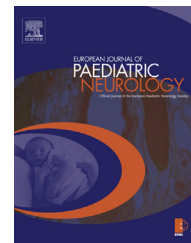




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Original article

Mirror movements in unilateral spastic cerebral palsy: Specific negative impact on bimanual activities of daily living



Caroline Adler ^{a,b}, Steffen Berweck ^{a,c}, Karen Lidzba ^b, Thomas Becher ^d,
Martin Staudt ^{a,b,*}

^a Clinic for Neuropediatrics and Neurorehabilitation, Epilepsy Center for Children and Adolescents, Schön Klinik Vogtareuth, Germany

^b Dept. Pediatric Neurology and Developmental Medicine, University Children's Hospital, Tübingen, Germany

^c Dr. von Hauners Children's Hospital, Ludwig-Maximilians-University Munich, Germany

^d Center for Child Neurology, Sana Klinik Düsseldorf, Germany

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ABSTRACT

Aim: Mirror movements are involuntary movements of the other hand during voluntary unimanual movements. Some, but not all children with unilateral spastic cerebral palsy (USCP) show this phenomenon. In this observational study, we investigated whether these mirror movements have a specific negative impact on bimanual activities of daily living.

Methods: Eighteen children (six girls; age range, 6–16 years; mean age, 12 years 1 month; SD, 3 years 3 month) with USCP, nine with and nine without mirror movements, underwent the Jebsen Taylor Hand Function Test (unimanual capacity) and the Assisting Hand Assessment (bimanual performance). In addition, we measured the time the participants needed for the completion of five activities we had identified as particularly difficult for children with mirror movements.

Results: Multivariate analysis demonstrated that mirror movements indeed have a specific negative impact on bimanual performance (Assisting Hand Assessment) and on the time needed for the completion of these five particularly difficult activities. This effect was independent from unimanual capacity.

Conclusion: Functional therapies in children with USCP and mirror movements should address this phenomenon.

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Abbreviations: MM, mirror movements; BANIMM, bimanual activities negatively influenced by mirror movements; JTHFT, Jebsen Taylor hand function test; AHA, assisting hand assessment; ADL, activities of daily living.

* Corresponding author. Clinic for Neuropediatrics and Neurorehabilitation, Epilepsy Center for Children and Adolescents, Schön Klinik Vogtareuth, D-83569, Germany. Tel.: +49 8038 901418; fax: +49 8038 903418.

E-mail address: mstaudt@schoen-kliniken.de (M. Staudt).

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1. Introduction

Unilateral spastic cerebral palsy (USCP), formerly termed “congenital hemiparesis”, is a common cause of disability in childhood, with an incidence of .6–1 per 1000 live births.¹ Many of these children experience problems in the execution of bimanual activities of daily living (ADL)^{2–4}. The main reason for these difficulties is obvious: Poor function of the paretic hand reduces its ability to assist the non-paretic hand during various bimanual tasks. And indeed, in patients with USCP, bimanual performance [as measured with the Assisting Hand Assessment (AHA)⁵] is strongly correlated with measures of unimanual function of the paretic hand like active supination and strength,^{6,7} the Jebsen Taylor Hand Function Test,⁸ the Melbourne Assessment of Unilateral Upper Limb Function^{3,8} or the Box and Blocks Test.²

Poor unimanual function of the paretic hand can, however, not fully explain the poor bimanual abilities in some children.⁴ Restrictions in bimanual activities often seem to exceed what would be expected from the degree of dysfunction of the paretic hand alone; furthermore, many hemiparetic children perform normally bimanual activities exclusively with the non-paretic hand, despite having reasonable unimanual capacity of the paretic hand.^{3,4,9} Possible explanations for this discrepancy could be sensory or visual neglect, the presence of bilateral brain injury, or co-existent dystonia. Our study focuses on yet another possible explanation: In some children with USCP, unimanual functions could be disturbed by simultaneous activity with the other hand. And indeed, this hypothesis has recently received support from experimental data.¹⁰

One candidate mechanism for this interference between activities of the two hands is a phenomenon called **mirror movements (MM)**: Many, but not all patients with USCP show involuntary movements with the other hand during voluntary unimanual movements^{11,12,13,2}. And in contrast to adult hemiparetic stroke, where MM apparently occur exclusively during voluntary movements of the paretic hand,¹⁴ MM in USCP are often observed both in the paretic and in the non-paretic hand.^{11,13}

The pathomechanism for these MM in most, if not all of the affected patients lies in a peculiar type of **cortico-spinal (re-) organization**: When the brain lesion leading to USCP disrupts the normal crossed cortico-spinal projections from the lesioned hemisphere, the contra-lesional hemisphere can preserve its normally transient ipsilateral cortico-spinal pathways.¹⁵ Thereby, the contra-lesional hemisphere can take over motor control over the paretic hand. Thus, in this situation, the two hands are controlled by the same hemisphere – and this constellation is, with probably only a few exceptions (e.g. patients #16 and #17 in Holmström et al.; the case reported in Staudt et al., 2012^{2,16}), accompanied by mirror movements.^{12,13,17}

The question whether, in USCP, MMs interfere specifically with bimanual coordination was first addressed by Kuhtz-Buschbeck et al.¹¹: With a qualitative assessment tool, the authors observed that patients with pronounced mirror movements assisted less with their paretic hand during bimanual tasks (like carrying a tray, opening a bottle, cutting a

sausage with a knife and fork, holding and cutting paper with scissors, buttoning, tying a knot).

The problem with this approach is that, in the meantime, it became evident that patients with ipsilateral cortico-spinal projections to the paretic hand (and, therefore, most patients with MMs) generally show a poorer function of the paretic hand than patients with preserved crossed cortico-spinal projections (and without MMs^{2,12,13}). Therefore, this poorer unimanual function in patients with MM could also explain why the paretic hand is less used for assisting the non-paretic hand in USCP with MMs – thus questioning a specific negative impact of MMs.

Consequently, in the current study, we addressed this issue by means of a multivariate analysis including unimanual capacity, bimanual performance and mirror movements. We asked specifically whether USCP patients with MMs showed a poorer bimanual performance than patients without MMs - independent from their unimanual function.

2. Materials and methods

The study was conducted in two phases. In **PHASE 1**, we sought to identify bimanual activities of daily living (ADLs) which are potentially influenced by MMs. In **PHASE 2**, we assessed bimanual performance of a subset of the ADLs identified in PHASE 1 in participants with and without MMs, together with established measures of unimanual capacity (the Jebsen Taylor Hand Function Test) and of bimanual performance (the Assisting Hand Assessment). Informed written consent and approval from the local ethics committee were obtained.

PHASE 1: We developed a questionnaire comprising 33 bimanual ADLs which are difficult for patients with USCP (Fig. 1). These ADLs were taken either from already existing assessments like the CHEQ¹⁸ and Abilhand kids⁶ or from interviews we performed with four adolescent and adult patients with USCP suffering from marked MMs. In this questionnaire, both the child and the parents decided independently for each of the 33 ADLs whether the ADL was relevant for the child, and whether the child used one or two hands for the ADL. Then, they scored (a) the speed and (b) the quality of the performance on a five-point ordinal scale when compared with healthy peers, with score 1 indicating that the item could not be performed at all, although it was considered relevant. In this questionnaire, we included not only ADLs which require asymmetrical movements of the two hands (like climbing a ladder; hypothesizing that this would be particularly difficult for patients with MMs), but also ADLs in which both hands perform symmetric movements (like rolling out dough with a rolling pin; hypothesizing that MMs should not make a difference here).

Questionnaires were sent to the families of 27 children (age range, 6–16 years) with USCP and impaired hand function, and 24 families completed the questionnaire. The children were screened with the help of video-tapes for the presence or absence of MMs while performing opening and closing of the hand, sequential finger-thumb opposition and alternating supination/pronation of the hand¹⁹ (following a protocol including camera and body position), and were only included

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