48</sup> The physical restraint of swaddling presumably prevents infants from turning prone during sleep before they have gained experience in turning to prone and back again when awake.<sup>34</sup> Because inexperienced prone sleepers are especially at risk for SIDS, this could explain, in part, the reduced risk associated with swaddling.<sup>49</sup> A relatively large case-control study combined with a smaller prospective cohort study showed that if swaddled infants are placed prone, they have a 12-fold increase in risk for SIDS, whereas nonswaddled prone infants have a 3-fold increase in risk.<sup>45</sup> In view of this finding, it is important to note that in a small retrospective cohort study, some swaddled infants were already able to turn prone after 3 months of age.<sup>50</sup> Recommendations concerning swaddling, therefore, should address the difference in SIDS risk associated with supine and prone sleeping. Theoretically, the decreased arousal associated with swaddling

could also prevent arousal in life-threatening situations. Epidemiologic evidence clearly shows that being supine and swaddled decreases the SIDS risk more than being supine without swaddling; thus, the motor restraint that prevents the life-threatening situations seems to carry more weight than the decreased arousal as long as the infant remains supine.

Some authors warned, in 2 case-control study reports, against tight wrapping and the possible increased risk for SIDS, because hypothetically, respiratory function could be compromised.<sup>51,52</sup> The authors suggested that firm tucking-in while the infant is in a prone position could push his or her face forcefully into the mattress or pillow.<sup>51</sup>

As 1 case report and some studies have suggested, hyperthermia as a possible adverse effect of swaddling could also increase the risk of SIDS, especially when the infant's head is covered.<sup>53-56</sup> On the other hand, 3 studies indicated that swaddling might be protective against SIDS in cold winters, because swaddled infants cool-down less.<sup>46,47,57</sup> Williams et al<sup>58</sup> demonstrated that SIDS is also associated with too little thermal isolation, and this is particularly the case when (nonswaddled) infants are not firmly tucked-in.

## Respiratory Infections

In a relatively small retrospective cross-sectional cohort study it was shown that infants in Turkey and China who have been (completely or partially) swaddled for at least 3 months have a 4 times higher incidence of (radiologically confirmed) pneumonia and upper respiratory infections than infants who were unswaddled.<sup>16</sup> A hospital-based retrospective case-control study (with nonmatched controls) indicated that being swaddled while exposed to sunlight carries a risk for subclinical vitamin D deficiency in Indian children, which in turn has been associated with an increased risk for acute lower respiratory infections.<sup>59</sup> This is also suggested in an expert opinion to be of influence in Mongolia, where it is common to swaddle an infant from head to toe, exposing only the face, for the first few weeks or months of life.<sup>38</sup>

In a small case-control study with 40 neonates with radiologically confirmed moderate pneumonia in Beijing, China, Li et al<sup>60</sup> found that unswaddled infants in the prone position had 18% higher oxygen tension than swaddled supine infants and 12% higher oxygen tension than unswaddled supine infants. The fact that the oxygen saturation level is higher in the prone than in the supine position is supported by a small case-control study by Chaisupamongkollarp et al<sup>61</sup> in which prone positioning in spontaneously breathing infants with pneumonia resulted in a statistically significant increase in mean oxygen saturation. Kahn et al<sup>33</sup> also found indications for cardiorespiratory compromise associated with swaddling, especially tight swaddling. This degree

of tightness was less than that imposed by some of the traditional methods studied. Overly tight swaddling could lead to atelectasis (incomplete expansion) and potentially increase susceptibility to infection.<sup>34</sup> In conclusion, the tightness of swaddling might influence the risk of respiratory infections. If swaddling causes decreased exposure to sunlight, there is a risk for vitamin D deficiency, which can then increase the risk of respiratory infections. In these studies, however, no confounding factors were included, the groups were small, and some of the methods were inconsistent.

### Rickets and DDH

A retrospective case-control study showed that complete or partial swaddling from birth on did not influence the incidence of rickets or bone properties as measured by ultrasound.<sup>62</sup>

The term “developmental dysplasia of the hip” indicates a dynamic disorder that may get better or worse as an infant develops, depending on management in the first months of life.<sup>63</sup> Eleven epidemiologic studies have shown that the incidence of DDH is highly correlated with the traditional use of swaddling for newborn infants.<sup>15,64–73</sup> In 1 study, other factors such as breech position, congenital muscular torticollis, congenital foot deformities, and positive family history of hip dysplasia were more important risk factors for DDH than postnatal swaddling.<sup>74</sup> Animal models and observations in the neonatal period show that when the hip and knee are forcibly extended either by a diaper or infant clothing, it may cause prolonged tension subluxation or even dislocation of the femoral head.<sup>64,65,75,76</sup>

Research into the geographic and racial incidence of DDH shows that in cultures in which the hips are kept in a flexed position, the incidence of DDH is much lower compared with cultures in which the legs are kept in extension (eg, when swaddled on a cradleboard).<sup>65–67</sup> The incidence of DDH in Japan used to be high before 1965, when a so-called swathing diaper was widely used.<sup>65</sup> In 1973, advice was given in Japan to avoid prolonged extension of the hip and knee of infants during early postnatal life.<sup>67,68</sup> Afterward, a decrease in the incidence of DDH in 3- to 7-month-old infants was reported.

In summary, DDH can be promoted by swaddling, especially when the legs are not free to bend and flex. Attention to this adverse effect is of utmost importance.

### Effects on Pain Control

The effect of swaddling on recovery from painful stimuli has been addressed in a few case-control studies. Both pacifiers and swaddling can soothe infants after a pain stimulus (Cochrane RCT).<sup>24</sup> Swaddling is less immediately effective compared with pacifier use but is also less subject to rebound after termination of the intervention compared with a pacifier in term infants.<sup>24</sup> Another RCT

(Cochrane RCT) showed that premature infants (<37 weeks' gestational age or <2500 g body weight) in swaddling return to their baseline HR and oxygen saturation (SpO<sub>2</sub>) in shorter time periods compared with those in containment (being surrounded by blanket rolls).<sup>26</sup> In preterm infants (postconceptional age: 31–36 weeks), swaddling is an effective means of speeding up recovery from heel lance (decrease in HR, increase in arterial oxygen saturation), whereas in infants of 27 to 30 weeks' postconceptional age, recovery after heel lance is not influenced by swaddling, except for an increase in arterial oxygen saturation levels when swaddled.<sup>77</sup>

### Effects on Crying Behavior

As shown in a Cochrane RCT, swaddling in infants with neonatal cerebral insults as an intervention for the management of excessive crying (ie, at least 3 hours/day of crying for at least 1 week) decreased the amount of crying significantly compared with massage.<sup>23</sup> These infants (aged 0–3 months) were swaddled with a blanket wrapped around the whole body with the head covered and minimal hip restraint over a period of 3 weeks for at least 3 times per day for at least 30 minutes each time. Swaddling was associated with a significant decrease in postintervention crying (measured with a diary that recorded crying, sleeping, and feeding patterns<sup>78,79</sup>) by 28% compared with massage (5%). Furthermore, swaddling was associated with significantly improved neurobehavioral organization (Neonatal Behavioral Assessment Scale cluster scores), a significant reduction of maternal anxiety (State-Trait Anxiety Inventory), and an increase in parental satisfaction after swaddling. These results suggest that swaddling suppresses crying by protecting infants with brain lesions from external and internal stimulation and improves the neurobehavioral organization of these infants. The reduction in crying that is achieved in this fashion probably helps to alleviate parental anxiety and stress.

However, because there have been very few systematic studies of the time-related change in crying in infants with cerebral lesions, longer follow-up studies are needed.

Swaddling can be used as an effective strategy to support infants with neonatal abstinence syndrome.<sup>80</sup> In an RCT, adding swaddling to an intervention that offered regularity and stimulus reduction for excessive crying gave no extra benefit, although a small but significant effect was shown in infants aged 1 to 7 weeks at randomization.<sup>81</sup>

### Effects on Breastfeeding and Postnatal Weight

In a Russian randomized trial, 176 mother-infant dyads were studied right after birth of the infant and managed for 5 days. The study showed that infants who were swaddled directly after birth did not differ from infants who were clothed in Western infant attire in respect to

breastfeeding variables (number and duration of feeds, amount of supplements, and amount of ingested breast milk).<sup>28</sup> Infants who were swaddled had delayed recovery of weight gain if they were subjected to separation from their mother for the first 2 hours after birth and if they were not able to room in with their mother but were kept in a separate nursery and received supplemental feeds. The authors hypothesized that because touch has been shown to influence growth (eg, by stimulating the release of gastrointestinal hormones), swaddling could have a negative effect by limiting tactile stimulation. If this hypothesis holds true, the effect of a less-rigorous swaddling might not be as apparent.

### Swaddling Start and Duration

In several descriptive studies, the duration of swaddling has been measured, and it seems to vary widely across different cultures. In Chisholm's study into cradleboard use, Navajo Indians place their infants on cradleboards within a few days of birth and continue the use of the board for an average of 10.2 months, ranging up to 2 years of age (J. S. Chisholm, PhD, *Developmental Ethology of the Navajo*, unpublished PhD thesis, 1978). The exact duration is determined individually. The daily amount of time spent on a cradleboard shows wide individual variation but probably averages ~60% to 70% in the first 6 months of life and ~30% later. With the older children, the board may simply be used as a sleeping place (in the Navajo tribe, the cradleboard is also used in an upward position and placed in close proximity of the mother).

A Dutch descriptive retrospective study that included children who were seen at a well-infant clinic where swaddling was integrated in the usual care demonstrated that children were swaddled for an average period of 12 weeks, starting at an average age of 13 weeks.<sup>50</sup>

In rural Turkey, swaddling is common practice during the entire first year of life.<sup>29</sup>

In the rural minority areas of Yunnan, China, the average duration of swaddling is 35 days.<sup>36</sup> The binding to a cradleboard, accomplished by means of lacing strings or strips of cloth passed over the body and allowing only slight flexion of the legs, is applied to Hopi Indian children in their first 3 months of life.<sup>82</sup> From 3 months until 6 to 12 months the cradle is used only during sleeping or "according to the desires of the child."

A retrospective study showed that Mongolian infants were completely swaddled during their first 4 months of life and partially swaddled until they were 5 months of age, on average.<sup>62</sup> In Russia, it is also common to swaddle infants immediately after birth, leaving only the infant's front face unbound.<sup>28</sup>

## DISCUSSION

### Only 9 RCTs that evaluated the effect of swaddling were identified.<sup>20-28</sup>

The following beneficial effects have been identified.

1. Healthy infants aged  $80 \pm 7$  days (range: 24–180 days) who are swaddled during sleep have less startles, arouse less, and sleep longer.<sup>20</sup> Infants who sleep supine have decreased awakenings during QS when swaddled. During REM sleep, behavioral arousals are unchanged, but an infant is more likely to return to sleep on his or her own. Because prone sleeping is often started when infants sleep poorly or restlessly, these findings are of importance.
2. Preterm infants show improved neuromuscular development when swaddled<sup>21</sup> and less physiologic distress, better motor organization, and more self-regulatory ability when swaddled during weighing.<sup>22</sup> In VLBW infants in a double-walled incubator, abdominal temperature is higher when swaddled.<sup>25</sup>
3. In excessively crying infants with cerebral damage, swaddling decreases significantly the amount of crying compared with massage.<sup>23</sup>
4. Swaddling during heel sticks makes premature infants return to their baseline HR and  $SpO_2$  measures more quickly,<sup>26</sup> and it can soothe preterm infants after pain.<sup>24</sup> Swaddling is less-immediately effective than pacifier use but is also less subject to rebound compared with a pacifier.
5. Swaddling did not influence breastfeeding parameters such as number and duration of breastfeeds, amount of ingested milk, and total duration of breastfeeding time.<sup>28</sup>

Before reintroducing this traditional method of infant care, possible detrimental effects need to be addressed. Well-conducted studies have revealed the following potential adverse effects of swaddling.

1. Clear evidence exists about the risk of swaddling for the development of hip dysplasia, especially when the child is swaddled in extension and adduction. This detrimental effect of swaddling is related to the misapplied use of the practice. Swaddling in a manner that allows the hips and knees to move freely might not have this risk-increasing adverse effect, but more studies are needed to test this hypothesis. The studies that showed beneficial effects of swaddling have been conducted with the infants' lower extremities wrapped loosely, but the contribution of wrapping their legs on sleep, pain relief, and excessive crying also needs to be addressed.
2. There have been indications of an increased risk of overheating.
3. There is an increased risk of SIDS, but only when the swaddled infant is placed prone or is able to turn to the prone position.
4. Some evidence exists for an added risk of vitamin D deficiency and acute respiratory infections. The rela-

tion between swaddling and acute respiratory infections has been set out in 4 studies, all of which were conducted in non-Western countries. In these countries, a higher risk of respiratory infections also seems to be related to the tightness of swaddling. There is no indication that the vitamin D deficiency is such that it can lead to rickets.

5. Swaddled infants who are briefly separated from their mothers after birth or are placed in the nursery and receive supplements have a delayed weight-loss recovery.

As soon as traditional swaddling practices are introduced into a Western society with (centrally) heated houses and highly insulating bedding, one should be aware of the possible adverse effects of these practices and discuss them with these ethnic groups. In the Netherlands, 80% of Turkish and Moroccan parents were swaddled in infancy.<sup>34</sup> Nowadays, 15% of the Turkish children and 20% of the Moroccan children living in the Netherlands are swaddled, whereas ~6% of Dutch infants are swaddled.<sup>44</sup> Observation and clinical practice shows that these ethnic groups often swaddle inappropriately; the legs and hips are swaddled very tightly in extension and adduction. Special support and education is necessary for these ethnic groups.

The risk for SIDS seems to be increased by sleeping in a prone position when swaddled and by swaddling with the head covered. In a supine position, swaddling seems to be protective, although this differs with the way that swaddling is applied. Up to a certain age, swaddling hinders turning prone, but on the other hand, when an infant is prone, his or her risk of SIDS significantly increases.

## CONCLUSIONS

There are many different insights into the technique of swaddling. It has been used by many cultures and in many ways. When not used properly, swaddling can be a dangerous intervention that increases the risk of DDH, SIDS, and overheating. It can be used safely, however, if accompanied by advice about sleeping position, the way the child is swaddled (head free), the amount of (extra) bedding, and the tightness of the swaddling around the chest, hips, and knees. Preterm infants can benefit from swaddling as well, although the technique might need to differ from postnatal swaddling of full-grown infants.

The issue that needs replication, however, is whether other methods of infant restraint that carry hardly any risk, such as firm tucking-in, can have the same effect on crying and sleep behavior.

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