Research Letter

Effect of Robot-Assisted Gait Training on Selective Voluntary Motor Control in Ambulatory Children with Cerebral Palsy

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ABSTRACT

This pilot study investigated the efficacy of a four week robot-assisted gait training in twelve childrenwith spastic diparesis. Short-term results and a 3-month follow-up showed statistically significantly increased selective motor control, walking farther distances, gross motor score, and decreased joint contractures.

Keywords: *Cerebral palsy, Gait, Joint range of motion, Lokomat, Motor control*,

Cerebral palsy affects movement and posture, resulting in a limited activity that is attributed to non-progressive disturbances occurring in the fetal or infant brain [1]. Since robot-assisted gait training (RAGT) induces changes in the brainplasticity, it appears promising in improving gross motor control of CP children with cerebral palsy [2-4].It could be hypothesized that RAGT can affect impaired selective voluntary motor control (SVMC), which is the inability to activate muscles to achieve a voluntary posture or movement [5]. Therefore, this pilot study investigated the efficacy of RAGT as mono-therapy on lower limb SVMC, joint range of motion (ROM), walking ability, and gross motor measures.

The study received ethics committee approval from participating institutions. All parents and children provided written informed consent for participation. Twelve children mean (SD) age, 10.9 (3.3) year; 2 girls) were tested at the baseline, after four weeks of intervention, and at 3-month follow-up. Children withspastic diparesis with toe-walking and/or scissoring patterns aged between 5–17 years were recruited. Only children who could attend the 4-week RAGT program regularly were enrolled. Children were excluded if they had used any muscle relaxants within the previous 6 months or had orthopedic surgery within the last year [2-4].

Standardized, validated questionnaires and evaluations [5-8] were used: goniometry, Selective Control Assessment of Lower Limbs Evaluation (SCALE), D and E parts of Gross Motor Function Measurement (GMFM), 10-meter walk test (10MWT) and 6-minute walk test (6MWT). During walking tests, all children wore footwear and orthoses, if regularly used. For SCALE, children performed isolated movements of the hip, knee, ankle, subtalar, and toe joints. Scores were assigned as: normal - joints moved selectively within at least 50% of the possible ROM, and at a physiological cadence; impaired - movement performed slower below 50% of ROM, with mirror and/or synergistic movements; or unable - no joint movement performed or synergy patterns present. Pre-post intervention goniometry and SCALE evaluations showed bilateral asymmetries in lower limbs across all children. Asymmetries were recorded as 'more impaired limb (MIL)' and 'less impaired limb (LIL)'.

The Lokomat Pro device (Hocoma AG, Volketswil, Switzerland) was used [9]. Children attended 20 sessions scheduled on 20 consecutive working days. Therapy ranged 30-45 minutes and progressively increased by at least 3 minutes every other day [mean (SD), 39 (6) minute]. Walking speed [mean (SD), 1.4 (2.38) km/h] was set individually. The walking distance [mean (SD), 969 (172) meter] was gradually increased every other day by at least 50 meters. All children had an initial level of 50% body-weight support [mean (SD), 14.8 (4.76) kg] which was gradually decreased every other day for each child until the knee did not start to collapse into flexion during the stance phase.

Data were analyzed in MatLab (Mathworks Inc., USA). Shapiro-Wilk test (0.05 significance level) showed abnormal data distribution. The Wilcoxon sign rank test was used for the LIL and MIL, separately [10]. Spearman correlations were calculated for the following: goniometry/SCALE, GMFM D, E/10MWT, and GMFM D, E/6MWT.

Hip joint flexion contractures decreased bilaterally by 10° (P=0.004). Internal hip rotations decreased by 10° in LIL and 15° in MIL (P=0.002). Ankle dorsiflexion improved bilaterally by 10° (P=0.001). SCALE scores increased by 1.5 in LIL and 2.5 points in MIL (P=0.001). The 6MWT walking distance increased by 75 meters (P=0.001). 10MWT showed no significant change (P=0.89). GMFM-D improved by 8% (P<0.001) and GMFM-E by 6% (P=0.002). Correlations were found only between GMFM D, E scores and walking tests (rho=-0.614-0.784;P<0.05). Increased GMFM scores correlated with decreased time in 10MWT, and increased walking distance in 6MWT. There was no significant difference in short-term and 3-month follow-up data (P>0.05) across all measures.

Since active training seems to be more effective than passive training for motor learning and cortical reorganization in central motor impairments [2-4,9], RAGT likely improved motor control of CP children due to active training performed with a high-repetition-rate of guided movements in the most neutral pelvis and lower limbs position. To the best of our knowledge, this is the first study suggesting that RAGT improves SVMC and decreases hip joint internal rotation contractures. We support the previous suggestions that CP children increased walking distance following RAGT [2-4]. It has been shown that the combination of RAGT and physiotherapy improves GMFM D,E scores [2-4].

Our outcomes suggest that although expensive (~300,000 Euro), RAGT, which is primarily used in rehabilitation centers, can improve D, E scores even when used as a stand-alone therapy. Although this study provides a foundation on which future studies can be built on, RAGT should be investigated over longer periods in different populations to further determine its effectiveness.

Ethical Approval by both committees: (*i*) Charles University, Prague, the Czech Republic (number 120/2015) dated 12.8.2015 and (*ii*) University Rehabilitation Institute, Ljubljana, the Republic of Slovenia on 5.10.2015.

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