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| **CRITICALLY APPRAISED TOPIC** |

**FOCUSED CLINICAL QUESTION**

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| For a ten-year-old patient with musculoskeletal changes in his trunk due to neuromotor delay, is ribcage mobilization or positioning most effective in promoting airway clearance and increasing vital lung capacity? |

**AUTHOR**

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**CLINICAL SCENARIO**

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| This PICO question is derived from a capstone project proposed by Dana McCarty, with the end goal of presenting the findings to therapists in Guatemala. The patient population that the therapists and students from UNC often see in Guatemala are pediatric (and adult) patients that have these musculoskeletal changes in the trunk, leading to breathing difficulties. The findings from this question could help drive therapy in Guatemala, as well as the US. The goal is to find the most effective interventions that do not require much equipment, since the clinic in Guatemala does not have many resources. |

**SUMMARY OF SEARCH**

[Best evidence appraised and key findings]

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| -A total of 11 articles were found from the PubMed, CINAHL, and Web of Science databases that met the inclusion/exclusion criteria. One article is a systematic review, two articles are two-group cross-sectional designs, five articles are single-group cross-sectional designs, two articles are prospective single-subject alternating treatment designs, and one article is a retrospective single-group pre-post treatment study.  -Seated position affects pulmonary function in children with CP. Anteriorly-tipped chairs improve pulmonary function more than horizontal or posteriorly-tipped chairs in this patient population. Additionally, adapted seating with increased support in the head, neck, and thorax improves pulmonary function.  -Night time positioning equipment (NTPE) does not statistically significantly affect respiratory function during sleep in pediatric patients with severe cerebral palsy (CP).  -There is no research regarding rib mobilizations in the pediatric population with cerebral palsy. |

**CLINICAL BOTTOM LINE**

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| Current best evidence suggests that seated positioning plays an important role in pulmonary function in pediatric patients with CP. Patients who sit in anteriorly-tipped chairs demonstrate statistically significant improvements in pulmonary function in forced vital capacity (FVC) when compared to horizontally or posteriorly-tipped chairs. Furthermore, pediatric patients that sit in adaptive chairs with increased head, neck, and thorax support demonstrate increased pulmonary function. Additionally, NTPE does not significantly affect pulmonary function during sleep. Overall, research on this topic is very limited. There is no research regarding ribcage mobilization in the pediatric population. Future research needs to be conducted with larger sample sizes regarding positioning, in addition to research regarding rib mobilizations and respiratory function in pediatric patients with CP. |

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| ***This critically appraised topic has been individually prepared as part of a course requirement and has been peer-reviewed by one other independent course instructor*** |

**SEARCH STRATEGY**

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| **Terms used to guide the search strategy** | | | |
| **P**atient/Client Group | **I**ntervention (or Assessment) | **C**omparison | **O**utcome(s) |
| Child\*  Pediatric  “Neuromotor delay\*”  “Cerebral Palsy”  CP | “Rib mobilization\*”  “Rib mobility”  “Ribcage mobilization\*”  “Ribcage mobility” | Position  Positioning  Posture | “Airway clearance”  “Vital lung capacity”  “Vital capacity”  VC  Breathing |

**Final search strategy:**

**Pubmed Search:**

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| Search | Query |
| #8 | Search (#2 AND #4 AND #5) |
| #7 | Search (#2 AND #3 AND #5) |
| #6 | Search (#1 AND #2 AND #3 AND #4 AND #5) |
| #5 | Search ("airway clearance" OR "vital lung capacity" OR "vital capacity" OR VC or breathing) |
| #4 | Search (position OR positioning OR posture) |
| #3 | Search ("rib mobilization\*" OR "rib mobility" OR "ribcage mobilization\*" OR "ribcage mobility") |
| #2 | Search ("neuromotor delay" OR "cerebral palsy" OR CP) |
| #1 | Search (Child\* OR pediatric) |

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| **Databases and Sites Searched** | **Number of results** | **Limits applied, revised number of results (if applicable)** |
| **Pubmed:**   |  |  | | --- | --- | | #8 | Search (#2 AND #4 AND #5) | | #7 | Search (#2 AND #3 AND #5) | | #6 | Search (#1 AND #2 AND #3 AND #4 AND #5) | | #5 | Search ("airway clearance" OR "vital lung capacity" OR  "vital capacity" OR VC or breathing) | | #4 | Search (position OR positioning OR posture) | | #3 | Search ("rib mobilization\*" OR "rib mobility" OR  "ribcage mobilization\*" OR "ribcage mobility") | | #2 | Search ("neuromotor delay" OR "cerebral palsy" OR CP) | | #1 | Search (Child\* OR pediatric) |   **CINAHL:**  #1 AND #2 AND #4 AND #5  ("rib mobilization\*" OR "rib mobility" OR "ribcage mobilization\*"  OR "ribcage mobility")  **Web of Science:**  #1 AND #2 AND #4 AND #5  ("rib mobilization\*" OR "rib mobility" OR "ribcage mobilization\*"  OR "ribcage mobility")  **\*Initial search in all 3 databases using #1 AND #2 AND #3 AND #4 AND #5 yielded 0 results** | |  | | --- | | 66 | | 0 | | 0 | | 271064 | | 424580 | | 30 | | 77039 | | 2508119 |   6    4  9  4 | **No limits were applied – rib mobilizations had to be searched separately in order to find articles relating to that technique** |

## INCLUSION and EXCLUSION CRITERIA

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| **Inclusion Criteria** |
| -Patients aged 0-21 with neuromotor delay  -Used an outcome measure for respiratory function  -Patients have no other comorbidities  -Treatment includes rib mobilizations and/or positioning techniques |
| **Exclusion Criteria** |
| -Studies not in English |

**RESULTS OF SEARCH**

**Summary of articles retrieved that met inclusion and exclusion criteria**

A total of 11 articles were found that met the inclusion/exclusion criteria from the PubMed, CINAHL, and Web of Science databases. One article is a systematic review, two are two-group cross-sectional designs, five are single-group cross-sectional designs, two are prospective single-subject alternating treatment designs, and one is a retrospective single-group pre-post treatment study. All studies have been evaluated for study quality using the AMSTAR or Downs and Black checklists for study quality.

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| **Author (Year)** | **Study quality score** | **Level of Evidence** | **Study design** |
| **Reid and Sochaniwskly (1991)1** | **14/29 (Downs and Black)** | **Level IV** | **2 group cross-sectional design** |
| **Lephart and Kaplan (2015)2** | **20/29 (Downs and Black)** | **Level IV** | **Prospective single-subject alternating treatment design** |
| **Weiss (1991)3** | **19/29 (Downs and Black)** | **Level II** | **Retrospective single group pre-post treatment study** |
| **Redstone (2004)4** | **17/29 (Downs and Black)** | **Level IV** | **2 group cross-sectional design** |
| **Barks (2004)5** | **1/11 (AMSTAR)** | **Level I** | **Systematic Review** |
| **Barks (2011)6** | **15/29 (Downs and Black)** | **Level IV** | **Single group cross-sectional study** |
| **Leopando (1999)7** | **19/29 (Downs and Black)** | **Level IV** | **Single group cross sectional design** |
| **Hill et al. (2009)8** | **20/29 (Downs and Black** | **Level IV** | **Single group cross sectional pilot study** |
| **Shin et al. (2015)9** | **19/29 (Downs and Black)** | **Level IV** | **Single group cross sectional design** |
| **Littleton et al. (2011)10** | **20/29 (Downs and Black)** | **Level IV** | **Alternating treatment single-subject research design** |
| **Nwaobi & Smith (1986)** | **16/29 (Downs and Black)** | **Level IV** | **Single group cross-sectional design** |

**BEST EVIDENCE**

The following 3 studies were identified as the ‘best’ evidence and selected for critical appraisal. Reasons for selecting these studies were:

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| * **Nwaobi & Smith (1986)11:** Although this study is of a lower quality (16/29 on Downs and Black), it is one of the only two studies that directly addresses the PICO question regarding positioning and vital capacity and has served as a staple study regarding pulmonary function and positioning in children with CP for many later studies. * **Hill (2009)8:** This is one of the highest quality studies (20/29 on Downs and Black). While it does not use the outcome measures stated in the PICO question, it is a well-designed study that measures oxygen levels during sleep with and without a positioning device. The results of this study are important as children with CP have a greater risk of respiratory distress while sleeping. * **Shin (2015)9:** This is another of the highest quality studies at 19/29 on the Downs and Black scale. It meets the inclusion criteria and provides crucial information about vital capacity in 3 different positions in a chair in children with CP. |

**SUMMARY OF BEST EVIDENCE**

**(1) Description and appraisal of “Effect of adaptive seating on pulmonary function of children with cerebral palsy” by Nwaobi & Smith, 1986.**

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| **Aim/Objective of the Study/Systematic Review:** |
| The aim of the study is to measure the effects of adaptive seating on vital capacity (VC), forced expiratory volume in one second (FEV1), and expiratory time (ET) in non-ambulatory children aged 5-12 with cerebral palsy. |
| **Study Design**  [e.g., systematic review, cohort, randomised controlled trial, qualitative study, grounded theory. Includes information about study characteristics such as blinding and allocation concealment. When were outcomes measured, if relevant]  Note: For systematic review, use headings ‘search strategy’, ‘selection criteria’, ‘methods’ etc. For qualitative studies, identify data collection/analyses methods. |
| -This is a single-group cross-sectional study design.  -Eight subjects underwent testing in two different seating positions – a regular Everest and Jennings sling-seat wheelchair with a back, and an adapted wheelchair seat with lateral trunk and thigh supports, a lap belt, and chest panel. In the adapted seating condition, adjustments were made for hip flexion angle, foot rest height, length of seat, and height of back and headrest.  -The order of the testing in each condition was randomized, but the method of randomization was not reported.  -There was no blinding of the participants or of the researchers, and there was no follow-up necessary.  -The vital capacity (VC), forced expiratory volume in one second (FEV1), the percentage of the FEV1/VC, and expiratory time was analysed using T-tests. |
| **Setting**  [e.g., locations such as hospital, community; rural; metropolitan; country] |
| Though the setting was not specified, this is a cross-sectional study, so it was most likely conducted in an academic lab. |
| **Participants**  [N, diagnosis, eligibility criteria, how recruited, type of sample (e.g., purposive, random), key demographics such as mean age, gender, duration of illness/disease, and if groups in an RCT were comparable at baseline on key demographic variables; number of dropouts if relevant, number available for follow-up]  Note: This is not a list of the inclusion and exclusion criteria. This is a description of the actual sample that participated in the study. You can find this descriptive information in the text and tables in the article. |
| -There are 8 subjects in this study between the ages of 5-12.  -The mean age and gender of each participant was not stated.  -All participants have spastic cerebral palsy and are non-ambulatory.  -The participants’ levels on the Gross Motor Function and Classification System are not reported.  -The recruiting strategy was not stated.  -The patients had no evidence underlying lung disease prior to participating in this study. |
| **Intervention Investigated**  [Provide details of methods, who provided treatment, when and where, how many hours of treatment provided] |
| *Control* |
| This is a single-group cross-sectional study, so there is no control group. Each participant underwent both conditions. |
| *Experimental* |
| -Each child was tested in the Everest-Jennings sling seat with a back and the adapted wheelchair with supports.  -The child was placed in an upright position in the Everest-Jennings chair with a backrest, but had no other supports.  -In the adapted wheelchair, the child’s hip, knee, and ankle were placed in 90° of flexion (dorsiflexion for the ankle). Additionally, the head, neck, and trunk were supported to hold the child in an upright position.  -The order in which the child completed each trial was randomized.  -An adjustment period of 10 minutes was given to each participant after being moved to a chair condition before testing began.  -A Breon spirometer with an adapted mouthpiece for the pediatric population was used to measure all spirometry. It provides visual feedback of the performance for the participant in addition to measuring flow rates.  -Testing involved blowing as fast as possible into the Breon spirometer. The child was given many practice runs before testing began.  -A total of 4 trials were recorded in each condition. The amount of time in between trials was not reported. The highest score for vital capacity and forced expiratory volume in one-second (FEV1) were used for analysis, along with the longest expiratory time (ET).  -The providers of treatment were not specified. |
| **Outcome Measures** (Primary and Secondary)  [Give details of each measure, maximum possible score and range for each measure, administered by whom, where] |
| -The outcome measures used were: vital capacity (VC), forced expiratory volume in one second (FEV1), FEV1/VC percentage, and expiratory time (ET).  -FVC measures the amount of quick expiration that occurs following maximal inhalation.  -FEV1 measures the amount of expiration in one second following maximal inhalation.  -Expiratory time is the amount of time it takes to complete one forced expiration.  -Refer to Dugdale & Moeri. for expected VC and FEV1 values for children based on age, height, and weight.12  -Refer to Quanjer et al. for expected FEV1/VC and ET rates based on age and ethnic group.13 |
| **Main Findings**  [Provide summary of mean scores/mean differences/treatment effect, 95% confidence intervals and p-values etc., where provided; you may calculate your own values if necessary/applicable] |
| -The researchers found that there was a statistically significant difference in the two groups in VC, FEV1, FEV1/VC, and ET when p < .05.  -Vital Capacity in the wheelchair group had a mean of .97 liters (L) with a standard deviation of 0.29L, while the adapted seating group had a mean VC of 1.53L (SD 0.24L). FEV1/VC percentage is 51.7% (SD 16.93%) in the wheelchair group in comparison to 78.4% (SD 17.23%) in the adapted seating group, and ET is 2 seconds (SD 2.3s) in the wheelchair group and 3.1s (SD 3.58s) in the adapted seating group. Individual p-values were not reported. Instead, changes were reported as percentages between the two conditions for each outcome measure. There was a 57.7% increase from the wheelchair condition to the adapted seating condition for VC, 51.6% increase from the wheelchair to adapted seating condition for FEV1/VC, and a 55% increase from the wheelchair to the adapted seating condition for ET. |
| **Original Authors’ Conclusions**  [Paraphrase as required. If providing a direct quote, add page number] |
| The authors concluded that adapted seated that supports the head, neck, and thorax improves respiratory function in children with CP. They ascertain that this improvement is due to the improved alignment of the thorax and abdomen, which allows for improved control of the muscles used to breathe. |
| **Critical Appraisal** |
| **Validity**  [Identify the strengths and limitations of the study, including potential sources of bias. Comment on the overall methodological quality (including the score) as you determined from your assessment of the article. Comment on anything you believe was missing in the paper.] |
| This study scored a 16/29 on the Downs and Black checklist for measuring study quality. Some of the points lost do not pertain to this study, including blinding of the participant and researcher to the intervention being studied. However, this study also lost points for insufficient reporting of patient characteristics, no discussion of possible confounders, no report of possible adverse events due to the intervention, no specific probability values were reported, no discussion on the recruiting methods of the subjects, no report on how the intervention conditions were randomized, no adjustment for confounding variables was made, and no power analysis was reported.  This is one of the only studies that researches the impact of positioning on respiratory function in children with CP. However, there are a few limitations of the study. There are only 8 participants, creating a small sample size that cannot be generalized to the overall population of children with CP. This small sample size may underpower the study. Additionally, the authors do not report any psychometric properties of the participants including height, weight, gender, or Gross Motor Function Classification System (GMFCS) levels. They also do not report individualized p-values. Furthermore, participants were only included in the study if they could follow directions, which limits the applicability of the results to all pediatric patients with CP. Another limitation is that the researchers do not give exact specifications for the adapted seating, such as seat depth and upper extremity support. This could lead to an internal validity issue as each participant may be positioned in a different way, skewing results. |
| **Interpretation of Results**  [This is YOUR interpretation of the results taking into consideration the strengths and limitations as you discussed above. Please comment on clinical significance of effect size / study findings. Describe in your own words what the results mean.] |
| This study is one of the only studies that uses vital capacity to determine positioning effects in children with CP. These results suggest that an adapted seat with great trunk support improves respiratory function in children with CP. However, while the results show there is significant improvement in VC, FEV1/VC percentage, and ET in an adapted seat with increased support, there is a small sample size and the study does not report individual p-values. The effect size for VC is 0.73, for FEV1/VC % is 0.62, and for ET is .23. Given these numbers and the small sample size, it would be important to conduct more research with a greater sample size and more detailed instructions of the methods before generalizing these findings to the entire pediatric population with CP. |

**(2) Description and appraisal of “Sleep quality and respiratory function in children with severe cerebral palsy using night-time postural equipment: a pilot study” by Hill et al., 2009**

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| **Aim/Objective of the Study/Systematic Review:** |
| The aim of the experiment is to examine the effects of night-time postural equipment (NTPE) on sleep quality and respiratory function in non-ambulatory children with CP. |
| **Study Design**  [e.g., systematic review, cohort, randomised controlled trial, qualitative study, grounded theory. Includes information about study characteristics such as blinding and allocation concealment. When were outcomes measured, if relevant]  Note: For systematic review, use headings ‘search strategy’, ‘selection criteria’, ‘methods’ etc. For qualitative studies, identify data collection/analyses methods. |
| -This is a single-group cross-sectional pilot study design: each participant was assessed over 2 nights – 1 while using the NTPE and 1 without the positioning equipment.  -Each participant had at least 3 nights of recuperation at home between the two nights in the laboratory.  -Neither the subjects nor the researchers were blinded to the different conditions, but the conditions were randomized in order for each participant using a sealed envelope method.  -Measurements were taken with polysomnography using the Alice 5 – Respironics system. The Alice 5 system used an “electroencephalogram (EEG) (C3/A2, O1/A2, C4/A1, O2/A1), right and left electro-oculogram (EOG), bipolar submental electromyogram (EMG); diaphragmatic EMG, thoracic and abdomical exursions (piezo bands) and nasal airflow (Protech, Mukilteo, WA, USA), pulse oximetry (Masimo, Irvine, CA, USA), ECG, body position sensor and synchronous video-recording” to take measures.8(pg.1810)  -Researchers then used the data collected to score sleep staging used for analysis.  -Outcomes were measured continuously throughout the night, with sleep stages, arousals, obstructive apnoeas, hypopnoeas, and the apnoea/hypopnoea index (AHI) determined from the data collected over night.  -No follow-up was necessary.  -Data were analysed by the Shapiro-Wilk test, the Wilcoxon-signed rank tests, paired-sample t-tests, the chi-squared test, and the Mann-Whitney U-test depending on the variables being analysed.  -A Bonferroni adjustment was used to set significance at p < 0.0003 for analysis of sleep variables between sleep conditions.  -One-way t-tests were used to compare data from this study with sleep data of typically developing children with significance set at p < .05. |
| **Setting**  [e.g., locations such as hospital, community; rural; metropolitan; country] |
| -The study took place in a pediatric research laboratory in the Southampton area of the United Kingdom. |
| **Participants**  [N, diagnosis, eligibility criteria, how recruited, type of sample (e.g., purposive, random), key demographics such as mean age, gender, duration of illness/disease, and if groups in an RCT were comparable at baseline on key demographic variables; number of dropouts if relevant, number available for follow-up]  Note: This is not a list of the inclusion and exclusion criteria. This is a description of the actual sample that participated in the study. You can find this descriptive information in the text and tables in the article. |
| -10 participants with severe CP: 5 females, 5 males.  -Ages range from 5.3-16.7, with an average age of 10.9 years.  -The participants in the Gross Motor Function Classification System (GMFCS) are all either level IV or V.  -There were 11 participants initially, but one dropped out due to family stress.  -Subject 6 was excluded from within subject analyses due to the development of an illness during her second night of data collection (NTPE condition) with only one recorded REM cycle for the night.  -No follow-up was required with this population.  -The way in which the patients were recruited is not stated, though the patients were from the same community (Southampton) and were using the NTPE prior to this pilot study.  -The amount in which each participant was using the NTPE prior to the study was not reported. |
| **Intervention Investigated**  [Provide details of methods, who provided treatment, when and where, how many hours of treatment provided] |
| *Control* |
| -There was no control group because this is a single-group cross-sectional design looking at the effects of NTPE on sleep quality and respiratory function. All participants were assessed while sleeping with and without the NTPE equipment. |
| *Experimental* |
| -The NTPE is a supportive mattress with additional padded supports used to hold the body in a position that will prevent the formation of contractures and deformities in the trunk, hips, and legs, and can be used in a supine or side-lying position.  -Each participant underwent two nights of sleep analysis in the pediatric research laboratory. One night was spent sleeping without any positioning equipment and one night was spent sleeping with the NTPE.  -The two nights spent in the laboratory were separated by at least three days to allow the patients to recuperate and the order of the patient’s sleeping condition in the first night was randomized using a sealed envelope method.  -Polysomnography was performed by the Alice 5 – Respironics system measuring EEG, EOG, EMG, nasal airflow, and pulse oximetry readings while the patients slept.  -The measures collected during the study through the Alice 5 were then compared to polysomnographic measures taken on typically developing children of similar ages published by Uliel et al.14  -The providers of the treatment were not specified. |
| **Outcome Measures** (Primary and Secondary)  [Give details of each measure, maximum possible score and range for each measure, administered by whom, where] |
| -Outcome measures included: sleep onset latency, total sleep time, sleep efficiency, total arousal index, percentage of total sleep time in stage 2, percentage of total sleep time in stages 3 and 4, percentage of total sleep time in REM sleep, mean overnight SpO2, minimum SpO2, apnoea/hypopnoea index (AHI), and the snoring and daytime sleepiness subscales of the Pediatric Sleep Questionnaire (PSQ).  -All polysomnographic measures were collected by the Alice 5.  -It is not specified who worked with the patients and who conducted the analysis of the data.  -Sleep onset latency measures “time in minutes from lights out to sleep onset.”8(pg.1810)  -Total sleep time measures the “time in minutes from sleep onset to sleep offset that is spent asleep.”8(pg.1810)  -Sleep efficiency is the “percentage of time from sleep onset to sleep offset spent in sleep.”8(pg.1810)  -Sleep efficiency in typically developing children was measured at 90.8%.11  -Arousal index is the “number of EEG arousals per hour of total sleep time”.8(pg.1810)  -The total arousal index in typically developing children in Uliel et al. is 5.29.14  -There are four sleep stages and REM sleep – typically developing children in the Uliel et al. study spent 48.9% of sleep in stage 2, 25.2% in stages 3 and 4, and 17.4% in REM sleep.14  -The maximum possible measure of SpO2 is 100%, but typically developing children in Uliel et al. have a mean overnight SpO2 of 97.2% and a minimum SpO2 of 94%.14  -A maximum of 4 points can be scored on each subscale of the PSQ.8,15 |
| **Main Findings**  [Provide summary of mean scores/mean differences/treatment effect, 95% confidence intervals and p-values etc., where provided; you may calculate your own values if necessary/applicable] |
| -The researchers found no significant differences between sleep quality in the two sleeping conditions:  +Sleep onset latency in the NTPE group was 65.9 minutes (SD 52.6) compared to 32.9 minutes (SD 26) in the unsupported group, p=.06.  +Sleep efficiency = 80.7%, SD=15.4 for the NTPE group and 83.1%, SD=12 in the unsupported group, p=.57.  +Percentage of time spent in stage 1 for the NTPE group is 1.7%, with an IQR of 3.1 and a range of 0.2-6.6 and a mean of 3.6%, IQR of 3.6, and range of 0.6-8 in the unsupported group for a p-value of 0.29.  +Percentage of time in stage 2 for the NTPE group = 46.3%, SD=10 and 50.5%, SD=11 for the unsupported group, p=.21.  +Percentage of time spent in stages 3 in the NTPE group was 6.4%, SD=1.7 and a mean of 6.2%, SD=2.4 in the unsupported group with a p-value of .83.  +Percentage of time spent in stage 4 in the NTPE group was 33.3%, SD=10.6 and 29%, SD=10.6 for the unsupported group with a p-value of .13.  +Percentage of time spent in REM sleep in the NTPE group was 11.5%, SD=5.1 and 11%, SD=4.6 in the unsupported group, p-value = .84.  +Total sleep time for the NTPE group was 412.5 minutes with an interquartile range (IQR) of 174.8 and a range of 170-423.5 and a mean of 421 minutes with an IQR of 96 and a range of 344-505.5 in the unsupported group, for a p-value of p=.08.  +The number of REM cycles in the NTPE group was 4 (IQR 1.5; range 2-4) and 2 (IQR 2; range 2-4) in the unsupported group for a p-value of .33.  +Total arousal index of 8.5 in the NTPE group with an IQR of 7.3 and a range of 6.5-26.9, and a median of 10.8, IQR of 9.2, and range of 4.2-17.1 for the unsupported group, for a p-value of .95.  -The researchers also found no significant differences in SpO2 levels between the two groups as well:  +Minimum SpO2 levels in the NTPE group had a median of 92, (IQR 1.5; range 90-96), and in the unsupported group, the median was 91 (IQR 5; range 86-95), p-value = .05.  +Additionally, the mean SpO2 level in the NTPE group had a median of 95, with an IQR of 1.5, and a range of 95-97 while the unsupported group had a median of 97, with an IQR of 3 and a range of 93-99, for a p-value of .2.  -The researchers found that SpO2 levels were higher in 3/9 subjects when sleeping with the NTPE and the percentage of time with an SpO2 level of greater than 95% was higher with the NTPE in these same 3 children, lower for 3 children, and about equal for the other three children.  -Overall, no statistically significant results were found between the two conditions relating to sleep quality and respiratory function while sleeping. However, minimum SpO2 levels reached a significance level of .05 (statistically significant results are p < .05), and sleep onset latency had a significance level of .06. The researchers did not assess for clinical significance, though it may have been beneficial in this case to determine if the patients perceived improved or diminished quality of sleep and respiration capacity while using the positioning equipment. |
| **Original Authors’ Conclusions**  [Paraphrase as required. If providing a direct quote, add page number] |
| The researchers found no significant differences in sleep quality or respiratory function in children with severe CP while sleeping in night time postural equipment vs. when they sleep unsupported. |
| **Critical Appraisal** |
| **Validity**  [Identify the strengths and limitations of the study, including potential sources of bias. Comment on the overall methodological quality (including the score) as you determined from your assessment of the article. Comment on anything you believe was missing in the paper.] |
| This study scored a 20/29 on the Downs and Black checklist for measuring study quality. It lost points because it did not mention principal confounders, it did not mention any adverse events that may occur due to the intervention, there was no attempt to blind the subjects or researchers from the different conditions (though this is not necessary for this type of study), there was no adjustment made for confounding variables in the analysis, and the study did not report power.  This study has a few limitations. Firstly, there are only 10 participants. With such a small sample size, these results cannot be generalized to the total population of children with severe CP. In addition, the researchers did not take into account how long the participants had been using NTPE or how often they had used it prior to the study. If the participants were newer users, the results may be skewed to demonstrate worse sleep quality, as a child is not familiar with the positioning equipment. Moreover, the researchers did not take into account the individual’s perception of breathing ability and sleep quality in each of the sleeping conditions. Though the results may not be statistically significant, they can still be clinically significant. Furthermore, the researchers did not measure the child’s overall respiratory capacity in each position (unsupported, supported in supine, and supported in side-lying). While SpO2 is a good measure to assess oxygenation throughout the body, there are other measures to assess maximum respiratory capacity for each position. While overall function may not show a difference, it is possible that one specific position has the highest potential for improved respiratory function. Finally, the children were only assessed over one night in each condition. There are a number of different things that could affect one night’s sleep, so it would be beneficial to assess each child in each of the conditions over multiple nights to get a more accurate depiction of sleep quality and respiratory function in each position. |
| **Interpretation of Results**  [This is YOUR interpretation of the results taking into consideration the strengths and limitations as you discussed above. Please comment on clinical significance of effect size / study findings. Describe in your own words what the results mean.] |
| Positioning can affect a child with CP’s ability to breathe.9 The results of this study suggest that NTPE does not affect sleep quality or respiratory function during sleep in children with severe CP. These findings are important because many children with severe CP require NTPE to prevent contractures and hip subluxation. These results suggest that there is no benefit nor disadvantage to wearing the NTPE on sleep quality or respiratory function as this study did not have any statistically significant findings related to sleep quality or respiratory function. However, the researchers did not assess clinical significance.  Given the small sample size, small effect size, the lack of assessment of total respiratory capacity in each condition, and the lack of assessment in patient perception of sleep quality and respiratory function in each condition, more research should be conducted before concluding that NTPE does not affect sleep quality or respiratory function in children with severe CP.  Future studies should assess patients in each condition over a longer period of time (multiple nights each), in both the supine and side-lying positions in the NTPE, the patient’s perceptions of sleep quality and respiratory function in each condition, and the patient’s total respiratory capacity in each position. Other respiratory measures such as forced vital capacity (FVC) and forced expiratory volume in one-second (FEV1) should be used to assess overall respiratory function in each position prior to sleeping. |

**(3) Description and appraisal of “Effects of seat surface inclination on respiration and speech production in children with spastic cerebral palsy” by (Hwa-Kyung Shin, Eun-Jin Byeon, & Seok Hun Kim, 2015)**

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| **Aim/Objective of the Study/Systematic Review:** |
| The aim is to examine the effects of seat positioning on respiratory ability and speech production duration through forced vital capacity (FVC), forced expiratory volume in one second (FEV1), peak expiratory flow (PEF), and maximum phonation time (MPT). |
| **Study Design**  [e.g., systematic review, cohort, randomised controlled trial, qualitative study, grounded theory. Includes information about study characteristics such as blinding and allocation concealment. When were outcomes measured, if relevant]  Note: For systematic review, use headings ‘search strategy’, ‘selection criteria’, ‘methods’ etc. For qualitative studies, identify data collection/analyses methods. |
| -This is a single-group cross-sectional design: Each participant was assessed for respiratory function and maximum phonation duration in 3 different conditions: seat surface inclined 0°, tipped anteriorly 15°, and tipped posteriorly 15° during an hour-long session.  -Neither the subjects nor the researchers were blinded to the different conditions, but the conditions were randomized in order for each participant.  -Manner of randomization not specified.  -No follow-up was necessary.  -Measurements of respiratory function were performed by the Cardio Touch 3000S—The respiratory outcome measures include: forced vital capacity (FVC), forced expiratory volume in one second (FEV1), and peak expiratory flow (PEF).  -Measurements of maximum phonation time were taken using a stopwatch as the child made the sound “ah” for as long as they could.  -Three trials were performed for each test, the maximum value for each test was used for further analysis.  -One-way analysis of variance (ANOVA) was used to determine differences in each outcome measure (FVC, FEV1, PEF, and MPT)  -Significance was set at P<.05.  -Any further analysis when significance was determined was performed using Tukey tests. |
| **Setting**  [e.g., locations such as hospital, community; rural; metropolitan; country] |
| This study was performed in a local rehabilitation center in the Gumi area of Korea. |
| **Participants**  [N, diagnosis, eligibility criteria, how recruited, type of sample (e.g., purposive, random), key demographics such as mean age, gender, duration of illness/disease, and if groups in an RCT were comparable at baseline on key demographic variables; number of dropouts if relevant, number available for follow-up]  Note: This is not a list of the inclusion and exclusion criteria. This is a description of the actual sample that participated in the study. You can find this descriptive information in the text and tables in the article. |
| -There are 16 participants: 8 males, 8 females.  -The age range is 6-12, and the mean age is 10.06 years.  -The mean height in centimeters was 127.31, the mean weight in kilograms is 28.36.  -The participants on the Gross Motor Function Classification System (GMFCS) ranged from levels I-IV, with a mean level of 2.44.  -The way in which the participants were recruited was not specified.  -All participants were included in the analysis.  -No follow-up required with this population. |
| **Intervention Investigated**  [Provide details of methods, who provided treatment, when and where, how many hours of treatment provided] |
| *Control* |
| There was no control group as this was a single-group cross-sectional design looking at the effects of three different seating positions on respiratory function and speech production. All participants were tested in all 3 conditions. |
| *Experimental* |
| -Each participant underwent an hour-long testing session.  -It is not specified who conducted the respiratory assessment in each position, but speech therapists assessed the phonation duration.  -Each participant sat on a backless bench in each of the three positions (0° inclined, anteriorly tipped 15°, and posteriorly tipped 15°), guarded closely by a physical therapist.  -The participants sat in each seat position for 5 minutes before testing began to allow time for the child’s respiration to normalize.  -Measurements of respiratory function were performed by the Cardio Touch 3000S—The respiratory outcome measures include: forced vital capacity (FVC), forced expiratory volume in one second (FEV1), and peak expiratory flow (PEF). The child’s nose was plugged during testing to avoid air leakage.  -To measure the maximum phonation time, a stopwatch was used by a speech therapist to determine how long the child could produce the sound “ah”. A total of 3 trials were performed, with the longest value used to analysis.  -For each outcome measure, directions and demonstrations were performed before the child completed the task.  -The child was given 3 trials for each outcome measure, with a 3-minute rest period between each trial. The highest value for each measure was used for further analysis. |
| **Outcome Measures** (Primary and Secondary)  [Give details of each measure, maximum possible score and range for each measure, administered by whom, where] |
| -The outcome measures included forced vital capacity (FVC), forced expiratory volume in one second (FEV1), peak expiratory flow (PEF), and maximum phonation time (MPT).  -FVC, FEV1, and PEF were measured using the Cardio Touch 3000S.  -MPT was measured using a stopwatch.  -It was not specified who performed the respiratory function measures, but speech therapists measured the MPT.  -FVC measures the amount of quick expiration that occurs following maximal inhalation.  -FEV1 measures the amount of expiration in one second following maximal inhalation.  -PEF measures the speed of expiration following maximal inhalation.  -To find expected mean and range for FVC, FEV1, and PEF for a child of a specific age, gender, height, and weight, refer to Dugdale & Moeri (1968).12  -MPT measures the maximum duration that the child can produce the sound “ah”. |
| **Main Findings**  [Provide summary of mean scores/mean differences/treatment effect, 95% confidence intervals and p-values etc., where provided; you may calculate your own values if necessary/applicable] |
| -The researchers found that FVC values were significantly different between the 3 conditions (P=.03). Further analysis showed a significant difference between the anteriorly tipped (1.41 +/- 0.38L) and posteriorly tipped conditions (1.38\* +/- 0.38L) (P<.05), but not between the anteriorly tipped condition and the horizontal condition (1.09\* +/- .34L) (P>.05). The anteriorly-tipped condition had the greatest forced vital capacity – demonstrating the best lung function.  -\*NOTE: It appears that the researchers erroneously flipped the values of the posterior and horizontal conditions in the text because written as above (as it is written in the article) does not make sense. However, when looking at Figure 2 in the article, the lab values appear to be switched so that horizontal is 1.38L and posterior is 1.09L, which would make more sense with the p-values found.  -No significant differences were found between the three conditions for FEV1 (P=0.11) or PEF (P=0.21). However, the anteriorly tipped and horizontal conditions had higher and more similar results, when compared to the posteriorly tipped condition (FEV1: anteriorly-tipped- 1.25 +/- 0.32L, horizontal- 1.24 +/- 0.32L, posteriorly-tipped- 1.02 +/- 0.37L; PEF: anteriorly-tipped- 2.11 +/- 0.88L/s, horizontal- 2.13 +/- 0.73 L/s, posteriorly-tipped- 1.82 +/- 0.79 L/s).  -Additionally, MPT did not differ significantly between the three conditions (P=.07). However, it was longer in the anteriorly-tipped position (6.91 +/- 2.09s) than in the horizontal (6.73 +/- 1.81s) and posteriorly-tipped (5.45 +/- 1.83s) conditions. A longer duration would suggest better speech production. |
| **Original Authors’ Conclusions**  [Paraphrase as required. If providing a direct quote, add page number] |
| Based on the significant results found in FVC measures between anteriorly and posteriorly inclined seating, the authors suggest that “adjustment of seat inclination may be an effective intervention to improve the respiratory function of children with spastic diplegic CP.”9(pg. 5) |
| **Critical Appraisal** |
| **Validity**  [Identify the strengths and limitations of the study, including potential sources of bias. Comment on the overall methodological quality (including the score) as you determined from your assessment of the article. Comment on anything you believe was missing in the paper.] |
| This study scored a 19/29 on the Downs and Black checklist for methodological quality. The study lost points for not reporting important adverse events that could happen as a consequence of the intervention conditions, no attempt was made to blind participants or researchers to the intervention conditions, the authors did not report a time-period during which the subjects were recruited, the authors did not report method of randomization or concealment of randomization (though these do not apply to this type of study design), the authors did not account for confounding variables during analysis, and no power analysis was reported.  There are a few limitations of this study: the wide range of GMFCS levels evaluated and the small sample size. Since CP can manifest itself physically in a variety of ways, it is important that each of the levels be assessed to determine the effectiveness of seat inclination for each level. Unfortunately, the study did not even report the number of participants in each level of the GMFCS so no analysis of the results based on GMFCS level could be performed. Moreover, this small of a sample size, especially a small sample size that includes four different levels of CP, does not allow the results to be generalized for the entire population of children with CP.  Another limitation is that the authors did not assess the patients’ perceived respiratory function in each position. Results that are not statistically significant can still be clinically significant. Since we do not know how the patients felt in each of the seat positions, we cannot determine whether or not there was a preferred seat position in which the participants felt they could breathe better, regardless of whether or not the result was statistically significant. |
| **Interpretation of Results**  [This is YOUR interpretation of the results taking into consideration the strengths and limitations as you discussed above. Please comment on clinical significance of effect size / study findings. Describe in your own words what the results mean.] |
| This study proposed that respiratory function may improve based on seat inclination. Significant results were found for the forced vital capacity outcome measure, but not for FEV1, PEF, or MPT. However, for each condition, the anteriorly-tipped seat produced better results. It is possible that the study is underpowered due to the small sample size, or that these results are clinically significant even if they are not statistically significant. Therefore, these results suggest that an anteriorly-tipped seat is the best seat position for children with CP to improve respiratory function. This study did not take into account the individual’s perception of breathing ability or the plausibility of sitting in an anteriorly-tipped chair for extended periods of time, and it combined the results for each GMFCS level, disregarding the fact that each child will have a different level of impairment, which could affect results. In addition, power was not addressed. Although I think this is an important study that can be applied clinically, more research needs to be conducted to assess the effect of the seat inclination on different levels of the GMFCS, the ideal angle of inclination for these kids so that they can tolerate sitting in this position for extended periods of time, and the participant’s perception of respiratory function in each of the stages so that clinically significant results can be obtained. |

**EVIDENCE SYNTHESIS AND IMPLICATIONS**

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| The research question attempts to compare positioning techniques to rib mobilization interventions in promoting airway clearance and improving pulmonary function in pediatric patients with musculoskeletal deformity due to neuromotor delay. However, there was no research on the effectiveness of rib mobilizations in the pediatric (or adult) population with neuromotor delay. Therefore, the two treatments could not be compared. Additionally, the quality of evidence for this topic is very low. There was one poorly performed systematic review (1/11 on the AMSTAR checklist for measuring study quality), one level II article that addressed rib mobility in an adult patient population with scoliosis (the closest there is to research regarding rib mobilizations as a treatment), and nine level IV articles.  Based on the evidence reviewed, positioning interventions in sitting improve the pulmonary function in this patient population. According to Shin et al., the most effective seated position for pulmonary function in a pediatric patient with severe CP is an anteriorly-tipped chair.9 Patients in this position demonstrated a statistically significant increase in FVC values in the anteriorly-tipped position, in addition to increases in FEV1, PEF, and MPT that were not statistically significant but may still be clinically significant. Moreover, Nwaobi & Smith found statistically significant increases in VC, FEV1/VC %, and ET in patients who sat in an adapted seat with increased head, neck, and thorax support rather than sitting in a typical wheelchair with a sling-back.11 However, Hill et al. found that supported positioning in the supine and side-lying position does not appear to improve pulmonary function during sleep.8 Research suggests that patients with severe CP who sleep in night-time positioning equipment (NTPE) do not differ in sleep quality and respiratory function during sleep from when they sleep without the NTPE.8  These results are important clinically as many children with CP and neuromotor delay require wheelchairs for transportation, and many spend the majority of the day in a wheelchair. Current research suggests that when selecting wheelchairs for patients in this population with poor trunk control, it is important for physical therapists to find wheelchairs that provide adequate support to the head, neck, and thorax.11 In addition, tipping the chair anteriorly 15° may further improve pulmonary function and respiratory outcomes.9 Furthermore, kids with CP are at risk of developing contractures and hip subluxations and may require NTPE. The results of this search indicate that NTPE does not affect pulmonary function during sleep, allowing children to be supported without risk of decreased respiratory function due to the positioning required for the equipment.8  While these findings provide some positive insight to the treatment of diminished pulmonary function in children with CP that use wheelchairs and NTPE, all sample sizes of the included studies were very small. Future research studies should attempt to increase the sample size of the intervention groups to increase the power of the studies and should separate intervention groups based on GMFCS levels in order to provide more specific protocols for patients based on their impairment levels. In addition, the studies should assess the effects of positioning over a longer period of time and should assess the optimum level of anterior tipping that will allow for improved pulmonary function without sacrificing patient comfort. Future studies should take patient perception of breathing ease into account as well. Moreover, research needs to be conducted on rib mobilization interventions in this population to improve respiratory outcomes. Due to the extremely limited amount of research there is for each topic, this is a difficult question to answer at this point in time. |

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