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Low-cost motion interactive video games in home training for children with cerebral palsy: a kinematic evaluation

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Abstract—**3D motion analysis was applied to assess goal-directed arm movements in 15 children with cerebral palsy (CP) before and after four weeks of home training with low-cost motion interactive video games. The results indicated that the children improved movement precision when playing the virtual games, improved movement smoothness when reaching for real targets, and reduced the involvement of the trunk especially when reaching with the non-dominant side.**

Keywords; children, cerebral palsy, video games, motion analysis, kinematics, motor rehabilitation, reaching.

I. Introduction

There is a growing interest among clinicians working with children to integrate motion interactive video games in rehabilitation to stimulate physical activity and enhance motor performance. In order to evaluate motor effects of gaming practice there is a need for sensitive assessment tools, which enable detailed analyses of even subtle changes in motor performance. Kinematic analyses of arm movements in children have lately been increasingly employed [1-4] and researchers are also beginning to apply kinematic measurements to evaluate differences in movement ability as a result of interventions in children [5]. To date only a few studies involving children have used kinematics to evaluate effects of training with motion interactive games [6]. The aim of this study was to kinematically evaluate if four weeks of practice with motion interactive games improves the quality of goal-directed arm movements in children with CP.

II. Methods

Fifteen children, 6-16 years of age, diagnosed with either unilateral or bilateral CP and with limited voluntary motor control of one or both arms were recruited from child rehabilitation centres in the mid northern part of Sweden. Each child was provided with a Sony PlayStation2® equipped with the game EyeToy®, Play3 for home training. Play3 includes about 20 different game experiences that typically involve practice of arm-coordination, postural stability and range of motion. The children were recommended to practice with the EyeToy-game for at least 20 minutes/day during the four weeks intervention period. The study was approved by the Regional Ethical Review Board (dnr 07-128). For a complete description of the participants and intervention design see Sandlund et al., 2010 [7].

Kinematics were captured with a five camera motion analysis system (Proreflex, Qualisys AB, Gothenburg, Sweden) that is based on infrared light and tracks the motion of spherical reflective skin markers. Three-dimensional coordinates from 27 markers placed on the arms, head and upper body of the children were sampled along with kinetic data from a force plate, which the children were seated on during the assessments. Movement registrations were taken before and after the intervention while children performed arm movements under two different conditions: 1) a *virtual condition*, captured while the children played one of the EyeToy games reaching for virtual targets; 2) a *real condition*, recorded while the children performed a non-practiced task, reaching for real objects (tassels) arranged in a similar way as the virtual targets in the game. In both conditions the children performed goal-directed arm movements with both the dominant and the non-dominant hand towards four different targets placed above and slightly in front of the child, with a high and a low target on each side. Six trials from each target, within each condition, and from each test were chosen for analysis. Thus, for each child the kinematic data analyzed from pre- and post-test consisted of in total 48 reaches towards the virtual targets and 48 reaches towards the corresponding real targets.

The kinematic parameters that were primarily investigated included: spatiotemporal characteristics (mean velocity, peak velocity, placement of peak velocity, and straightness of the movement); movement smoothness (jerk normalized to time and calculated as number of zero-crosses in the acceleration curve); movement precision (defined as the 95% confidence interval of the volume of the 3D ellipse defined by the end-positions of the hand in the six reaches towards each target); and the maximal helical shoulder angle. The cumulative movement path of the centre of pressure (COP) from the start to the end of each reach was calculated from the force plate recordings and used as an indication of trunk involvement during reach. As the children were seated on the force plate, movements of the trunk did also directly affect the COP. Thus, a longer cumulative path would reflect more trunk movements during reach.

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Statistics: Multilevel linear mixed models were applied to calculate differences between pre- and post-test. Such models can handle data with a hierarchical structure while allowing both fixed and random regression coefficients (intercept and slope). Thus, these models cope with large variations between individuals. A mixed model was developed for each variable and each condition (virtual and real).

III. Results

In comparison to the pre-test, the peak velocity was lower and the movements straighter in the virtual condition at post-test. Also in the real condition the peak velocity decreased significantly and in addition the mean velocity was lower at post-test when reaching for real targets. Otherwise there were no significant pre-post differences found in the spatiotemporal characteristics. The smoothness of the movements was significantly increased at the post-test when reaching for the real targets (Figure 1), while there was no significant difference after practice in the virtual condition. Movement precision, on the other hand improved significantly for the virtual targets while no improvements were found in the real condition (Figure 2). Further, the helical angle of the shoulder did not change between pre- and post-test, neither in the virtual nor in the real condition. Nevertheless, a calculation of the coefficient of variation revealed a decreased variation in maximal shoulder angle at post-test in the virtual condition. Finally, the COP path decreased in the virtual condition and likewise when reaching with the non-dominant arm in the real condition, indicating less involvement of the trunk during reaches after practice.

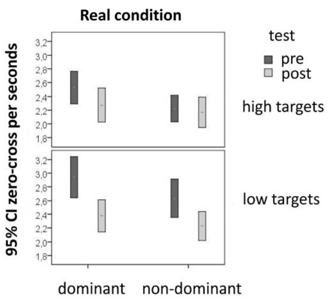

Figure 1. Movement smoothness when reaching for real targets.

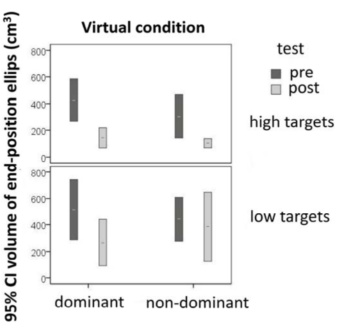

Figure 2. Movement precision in the virtual condition.

IV. Discussion

According to earlier kinematic studies of reaching movements in children with CP, fast and straight movements are often associated with improved movement control. In our study there was a trend of slower movements at post-test. However, in the game used during these assessments the child acts as a maestro of an orchestra and in this context fast and straight movements are not necessarily optimal. When observing the children during play it was obvious that they mastered the game better after practice (as also reflected by higher scores). One explanation for the slower movements may be that the children had learned the game, and were able to anticipate and plan the next move without any stress. Thus, the results regarding movement velocity must be interpreted in relation to the actual task, including the purpose and pace of the game. Altogether, the kinematic relevant parameters support the conclusion that practice with motion interactive games resulted in an improved motor control. The reduced variability in shoulder angles as well as the shorter COP paths indicates that the children used a more economic reaching strategy with less trunk involvement during play. In addition, movement precision increased in the virtual condition, but the accuracy constraints of the virtual targets seemed too low to yield significant improvements in movement smoothness. However, when reaching for real objects, with higher accuracy constraints, movement smoothness increased significantly. The results of this study illuminate the importance of considering both the nature of the task and the context in which movements are performed when selecting and interpreting kinematic parameters, perhaps especially in virtual games.

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References

[1] Jaspers E, Desloovere K, Bruyninckx H, Molenaers G, Klingels K, Feys H. Review of quantitative measurements of upper limb movements in hemiplegic cerebral palsy. Gait Posture. 2009 Nov;30:395-404.

[2] Chang JJ, Wu TI, Wu WL, Su FC. Kinematical measure for spastic reaching in children with cerebral palsy. Clinical Biomechanics 2005;20:381-388.

[3] Domellof E, Rosblad B, Ronnqvist L. Impairment severity selectively affects the control of proximal and distal components of reaching movements in children with hemiplegic cerebral palsy. Developmental Medicine and Child Neurology 2009;51:807-816.

[4] Ronnqvist L, Rosblad B. Kinematic analysis of unimanual reaching and grasping movements in children with hemiplegic cerebral palsy. Clinical Biomechanics 2007;22:165-75.

[5] Mackey AH, Miller F, Walt SE, Waugh MC, Stott NS. Use of three-dimensional kinematic analysis following upper limb botulinum toxin A for children with hemiplegia. European Journal of Neurology 2008;15:1191-8.

[6] Chen YP, Kang LJ, Chuang TY, Doong JL, Lee SJ, Tsai MW, Jeng SF, Sung WH. Use of virtual reality to improve upper-extremity control in children with cerebral palsy: A single-subject design. Physical Therapy 2007;87:1441-1457.

[7] Sandlund M, Lindh Waterworth E, Häger C. Using motion interactive games to promote physical activity and enhance motor performance in children with cerebral palsy. Developmental Neurorehabilitation 2011;14:15-21.