**PICO Question: For babies birth to six months, does participation in regularly scheduled prone positioning (“tummy time”) vs. unstructured positioning improve gross motor development?**

**Introduction**

Early intervention physical therapists are responsible for evaluating infant motor development and facilitating the acquisition of developmental motor milestones. Progressing through a pattern of established milestones is an indicator of the infant’s neurologic and motor development. Prone positioning is important for the development of antigravity behaviors including head, neck and trunk control, upper extremity weight bearing, shifting and reaching.1These skills prepare the infant for mobility through creeping, pull to stand and eventually ambulation. Infant mobility is crucial for environment exploration, object manipulation, and problem solving which lead to neurologic and sensory development.2 Children who achieve motor milestones late may risk long term motor and neurologic developmental delay.2

 In 1992 the American Academy of Pediatrics (AAP) recommended that all infants sleep in the supine position to reduce the risk of sudden infant death syndrome (SIDS). Since this recommendation the incidence of SIDS decreased 50%, however clinicians report delayed motor development in children who sleep supine.3 Spending increased time in supine is also associated with plagiocephaly and torticollis.4,5

Plagiocephaly is deformation of the skull producing the appearance of an asymmetric head and face. One cause of plagiocephaly is external forces on the skull caused by infant positioning during sleep and play. If not treated early plagiocephaly and the associated facial changes will be permanent.4 This facial asymmetry may cause chronic ear infections, visual field defects, teeth malalignment, and psychosocial implications.4,6 Torticollis is a contracture of the sternocleidomastoid muscle causing the head to approximate one shoulder. Torticollis results from positioning the infant’s head in one direction, and is frequently associated with plagiocephaly and limited prone positioning.6 Infants with torticollis are unable to fully turn their head causing developmental impact. Implications may include skewed internal sensory maps and body image formation, decreased midline postural stability, and decreased movement and balance.6

The purpose of this literature review is to investigate the effects of wakeful prone positioning on motor development. Researchers postulate that participating in prone “tummy time” while awake may counter the negative developmental implications associated with supine sleeping.1 The review will highlight long and short term findings related to gross motor skill acquisition following “tummy time” programs. The goal of compiling this information is to determine evidence based recommendations to support a parent education initiative. As such, the review will also include information regarding current parent practices and effective methods of education. Article comparisons will focus on research design, intervention, outcome measures, findings, and applicability to practice. Critical appraisal of articles will include assessment of bias, power, and validity.

**Research Design and Intervention**

Articles related to this PICO question vary in research design. Jennings et al. and Lobo et al. utilized a randomized control trial design.2,7 These two papers contain higher level evidence compared to the others because they employed an experimental and control group. Lobo et al. recruited 28 families and randomly assigned 2 month old infants to either the social interaction group (control) or the positioning and handling group (experimental). Members of the social interaction group were placed in supine and engaged in parent social interaction 15 minutes per day for 3 weeks. Positioning and handling group babies were placed in developmental positions including prone, supported sitting, and supported standing 15 minutes per day for 3 weeks.2 The developmental progress between groups was compared over a 12 month period. Jennings et al. randomly assigned 78 families with newborns to one of four parental education groups.7 Group 1 (control) received their pediatrician’s typical advice, group 2 received a nurse home visit and viewed a positioning and handling video, group 3 received a nurse home visit, but did not watch the video, and group 4 received a positioning and handling brochure during a nurse home visit or in their pediatrician’s office. Researchers compared infant prone time based on the type of education.7

Kuo et al., Majnemer et al. and Lung et al. implemented longitudinal cohort designs to investigate positioning effects on development over time.8,9,10 Kuo et al. followed 335, 4 month old infants for 20 months. Caregivers completed prone activity and milestone acquisition questionnaires at 4, 6, 12, and 24 months of infant age. Researchers assessed the infants’ development at 6 and 24 months of age.8 Majnemer et al. followed 81, 4 month old infants and 72, 6 month old infants until 15 months of age. Caregivers completed a questionnaire containing demographic information, infant sleeping habits, and wakeful prone activity descriptions, and a 3 day positioning diary. Infant motor development was assessed at 4 or 6 months and at 15 months of infant age.9 Lung et al. recruited 1783, 6 month old infants and followed participants for 30 months. Researchers interviewed the parents regarding demographic information, birth history, infant illness, and sleep position. The children’s development was assessed at 6, 18 and 36 months of age.10

 The final three studies, by Dudek-Shriber et al., Zachry et al. and Rocha et al., utilized cross-sectional research designs.1,3,11 Dudeck-Shriber et al. recruited 100, 4 month old infants to investigate the relationship between prone activity and motor development. Researchers assessed the infants’ motor development at 4 months of age and compared milestone achievement to parental reports of prone activity.1 Zachry et al. provided questionnaires to 205 caregivers of infants ages birth to 24 months. Parents reported their knowledge of tummy time recommendations, understanding of complications associated with lack of tummy time, their source of knowledge, and the amount of time their infant spent in prone. The authors compiled the data to analyze current infant positioning knowledge and practices.3 Rocha et al. recruited 40 infants ages birth to 4 months to investigate positioning effect on hand function development and exploratory behavior. The authors observed the infants for 3 minutes in prone, supine and sidelying. Researchers quantified the frequency and duration of hand-to-hand and hand-to-mouth behavior and assessed postural control in each position.11

 The articles included in this review range from high level evidence randomized control trials to moderate level evidence cross-sectional studies. Based on the hierarchy of evidence, high ranking articles, such as those by Jennings and Lobo, may warrant greater confidence and clinical applicability.12 All articles included for review to address this PICO question are level 3 evidence or higher. Therefore results are clinically important, and together may be trusted to implement change.12 Seven articles related to this research topic implemented questionnaires. This may be problematic as questionnaires have high potential for response and recall bias.8 Results based on parent report are not regarded with high confidence due to inaccuracy probability. Six articles included developmental assessment along with parent report which increases acceptability. However, the developmental outcome measure psychometric properties determine confidence.

**Outcome Measures**

The two most frequently used outcome measures across these studies were the Albert Infant Motor Scale (AIMS) and the Peabody Developmental Motor Scale 2nd Edition (PDMS-2). The AIMS was conducted by Dudek-Shriber et al., Majnemer et al., and Lobo et al.1,2,9 The AIMS is a norm-referenced observational measure appropriate for infants from birth to 18 months or the onset of independent walking. Clinicians observe infants in prone, supine, sitting and standing and score either a 1, for observed, or 0, not observed, on 58 items. Scores are compared to a normative sample of 2202 infants. The AIMS is a reliable and valid measure with reported interrater reliability r=0.96-0.99, test-retest reliability r=0.86-0.99, concurrent validity with the PDMS r= 0.97, concurrent validity with the Bayley Scales of Infant Development (BSID) r=0.98, 80% sensitivity, 90% specificity, and 70% positive predictive value.9,13,14 The PDMS-2 was included in studies by Majnemer et al. and Jennings et al. The PDMS-2 is a norm-referenced standardized measure of gross and fine motor skills for children ages birth to 5. Clinicians score children using a 3-point scale on 151 gross motor items and 98 fine motor items. The PDMS-2 is reliable and valid with reported internal consistency reliability r=0.96-0.97, test-retest reliability r=0.89-0.93, inter-rater reliability r=0.96, and concurrent validity with the original PDMS r=0.84-0.91.15

Other outcome measures utilized include the Taiwan Birth Cohort Study Instrument (TBCS),10 the Comprehensive Developmental Inventory for Infants and Toddlers (CDIIT)8 and various author developed questionnaires. The TBCS is a self-report inventory of gross motor, fine motor, language and social dimensions with adequate reliability, internal consistency and validity. TBCS psychometric properties are as follows: internal consistency r=0.48-0.71, content validity with the BSID motor criteria r=0.66, and construct validity r=0.91.16 The CDIIT is a standardized measure with a normative sample of 3703, 3-71 month old Taiwanese children and includes 5 developmental domains. Kuo et al. assessed children using only the gross motor and fine motor domains.8The CDIIT has good reliability and validity with reported inter-rater reliability r=0.97-1.00, test-retest reliability r=0.87-0.99, and concurrent validity with the BSID r=0.80-0.97.17,18 The psychometric properties regarding researcher developed questionnaires were not discussed in any study. The outcomes determined solely through questionnaire may not be valid or reliable limiting results confidence. Overall the outcome measures chosen to investigate positional impact on motor development are valid and reliable.

**Findings**

The findings of the included studies were overwhelmingly positive. As a body of evidence they support earlier achievement of motor skills following prone positioning. The evidence also suggests a need for parental education regarding positioning recommendations. Conflicting results arose regarding the long-term developmental impact of positioning. Several studies reported lasting developmental differences following prone activity, however others reported a transient effect fading by 6 months of age.

 Majnemer et al. found that infants who participated in prone sleeping or prone wakeful activity had significantly greater scores on the AIMS and PDMS-2 at 4 and 6 months of age (p <0.05). Additionally, prone sleeping and wakeful activity significantly correlated with motor milestone achievement at 6 and 15 months of age (p<0.05).9 Lobo et al. reported immediate, short term and long term results. Immediately following intervention the positioning and handling group babies (experimental group) had a significantly greater increase on the AIMS from baseline compared to the social interaction group babies (control) (p<0.01). At 3-5 months of age, the experimental group had greater AIMS prone subscale, sitting subscale and total score advancement (p<0.01) and began reaching earlier than the control group (p<0.05). 7-12 months post intervention the experimental group infants achieved object grasp, manipulation and transfer, creeping, supported walking, and independent walking significantly earlier than the control group (p<0.05).2 Jennings et al. reported, at 6 month evaluation, that infants who were placed in prone “more than once per day” had significantly greater PDMS-2 locomotion scores compared to infants who were placed in prone “less than once daily” (p=0.001). Additionally infants who were placed in prone “once per day” had significantly greater PDMS-2 locomotion scores compared to infants “seldom placed in prone” (p=0.0367). At 18 month evaluation, infants who were routinely placed in prone until 6 months of age had significantly greater PDMS-2 locomotion scores compared to infants not routinely place in prone (p=0.015). They also found that prone activity was most frequent for infants of parents who received brochures during a home nurse visit (p=0.001).7

 Kuo et al. and Lung et al. reported transient infant positioning developmental impact.8,10 Kuo et al. found a significant correlation between increased prone activity and achievement of rolling, crawling, creeping, sitting (p<0.0167) and a higher 6-month CDIIT gross motor score (p=0.018). However, prone position exposure did not significantly affect walking achievement or 24-month CDIIT motor scores.8 Lung et al. reported that sleeping supine resulted in delayed gross and fine motor development at 6 months of age (p=0.03); this effect was no longer significant at 18 or 36 months of age. Chronic illness was the most predictive variable of long term motor delay.10

 Dudek-Shriber et al. and Rocha et al. found relationships between prone activity and motor development, however they did not follow participants over time to investigate long term impact.1,11 Dudek-Shriber et al. reported that participating in wakeful prone activity significantly correlated with greater AIMS prone, supine and sitting scores(p<0.016). Infants who spent at least 1 hour and 21 minutes per day in wakeful prone achieved motor milestones earlier compared to those who spent less time in prone(p<0.001).1 Rocha et al. found that hand-to-mouth behavior was most frequent in prone for birth-2 month old infants and in sidelying for 3-4 month old infants. Hand-to-hand behavior occurred most frequently in sidelying in all age groups.11

Zachry et al. reported findings related to caregiver knowledge and their prone play practices.3In their sample, 25% of caregivers were not aware of prone play recommendations. Of the 75% who were aware, 25% were not informed about potential limited prone complications. Based on parental recount: 29.8% of infants spent < 15 minutes/day in prone, 24.9% spent 31-60 minutes/day in prone, 13.2% spent 1-2 hours/day in prone and 8.8% spent > 2 hours/day in prone.3

The collective findings of this study suggest that yes, participation in prone positioning vs. unstructured positioning improves gross motor development. However, there is conflict regarding the long term implications of prone positioning practice. Furthermore evidence supports a need for prone activity parental education and suggests that brochure distribution may increase prone participation.

**Critical Appraisal**

Only two authors discussed power and sample size justification.1,8 Researchers who do not calculate power may not recruit large enough samples to detect true effect. Low power reduces the likelihood that significant findings reflect true population validity.19 As six authors included in this review did not calculate power, their study validity is limited. Dudek-Shriber et al. determined a sample of 100 participants was needed to achieve a power of 0.80 at alpha=0.05 with a medium effect size (d=0.50).1 Kuo et al. calculated that a sample of 72 participants was needed to achieve a power of 0.90 at alpha =0.05.8 Dudek-Shriber et al. and Kuo et al. included a greater sample than needed to achieve adequate power, therefore their significant findings are valid and applicable to the general population.1,8 Additional study power is unknown, therefore true population effect cannot be determined.

 Studies were similar regarding bias and limitations. Common themes included recruitment of a non-random, homogeneous sample,1,2,3,7,8,9,10 small sample size with no power justification,2,7,9,11 lack of control group,1,3,7,8,9,10 and a high probability of recall and response bias.1,2,3,7,8,9,10 Authors did not mention blinding, questionnaire reliability or validity or intervention training. Future authors should recruit heterogeneous samples including typically developing infants and infants with disabilities from varied cultural backgrounds. A greater representation of randomized control trials employing experimental and control groups would enhance evidence validity and applicability. Future researchers should utilize standardized measures to investigate outcomes rather than questionnaires to reduce recall and response bias.

**Conclusion**

 As a whole this research demonstrated a positive correlation between prone positioning and gross motor development. The results of this review support value and need for a parent education initiative targeting wakeful prone position participation. Additionally, incorporating prone activity in therapy may be beneficial for infants with developmental delay.1 Early intervention physical therapists should include assessment of current prone activity when evaluating motor development and educate caregivers as appropriate.

 Although significant results were reported across all studies, future higher level evidence is needed to increase validity. Future authors should investigate the impact of a prone positioning program for infants with developmental delay. Future research in this area may help reduce preventable motor and neurologic delay and decrease the incidence of plagiocephaly and torticollis deformities.2,4,5

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