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Beginning power mobility: An exploration of factors associated with child use of early power mobility devices and parent device preference

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Abstract

Objectives: Describe and compare young children's use of four early power mobility devices and examine associations between child and environmental factors that may influence power mobility use and parent device preference.
Design: Cross-sectional observational study.
Methods: Power Mobility Days introduced four devices: Wizzybug, Bugzi, Tiger Cub, and a switch-adapted ride-on toy car in a single 60–90 min, play-based session.
Results: A convenience sample of 74 children, aged 9–68 months (mean: 32.45, SD: 14.08) with mobility limitations, and their parents participated. Children had a range of motor, postural and communication profiles, with cerebral palsy being the most common condition ($n = 55$; 73.33%). Assessment of Learning Powered mobility use phase achieved ranged from 1 to 6; mean: 2.34; median: 2. For children who tried all four devices ($n = 51$), Friedman test (χ^2: 8.27, $p = 0.04$) suggests Assessment of Learning Powered mobility use phase differs across devices. Of 73 parents who identified a device preference, 43 (59%) chose Wizzybug. Regression analyses suggest that access method and communication function may influence children's power mobility use, while age, access and postural support requirements may influence parent device choice.
Discussion: Parent impressions of an early power mobility device may be influenced by many factors, yet be less influenced by child performance.

Keywords

Assistive technology, mobility devices, occupational therapy, rehabilitation, seating, statistical analysis (medical), wheelchair

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Introduction

Self-directed mobility allows children to explore, influencing development across cognitive, perceptual, social and motor domains.[1] For children with disabilities and developmental delays, a lack of independent mobility in early childhood can 'set them on a slow and disadvantaged developmental spiral' (Durkin, p.163).[2] Learning occurs through active perceptual-motor experience and early intervention should promote early sitting, interaction with toys and independent mobility.[3]

Power mobility use can promote independent mobility for children with disabilities,[4] positively influence overall development[5,6] and may be introduced as early as eight months of age.[7] Children with mobility challenges can use powered devices to explore their environment in a similar manner to their peers, helping increase play, socialization and participation in meaningful and age-appropriate activities.[8] However, power

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mobility is rarely prescribed to children under two or three years of age.[9]

Limited availability of developmentally-appropriate devices is one factor that may contribute to this gap between the growing body of research evidence and early implementation.[10] Studies suggest that size, weight, safety and transportation of power mobility devices are major concerns for parents of young children.[5,11] While child-and-family-friendly options such as switch-adapted ride-on toys and novel devices developed specifically for young children[12] may help, funding and availability are also considerations.[10] Single-subject, case studies and small group studies have explored the impact of providing independent mobility through ride-on toys[4,5,11]; however, none have examined the introduction of different kinds of power mobility devices to young children.

This is the first study, to our knowledge, that aims to describe and compare young children's use of different early power mobility devices during a single introductory play-based session. It also explores associations between various child and environmental factors that may influence parent device preference and child's potential use of power mobility. We anticipated that potential locations of use, home accessibility, transportation, postural support requirements and access method (switch, joystick or other specialty controls), as well as their child's ability to use the device might influence parents' device impressions.

Method

This cross-sectional, observational study recruited a convenience sample of young children and their families to participate in a Power Mobility Day. These were single exploratory, play-based sessions where children explored four different power mobility devices along with their parents and primary therapists. University of British Columbia Children's and Women's Research Ethics Boards granted ethics approval and all participating parents provided written informed consent.

Participants and recruitment

Power Mobility Days were conducted at the provincial paediatric rehabilitation facility (Sunny Hill Health Centre for Children) and eight different community child development centres throughout British Columbia. Researchers collaborated with community therapists to organize each Power Mobility Day. Children from the different communities were recruited by their primary community therapists or their seating and mobility therapists using purposeful sampling.

Inclusion criteria:

- Children aged between six months and five years of age with a diagnosis or delay that suggested limited mobility in early childhood.
- Parents who were willing to participate in a single 1–1½ h play-based session with their child.

Parents needed sufficient English to participate in the Power Mobility Day and complete ratings, although some used an interpreter to ensure full understanding of consent processes.

Materials

Devices included: Bugzi (http://meru.org.uk/what-we-do/bugzi/); Wizzybug (www.designability.org.uk/product/wizzybug/); switch-adapted ride-on toy car (various models, available from toy stores) hereafter referred to as Car; and Tiger Cub power wheelchair (previously available from www.invacare.com – now discontinued). Bugzi and Wizzybug are specially designed for children under six years and include adjustable seating systems with trunk and head support. During Power Mobility Days, Wizzybug was operated with a left or right side-mounted proportional joystick. Bugzi was operated with a digital joystick or between one and three switches positioned with Velcro on a large tray. For children with very limited hand function, switches were mounted to the headrest or on either side of the head using adjustable mounts. Cars were customized with single-switch access plus seats with trunk support, and head support if required. Tiger Cub, a scaled-down version of a traditional power wheelchair, had fully supportive seating (including pelvic, thigh, trunk, head, arm and foot supports) and either midline joystick or proximity head array access. Upper limb support was provided with a tray if required. See Figure 1 for typical device setups.

Procedures

Children were scheduled into a Power Mobility Day at a convenient time and location and, depending on numbers in the different communities, could be group or individual sessions. During group sessions, arrival times were offset throughout the day with two to three children, their parents and therapists often present at any one time. Individual children typically spent between 60 and 90 min exploring the devices. Sessions took place in large-enough play spaces to ensure safety and manoeuvrability for multiple devices. Children and their families were introduced to power mobility experiences in a play-based setting that promoted play and socialization, similar to typical infant/toddler/preschool drop-in gym recreational programmes.

Figure 1. Typical device setups for Power Mobility Days. Clockwise from top left: Tiger Cub, Car, Bugzi and Wizzybug.

Participants were engaged in movement-based activities such as ball games, music or catching bubbles, depending on the child's interest and tolerance. Order of device trial was determined by child and/or parent preference. Child motivation and engagement guided length of time in each device, total length of session and whether or not the child repeated experiences in any devices. Parents were encouraged to take an active role in being a 'responsive partner', guiding their children's play and exploration[13] without expectation that power mobility prescription would be a necessary next step. Community therapists assisted in engaging children in play during the device trials. This novel approach is in contrast to typical rehabilitation appointments where power mobility assessment is part of individual device prescription.[14]

Data collection

Sample descriptors were collected either prior to or at the start of the session and included: socio-demographic information, Gross Motor Function Classification System (GMFCS)[15]* or equivalent level of function for children with diagnoses other than cerebral palsy; Manual Ability Classification System (MACS)[16]* or mini-MACS[17]* (for children under four years); Communication Function Classification System (CFCS)[18]; and Level of Sitting Scale (LSS).[19] The GMFCS, MACS, Mini-MACS and CFCS each have five levels with V being the most severe. They were developed for children with cerebral palsy, although the CFCS has now been validated for other disabilities. These standardized, valid and reliable classifications[20] were used with all children (regardless of diagnosis) only to provide a quick and common descriptor of current functional abilities. Although a brief generic functional descriptor would have been preferred, to the best of our knowledge, one has yet to be developed.[21]

The LSS classifies sitting ability along an eight-point scale and is valid for all children. At level 1, two adults are required to support the individual in bench sitting for 30 s. Those who can be supported by one person from the head downwards are classified at level 2, from the trunk downward at level 3 and from the pelvis at level 4. Children at level 5 can bench sit with feet unsupported for 30 s without movement while those at levels 6–8 can lean forwards, sideways and backwards respectively and re-erect while seated. LSS has a significant inverse correlation[22] with GMFCS.

Children's experiences using the different devices were video-recorded, and at the end of the session, parents identified their preferred device. Video-recordings were captured by researchers, community therapists, volunteers or occupational therapy students, depending on availability of personnel at each site. A standard video-recording protocol was not possible due to the non-experimental, clinic-based nature of the sessions, variability in environment and numbers of children and/or adults present. Field notes recorded order of device trial, child response and parent comments.

The Assessment of Learning Powered mobility use (ALP),[23] an eight-phase process-based measure describing occupational performance using a power mobility device, was scored later from video by consensus of two consistent raters. Individuals functioning at Phase 1 or 2 are just beginning to explore effects of joystick or switch activations while by Phase 3, they demonstrate understanding of cause–effect relationships. At Phases 4 and 5, individuals are exploring different activation effects and directional control and by Phase 6, they have established basic steering control. At Phase 7, individuals begin to use the device to participate in other activities, while Phase 8 describes expert control. The ALP has established validity for a wide range of ages and abilities and was developed from a previous measure that demonstrated good reliability (κ_w 0.85).[23] Recent unpublished research indicates that the ALP has good inter-rater reliability (κ_w 0.85) between therapists and caregivers (L. Nilsson, personal communication: March 5, 2020).

Data analyses

Study data were managed using REDCap[24] electronic data capture tools and open-source R version 3.5.1 was used for all statistical analyses.[25] Descriptive analyses of participant characteristics (age, sex, diagnostic group, functional classifications and environmental factors) included frequencies, percentages, range and measures of central tendency and dispersion as appropriate for data type. To further explore factors influencing ALP phase differences between devices, three sub-group analyses were conducted: (i) ALP Stable (children whose ALP phase did not change more than one phase across devices); (ii) ALP Change (children whose ALP phase changed by two or more phases across devices and (iii) ALP 4–6 (children who achieved ALP 4 or higher in at least one device).

A non-parametric statistical approach was selected as measures used primarily ordinal data. Friedman's Test examined possible differences in ALP phase across the four devices. Spearman's correlation coefficients and Fisher's exact test examined associations between ALP phase and the various child descriptors as well as device preference. Spearman correlations between classifications for entire sample and diagnostic sub-groups were also conducted to address potential concerns regarding use of cerebral palsy-specific classifications for other diagnostic groups as well as to assess for potential collinearity. Estimates were interpreted as follows: $>0.75=$ excellent, >0.5–$0.75=$ good, >0.25–$0.5=$ fair and 0–$0.25=$ weak.[26] Significance levels for all analyses were set to $p\leq 0.05$.

For Fisher's exact test and regression models, five-level classifications were dichotomized according to function (I–III or IV/V) while LSS was dichotomized as able to sit (5–8) or requires postural support (1–4). Access method was dichotomized as joystick or switch according to method used for the highest ALP phase achieved. For multinomial regression and Fisher tests, ALP phase was divided into three clusters: 1–2 (exploring functions), 3 (cause-effect) and $\geq$4 (exploring sequencing and performance).

Variables to explore associations between ALP phase, parent device preference and child characteristics were identified a priori, based on clinical relevance.[27] Spearman correlation estimates were used to assess possible collinearity between predictors. Linear mixed effects regression (lme4)[28] explored factors influencing ALP phase. Fixed effects included child characteristics and access method with switch access as the reference category. Random effects included intercepts for subjects and device used. Multinomial logistic regression (nnet)[29] explored factors influencing parent preference of a device other than Wizzybug, with lower functional levels as reference categories. Effects and interaction terms were added systematically to the model and compared to the model without that effect or interaction via Likelihood Ratio Tests and Bayesian Information Criterion.

Results

Seventy-five children aged 9–68 months (mean: 32.45; SD: 14.08) were recruited, and their parents and therapists completed consent forms, classifications and socio-demographic information. Males ($n=38$) and females ($n=37$) were equally represented. Seventy-four children participated in one of 22 Power Mobility Days conducted in nine locations between April 2016 and March 2018. One parent did not

Table 1. Participant children's ages, diagnoses and functional classification descriptors ($n = 75$).

Age mos	No. (%)	Diagnostic grouping CP	O	NM	D	Sex M	F	GMFCS* I/II	III	IV/V	MACS/mini-MACS* I/II	III	IV/V	CFCS I/II	III	IV/V	LSS 6–8	5	2–4
6–12	3 (4)	1	1	1		2	1		1	2	1	1	1			3			3
13–18	15 (20)	8	6	1		7	8	2	2	11	4	3	8			15		3	12
19–24	8 (10)	4		1	3	3	5		2	6	3	2	3		1	7		4	4
25–30	7 (9)	6	1			4	4		2	6	3	2	2		2	5		2	5
31–36	9 (12)	8	1			5	4	1	3	5	4	3	2		4	5	2	2	5
37–42	16 (21)	14	1	1		7	9	1	6	9	3	6	7	2	2	12	2	5	9
43–48	7 (9)	7				4	3		4	3	2	3	2	2	2	3	2	1	4
49–54	6 (8)	5	1			4	2	1		5	1		5			6	2		4
55–60	3 (4)	1	1		1	3			1	2	1		2	1		2	1	1	1
61–68	1 (1)	1				1				1			1			1			1
Totals	75	55	12	4	4	39	36	5	22	48	22	20	33	5	11	59	9	18	48
%	*100*	*73.33*	*16*	*5.33*	*5.33*	*52*	*48*	*6.7*	*29.3*	*64*	*29.3*	*26.7*	*44*	*6.7*	*14.7*	*78.6*	*12*	*24*	*64*

*: or equivalent functional ability (when used with a diagnosis other than CP); CFCS: Communication Function Classification System; GMFCS: Gross Motor Function Classification System; CP: cerebral palsy or a diagnosis falling under the contemporary definition of cerebral palsy[30]; D: neurodegenerative diagnosis; LSS: Level of Sitting Scale; mos: months; MACS: Manual Abilities Classification System; NM: neuromuscular diagnosis, e.g. spinal muscular atrophy; no.: number; O: other neurological diagnoses, e.g. spina bifida.
Source: reproduced with permission from Smithers-Sheedy et al., 2014.[30]

provide some demographic information and another did not identify preferred device resulting in different sample numbers. Children with diagnoses meeting the contemporary definition of cerebral palsy[30] comprised the largest group ($n = 55$; 73.33%). Remaining children had other stable neurological conditions ($n = 12$), neuromuscular ($n = 4$) or neuro-degenerative ($n = 4$) diagnoses. Table 1 provides details of child descriptors for visual comparison according to 10 different six-month age groups. LSS ratings are arranged similarly to other classification groupings for ease of reference. Appendix 1 provides more detail on participants with a diagnosis other than cerebral palsy. Since some children's diagnoses are very rare, categories were used to reduce risk of participant identification.

Most children had significant gross motor limitations (GMFCS levels IV and V ($n = 48$; 64%) or inefficient mobility (Level III; $n = 22$; 29%); however, a few children anticipated to be community ambulators at older ages (Levels I/II; $n = 5$; 7%) also participated. There were similarities between GMFCS distributions and those (i) requiring significant postural support (LSS 2–4; $n = 48$; 64%), (ii) able to sit without movement (Level 5; $n = 18$; 24%) and (iii) able to move in and out of their base of support while seated (Level 6–8; $n = 19$; 12%). Manual abilities[16,17] appear more evenly distributed while, in this young age sample, most children ($n = 59$; 78%) were communicating with familiar adults inconsistently or rarely (CFCS IV–V).

Spearman correlations were excellent between GMFCS and MACS (0.77 total sample; 0.76 cerebral palsy; 0.84 all other diagnoses) and good between GMFCS and LSS (–0.71 total sample; –0.72 cerebral palsy; –0.71 all other diagnoses). Correlations between CFCS and other classifications were fair. Results for cerebral palsy, other diagnoses and total sample were broadly consistent (Appendix 2).

Table 2 outlines parent and environmental descriptors for our sample. While many parents were very interested when initially approached, those who were 'Somewhat interested' ($n = 27$; 36%) were '*unsure of the benefits for our child*' while two were 'Somewhat upset' – '*not understanding that it doesn't replace a walker*'.

Children did not all use every device for a variety of reasons including: fatigue, prior experience or it was unsuitable for that child. The Wizzybug was unavailable for three children and Bugzi was unavailable for another child, otherwise all four devices were available for every session, and the decision to not trial a device was related to child needs and abilities (including child choice) or parent preference. Video-recordings per device ranged from 3 s (for a child who was upset and would not remain in the device) to 17 min 30 s (mean: 4 min 12 s; SD: 3 min 22 s). Video length differed between the four devices, but differences were not statistically significant.

Table 3 demonstrates that ALP phase total group scores were similar across all devices (mean: 2.34; median: 2). Sub-group analyses for 11 children who changed more than one ALP phase between devices (ALP Change) and 14 children who achieved ALP phase 4 or higher in at least one device (ALP 4–6) found differences, with medians ranging from 3 in the Car to 5 in Tiger Cub. Appendix 3 provides additional sub-group descriptive information. While age range across sub-groups was similar, children whose ALP

Table 2. Parent and environmental descriptors.

Accompanying parent	No. (%)	Primary language	No. (%)	Parent educational level	No. (%)
Mother	62 (82.7)	English	69 (92)	Did not attend Secondary School	1 (1.3)
Father	10 (13.3)	Punjabi	2 (2.7)	Attended Secondary School	7 (9.5)
Grandparent	1 (1.3)	Russian	1 (1.3)	Secondary School graduate	17 (23)
Foster parent	2 (2.7)	Turkish	1 (1.3)	Post-secondary education	27 (36.5)
Total	75 (100)	Farsi	1 (1.3)	Under-graduate degree	16 (21.6)
		Arabic	1 (1.3)	Graduate degree	6 (8.1)
		Total	75 (100)	Total	74 (100)

Location	Urban	Rural	Total (%)	Parent attitude	Initial	PM day	Therapist attitude[a]
				Somewhat upset	2 (2.7)		
Metro	25		25 (33.4)	Neutral	6 (8.1)	1 (1.3)	4 (5.4)
Day travel	27	8	35 (46.6)	Somewhat interested	27 (36.5)	23 (31.1)	18 (24.3)
Distant	10	5	15 (20)	Very interested	38 (51.4)	50 (67.6)	52 (70.3)
Total (%)	62 (82.6)	13 (17.4)	75 (100)	Do not know	1 (1.3)		
				Total	74 (100)		

Home type	Elevator	Ramp	1–2 steps	Multi-steps	Total (%)	Inside space	Outside space
Apartment	3				3 (4.1)	2	2
Suite		2	1	1	4 (5.4)	2	3
Mobile home			1		1 (1.3)		1
Single-level		5	3		8 (10.8)	8	8
Multi-level		6	20	32	58 (78.4)	43	56
Total No. (%)	3 (4)	13 (17.6)	25 (33.8)	33 (44.6)	74 (100)	55 (74.3)	70 (94.6)

Vehicle type $n = 74$	No.	No ramp	Portable ramp	Installed ramp
No vehicle	2			
Small car	7	6	1	
Mid-size car	6	6		
Mini van	22	18		4
SUV	32	31	1	
Pickup truck	13	11	2	
Total	80	72	4	4
Multiple vehicles = 7 Missing data = 1				

Preschool/Daycare attendance $n = 74$			
Days/week	No. (%)	Hours/day	No. (%)
None	40 (54)	None	40 (54)
1 day	1 (1.3)	<2 h	3 (4.1)
2 days	17 (23)	2–4 h	15 (20.3)
3 days	9 (12.2)	5–7 h	6 (8.1)
4 days	3 (4.1)	>7 h	10 (13.5)
5 days	4 (5.4)		
Total	74 (100)		74 (100)

[a]Parent impression of their child's therapist's attitude towards power mobility.

phase showed less variability (ALP Stable) appear to have more complex profiles.

Pairwise correlations among ALP phase in the different devices ranged from $r_s = 0.65–0.86$, $p < 0.001$, with strongest correlations between Wizzybug and Tiger Cub (Appendix 4); sample size varied between all complete device pairs ($n = 56$ to $n = 66$). For children who tried all four devices ($n = 51$), Friedman test was statistically significant (χ^2: 8.27, $p = 0.04$) for ALP phase differences. Fisher's exact tests of independence were significant ($p \leq 0.05$) between ALP cluster (1–2, 3 or $\geq$ 4) and GMFCS, CFCS or LSS groups for ALP Change sub-group ($n = 11$); and between ALP cluster (1–2, 3 or $\geq$ 4) and GMFCS or CFCS for ALP 4–6 sub-group. Fisher tests were not significant between ALP cluster (1–2, 3 or $\geq$ 4) and parent device preference or any environmental factors.

Table 4 illustrates linear mixed effects regression results exploring factors influencing ALP phase. Some characteristics (such as age) or functional classifications were only significant when entered as individual models. To avoid collinearity in both regression models, variables strongly correlated (e.g. GMFCS and LSS) were not entered together. In the final model, ability to communicate with unfamiliar people (CFCS I–III) and ability to use a joystick accounted for most variance in ALP. More complex models (combining more variables) could not be fit due to the small numbers included in each cell.[26,27]

Table 3. Comparison of children's power mobility skill across devices for total sample and sub-groups.

ALP phase across devices for total sample $n = 74$

Device used	ALP 1	ALP 2	ALP 3	ALP 4	ALP 5	ALP 6	Mean ALP (median)	Missing trials
Wizzybug	19	23	16	5	5	1	2.38 (2)	Wizzybug 5
Bugzi	19	26	14	6	4	0	2.27 (2)	Bugzi 5
Tiger Cub	21	19	17	4	5	3	2.45 (2)	Tiger cub 5
Car	18	20	17	5	0	0	2.15 (2)	Car 14
Total/267 trials	77 *(29%)*	88 *(33%)*	64 *(24%)*	20 *(7.5%)*	14 *(5%)*	4 *(1.5%)*	2.34 (2)	29/296 *(10%)*

ALP phase subgroup analyses

1. ALP Stable group: ALP phase did not change more than one phase across devices, $n = 63$

Device used	ALP 1	ALP 2	ALP 3	ALP 4	ALP 5	ALP 6	Mean ALP (median)
Wizzybug, $n = 59$	18	22	14	3	2	0	2.00 (2)
Bugzi, $n = 58$	17	24	12	4	1	0	1.94 (2)
Tiger cub, $n = 58$	20	18	15	3	2	0	1.95 (2)
Car, $n = 49$	18	17	10	4	0	0	1.56 (1)
Total/224 trials (%)	73 (32.59)	81 (36.16)	51(22.77)	14 (6.25)	5 (2.23)	0	

2. ALP Change group – children whose ALP phase changed by more than one ALP phase across devices, $n = 11$

Device used	ALP 1	ALP 2	ALP 3	ALP 4	ALP 5	ALP 6	Mean ALP (median)
Wizzybug, $n = 10$	1	1	2	2	3	1	3.45 (4)
Bugzi, $n = 11$	2	2	2	2	2	0	3.18 (3)
Tiger cub, $n = 11$	1	1	2	1	3	3	4.18 (5)
Car, $n = 11$	0	3	7	1	0	0	2.82 (3)
Total/43 trials (%)	4 (9.30)	7 (16.28)	13(30.23)	6 (13.95)	8 (18.60)	4 (9.30)	

ALP 4–6 group – children who achieved ALP phase 4 or higher in at least one device, n = 14 (includes children from both stable and change groups above)

Device used	ALP 1	ALP 2	ALP 3	ALP 4	ALP 5	ALP 6	Mean ALP (median)
Wizzybug, $n = 13$	0	0	2	5	5	1	4.07 (4)
Bugzi, $n = 14$	0	1	3	6	4	0	3.93 (4)
Tiger cub, $n = 14$	0	0	2	4	5	3	4.64 (5)
Car, $n = 14$	0	1	8	5	0	0	3.29 (3)
Total/55 (%)	0	2 (3.64)	15 (27.27)	20 (36.36)	14 (25.45)	4 (7.27)	

ALP: Assessment of Learning Powered mobility use.

Based on the linear mixed effects regression model including an interaction for CFCS and access method ($p < 0.05$), the average ALP phase for children with limited communication (CFCS IV–V) who used switches was 1.47 ($\pm$0.18). For switch users, being CFCS I–III appeared to have a negative effect on ALP phase (–0.46), although not statistically significant ($p = 0.56$). In contrast, ability to use a joystick had a large positive effect (0.8) leading to an average ALP phase of 2.27 ($\pm$0.21). For those children who were CFCS I–III in addition to successfully using a joystick, average ALP phase in this exploratory session was 3.34 ($\pm$0.84).

Of 73 parents who identified a device preference, 43 (59%) chose Wizzybug while Tiger Cub was least preferred ($n = 5$; 7%) (Table 5). From the combined regression model exploring factors influencing device preference (age, access method and LSS), if the child was able to use a joystick, odds of choosing Bugzi ($n = 15$, 20%) or Car ($n = 10$, 14%) decreased by 86% or 91%, respectively. If the child could sit without external support, odds of the parent choosing Bugzi over Wizzybug decreased by 92%. Due to small numbers, results for Tiger Cub are difficult to interpret meaningfully. Results were consistent between univariate and multivariate analyses.

Table 4. Linear mixed effects models for factors associated with ALP Phase, $n = 74$.

Variable	Mean ALP (median)	Fixed effects Coefficient (95% CI) p value	Random effects Coefficients (SD)	
Individual models			Subject	Device used
Age (mean)	2.32 (2)	0.03 (0.01–0.05) <0.001[a]	0.92 (0.92)	0.02 (0.13)
Gross Motor Function Classification System				
IV–V	2.01 (2)	Reference level		
I–III	2.86 (3)	0.83 (0.34–1.31) 0.0013[b]	0.96 (0.98)	0.02 (0.14)
Manual Abilities Classification System (MACS and mini-MACS)				
IV–V	1.95 (2)	Reference level		
I–III	2.56 (2)	0.63 (0.15–1.12) 0.01[c]	1.02 (1.01)	0.01 (0.14)
Communication Function Classification System				
CFCS IV–V	1.99 (2)	Reference level		
CFCS I–III	3.47 (3)	1.50 (1.00–2.00) <0.001[a]	0.73 (0.86)	0.02 (0.14)
Level of Sitting Scale				
1–4	2.19 (2)	Reference level		
5–8	2.51 (2)	0.35 (–0.16 to 0.86) 0.2	1.09 (1.05)	0.02 (0.13)
Access method				
Switch	1.45 (1)	Reference level		
Joystick	2.73 (3)	0.76 (0.76–1.68) <0.001[a]	0.79 (0.89)	0.02 (0.13)
Random intercept model				
Communication Function Classification System			Subject	Device used
IV–V	1.99 (2)	Reference level	0.56 (0.75)	0.02 (1.13)
I–III	3.47 (3)	1.20 (0.74–1.67) <0.001[a]		
Access method				
Switch	1.45 (1)	Reference level		
Joystick	2.73 (3)	0.92 (0.51–1.33) **<0.001**[a]		
Intercept		1.39 (1.04–1.75) **<0.001**[a]		
Interaction model				
Communication Function Classification			Subject	Device used
IV–V	1.99 (2)	Reference level	0.54 (0.73)	0.02 (0.13)
I–III	3.47 (3)	–0.46 (–2.02 to 1.08) 0.56		
Access method				
Switch	1.45 (1)	Reference level		
Joystick	3.47 (3)	0.80 (0.39–1.21) **<0.001**[a]		
CFCS I–III: Joystick		1.82 (0.21–3.44) **0.03**[c]		
Intercept		1.47 (1.12–1.82) **<0.001**[a]		

ALP: Assessment of Learning Powered mobility use; CI: confidence interval; SD: standard deviation.
[a]$p \leq 0.001$.
[b]$p \leq 0.01$.
[c]$p \leq 0.05$.

Discussion

Although ALP phase median total group scores were consistent across devices, Friedman test results and sub-group analyses demonstrate differences ranging from phase 3 in the Car to phase 5 in the Tiger Cub. While Car allowed exploration of cause-effect, the postural support and ability to customize joystick positioning provided by Tiger Cub may have enhanced children's ability to explore direction. Parent device preference, however, appeared to be less influenced by child performance than by other factors. The Wizzybug (preferred by 59%) is compact, lightweight, has a toy-like appearance and was specifically designed for young children.[12] These aesthetic and functional features may have influenced parents, as it was not necessarily the device in which the child demonstrated the most advanced skills (as measured with the ALP).

No child achieved ALP phase ≥ 4 in the Car while Tiger Cub had the largest number of children ($n = 3$) achieving ALP phase 6. While most children had limited variability, change of two or more ALP phases may suggest that either a learning effect occurred over the course of the session or that the device features influenced performance. Sub-group analysis comparing the

Table 5. Parent device preference and multinomial logistic regression results for associated factors.

Parent device preference, $n = 73$			
Reference level: Wizzybug ($n = 43$; 59%)	Bugzi ($n = 15$; 20%)	Car ($n = 10$; 14%)	Tiger cub ($n = 5$; 7%)
Individual models ($n = 73$)			
	OR (95% CI) *p*	**OR (95% CI) *p***	**OR (95% CI) *p***
Age (months)	1.07 (1.02–1.13) ***0.006***[a]	0.98 (0.93–1.04) *0.55*	1.02 (0.96–1.10) *0.50*
Gross Motor Function Classification System			
IV–V ($n = 46$)	Reference level	Reference level	Reference level
I–III ($n = 27$)	0.19 (0.04–0.97) ***0.04***[b]	1.26 (0.32–5.01) *0.74*	0.32 (0.03–3.06) *0.32*
Manual Abilities Classification System (MACS and mini-MACS)			
IV–V ($n = 31$)	Reference level	Reference level	Reference level
I–III ($n = 42$)	0.17 (0.05–0.65) ***0.009***[a]	0.13 (0.25–5.02) *0.88*	0.32 (0.05–2.15) *0.24*
Communication Function Classification System			
IV–V ($n = 57$)	Reference level	Reference level	Reference level
I–III ($n = 16$)	0.51 (0.09–2.64) *0.42*	0.82 (0.15–4.53) *0.82*	2.2 (0.32–15.07) *0.42*
Level of Sitting Scale			
1–4 ($n = 46$)	Reference level	Reference level	Reference level
5–8 ($n = 27$)	0.18 (0.03–0.88) ***0.03***[b]	0.77 (0.19–3.11) *0.71*	0.29 (0.03–2.79) *0.28*
Access method			
Switch ($n = 23$)	Reference level	Reference level	Reference level
Joystick ($n = 50$)	0.26 (0.07–0.93) ***0.04***[b]	0.10 (0.02–0.46) ***0.003***[a]	0.91 (0.09–9.32) *0.94*
Assessment of Learning Powered mobility use (ALP) individual models: phase achieved in Tiger cub ($n = 68$)			
ALP 1–2 ($n = 39$)	Reference level	Reference level	Reference level
ALP 3 ($n = 17$)	0.9 (0.23–3.89) *0.95*	0.54 (0.09–3.08) *0.49*	Insufficient cell size to estimate
ALP 4–6 ($n = 12$)	0.3 (0.03–2.69) *0.28*	Insufficient cell size to estimate	1.55 (0.2–10.9) *0.66*
Combined model ($n = 73$)			
Age (months)	1.11 (1.04–1.18) ***0.001***[c]	1.01 (0.95–1.07) *0.81*	1.04 (0.97–1.13) *0.28*
Access method			
Switch ($n = 23$)	Reference level	Reference level	Reference level
Joystick ($n = 50$)	0.14 (0.03–0.72) **0.02**[b]	0.09 (0.02–0.47) ***0.004***[a]	0.69 (0.06–7.98) *0.77*
Level of Sitting Scale			
1–4 ($n = 46$)	Reference level	Reference level	Reference level
5–8 ($n = 27$)	0.08 (0.01–0.55) ***0.01***[a]	0.86 (0.16–4.64) *0.86*	0.21 (0.02–2.24) *0.20*

OR: odds ratio.
[a] $p \leq 0.01$.
[b] $p \leq 0.05$.
[c] $p \leq 0.001$.

11 children whose ALP phase changed by more than one phase across devices (ALP Change) with those whose ALP phase showed limited variability (ALP Stable) suggests that children's postural support requirements, communication and motor abilities may have been influential. In our study, only joystick users achieved ALP phase ≥ 4, and only one switch user progressed more than one ALP phase during the single session. Switch users may have had more complex profiles, or it may be that alternate access methods are more cognitively challenging and take longer time periods to achieve proficiency.[7] Mockler and colleagues also found that proportional access methods were associated with proficiency after one year of power wheelchair use.[31]

Although age appeared to impact ALP phase when examined independently of other factors, it was not significant for the total group in our multivariate models. This is similar to Mockler's study[31] whose findings suggested that access method, cognitive level and a diagnosis without brain involvement were influential.[31] We had anticipated using CFCS as a proxy indicator since assessing cognitive level in children with severe motor impairment is challenging.[31] Many (40%) of our sample had very limited ability to handle objects and a further 26.7% required assistance in setting up or adapting objects to be handled and would therefore have been unable to complete standardized cognitive measures (Table 1). However, CFCS is heavily influenced by age, as is development of sitting ability (Table 1). While all classifications described current level of functioning, LSS and CFCS (both lacking age bands) may be less discriminating for the youngest children. Only 16 children (21%) were able to communicate with unfamiliar people (CFCS I–III) and this may have influenced results. Of note, is that 10 of these more-able communicators were included in the ALP Change group.

In our study, child age was associated with parent device preference, although statistically significant only for Bugzi. This may have been influenced by child abilities as older children had more complex profiles. Children whose parents preferred Bugzi also appeared to require more external postural support and used switch(es). The Bugzi's Mini-CAPS specialized seating system includes a full tray for upper body support, as well as different head support options (www.activedesign.co.uk) to meet the needs of children with higher postural support requirements. While the Car was also preferred for switch users, it did not accommodate the complex positioning needs of some children.

Although not statistically significant (possibly due to small numbers), parent preference for Tiger Cub may have reflected a need for greater tilt-in-space and specialty access requirements (sensitive joysticks, midline joystick positioning or proximity head controls). The exploratory child-and-family-led nature of Power Mobility Days meant that access method may have varied according to child, parent or therapist preference rather than being specifically matched to the child's abilities. While postural control in sitting correlated with gross motor function, LSS is validated for all diagnoses and may more-finely discriminate functional abilities for children with whole body impairment.[22] LSS was associated with greater variability in ALP scores across devices ($p \leq 0.02$), reinforcing the importance of postural support in relation to function.

In our study, parent device preference may have been influenced by factors other than the child's skill demonstrated during the single session. Although qualitative data from the field notes have yet to be formally analysed, some comments indicate that parents chose a device they thought would advance their child's skill or would be more useful in their lives, rather than one that suited current abilities. A recent study exploring parent experiences following their young child's use of power mobility for one year[32] suggests that child proficiency does not necessarily influence family experience. Families of children who did not achieve competent use reported similar experiences to those who did, seeing new abilities in their child and changing their expectations. In other studies, parents described happiness and enjoyment as being important outcomes for the whole family,[12] while a positive impact on parental stress and family interactions has been measured.[33]

We expected to find a relationship between environmental factors and parent device preference but this was not supported, possibly due to the lack of variability in family home environments and vehicles. Our results suggest that young children with mobility limitations often live in homes with limited wheelchair accessibility, and few families have vehicles that can accommodate large and heavy power wheelchairs. This reinforces the need for increased availability of more portable and developmentally-appropriate devices for young children.[10]

Limitations

Our method of sampling may limit generalizability of findings, since therapists and families participating may have been more open to the idea of power mobility. Although 74 children is a large sample for this area of study, the heterogeneity of our sample limited potential subgroup analyses. However, community therapists, working in various locations, identified and recruited children they thought appropriate, suggesting that the sample may represent typical early intervention caseloads.

Due to the lack of a generic gross-motor/fine-motor descriptor, we used cerebral palsy-specific descriptors[15–17] for all children. Concerns with the validity of this approach have been raised in the literature,[21] and we recognize that it would be inappropriate to use these for anything other than a descriptor of current functioning. As an alternative functional descriptor, we presented results from LSS, which is valid for all diagnoses and has a strong inverse correlation with GMFCS in children with cerebral palsy.[22] Statistical analyses confirmed that postural control in sitting was associated with parent device preference and has more relevance than gross motor function as described by GMFCS. It would have been ideal to include a valid and reliable measure of cognitive function; however, to our knowledge, there is a lack of cognitive function measures that have been validated for the range of our sample's ages and functional abilities.

This study aimed to increase awareness and engagement with providing early power mobility experiences. Family and child-led exploration meant that device trials were not highly controlled and, as a result, we have varying numbers for different analyses. However, these missing data are informative; many children had previous experience with switch-adapted cars and parents wanted to explore other options. Devices were set up with different access methods to increase awareness of different options. However, this variability may have influenced the learning process and ALP phase achieved, depending on the child's developmental level, cognitive and physical abilities.

Due to the non-experimental clinical setting, there was high variability in the length of video data captured for each device and for each child and this may also have influenced assessment of ALP phase. However, field notes were used to confirm impressions where video data was limited.

Despite different therapists and different numbers of children in the sessions, these participant-led sessions were positive experiences across a number of communities that encouraged families to explore power mobility in early childhood. Therapists and parents from various communities have asked to continue these sessions as part of regular clinical practice to introduce power mobility in a non-threatening way. A sample of parents were interviewed following the Power Mobility Day regarding their experiences and many described their children's reactions and preferences. These qualitative data have been analysed and are under submission as a separate manuscript. Additional manuscripts describing device ratings from parents and therapists along with results from a subsequent six-month loan of one of the devices for a subgroup of children are in process. Future studies with more controlled, experimental designs would be beneficial to confirm these preliminary findings.

Conclusion

Power mobility can be successfully introduced to young children with a range of mobility needs in individual or group community settings. Children's power mobility use, as measured in a single exploratory session, appears to be influenced by opportunities to try devices with different access methods and varying degrees of postural support. Parents' preference for an early power mobility device may be influenced by many factors including child age, access method and need for postural support, yet may be less influenced by child performance in that device. Different early power mobility devices may provide infants, toddlers and preschool children opportunities for learning, play and exploration, that in turn may influence parent and therapist expectations of child potential.

Clinical messages

- Exploratory play-based power mobility sessions are feasible to conduct in clinical practice and may be a non-intimidating means of introduction for families of young children.
- Power mobility interventions may allow young children opportunities to play and explore, whether or not prescription of a power mobility device is a long-term goal.

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RWL initiated the idea and designed the study. RWL and DAF conducted the study. RWL completed the statistical analysis with consultation from JB and DAF. RWL wrote the first draft of the manuscript and refined and revised the manuscript for publication with DAF. All authors commented on and agreed to the final manuscript.

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Supplemental material

Supplemental material for this article is available online.

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