ORIGINAL ARTICLE

Ipsilateral Deficits in 1-Handed Shoe Tying After Left or Right Hemisphere Stroke

Janet L. Poole, PhD, OTR/L, Joseph Sadek, PhD, Kathleen Y. Haaland, PhD

ABSTRACT. Poole JL, Sadek J, Haaland KY. Ipsilateral deficits in 1-handed shoe tying after left or right hemisphere stroke. Arch Phys Med Rehabil 2009;90:1800-5.

Objective: To examine 1-handed shoe tying performance and whether cognitive deficits more associated with left or right hemisphere damage differentially affect it after unilateral stroke.

Design: Observational cohort comparing ipsilesional shoe tying, spatial and language skills, and limb praxis.

Setting: Primary care Veterans Affairs and private medical center.

Interventions: Not applicable.

Participants: Volunteer right-handed sample of adults with left or right hemisphere damage and healthy demographically matched adults.

Main Outcome Measure: The number of correct trials and the total time to complete 10 trials tying a shoe using the 1-handed method.

Results: Both stroke groups had fewer correct trials and were significantly slower tying the shoe than the control group. Spatial skills predicted accuracy and speed after right hemisphere damage. After left hemisphere damage, accuracy was predicted by spatial skills and limb praxis, while speed was predicted by limb praxis only.

Conclusions: Ipsilesional shoe tying is similarly impaired after left or right hemisphere damage, but for different reasons. Spatial deficits had a greater influence after right hemisphere damage, and limb apraxia had a greater influence after left hemisphere damage. Language deficits did not affect performance, indicating that aphasia does not preclude using this therapy approach. These results suggest that rehabilitation professionals should consider assessment of limb apraxia and ipsilesional skill training in the performance of everyday tasks.

Key Words: Apraxias; Motor skills; Rehabilitation; Self care; Stroke.

DRESSING IS A COMPLEX skill generally requiring the use of balance; cognitive abilities, including limb praxis and spatial abilities; and both upper extremities. Unilateral stroke often results in significant residual motor impairment on 1 side of the body, requiring daily tasks to be performed using the upper extremity ipsilateral to damage. Dressing both upper and lower extremities has been reported to be difficult even at 2 years poststroke.[1] Most of this literature has focused on upper-body dressing and the underlying deficits that influence the ability to relearn to dress, including limb apraxia and spatial deficits.[2-5] Few studies have examined lower-extremity dressing, although 1 study showed that the severity of hemiparesis strongly predicted lower-body dressing ability[2] because balance and gross motor functions are needed.

Tying shoelaces is an aspect of dressing that has not been examined routinely.[2] In the rehabilitation literature, a technique called 1-handed shoe tying has been developed to help people after stroke tie a shoe with 1 hand. This is an important practical issue because there are several advantages of wearing laced shoes versus shoes with Velcro or elastic closures. For example, laced shoes (1) may be more compatible with metal ankle foot orthoses[6]; (2) include top eyelets that provide a snug closure, which reduces heel slippage[7]; (3) provide more support to the arch of the foot[6]; and (4) are available in more shoe styles. The last point may be especially important for young people with stroke. However, despite the advantages of wearing laced shoes and the need to be able to tie them with 1 hand for individuals with hemiparesis, the 1-handed shoe tying method has been considered difficult and impossible to learn by individuals with cognitive or perceptual deficits.[8]

Shoe tying involves a variety of cognitive skills that are impaired after unilateral stroke, including spatial skills, motor sequencing skills, and language skills to understand the task instructions. Spatial deficits, which are more common after RHD than LHD,[9] have been shown to influence dressing,[2] but their influence has not been examined in 1-handed shoe tying. Visual neglect, organizing complex spatial behaviors, and visuoperceptual deficits are just a few examples of the types of visuospatial deficits that are more impaired after RHD than LHD and could plausibly influence 1-handed shoe tying.[9] There is evidence from functional imaging studies in neurologically intact adults[10-12] and studies in patients with unilateral brain damage[13-15] that sequencing is controlled more by the left than the right hemisphere, and such deficits are more common in those diagnosed with limb apraxia.[16] In addition, more recent studies have shown that limb apraxia in the ipsilateral upper limb after stroke has a functional impact on a variety of tasks, including simulated activities of daily living.[3-5,17-20] Limb apraxia could also affect the ability to learn 1-handed shoe tying.

List of Abbreviations

LHD	left hemisphere damage
OR	odds ratio
RHD	right hemisphere damage

From the Occupational Therapy Graduate Program (Poole), Psychiatry (Sadek, Haaland), and Neurology (Haaland) Departments, University of New Mexico School of Medicine, Albuquerque, NM; and Research Service (Haaland) and Behavioral Health Care Line (Sadek, Haaland), New Mexico Veterans Affairs Healthcare System, Albuquerque, NM.

Supported by the Department of Veterans Affairs (Rehabilitation Research and Development, grant no. B4125R, and Clinical Services Research and Development).

No commercial party having a direct financial interest in the results of the research supporting this article has or will confer a benefit on the authors or on any organization with which the authors are associated.

Reprint requests to Kathleen Y. Haaland, PhD, Research Service (151), NMVAHCS, 1501 San Pedro SE, Albuquerque, NM 87108, e-mail: *khaaland@unm.edu*.

0003-9993/09/9010-00952$36.00/0
doi:10.1016/j.apmr.2009.03.019

One small pilot study[21,22] showed that patients with LHD could learn to tie shoes using the 1-handed method, but persons with limb apraxia[21] required significantly more trials to learn and retain the task than healthy controls. Moreover, those with limb apraxia made more sequencing and perseveration errors, suggesting difficulty making transitions between steps of a sequence or remembering the steps.[21] Therefore, the present study examined the ability to perform 1-handed shoe tying and examined whether cognitive deficits more associated with LHD or RHD would differentially affect ipsilesional shoe tying performance after unilateral stroke. Our study had 2 hypotheses: (1) patients with LHD or RHD after stroke would demonstrate similar degrees of 1-handed shoe tying impairment in the ipsilateral limb relative to a healthy control group using their left or right hand, and (2) the underlying mechanisms for the shoe tying impairment in the LHD and RHD groups would be different. That is, we predicted that limb apraxia, and possibly aphasia, would have a greater influence on the performance of the LHD group, and spatial deficits would have a greater influence on the performance of the RHD group.

METHODS

Participants

We examined 110 right-handed participants: 20 with RHD, 28 with LHD, and 62 healthy, able-bodied control subjects with no self-report of neurologic diagnoses (healthy controls, 24 who tied the shoe with their right hand and 38 who tied the shoe with their left hand). Only participants with neuroradiologically confirmed strokes to either the left or right hemisphere were included. Participants with stroke were excluded if there was a history of (1) neurologic disease other than stroke, (2) damage to the cerebellum or brain stem or significant periventricular white matter changes or cortical atrophy confirmed neuroradiologically, (3) major psychiatric diagnosis, (4) hospitalization for substance abuse, (5) sensory or motor peripheral disorders, or (6) left handedness. Control participants were required to meet the same criteria and have no history of stroke. Informed consent was obtained from all participants according to the Declaration of Helsinki. The study was approved by the institutional review board of the New Mexico Veterans Affairs Health Care System. Table 1 shows the demographic characteristics and other descriptive information for all groups.

Table 1: Demographic, Neurologic, Neuropsychologic Variables, and Outcome Measures for All Groups

Variable	Control (n=62)	LHD (n=28)	RHD (n=20)
Age (y)	64.6±12.0	59.6±12.1	66.2±12.2
Sex (female, %)	41.9	21.4	45.0
Education (y)	14.5±2.4	13.7±3.5	13.7±2.8
Years poststroke	NA	4.8±5.7	4.2±6.8
Lesion volume (mL)	NA	70.8±76.0	96.1±130.3
Limb apraxia (no. correct)*	13.6±1.1	11.8±2.7†‡	13.6±1.4
Incidence of apraxia (%)§	NA	35.7	5.0
Aphasia quotient*	98.9±1.0	76.4±28.4†‡	97.7±2.3†
Block Design*	8.5±2.2	7.5±2.6†	5.9±2.5†‡
Right motor index*	46.4±6.6	29.8±15.8†‡	42.8±8.9
Left motor index*	46.5±7.0	45.9±7.8	32.6±18.9†‡
Shoe time score*	80.4±25.3	120.0±74.5†	118.9±48.8†
Total correct shoe trials*	9.1±1.0	7.8±2.9†	7.8±2.4†

NOTE. Values are mean ± SD or as otherwise indicated. Block Design is expressed as a scaled score (10±3) relative to the normative sample.[45]
Abbreviation: NA, not applicable.
*Significant group difference across 3 groups using analysis of variance ($P<.01$).
†Impaired relative to control group (Tukey test, $P<.05$).
‡Impaired relative to other stroke group (Tukey test, $P<.05$).
§Signficant group difference across 2 groups using chi-square ($P<.05$).

Measures

Ideomotor limb apraxia. Ideomotor limb apraxia was assessed with a 15-item test that assesses the ability to imitate 15 gestures: 5 meaningless, 5 intransitive, and 5 transitive.[23,24] The test was videotaped, and when the scores of 2 independent raters were not the same, a consensus score was agreed on by the 2 raters. Participants were considered to have apraxia if they made spatiotemporal errors on 4 of the 15 items (2 SDs greater than the healthy control group).[23] Spatiotemporal errors included errors in internal hand position, hand orientation, target (eg, shave hair, not face), and/or body-part-as-object (eg, use extended index finger to brush teeth). An item was scored as incorrect if any of these errors occurred, but additional errors on a single item did not result in a lower score. Interrater reliability for this limb apraxia test is high based on a previous study.[24]

Cognitive measures. Aphasia was assessed with the Western Aphasia Battery,[25] which provides an Aphasia Quotient that reflects all aspects of language. Spatial abilities were measured with the Block Design subtest from the Wechsler Adult Intelligence Scale–Revised.[26] This test requires the construction of designs to match patterns on cards using 4 or 9 blocks; the blocks have 2 all red, 2 all white, and 2 half red and half white sides. Higher scores indicated higher spatial abilities.

Motor indices. The motor indices are expressed as T scores with mean ± SD of 50±10 relative to a normative sample, based on grip strength and finger tapping.[27] Grip strength was the maximum grip scores for 2 trials measured with a Smedley hand dynamometer,[a] and the finger tapping score was the mean tapping rate of a telegraph key across five 10-second trials. The motor indices scores were calculated for descriptive purposes only. Higher scores indicated better motor function.

1-handed shoe tying. For the shoe tying task,[28] the shoe was placed on a table in front of the participant to eliminate the impact of poor trunk balance on shoe tying performance. The shoe was laced in such a fashion that only 1 lace was available for tying (fig 1A). Participants were given the following verbal instructions with demonstration: "First you put the end of the shoe lace through the top lace on the shoe (fig 1B). Then you pull the lace until it is almost all the way through like this (leave about three fourths of an inch of lace that has not been pulled through) (fig 1C). Then take your thumb and index finger and reach through this small loop and pinch part of the loose lace (fig 1D). Then you pull the lace through making a knot." Participants with stroke used the hand ipsilateral to the stroke. After the task was demonstrated using the same hand that the participants were to use, participants were instructed to try to tie the shoe 10 times in a row. Each trial was timed separately by the researcher. The researcher demonstrated the task with the initial instructions and then only after each incorrect attempt. The score was the number of correct trials (knot tied snug) out of 10 and the total time (summation of time for each trial) to complete 10 trials.