The effects of prone versus supine position on motor development in healthy infants

LITERATURE REVIEW

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HANZEHOGESCHOOL GRONINGEN | INTERNATIONAL PHYSIOTHERAPY

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Preface

This literature review was conducted as part of the International Physiotherapy Programme of the Hanzehogeschool Groningen as the final graduation assignment. It is going to investigate the effects of prone and supine positioning of infants on motor development.

I chose this specific topic because of my clinical observations during my internships, which were part of the final year of my study programme. I did my internships in the area of paediatrics and encountered a lot of parents asking me specific questions about how to handle their infants. Feedings, car seats, types of slings for babywearing and strollers or prams were common discussion topics. The most common question, however, that I was asked was: “Why would I need to put my child on their belly? I heard that babies are safer on their backs.” I could only give educated guesses as answers to the parents but never had the evidence at hand to back me up. It was one of my goals to gain more in-depth knowledge and find evidence about this topic, before I start working as a paediatric physiotherapist.

I hope to be able to have an impact on parents concerning their actions on their infants and how such a small decision as what position to lay the baby in, can have such a big impact on their lives.

I would like to thank my supervisor Caspar Mijlius for providing great feedback and guidance during the research and writing process of this bachelor thesis.

Helena Rygol

Oldenburg (Germany), 17.04.2021

Abstract

Background

Since the recommendation from the American Academy of Pediatrics in 1992 to have infants sleep in supine position, as it may decrease the chance for the Sudden Infant Death Syndrome (SIDS) was published, there have been a lot of infants spending less time in prone position because of the fear of SIDS. With the overall increased use of the supine position, health care workers have questioned whether this has an effect on the acquisition of infant motor milestones.

Objective

The objective of this study is to determine the effects of prone versus supine position on motor development in infants.

Methods

In order to examine this question, there was an online literature research conducted. This search was conducted in four databases: PubMed, PEDro, CINAHL and Science Direct. English full-text articles about a population of healthy infants under the age of 12 months, who were exposed to both prone and supine position and were measured on motor development were included in this review. The quality assessment was conducted through the “Strengthening the Reporting of Observational Studies in Epidemiology” (STROBE) and the data synthesis was done by using a Best Evidence Synthesis.

Results

There is moderate evidence that some motor milestones were attained earlier in a group of infants that have spent increased time in prone position. There is insufficient evidence that spending increased time in supine position will have a negative effect on motor development.

Conclusion

This literature review demonstrates that there are beneficial effects of increased prone positioning on motor development, while there is inconclusive data about the effects of supine position, as there is limited evidence that focuses on the effects of supine position.

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Introduction

The American Academy of Pediatrics (AAP) recommended in 1992 that “healthy infants, when being put down for sleep, be positioned on their side or back”, instead of sleeping prone, in order to try to reduce the risk for the Sudden Infant Death Syndrome (SIDS) (APP, 1992). This advice, together with the following “Back to Sleep” campaign evoked that the percentage of infants sleeping in prone position had decreased from 70% in 1992 to 27% in 1995 (AAP, 1996). Furthermore, it led to a reduction of the incidence of SIDS in the United States of America by 40% between 1992 and 2000 (Salls et al., 2002). However, paediatricians speculated whether the increased prone laying, during sleep and awake phases, affects infant motor development (Davis et al., 1998). There are some articles that reported a change in motor milestone achievement within the first year of life, if infants were sleeping in supine position instead of prone (Jantz et al., 1997; Salls et al., 2002; Pin et al., 2007). Developmental milestones include skills in the areas of social, cognitive, visual, auditory, language, motor and self-help. (Stabel et al., 2013)

The Physiotherapy Guide to Developmental Delay by the American Physical Therapy Association (APTA) states that around 14% of toddlers and pre-schoolers in the United States are classified as having developmental delay (APTA, 2018). Furthermore, as many as 25% of children under the age of 5 years are at risk for developing disabilities or developmental delay (APTA, 2018). This is why it is crucial to recognise any developmental delay early and start interventions as soon as possible, as they promote motor development and may prevent future disabilities (APTA, 2018; Fernández Rego et al., 2016). The functional performance of the infants is greatly influenced by how much time they spend in prone position while being awake or asleep, in their first year of life (Dudek-Shriber & Zelazny, 2007).

Paediatric physiotherapists are responsible for evaluating several aspects of infant motor development within the first year of their lives, with emphasis on the acquisition of developmental motor milestones. They are specialised in evaluating children and their environment and give detailed guidance on building gross motor skills to the families (APTA, 2018). Physiotherapeutic treatments are often supported by regular check-up appointments by the midwife and the paediatrician as an interdisciplinary team. In order to acquire some specific infant motor milestones, the infant needs to use upper body strength to, e.g., push up in order to start rolling over. Upper body and general core strength are mostly developed in prone position (Adolph & Franchak, 2017). This and the author´s clinical observations led to the hypothesis that prone laying would not only prevent disabilities but also encourage the earlier acquisition of motor milestones.

All in all, it is insightful to gain more in-depth knowledge from the current evidence in literature. Knowing the impact that the prone position has on the motor development of infants, could aid the decision-making process for physiotherapists, paediatricians and midwives on what sleeping and play positions are recommended for their patients and why. Therefore the aim of the study is to determine the effects of prone versus supine position on motor development in healthy infants.

In this context, healthy infants are defined as babies before the age of 12 months, born to term and without any disabilities or health conditions at birth (Majnemer & Barr, 2005).

Methods

Research design

The design of this study is a literature review, written according to the PRISMA guidelines (Moher et al., 2009). It was conducted to methodologically search for literature. The developmental effects of prone and supine positions on infants younger than one year were investigated. The study was conducted by one student of the International Physiotherapy Programme at the Hanzehogeschool University of Applied Sciences, Groningen, the Netherlands.

Search strategy

An online research was carried out from the 8th of February 2021 to the 19th of April 2021. The databases used were PubMed, PEDro, CINAHL and Science Direct. These specific databases were used because they include scientific evidence from the medical field or are even designated to physiotherapy. The disadvantages and advantages of each database can be found in Appendix A. These were considered when deciding on which databases to use. All the chosen studies were already published; therefore, no ongoing studies were analysed.

Search string

The search string used in the four databases was developed to adequately identify studies relevant to find suitable answers to the research question.

Keywords were formulated utilizing the PICO method (population, intervention, comparison, outcome). The population were healthy infants under one year old, excluding all babies who were born prematurely or had any other diseases detected in pre- or postnatal examinations. The intervention was placing the infant in prone position and the comparison was supine position. The outcome to be measured was motor development.

These keywords were combined with the Boolean operators “AND” and “OR” to specify the search in PubMed, CINAHL and Science Direct. In the database PEDro, the Boolean operators were not used, as PEDro does not include this function in their search. Similar words for each key term were selected from websites such as Dale dictionary, synonym.com and thesaurus.com, in order to get a wide range of search terms to find the most suitable studies.

One of the criteria for inclusion was that the articles were published between 1992 and 2021, as in 1992 there was a big change in positioning, due to the increased knowledge about the association between SIDS and the prone sleeping position. This article focused on the current evidence that was published since this change.

The final search terms per database and the used filters are presented in *table 1.*

Table 1: Final search actions

Database	Filters	Search terms
PubMed	Full text Published between 01.01.1992 and 17.04.2021	"(infants sleeping OR early life OR infants) AND (motor development OR motor performance) AND (sleeping position OR awake positioning OR play position OR wakeful prone positioning)"
CINAHL	Age: infant	"(prone position OR prone positioning OR prone) OR (supine position OR supine position OR supine) AND (motor development OR motor skills OR physical development) OR (motor milestones) AND (sleeping position) OR (awake position)"
Science Direct	Published between 1992-2021 Subject areas: Nursing and Health professions	"(infants sleeping OR early life OR infants) AND (motor development OR motor performance) AND (sleeping position OR awake positioning OR play position OR wakeful prone positioning)"
PEDro	No filters applied	"infants motor development prone positioning"

Selection procedure

Studies for inclusion were selected independently by the author. After the search action was completed, the selection was carried out in steps. At first, the titles and abstracts of all the studies were screened for relevance and the duplicates were removed manually. All remaining articles were noted down for full-text analysis.

Inclusion and exclusion

For inclusion, the studies had to include healthy infants under the age of 12 months, who were placed in both prone and supine position at some point and that had undergone tests for their motor development within their first year. The inclusion criteria were broad, as there is limited research done about this topic.

Studies were selected based on the following eligibility criteria and their relevance after a full-text screening.

Table 2: Inclusion and Exclusion criteria

Inclusion Criteria	Population	Healthy infants under 12 months
	Research design	Randomized controlled trials, cross-sectional studies, longitudinal studies, case-control studies and cohort studies
	Intervention	Supine positioning, prone positioning
	Outcome Measurement	Motor development
Exclusion Criteria		Abstract only, other languages than English, published in 1991 or earlier, animals

Methodological quality assessment

To assess the methodological quality of the articles the "Strengthening the Reporting of Observational Studies in Epidemiology" (STROBE) (von Elm et al., 2014) assessment form was used since all the included studies are observational. There were no randomized controlled trials found during the search that met the inclusion and exclusion criteria. The STROBE consists of a 22-item checklist. This list can be seen in Appendix B. A score is considered sufficient if it is ≥15. The individual scores for the articles can be seen in Appendix C.

As this is usually a tool used to aid the author of observational studies in their writing and not for quality assessment. Therefore, a second analysis for the level of evidence according to Harbour & Miller, (2001) was applied. In this tool, the articles were classified with the letters A – D according to their quality. These scores can be seen in *table 7*.

Data extraction

The data extracted from each of the selected articles included the authors' names, year of publication, study design, sample size, age of participants, interventions, measurement instruments and outcomes about motor development. The extracted data for each article was inserted into a standardized form.

Statistical analysis

The results from the individual studies were compared according to their outcome from the development assessment tests performed while considering what age the participants had. Outcomes from the studies were considered significant if their p-value was <0.05. To determine the quality of evidence, no calculations with the standard deviations and effect sizes were done, as the Best Evidence Synthesis described by Kennedy et al., (2010) was chosen.

It is an approach in which the quality of each article and the number of articles, with similar or the same outcomes, are analysed. The quality of evidence is then classified as strong, moderate, limited, mixed or insufficient, which can be seen in *table 3*. It answered the question of what motor developmental effects the different positions have that an infant is placed in. Both significant and non-significant trends were considered and reported.

Table 3: Best evidence Synthesis guideline from Kennedy et al., (2010)

Level of evidence	Minimum quality	Minimum quantity	Consistency	Terminology for messages
Strong	High (>85%)	Three	Three high-quality studies agree If more than three studies, ¾ of the medium and high-quality studies agree	Recommendations
Moderate	Medium (50-85%)	Two high quality OR two medium quality and one high quality	Two high-quality studies agree OR Two medium quality and one high-quality study agree. If more than three studies, more than 2/3 of the medium and high-quality studies agree	Practice considerations

Limited	Medium (50 – 85%)	One high quality OR two medium quality and one high quality	If two studies (medium and/or high quality) agree If more than two studies, more than ½ of the medium and high-quality studies agree	-
Mixed	Medium and high	Two	Findings from medium and high-quality studies are contradictory	-
Insufficient	No high-quality studies, only one medium quality study, and/or any number of low-quality studies			

Results

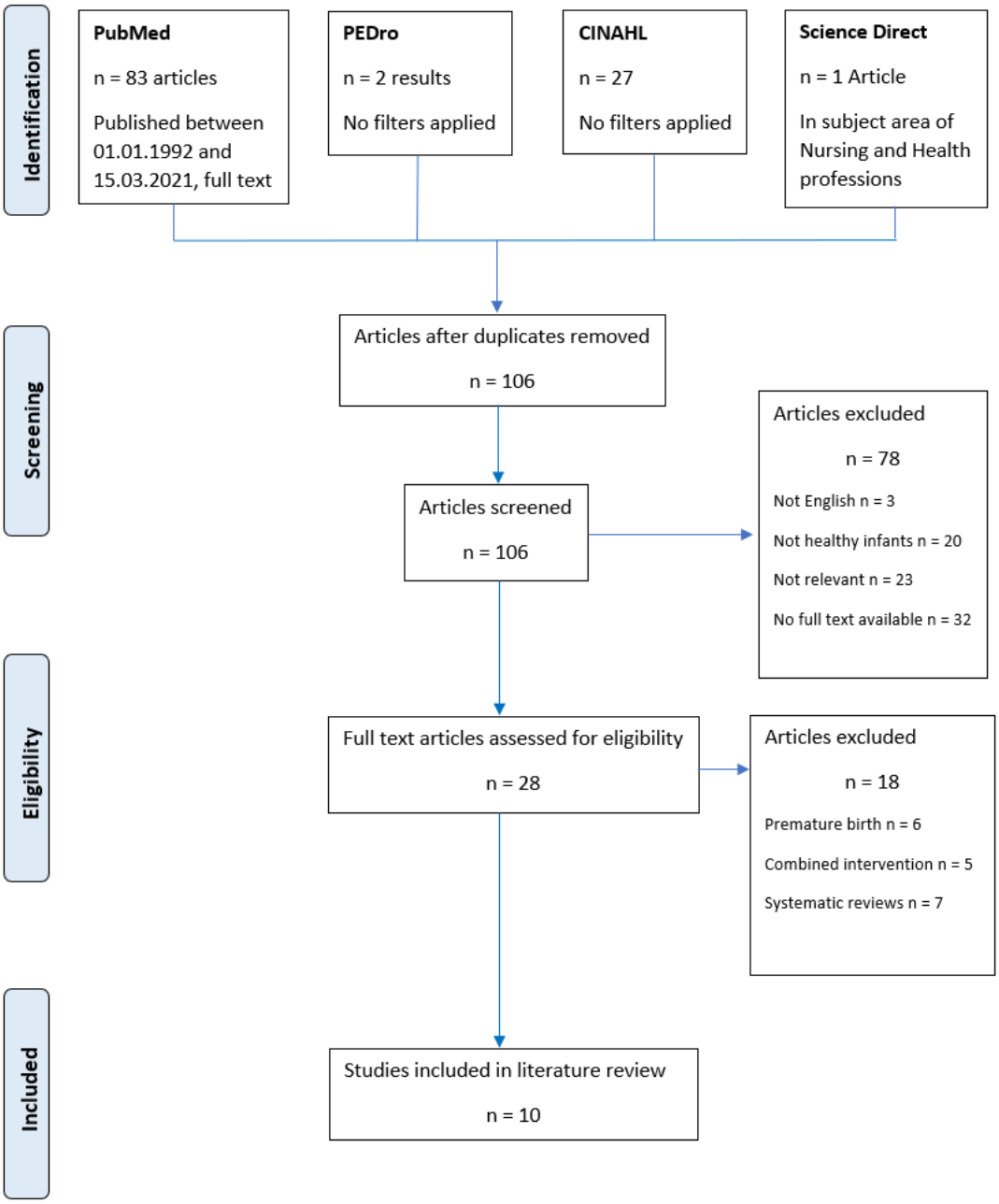
Study selection

In the search, that was performed from February to April 2021, 113 potentially eligible studies were found. Out of those, a total of 10 articles were included in this review, while 103 articles were excluded. The reasons for exclusion, besides the inclusion and exclusion criteria, which can be seen in *table 2,* were no given full text, duplication or irrelevance in reference to the research question.

The complete process that led to the identification of the 10 included studies can be seen in *Figure 1.*

Search string

Figure 1: search string



Methodological quality of selected articles

Six Cohort studies and four cross-sectional were included in this review. Their methodological quality was assessed using the STROBE statement (von Elm et al., 2014). All included studies scored more than 15 out of the 22 points as seen in *Table 5.* A more detailed overview of the STROBE scoring can be seen in Appendix C.

Table 5: Methodological quality score according to the STROBE statement

Article	**Methodological score**
Carmeli et al., 2009	**15**
Davis et al., 1998	**21**
Durek-Shriber et al., 2007	**18**
Jantz et al., 1997	**17**
Kuo et al., 2008	**20**
Majnemer et al., 2005	**20**
Majnemer et al., 2006	**18**
Monson et al., 2003	**17**
Russel et al., 2009	**15**
Salls et al., 2002	**16**

Data overview

Population

Altogether, 1511 participants were included in the studies. The distribution between males and females was generally 50/50, although three studies (Carmeli et al., (2009); Salls et al., (2002); Jantz et al., (1997)) did not specify the gender of their participants. The age ranged between 1 week and 12 months. The study populations were mainly of good size, as almost half of the articles describe that the power analysis criteria were met (Dudek-Shriber & Zelazny, (2007); Kuo et al., (2008); Davis et al., (1998); Salls et al., (2002)). The smallest population size was 30 participants and the largest 351 participants. The definition of healthy infants was the same across the studies, always including babies born at full term (>36 weeks) and not having any health impairments. The participants were of different ethnicities as the studies are conducted on different continents and in different countries but none of the articles excluded a certain ethnicity. One study only included two-parent households (Carmeli et al., 2009) while the other studies did not specifically rule out single parents.

Intervention

The type of intervention varied in the sense that some studies like Russell et al., (2009), Kuo et al., (2008) and Monson et al., (2003) focused on purposefully placing the infants in prone position while awake. While others like Jantz et al. (1997), Carmeli et al. (2009) and Davis et al. (1998) concentrated on observing the sleeping positions and wakeful positions that the parents put their children in, without any instructions. The children that lay predominantly in one position were then classified into either a prone or supine groups and these groups were seen as interventions and their effect was investigated. In addition, Majnemer et al., (2005) and Monson et al., (2003) had their main focus on supine laying or sleeping and compared it to prone position, while all other studies encouraged the prone position and compared it to supine.

Russell et al., (2009) and Monson et al., (2003) required at least 30 minutes of prone position and Salls et al., (2002) 15 minutes, in order for infants to be divided into the group with prone interventions and then checked how both groups performed on their developmental tests.

In contrast Dudek-Shriber & Zelazny, (2007) and Majnemer & Barr, (2005, 2006) observed which infants achieved certain milestones and then analysed how much time they had spent in prone position, over the course of 24 hours and drew conclusions from that. Similarly, Kuo et al., (2008) and Carmeli et al., (2009) solely compared how much time was spent in prone or supine position respectively and used that for their division into a prone preference and a non-prone preference groups. However, Davis et al., (1998) and Jantz et al., (1997) categorized the infants into the intervention groups only according to their preferred sleeping position.

Some studies also included side sleeping positions but saw no effects so they were included with the supine sleeping groups (Davis et al., 1998; Jantz et al., 1997). They all had in common that they studied the effects of the afore mentioned positions on motor development.

Data collection

Their mode of data collection varied. Monson et al., (2003) and Jantz et al., (1997) gave the option to conducted personal interviews. In contrast, Davis et al., (1998), Kuo et al., (2008), Carmeli et al., (2009), Majnemer & Barr (2005, 2006) and Dudek-Shriber et al., (2007) gathered the necessary information via a parental log or diary that parents wrote in, over a specific timeframe, to record the sleep and wakeful positions that their infant spends their time in. The requirements for what to depict in the diaries or logs differed between the studies. Dudek-Shriber & Zelazny, (2007) asked to record how much time was approximately spent in either position while Kuo et al., (2008) had pre-set categories of either 0 min, 1- 19 min, 20 to 39 min, 40- 59 min. 60-120 min and > 120min. Majnemer & Barr, (2005, 2006) and Carmeli et al., (2009) asked what positions the infants were routinely placed into sleep or play.

Outcome

As for evaluating motor development, different tests were used. Most studies use the Alberta Infant motor scale (AIMS), which is a widely recognized tool for assessing an infant´s gross motor development (Piper et al., 1992). Others used a part of the Comprehensive Developmental Inventory for Infants and Toddlers (CDIIT)(Liao & Pan, 2005). This tool assesses five different developmental areas such as cognition, language, motor, social and self-care skills. The articles included in this review used the gross motor part of this assessment tool which is abbreviated with GMDQ (Tsai et al., 2016; Hwang et al., 2010). A few studies did not follow any particular protocol but rather decided on a few milestones that they found to be important. Russell et al., (2009), Jantz et al., (1997) and Salls et al., (2002) used other guidelines or references to determine motor development. The specific scores of the tests were rarely given, only a p-value was available to represent any changes or differences between groups.

While most studies investigated the effects of prone or supine position on motor development, some like Russell et al., (2009) and Kuo et al., (2008) also looked at what the ideal amount of time is to be spent in that position.

A detailed description of the extracted data can be found in *table 6.*

Table 6: Data extraction of all articles

Study	Design	Participants (age)	Intervention	Measurement instrument	Data collection	Outcome	Level of evidence
Carmeli et al., 2009	Longitudinal cohort study	n = 75 (6 mo)	Awake and sleep positions (supine and prone)	AIMS	Parental log	Analysis of AIMS percentile at 6 months as related to actual or preferred position revealed **no significant difference**	C
Davis et al., 1998	Longitudinal cohort study	n = 351 (1 week, 1-6 mo)	Prone and supine (Sleep positions)	<u>Motor milestones:</u> Rolling Sitting Transfer objects Creeping Crawling Pull to stand Walk (10-15 steps)	Parental log	**Significant earlier attainmen**t of milestones: sitting, crawling, pull to stand **(p<.05)**	B
Durek-Shriber et al., 2007	Cohort study	n = 100 (4 mo)	Prone position (awake and asleep)	AIMS	Parent questionnaire	**Significant differences (p<.001)** in achievement of tested milestones (7 prone, 3 supine, 3 sitting milestones)	B
Jantz et al., 1997	Retrospective longitudinal cohort study	n = 343 (4, 6 mo)	Supine sleeping	Denver developmental screening test (revised)	Telephone survey, office interview or letter	Supine or side sleepers were less likely to **roll over (p<.001) at 4 mo** Other milestones – **no significant changes**	C
Kuo et al., 2008	Longitudinal cohort study	n = 280 (4, 6, 12, 24 mo)	Prone position (awake)	GMDQ <u>Motor milestones:</u> Rolling Crawling Transferring objects Sitting Walking	Parent questionnaire	**Crawling** attained **significantly** earlier **(p=.012)** No effect on other milestones **No effect on GMDQ**	B

Majnemer et al., 2005	Cross sectional study	n = 71 (4, 6 mo)	Supine position (sleep)	AIMS GMDQ	Parent diary	**Prone group: Significantly** higher **AIMS** percentile at 4 mo **(p<.01**) and 6 mo **(p<.0001)** **Significant** difference **GMDQ (p<.001)** **GMDQ score 4 mo = 96.3** **GMDQ score 6 mo = 88.9** **->almost 1 SD below the normative mean for supine group**	D
Majnemer et al., 2006	Cross-sectional study	n = 75 (4, 6 mo)	Prone and supine positions (awake)	AIMS GMDQ	Parent diary	**Significantly** correlated with **AIMS** prone raw score, total score and percentile score at: 4 mo **(p<.05).** **r= 0.27 to 0.33*** 6 mo **(p<.01)** **r= 0.39*** **GMDQ** at 6 mo **p= .001** **r= 0.49***	D
Monson et al., 2003	Cohort study	n = 30 (6 mo)	Prone position (awake)	AIMS	Parent interview	**Significantly** higher **AIMS**: Raw score (**p= .004)** Percentile score **(p<.001)** Prone raw score **(p<.001)** Supine raw score **(p<.019)** **No significant** difference at AIMS: Sitting raw score **(p=.24)** Standing raw score **(p=.79)**	C

Russell et al., 2009	Cross sectional study	n = 120 (6 weeks)	Prone position (awake)	Bly development guideline**	Parent questionnaire	**Significant** greater: prone head control **(p<.0001)** active movement of the arms **(p< .0001)** pushing up on the arms **(p< .0001)** elbow positioning in relation to the shoulder **(p= .0039)** weight bearing on hands in the mid position **(p= .0002)** anterior thigh positioning in relation to the floor **(p= .0008)** knee extension **(p= .0334)** There **was no significant** association with keeping hands open or not and pull-to-sit action **(p > .05).**	D
Salls et al., 2002	Cross-sectional study	n = 66 (2, 4, 6 mo)	Prone and supine position (awake and asleep)	Denver II gross motor sector ***	Parent questionnaire	**Significantly** earlier achievement at **2 mo** of head up 45° head up 90° sitting with head steady **No significant** association at 4 and 6 mo No p values given	D

mo= months old

AIMS= Alberta Infant Motor Scale

GMDQ= Comprehensive Developmental Inventory for Infants and Toddlers (gross motor aspect)

**effect size only depicted if the relevant data was available*

*** Bly´s development guideline includes: when prone, their ability to turn head, lift head 45°, displace weight on upper trunk or thorax, actively move arms, push up on arms, have elbow behind the shoulder, bear weight on hands with forearms in mid-position, have hands open or not open, move anterior thigh, and extend knee <180°; when being pulled to sit: head control, presence of shoulder girdle elevation, any activity of the legs, and presence of hip flexion resistance*

**** Denver II gross motor sector includes: (head up 45°, head up 90°, sitting with head steady, chest up with arm support, rolling over, pulling to sit (no head lag), sitting (no support)*

Supine position

All articles included both supine and prone positioning in their interventions, but some lay their focus more on the supine and others on the prone position.

Majnemer et al., (2005) and Majnemer et al., (2006) examined whether supine sleep positioned infants have delayed motor skills and whether delays are possibly associated with decreased exposure to prone position during the day. They found that supine sleeping infants that are positioned in prone position during the day, achieved a significantly higher AIMS percentile and better scores in the GMDQ at both four and six months old. In addition, Jantz et al., (1997) found that supine or side sleepers who were not placed into prone position regularly during the day, were less likely to roll over at the four-month check-up ($p<.001$). However, Jantz et al., (1997) also concluded that other milestones did not show statistically significant changes.

Prone position

In the process of determining the effects of prone positioning on motor development, questionnaires (Russell et al.,(2009); Salls et al., (2002)) and diaries (Majnemer et. al., (2005) and (2006)) were used to gather information from participants between six weeks and six months old. The development was measured through the use of different measurement instruments. However, the overall consensus was that the prone position has a positive effect on motor development.

While Majnemer et al., (2005), Davis et al., (1998); Dudek-Shriber & Zelazny, (2007); Monson et al., (2003) and Majnemer et al., (2006) stated that prone positioning while awake, was significantly associated with a positive outcome on the AIMS percentile at both four and six months ($p<.01$; $p<.05$; $p<.001$; $p<004$ and $p<.0001$), Salls et al., (2002) only found a significant correlation between prone positioning and the AIMS percentile in participants of two months old, who spend more than 15 minutes of awake time in prone position. They found no significant association with the time that was spent in prone during playtime and motor development at four and six months of age. As the only author who tested infants at six weeks old, Russell et al., (2009) found that spending more than 30 minutes in prone position was significantly associated with ability in prone head control ($p < .0001$), active movement of the arms ($p < .0001$), pushing up on the arms ($p < .0001$), elbow positioning in relation to the shoulder ($p = .0039$), weight bearing on hands in the mid position ($p = .0002$), anterior thigh positioning in relation to the floor ($p = .0008$) and knee extension ($p = .0334$).

Kuo et al., (2008) who tested infants at ages 4, 6, 12, and 24 months, found improvements in the prone group, in attaining the milestone of crawling on the abdomen earlier, than infants without prone experience. This is the only milestone that they found a significant change in. However, Dudek-Shriber et al., (2007), Davis et al., (1998) and Monson et al., (2003) all found significant changes in several milestones groups at four and six months. Although Monson et al., (2003) and Dudek- Shriber et al., (2007) both found significant changes in the achievement of prone, supine and overall AIMS scores, only Dudek- Shriber et al., (2007) also found significant changes in the achievement of sitting milestones ($p<.001$). Davis et al., (1998) stated that they encountered significant changes in the areas of sitting, crawling and pulling to stand ($p<.05$). Yet, when taking maternal education, race, sex, birth weight and the number of siblings into consideration, the only statistically significant difference was for the milestone pull-to-stand ($p<.01$).

Carmeli et al., (2009) is the only study that found that there was no significant difference in AIMS percentile at 6 months related to the actual or preferred position of the infant.

Level of evidence

All the studies included in this review were observational studies, which is one of the lowest categories of scientific evidence as within their design they have areas of bias that would not be found in randomized trials (Petrisor & Bhandari, 2007). However, not all cohort or cross-sectional studies are done with the same standards and therefore they can be graded slightly differently.

Even though Davis et al., (1998) and Salls et al., (2002) are both observational studies, Davis et al., (1998) get a higher classification because of the great sample size, higher level of follow-up and smaller risk of bias.

The study of Kuo et al., (2008) is a longitudinal cohort study design with sufficient population size and therefore gets classified into class B. In contrast, Salls et al., (2002) is a cross-sectional study with a small sample size and no comparative group and therefore classifies as D, resulting in being considered a low level of evidence.

The other articles were classified in the same manner according to the criteria in the article from Harbour & Miller, (2001).

Table 7: Description of the level of evidence of studies using CBO (Harbour & Miller, 2001)

Study	**Classification**
Carmeli et al. 2009	**C**
Davis et al. 1998	**B**
Durek-Shriber et al. 2007	**C**
Jantz et al. 1997	**C**
Kuo et al. 2008	**B**
Majnemer et al. 2005	**D**
Majnemer et al. 2006	**D**
Monson et al. 2003	**C**
Russell et al. 2009	**D**
Salls et al. 2002	**D**

Best Evidence Synthesis

There were two interventions examined that are relevant to this review. The intervention groups are split up into prone and supine groups. Overall, there was moderate evidence that spending time in prone position is correlated to earlier attainment of several gross motor milestones. Carmeli et al., (2009) was the only author that found that there was no significant correlation between the positions, that the infant spent their time in, and the score of the AIMS and therefore motor development. Their article was of moderate quality with a small population size.

Prone position

Out of the nine studies, studying the effects of prone position on motor development, there was limited evidence for one to four milestones being attained earlier. These milestones being sitting, crawling, pulling to stand or head control (Davis et al., 1998a; Kuo et al., 2008; Salls et al., 2002). The improvements of these milestones were observed between two and twelve months of age.

The other six articles found moderate evidence for more than four milestones being attained earlier in the group of infants that spent increased time in prone position. These milestones varied per article or were just summarised in the scores of either the AIMS or GMDQ. Dudek-Shriber et al., (2007), Monson et al., (2003) and Majnemer et al., (2005, 2006) all found significant evidence that the AIMS scores were higher at four and six months. In addition, Majnemer et al., (2005) and Majnemer et al., (2006) documented an increase of scores on the GMDQ while Kuo et al., (2008) did not find a significant increase.

Supine position

Supine position was only used as the main intervention and focus point in one of the included studies. There is insufficient evidence that spending increased time in supine position will have the effect of infants being less likely to roll over at four or six months (Jantz et al., 1997).

Discussion

General

The main objective of this review was to establish what effects the prone and supine positioning of infants has on their motor development. This review found a significant positive effect of prone positioning. Certain motor milestones seem to be achieved earlier in infants who spent increased time in prone position, compared to supine position. However, for supine position, there is only limited evidence that it could lead to later achievement of motor milestones (Carmeli et al., 2009). Overall, supine position is not in the focus of most research, as since the 1992 "Back to Sleep" campaign by the APP, most babies sleep in supine position already and the fear of healthcare professionals is rather that infants do not lie in prone position enough (Davis et al., 1998). This fear stems from the belief that the prone position may be more beneficial for motor development (APTA, 2018).

A systematic review by Hewitt from 2020 looked into the correlation between "tummy time", increased time spent in prone position, and infant health outcomes (Hewitt et al., 2020). One of the possible health outcomes was development. They also found that the studies that they examined, revealed a positive effect of tummy time on motor development. They included all infants whether they were healthy or not, premature or born at term which results in a very varied population that may differ a lot from patient to patient. In addition, this review included articles with combined interventions such as prone positioning with equipment use (such as swings), which brings the question of how valid and reliable the strong correlation of just prone position and motor development is. There were 10 studies included in this review which only included articles with one intervention at a time, healthy infants and included some additional articles that the systematic review from Hewitt et al., (2020) did not include.

Weak and strong points

The weak points of this review lie primarily within the methods chosen and the literature selected. There were different search terms used in the chosen databases, which reduces the methodological validity as the process of generating research findings was not followed the same way for each database. Although this is a limitation, it was necessary to produce any relevant results from the search. There is limited data available about the topic and there is a need for further research to be done.

In addition, almost no effect sizes or other statistical data were given in the included studies, which made it difficult to determine how studies came to their conclusions and if it is reliable to follow their advice. This review was conducted by only one researcher and not controlled by a second reviewer which increases the risk for bias when excluding studies early on.

Another weakness that could also be a strength, is that all the articles chosen were observational studies. While observational studies have a lower level of evidence, they are often used in medical research (von Elm et al., 2014). They have a role in research into the benefits and harms of medical interventions, as randomised control trials may not be able to answer all the relevant questions about a given intervention. Furthermore, it was the only type of study that was available and was included after the process of in- and exclusion.

The studies used different outcome measurements such as AIMS, GMDQ, specific milestones or others which may explain the heterogeneity between the results of the studies, as it is hard to compare something that was tested differently and may have had different criteria. The AIMS is designed to specifically test motor development of infants (Piper et al., 1992) while the GMDQ is just one part of the Comprehensive Developmental Inventory for Infants and Toddlers which investigates several aspects of development (Tsai et al., 2016). Using a variety of measurement tools can be criticised as it is difficult to compare their results. However, it brings a greater chance of variety which is positive as no measurement tool is perfect. Standardized motor development assessment tools have limited validity in different cultures as the normative sample was only established in one culture (Mendonça et al., 2016).

As the method of gathering data about the time spent in prone and supine positions varied, the data might be more subjective to each researcher as no standardised protocol was used. While Davis et al., (1998) and Majnemer & Barr (2005, 2006) used diaries or logs that the parents filled in, over the course of a few weeks or months, others like Monson et al., (2003) only used one interview at the testing point which could lead to possible parental recall bias, since most parents do not monitor exactly what their infant does or how it lies, when not asked for this specifically. Furthermore, parents might fail to fill in diaries over time and then fill them out in retrospect, which could potentially give false results.

Only Jantz et al., (1997) used phone calls to remind parents to fill in their diaries, which seems to have aided in keeping their follow-up consistent and their dropout rate at a low level. It would be more recommendable to use an objective standardised measurement about the time being spent in prone or supine position. This may lead to the method of data collection being more reproducible and therefore make the results more reliable. Additionally, some of the questionnaires were conducted in a different language, as the studies were conducted in different countries. While the study by Russell et al., (2009) was conducted in South Africa and interviews were done in English or Afrikaans, Carmeli et al., (2009) conducted their research in Israel where interviews were conducted in English or Arabic. Having to translate questionnaires back and forth increases the risk for bias during translation.

The quality of the included studies is generally moderate to low. Even though there was significant evidence found in almost all articles, it should be read while keeping in mind that it is based on moderate to low-quality studies. The participants of the studies varied in age (1 week to 12 months old) which makes it hard to give one conclusive answer to at what age the different positions showed an effect on motor development. Lack of information given about population characteristics and families made it very challenging to compare them.

It is rare that the effects of both prone and supine positions were assessed. Usually, either one or the other were examined and one not selected was just recorded as additional data. It was difficult to see whether there were any positive effects of supine position or negative effects of prone position on development, as articles usually had a certain hypothesis in mind and followed this lead. This hypothesis was either, what the beneficial effects of prone position were (Dudek-Shriber & Zelazny, 2007; Russell et al., 2009) or if there were negative consequences of the supine position on motor development (Majnemer & Barr, 2005, 2006). This increases the difficulty to give a clear answer to the research question.

Lastly, not only the measurement instruments varied but also the professions of the assessors of the development. In Salls et al., (2002) the assessment of motor development was conducted by occupational therapists, whereas in Jantz et al., (1997) the assessment was done by paediatricians and in Carmeli et al., (2009) by a physiotherapist. And while it usually should not matter who does the assessments, there might be slight discrepancies on background knowledge or points of focus on behalf of the assessors.

The differences in measurement protocol, data gathering methods, types of intervention and resulting outcomes make homogeneity almost impossible. However, despite all these differences it was possible to draw some relevant conclusions as the differences were not too grave.

Kuo et al., (2008) and Davis et al., (1998) which both had sample sizes of over 280 participants and tested very similar milestones, both agreed that the milestones of sitting, crawling, pulling to stand and head control can be achieved earlier in a group of infants that spends increased time in prone position. Both these studies had a moderate level of evidence. In addition, both these studies were longitudinal cohort studies which increases the chance that attainment of milestones is noticed more easily as there are several check-up points over time. Two of the highest-quality studies from this review agreed on these specific milestones being achieved earlier in the prone group. Why?

It could be explained by the fact that when infants first lie in prone position they start their fight against gravity (Adolph & Franchak, 2017). The infants have a far stronger need to develop their dorsal muscle chain to be able to be active in this position. As lifting their head or going into a crawling position includes raising body parts off the ground, it creates a disequilibrium (Adolph & Franchak, 2017). This may lead to stabilising muscles being more developed which explains why the milestones of head control, crawling and sitting would be achieved earlier, as these all include a substantial amount of stabilisation. In addition, the prone position is a much more active position which encourages exploration as infants have a wider visual field (Adolph & Franchak, 2017). Combining the acquired stable postural base with the curiosity of the infant, may open up new possibilities for the infant to acquire knowledge and explore their surroundings. This may explain why pulling to stand is another milestone that is achieved earlier in an infant that spends increased time in prone position.

Conclusion

Placing infants in prone position has a positive effect on motor development, while supine position seems to have a neutral or no effect on motor development. It is still recommended that babies and infant spend their sleeping time on their backs, as it might reduce the chance for SIDS (APP, 1992), but there should be some supervised prone playing time added early on into a daily routine, to facilitate good motor development.

The health effects of prone positioning of infants during the day is an important matter that needs to be investigated further. It would be especially favourable to see some higher quality studies being conducted like a high quality randomised control trial. The information gathered should then also be brought to the general public.

Relevance

Knowing what position to place an infant is not only interesting for healthcare workers in hospitals and practices but also a piece of information that is often asked by parents. The knowledge about what benefits certain positions, as the prone position, bring to motor development, can aid the child in their early exploration, facilitate their learning processes and also prevent motor developmental delay.

Nowadays prevention is one of the most important parts of the job of a physiotherapist. Early identification of developmental delay can lead to earlier, more effective and more affordable treatment during the infancy and preschool years (APTA, 2018). In Germany, it is part of the job description of many paediatric physiotherapists to give this type of advice and recommendations to parents. It is believed that it can be beneficial for parents to not act out of fear of SIDS, but to have sufficient knowledge of what evidence proves to be safe and what is beneficial for their infant and their early motor development.

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Appendices

Appendix A

Database	Advantages	Disadvantages
PubMed	- Peer-reviewed studies - Ability to search with MeSH terms - Good advanced search possibility - A lot of articles - Contains high-quality articles	- Not all articles were relevant although the advanced search was used - Searching in MeSH term can take up time
PEDro	- Physiotherapy specific studies - Peer-reviewed articles - PEDro ranks articles by quality (easily accessible)	- Limited Data
CINAHL	- Wide range of articles about health care - Peer-reviewed articles	- A lot of old literature or books instead of papers or articles
Science direct	- Specific filters for subcategories -> easy to make specific	- Not as much variety in articles about physiotherapy

Appendix B

Description of methodological analysis using Strobe statement for observational studies (von Elm et al., 2014)

	Item number	Recommendation
Title and Abstract	1	(a) Indicate the study's design with a commonly used term in the title or the abstract (b) Provide in the abstract an informative and balanced summary of what was done and what was found
Introduction		
Background/rationale	2	Explain the scientific background and rationale for the investigation being reported
Objectives	3	State-specific objectives, including any prespecified hypotheses
Methods		
Study design	4	Present key elements of study design early in the paper
Setting	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection
Participants	6	(a) Give the eligibility criteria and the sources and methods of selection of participants
Variables	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable
Data sources/measurement	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group.
Bias	9	Describe any efforts to address potential sources of bias
Study size	10	Explain how the study size was arrived at
Quantitative variables	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why
Statistical Methods	12	(a) Describe all statistical methods, including those used to control for confounding (b) Describe any methods used to examine subgroups and interactions (c) Explain how missing data were addressed (d) If applicable, describe analytical methods taking account of sampling strategy (e) Describe any sensitivity analyses

Results		
Participants	13*	(a) Report numbers of individuals at each stage of study- eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed Give reasons for nonparticipation at each stage, consider the use of a flow diagram
Descriptive data	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders (b) Indicate the number of participants with missing data for each variable of interest Cohort study-Summarise follow-up time (e.g., average and total amount)
Outcome data	15*	Cohort study-Report numbers of outcome events or summary measures over time Case-control study-report numbers in each exposure category, or summary measures of exposure Cross-sectional study-report numbers of outcome events or summary measures
Main results	16	(a) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included (b) Report category boundaries when continuous variables were categorised (c) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period
Other analyses	17	Report other analyses done- eg analyses of subgroups and interactions and sensitivity analyses
Discussion		
Key results	18	Summarise key results with reference to study objectives

Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, a multiplicity of analyses, results from similar studies, and other relevant evidence
Generalisability	21	Discuss the generalisability (external validity) of the study results
Other information		
Funding	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based

*Give information separately for exposed and unexposed groups

Appendix C

STROBE Statement checklist (von Elm et al., 2014)

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	**STROBE score**
Russel	1	1	1	1	1	1	1	1	0	1	1	0	0	0	1	1	0	1	0	1	1	0	**15 /22**
Durek-Shriber	1	1	1	1	1	1	1	1	1	1	1	1	1	0	1	1	0	1	1	1	0	0	**18 /22**
Kuo	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0	0	1	1	1	1	1	**20 /22**
Majnemer 2005	1	1	1	1	1	1	1	1	1	0	1	0	1	1	1	1	1	1	1	1	1	1	**20 /22**
Carmeli	1	1	1	1	1	1	1	1	0	1	1	0	1	0	1	1	0	0	1	1	0	0	**15 /22**
Majnemer 2006	1	1	1	1	1	1	1	1	0	1	1	0	1	1	1	1	0	1	1	1	1	0	**18 /22**
Davis	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	0	1	1	1	1	1	**21 /22**
Salls	1	1	1	1	1	1	1	1	0	0	1	0	0	0	1	1	1	1	1	1	1	0	**16 /22**
Monson	1	1	1	0	1	1	0	1	1	0	1	1	1	1	1	0	1	1	1	1	1	0	**17 /22**
Jantz	1	1	1	1	1	1	1	1	1	1	1	0	1	0	1	0	1	1	1	0	1	0	**17 /22**