Interventions for Upper-Limb Intention Tremor in Multiple Sclerosis

A Feasibility Study

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Approximately 25% of people with multiple sclerosis (MS) experience upper-limb intention tremor (ULIT), which limits their ability to participate in daily activities. Little research has been conducted on the effectiveness of available treatments for ULIT. The objectives of this study were to investigate the use of occupational therapy interventions to improve eating and handwriting performance in adults with MS and ULIT and, based on these findings, to provide recommendations for the development of a treatment protocol for ULIT. Six adults with MS and ULIT were recruited from an MS clinic. Participants rated their pre- and post-intervention functional performance using the Multi-Dimensional Assessment of Tremor. Interventions included education about tremor, proximal stabilization, hand-over-hand technique, weighted tool, weighted wrist, and splinting. Participants evaluated the techniques using visual analogue scales (VASs). One month after the intervention, participants were interviewed to assess sustainability of the techniques. Pre- and post-intervention functional scores, VAS scores, and qualitative reports were used to evaluate the success of the techniques in improving participants' abilities in eating and handwriting. Preliminary evidence demonstrates the usefulness and sustainability of the behavioral strategies and the use of multiple techniques simultaneously in the treatment of ULIT. Further investigation is needed to support the use of weights and splints. Recommendations for the further development of a ULIT treatment protocol were provided. ***Int J MS Care.*** **2010;12:122–132.**

Approximately one-quarter of people with multiple sclerosis (MS) experience tremor of the upper limb. In most cases, this tremor occurs during voluntary muscle contraction. Intention tremor occurs during visually guided, goal-directed movement and has a negative effect on function. The amplitude of intention tremor increases with growing proximity to the target and precision of the activity, making tasks such as eating, writing, drinking, and using a computer extremely challenging.[1-3]

The exact cause of intention tremor is disputed, but it is strongly related to other movement disorders such as ataxia, dysmetria, dysarthria, and dysdiadochokinesia, suggesting damage to the cerebellum or its connections.[1,3] Intention tremor is seen primarily in the fingers, hand, and wrist but may also occur in the lower extremity, torso, and neck.[4] It may also be associated with hypotonia, which further limits functional performance. In wrist extension and flexion, intention tremor has a frequency of 3 to 4 Hz and an amplitude of up to 30°.[1,4,5]

Tremor can be assessed in several ways, including basic clinical performance-based examinations such as handwriting assessments, drawing tests, Nine-Hole Peg Test, finger-to-nose tests, and target board tests[2,6-9]; functional questionnaires measuring the effect of tremor on activities of daily living[7]; classification scales (absent, mild, moderate, or severe) and rating scales such as the Fahn tremor rating scale[10,11]; and kinematic assessments such as accelerometry, polarized light goniometry, and computer-aided tracking of joints.[11,12] Recently a comprehensive assessment instrument, the Multidimensional Assessment of Tremor (MAT), was developed and validated to assess tremor severity in people with MS and its impact on activities of daily living.[13] This comprehensive

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tool comprises four parts and is further described in the "Methods" section.

An upper-limb intention tremor (ULIT) is strongly correlated with disability in MS. In a variety of single-case and larger studies, intention tremor was found to affect the activities of eating, drinking, shaving, putting on makeup, picking up the phone, handwriting, using the computer, cutting meat, and, to a lesser extent, using a television remote-control device. Intention tremor also causes disability by reducing participation in social, household, and recreational activities because of the patient's fear of making a mess and experiencing embarrassment and frustration.[4,14,15]

Given the disabling potential of ULIT, effective treatment is essential to preserve an individual's ability to participate in daily life activities. Unfortunately, although various treatment options have been developed, there is little evidence to support their use. Medical treatments such as medication, thalamotomy, and thalamic stimulation are available, but these treatments either have limited evidence of effectiveness or have risks and side effects that outweigh their potential benefits.[1,11]

Occupational therapy (OT) interventions for intention tremor have traditionally focused on reducing and compensating for tremor to improve function.[3] These interventions include the use of viscous damping,[3] weights, weighted tools and utensils, joint approximation and compression, positioning, proximal stabilization, adapted equipment to reduce manual demands (eg, "soap-on-a-rope"), and environmental adaptations.[2,3,14,16] Additionally, many orthoses have been designed to isolate or provide resistance to tremor and have been reported to slightly improve eating independence. However, acceptance of the devices has been poor because they are deemed "obtrusive, uncomfortable, or technologically complex."[15(p508)] According to Alusi et al.,[1(p133)] individuals with MS often deal with their tremor on their own by "reaching with both hands, bracing an arm during manual tasks, or restraining [the tremor] to prevent injury."

Despite the variety of interventions available, their effectiveness has not been well established in the literature. In the literature on interventions for intention tremor are two systematic reviews and one meta-analysis. However, they had significant limitations, including a small number of reviewed studies, a lack of standardized assessments across studies, a lack of randomized controlled trials on the topic, and a failure to isolate distinct treatment modalities. A 2003 Cochrane review of OT for MS[17] found a lack of efficacy studies in most intervention areas. Another Cochrane review focusing on treatment for tremor in MS[12] found a lack of evidence to support any type of treatment. Orthoses and weighting were the only OT interventions included, and they were combined with physical therapy and neurosurgical interventions for data analysis. A meta-analysis of OT for individuals with MS concluded that more rigorous research was needed to fully understand treatment effectiveness.[18] This article also failed to isolate OT from other interventions.

Smaller studies have offered more hope, but they are limited by their small sample size and often include confounding variables such as co-interventions. In a cohort study, Jones et al.[16] reported that the use of adaptive equipment and aids, environmental change, and modification of methods appeared effective but that there was little empirical support for their use. In a single-case study, Gillen[14] found that interventions such as positioning and orthoses improved independence in performing meaningful daily tasks, but the results could have been confounded by simultaneous use of other interventions (physical therapy and medications).

In another study, McGruder et al.[15(p515)] found that adding weight to the distal upper limb was effective in two of five participants with static brain lesions in diminishing intention tremor during "skilled purposeful movement" in the intermediate term. It was hypothesized that the effect may have been due to increased proprioceptive input to the cerebellum and increased inertia in the direction of gravity, causing the muscles to work harder. This study, however, was limited by a small sample size (n = 5) and participant use of compensatory strategies in addition to the studied intervention. Finally, in a study of 18 patients, Feys et al.[19] found that cooling of the distal joints of the forearm reduced forearm tremor amplitude and frequency and increased functional capacity for at least 30 minutes. Therefore, it was suggested that cooling of the forearm before performing activities of daily living might be a useful strategy. However, proximal joints were not included in the intervention, and patients with severe tremor were excluded.

Given the limited evidence to support any specific type of OT intervention for intention tremor in people with MS, the objectives of the current study were as follows: 1) to investigate the use of behavioral interventions and assistive devices to improve eating and handwriting

performance in adults with MS and ULIT; 2) to evaluate the self-perceived efficacy of techniques among participants to determine patterns of success or failure when using these techniques; 3) to gather information about the subjective experience of tremor and the feasibility of interventions; and, based on these results, 4) to provide recommendations for the development of a treatment protocol for ULIT in MS patients.

Methods

Participant Recruitment

Participants were identified by convenience sampling from an occupational therapist's caseload from the University of British Columbia (UBC) MS clinic and made aware of the study. Patients who expressed interest in the study were contacted by the investigators and received an information package explaining the study.

Data Collection

Data collection comprised five segments: prior to intervention, Session 1 (administration of the intervention), daily for 1 week following Session 1, Session 2, and 1 month later. Before the intervention, participants completed the demographics form and Part D of the MAT (described below under "Measures"). At Session 1, Parts A, B, and C of the MAT were completed and Part D was reviewed. The treatment protocol was then administered in this session and participants used a visual analogue scale (VAS) to indicate their preferences as techniques were introduced and removed. During a 1-week trial period, participants completed the VAS daily. At Session 2, the investigator re-administered Part D of the MAT and observed the participant's performance of the chosen technique or techniques, noting any modifications that occurred during the week. Finally, 1 month after Session 1, an investigator contacted the participants by telephone to ask questions about their current use of techniques and request feedback on the study design and protocol. The investigators also recorded patients' comments and observations throughout the research process to gain further insight into the results.

Treatment Protocol

To establish a protocol of treatment for ULIT, this study used a pre/post methodology with two intervention sessions followed by a structured telephone interview 1 month after the intervention. The treatment protocol established for this study was a stepwise system of introducing techniques and building on successes as follows (Table 1):

1. Participants received education on intention tremor and proximal stabilization as a basic technique to use with all other techniques.
2. With participants seated at a table, four techniques were tested one at a time in an introduction-removal method during the activities of handwriting and eating finger food. The order of introduction and removal is shown in Table 1.
3. If after testing the four techniques, more than one technique was helpful, participants were asked to try combining techniques.
4. Participants rated their satisfaction, performance difficulty, and severity of tremor using the VAS to help them decide systematically which technique or techniques were most effective and preferred.
5. Participants were asked to use their chosen technique or combination of techniques once a day for 1 week (or more often if applicable) and to track their experience using the same scale.

Measures

The *MAT*[13] was used in this study to measure the severity and impact of the participants' intention tremor. The MAT is composed of four parts. Part A describes the individual's tremor and the impact of factors such as activity, time of day, and stress; Part B describes the psychosocial effects on tremor; Part C measures tremor severity; and Part D measures functional performance related to tremor. Part D was used as an outcome measure to determine whether participants experienced any change in function after being introduced to OT intervention strategies. Participants also used the *VAS* to rate their satisfaction, performance difficulty, and tremor severity when testing techniques in the first intervention session. The same scale was then used daily during the week when participants tested their chosen technique or combination of techniques. One month after the intervention, a *structured interview* was conducted to assess the sustainability of the techniques and to collect participant feedback on the study protocol and process.

Data Analysis

Comparisons of pre- and post-intervention MAT Part D scores and VAS scores were used to analyze the usefulness of interventions to improve eating and handwriting performance. Qualitative data gathered about

Table 1. Treatment protocol

Baseline

Education on intention tremor and proximal stabilization: Support of the trunk against the table, humerus against the body, and/or elbow on the table.

Stepwise Introduction of Techniques

1. **Hand-over-hand technique:** Use of the non-dominant hand to support the other hand.

2. **Weighted wrist:** Use of wrist weights from ½ to 2 lbs on the dominant arm, introduced in ½-lb increments from lightest to heaviest.

3. **Weighted tool:** Use of a commercially available ½-lb weighted pencil

OR a ¼-lb soft weighted pen wrap (handwriting only).

4. **Splint:** Use of a commercial universal wrist splint to provide distal support.

5. **Coupling:** Combination of any two or more techniques (if relevant).

the protocol and the intervention experience through researcher observations and participant comments were also analyzed.

Ethics

Ethical approval for this study was granted through the UBC Clinical Research Ethics Board and the Vancouver Coastal Health Research Institute.

Results

Participants

Ten adults were recruited for the study through the UBC MS clinic. Four did not participate: two were unable to be contacted, one withdrew from the study because of the distance of travel to the study location, and one did not have tremor. The six participants in the study had a mean age of 48 years and a mean disease duration of 13 years, and 67% were female (Table 2). All six participants presented with bilateral ULIT. Table 3 shows participants' tremor status at the start of the study (MAT scores).

Prior to the beginning of the study, all participants had independently tried a range of strategies to mitigate the effects of tremor (Table 4). Each participant was already using at least two techniques, and some participants were using up to eight different techniques. Some of these strategies were self-discovered, while others were therapist-taught.

Table 2. Demographic data on participants (n = 6)

Characteristic	Value
Age, y	
Mean	48
Median	45
Range	32–66
Gender	
Female	4
Male	2
Marital status	
Never married	4
Married	1
Separated/divorced	1
Level of education	
Some high school	1
Some postsecondary	1
Professional/graduate degree/ vocational certificate	4
Employed	
No	4
Part-time	2
MS type (all progressive)	
Primary	2
Secondary	4
Duration of MS, y	
Mean	13
Median	9.5
Range	5–34
Extended Disability Status Scale scores (range, 0–10)	
Mean	6.8
Median	8
Range	4–8.5

Note: Unless otherwise indicated, data are given as number of participants.

Table 3. Participants' tremor status at the start of the study (n = 6)

Multidimensional Assessment of Tremor (MAT) scale	Mean	Median	Range
Part C–TSS[a]	75	67	58–88
Part D–FSS[b]	63	61	33–88

[a]Tremor Severity Scale from Part C of the MAT; range, 0 (no tremor) to 100 (most severe tremor).
[b]Functional Severity Scale from Part D of the MAT; range, 0 (no impact) to 100 (greatest impact on function).

Table 4. Techniques used before the study to functionally reduce tremor

	Participant					
	1	2	3	4	5	6
Proximal stabilization	✓	✓	✓		✓	✓
Distal stabilization using table/lap tray	✓	✓	✓	✓		✓
Hand-over-hand technique	✓	✓	✓	✓	✓	
Using less-affected hand			✓		✓	
Reducing travel[a]		✓	✓			
Conscious muscle relaxation			✓			
Wrist splint					✓	
Weighted elbow	✓					
Elbow tensor					✓	
Finger clip for pen			✓			
Built-up pen		✓	✓			

Note: Techniques introduced by self-discovery or therapeutic intervention.
[a]Bringing the head and trunk forward to meet the target (eg, the hand when eating) to reduce the distance the limb has to travel.

Data were collected in locations that were acceptable to both the participants and the researchers. Thus, three participants were seen in their homes and three were seen at the UBC occupational therapy research laboratory.

Objective 1: Investigation of the Use of Behavioral Strategies and Assistive Devices for ULIT in MS

The pre- and post-intervention scores on the items of handwriting and eating of the Functional Severity Scale (FSS) from Part D of the MAT were analyzed. In addition, VAS scores at baseline were compared with the averages and ranges of VAS scores reported during the week following intervention to evaluate functional change in satisfaction, performance difficulty, and tremor severity. "Baseline" refers to the participants' performance when using only proximal stabilization as demonstrated in Session 1 of the study.

FSS Data

For the purpose of this study, clinically significant changes for the items of handwriting and eating on the FSS (Part D of the MAT) were defined as differences in scores of one or more levels. Clinically significant improvements in the post-intervention scores were found only for one participant, whose handwriting score improved by two levels and eating score by one level. This participant's functional performance improved with the use of bilateral wrist splints and the hand-over-hand technique. The FSS item scores for handwriting and eating for the remaining five participants either remained unchanged or showed a change that was not clinically significant.

VAS Data

Visual analogue scale scores related to handwriting and eating (Table 5) were recorded by participants daily over the 1 week following intervention; however, several participants did not complete the scales because they qualitatively reported no change in their satisfaction, performance difficulty, or tremor severity (Participants 2 and 6 for handwriting, and Participants 2, 5, and 6 for eating).

The VAS ratings for Participant 1 demonstrated increased satisfaction, decreased performance difficulty, and decreased tremor severity. These ratings are consistent with this participant's clinically significant FSS improvements.

Although the FSS scores for Participant 3 showed no change, her VAS ratings showed an increase in satisfaction, along with decreases in both performance difficulty and tremor severity. The participant experienced a functional improvement with the use of the ¼-lb pen weight wrap, combined with behavioral and positioning strategies.

Participant 4's VAS ratings for handwriting showed that he experienced increases in performance difficulty and tremor severity over the week, causing a decrease in his satisfaction compared with baseline. It should be noted, however, that this participant reported that in his daily life he regularly avoids writing, as it is a source of frustration. In terms of eating, there was a marked improvement in Participant 4's satisfaction when using the hand-over-hand technique and distal and proximal stabilization.

Participant 5 showed little to no change in his range of VAS ratings over the week in terms of satisfaction,

***Table 5.* Visual analogue scale[a] scores for handwriting and eating: baseline from first session (pre-intervention) and mean and range at 1-week follow-up (post-intervention)**

	Satisfaction			Performance difficulty			Tremor severity		
Participant	Baseline	Mean	Range	Baseline	Mean	Range	Baseline	Mean	Range
Handwriting									
1	0.0	4.3	3.8–4.9	5.4	5.2	3.1–6.4	9.7	5.6	4.2–6.7
3	0.2	3.3	0.6–5.8	9.9	5.9	3.9–7.7	9.9	4.5	2.0–6.4
4	3.0	1.7	1.2–3.0	4.6	8.6	4.6–9.0	4.0	8.7	4.0–9.0
5	0.3	0.6	0.3–1.0	9.4	8.8	8.5–9.4	10.0	9.1	8.5–10
Eating									
1	3.0	5.0	3.7–6.5	5.3	5.5	4.7–7.0	8.5	5.6	4.4–7.1
3	1.5	4.8	2.0–7.5	6.0	3.2	1.3–5.5	9.0	3.8	2.1–5.6
4	4.9	1.5	1.5–4.9	7.5	7.8	7.0–8.4	7.4	7.7	7.4–8.4

[a]Scales range from 0 to 10 as follows: satisfaction: 0 = no satisfaction, 10 = extreme satisfaction; performance difficulty: 0 = no difficulty, 10 = extreme difficulty; tremor severity: 0 = no tremor, 10 = extreme tremor.

performance difficulty, and tremor severity using his chosen techniques.

Objective 2: Self-Perceived Efficacy of Techniques

Table 6 shows the number of participants who chose each technique when introduced during the initial session and the number who continued to use it after 1 week and 1 month. Table 7 shows the specific techniques used by participants at the completion of the study. The following patterns of success and failure using the various techniques were demonstrated:

- All participants used proximal stabilization and continued to use it 1 month later.
- The hand-over-hand technique was chosen by five participants and also showed good sustainability of success.
- Weights were previously used by one individual (Participant 1), who discarded the technique at Session 1. Three other participants tried weights after Session 1 but had abandoned the technique 1 week later.
- Wrist splints were used by two people: one who had used them previously with minimal success and one who had not tried them before but encountered great success with bilateral splints.
- Weighted pens were effective only for one participant who chose a small, soft ¼-lb weight rather than the heavier, bulkier commercial weighted pens.

Table 6. Selection and continued use of techniques by participants throughout the study

Technique	No. of participants who selected/used the strategy (n = 6)		
	After Session 1	1 week later	1 month later
Proximal stabilization	6	6	6
Hand-over-hand technique	5	5	5
Wrist weight	3	0	0
Weight on pen	1	1	1
Wrist splint	2	2	2
Combined techniques			
Splint and weight	1	0	0
Proximal stabilization and hand-over-hand technique	5	5	5
Pen clip and ¼-lb weight wrap	1	1	1
Proximal stabilization with distal stabilization (lap tray or table) and hand-over-hand technique	4	4	4

Table 7. Techniques selected and used up to 1 month after intervention session by participants

	Participant					
	1	2	3	4	5	6
Proximal stabilization	✓	✓	✓	✓	✓	✓
Hand-over-hand technique	✓	✓	✓	✓	✓	
Distal stabilization using table/lap tray	✓	✓	✓	✓		✓
Using less affected hand			✓		✓	
Reducing travel		✓	✓			✓
Conscious muscle relaxation			✓			
Bilateral wrist splints	✓				✓[a]	
Finger clip for pen			✓			
Weighted pen wrap (¼ lb)			✓			
Built-up pen		✓				
Total number of techniques used	4	5	8	3	4	3

[a]Occasionally.

Objective 3: Information About the Subjective Experience of Tremor and the Feasibility of Interventions

Experience of Interventions

Participant and researcher observations during this study provided qualitative data that will be useful in developing a treatment protocol for ULIT in MS. Table 8 summarizes participant and researcher observations regarding experiences, successes, and failures using the protocol and testing the interventions.

In addition to observations about the techniques themselves, the participants also provided insight into factors that affected their writing and finger-feeding success. These include the ability to keep the pen on the paper, the proximity of the paper or food (affected by the fit, comfort, and/or bulkiness of assistive devices), and the amount of energy needed to pick up a pen.

Table 8. Summary of observations of researchers and participants during and after intervention

Technique	Participant observations	Researcher observations
Proximal stabilization	• Appreciated acknowledgment of this technique because they did not realize they were doing it	• All but one participant did this previously as a result of self-discovery. • All found helpful
Hand-over-hand technique	• Most comfortable technique • Made whole body shake in one participant with severe tremor • One participant used it for writing but not for eating due to severe bilateral tremor.	• Most participants found it helpful as long as one extremity had less tremor than the other.
Wrist weight	• Makes tremor worse • Tiring • Cumbersome • Decreases function • Difficult to put on/take off independently • Decreases stability • One participant felt a heavier weight might have been more effective.	• Those who found initial improvement did not find the change to be sustained and abandoned the weight. • Weights used in this study were awkward to put on. They were also quite large on the wrists of the women. • Downward pressure in combination with the weight seemed slightly more effective for one participant but was not explored in detail.
Splint	• Significant benefit with bilateral splints for one participant, minimally helpful for another participant; made tremor worse for three participants, no effect for one • Felt bulky • Concern about getting messy with eating • One individual felt that splinting his wrist was too far from the tremor source, and that if there was a way to splint the shoulder it would help more.	• Universal splints did not fit most clients well. • Custom splints may have improved effectiveness.
Weighted pen (½ lb commercial)	• Too big and too heavy • Made tremor worse • Awkward	• No participants selected ½-lb commercial weighted pens as effective.
Other observations	• Participants did not realize how often they were using the hand-over-hand and proximal stabilization techniques. • Was helpful to know what they were doing	• Individuals sometimes reduced the travel distance to the paper or finger food by lowering the head or bringing the entire torso toward the object.

Experience of Tremor

Qualitative data were collected in this study to acquire insight into the subjective experience and feasibility of interventions for tremor. The top three activities participants had the most difficulty with were handwriting (reported by five participants), eating (four participants), and using a computer (three participants). This supports the selection of handwriting and eating as the targets of intervention in this study.

Participants also reported factors that influence tremor severity; these factors must be considered when implementing an intervention. Fatigue, stress, and overstimulation (each cited by four participants) were the three most problematic factors, followed by heat (three participants), cold (two participants), and "when emotional" (one participant).

Finally, Part B of the MAT provided important information about the psychosocial experience of tremor. Five of the six participants reported frustration and half of the participants reported experiencing depression and embarrassment due to their tremor. When asked to describe their experience of frustration, participants responded with comments such as the following: "It is frustrating because it takes time to do a simple task" (Participant 1). "It is frustrating to be spilling stuff and trying to do something I can't do because of my tremor" (Participant 2). "I have to pay attention to things that people don't normally have to. There are so many things I can't do" (Participant 6). These feelings of depression and embarrassment kept participants from engaging in activities. One participant summarized this by saying, "I avoid activities where tremor is worse" (Participant 6). These psychosocial experiences are important to consider both in the compassionate design of the study and in promoting participation in the study.

Discussion

The results of this preliminary study provide valuable insight into the experiences with and success of behavioral and assistive device techniques to manage ULIT in people with MS. They also provide guidelines for a treatment protocol to be developed in the future.

The results support previous research suggesting that splints have low acceptance because of their obtrusiveness or poor fit.[16] They also provide further evidence of individuals' abilities to discover their own ways of coping with tremor, such as using both hands (eg, the hand-over-hand technique) and bracing (eg, distal stabilization using a table or lap tray). This is an important insight, because it indicates that earlier introduction of these techniques through therapy rather than self-discovery could decrease frustration and enhance function sooner.

Clinically significant functional improvement was found in only one participant in this study. When interpreting this result, however, it is important to consider the history of each individual. All participants entered the study already using at least two and as many as eight techniques. This fact alone provides evidence for the ongoing usefulness of the techniques that were most commonly used among the sample. For future studies, a broader recruitment strategy that targets individuals with a greater range of intention tremor severity could reduce potential bias.

This preliminary study provided important information regarding the treatment of intention tremor. Five of six participants had already been using proximal stabilization (Table 4), and the one participant who had not previously used it adopted this strategy and continued to use it 1 month after its introduction. Proximal stabilization was, therefore, found to be successful over the long term. Similarly, it was discovered that five of six participants had already discovered and been using the hand-over-hand technique to improve their ability to participate in specific activities. It was also found that this technique was always used in combination with proximal stabilization and was usually combined with distal stabilization of the forearm using a table or lap tray. Reduction of travel by lowering the head or torso toward the target object was also discovered to be an effective technique for some participants when eating. All participants who chose these behavioral techniques after the initial session continued to use them at the end of this study, demonstrating the long-term sustainability of behavioral techniques.

Wrist splints were ineffective for most participants; however, two of the six participants found the use of bilateral wrist splints to be effective in combination with the hand-over-hand technique. It is important to note that many participants did not choose the wrist splints because they found them to be bulky and difficult to put on (Table 8). These comments indicate that if a customized splint were tested, more participants might find this intervention effective. The purpose of the wrist splint was to provide distal stabilization to the upper extremity at the wrist; however, during the study it was noted that five out of six participants stabilized their wrist using a table or lap tray during writing and eating. Thus it appears that using a table or lap tray is a more successful and sustainable method of achieving distal stabilization than use of a wrist splint.

Wrist weights were initially chosen but then abandoned by three participants after 1 week, indicating that this technique was not sustainable. The participants' experience of using the weights (Table 8) provides insight into the reasons for abandonment of the weights. These subjective data should be taken into account in exploration of more suitable wrist weight designs for this population in terms of fit, comfort, and ease of donning.

The commercial ½-lb weighted pen was not selected by any participant; however, one participant found that a lighter (¼-lb) weighted pen wrap improved her writing ability. Therefore, adding lighter weights to any pen may be preferable to using commercial weighted pens. It should be noted, however, that the weighted wrap provided a built-up pen grip that was soft and comfortable; therefore, it is unclear whether the weight or the added girth and comfort of the wrap was the influential factor.

Protocol

The successes, failures, and sustainability of techniques (Tables 4, 6, 7) in combination with subjective data and observations (Table 8) provide important information to assist in the development of a treatment protocol. The results indicated that proximal stabilization was useful for all participants and should therefore continue to be included in the protocol. The hand-over-hand technique was the second most successful, and it should also be included in the protocol after the introduction of proximal stabilization, as it was always used in combination with another technique. Other behavioral techniques such as distal stabilization using a table and reducing the travel required by the upper limb should also be incorporated.

Because of the success of behavioral strategies (eg, proximal and distal stabilization and the hand-over-hand technique) compared with assistive devices (eg, wrist splints and weights), we suggest following an intervention protocol that introduces behavioral strategies first and then augments the treatment with assistive devices (eg, wrist splints, weights, and pen accessories) if the individual finds them helpful. Future studies may also include the reduction of travel in their behavioral treatment list.

Inconsistencies were found between baseline and weekly scoring on the VAS for chosen techniques. This finding suggests that individuals' scores may have been affected by comparison of techniques in the initial session, with the experience changing when the comparison context was removed. Further exploration of this issue may be warranted.

Study Design

The design of this study was beneficial for many reasons. When evaluating the new treatment protocol, it was useful to consider participant feedback. For example, recommendations for future studies were based on participant feedback concerning factors that limited the use of the adaptive aids such as splints and weights. This study also evaluated the influence of the disease and the tremor experience of the participants, prompting the recommendation to use broader recruitment strategies in future studies. Additionally, this study recognized the techniques that participants had discovered independently. Participants appreciated this recognition of their ability to problem-solve. Finally, when designing the intervention protocol, proximal stabilization was established as a basic technique to use with all other interventions. This decision was based on clinical experience suggesting that participants would intuitively use proximal stabilization to mitigate their tremor regardless of their awareness of the adaptation. The study findings supported this design.

Limitations

The sample size of this study was small, with only six participants recruited through convenience sampling. Moreover, on analysis of participant baseline data, a possible sample bias was noted, as most of the participants had more profound tremor than would be seen with random selection. In addition, an unintentional cohort bias was noted, because most participants had already discovered, either independently or through therapy, a minimum of two techniques to mitigate their tremor and/or seemed to have resigned themselves to dealing with the tremor as they had been for several years. Finally, the time of day of the sessions was not standardized. This may have affected the results because of the fluctuating nature of MS-related fatigue.

Practice Points

- Upper-limb intention tremor (ULIT) affects one-quarter of people with MS and limits their ability to participate in daily activities.
- Little evidence exists to support the effectiveness of available occupational therapy and other treatments for ULIT.
- This pilot study provides preliminary evidence of the usefulness and sustainability of various behavioral strategies for ULIT.
- Further investigation is needed to support the use of assistive devices such as weights and splints.

Conclusion

A comprehensive literature review of previous research on MS and ULIT helped establish the need to further investigate the effectiveness of OT interventions for tremor, providing a strong foundation for this study. Despite the limitations and the preliminary nature of this study, it provides important information and is a first step in gathering more rigorous and conclusive data on these interventions.

Preliminary evidence has been gathered to support the use of behavioral strategies (such as stabilization and the hand-over-hand technique) in the treatment of ULIT in MS, as well as the use of many strategies simultaneously. Evidence for the usefulness of tested adaptive aids in this population is inconsistent and limited.

It is recommended that follow-up studies improve the treatment protocol by introducing behavioral strategies before assistive devices, by including distal stabilization (using a table or lap tray) and reduction of travel to the tested behavioral techniques, and by customizing wrist splints to improve their fit and comfort. Future studies that implement these recommendations and use larger and broader samples will enhance these preliminary findings and assist in the development of best practice standards for therapeutic interventions for ULIT in MS. Long-term studies are needed to determine whether treatment techniques should be modified as tremor progresses and to consider the role of other MS clinicians in the treatment protocol. □