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Examining the Delivery Mode of Mental Practice in Reducing Hemiparesis: A Randomized Controlled Trial

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Examining the Delivery Mode of Mental Practice in Reducing Hemiparesis: A Randomized Controlled Trial

Abstract

Background: Mental Practice (MP) is an effective intervention to address upper extremity (UE) hemiparesis post-stroke. However, parameters for the delivery mode of MP have not been defined. Therefore, this study's purpose was to define delivery mode parameters by comparing the effectiveness of audio-guided and video-guided MP.

*Method:*Eighteen participants, < 1-month post-stroke, with UE hemiparesis were randomized to a MP, repetitive task practice (RTP) or control group. The MP groups performed audio-guided or video-guided MP, 5x/week. The RTP group physically performed the functional tasks. The control group received traditional stroke rehabilitation. The Fugl-Meyer Assessment (FMA-UE) and Wolf Motor Function Test (WMFT) were used to assess change in UE hemiparesis.

*Results:*Wilcoxon signed-rank test demonstrated audio MP increased FMA-UE scores from pretest (Mdn = 34.0, Mean = 34.0, *SD* =9.56) to posttest (Mdn = 49.0, Mean = 49.6, *SD* =7.5), p = .042, r = .64. Similar improvement in FMA-UE scores was found with traditional therapy. Audio MP decreased WMFT time, pretest (Mdn = 10.5, Mean = 49.9, *SD* = 59.1) to posttest (Mdn = 4.1, Mean = 3.5, *SD* = 1.4), p =.043, r =.63.

Conclusion: Audio MP and traditional therapy appear to decrease impairment and increase the functional abilities of the UE following stroke. Video MP and RTP does not have this effect.

Comments

The authors declare that they have no competing financial, professional, or personal interest that might have influenced the performance or presentation of the work described in this manuscript.

Keywords

mental practice, stroke, upper extremity, hemiparesis, rehabilitation interventions

Cover Page Footnote

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Credentials Display

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In the United States, more than 795,000 people have a stroke every year (Virani et al., 2020). Moreover, 80% of the stroke population will experience upper extremity (UE) hemiparesis in the acute phase of recovery (< 6 months post-stroke) (Hatem et al., 2016). Because of residual sensorimotor deficits in the UE, hemiparesis often leads to extreme difficulty or inability to perform activities of daily living, such as getting dressed or eating, and a profound decline in the health and well-being of the stroke survivor (Mayo et al., 2002; Viraniet al., 2020). Although there are several efficacious occupational therapy interventions for the hemiparetic UE, most of these interventions are directed toward the individual with minimal UE impairment and in the chronic stage of stroke recovery. Limited options are available for the hemiparetic UE with significant impairment and in the acute phase of stroke recovery (Hebert et al., 2017; Nakayama et al., 1994). Mental practice (MP) is considered a safe and feasible intervention that addresses these limitations through cognitive rehearsal of a motor task without physical movement (Page & Peters, 2014).

Imaging studies demonstrate a significant overlap in cortical activity when thinking about performing a movement and actual motor execution (Malouin et al., 2013; Stephan et al., 1995). This activation pattern is advantageous for the stroke survivor with minimal UE movement, as it provides the opportunity to perform task-specific repetitions through independent cognitive rehearsal. MP is widely considered an efficacious intervention that, when integrated with physical practice, reduces UE impairment and improves motor function (American Occupational Therapy Association [AOTA], 2015; Page & Peters, 2014; Peters & Page, 2015).

Despite the efficacy, MP has not been incorporated into clinical practice consistently (Peters & Page, 2015). It may be difficult for an occupational therapist to implement an MP protocol because of high variability in how MP is provided, leaving questions concerning clinical application (Malouin et al., 2013). Previous studies have aided in providing some specifics on implementing MP interventions. It is widely agreed that MP is most efficacious when combined with repetitive task-specific practice (RTP) (Peters & Page, 2015). Page and colleagues (2011) identified that 60 min of audio-guided MP is the most effective duration of MP to reduce UE impairment when compared to 20 and 40 min. Moreover, researchers found that performing MP from a first- or third-person perspective may not be an important parameter in MP interventions (Nilsen et al., 2012).

Although these studies are informative in developing a protocol, more information is needed to implement the intervention in clinical practice. An extensive scoping review by Harris and Hebert (2015) found that at least six modes of MP are used throughout the literature, including audio or video recording, visual prompts, written instructions, and self-initiated or recorded pictures. To date, no studies have compared the effectiveness of each mode of delivery. This study further defines the parameters of MP delivery by examining the effectiveness of two delivery modes: audio-guided MP and video-guided MP.

The purpose of this experimental study is to examine the differences between audio-guided MP, video-guided MP, RTP, and traditional therapy in reducing impairment and increasing the functional abilities of the hemiparetic UE following a stroke. We hypothesized that:

1. Participants receiving video-guided MP will demonstrate greater reductions in UE impairment and increased UE functional abilities compared to patients receiving audio-guided MP.
2. Participants receiving audio- or video-guided MP will demonstrate greater reduction in UE impairment and increased UE functional abilities compared to patients receiving traditional therapies or RTP alone.

Method

Design

A pretest/posttest randomized controlled design was implemented to examine the outcome measures between the four groups. All of the patients that met the initial screening criteria were approached by a research therapist for written informed consent approved by the institutional review board (Protocol Number 2018-02). Three assessments were administered to determine eligibility for the study.

Participants

Eighteen participants were recruited through convenience sampling from an inpatient rehabilitation hospital in Rockville, MD. Participants with a primary diagnosis of stroke were screened for participation with the following inclusion criteria: (a) aged 18–80 years, (b) less than one-month post-stroke, (c) hemiparesis of one UE, and (d) moderate UE impairment as defined by a score of 20–50 on the Fugl-Meyer Assessment Upper Extremity (FMA-UE). The exclusion criteria were: (a) history of prior stroke, (b) comorbidities (severe neurological, orthopedic, rheumatoid, or cardiac impairments), (c) severe spasticity, (d) severe cognitive impairments based on a score less than 22 on the Mini-Mental State Examination (MMSE), (e) inability to perform mental imagery, score < 25 on Movement Imagery Questionnaire-Revised Second version (MIQ-RS), (f) severe aphasia based on speech therapist evaluation, (g) low English proficiency, and (h) severe pain noted by self-report of greater than a 5 on the visual analog scale.

Eligibility Assessments

The MMSE is a brief screening tool that provides a quantitative assessment of cognitive impairment (Folstein et al., 1975). The MMSE consists of 11 questions or tasks grouped into seven cognitive domains: (a) orientation to time, (b) orientation to place, (c) registration of three words, (d) attention and calculation, (e) recall of three words, (f) language, and (g) visual construction (Folstein et al., 2002). The maximum score is 30, where a score of less than 22 indicates cognitive impairment and was an exclusion for participation in the study.

The MIQ-RS was used to measure the participant's ability to perform mental imagery. The revised version tests the ability of people with restricted mobility through a 14-item questionnaire that rates the participant's ability to imagine on a 7-point Likert scale, including seven visual and seven kinesthetic items (Butler et al., 2012; Page & Peters, 2014). The MIQ-RS has good reliability (ICC range: .83–99) and internal consistency (Cronbach alpha: .95–98). The participants who scored < 25 on the MIQ-RS were excluded from the study as a result of impaired ability to perform mental imagery.

The FMA-UE was used as an assessment to determine eligibility and as an outcome measure. The participants were considered eligible to participate in the study if they scored 20–50 on the UE portion, demonstrating moderate UE impairment.

Using computer software randomization, the participants that met the inclusion criteria were randomly assigned to one of four groups: (a) audio MP, (b) video MP, (c) RTP, or (d) traditional therapy group. The principal investigator assigned the participants to the allocated interventional groups. All of the participants were administered the outcome measures (pretest) within 3 days of admission and (posttest) within 3 days before discharge. Scores from the primary outcome measures were examined to determine the effects of the intervention.

Primary Outcome Measures

Two primary outcome measures were administered at baseline (within three days of admission) and at discharge (no more than three days prior to discharge) to examine changes in the hemiparetic UE.

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To assess the functional abilities of the UE, the Wolf Motor Function Test (WMFT) was administered. The WMFT is a quantitative measure of UE motor ability through timed and functional tasks. Fifteen tasks are performed, including six timed joint-segment movements and eight timed integrative functional movements. Tasks are rated on a 6-point ordinal scale where 0 = *does not attempt* and 5 = *movement appears to be normal*. Time score and Functional Ability score (FAS) are calculated to indicate the functional abilities of the UE. High reliability and validity properties of the WMFT have been well documented (Edwards et al., 2012; Wolf et al., 2001; Wolf et al., 2006)

The FMA-UE was administered to measure the impairment of the UE (Fugl-Meyer et al., 1975). The FMA-UE is highly used as a quantitative measure of the UE in stroke research. UE movements are rated on a 3-point ordinal scale where 0 = *unable to perform*, 1 = *performs partially*, and 2 = *performs fully*. Cumulative scores range from 0–66, where a lower score indicates more impairment. The FMA-UE has high test-retest reliability r = .99, interrater reliability rs = .96-97, and construct validity (Duncan et al., 1983; Nilsen et al., 2012).

Intervention

MP Protocol

The audio MP and video MP participants were assigned to perform MP followed by physical practice of one of four motor tasks: (a) wiping a table, (b) picking up a cup, (c) brushing hair, and (d) turning the page of a book. The assigned motor task was performed through MP and physical practice 3x/week, and MP only 2 days/week. This design was implemented with consideration to the clinical application in acute inpatient rehabilitation hospitals, whereas the patients may perform MP with their therapist during the week and independently on the weekend without additional strain on staffing needs. MP was provided at an MP station in the therapy gym, equipped with a tablet and noise-cancellation headphones. Each therapy session included at least 20 MP repetitions and 10 physical practice repetitions of the task. The motor task assigned to the participants was determined based on the participant's score on the FMA-UE. These tasks progress from gross motor/proximal movements to fine motor/distal movements. Table 1 displays the assigned task based on the FMA-UE score. The FMA-UE was re-administered weekly to allow the patient to progress to more challenging tasks as needed. The participants were trained on the instructions to perform MP. Emphasis was placed on seeing and feeling the motor task being performed with their affected UE without physically moving.

Table 1
Task Assignment According to Fugl-Meyer Assessment Upper Extremity Score

Fugl-Meyer Assessment Upper Extremity Score	Assigned Task
20-27	wiping a table
28-35	picking up a cup
36-42	brushing hair
43-50	turning a page

Note. The Fugl-Meyer Assessment Upper Extremity was re-administered weekly to allow the patient to progress to more challenging tasks as needed.

Experimental Groups

Audio MP

The audio MP group listened to an audio recording that used multisensory cues to facilitate the mental rehearsal of each task. For example, the task of picking up a cup described the visual image of the ice in the cup, the wet/cold feeling of the cup, and satiation after swallowing. One repetition was considered whole-task completion: reaching, grasping, drinking from, and releasing the cup. As shown in

Table 2, the protocol for both MP experimental groups was performed 5 days/week to include MP and physical practice of the assigned task.

Table 2
Mental Practice Protocol

Parameters	Dosage
MP and physical practice of the following tasks: wiping a table picking up a cup brushing hair turning a page	20 MP repetitions and 10 physical practice repetitions (3 days/week) 20 MP repetitions (2 days/week)

Note. MP = mental practice.

Video MP

The Video MP group watched a video recording that used multisensory cues to facilitate the mental rehearsal of each task. The video demonstrated the task from a first-person perspective, as if looking at your UE from your own eyes view. In addition to watching the task being performed, audio multisensory cues were given.

Immediately following MP 3 times a week, therapists facilitated physical practice to include at least 10 repetitions of the assigned motor task. Therapists were trained to grade the task to challenge the participant but were limited to the use of essential equipment to complete the task, for example, a table, a cup, a brush, or a book.

RTP Group

To control for the effects of physical practice following MP on the impairment and functional abilities of the UE, an RTP-only group was included. This was also completed in previous MP studies (Page et al., 2011). The RTP group received the same treatment as the MP groups except for the exclusion of completing MP.

Traditional Therapy Group

The control group received traditional occupational therapy stroke rehabilitation, including range of motion, weight-bearing, massage, modalities, and task-oriented training.

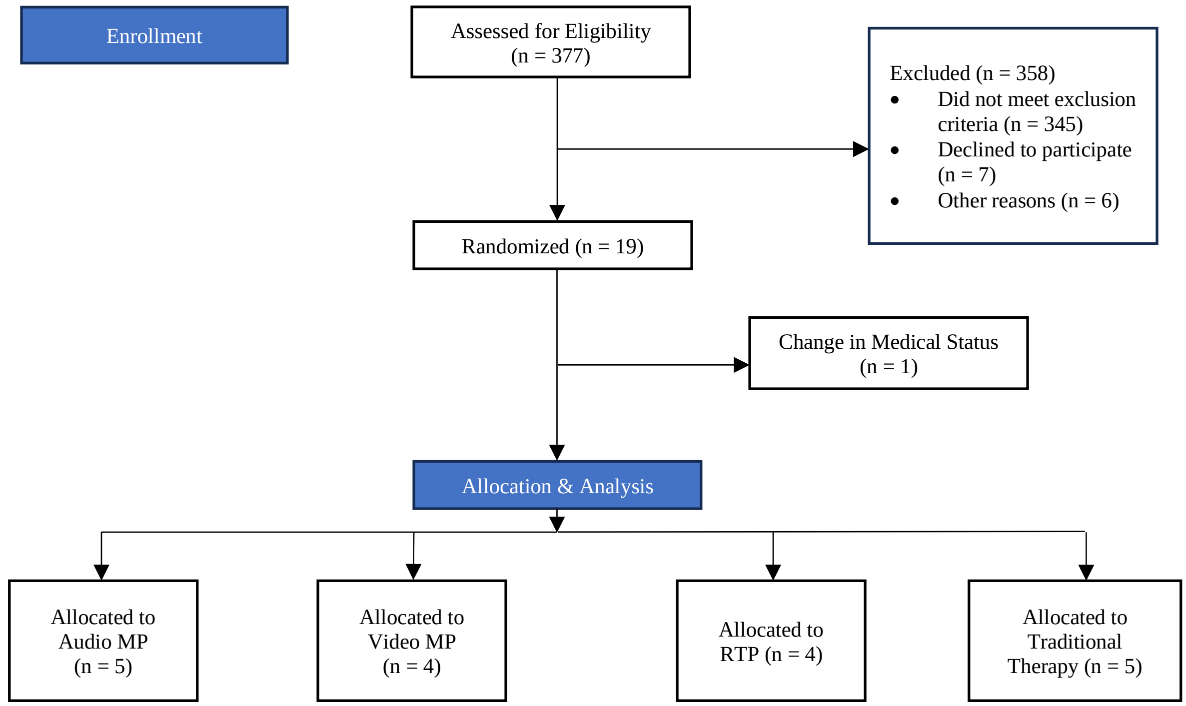
Data Analysis

Each group's median change from pretest to posttest score was calculated and compared for the primary outcome measures. Wilcoxon signed-rank test was used to examine the outcomes from pretests to posttests in each group. The Wilcoxon signed rank test was deemed appropriate for statistical analysis of a small sample size, non-parametric data, with repeated measure design. The level of statistical significance was set at $p < .05$. IBM SPSS Statistics for Mac, version 25, was used to analyze all data.

Results

Eighteen participants were included and completed all aspects of the study. Using the outlined inclusion/exclusion criteria, the researchers screened 377 participants. We excluded 358 for the following reasons: (a) age, n = 109; (b) no hemiparesis, n = 104; (c) history of stroke, n = 76; (d) aphasia, n = 21; (e) low English proficiency, n = 20; (f) comorbidities, n = 15; (g) denied consent, n =7; and (9) other, n =6. Ultimately, 19 patients were found eligible and provided written informed consent to participate in study activities. One participant was unable to complete the study because of a change in medical status. Five participants were randomized into the audio and traditional therapy group, and four participants in the video and RTP groups. Figure 1 outlines the screening, enrollment, and allocation process.

Figure 1
Enrollment and Allocation Flowchart



Note. n = sample size; MP = mental practice; RTP = repetitive task-specific practice.

The majority of the participants were female (N = 11, 61.1%), Caucasian (N = 9, 50.0%), with at least some college education (N = 15, 83.3%), an average age of 63 years (M = 62.83), and all of the participants incurred an ischemic stroke. A complete breakdown of the participant demographics is shown in Table 3. Table 4 provides median change scores for the FMA-UE and WMFT in each group.

Table 3
Frequencies and Percentages for Participant Demographics

Demographic Variable		n	%
Gender	Female	11	61.1
	Male	7	38.9
Ethnicity	African American	1	5.6
	Caucasian	9	50.0
	Hispanic	4	22.2
	Asian	4	22.2
Education	Less than a high school diploma	1	5.6
	High school diploma	1	5.6
	Some college or college graduate	15	83.3
	Unknown	1	5.6
Stroke Type	Ischemic	18	100.00
	Hemorrhagic	0	0.0
	RUE Affected	9	50.0
	LUE Affected	9	50.0
Age	Audio Group	71.4(7.1)	
	Video Group	58.5(8.8)	
	M(*SD*)	62.8(10.4)	
	RTP Group	59.0(11.5)	
	Traditional Group	60.8(11.2)	
	Range	43-80	

Note. RUE = right upper extremity; LUE = left upper extremity; n = sample size; M = mean; *SD* = standard deviation; RTP = repetitive task-specific practice.

Table 4
Change in UE Impairment and Functional Abilities

	Pretest		Posttest				
	Mdn	M(SD)	Mdn	M(SD)	Z	p	r
FMA-UE							
Audio (5)	34.0	34.0(9.6)	49.0	49.6(7.5)	2.03	.042	.64
Video (4)	31.0	31.5(11.8)	52.5	52.5(8.0)	1.83	.068	.64
RTP (4)	27.0	31.0(13.3)	53.0	54.0(7.1)	1.84	.066	.65
Traditional (5)	22.0	27.2(10.1)	41.0	38.2(11.0)	2.03	.043	.63
WMFT- Time (Seconds)							
Audio (5)	10.5	49.9(59.1)	4.1	3.5(1.4)	2.02	.043	.63
Video (4)	61.5	61.1(68.0)	3.1	4.2(3.3)	1.60	.109	.57
RTP (4)	64.5	63.0(65.9)	3.7	3.7(1.4)	1.82	.068	.64
Traditional (5)	120.0	75.6(60.8)	17.5	38.0(43.7)	2.02	.043	.63
WMFT- Functional Ability Score							
Audio (5)	2.0	2.4(1.5)	4.0	4.0(.7)	1.85	.063	.59
Video (4)	2.5	2.5(1.7)	4.0	4.0(.8)	1.60	.109	.56
RTP (4)	1.5	2.0(1.4)	4.0	4.0(.0)	1.63	.102	.57
Traditional (5)	1.0	1.6(1.3)	3.0	2.80(1.30)	1.60	.109	.51

Note. RTP = repetitive task-specific practice; FMA-UE = Fugl-Meyer Assessment Upper Extremity; WMFT = Wolf Motor Function Test; M = mean; *SD* = standard deviation; Mdn = median.

UE Impairment

To determine changes in UE impairment, the researchers used the FMA-UE pretest/posttest scores. The Wilcoxon signed-rank test demonstrated that audio MP increased FM scores from pretest (Mdn = 34.0, Mean = 34.0, *SD* = 9.6) to posttest (Mdn = 49.0, Mean = 49.6, *SD* = 7.5), n = 5, Z = 2.03, *p* = .042, Effect size r = .64. Similar improvement in FM scores was found with traditional therapy, pretest (Mdn = 22.0, Mean = 27.2, *SD* = 10.1) to posttest (Mdn = 41.0, Mean = 38.2, *SD* = 10.9), n = 5, Z = 2.02, *p* = .043, r = .63. There was no statistically significant change in FM scores for video MP pretest (Mdn = 31.0, Mean = 31.5, *SD* = 11.8) to posttest (Mdn = 52.5, Mean = 52.5, *SD* = 8.0), n = 4, Z = 1.83, p = .068, r = .64, and RTP groups pretest (Mdn = 27.0, Mean = 31.0, SD = 13.3) to posttest (Mdn = 53.0, Mean = 54.0, SD = 7.1) n = 4, Z = 1.84, *p* = .066, r = .65. However, the medium effect size (r) in all groups indicates that all four groups had improved FM scores.

UE Functional Abilities

Changes in the functional abilities of the UE were determined by WMFT time scores and FAS scores (see Table 4). Audio MP decreased WMFT time, pretest (Mdn = 10.5, Mean = 49.9, *SD* = 59.1) to posttest (Mdn = 4.1, Mean = 3.5, *SD* = 1.4), Z = 2.02, p = .043, r = .63. Traditional therapy showed similar gains in WMFT time, pretest (Mdn = 120, Mean = 75.6, *SD* = 60.8) to posttest (Mdn = 17.5, Mean = 38.0, *SD*

= 43.7), Z = 2.02, p = .043, r = .63. There was no statistically significant change in WMFT scores for video MP pretest (Mdn = 61.5, Mean = 61.1, *SD* = 68.0) to posttest (Mdn = 3.1, Mean = 4.2, *SD* = 3.3), n = 4, Z = 1.60, p = .109, r = .57, and RTP (Mdn = 64.5, Mean = 63.0, *SD* = 65.9) to posttest (Mdn = 3.73, Mean = 3.7, *SD* = 1.4), n = 4, Z = 1.82, p = .068, r = 64. The medium effect size (r) in all groups indicates that all four groups had improved functional abilities. Among all groups, no statistically significant change was found between pretest/posttest scores for the WMFT-FAS.

Discussion

Rehabilitation efforts are most optimal when occupational therapists exploit strengths to facilitate remediation. Leveraging the strength of audio-guided MP to elicit motor behavior could supplement existing occupational therapy approaches for the stroke survivor with UE hemiparesis. The current findings have several clinical implications. First, the results align with previous MP studies that demonstrate MP is an advantageous and feasible treatment for individuals post-stroke with UE hemiparesis (Nilsen et al., 2012). Furthermore, this study demonstrates the benefits of an MP protocol with this population in the acute inpatient rehabilitation setting. Research in MP and UE hemiparesis has largely been relegated to patients in the chronic phase of recovery (> 6 months post-stroke) and in the outpatient or home health settings (74% of MP research studies) (Malouin et al., 2013). This study aids in addressing a gap in the literature and supporting MP in the acute stage of recovery.

This study's findings also demonstrated that audio-MP had similar benefits to the hemiparetic UE as traditional therapy. This protocol used MP in the therapy process. The impetus to perform MP in the acute rehabilitation setting may be in using MP as an adjunct therapy that patients perform independently and in addition to therapy time. Future studies are needed to examine if the addition of MP to traditional stroke therapy will yield increased effects on the hemiparetic UE. Likewise, experimental designs with large sample sizes are needed to further demonstrate the effectiveness of MP in this setting.

Subjective data from participant feedback also provided insight as to why the results did not match our initial hypothesis that video-guided MP would have increased effects on the hemiparetic UE when compared to audio-guided MP. The participants in the audio-guided group verbalized an increased desire to use their affected UE following MP sessions. "It makes me really want to practice with my arm, give me a cup." The participants in the video-guided group verbalized feeling as if they were watching someone else perform the task, indicating a more passive role in their experience, whereas the audio-guided participants may have experienced an active role that better facilitates cortical reorganization. Further information is needed on the subjective experience and the acceptability of MP with individuals following a stroke.

MP Recordings

While previous MP studies incorporated a relaxation period and time to "return to the room" in each MP recording, this was purposely eliminated in this study. First, this was helpful in reducing the time of each recording, which was advantageous for patients with short attention spans. Second, this promotes maximizing functional equivalence, or the attempt to make MP as close as possible to motor execution (Wright & Smith, 2009). Functional equivalence is believed to facilitate stimulating the same cortical areas as motor execution, thereby reaping the same benefits (Wakefield et al., 2013). The natural occurrence of completing most motor tasks does not include a period of relaxation, thereby decreasing functional equivalence.

Other areas of maximizing functional equivalence used in the design of this study include consideration of the environment, task, and perspective. With consideration of the environment, performing MP and RTP in the natural setting in which the motor task is typically performed was used. It is also understood that MP is more effective if the content of the mental imagery is appropriate to the skill level of the participant (Wakefield & Smith, 2012). Therefore, the MP and motor task performed for each participant was assigned based on their FMA-UE Score (UE skill level). Finally, the internal perspective was considered closer to motor execution than an external perspective. Thus, all MP recordings were used from a first-person (internal) perspective.

Limitations and Future Directions

Study limitations in the design and statistical analysis should be considered when applying these results to clinical practice. General limitations of the Wilcoxon signed-rank test as a statistical analysis should be considered. The participants may have the same values for scores in each outcome measurement. This could lead to the same relative ranks, which has the potential to dilute the Wilcoxon signed-rank test. The Wilcoxon signed-rank test was used because of the small sample size, which may deem it difficult to apply the results to the general stroke population. The sample size was influenced by a large inclusion/exclusion criterion that was necessary to reduce the heterogeneity of the participants. Therefore, this study is considered a pilot study in nature, with the intent to use the results for a larger randomized control trial in the future. Despite efforts to limit the heterogeneity of the participants, pretest scores for the outcome measures varied between groups, which may have impacted our findings.

In addition, because of the unpredictable nature of discharges in the acute inpatient rehabilitation setting, the length of each participant's intervention was based on their length of stay. The study participants also performed different tasks based on their baseline FMA-UE. These variables may have confounded results. Finally, although most MP studies use time as a measure of dosage, time neglects to take into consideration the variance in the number of repetitions that occur in each time period. This study was novel in addressing this variance by using the number of repetitions as a more effective method for the treatment dosage. Although the authors consider this a strength of the study, the study participants received varied time spent in MP, which may be considered a limitation. Future studies should consider the use of whole-task completion as one repetition to assist with data collection and replication in future studies.

Conclusion

This research adds to the body of literature that supports MP in the acute phase of stroke recovery, specifically in the inpatient rehabilitation hospital setting. Audio MP should be considered an advantageous mode for MP delivery. By defining the most effective delivery mode of MP, the occupational therapist is more equipped to choose the most effective intervention, resulting in better outcomes for the patient with UE hemiparesis following a stroke. Occupational therapists can supplement current clinical practice with MP. More research is needed that combines imaging with this population to identify the specific cortical effects of MP.

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