Weighted Wrist Cuffs for Tremor Reduction During Eating in Adults With Static Brain Lesions

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OBJECTIVE. This study examined whether weighting the forearm during feeding decreased tremors and increased functional feeding in adults with intention tremor caused by static brain lesions.

METHOD. Five individuals with various diagnoses, ages 30–81, were videotaped during 8 or 16 meal sessions, alternating treatment and control conditions within each meal. In this single-case design, treatment consisted of application of a weighted fabric wrist cuff and the baseline (control) condition employed an identical cuff with the weights removed. Dependent variables studied were time to acquire and deliver a bite, grams of food eaten, number of times food was spilled, number of times a compensatory technique was used, participant self-rating, and investigator rating of the severity of the tremor.

RESULTS. All five participants demonstrated improvement during treatment in one or more of the dependent variables. t Tests of the means of baseline and treatment half-sessions incorporating conservative control of Type I error revealed the following statistically significant improvements under the weighted condition: Participants 3, 4, and 5 took less time to acquire a bite; Participants 4 and 5 made fewer spills; Participants 3 and 5 showed a diminished tremor. There were no statistically significant decreases in function on any variable for any participants during the weighted condition.

CONCLUSION. The application of weight to the wrist of a person with upper-extremity tremor is accompanied by some functional improvement in self-feeding for some individuals. The size of benefit seems to be sensitive to the amount of weight used.


Intention tremor is a coarse, rhythmical shaking in the upper extremities evoked by purposeful movement and intensified as the goal of movement is approached. Intention tremors are caused by lesions to the brain stem, cerebellum, basal ganglia, or associated subcortical areas. Such lesions may be static or progressive depending upon etiology. In the presence of intention tremor, purposeful movements toward an object are often inaccurate, but not inappropriate or involuntary (Wood & Eames, 1989). Researchers estimate that 160,000 to 1 million Americans experience intention tremor in at least one upper extremity (Ficke, 1992). The typical person with intention tremor is young and active, with a long life expectancy (Gordon, Mann, & Willer, 1993).

Intention tremors affect particularly those tasks that require accuracy and precision, such as eating and drinking. A person may have difficulty in maintaining adequate nourishment given an inconsistent ability to bring food to the mouth (Yuen & D’Amico, 1998). For such persons, eating requires extensive time and energy and is often unsuccessful. Frustration is common, especially in those who are cognitively aware of their decreased performance (Kovich & Bermann, 1988). In addition, incoordination may be a source of embarrassment and contribute to social isolation and depression. Treatment in occupational therapy has usually...
encompassed compensation for decreased functional performance (Finlayson & Garner, 1994; Kovich & Bermann; Wood & Eames, 1989). One such compensation is the application of weight to the upper extremity or to eating utensils.

Two hypotheses explain why weighting the distal extremity may decrease intention tremors. One hypothesis asserts that weighting a limb increases proprioceptive input from muscle and joint sensory organs to the cerebellum, resulting in increased biofeedback that facilitates co-contraction and brings about stability (Finlayson & Garner, 1994; Gapsis, 1990; Kovich & Bermann, 1988; Wood & Eames, 1989). An alternative hypothesis is that tremors are reduced by purely biomechanical factors. The weight on the distal limb requires the muscles to work harder and hence fatigue more quickly and may quiet the tremor by increasing the inertia that the muscles must overcome. Some theorists also suggest that the use of weights may increase tremors over time. Although no empirical evidence exists to support one hypothesis over another, the practice of using weights to treat tremors continues.

Techniques recommended to decrease the magnitude of intention tremor or diminish its effects include: use of proximal and distal limb segment stabilization through positioning; emphasis on axial postural control improvement; use of resistance; weight bearing and joint approximation; and use of bracing (Dahlin-Webb, 1986; Finlayson & Garner, 1994; Kovich & Bermann, 1988; Trombly, 2002; Umphred, 1995; Wood & Eames, 1989). All sources cited above also specifically mentioned the use of weights to decrease the magnitude of the tremor. Dahlin-Webb noted that a weight cuff is preferable to weighted utensils because the amount of weight can be more easily modified and controlled. Kovich and Bermann warned that, although weighting may be successful initially in reducing tremor, it may lead to gradual accommodation to the extra weight. Umphred warned that the use of weights may exaggerate the problem once weights are removed.

A few studies have examined the effects of increasing resistance to movement or of bracing tremulous extremities. Erickson, Lie, and Wineinger (1989) studied 25 adults with multiple sclerosis and intention tremor and found that proximal extremity bracing increased the use of the upper extremity, but was poorly tolerated as a treatment method. Participants reported skin breakdown and muscle pain. Cooke (1958) studied the effects of resistance provided by elastic bands on tremor in persons with multiple sclerosis. Although there was a small, nonsignificant improvement in upper-extremity control, the intervention appeared to cause the tremor to spread to extraneous muscles resulting in more impaired functional performance.

Orthoses designed to isolate tremor or provide resistance to it include the “Neater Eater” (Michaelis, 1988), the “Tremor Isolator” (Broadhurst & Stammers, 1990), the “Controlled Energy Dissipation Orthosis” (Aisen, Arnold, Baiges, Maxwell, & Rosen, 1993; Arnold & Rosen, 1993; Rosen, Arnold, Baiges, Aisen, & Eglovstein, 1995) and the “Viscous Beam Tremor Suppression Orthosis” (Kotovsky & Rosen, 1998). None of these has been extensively researched but each is reported to have mild positive effects on eating independence. Individual acceptance of obtrusive, uncomfortable, or technologically complex orthoses has been poor (Kotovsky & Rosen, 1998).

Medical equipment catalogs advertise weighted cuffs and utensils and universal holders purported to minimize tremor or its effects (adaptAbility, 2001, p. 59; Tumble Forms, 2001, p. 56, 61; S&S Worldwide, 2001, p. 116). Reports in the rehabilitation literature on the use of weighted cuffs or utensils to decrease intention tremor have been theoretical or descriptive in nature (Dahlin-Webb, 1986; Finlayson & Garner, 1994; Trombly, 2002; Umphred, 1995; Wood & Eames, 1989; Yuen & D’Amico, 1998). The need for an efficacy study to provide evidence for this common treatment modality is clear. The purpose of this study, then, was to determine whether weighting the distal upper extremity during feeding activities did indeed decrease tremors and increase functional feeding ability in adults with an acquired intention tremor from a nonprogressive brain lesion.

Method

Research Design

An alternating treatment, single-case design was chosen to allow for individualization and alteration of treatment over the course of a study while tracking individualized dependent variables (Portney & Watkins, 2000). No parameters are given in the literature for selecting the most appropriate weight, therefore, single-case design was chosen to allow the data gatherer to respond to her own and to each study participant’s impressions of the efficacy of the weight in reducing tremor. An alternating treatment design allowed for comparison of baseline (control) and treatment performances within sessions and overall.

Each session consisted of a meal. Participants ate one half of each meal while wearing a weighted cuff (treatment condition) and the other half of the meal while wearing a nonweighted cuff (baseline or control condition). The order of conditions for participants 1 through 3 was determined at random at the beginning of each session, and for participants 4 and 5 randomly determined for the first session and alternated in subsequent sessions. Thus, each partici-
pant served as his or her own control for each session, eliminating the need to rigorously control menus across sessions or participants. Sessions were videotaped. Six dependent variables were rated or counted during viewing of the tapes of each control or treatment half-session, when relevant. Feeding efficiency was measured by number of seconds needed to acquire a bite of food with the utensil and deliver it to the mouth (hereafter “time to acquire”) and the number of grams of food consumed. Feeding accuracy was measured by the number of times food was dropped or spilled and by the number of times a compensatory technique was spontaneously employed by the participant to ensure that the tremor did not prevent food from reaching the mouth. Bracing the elbow on the table during fork loading or bite delivery is an example of a compensatory technique used. Participants’ perceptions of the effectiveness of the weighted cuff were recorded on a rating scale as the fifth dependent variable. Finally, coinvestigators, blind to the presence of weight in the cuff, rated the severity of the tremor.

The flexibility of single-case design allowed the opportunity for study methods to evolve over time. Three adults participated in eight meal sessions. Two more participated in one or two prestudy sessions, aimed at determining optimal weights for the cuff, followed by 16 meal sessions. This longer data collection period proved useful, particularly for exploring order effect.

**Participants**

The study methods and informed consent protocol were approved by appropriate university and facility review boards. The study was conducted in two cities in the western United States. Participants were recruited from a roster nominated by therapists and administrators of area rehabilitation clinics and through contact with support groups. Potential participants were medically stable adults who demonstrated the oral motor capacity to eat solid and liquid foods, the upper-extremity function to be potentially self-feeding, and intention tremors in the upper extremity that interfered with self-feeding effectiveness. Five such individuals agreed to participate. Participants used their dominant hands in self-feeding except Participant 1 who used his more tremulous nondominant extremity. During videotaping, participants used any assistive devices for self-feeding to which they were accustomed except weighted utensils or cuffs.

**Instrumentation**

Measurement procedures were adapted from Sharpe and Ottenbacher (1990), who measured the accuracy of feeding in a child with Rett syndrome.

**Time to acquire.** Time was measured with a stopwatch during the review of the videotaped sessions. The stopwatch was started when the participant began to load the utensil and ended when the utensil entered the mouth. Due to the variability in control from one bite to the next, three load and delivery cycles were timed, then averaged to determine a value.

**Amount consumed.** Plates of food and cups of liquid were weighed before and after meals. The difference in weight between before and after, minus the weight of spilled food, was the amount of food consumed. A customized bib and tablecloth were fabricated with raised edges to catch all solid and liquid spills. It was weighed before and after each half of the meal and the difference was considered the weight of spills.

**Spills and compensations.** The number of times that the participant spilled or dropped food was recorded, as was the number of times that a compensatory technique such as limb stabilization was utilized.

**Self-rating.** After each whole session, each participant rated the effectiveness of the weighted cuff using a 0 to 10 scale, with 10 representing complete reduction of the tremor, 5 representing no change, and 0 representing severe aggravation of the tremor. Gapsis (1990) discussed individual opinion as critical in determining the effect of weight on tremor in persons with cerebellar dysfunction.

**Investigator tremor ratings.** After all sessions were recorded, two coinvestigators (first and third authors) reviewed the videotapes. Sessions were shown to investigators in a random order so that they were blind to the weighted versus nonweighted limb condition. In the nonweighted condition, participants wore a cuff with foam inserts that appeared identical to the weighted cuff. The raters watched two paired half-meals (complete session) consecutively, then independently decided on ratings for both. During the first videotaped minute of eating and the first beverage consumption of each half-meal, the tremor was scored by the investigators on a six-point scale, with 0 representing “no discernible tremor,” 1 being mild, 3 moderate, and 5 a grossly apparent tremor that interfered with food acquisition and delivery.

**Interrater reliability.** Interrater reliability was established first by having coinvestigators record severity of the tremor from the tape of a single video session from each participant. Investigators discussed rating criteria and reassessed as necessary until they reached agreement for the variable of tremor rating. Then they rated the rest of the sessions independently. Total interrater reliability for all rating data was calculated by comparing tremor ratings from each investigator for each session. The number of times that raters agreed was divided by the total number of ratings to yield a percentage.
Procedures

Sessions were held in the rehabilitation clinic of the university or at the participant’s home. A checklist of pretest preparations was filled out prior to each session to monitor procedural reliability. A video camera was set up obliquely to the participant to record each session. Plates, glasses, and the bib and tablecloth were weighed before and after each half-meal.

Participants used the All Pro adjustable therapeutic wrist weights of 0 to 4 lb. weights in 1/5 lb. increments (Sammons Preston, 2001, p. 174), and were given the opportunity to select preferred cuff weight during simulated eating activities prior to initial data collection. An observed lack of control over eccentric contraction indicated a need to decrease the amount of weight used, whereas continued presence of the tremor indicated a need to increase the amount of weight used. As noted above, in the nonweighted control condition, participants wore the All Pro cuff with weights removed so that raters were blind as to which condition was being rated.

Meals were divided into two equal portions and put on separate plates, one for baseline (or control) and one for treatment. No more than two sessions were completed per day, with a range of 10 to 30 days between the first and last sessions.

Data Analysis

Data were plotted for visual analysis. Because the study participants served as their own controls, the means for baseline (or control) and treatment half-sessions were compared using a two-tailed, dependent t test to determine whether the differences noted between baseline (control) and treatment conditions achieved statistical significance (Portney & Watkins, 2000). Because multiple comparisons were to be performed, an appropriate procedure for controlling Type I error needed to be selected. Usually in single-case designs statistical tests of difference (e.g., between baseline and treatment condition performances) are conducted “per comparison” at an alpha level of .05 (e.g., binomial test) (Portney & Watkins). On the other hand, whenever multiple t tests are performed in traditional experimental designs, it is customary to adjust the comparison procedure to avoid an inflation of the overall (“experiment-wise”) error rate (Portney & Watkins). Commonly the procedure chosen with t tests is a Bonferroni adjustment, where the desired alpha level (.05) is divided by the number of comparisons conducted (say, four) to yield the per comparison alpha level (.05/4 = .0125). For the current study, in order to make conservative comparisons, but also balance Type I and Type II error rates, we devised a compromise: “per participant” Bonferroni adjustment. A distinct alpha level was set for each participant, based on the number of meaningful comparisons conducted for that participant (to establish a “familywise” error rate [Portney & Watkins]). Thus the per comparison alpha levels for participants 1 through 5 were .0125, .0167, .01, .0125, and .0125, respectively.

Two dependent t tests were also performed to detect any order effect in tremor rating, comparing performance when the wrist weights were worn in the first half-session with when they were worn in the second half-session. These tests were applied to participants 4 and 5, whose data were gathered over a longer period (16 vs. 8 weeks).

Results

The mean intrarater agreement on the variable tremor rating for all half-meals in all sessions of all participants was 76% (85/112 ratings). Mean intrarater agreement for direction of change in rating between baseline and treatment across all sessions and in all participants was 69% (38/56 ratings). When raters disagreed, an average value was recorded for use in the table and figures that follow.

Visual analysis of Figures 1 and 2 reveals rather consistent separations between the plots of variables during the weighted treatment condition and plots of the same variables, in the nonweighted baseline (control) condition. In nearly all sessions for all variables performance was better with the weighted cuff than in the nonweighted condition.

Table 1 lists mean values for all variables. Results indicate that the use of a weighted wrist cuff was effective in significantly decreasing either the tremor or some effect of the tremor for three of the five participants. Order effects for participants 4 and 5 were not statistically significant. Because the use of t tests in a single case study violates one of the assumptions of statistical analysis, namely independence of individual data points from one another, these t test results should be interpreted cautiously (Franklin, Allison, & Gorman, 1996).

Individual Participant Results

Participant 1 was a 58-year-old White male, 43 years post-traumatic brain injury (TBI). He demonstrated limited pronation and supination, exaggerated hand and mouth opening to compensate for decreased upper-extremity control, and involuntary finger movements when grasping. The amount of food consumed and number of spills per half-session remained fairly consistent over sessions and between treatment and baseline half-sessions. Less time to acquire and deliver a bite (Figure 1, 1a) was apparent with use of the weighted cuff. The difference, however, just fails to achieve statistical significance when subjected to conservative statis-
Figure 1. Dependent variable data for participants 1, 2 & 3 with sessions plotted on the horizontal axis. 1a, 2a, & 3a: Time required to acquire a bite (sec). 1b & 3b: Number of times (#) food was spilled in each half-meal. 2b: Amount of food consumed (g) in each half-meal. 1c & 2c: Participant self-rating of the effectiveness of the weight. 3c: Number of times (#) the participant used compensatory techniques in each half-meal. 1d, 2d, & 3d: Investigator rating of tremor.

**In these sessions, the treatment cuff was worn during the first half-meal.
Figure 2. Dependent variable data for participants 4 and 5 with sessions plotted on the horizontal axis. 4a, 5a: Time to acquire a bite (sec). 4b, 5b: Number of times (#) food was spilled in each half-meal. 4c, 5c: Participant self-rating of the effectiveness of the weight. 4d, 5d: Investigator rating of tremor.

**In these sessions, the treatment cuff was worn during the first half-meal.
Appetite, hunger, and nutritional management. For example, if a patient is not eating because of decreased appetite, potential causes should be identified and interventions implemented to support increased intake. This may involve dietary modifications, nutritional supplements, or the use of appetite stimulants. If emotional factors are contributing to decreased appetite, counseling or referral to a mental health professional may be necessary.

In this case study, the occupational therapist evaluated the patient's ability to eat independently and identified specific challenges related to upper-extremity control. Compensatory techniques included stabilizing his right elbow on the table during both food acquisition and delivery, and bringing his head and trunk forward to meet his hand or straw. Participant 3 ate somewhat impulsively, often overloading his utensils or taking very large bites. Visual analysis of the dependent variable of food consumed by participant 3 indicated no difference between treatment and baseline half-sessions. The data on the number of spills (Figure 1, 3b) indicated that participant 3 often spilled more during baseline (or control) half-sessions than during treatment half-sessions. The number of compensatory techniques (Figure 1, 3c) utilized was similarly greater during baseline half-sessions. Tremor ratings indicated a decreased tremor (Figure 1, 1d) during the treatment condition (Table 1). This significant difference is clearly seen in the separation of plot lines for variables under the two conditions (Figure 1, 3d). Self-reported perception of effectiveness of the weight may not be a valid measure for this participant as he was initially unable to state whether the weight was helpful. In later sessions he associated the rating number he chose with the jersey number of his favorite NFL quarterback.

Participant 4 was a 51-year-old White female. Eight years prior to the study, she sustained multiple cerebrovascular accidents in the space of a week. Participant 4 used a covered mug to drink and a spoon as her preferred utensil for safety reasons. She ate in her wheelchair with her food positioned in her lap so as to stabilize her arm against her trunk. Her tremors worsened dramatically during direct observation, so meals were filmed in her home while the second author waited in the adjacent room. This participant’s selffeeding was characterized by a lack of pronation and supination, exaggerated hand opening to compensate for lack of

Table 1. Comparison of Means for Baseline (Control) and Treatment Half-Sessions

<table>
<thead>
<tr>
<th>Dependent variable</th>
<th>Participant 1</th>
<th>Participant 2</th>
<th>Participant 3</th>
<th>Participant 4</th>
<th>Participant 5</th>
</tr>
</thead>
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<tr>
<td>Time to acquire (sec)</td>
<td>4.5</td>
<td>3.0</td>
<td>4.1</td>
<td>3.2</td>
<td>5.1</td>
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<tr>
<td>Food consumed (g)</td>
<td>187.0</td>
<td>189.0</td>
<td>38.5</td>
<td>55.0</td>
<td>147.3</td>
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<td>Spills (#)</td>
<td>6.6</td>
<td>2.5</td>
<td>ns</td>
<td>ns</td>
<td>5.6</td>
</tr>
<tr>
<td>Compensations (#)</td>
<td>b</td>
<td>b</td>
<td>b</td>
<td>b</td>
<td>12.5</td>
</tr>
<tr>
<td>Tremor rating (#)</td>
<td>1.9</td>
<td>2.2</td>
<td>ns</td>
<td>ns</td>
<td>4.3</td>
</tr>
<tr>
<td># of comparisons</td>
<td>4</td>
<td>3</td>
<td>5</td>
<td>4</td>
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<tr>
<td>Alpha level, Bonferroni adjusted</td>
<td>α = .0125</td>
<td>α = .0167</td>
<td>α = .01</td>
<td>α = .0125</td>
<td>α = .0125</td>
</tr>
</tbody>
</table>

* This participant made no spills.
* This participant used postural compensations with every bite.

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Participants 2 was a 42-year-old Black female 2 months post-brain tumor resection who had lost 15 pounds since surgery. She demonstrated limited pronation and supination, difficulty opening and closing her hand, and synergistic movements of her right upper extremity. Food acquisition and delivery were methodical and her head was brought forward to meet her hand with every bite. Time to acquire and deliver bites was decreased (Figure 1, 2a) in the treatment condition but not significantly so. Visual analysis of the data for participant 2 shows that the amount of food consumed (Figure 1, 2b) was greater during treatment than baseline and that there was a general ascending trend over time in the half-sessions when no weight was used as well. This trend may indicate carryover from intervention. Participant 2 demonstrated hypertonicity, dysmetria, and dysynergia, in addition to tremor. These motor symptoms appeared to dampen or mask her tremor, which was always minimal. Thus, a ceiling effect was noted in ratings of her tremor (Figure 1, 2d). Yet self-rating indicates that the participant perceived the cuff to be a benefit in tremor reduction (Figure 1, 2c).

Participant 3, a 30-year-old White male, sustained a TBI 12 years prior to the study. He used a weighted plate, plate guard, and a salad fork with shorter and duller tines. His mealtime behavior was characterized by frequent spills and frequent use of techniques to compensate for his lack of upper-extremity control. Compensatory techniques included stabilizing his right elbow on the table during both food acquisition and delivery, and bringing his head and trunk forward to meet his hand or straw. Participant 3 ate somewhat impulsively, often overloading his utensils or taking very large bites. Visual analysis of the dependent variable of food consumed by participant 3 indicated no difference between treatment and baseline half-sessions. He required significantly fewer seconds ($t = 4.44, p = .003$) to acquire and deliver bites while wearing the weighted cuff (Figure 1, 3a). The data on the number of spills (Figure 1, 3b) indicated that participant 3 often spilled more during baseline (or control) half-sessions than during treatment half-sessions. The number of compensatory techniques (Figure 1, 3c) utilized was similarly greater during baseline half-sessions. Tremor ratings indicated a decreased tremor ($t = 9.00, p < .001$) during the treatment condition (Table 1). This significant difference is clearly seen in the separation of plot lines for variables under the two conditions (Figure 1, 3d). Self-reported perception of effectiveness of the weight may not be a valid measure for this participant as he was initially unable to state whether the weight was helpful. In later sessions he associated the rating number he chose with the jersey number of his favorite NFL quarterback.

Participant 4 was a 51-year-old White female. Eight years prior to the study, she sustained multiple cerebrovascular accidents in the space of a week. Participant 4 used a covered mug to drink and a spoon as her preferred utensil for safety reasons. She ate in her wheelchair with her food positioned in her lap so as to stabilize her arm against her trunk. Her tremors worsened dramatically during direct observation, so meals were filmed in her home while the second author waited in the adjacent room. This participant’s self-feeding was characterized by a lack of pronation and supination, exaggerated hand opening to compensate for lack of
upper-extremity control, frequently overshooting the target, and exaggerated mouth opening to compensate for end-range tremors. Statistical analysis of the dependent variable “time to acquire” (Table 1 and Figure 2, 4a) indicated that the participant was able to load her spoon and deliver food to her mouth in significantly less time while wearing the weighted cuff ($t = 5.087, p = .000$). Visual and statistical analysis of the dependent variable of amount of food consumed indicated no difference between baseline and treatment half-sessions and plots for this variable are not depicted in Figure 2. The number of spills per half-session (Table 1 and Figure 2, 4b) was significantly lower during treatment half-sessions compared with baseline ($t = 5.174, p = < .001$). Participant 4 utilized compensatory strategies with every bite, thus this dependent variable was not meaningful. Both self-ratings (Figure 2, 4c) and visual analysis of investigators’ tremor rating (Figure 2, 4d) indicated that the weighted wrist cuff was somewhat helpful in decreasing tremor, but this finding was not confirmed statistically.

Participant 5, an 81-year-old White female, developed tremors secondary to encephalitis 10 years prior to this study. Her tremor was highly variable, sometimes being moderate to severe, other times not visibly apparent. She consistently paused to rest her wrist on the table after loading her eating utensil and before bringing it to her mouth. She showed decreased pronation and supination and demonstrated elbow flexion–extension and wrist flexion–extension tremors. She frequently used her non-dominant hand either as an assist to scoop food onto her utensil or to bring food to her mouth while her dominant hand held a knife. Statistical and visual analyses revealed a decreased amount of time to acquire and deliver bites (Table 1 and Figure 2, 5a) ($t = 4.5, p = .003$), a decreased number of spills (Table 1 and Figure 2, 5b) ($t = 2.86, p = .012$) and decreased tremor rating (Table 1 and Figure 2, 5d) ($t = 3.16, p = .006$) while she wore the weighted wrist cuff. The amount of food consumed did not change between baseline and treatment. Self-ratings (Figure 2, 5c) showed that Participant 5 felt that the weighted cuff either made little difference or negatively affected her ability to self-feed.

**Discussion**

The primary purpose of this study was to provide a test of the therapeutic principle of weighting the distal upper extremity to decrease tremor or its effects on skilled movement. The data partially support that principle because while wearing a wrist weight three of five participants improved feeding performance on one or more of the variables studied.

The increased proprioceptive input rationale does not appear to tell the whole story, however. The competing explanation of increased inertia and fatigue deserves more exploration because inertia could account for some of the other observations of motor behavior made in this study. Participants 3 and 4 demonstrated tremors in two planes—horizontal and vertical—when using the nonweighted cuff. When wearing the weighted wrist cuff, they demonstrated tremors primarily in one plane (horizontal), indicating an improvement in control. The fact that tremors in the vertical plane decreased more dramatically than those in the horizontal plane points to the biomechanical effect of increased inertia in the field of gravity as the rationale for tremor reduction with distal weighting. Similarly, participant 5 originally demonstrated elbow flexion and extension and wrist flexion and extension tremors, but with the use of the weighted wrist cuff, her tremors were isolated to the wrist.
Thus movements occurring distal to the weight did not benefit from the increase in inertia.

Too much weight may be worse than, or no better than, no weight at all in altering tremor. Participants 1 and 3 required a reduction in the weight that had been originally selected prior to the first session. This was done for each after session 3. Their response to a nonoptimal weight, as measured by investigators in tremor rating and their own self-rating, appeared to be a more pronounced tremor than when the optimal weight was in use. Selecting the correct amount of weight for the person's needs appears to be crucial when using this treatment approach.

The primary purpose of this study was to examine the effects of weighting the distal upper extremity on tremors and feeding effectiveness. In addition, useful observations were made that can help therapists make a selection of weight appropriate to their clients. Moreover, three of the five study participants provide support for Gapsis' contention (1990) that the person's subjective assessment of the effectiveness of the weight is key in predicting the usefulness of the weight in reducing tremor. Participant 5 did not experience the cuff as helpful, even during sessions subsequently rated by investigators as evidencing diminutions in her tremor. Participant 3 was unable to offer subjective ratings with a rational basis. In these cases, a visual analysis of the severity of the tremor at several different weight levels may be the most effective means of determining ideal weight.

**Limitations of the Study**

Participants 1, 3, and 4, whose tremors were most visible, had experienced brain injuries years before this study. These participants had already developed compensatory strategies to assist them in performing the task of eating. Although positive change from the weight was noted, it is possible that such improvement was limited due to the length of time elapsed between injury and research intervention.

Interrater agreement was affected by bite-to-bite variability in tremor and lack of clear guidelines for rating the tremor. In fact, raters noted that a particularly tremulous utensil-to-plate-to-mouth cycle was often followed by a particularly smooth one. It became apparent that the participants' adaptation to their tremors was a very dynamic process, ongoing and varying from moment to moment. Because of the differences of magnitude and visibility of the tremor across participants, each new participant necessitated a different application of the crude scale devised for rating tremors. This challenge was partly resolved through the use of prestudy sessions to determine optimal wrist weight and to give the raters the extra sessions on which to practice rating each participant.

**Suggestions for Future Research**

Participant 1 expressed the opinion that he performed more poorly during the second half of those sessions in which he wore the weighted cuff for the first half. Umphred (1995) speculated that tremor might rebound to more exaggerated levels in the period of time after weights or resistance are removed. This single participant's observation provides both a cause for concern and some direction for future research. It is certainly possible that an immediate increase in tremor (rebound effect) follows removal of weight from an extremity. Furthermore, the 30-day maximum time frame for participants in this study did not allow a test of the hypothesis that weighting may increase tremors over time, as rhythmically contracting muscle groups are strengthened. Both the issues of short term tremor exaggeration via rebound and of longer term tremor increase over time deserve investigation.

If efforts are made to replicate or extend this study, it is suggested that raters score more than just the apparent tremor. Several participants compensated for instability by flexing the neck or the trunk to meet each bite, by stabilizing the forearm on the table or by adopting other idiosyncratic strategies. In theory, these kinds of truncal and limb adaptations may be seen when the tremor is worse and the person feels less stable. Additional camera angles would be necessary to quantify axial and proximal limb movements. In participants 1 and 4, another potentially measurable variable was the width of mouth opening. Some participants clearly adapted to the excursion of the tremor by exaggerating mouth opening as the utensil approached. Mouth opening circumference could potentially be measured on videotape.

Finally, this study examined tremor reduction via weighting of the upper limb in persons with static brain lesions. It could be repeated on individuals with progressive conditions that cause tremors, such as multiple sclerosis.

**Clinical Significance and Conclusion**

There is increasing recognition that treatment protocols in occupational therapy, as in medicine, must be based on solid research evidence (Holm, 2000). The current study tested the long-held treatment principle that adding weight to the distal upper limb would diminish intention tremor or its effect on skilled purposeful movement. Results indicate that this treatment principle is at least partially valid, and it merits additional research to establish the parameters of its utility. Specifically, the results of this study showed that weighting the upper extremity to reduce tremor in the treatment of adults with static acquired brain lesions can, for some, be an effective treatment in the immediate, and,
perhaps, the short term. It is important, however, that clinicians first determine through skilled observation what amount of weight would be most beneficial to the person. The effect of distal weighting, and even the mechanism by which it works, appear to differ from person to person. Thus, clinicians are advised to consider a range of variables including speed, accuracy, quality of movement, and self-report in determining the effectiveness of a particular weight in the treatment of intention tremor and skilled upper-extremity movement. ▲

References