Neuromuscular taping for the upper limb in Cerebral Palsy: A case study in a patient with hemiplegia

Filippo Camerota[1], Manuela Galli[2,3], Veronica Cimolin[2], Claudia Celletti[1], Andrea Ancillao[3], David Blow[4], & Giorgio Albertini[3]

[1]*Physical Medicine and Rehabilitation Division, Orthopaedic Department, Umberto I Hospital, Sapienza University, Rome, Italy,* [2]*Department of Electronics, Information and Bioengineering, Politecnico di Milano, Milano, Italy,* [3]*IRCCS "San Raffaele Pisana", Tosinvest Sanità, Roma, Italy, and* [4]*NeuroMuscolar Taping Institute, Roma, Italy*

Received 10 June 2013
Revised 24 July 2013
Accepted 25 July 2013
Published online 1 October 2013

Introduction

Hemiplegia is a form of spastic Cerebral Palsy (CP) in which one arm and leg on either the right or left side of the body is affected. It is the most common syndrome in children born at term and is second in frequency only to spastic diplegia among preterm infants [1]. Patients with spastic hemiplegia have unilateral prehensile dysfunction as a consequence of lesions in the sensorimotor cortex and corticospinal tract. The upper limb is usually more severely involved than lower one. This limits reaching, grasping and object manipulation, interfering also with exploration, play, self-care and other activities of daily living [2]. Common treatments include botulinum toxin, orthopaedic surgery constraint induced movement therapy, pharmacotherapy for muscle tone, occupational therapy and traditional physiotherapy [3].

Over the last 5 years in Europe, proprioceptive Neuromuscular Taping (NMT) technique has become a mainstream treatment protocol in post-operative, oncological, neurological care of patients and in sports medicine [4].

This innovative taping application is based on eccentric stimulation of the skin, muscle tissue, tendons, neurological vessels, lymphatic and vascular pathways improving their functioning. NMT provides passive stretching through the application of a tape with eccentrical properties encouraging flexibility and coordination and bettering range of movement in patients suffering with excessive muscle contraction due to different clinical conditions. It has been claimed that the effects are may be due to the sensorimotor and proprioceptive feedback mechanisms. It has been hypothesized that the application of NMT is able to stimulate cutaneous mechanoceptors. These receptors activate nerve impulses when mechanical loads (touch, pressure, vibration, stretch and itch) create deformation. Their activation by an adequate stimulus causes local depolarization, which triggers nerve impulse along the afferent fibres travelling towards the central nervous system.

However, few applications support the use of this type of tape to improve the upper-body functionality CP. In addition, different techniques were used (kinesio, functional taping and NMT) [5–10] and to our knowledge no assessments using quantitative movement analysis were conducted to evaluate the NMT effects.

The aim of this case study presentation is to use motion analysis approach to evidence, in a quantitative way, the biomechanical alterations in terms of range of motion, trajectories changes as well as movement smoothness induced by the NMT intervention on upper limbs in CP.

Correspondence: Veronica Cimolin, Department of Electronics, Information and Bioengineering, Politecnico di Milano, p.za Leonardo da Vinci 32, 20133 Milano, Italy. Tel: +39-02 23993359. Fax: +39-02 23993360. E-mail: veronica.cimolin@polimi.it

Case report

The participant is a female now aged 17 and is affected by left hemiplegia, due to CP, connected to a vasculopathy. The hemiplegia incurred after a chemotherapeutic treatment. From the observational analysis the patient was not able to control the position of the left hand, which appeared flexed with the fingers closed. She very often used the right hand to open the finger and to place the hand correctly in the start position.

The tape was applied in a particular way that characterized the NMT application with the aim to rise the skin in a wave, amplifying the stretching/contraction effect of the skin itself. NMT was applied by the same physical therapist every three days and placed with five single strips of a1 cm wide on the fly and palm of the left hand and with a fan type of tape in the anterior and posterior side of the left shoulder [11] (Figure 1). The taping was constantly applied and changed every three days by the same physiotherapist for total five applications; patient was invited to normally use his hand during this period without changing her habits. No additional rehabilitative treatment was done during this period.

The analysis consisted in a preliminary clinical examination followed by a 3D movement analysis of the upper limb with synchronized video recording. The analysis was conducted at the time of enrolment before the application of NMT and was repeated at the end of the treatment (two weeks after application of NMT).

As concerns the requested task the reaching movement was examined. This task was considered representative of everyday functional activities, with similar task having been described in previous studies examining upper limb movement [12–17]. The participant was comfortably seated on an adjustable stool with a table positioned in front of her. The starting position for the task required the patient to place her hand on the table surface directly in front of her with the elbow flexed to approximately 90°, the forearm in slightly pronation and the wrist in a neutral position. The starting position on the table surface was indicated by a small white strip applied over the table. Neither the trunk nor the head were restrained. The reaching task involved leaning forward and extending the elbow to touch a stationary target positioned on the table at a predefined distance and then returning the hand to the starting position. This distance was measured using the affected arm and it was 80% of the arm length, from the olecranon process to the third fingertip. The position of the table was moved to achieve this set measured distance and to ensure the standardization of the reaching distance.

Figure 1. Patient's preparation and taping application.

The subject was asked to move the arm to reach the target and then move back the hand to touch the starting position mark. The movement was repeated six times for each trial and the subject was left free to adjust the speed. The task was completed separately by both the affected and the unaffected arm. Three trials were acquired for each arm. To minimize the fatigue effect, a 30 s rest interval between trials was allowed.

The kinematics of the upper limb was recorded using an optoelectronic system with passive markers (ELITE2002, BTS, Milan, Italy), equipped with 12 infrared cameras working at a sampling rate of 100 Hz, and a video system synchronized with the optoelectronic system (BTS, Milan, Italy). Passive markers were placed at special landmarks, directly on the subject's skin, to identify the position of the head, the trunk and the upper limb (arm, forearm and hand) [15, 16]. Each movement was segmented into three sequential phases, according to the literature [16]: going phase (i.e. the phase towards the target); adjusting phase (i.e. the phase dedicated to precisely locating the target) and returning phase (i.e. the phase towards the initial position) (Figure 2).

From the 3D coordinates of each marker, the followings parameters were identified and calculated:

Movement Duration (MD) indices: The duration of the three movement phases and of the total movement (MD: Movement Duration; Going MD, Adjusting MD, Returning MD and Total MD) [16, 18];

Movement smoothness and precision indices: Adjusting Sway (AS index; it is defined as the length of the 3D path described by the fingernail during the adjusting phase, which is a measure of the adjustments made to reach the final position and it represents an expression of the degree of precision) [19], Index of Curvature (IC; it is calculated as the ratio of the fingernail 3D path length to the linear distance between the initial and the final pointing position and is representative of movement smoothness during the ongoing phase) [20], Average Jerk (AJ; it is the mean value of the derivative of the acceleration and decreases with increased smoothness of movement; it is often used as a measure of the quality of selective motor control) [21], number of movement units

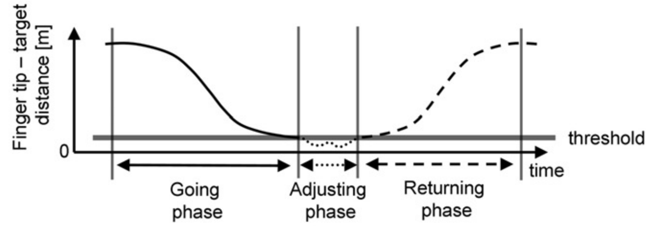

Figure 2. Schematic representation of the distance of the finger from target during reaching movement.

(NMU; it is computed as the number of velocity peaks that exceeded the 10% of peak velocity and it represents the number of online corrections performed by the subject during the ongoing phase, trying to avoid the inclusion of tremor components that occurs at the end of movement) [12];

Angle indices: Range of motion at the elbow (ROM elbow), shoulder (ROM shoulder) and wrist (ROM wrist), calculated as the difference between the maximum and minimum values of the aforementioned angles [17].

The mean values for all the previously defined parameters were computed over the six repetition of each trial. Then the data were averaged over the three sessions, obtaining a value for each arm. Results were then compared with the values of the age-matched control group (CG) [17].

As concerns the 3D upper limb kinematics (Table I), in the pre-test session, we can observe that the patient performed the movement with the affected arm slower and with a longer duration, in particular during the adjusting and returning phase (Adjusting MD, Returning MD, Total MD and MV indices). As regards movement smoothness, patient was characterized by higher values of the Index of Curvature (IC index), of the Average Jerk (AJ index), of the Number of Movement Unit (NMU index) and of the Adjusting Sway (AS index) than the unaffected limb and the CG. As regards the ranges of motion, her shoulder exhibited limited excursion on the sagittal plane and higher ROM on the frontal plane; the elbow joint displayed a high range of movement, too. The strategy of the non-affected limb was similar to the one chosen by the CG.

After the intervention, the affected limb improved in terms of adjusting MD, returning MD and Total MD indices; the AJ, NMU and AS indices reduced their values indicating smoother and less segmented trajectories (Figure 3). ROM of shoulder and elbow joints also improved. No significant changes were displayed for the unaffected arm, with the exception of shoulder excursion on the sagittal plane which improved.

Discussion

This case report aimed to quantify the effects of the NMT in the upper limb of a girl with CP. Our results showed an upper limb function improvement when NMT was used. In particular, our data showed that, after the intervention, the movement of the affected arm was faster, in particular in the adjusting and returning phase. The movement was also smoother and with a more physiological range of motion at shoulder and elbow. After the taping removal, we found in fact a reduction of the adjusting and returning phase duration, a lower value of average jerk parameter and improved upper limb ranges of motion if compared to pre-test condition. In particular, the treatment drove the movements inside a more functional range of motion starting from a more proper rest position. This probably favoured the disruption of global pathological motor schemes, favouring the acquisition of more proper ones, allowing the emergence of a more physiological movement [10].

The hypothetic mechanism underwent this application, also if merely speculative, should be that NMT may play a key role as a sensitive input that may be integrated by the central nervous system and used for assisting motor program execution process known as Sensorimotor integration.

These results are similar to those already found for upper limbs [10] even if literature regarding NMT in CP is poor. It is important to underline that a comparison is difficult to be performed as in Mazzone et al.'s paper [10], the technique used was different and the outcome assessment was conducted using clinical scales and no quantitative data were presented. So, our study represents the first attempt of quantification of NMT effects on upper limb movement in CP.

Further randomized controlled investigations on wider samples are certainly needed to assess effectively the effects of the intervention. In addition, it should be interesting to assess if the improvements will be maintained over time without further changes. Future studies should also investigate if NMT results in a reduction of muscle tone, inhibition of pathological schemes and support of proper functioning. Nevertheless, the fact that upper limb kinematics improvements occurred after the treatment period suggests that NMT seems to be a promising intervention for improving upper limb function in patients with CP.

Table I. Kinematic measures (mean and standard deviation) for the patient in the two sessions (pre-test and post-test session) and for the CG.

	Pre-test		Post-test		
	Affected limb	Unaffected limb	Affected limb	Unaffected limb	CG
Movement duration (MD) (s)					
Total MD	2.21 (0.37)	1.61 (0.24)	1.64 (0.06)	1.76 (0.16)	1.97 (0.15)
Going MD	0.79 (0.09)	0.67 (0.02)	0.75 (0.01)	0.74 (0.24)	0.82 (0.17)
Adjusting MD	0.46 (0.05)	0.28 (0.06)	0.22 (0.06)	0.29 (0.19)	0.28 (0.15)
Returning MD	0.95 (0.23)	0.66 (0.05)	0.71 (0.01)	0.73 (0.11)	0.75 (0.12)
Movement smoothness and precision					
IC	1.33 (0.04)	1.09 (0.06)	1.35 (0.02)	1.28 (0.26)	1.09 (0.15)
AJ (mm/s^3)	328.75 (31.48)	212.717 (20.68)	255.73 (14.22)	260.38 (15.64)	229.62 (14.60)
NMU	8.20 (0.01)	4.00 (0.04)	7.70 (0.14)	4.80 (3.96)	2.77 (1.45)
AS (mm)	34.85 (1.20)	18.8 (2.63)	12.8 (4.95)	7.03 (2.98)	8.71 (5.38)
Angles (°)					
ROM shoulder flex-extension	13.15 (1.63)	19.13 (2.37)	35.10 (0.28)	26.60 (3.11)	27.26 (9.90)
ROM shoulder ab-adduction	30.30 (1.27)	25.12 (2.94)	16.60 (0.23)	24.53 (3.11)	21.5 (5.90)
ROM elbow flex-extension	31.09 (0.71)	11.2 (0.82)	15.91 (0.57)	17.85 (1.91))	15.32 (3.51)
ROM wrist flex-extension	10.1 (0.57)	9.21 (0.60)	7.95 (0.92)	5.95 (4.77)	8.81 (0.63)

MD: Movement Duration; MMV: Mean Movement Duration; IC: Index of Curvature; AJ: Average Jerk; AS: Adjusting Sway; NMU: number of movement units; ROM: Range Of Motion.

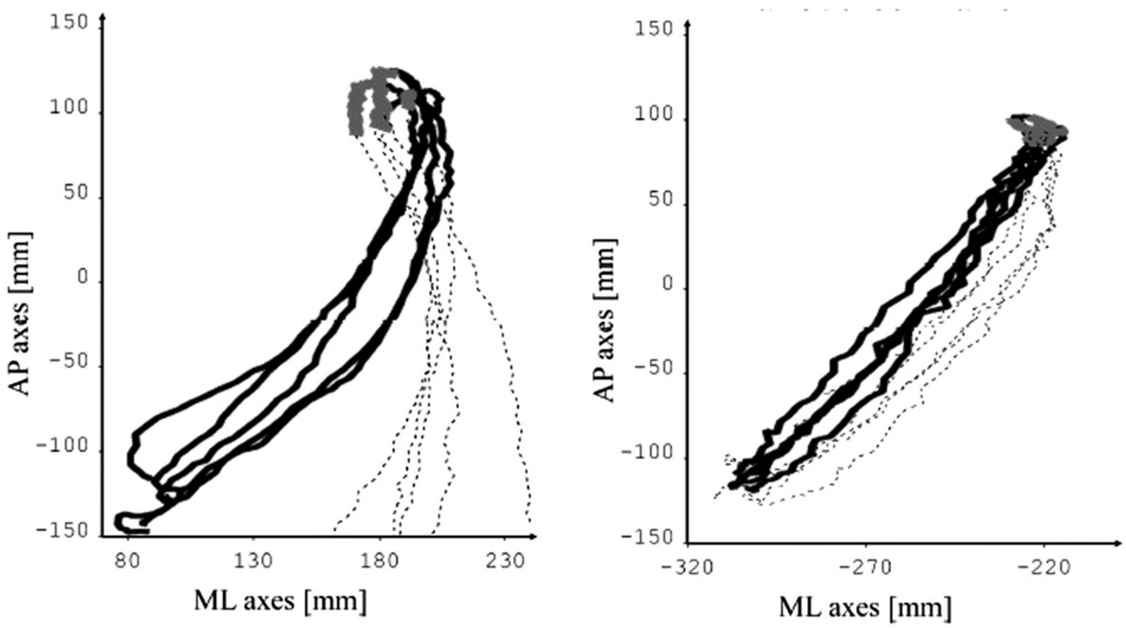

Figure 3. Trajectory of the marker placed on left finger of the patient in the transversal plane in the PRE (left) and POST (right) session (bold black line: trace during going phase; grey bold line: trace during adjusting phase; dotted line: trace during returning phase). AP: Antero-Posterior; ML: Medio-Lateral.

Declaration of interest

The authors report no conflict of interest. The authors alone are responsible for the content and writing of this paper.

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