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Original Paper

Effective Assessment of Power Standing Device to Adults with Permanent Lower Limb Paralysis

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Abstract

Introduction: *Standing routine is a known beneficial daily activity for both healthy and disabled persons, especially those with permanent lower limb paralysis. However, the prescription of standing device for adults with permanent paralysis was inadequate and non-standard in existing local practice because of lack of good design and evidence based funding support.* ***Objective:*** *In view of the availability of new advances in power standing device, we aim to perform an effective health technology assessment (HTA) from professional and users perspectives to develop the decision pathway in prescription for long term home use.*

Methodology: *A functional test and social cost analysis was performed on one high cost new standing mobile devices in recent market. A practical workshop and surveys were performed to collect feedback from 24 healthcare professionals and 8 expert users on a spectrum of new standing mobile device.*

Results: *From the survey results, there was consensus among all participants that 'Standing' as daily routine at home is essential and beneficial. 62.5% of healthcare professionals would provide training to users and their cares to facilitate users to perform standing at home. Eight factors were identified from factor analysis in affecting the choice of standing devices for home use by healthcare professionals and users. Users scored high (mean=9.25/10) in "compliance with the new power standing mobile device". The cost analysis showed considerable savings in social costs in using even the high-cost power standing mobile device.*

Discussion: *The group welcomed power standing device with or without mobile function to support their standing activity at home. A possible clinical decision for prescribing different standing devices with identified factors was summarized.* ***Conclusion:*** *More recent researches have reported the negative health issues associated with prolonged sitting. With more innovative product designs, the*

power standing devices with or without mobile function is a new concept welcomed by both healthcare professionals and users in promotion of their health, preventing complications as well as independent living in home environment. A larger scale of HTA with structured cost-effectiveness analysis is essential to inform the healthcare resources planners.

Keywords

Standing in paraplegia, Upright mobility, Home use assistive technology, Health technology assessment

1. Introduction

A health technology is "any intervention that may be used to promote health, to prevent, diagnose or treat disease or for rehabilitation or long-term care" (HTA Glossary, 2017). It thus encompasses medical devices ranging from simple wooden tongue depressors and assistive devices, to the most sophisticated implants, medical imaging systems, drugs, medical and surgical procedures, and the organizational and supportive systems within which such care is provided. Health Technology Assessment (HTA) "improves the uptake of cost-effective new technologies in local settings. It also prevents the uptake of technologies that are of doubtful value for the health system" (WHO, 2011)

Prescription of assistive device to improve and maintain health of persons with chronic disabilities & prevention of unnecessary interventions or admissions due to secondary complications was imminent in view of increasing volume of permanent wheelchair users globally. About 15% of the world's population lives with some form of disability, of whom 2-4% experience significant difficulties in functioning and 1% estimated to be permanent wheelchair users. This global estimate for disability is on the rise due to population ageing and the rapid spread of chronic diseases, which date from the 1970s and suggested a figure of around 10% (WHO, 2011).

"Standing" as a daily routine, can enable certain individuals to improve functional access and enable participation in Activities of Daily Living (ADLs). It improves preserved muscle strength, range of motion and reduces the risk of contractures and spasticity in lower limbs. Standing can also promote vital organ capacity including pulmonary, bowel and bladder function, bone health, circulation which may in turn minimize the occurrence of pressure ulcers (Alekna et al., 2008; Damcott, Blochlinger, & Fouolds, 2013; Glickman, Geigle, & Paleg, 2010; Hohman, 2011; Paleg, Smith, & Glickman, 2013; Robling et al., 2002; Speigle, Maureer, & Sorenblum, 2010). Other than physical aspects, routine standing can provide numerous psychosocial and quality of life benefits (Arva et al., 2009; Dicianno, Morgan, Lieberman, & Rosen, 2013). An effective standing schedule was described as at least 5 times per week, 30 minutes duration and 5 times a week. This was suggested for improvement in outcomes such as self-care, standing balance, range of motion, strength, spasticity, pain, skin integrity and bowel/bladder functioning (Hohman, 2011). While another recommendation of 60 minutes 4-6 times a week for improvement in bone mineral density and mental status was also stated (Paleg, Smith, & Glickman, 2013).

Although several clinical researches and professional guidelines developed in overseas countries stressed on the importance and cost effectiveness of routine standing, the current practices across healthcare professionals varies and seldom reported. Local scenarios also faced with the documented disabling barriers including inadequate policies and standards, lack of provision of services, problems with technology design, inadequate funding and accessibility issues (WHO, 2011; HKSAR, 2014). In fact, at present, "supported standing" as home routine was not an area enlisted in local welfare or government funding subsidies for the disabled.

The emerging new advances in power standing device that can allow the user to perform standing independently sheds light in this arena. Without the pre-requisite of constant caregiver support & clumsily built facilities to stand, the use of power standing device is believed to be greatly enhancing the users' compliance and habituation to perform standing at home. Hence, we have performed a technology review, practical workshop as well as surveys to collect feedback from healthcare professionals and expert users on a spectrum of new standing devices in recent markets, aiming to develop a decision pathway for prescription for power standing devices for local reference.

1.1 Objective

Through the technology review, practical workshop and survey implemented on home-use power standing devices for a group of healthcare professionals and expert users, we aim to:

1) Collect information on the current practice
2) Explore cost effectiveness on new technologies
3) Develop decision pathway for prescription

2. Methodology and Data Management

In order to evaluate and select among different technologies the best fitted for the target users, some useful steps were used. It was very helpful to obtain information about technology that could provide innovative or improved product in the assistive technology business (ECRI, 2016; Bakouros, 2000). Every step included one or more searching & data management *tools*, which are essential and necessary for the implementation procedure. These steps were summarized as follows: (1): *Work Team Establishment* for a Preliminary Assessment—Pre-Evaluation Panel; (2): *Selection* or *Rejection* of the proposed technology, on the basis of the pre-evaluation made in step1. (3): Identification of *Key Areas / Key Informants* where additional information / evidence is required. (4): *Comparison* of *New Information* arising from step 3 with that used in the initial decision (step1). (5): *Assessment* of possible *Conflicts*. (6): Decision to *Terminate* or to *Proceed*, repeating steps 3-5. (7): Detailed Evaluation and report.

2.1 Evidence Building

The principle investigator organized a pre-evaluation panel (PEP) of 4 persons who were the seniors and specialists in the Centre relevant in the delivery of the intervention "Standing". The PEP input assisted the principle investigator to formulate the necessary materials for the key informant forum and

survey including technical brief of the power standing devices, brain-stormed the key questions, suggested key informants and gave feedback on any precautionary issues from clinical practice about the technology to be studied.

2.2 Practical Workshop and Survey

PEP identified the 6 Key Areas into 21 questions to be explored in "standing as home exercise" through workshop discussions and surveys including 1. Current knowledge in product availability and practice: frequency & duration and methods employed for standing; 2. Experience of prescription: type of standing devices, efficacy in management of complications; 3. Priorities of concerns in prescription, 4. Acceptable price range; 5. Perceived benefits and Compliance; 6. Comparison of different standing devices. Visual analogue scale of score 1 to 10 was used to show agreement to described statements.

The PEP suggested a panel of over 30 Key Informants who represent subject experts including occupational therapists, physiotherapists, wheelchair mechanist & social worker from local hospitals and non-governmental organizations; and users with either paraplegia, tetraplegia, neuromuscular disease through a half-day practical workshop or individual interview.

A spectrum of local available standing devices was examined and tested on-site during the practical workshop by the 32 key informants including:

1. Power standing device (static)
2. Manual standing device (static)
3. Power standing mobile device (new device in local market)
4. Manual wheelchair with power standing
5. Power wheelchair with power standing

To equip the key informants with a better understanding of the new "power standing mobile device" for the survey, a technical brief of device was prepared.

Table 1. Technical Brief of Power Standing Mobile Device

Power method	● mechanical or electromechanical system manipulated via levers or controller moving the seat surface from horizontal into a vertical or anteriorly sloping position while maintaining the hip and knee joint extended with feet anchored on floor level.
Dimension	● compact ● suitable for small home environment
Mode of operation	● self-manageable harness system, independent operation of power/mechanical control without helper in indoor environment
Support mechanism	● a full vertical standing position can be achieved directly from sitting ● auto-adjusted solid three-point support (chest, lower back to buttock & knee) during the whole process of standup and maintained at any interim level.
Transport method	● transportable / relocated by single normal person
Emergency	● auto stoppage when chest being compressed

mechanism	● manual stoppage at any level of standup
Potential hazard	● minimal pressure points from chest below
	● minimal shearing force during transfer from & to chair
Add-on Functions	● self-operated mobility function during standing with turning radius <=0.6m
	● remote control the mobility function when user away from the device.

2.2 Cost Analysis

The cost analysis method for assistive technology was not common compared with medical or diagnostic equipment. In this study we adopted the method in evaluating the power wheelchair program in Italy (Andrich & Caracciolo, 2007) in which we compared the human costs and social costs for maintaining standing exercise programs at home with and without using "power standing mobile device" (where the maximum cost was referenced). It is used as an informative instrument to enable clinicians and users to become aware of the economic consequences of their decisions. Based on different scenarios, carried over a number of years, it has been made to infer social cost indicators (caregivers & professional input) for scenarios. The 9 year costing analysis was created for those users who were potential users and assumed safe for performing self-standing at home if the device was provided at cost.

3. Results

3.1 Survey Results

A survey was carried out to collect the feedback from the key informants at the end of the workshop or individual interview. Total 32 questionnaires were collected from the key informants, out of which 24 came from healthcare professionals and 8 came from users. The healthcare professionals included occupational therapists, physiotherapists, wheelchair mechanist & social worker with average 15 years of experience and 8 users with either paraplegia, tetraplegia, neuromuscular disease with 7.7 years of onset average.

In exploring the current practice among the healthcare professionals, 62.5% of them would provide training to users and their cares to facilitate users to perform standing at home after hospital discharge. However, the users showed more concerns over prevention of complications of being chair bound and strongly believed (mean score >9) that the complications can be resolved by standing. 41.7% of healthcare professionals asked their users to perform standing at least once per day. However, most of the users reported that they couldn't follow the advised regime due to different reasons, e.g., lack of caregivers' assistance, risk of fall while standing, unfit devices, developed upper limbs pain and lack of functional purposes.

Similarly, both healthcare professional & users also strongly agreed to the positive benefits of routine standing in resolving complications of being chair-bound. As an innovative or improved assistive

standing device, the "Power standing mobile device" was more preferred (mean score >8) than the other four conventional standing devices (shown in the forum) by both healthcare professionals and users in terms of its efficiency (mean score 8.7 & 8) and, functionality (mean score 8.6 & 8.2) and device compliancy (mean score 8 & 9.25). However, lower score were obtained when comparing the "power standing mobile device" with "ceiling mounted hoist" (mean score 7.3 & 4.3) or "power wheelchair with standing function" (mean score 7.5 & 6.3). That was obvious when these two other devices were serving more than one functional needs which may not be simply replaceable by power standing device.

Table 2. Mean Score Comparison on Benefits of New Standing Device

Q5	Statements	Professional score Mean / 10 (SD)	Users score Mean / 10 (SD)
I	New device allows a more efficient and effective way than conventional devices	8.7 (±1.3)	8.0 (±2.4)
ii	Mobility function of new device is essential to users who are socially active or home alone	8.6 (±1.2)	8.2 (±1.4)
iv	Users will be more compliant to new device than conventional devices	8.0 (±1.5)	9.25 (±0.9)

In order to have more understanding in **Factors affecting prescription**, Principal Component Analysis (rotated with Varimax Kaiser Normalization method) of collected data was performed. There are 8 significant factors (Eigenvalues 6.728 to 1.166; 93.167% cumulative variance). The factors (factor loading > 0.80) which significantly influence prescription and application of the standing devices were grouped and renamed below in decreasing loading order as Acceptable price & Perceived benefits, Professional experience, Benefit of device in indoor application, Knowledge of the device, Caregiver burden, Caregiver availability, Home space and Avoid complications.

Table 3. Principal Component Analysis (Rotation with Varimax with Kaiser Normalization)

Total Variance Explained						
Component	Initial Eigenvalues			Rotation Sums of Squared Loadings		
	Total	% of variance	Cumulative %	Total	% of variance	Cumulative %
Acceptable price range vs. effectiveness	5.728	22.912	22.912	4.319	17.275	17.275
Professional experience	5.161	20.644	43.556	4.290	17.159	34.434
Benefit of device in indoor application	3.395	13.580	57.137	2.978	11.914	46.347
Knowledge of device	2.544	10.178	67.314	2.778	11.111	57.458

Carer burden	2.225	8.900	76.214	2.740	10.958	68.416
Carer Availability	1.666	6.664	82.878	2.304	9.217	77.633
Home space	1.406	5.624	88.502	2.022	8.088	85.721
Help avoid complication	1.166	4.665	93.167	1.861	7.446	93.167

3.2 Costing Analysis Results

The highest cost of the standing device, i.e., the power standing mobile device, was regarded as the "intervention" for calculation. Three levels of assistance were adopted for comparison between with or without the "intervention". The recommended regime of standing exercise for 5 times a week and 30 minutes per day was used for hourly cost estimation. And we assumed for those that can perform standing independently in using the power standing device after adequate training, level B (caregiver with knowledge and ability) and level C (professional) assistance are not required. The 9 year costing analysis finding clearly showed that using of "power standing mobile device", though relatively expensive in terms of initial purchase price, lead to savings of HK$ 0.07M in social costs due to the reduced burden of care per user per year.

Table 4. Valuation of Yearly Human Cost for Standing Exercise at Home with and without Intervention

	# Assistance Level	Actions per week	Minute per action	hourly cost equivalent HK$	Yearly Cost HK$
With intervention (power standing mobile device)	Level A	5	5^	34.5*	747.5
	Level B	0	0	99.2**	0
	Level C	0	0	208.3***	0
					HK$ 747.5
Without Intervention^^	Level A	0	0	34.5*	0
	Level B	5	30	99.2**	12896
	Level C	0.25	60	208.3***	2707.9
					HK$ 15604

Note. # Level A Assistance = That which can be provided by anybody; # Level B Assistance = That requiring basic caring knowledge & good physical capabilities; # Level C Assistance = That requiring specific professional qualification (e.g., nurse / physiotherapist etc.). ***** The Statutory Minimum Wage rate HK$34.5 per hour with effect from 1 May 2017. ****** Hourly wage equivalent for a Social Welfare Department for NGO Personal Care Worker with Mid pt MPS=6 in May, 2018. ******* Hourly wage for Home Rehab Service from Allied Health Professional with Mid pt MPS =19 in May, 2018. ^ 5-min human cost (Level A) is estimated for a 30-min standing exercise session at home with intervention. ^^ Domiciliary support from Allied Health Professional at frequency of once per 4 weeks is included when without intervention.

Table 5. Valuation of the Social Cost (HK$) for a 9-year Plan with & without AT Intervention

		Social Costs With Intervention (power standing mobile device used) HK$	Social Costs w/o Intervention (walking frame + manual support only) HK$
Year 1	Investment	80000	500
	Maintenance	0	0
	Service	0	0
	Assistance	747.5	15604
Year 2	Investment	0	0
	Maintenance	0	0
	Service	0	0
	Assistance ^	770	16072
Year 3	Investment	0	0
	Maintenance	0	0
	Service	0	0
	Assistance ^	793	16554
Year 4	Investment	0	0
	Maintenance	4000	0
	Service	2000	0
	Assistance ^	817	17051
Total Expenditure in 9 years **(TE9)**[#]		99594	159023
Remaining value (20 % yearly depreciation rate) **(RV9)**[#]		10737	67
Total Cost for 9 year **(TE9 – RV9)**		HK$ 88,857	HK$ 158,956

Assistance ^ : 3% yearly inflation of human assistance cost adjustment included.

4. Discussion

From the survey results, to prescribe standing routines for users with permanent lower limb paralysis was not a standard practice as such with only 62.5% of positive response. There was high consensus

among 24 healthcare professionals and agreed by 8 users that "Standing" as a daily routine at home is essential and beneficial in terms of reduction of complications and health maintenance. Although there are still no overwhelming evidence in supporting standing need of the disabled, the group do believe power standing device would be welcomed by everyone to support their standing activity at home. From the cost analysis, application of power standing mobile device also demonstrated its cost-effectiveness in terms of social costs. The clinical decision pathway in prescribing a suitable standing device for home use is nothing simple as reflected by the multiple factors being analyzed. In fact, the professional forum have spent much time in discussion on the factors weighing but no conclusion could be drawn as different users have highly individualized concerns in his physical, social, environmental and psychological needs. Here we intend to devise a possible clinical decision for prescribing different standing devices with identified factors based on the above results and overseas guideline (LTCSA, 2012) summarized in the following chart.

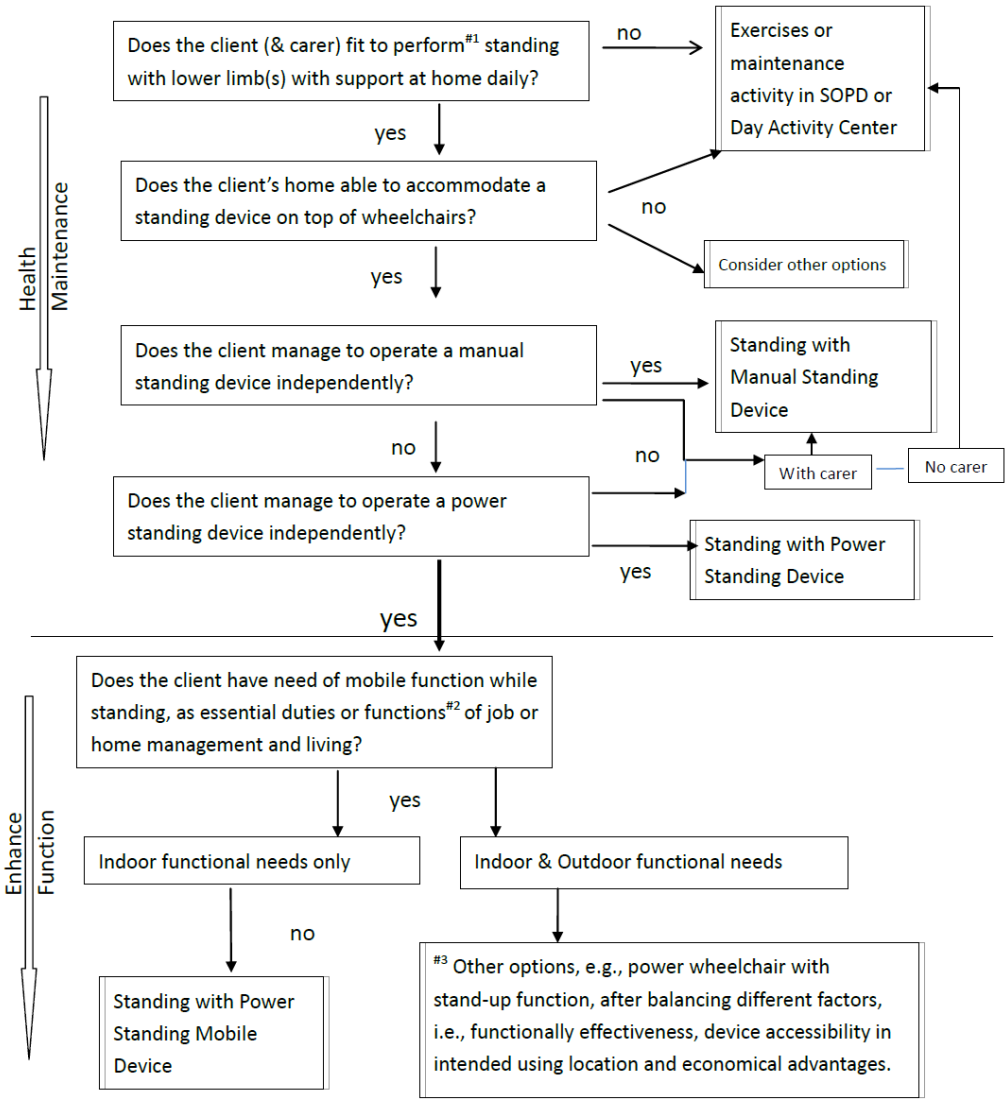

Figure 3. Clinical Decision in Prescribing Standing Devices

As reflected from factor analysis, "cost effectiveness" is the priority concern in prescription. If a standing device is to be prescribed to improve client's physical function(s), the benefits should be substantiated through measurement of functioning before and during trial of a standing device. For enhancing performance and participation with activities, repeated trials of the standing device by the potential user, in the environment, especially in a congested area, in which it will be used, are essential before a definitive standing device prescription is made. Therapist needs to justify how the user's specific duties, and /or ADLs are impacted by the standing device.

To support the concerns identified in this study of whether caregiver burden can be relieved through the use of power standing device, training of device application to equip potential user with safe and proficient skills in device using, i.e., transfer, device parts operation, users' physical tolerance, maneuver and emergency handling, is deemed necessary before prescription. On the other hand, not everybody is an appropriate candidate for standing. Some contraindications and precautions include but are not limited to existing contractures, skeletal deformities, lack of standing tolerance, bone mass density loss, postural hypotension, sacral shearing, and the need for adaptive or custom seating (Arva et al., 2009). Special precautions were described so as when utilizing standing device in order to avoid the risk of injury, such as fractures, a professional (either physiotherapist or occupational therapist) must be involved with the assessment, prescription, trials and training in the use of equipment (Dicianno, Morgan, Lieberman, & Rosen, 2013).

Besides, therapist should also take user's home or workplace environment into consideration and make adjustment if indicated in order to fully utilize the device. Nevertheless, home space is always the limiting factor in the congested housing environment in Hong Kong which considerations and acceptance by the family members are also crucial.

5. Conclusion

As an innovative product, the "power standing mobile device" has applied the concept of "Upright Mobility". It not only serves as purely a standing device, but also serves both functions of enhancing users' daily function by changing users' posture and indoor mobility. And it is proven as social cost-saving. It is a new concept welcomed by both clinicians and users in our study that required our openness and creativeness to prescrib.

Mainstream wisdom seems to be catching up with what seating & mobility clinicians have known for decades that more recent researches are looking at healthy adults who sit most of the day and have reported the negative health issues associated with prolonged sitting. Although it seems to have no overwhelming evidence in supporting standing need of the disabled in adult population, we do believe the standing activity is a "basic and essential activity" to everyone and need to be addressed. From the cost analysis, application of power standing mobile device already demonstrated its cost-effectiveness in terms of social costs, without mentioned the medical costs savings in prevention of complications & hospital admissions.

The newly designed power standing devices demonstrated dominant preference and practical advantages when compared with most of conventional assistive standing devices according to informants' evaluation. For cases that need multiple devices to assist functions, especially those who are using or going to use power wheelchair, clinicians should assess their potential and genuine needs according to the factors suggested.

The healthcare professionals in the community support services centers differ from the hospital based services, focused on the development and adoption of home-use advanced assistive technology to enhance the long term outcome of rehabilitation service. The technology assessment report here compiled tried to provide the healthcare professionals across hospital and community settings with comprehensive, evidence-based information on related conditions of disabilities and feasibility of adoption of new assistive technologies. We also identified service gaps in the selected areas, identified weakness in present support and suggested needs for future service planning. To bring the broadest range of experts into the development of evidence reports and technology assessments, the community rehabilitation team should enter into collaborations with academics, other healthcare providers and related organizations; and to undergo peer review and user comments. This was the very first HTA process undertaken in home-use assistive technologies in local government funded service. Through the process, we achieved to inform the healthcare planners the safety, efficacy and evidence of the Power Standing devices and could be develop further for future assessment for items which are 1) Innovative or improved products new to local service, 2) with potential to meet the existing service needs / service gap, 3) provide a better alternative way to meet the special needs of our users, 4) expected healthcare & social cost savings to current practice.

Ethical approval:

All procedures performed in studies involving human participants were in accordance with the ethical standards of the institutional and/or national research committee and with the 1964 Helsinki declaration and its later amendments or comparable ethical standards. Informed consent was obtained from all individual participants included in the study.

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