Kinematic Assessment Force of Writer’s Cramp Before And During Cramp

azim alinejad\(^1\), fariborz rahimi\(^2\)

\(^1\)Department of Electrical Engineering, Ahar Branch, Islamic Azad University, Ahar, Iran
azim_alinejad@yahoo.com (Corresponding author)

\(^2\)Department of Electrical Engineering, bonab university, bonab, bonab, Iran
fariborz.rahimi@gmail.com

Abstract
In this paper, kinematic characteristics of writing are compared in 5 patient with writer’s cramp who performed a set of standardized writing task. The kinematic characteristics thumb and forefinger force before and during cramp. The effect of writing on different inclined supporting surfaces is also investigated. Our results indicate that inclined surfaces aspects of writing discomfort in writer’s cramp subjects. Although the change in arm joint angles and fingers/hand pressure is not generalizable between patients, such kinematic evaluations seem to be a key factor in the outcome of any personalized treatment or rehabilitation strategy.

Keywords: writer’s cramp; finger force; kinematic assessment; standardized task

1- Introduction
Writer’s cramp, a task-specific hand dystonia, is a writing disorder primarily characterized by unusual postures of the upper limb during handwriting [1]. Muscular hyperactivity, impaired handwriting, increased grip force, and irregular pen movements have been reported by writer’s cramp patients during handwriting tasks [4]. Subjective clinical rating scales such as the Arm Dystonia Disability Scale (ADDS) and the Writer’s Cramp Rating Scale (WCRS) have been suggested to assess functional impairment in writer’s cramp patients [2], [3]. Recently, kinematic aspects of handwriting related to pen use have also been introduced to assess and characterize affected patients more objectively. However, it is still unclear which body joints are most abnormal, and whether such kinematic abnormalities are consistent for most writer’s cramp patients [3]. Hermsdörfer et al. [4] measured pen-use related kinematic parameters and grip force in patients with writer’s cramp and control subjects. They have shown that finger grip forces are important descriptors of individual impairment characteristics and are independent of writing kinematics. In another study, Schneider et al. [7] suggested that script production of writer’s cramp patients be examined. In their study, patients showed significant deficits in pen kinematics and
force parameters during writing, but no consistent differences between the two subtypes of patients were found. Yu et al. [5] documented the handwriting process in a group of healthy young adults and measured the wrist joint angle during a writing task using an electrogoniometer. Their results suggest that writing difficulties could be associated with in-air trajectory length as well as wrist joint extension. However, such measurements do not seem to be enough to fully characterize kinematic aspects of writing. Previous studies [2], [7]-[9] have introduced various writing tasks of different complexities, ranging from different test sentences to simple repetitive drawing tasks. Zeuner et al. [3] suggested that sensitivity in detecting writer’s cramp may be greater in the kinematic analysis of pen use for the production of superimposed circles as opposed to writing a test sentence. Various therapies have been suggested for writer’s cramp, including neurotoxin injection [11] and trans-cranial magnetic stimulation (TMS) [12]. Some rehabilitative strategies focus on sensory training. Such strategies are designed to help patients activate their muscles more selectively [6]. However, the possibilities for rehabilitation, considering sensory manipulation are less explored in the literature [13]. The role of each involved joint and muscle needs to be objectively and reliably identified regardless of which treatment or rehabilitation strategy is chosen to intervene with this debilitating symptom. In this study, we conducted full upper-limb kinematic analysis of multiple writing and drawing tasks in writer’s cramp patients. Since features of writer’s cramp can be unique in every patient, the main goal was to identify whether kinematic assessment shows consistent differences before and during cramping of individual patients. Given the possibility of proprioceptive input abnormality as a possible mechanism for production of dystonia, inclined surfaces at differing angles were studied both as modifiers of proprioception and also as a simple, individualized rehabilitation strategy.

2- METHODS

2-1-subject

Seven writer’s cramp patients (1 female, 6 males; mean age, 61 years; age range, 52–70 years) were recruited. All participants gave written informed consent. The study was approved by the Research Ethics Board (REB) at Western University. In two patients, there were no noticeably significant levels of cramping during the tasks, so the analysis was based on the results from five patients. None of the participants were receiving any other form of treatment, such as physical therapy or botulinum toxin injections.

2-2- Setup

As illustrated in Fig. 1, kinematic assessment was carried out using the Noraxon kinematic system which involves surface attachment of three electrogoniometers (wrist, shoulder, elbow), two accelerometers (hand, finger), and one torsiometer (forearm). These sensors are non-invasive and are required to collect the kinematic data. To measure the grip force
produced by the thumb and index fingers during writing, the pen being used to write was equipped with two force sensors. The surface upon which the patient placed their hand was also pressure-sensitive to measure the normal hand pressure exerted by the participant’s hand during writing. Participants performed a series of standardized scripted writing tasks while wearing the kinematic sensors. The same tasks were carried out on simple inclined supporting surfaces tilted at a fixed angle (30°).

![Experimental setup](image)

**Fig.1.** Experimental setup

**2-3-Tasks**

Participant were asked to perform the following standardized tasks while wearing the kinematic sensors: writing a standard sentence: "Today is a bright and sunny day", The participants repeated the same tasks on the following surfaces: (1) flat, (2) tilted towards the dominant hand, (3) tilted away from the dominant hand, and (4) tilted towards the participant Every session began with completion of clinical scales and measurement of hand grip strength. The first task was a simple pre-adaptation task. Subjects were seated on a height-adjustable chair in front of a desk. They wrote on sheets fixed on a force-sensitive writing pad, using a pen equipped with force sensors. Wires were fixed to the subject’s forearm (see Fig. 1). Participants were asked to self-report the moment cramping began and the level of cramping, based on a numerical scale from 0 being “no cramp” to 4 maximal pain/discomfort”.

**2-4- Analysis**

Nine kinematic measures were chosen to characterize distinct aspects of motor control in standardized writing and drawing tasks. These measures include: thumb force, index force, hand force, wrist flexion/extension, wristulnar/radial,forearmpronation/supination, elbowflexion/extension,shoulderflexion/extension, and shoulder abduction/adduction. The mean value of each measure for each task before and during the cramp was calculated. Among all the tasks, four which presented the most severe level of cramping were selected. These tasks are illustrated in Fig. 2.

![Selected tasks](image)

**Fig. 2.** Selected tasks, (a) small spiral, CCW, (b) standard Sine, high frequency – left to right, (c) sine - low amplitude, high frequency - left to right, (d) sentence “Today is a bright and sunny day"
3- Results

Demographics of all participants along with some key clinical scales representing the severity of this symptom are presented in Table I. By comparing the each of 4 performance, to 5 patients with muscle spasms (hand cramps), at least one cramp, inclined to improve and relieve pain severity Of muscle showed.

![Figure 3](image3.png)

**Table 1. Demographics and clinicals for all patient**

<table>
<thead>
<tr>
<th>Patient Number</th>
<th>Sex</th>
<th>Age (yr)</th>
<th>Symptom Side</th>
<th>Symptom Duration (yr)</th>
<th>Beck Anxiety Inventory</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>M</td>
<td>52</td>
<td>R</td>
<td>3</td>
<td>17</td>
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<td>55</td>
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<td>M</td>
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<td>L</td>
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<td>8</td>
</tr>
</tbody>
</table>

Since the slope or ramps that occurred for all participating patients, is different, in this study, the most idea surface that in the process of reducing cramps has great affect, is investigated. In Figure 3, is shown.

![Figure 4](image4.png)

as can be seen in Fig. 4 to 8, changes of the force on the thumb, and forefinger, in four patients in this study, at before cramps and at the time cramps, the dominant hand, has been descending path and at total of cramps, eliminating Over time.

![Figure 5](image5.png)
4- Discussion

This study suggests that the use of inclined writing surfaces may improve handwriting in writer’s cramp patients. The possible alteration in the proprioceptive input related to the change in the writing surface angle may result in the use of a muscle-substitution strategy by the patient. This alteration of upper limb posture during handwriting, independently or through an open-loop sensory feedback mechanism [13], may be the basis of the perceived measured benefit in writing and cramping. While most changes in the kinematic parameters are likely to be cramp related, some of these measures may simply be related to the task itself. In order to more reliably pinpoint the factors that are related specifically to the cramps, kinematic data collection on age-matched healthy controls performing the same tasks are currently being carried out. Comparing these kinematic parameters between patients and controls at various time points during task performance could help differentiate task-related versus cramp-related kinematic features. The idea of writing on inclined surfaces which alter handwriting posture shows therapeutic potential in avoiding focal hand dystonia. For all of the patients, there was at least one slanted surface over which cramp severity, latency, or both were improved. The changing of the writing surface angle is a portable, simple and cost-effective alternative to other suggested therapies and devices which may seem awkward to use in public.
By analyzing the limb kinematic signature of joint angles and forces during cramping among the participants, it appears that this phenomenon is less generalizable in terms of body joint involvement (comparing percent change among the 9 kinematic parameters). Hence, a personalized evaluation, using objective kinematic assessments, can help identify the muscles involved in order to either injecting them with focal agents such as botulinum toxin or for designing personalized rehabilitation strategies such as writing on an inclined surface at a particular angle.

5- Conclusion

In 5 writer’s cramp patients, we analyzed the kinematics of writing and drawing movements performed on three slanted and one flat writing surface. We considered handwriting to probe different aspects of manual motor control. Our results suggest that changing the writing, surface may help reduce the cramp severity or delay its happening. Furthermore, the kinematic assessment showed significant changes before and during cramping for all participants. These changes might not be consistent for all the participants, personal aspects of this symptom. hence emphasizing the personal aspects of this symptom.

Acknowledgment

Authors acknowledge the contribution of all colleagues, patients, and staff at the Movement Disorders Centre, London Health Sciences Centre, London, Ontario, Canada, who participated in this study.

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