To what extent does cane handling technique training impact wrist flexor and extensor activation?

Erin Hanscom [1], Samantha Lorenzetti [1], Anne Qu [1], Allie Tunick[1], Rumit Singh Kakar [1], Karen Lohmond [1], Joshua Tome [1]

[1] *Ithaca College*

INTRODUCTION

A report published in 2011 stated that 16.4% of Americans aged 65 and older use canes for mobility purposes [1]. Canes are identified on the World Health Organization (WHO) assistive technology priority list as one of the 50 most essential pieces of assistive technology needed worldwide [2]. Canes and walking aids improve individuals' stable balance and ambulation in both functional activities and community mobility [3]. There are, however, adverse consequences associated with repetitive cane use. These include decreased ability to regain balance when it is compromised such as during tripping or falling, as well as significant strength and metabolic demands with long-term use [3]. Cane use can compromise the integrity of an individual's upper extremity over an extended period of time by decreasing dexterity, motor control and sensorimotor function which can lead to conditions such as carpal tunnel syndrome, tendonitis, osteoarthritis in the wrist and hand [4]. Increased forearm muscle activation and repetitive and sustained weight-bearing increase the occurrence of these detrimental effects [3].

One of the reasons that these negative consequences of cane use can occur is that cane-using individuals often do not receive instruction about how to fit or use the device properly [5, 6]. Canes are often obtained by community dwelling adults who independently decide that they need them to compensate for decreased strength, balance or pain [7]. Although individuals often seek and purchase these devices independently, training in the use of mobility devices has been shown to improve their outcomes [7, 8]. Effective training times reported in academic literature range from 5 minutes to 30 minutes depending on the diagnosis of focus [9, 10].

The recommended length of a cane is the height from the ground to the ulnar styloid process and should offset 20-30% of the person's body weight [11]. The user's elbow should be at about a 30-degree angle while the cane should be used on the uninvolved or "stronger" side of the body [12].

The topic of detrimental effects of cane use on the upper extremity and hand function has little research and there is a clear gap in the literature about how it can affect the upper extremity. Further research on the impacts of cane use is necessary in order to identify solutions and adjustments to canes and cane use that promote the highest form of function possible for users, with the least negative physical impact.

While there is a wide variety of notable issues resulting from cane use, this study aims to explore how cane users acquire their canes and how they learned to use it. It will also focus on whether a cane fitting and a short training session will positively impact the way individuals are using their canes in regard to upper extremity damage and dysfunction.

Hypothesis

Cane users are not properly fitted for canes nor trained in proper cane use techniques. This results in improper cane handling and use, leading to increased forearm flexor and extensor muscle activation and detrimental effects to the upper extremity.

Research Questions

1. To what extent does cane handling technique training impact wrist flexor and extensor activation?
2. Do individuals who acquire canes without prescription use their canes properly?
3. To what extent does improper cane fitting and use result in greater forearm musculature activation?

METHODS

Research design

This study, approved by our college's Institutional Review Board, was conducted using a quasi-Experimental case study design, using quantitative descriptive statistics to compare pre and post test scores. Each participant was compared to themselves, independent from the other participants in the study and acting as their own control variable.

Participants

Five community dwelling elders 65 years or older who use a single-point cane most or all of the time were recruited to participate in this study. Participants were excluded if they reported use of a cane other than a single-point cane and/or scored less than 24 points on the MMSE, which indicates a mild cognitive impairment. Participants were recruited through email newsletters, publicly posted community flyers, word of mouth, and general online announcements through the Ithaca College Intercom program.

Data acquisition

Electromyography (EMG) data was recorded from surface electrodes placed on flexor and extensor muscles of the arm gripping the cane. EMG data were wirelessly transmitted to the sampling computer using a 16-channel Delsys Trigno Avanti unit [14]. The Tigno bandwidth was 200-500 Hz with a signal-to-noise-ratio of 1μV root mean square (RMS) baseline noise. The preset amplification was 10 MΩ, with a common-mode rejection ratio of 100 dB.

Wrist motion was recorded using APDM's Opal Movement Monitor system [15]. Sensors were placed via manufacturer's instructions on the dorsal aspect of the wrist and hand, such that the USB charging port pointed distally toward the middle digit on the cane gripping limb. Each Opal sensor contains a triaxial accelerometer, gyroscope, and magnetometer sampling at 128 Hz.

Procedure

Participants were fitted with both the surface EMG sensors and the Opal inertial sensors. Each participant was then asked to complete three trials of overground walking. Each walking trial began with a three to four second period of independent standing (i.e., without their cane) which was used to calibrate the inertial sensors. Following this, the participant completed the 10m walk at their preferred pace. Participants used their cane with no adjustments or instruction for these initial trials, hereafter referred to as pre-test trials.

Following the pre-test trials, participants underwent a short (5-10 minutes) assessment by an occupational therapy (OT) student. During this assessment, the OT student educated the patient on proper cane use and adjusted the cane for optimal fit. Optimal fit for this study was defined as maintaining the length of the cane such that with the arm hanging at the side at rest the top of the cane reaches the ulnar styloid of the wrist [16]. The user was instructed to practice maintaining about a 30-degree angle and the elbow, as confirmed with a standard goniometer, while the cane was used on the uninvolved or "stronger" side of the body. Participants were then allotted 10-15 minutes to practice walking with the adjusted cane, while the OT student provided feedback.

After participants indicated they were comfortable with the cane modifications they completed an additional three trials of walking on the 10m walkway at their self-selected pace with the fitted cane. Participants received no coaching or instructions during these ambulation trials, hereafter referred to as post-test trials. Wrist position and forearm muscle activation were simultaneously recorded from inertial and EMG sense, respectively, throughout each trial as described above.

Data analysis

All outcome variables were assessed in the middle portion of the walking trial, to avoid the initial acceleration and final deceleration phase; thus, all outcome measures represent steady-state walking at the participant's self-selected speed. During the steady-state phase of each walking trial, local maxima and minima for wrist flexion and extension were recorded and averaged over five consecutive flexion/extension cycles. The raw data from the EMG sensors were fully rectified. The main EMG outcome measure was peak amplitude of activation (mV) of each muscle group during the steady-state period for each walking trial pre- and post-cane training. All data collection was triggered simultaneously through the Opal's Movement software's external trigger [15]. Raw data were then exported to text files and all data inspection and calculations were performed via custom written MATLAB code [17]. Due to the small sample size, case-by-case comparisons were made such that each participant's pre- and post-training average peak flexor and extensor muscle activation and average peak wrist flexion and extension were compared. Lastly, demographic data and information regarding the history of cane use were compiled from questionnaire responses (see Table 1).

RESULTS

Table 1. Participant demographics

Survey Questions	Participants				
	1	2	3	4	5
Age	81	90	72	80	87
Years of cane use?	8 years	4-5 years	1-2 years	2 years	1-2 years
Was the cane prescribed?	No	No	Yes (Doctor & PT)	No	No
Where was the cane acquired?	Pharmacy	N/A	Pharmacy	Other	Other
Did you receive cane instruction or fitting?	No	No	No	No	No
Reason for cane use?	Balance, hip replacement	Balance, no medical condition	Injury, muscle damage	Balance	Balance
Pain or discomfort?	Hand numbness	N/A	N/A	Wrist and hand stress	Hand pain

All participants in the study obtained their canes on their own with no instruction in how to fit or use their devices, and all participants needed cane height adjustment. Two participants, 1 and 4, demonstrated an increase in average peak and overall peak wrist flexion and a decrease in average peak and overall peak wrist extension. This suggests that post-training, these participants' wrists were aligned in a more neutral position than prior to the fitting. Participant 2 demonstrated a decrease in average peak wrist flexion and an increase in average peak wrist extension, contradicting our hypothesis. Overall, minimal changes were observed in EMG values pre- and post-fitting across all participants. Participants received follow-up questions one month post study via email or phone call. Three of the five participants responded. Participant 3 responded positively and reported using the cane in the adjusted form with a more upright posture. They also reported initial pain around the thumb but contributed that pain to a diagnosis of arthritis. The pain subsided and the participant was pleased with the results. Participant 4 also responded with positive results. They began using an aluminum adjustable cane, rather than the wooden one he had been previously using as a result of the research study. They reported greater ease using the cane and decreased pain upon use.

DISCUSSION

Due to observed balance deficits, one participant required assistance from an occupational therapy student during ambulation, which may have impacted the results, generating values contradictory to our hypothesis. Other factors impacting results include short training session, with limited time to revise established cane-use habits as well as ambulation in an unnatural study setting (in a lab).

Limitations to our study include a small sample size thus these findings are not generalizable. Future research on this subject may benefit from use of foot sensors to record gait cycles to match with wrist angle and EMG data. Tools such as a quality of life measure may help qualify the practical implications of cane fitting and training on cane-users.

Despite the study limitations and need for further research, our study outlines the general procedure to assess the impact of cane-fitting and training on upper extremities of cane-users and affirms the lack of knowledge cane-users are provided during selection and use of their walking device.

CONCLUSION.

Consistent with other studies [3,6], our study revealed that older adults often purchase their own walking aides, do not receive instruction in their use and are not correctly fitted for these devices. More research into this topic is needed. Implications for educational information provided to elders who use canes at multiple levels is indicated. Education may help to mitigate falls and upper extremity overuse injuries resulting for improper cane use.

REFERENCES

[1] Gell, N. M., Wallace, R. B., LaCroix, A. Z., Mroz, T. M., & Patel, K. V. (2015). Mobility device use in older adults and incidence of falls and worry about falling: Findings from the 2011-2012 national health and aging trends study. *Journal of the American Geriatrics Society*, *63*(5), 853–859. doi:10.1111/jgs.13393

[2] World Health Organization (2016). Priority assistive products list. *Publications of the World Health Organization.* https://www.who.int/phi/implementation/assistivetechnology/global_survey-apl/en/

[3] Bateni, H., & Maki, B. E. (2005). Assistive devices for balance and mobility: Benefits, demands, and adverse consequences. *Archives of Physical Medicine and Rehabilitation*, *86*(1), 134–145. doi:10.1016/j.apmr.2004.04.023

[4] Son, S.M., Kwon, J.W., Nam, S.H., Lee, N.K., Kim, K., Kim, C.S. (2012). Adverse effects of motor-related symptoms on the ipsilateral upper limb according to long-term cane usage. *NeuroRehabilitation, 31*(2), 137-141. doi: 10.3233/nre-2012-0782

[5] Gooberman-Hill, R., & Ebrahim, S. (2007). Making decisions about simple interventions: Older people's use of walking aids. *Age and Aging, 36*(5), 569-573. doi:10.1093/ageing/afm095

[6] Liu, H., Eaves, J., Wang, W., Womack, J., & Bullock, P. (2011). Assessment of canes used by older adults in senior living communities. *Archives of Gerontology and Geriatrics*, *52*(3), 299–303. doi: 10.1016/j.archger.2010.04.003

[7] Dogru, E., Kizilci, H., Balci, N. C., Korkmaz, N. C., Canbay, O., & Katayifci, N. (2016). The effect of walking sticks on balance in geriatric subjects. *Journal of physical therapy science, 28*(12), 3267–3271. doi:10.1589/jpts.28.3267

[8] Tu, C., Liu, L., Wang, W., Du, H., Wang, Y., Xu, Y., & Li, P. (2017). Effectiveness and safety of wheelchair skills training program in improving the wheelchair skills capacity: A systematic review. *Clinical Rehabilitation*, *31*(12), 1573–1582. doi.org/10.1177/0269215517712043

[9] Cha, Y.J. (2015). Do traditionally recommended cane lengths equally influence walking in patients after stroke? *Disability and Health Journal, 8*(1), 136-139. doi:10.1016/j.dhjo.2014.07.001

[10] Jones, A., Silva, P.G., Silva, A.C., Colucci, M., Tuffanin, A., Jardim, J.R., & Natour, R. (2012). Impact of cane use on pain, function, general health and energy expenditure during gait in patients with knee osteoarthritis: a randomized controlled trial. *Annals of the Rheumatic Diseases, 71*(2), 172-179.

[11] O'Sullivan, S. B., Schmitz, T. J., & Fulk, G. D. (2014). Ambulatory assistive devices: Types, gait patterns, and locomotor training. *Physical rehabilitation* (6th ed.). Philadelphia: F.A. Davis Company.

[12] Li, Z., Chou, C. (2014). The effect of cane length and step height on muscle strength and body balance of elderly people in a stairway environment. *Journal of Physiological Anthropology,* 33(36).

[13] Haddas, R., Lieberman, I., & Kakar, R. (2019). A comparison of muscular activity during gait between walking

sticks and a walker in patients with adult degenerative scoliosis. *Spine Deformity, 7*(3), 454–466. doi: 10.1016/j.jspd.2018.09.067

[14] Delsys Inc. (2019) *Trigno Avanti Platform*. https://www.delsys.com/trigno

[15] APDM Inc. (2019) *The Opal.* https://www.apdm.com/wearable-sensors

[16] O'Sullivan, S. B., Schmitz, T. J., & Fulk, G. D. (2014). Ambulatory assistive devices: Types, gait patterns, and locomotor training. *Physical rehabilitation* (6th ed.). Philadelphia: F.A. Davis Company.

[17] The MathWorks, Inc. (2020). MATLAB Code. https://www.mathworks.com/discovery/matlab-code.html