Scoliosis Braces Designed for Adolescents with Cerebral Palsy

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Keywords: Functional Design, FEA Model, Cerebral Palsy

According to the Center for Disease Control and Prevention (CDC) Autism and Development Disabilities Monitoring (ADDM) Network, almost 1 in 323 children are diagnosed with Cerebral Palsy (CP) (Center, 2019). Out of the number of adolescents who are diagnosed with CP, 21%-64% develop scoliosis. (Cloake & Gardner, 2016). Numerous braces have been designed to counteract the worsening development of scoliosis, but there has yet to be one designed specifically for adolescents with CP. The needs of these children are unlike able-bodied ones. In the study performed by Tsirikos (2010), children with CP were asked to wear a “normal” scoliosis brace. Many fit issues of scoliosis braces were brought to the surface: skin irritation, respiratory issues, feeding/swallowing constrictions, and lack of neck/head support. Therefore, the purpose of the designs illustrated below is to create an effective scoliosis brace that obtains features beneficial for adolescents with CP, specifically ones who are dependent on a wheelchair.

There are numerous types of braces designed for scoliosis patients; Boston brace, Wilmington brace, Charleston Bending brace, Providence brace, etc. Their features are varying different requirements: duration of wear, severity level, sizes, and material preference. For example, the Boston brace, which is the most common brace, is marketed with various mold sizes (McAfee, 2016). In contrast, the Wilmington brace is custom-fit to the patient. Moreover, both the Boston and Wilmington brace suggested use is to wear during the day, where the Charleston brace is designed for nighttime use. Each brace is designed with varying details to alleviate the issues of the specific client in need.

To develop more effective scoliosis brace for young patients with CP, the FEA model created by Lamb and Kallal (1992) was used as the framework for designing the braces.

Functional: According to Bousquet and Gunnar (2010), 29% of their sample of 562 children with CP used wheelchairs indoors and 41% outdoors. Since the number is substantial, it is important to gear the design towards the effects of sitting in a wheelchair for long hours in the day. Skin irritation has also been a problem of other braces. CP diagnoses have more sensitive skin; therefore, needs materials that don't feel too harsh.

Expressive: Obtaining positive self-esteem is also explored with designing the braces. Children who are diagnosed with CP have lower self-esteem than ones that are not, especially young females (Shields et al., 2005).

Aesthetic: One of the effects of Cerebral Palsy is the need for Sensory Integration Therapy. Often times these children show signs of poor sensory integration ability, which can impact their neurological functioning and motor control (Sensory, n.d). By designing the braces with bold and bright colors, it will not only look attractive but heighten their visual sensory abilities.

Brace Design 1: Made up of similar polyurethane material as others. Worn outside of clothes. Focuses on comfort for CP wheelchair users with Scoliosis.

Brace Design 2: Made up of a Microfiber material. Can be worn both under clothes or on top. Material is designed for CP adolescents with sensitive skin.

In Brace 1, it attempts to solve the problems of other scoliosis braces. The brace is constructed with polyurethane using 3D printing to customize the fit. The main feature of this brace is the opened front piece. This is designed to relieve chest pressure, which would help respiratory and consumption issues. Since straps are needed for this design to ensure a compressed fit across the body, they are raised $\frac{1}{2}$ " above the brace. Therefore, the straps itself will not cause pressure on the chest. The design also features a neck/head support element. This will allow a more upright position which will increase comfort while sitting. The back of the brace provides full support of the bent spine. Corrective and Stabilized Pads are placed within the brace to fix the spine's curvature. Openings placed on the side and center back are used as pressure relievers. The side opening is customized depending on the spine's curvature.

Similar to Brace 1, Brace 2 allows freedom within the chest to ensure a clear respiratory system. This design could be seen as more effective since the design is more structured to counteract the spines curvature and the pads are more reinforced. Instead of using strictly the polyurethane, this design consists of encasing the relatively thinner mold with dense foam and a layer of microfiber material. The foam allows more cushion against the skin, while the microfiber material allows it to be worn directly on the skin-sensitive patients. Since the brace is overall thinner and the fabric feels better at the hand, it would be effective under the wearer's clothes. This will allow the children to feel more positive while wearing the brace and won't feel judged about it.

Both braces would be completely customizable. Using 3D technology, each brace would form perfectly to the patient's body. The placement/thickness of the pads and the relief holes will be included wherever the patient needs it the most to be affective. To encourage individuality and sensory development, prints can be added to whichever brace. The colors of the prints are bright with neon tones, which is often used to aid in vision sensory therapy (Sensory, n.d). By comparing other marketed braces and the once designed above, the recommended use of both braces would be 12-16 hours for wheelchair users.

Unlike able-bodied scoliosis patients, ones who are diagnosed with Cerebral Palsy have needs specific to their disability. Braces that are on the market for scoliosis currently don't regard CP patients. The braces illustrated above, are designed for these patients in mind. Currently only Phase 1 of the designs have been explored; Phase 2 is to follow with further research and physical prototypes. In attempt to fulfill the needs of the adolescent patients with CP, these braces should be marketed.

References:

- Bousquet, E., Gunnar, H. (2010, August 16). Use of manual and powered wheelchair in children with cerebral palsy; a cross-sectional study. *US National Library of Medicine National Institutes of Health*, 10(59), 59. doi: 10.1186/1471-2431-10-59).
- Center for Disease Control and Prevention. (2019, April 30). Data and statistics for cerebral palsy. Retrieved from <https://www.cdc.gov/ncbddd/cp/data.html>.
- Cloake, T., Gardner, A. (2016, December). The management of scoliosis in children with cerebral palsy: A review. *Journal of Spine Surgery*, 2(4), 299-309. doi: 10.21037/jss.2016.09.05.
- McAfee, P. (2016, December 8). Types of scoliosis braces. Retrieved from <https://www.spine-health.com/conditions/scoliosis/types-scoliosis-braces>.
- Sensory. (n.d). Retrieved from <https://www.cerebralpalsy.org/information/sensory>.
- Shields, N., Murdoch, A., Loy, Y., Dodd, K. J., Taylor, N. F. (2006) A systematic review of the self-concept of children with cerebral palsy compared with children without disability. *Development Medicine & Child Neurology*. 151-157. Retrieved from <https://onlinelibrary.wiley.com/doi/pdf/10.1017/S0012162206000326>.
- Tsirikos, A. (2010). Development and treatment of spinal deformity in patients with cerebral palsy. *Indian Journal of Orthopedics*, 44(2), 148—158. doi: 10.4103/0019-5413.620