O56-Bimanual coordination in stroke recovery: Kinematic analysis provides open leads to individualize upper limb rehabilitation

Julien Metrot[1], Isabelle Laffont[1,3], Isabelle Relave[1,3], Huey-Yune Bonnin[2], Jacques-Yvon Pelissier[1,2], Liesjet VanDokkum[1], Kjerstin Torre[1] & Denis Mottet[1]

[1] Movement to Health Laboratory EA 2991, EuroMov, University Montpellier 1

[2] Grau du Roi Medical Center, Nîmes CHU

[3] Physical Medicine and Rehabilitation Unit, Montpellier CHRU

julien.metrot@univ-montp1.fr

Better understand how bimanual coordination evolves during the first weeks of natural recovery after stroke is needed to address bimanual rehabilitation. 15 stroke patients realized seven kinematic assessments once a week during six weeks and at three months. The grasping task was performed through 3D-movement analysis in three different conditions: unimanual with the non-paretic limb, unimanual with the paretic limb, and bimanual. Inter-limb coordination became efficient about 6 weeks after stroke. Bimanual coordination is optimized around this period of recovery, indicating a possible beneficial effect of bimanual rehabilitation. Moreover, inter-limb coordination showed disruption at movement onset but also at movement goal. This kind of disorders could be specifically retrained during rehabilitation.

Keywords: Bimanual coordination, upper limb recovery, kinematics, stroke, prehension

INTRODUCTION

After rehabilitation, about 80% of post-stroke patients still suffer upper limb disability, which impairs their daily living activities and often leads to major incapacities. One of the promising techniques in stroke rehabilitation is the bimanual training, using inter-limb coordination to favor motor recovery. In a bimanual task, both upper limbs influence and are dependent on each other to perform the task. This process entails that the non-paretic limb involves the paretic limb and improves its output (McCombe Waller & Whitall, 2008) but also that the paretic limb compels the non-paretic limb to match the affected limb lower capabilities.

Bimanual training has been proven efficient (Cauraugh et al., 2009). However, most studies don't take into account patients' characteristics, such as recovery phases and improvements have not been demonstrated in all stroke patients. Hence, the interest of rehabilitation based on bimanual mode is still controversial (McCombe Waller & Whitall, 2008) and few are known about post-stroke natural recovery of bimanual coordination.

The goal of the present study is to observe and characterize the evolution of movement kinematics in stroke patients during the first three months of standard rehabilitation (no specific bimanual rehabilitation added), and with a focus on bimanual coordination. We also address which relevant factors may predict the efficiency of bimanual rehabilitation.

METHOD

12 hemiparetic patients (65.6±9.7) were included, within 30 days after a primary unilateral ischemic/hemorrhagic stroke. Seven kinematic assessments of grasping movements occurred once a week starting from inclusion and at a follow-up assessment 3 months after inclusion.

Patients were asked to grasp a 5 cm ball lying on the table, and to move it to the target place with comfortable speed. The grasping task was performed in three different conditions: unimanual non-paretic limb, unimanual paretic limb and bimanual movement. In the bimanual condition, patients were asked to activate movement simultaneously and grasp the ball with both arms.

Kinematic assessment relied on a 3D motion recording system (Polhemus). For each hand, we computed the following variables to summarize the kinematic features: maximal tangential velocity (Vmax), time to peak velocity (TPV), movement time (MT), number of hand velocity peaks (NVP), and between-hand delay at movement beginning (ΔBEG), ending (ΔEND), and at velocity peak (ΔTPV).

RESULTS & DISCUSSION

For unimanual reaching, we found that kinematics was altered in the non-paretic limb, but evolved towards fluency during recovery: decrease of NVP, TVP and MT, increase of Vmax.

For bimanual reaching, MT was globally higher for the paretic upper-limb (p=.02). After four weeks of standard treatment, the two limbs had similar MT (Figure 1-A) but also reached the velocity peak simultaneously (TPV), the kinematics of the non-paretic limb matching with those of the paretic limb in bimanual condition. It seems that bimanual coordination started to be efficient around 7 weeks after the onset of stroke. If our hypothesis is exact, that could indicate a possible beneficial effect of a bimanual rehabilitation around this period. Accordingly, bimanual rehabilitation could be started around the second month post-injury.

We also found inter-limb asynchronies at onset movement and goal movement between the two limbs. We found no time effect on movement onset (p=.73) and on movement goal (p=.15). ΔBEG was longer than ΔEND (the difference ΔBEG-ΔEND being positive) after W4 meaning that the paretic limb caught up the normal limb during the reaching movement. This symmetry of the two upper limbs could be considered as a consequence of inter-limb coordination. As Wu et al. (2009), we proposed that the disorder in limited coordination at movement onset should be specifically retrained during stroke rehabilitation.

The evolution of the time difference between the two hands at the velocity peak (ΔTPV) during recovery is represented on Figure 1-B. The one-way with repeated measures ANOVA showed an effect of time (p<.01) on this delay ratio. Differences between the two limbs cancelled at W4 and W12.

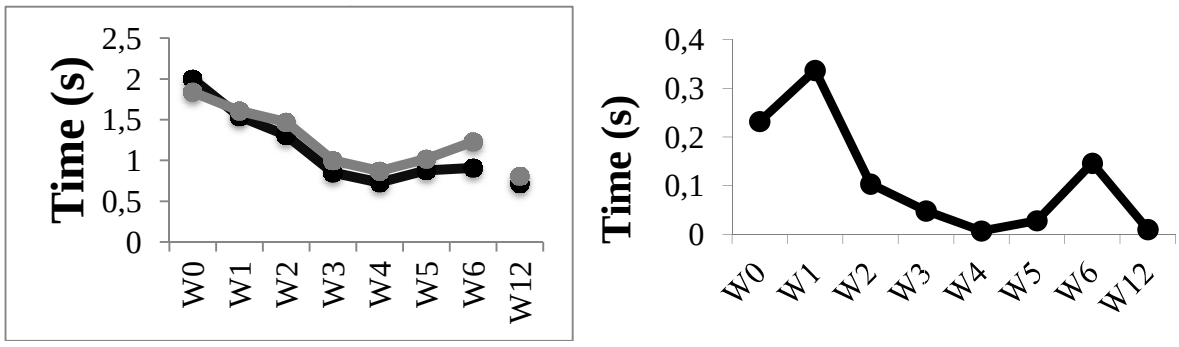

Fig. 1-A: Movement Time (MT) as a function of recovery. The MT is higher for the paretic hand (grey) than for the non-paretic hand (black), but only for the first three weeks of treatment. Fig. 1-B: Evolution of ΔTPV as a function of recovery. The between-hand difference evolves over recovery.

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