Robotic trunk support trainer improves upper body control of children with cerebral palsy

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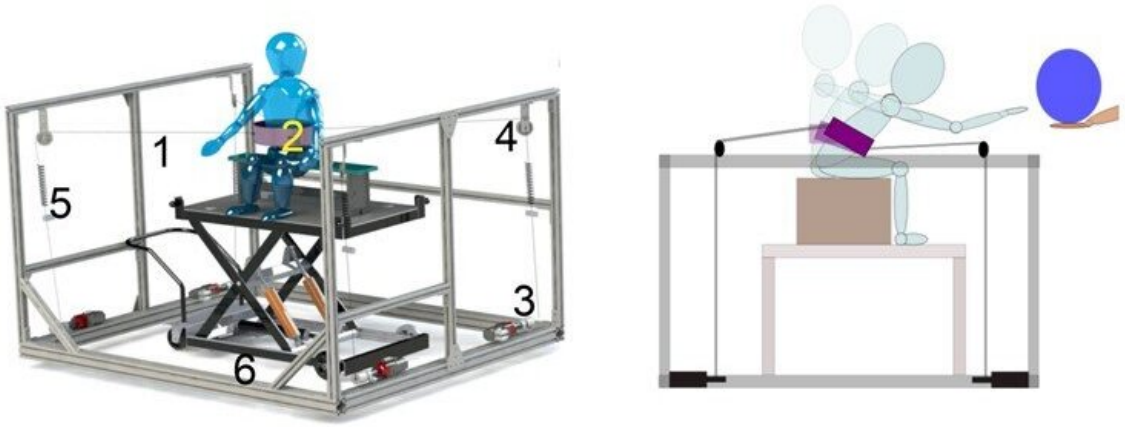

Left figure: TruST is composed of four steel cables (1), connecting a pliable belt (2), with the motor/spools (3), through pulleys (4). Cable tensions are measured with springs and load cells (5). A lift table (6) is used to regulate the height of the seated child to keep the belt and cables in the horizontal plane. Right figure: Force field characterization. A ball (blue circle) is used as a reference point and to encourage the child to reach as far as possible during the functional reach test. Children have to recover upright sitting without assistance after achieving the maximum reaching distance. Credit: Victor Santamaria, Moiz Khan,Tatiana

Cerebral palsy (CP) is the most common childhood physical disability—2.0-3.5 per 1000 births—and children born with it have impaired development and diminished control of movement and posture. In particular, children with moderate to severe bilateral CP have poor upper extremity abilities and segmental trunk control deficits, limiting independent functional sitting. Many children with CP need wheelchairs to travel long distances, and some need wheelchairs in most settings. A treatment designed to improve their sitting control abilities would greatly improve their ability to function independently, live an active physical life, and participate in social activities.

Researchers at Columbia Engineering report that their newly developed robotic Trunk Support Trainer (TruST), when combined with active practice of postural movements, improves trunk and reaching control in children with CP who have impaired sitting control. This finding is in line with their earlier study on adults with spinal cord injury who were able to expand their sitting workspace when TruST actively assisted their trunk movements.

The team then investigated the effectiveness of TruST on children with trunk control issues. They ran a two-year-longitudinal pilot study on four children aged 6-14 years with CP and sitting control problems to examine how TruST technology can be used to provide an optimal amount of trunk support while the children are trained in activities and games. After completion of TruST-intervention, the children showed short- and long-term postural and reaching control improvements. Most importantly, they were able to perform all the game-oriented activities without any external help coming from TruST, supportive straps, or a clinician. The study was published online today by *IEEE Transactions of*

Neural Systems and Rehabilitation Engineering.

"The ability to control the trunk in sitting posture is pivotal for everyday functions such as sitting, feeding, and social interactions," says Sunil Agrawal, professor of mechanical engineering and of rehabilitation and regenerative medicine. "Our Trunk Support Trainer, which we call TruST, is an innovative robotic device that helps physical therapists to not only support the children in the region of the trunk where they suffer from weakness and incoordination but also challenge them to perform rehabilitation tasks outside their base of support to improve their movement and coordination."

TruST is a motorized cable-driven belt placed on the child's trunk that exerts active-assistive forces when the trunk moves beyond postural stability limits. This means that TruST can provide assistance that is individualized for each child and can be systematically reduced as children improve trunk control during the training. Thus, TruST addresses postural-task progression in each training session by matching the assistive-force fields to the ability of each child to control the trunk in sitting. The idea is to assist the child's motor efforts when the trunk moves beyond these stability limits by modulating the wire tensions.

TruST-intervention is intense, about two hours per session, but completed over a relatively short time period for a total of 12 training sessions. Children had to wear additional strapping around the waist to secure their sitting position during the first 6 training sessions. However, after the 6th session, children acquired a level of trunk control that allowed the researchers to remove the waist straps so they could sit independently for training purposes.

"We wanted to scientifically demonstrate how robotic TruST can be used to deliver an intense activity-based postural and reaching training to improve the functional sitting abilities of children with CP and trunk

control problems", says Victor Santamaria, a physical therapist and associate researcher scientist in Agrawal's Robotics and Rehabilitation Laboratory, and first author of the paper.

Recent developments in robotic equipment have enabled clinicians to address engagement, repetition, and intensity for their patients to practice task-oriented movements in CP. A team led by Agrawal, together with other researchers at Teacher's College and the Columbia University Irving Medical Center, recently won a five-year National Institutes of Health R01 award (#1R01 HD101903-01) to conduct a randomized clinical trial.

The project—"Improving seated postural control and upper extremity function in bilateral CP with a robotic Trunk-Support-Trainer (TruST)"—will involve up to 80 children with poor trunk control. Some will use the TruST robotic rehabilitation while others will try conventional rehabilitation. This new NIH study will compare the efficacy of the motorized TruST to engage children in play-oriented practice while advancing their skill progression with static trunk support.

"Our new NIH project is a randomized clinical trial with a large sample size to study the efficacy of TruST-intervention as a unique therapeutic solution to promote seated functional abilities in children with bilateral CP," Agrawal adds.

More information: Victor Santamaria et al, Promoting Functional and Independent Sitting in Children with Cerebral Palsy Using the Robotic Trunk Support Trainer, *IEEE Transactions on Neural Systems and Rehabilitation Engineering* (2020). DOI: 10.1109/TNSRE.2020.3031580

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