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Utilization of orthoses and assistive devices among a national sample of lower limb orthosis users

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Abstract

Introduction: Lower limb orthoses (LLOs) and assistive devices (ADs) can be used together or separately to improve mobility when performing daily activities. The goal of this study was to examine utilization of LLOs and ADs in a national sample of adult LLO users.

Methods: A survey was designed to ask participants whether they typically use their LLOs and/or ADs to perform 20 daily activities. LLO users from orthotic clinics across the United States were invited to complete the survey. Descriptive statistics were used to examine utilization trends.

Results: Survey responses from 1036 LLO users were analyzed. Community-based activities were performed with LLOs by at least 80% of participants. Activities that involved walking short distances in the home were more often performed without LLOs or ADs. Among participants with the four most prevalent health conditions, LLO use in the community was greatest among participants with Charcot-Marie-Tooth disease.

Conclusions: LLOs were frequently used for a wide range of community-based activities. Simultaneous use of ADs and LLOs may be most beneficial for LLO users when performing activities outside of the home. Clinicians can discuss LLO and AD use with patients to optimize their functional outcomes at home and in the community.

Keywords

Assistive technology, ankle-foot orthosis, knee-ankle-foot orthosis, mobility devices, outcome measurement, activities of daily living

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Introduction

Individuals with neuromuscular and musculoskeletal health conditions that impair lower limb function frequently use orthoses to preserve or improve their mobility and independence.[1] Lower limb orthoses (LLOs) can stabilize and assist movement across one or more joint(s), potentially resulting in increased physical activity, improved balance, decreased energy expenditure, and reduced fear of falling.[2,3] Many individuals with lower limb impairments are also able to function without the use of their orthoses for brief periods

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of time or in familiar walking environments. However, the current literature has limited information on how LLO use might vary by characteristics of the individual or their environment.[4] A prior study examined orthosis use and community mobility using sensors attached to participants' orthoses.[5] The authors found that LLO usage and time spent at community locations were not associated with self-reported mobility or performance test outcomes, suggesting that decisions to use LLOs for different activities are not based only upon a user's mobility level. Further exploration into the situations for which people with LLOs choose to use them could offer insights into how LLO users make decisions to optimize their mobility.

Assistive devices (ADs), such as canes, crutches, and walkers can be used to improve an individual's stability by widening the base of support and reducing lower limb loads.[6] LLO users can also use ADs to address their functional impairments. Even with access to both LLOs and ADs, individuals may choose to perform certain activities without using any devices, using only LLOs or only ADs, or simultaneously using both LLOs and ADs. Device selection may depend on an individual's fatigue level, functional ability, and degree of support needed for a given activity or environment.[4] A systemic review that explored how ADs enable participation among adults with physical disabilities identified barriers to using ADs, including the weight of the device when interacting with a physical environment and social stigma.[7] These factors likely contribute to an individual's decision to use an AD for an activity. The extent to which ADs are employed by LLO users, and the environments where such devices are most frequently used, have not be previously reported. Exploring patterns of LLO and AD use across a range of different activities may help clinicians to better understand how patients with lower limb impairments generally use these devices to address their functional limitations.

Information about how LLOs and ADs are used may also be helpful for providing care to people with specific health conditions. Patterns of device use among people with commonly encountered health conditions, such as stroke, spinal cord injury (SCI), Charcot-Marie-Tooth disease (CMT) and multiple sclerosis (MS) may differ due to differences in symptoms and types of impairments. For example, orthoses are considered a rehabilitation mainstay for people with progressive CMT,[8] whereas people with MS may rely less heavily on LLOs due to their fluctuating symptoms.[9] Information about how LLOs and ADs are used by people with different health conditions may help orthotists and other healthcare professional provide better care to individual patients based on their underlying health conditions. Thus, the goal of this study was to determine how LLOs and ADs are used by people with lower limb functional impairments to perform various home- and community-based activities.

Method

Participants

A cross-sectional survey was administered to a large, national sample of LLO users to examine LLO and AD use. Device use data were collected as part of a study that aimed to develop a novel patient-reported item bank for measuring orthotic mobility.[10] Eligible individuals included adults with chronic functional or structural lower limb impairments who reported using a LLO on one or both legs for at least 6 months. For the purposes of this study, LLOs were limited to orthoses that extended proximally from the foot to a level above the ankle, including ankle-foot orthoses (AFOs), knee-ankle-foot orthoses (KAFOs), and hip-knee-ankle-foot orthoses (HKAFOs). Functional electrical stimulation (FES) devices were also eligible orthoses. Individuals with a major lower limb amputation were excluded, as lower limb prostheses were not a focus of this study. Minimum recruitment targets were established to ensure inclusion of participants with characteristics of clinical importance that may be difficult to identify in a convenience sample. These target characteristics included use of less commonly prescribed LLO designs, (i.e., knee-ankle-foot orthoses) and less prevalent health conditions (i.e., muscular dystrophy, traumatic brain injury, and post-polio syndrome). A minimum of 30 participants were recruited for each target characteristic.

Instrument

A custom device utilization survey was designed to ask participants about which devices (i.e., LLOs or ADs) they use to perform a variety of daily activities. Survey items were created by reviewing activities and movements that were identified as being important to LLO users in prior studies.[11,12] These items were then compared to mobility categories described by the International Classification of Functioning, Disability, and Health (ICF),[13] to identify additional activities that may be pertinent to orthosis users. The initial survey was then presented to a 13-person interdisciplinary advisory panel of stakeholders, including LLO users, prosthetist/orthotists, orthotic researchers, a clinical educator, a physical therapist, and representatives of LLO manufacturers for their review. The survey instructions and items were modified based on feedback from advisory panel members, then pilot tested with six LLO users. Pilot test participants were interviewed after they completed the survey and asked to comment on their interpretation of each item. Additional revisions, including the removal of one item and the addition of an example, were made to the survey to address concerns identified during pilot testing. A final version of the survey was then prepared for large-scale administration.

The final device utilization survey asks respondents to note which device(s) (i.e., LLOs and/or ADs) they usually use to perform 20 distinct mobility activities (see Appendix 1). The activities were broadly grouped into those that are performed in and around the home (7 items), those that are performed out in the community (9 items), and those related to exercise and recreation (4 items). Respondents were instructed to choose all devices that they would usually use to perform each activity. The options included leg brace(s), cane(s) or crutch(es), walker, and wheelchair or scooter. Respondents could also indicate that they would not use any devices to perform the activity or would never do the activity.

The survey was co-administered with questions about participants' demographics, health, and general (i.e., not activity-specific) LLO and AD use. Responses to these questions were used to characterize the study sample. Health-related questions asked about pain, comorbidities, and fall history. Questions about general LLO use asked how many days LLOs were used in a typical week, and how many hours they were used on days when they were worn. Questions about general AD use asked about the frequency with which various ADs were used. Participants were asked how often they use each type of AD, and response options included "never," "occasionally," and "daily."

Procedures

An electronic version of the survey was created with and administered using Research Electronic Data Capture (REDCap), a secure application hosted at the University of Washington. A public website was developed to provide potential participants with information about the study. The website also included a link to survey and information about how to request a paper survey if desired. Informational materials, including posters, flyers, and pamphlets were displayed in orthotic clinics and hospitals across the United States. Digital flyers were also distributed through online magazines, professional organization websites, and a professional listserv. Additionally, targeted email invitations were sent by a national orthotics provider to patients who had received a LLO. All procedures were approved by a University of Washington institutional review board and the study was deemed to meet exempt status criteria (STUDY00008704).

Analysis

Descriptive statistics were used to characterize survey participants and device utilization across the range of activities included in the survey. Participants' overall participation in survey activities was evaluated by summarizing the percent of respondents who indicated that they performed each activity. Participants were also grouped by health diagnoses, and responses to the device utilization survey items were compared between groups of participants with the four most prevalent primary health conditions (i.e., spinal cord injury [SCI], Charcot-Marie-Tooth disease [CMT], stroke, multiple sclerosis [MS]). Chi square tests were performed to identify significant differences ($p < .05$) in orthosis use across the four diagnosis groups. When statistically significant differences were discovered for a survey item, follow-up Chi Square tests were performed to identify which groups(s) were significantly different. A Bonferroni correction was applied to account for multiple comparisons. Differences with a p-value under .0083 were considered significant.

Results

Survey responses were obtained from 1036 LLO users (Table 1). Just over half of participants were women and the large majority reported being White (89%) and non-Hispanic (92%). Participants with any of the four most frequently reported primary health conditions (SCI, CMT, stroke, and MS) comprised 37% of the sample. Most participants reported using at least one AFO (91%) and few used at least one KAFO (8%). At least 30 participants with each of the target characteristics were recruited.

Overall use of LLOs across all study participants was high, with 72% of the sample reporting 6-7 days of use per week and 18% reporting 4-5 days of use. By contrast, only 10% of the sample reported using their LLOs 3 days or less per week. Daily usage of LLOs was also high, with 41% reporting they used their device 12 or more hours per day and 38% reporting 6–11 h per day. Only 21% of the sample reported using their LLO 5 h or less on days when they wore the device.

Respondents reported participating most in home-based activities (mean = 88%), with slightly fewer reporting participation in community-based activities (mean = 76%), and much fewer reporting participation in exercise and recreational activities (mean = 23%). The activities with the most participation (over 95% of the sample) included moving from the bedroom to the kitchen, getting up to go to the bathroom at night, meal preparation in the kitchen, performing chores within the home, going to the grocery store, and going out to eat at a restaurant. The activities with the least participation included jogging or running (7%), playing sports with others (18%), doing vigorous exercise (34%), hiking up and down hills (35%), and using public transportation (51%). Utilization of LLOs and ADs varied across activities. Activities for which a large percentage of participants performed without any devices included getting up to go to the bathroom at night (70%) and moving from the bedroom to the kitchen (50%). Community-based activities were performed with LLOs by most participants, ranging from 83% to 91%. Of those who used LLOs, a moderate percentage of participants also used

Table 1. Characteristics reported by study participants.

Characteristic	*n*	%	*Characteristic*	*n*	%
Gender			*Primary health condition*		
Woman	520	50	Spinal cord injury	102	10
Man	514	50	Charcot-Marie-Tooth disease	86	8
Other	2	<1	Stroke	66	6
Age			Multiple sclerosis	64	6
18–39 years	117	11	Post-polio syndrome	61	6
40–64 years	487	47	Muscular dystrophy	39	4
65 or more years	432	42	Traumatic brain injury	21	2
Ethnicity			Spina bifida	21	2
Hispanic or Latino	33	3	Cerebral palsy	19	2
Not Hispanic or Latino	948	92	Arthrogryposis	1	<1
Unknown or prefer not to answer	55	5	Multiple conditions	73	7
Race			Other condition[a]	483	47
American Indian or Alaskan Native	1	<1	*Orthosis type*		
Asian	17	2	Unilateral AFO	649	63
Black or African American	46	5	Bilateral AFO	283	27
Native Hawaiian or Pacific Islander	1	<1	Unilateral KAFO	62	6
White	927	91	Bilateral KAFO	14	1
Multiple races	18	1	AFO and KAFO	12	1
Other race	4	<1	Unilateral HKAFO	4	<1
Unknown or prefer not to answer	22	2	Bilateral HKAFO	2	<1
Military status			AFO and HKAFO	1	<1
Servicemember	2	<1	Unilateral FES	9	1
Veteran	127	12			
Not Servicemember or Veteran	907	88			

[a]Other conditions include peripheral neuropathy, leg injury, or other self-described health conditions.

ADs to perform these community-based activities, ranging from 24% to 35%. Device utilization varied when performing exercise and recreational activities. For example, 94% of participants reported using LLOs for hiking up and down hills, while 78% used LLOs for vigorous exercise (Figure 1).

Patterns of LLO use differed by health condition with certain activities. Significant differences in LLO utilization were most frequently identified between participants with MS and CMT, where use was often significantly less among those with MS than among those with CMT. Differences in orthosis use between participants with MS and CMT were statistically significant ($p = .0083$) for five of seven of the activities performed in and around the home, and eight of nine activities performed out in the community (Table 2).

Discussion

Study results indicate that participants were more likely to use LLOs and/or ADs for activities in the community compared to activities in and around their home. This finding may reflect a tendency to forego use of LLOs in familiar environments with known structural supports such handrails, counter tops or furniture, or during routine activities that tend to be of lower physical demand and/or shorter duration. The inconvenience of locating and putting on devices may also contribute to an individual's decision to perform activities without them. Understanding these variations in device utilization may help providers establish realistic expectations with patients regarding the activities for which LLOs and/or ADs could be most beneficial. However, engaging in certain activities without LLOs or ADs may have negative consequences. For example, Nikamp et al. described the incidence of falls for 16 participants who received an AFO during the subacute phase of their stroke recovery.[14] Within this group, nine participants experienced at least one fall during the first 8 weeks of the study, with seven of the 11 documented falls (64%) occurring when the participants were not wearing their AFO. The tendency for some individuals to forego use of their LLO at home may contribute to Schmid et al.'s observation that 80% of falls among those with chronic stroke occur at home rather than in the community.[15]

The proportion of individuals who use AFOs relative to those who use other types of LLOs in the current study sample generally aligns with the distribution of patients seen by orthotists in the United States. The most recent American Board for Certification in Orthotics, Prosthetics, and Pedorthics (ABC) Practice Analysis, e.g., indicates that AFOs

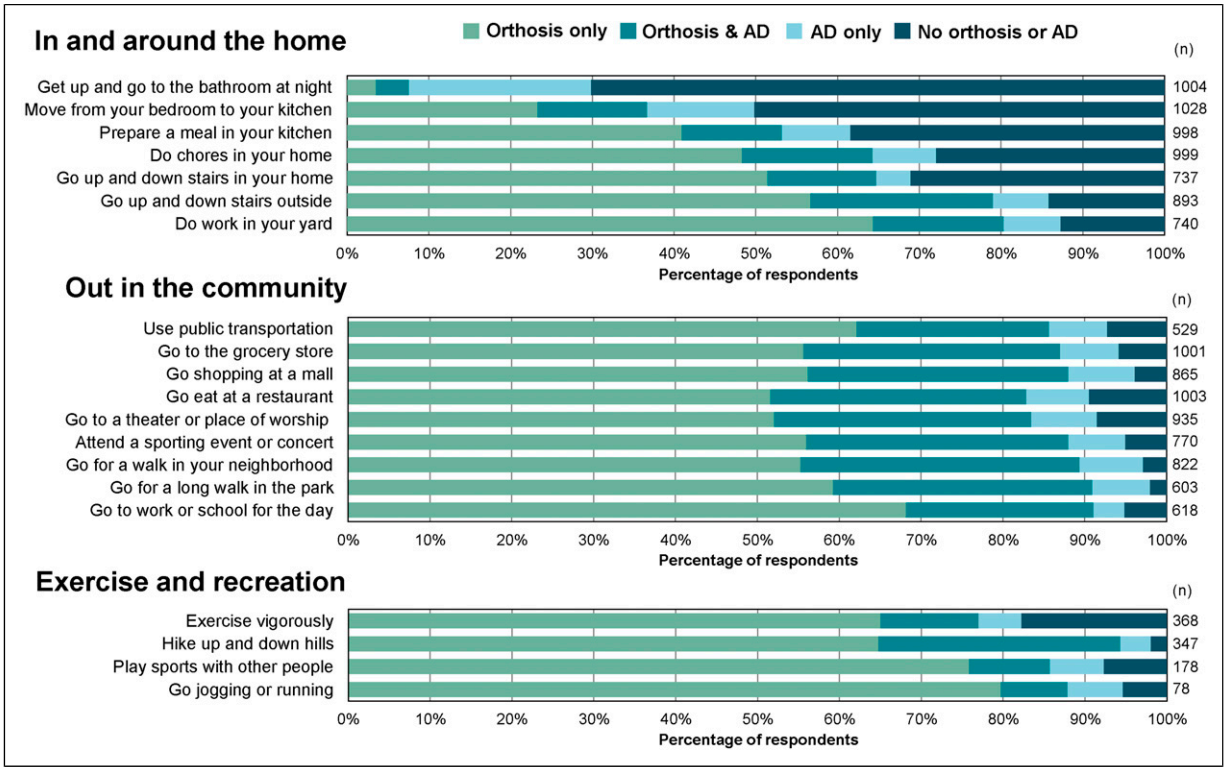

Figure 1. Percent of participants who usually use lower limb orthoses (LLOs) and/or assistive devices (ADs), or no devices, to perform activities included in the device utilization survey. The number of participants who reported performing each activity is noted to the right.

account for 82% of the LLO interventions considered for this study (i.e., AFOs, KAFOs, HKAFOs, and FES devices).[16] Users of LLOs generally reported participating in the physical activities included in the device utilization survey, with high numbers of participants engaging in those activities performed in and around the home and just slightly fewer numbers participating in community-based activities. Notably, the limited numbers of LLO users participating in some activities may reflect a lack of familiarity or opportunity associated with that activity rather than inadequate physical capacity. For example, the observation that more individuals navigate stairs outside (86%) than in their home (71%) suggests that some individuals have the physical capacity to navigate stairs but simply do not have stairs in their home. Similarly, the low numbers of participants who indicated they do not access public transportation (51%) likely reflects individual and community transportation resources more than it does these individuals' physical capacity.

In a prior qualitative study, LLO users who participated in focus groups described specific scenarios where they would choose to use no devices, LLOs only, ADs only, or both LLOs and ADs.[11] Similar to survey responses in the current study, examples from the focus group study included moving around the kitchen with no devices, walking a mile or less with LLOs only, walking more than a mile with ADs only, and running errands with LLOs and ADs. Focus group participants also discussed a decision-making process that required them to consider the trade-offs associated with using different types of devices. The participants described how they plan ahead to make sure they have ADs or LLOs available for specific activities. For example, one participant in that study reported that his KAFO was sufficient for walking short to moderate distances, but he would choose to use crutches without the orthosis for walking longer distances. Other participants shared their strategies of considering the availability of fixed supports such as handrails, countertops, or walls when planning to perform an activity.[11] These examples of planning ahead and not using devices when fixed supports are available may help explain why participants in the current study reported lower use of devices at home. Future studies could examine both the choice to use a device as well as information about the rationale for why they made that decision.

With respect to device utilization in specific clinical populations, conflicting LLO use patterns have been reported. For example, Vinci et al. reported on a cohort of 25 individuals with CMT indicated for bilateral LLOs due to foot drop or other lower limb weakness, of which only five

Table 2. Orthosis use percentages among participants with the four most frequently reported primary health conditions, and comparisons of orthosis use between groups.

	Item	SCI (n = 102)	CMT (n = 86)	MS (n = 66)	Stroke (n = 64)	Comparisons with significant differences (p < .0083)
1	*Get up and go to the bathroom at night*					
	Performs activity (n)	97	84	64	58	
	Performs with orthosis (%)	10%	7%	5%	17%	
	Performs without orthosis (n)	90%	93%	95%	83%	
2	*Move from your bedroom to kitchen*					
	Performs activity (n)	100	86	65	64	
	Performs with orthosis (%)	39%	45%	29%	52%	
	Performs without orthosis (%)	61%	55%	71%	48%	
3	*Prepare a meal in your kitchen*					CMT vs MS (p = .002),
	Performs activity (n)	101	85	61	56	MS vs stroke (p = .004)
	Performs with orthosis (%)	54%	62%	36%	63%	
	Performs without orthosis (%)	46%	38%	64%	38%	
4	*Do chores in your home*					CMT vs MS (p = .001),
	Performs activity (n)	101	84	64	56	stroke vs MS (p = .002),
	Performs with orthosis (%)	66%	70%	44%	71%	SCI vs MS (p = .004)
	Performs without orthosis (%)	34%	30%	56%	29%	
5	*Go up and down stairs in your home*					SCI vs MS (p < .001),
	Performs activity (n)	76	67	50	38	CMT vs MS (p = .007)
	Performs with orthosis (%)	76%	69%	44%	71%	
	Performs without orthosis (%)	24%	31%	56%	29%	
6	*Go up and down stairs outside*					CMT vs MS (p < .001)
	Performs activity (n)	92	75	57	50	SCI vs MS (p = .001)
	Performs with orthosis (%)	85%	88%	60%	76%	
	Performs without orthosis (%)	15%	11%	40%	24%	
7	*Do work in your yard*					CMT vs MS (p < .001)
	Performs activity (n)	84	63	40	33	
	Performs with orthosis (%)	76%	92%	63%	76%	
	Performs without orthosis (%)	24%	8%	38%	24%	
8	*Use public transportation*					CMT vs MS (p = .002)
	Performs activity (n)	58	42	33	31	
	Performs with orthosis (%)	88%	98%	73%	81%	
	Performs without orthosis (%)	12%	2%	27%	19%	
9	*Go to work or school for the day*					
	Performs activity (n)	71	48	34	28	
	Performs with orthosis (%)	89%	98%	79%	89%	
	Performs without orthosis (%)	11%	2%	21%	11%	
10	*Go to the grocery store*					CMT vs MS (p = .001),
	Performs activity (n)	102	86	62	56	CMT vs stroke (p = .002)
	Performs with orthosis (%)	86%	97%	79%	80%	
	Performs without orthosis (%)	14%	3%	21%	20%	
11	*Go shopping at a mall*					CMT vs MS (p = .001),
	Performs activity (n)	92	74	47	47	CMT vs stroke (p = .002)
	Performs with orthosis (%)	87%	97%	79%	81%	
	Performs without orthosis (%)	13%	3%	21%	19%	
12	*Go eat at a restaurant*					CMT vs MS (p = .001),
	Performs activity (n)	101	82	62	61	SCI vs MS (p = .003)
	Performs with orthosis (%)	89%	91%	71%	80%	
	Performs without orthosis (%)	11%	9%	29%	20%	

(continued)

Table 2. (continued)

	Item	SCI (n = 102)	CMT (n = 86)	MS (n = 66)	Stroke (n = 64)	Comparisons with significant differences (p < .0083)
13	*Go to a theater or place of worship*					CMT vs MS (p = .001)
	Performs activity (n)	94	81	54	60	
	Performs with orthosis (%)	83%	94%	72%	85%	
	Performs without orthosis (%)	17%	6%	28%	15%	
14	*Attend a sporting event or concert*					CMT vs MS (p < .001), SCI vs CMT (p = .006)
	Performs activity (n)	86	61	40	42	
	Performs with orthosis (%)	85%	98%	73%	88%	
	Performs without orthosis (%)	15%	2%	28%	12%	
15	*Go for a walk in your neighborhood*					CMT vs MS (p < .001)
	Performs activity (n)	87	68	49	42	
	Performs with orthosis (%)	89%	99%	76%	90%	
	Performs without orthosis (%)	11%	1%	24%	10%	
16	*Go for a long walk in the park*					CMT vs MS (p = .001)
	Performs activity (n)	69	48	31	29	
	Performs with orthosis (%)	87%	100%	77%	93%	
	Performs without orthosis (%)	13%	0%	23%	7%	
17	*Hike up and down hills*					
	Performs activity (n)	47	31	13	18	
	Performs with orthosis (%)	94%	100%	92%	89%	
	Performs without orthosis (%)	6%	0%	8%	11%	
18	*Exercise vigorously*					
	Performs activity (n)	51	22	20	15	
	Performs with orthosis (%)	80%	91%	80%	73%	
	Performs without orthosis (%)	20%	9%	20%	27%	
19	*Play sports with other people*					
	Performs activity (n)	27	9	7	6	
	Performs with orthosis (%)	70%	100%	86%	83%	
	Performs without orthosis (%)	30%	0%	14%	17%	
20	*Go jogging or running*					
	Performs activity (n)	11	1	1	3	
	Performs with orthosis (%)	91%	100%	100%	67%	
	Performs without orthosis (%)	9%	0%	0%	33%	

SCI: spinal cord injury, CMT: Charcot Marie Tooth disease, MS: multiple sclerosis.

reported acceptance and use of their devices.[17] By contrast, Zuccarino et al. performed a larger study with over 300 LLO users with CMT.[18] While usage patterns and wear times were not reported, over half of their sample agreed with the statement that "my orthosis is comfortable throughout the day." Findings from the present study tend to align more closely with Zucarrino and colleagues as LLO use among participants with CMT was more common during indoor household activities. Swinnen et al. reported that LLO users with MS (n = 20) tended not to use their devices in indoor, predictable walking environments where they could anticipate and accommodate walking difficulties, but instead wore their devices while ambulating outdoors where walking-surfaces were less consistent and predictable.[4] Findings from the present study largely aligned with these results as fewer participants with MS wore their LLOs during indoor activities than those in other health condition groups. Differences in utilization patterns between LLO users with CMT and LLO users with MS may reflect the underlying pathologies for these conditions. Patients with CMT often have a more complete neuromuscular weakness,[19] while patients with MS have graded neuromuscular fatigue with activity.[20]

One limitation of this study is the limited racial and ethnic diversity in the study sample. The current study sample also had a slightly higher proportion of AFO users than expected based on the ABC Practice Analysis.[16] Another potential limitation was a lack of information collected on symptom severity. Participants in this study were grouped by health conditions, but symptom severity

may vary substantially within a diagnosis group. Future studies that include in-person testing could also report information about symptoms and functional presentation. In the current study, participants were asked if they "usually" perform activities, rather than asking about how frequently they perform them. Information about the frequency with which LLO users perform each type of activity may provide more detailed data that could further inform clinicians about LLO and AD utilization. Also, the survey did not allow participants to report their levels of support received from others (e.g., caregivers, family, friends) when performing activities. A subsequent version of this survey could include a response option to indicate whether support from another person is needed in each situation. In the current study, participants needed to have a history of using a LLO for at least six months, and individuals who had received a LLO but never used it, were excluded from the study. The intention of this eligibility criteria was to include participants who had opportunities to experience the range of situations included in the survey after receiving their LLO. However, this strategy did bias the sample towards individuals who are generally more likely to use their LLOs. The current study provided a snapshot of LLO and AD utilization among people with a variety of health conditions. Longitudinal studies could examine changes in device utilization, or the effects of using devices separately or simultaneously over time. Another limitation was the selective analyses performed for the scope of this study. Additional analyses could be performed to compare other combinations of AD and LLO utilization for each survey item. Lastly, a large sample size was achieved because this study did not involve observational testing. Future studies with smaller sample sizes could also include sensors to compare device use and activity to survey responses.

Findings from this study provide clinicians involved in LLO rehabilitation with valuable information about the patients they treat. LLO users with a range of pathologies can perform some activities in and around the home without using devices. However, they increasingly choose to utilize LLO and AD in less-familiar outdoor and community settings. This knowledge can help clinicians establish reasonable expectations and priorities when providing LLO interventions. This information can also aid clinicians in communicating with patients the importance of both LLOs and ADs in outdoor environments. LLO and AD utilization appears to vary between certain primary diagnoses and these populations may benefit from information on typical device use across a range of activities. Those with MS, for example, may appreciate the insight that LLOs can improve their mobility out in their community, while those with CMT may find value in the expectation that LLOs can optimize mobility both at home and in the community. Acceptance of newly prescribed LLOs and/or ADs may be enhanced by providing patients with informed expectations on common usage patterns and assisting them in planning which devices to use in different circumstances.

Conclusion

Most LLO users in the United States regularly participate in a diverse range of physical activities both in and around the home and in the community. Fewer users, however, participate in activities characterized as exercise and recreation. LLOs were utilized extensively across a wide range of everyday activities, with fewer participants reporting use during home-based activities relative to activities in the community. Simultaneous use of ADs and LLOs was most frequently reported when performing outdoor activities. Clinicians can apply this information by discussing LLO and AD use with patients to optimize their functional outcomes at home and in the community.

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Supplemental Material

Supplemental material for this article is available online.

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