Reliability and Validity of the Four-Point Pusher Score: An Assessment Tool for Measuring Lateropulsion and Pusher Behaviour in Adults after Stroke

Emmanuelle Chow, BScPT (Hons);* Stephanie Parkinson, BAScPT, GDipNRehab, GCertHlthProfEd, MClinPT;* Joanna Jenkin, BScPT, GDipNRehab;† Alisha Anderson, BScPT (Hons), GDipNRehab;‡ Andrea King, BAScPT, MPT(Neur);‡ Heidi Maccanti, BAScPT, MPT(Rsch);§ Novia Minaee, BA(Psych), MBiostats;* Kylie Hill, BScPT, PhDPT*

ABSTRACT

Purpose: The authors determined the reliability and validity of the Four-Point Pusher Score (4PPS) among stroke survivors. **Method:** Stroke survivors were invited to participate within 48 hours of admission to a stroke rehabilitation unit in a tertiary hospital. Intrarater reliability was determined by examining scores assigned to the same patient by the same physiotherapist. Interrater reliability was determined by examining scores assigned to the same patient by two other physiotherapists. Validity was determined by examining associations with the Burke Lateropulsion Scale (BLS), Scale for Contraversive Pushing (SCP), and functional scales. **Results:** A total of 85 participants who were a median of 13 (interquartile range 9–21) days post-stroke completed this study. The weighted κ statistic for 4PPS intra- and interrater reliability was 0.97 ($p < 0.001$). Scores on the 4PPS were very strongly associated with scores on the BLS ($r_s = 0.95$) and the SCP ($r_s = 0.86$). Strong associations were evident between the 4PPS and the Berg Balance Scale ($r_s = -0.77$), Chedoke-McMaster Stroke Assessment postural control scale ($r_s = -0.76$), and FIM Motor sub-scale ($r_s = -0.64$; all p s < 0.001). **Conclusion:** The 4PPS is a reliable and valid scale to assess lateropulsion and pusher behaviour in stroke survivors in an in-patient rehabilitation setting.

Key Words: lateropulsion; neurological physiotherapy; postural balance; reproducibility of results; stroke.

RÉSUMÉ

Objectif : déterminer la fiabilité et la validité du score du pousseur en quatre points (SP4P) chez les survivants d'un accident vasculaire cérébral (AVC). **Méthodologie :** des survivants d'un AVC hospitalisés dans l'unité d'un hôpital de soins tertiaires depuis moins de 48 heures ont été invités à participer à une réadaptation après un AVC. Les chercheurs ont déterminé la fiabilité intraévaluateur en examinant les scores attribués par un même physiothérapeute au même patient, et la fiabilité interévaluateur en examinant les scores attribués par deux autres physiothérapeutes au même patient. Ils ont établi la validité en examinant les associations avec l'échelle de latéropulsion de Burke (ÉLB), l'échelle de poussée contralésionnelle (ÉPC) et les échelles fonctionnelles. **Résultats :** au total, 85 participants qui avaient subi leur AVC une médiane de 13 jours auparavant (plage interquartile de 9 à 21 jours) ont terminé l'étude. Le test de concordance pondéré de kappa pour déterminer la fiabilité intraévaluateur et interévaluateur des SP4P s'élevait à 0,97 ($p < 0,001$). Les SP4P s'associaient très fortement à ceux de l'ÉLB ($r_s = 0,95$) et de l'ÉPC ($r_s = 0,86$). Des associations solides étaient évidentes entre les SP4P et l'échelle d'évaluation de l'équilibre de Berg ($r_s = -0,77$), l'échelle de contrôle postural de Chedoke-McMaster ($r_s = -0,76$) et le sous-score moteur de mesure de l'autonomie fonctionnelle ($r_s = -0,64$; $p < 0,001$ dans tous les cas). **Conclusion :** le SP4P est fiable et valide pour évaluer le comportement de la latéropulsion et du pousseur des survivants d'un AVC dans un contexte de réadaptation hospitalière.

Pusher behaviour (PB) refers to a postural control disorder observed in some stroke survivors.^{1,2} Features of the severe form of this disorder include a spontaneously tilted posture, active use of the trunk and non-hemiplegic limbs to push toward the hemiplegic side of the body,

and resistance to passive correction of posture.¹ Researchers have also used alternative terms such as *contraversive pushing* and *lateropulsion* to describe this behaviour.^{2–4} The prevalence of PB among stroke survivors has been reported to range from 9.4% to 62.9%.^{4–9}

From the: *School of Physiotherapy and Exercise Science, Faculty of Health Science, Curtin University; †Ward A Neurological Rehabilitation; ‡State Rehabilitation Service, Fiona Stanley Hospital, Perth, Western Australia, Australia; §City Osteopathy and Physiotherapy, Singapore.

Correspondence to: Stephanie Parkinson, School of Physiotherapy and Exercise Science, Curtin University, GPO Box U1987, Perth, WA 6845, Australia; s.parkinson@curtin.edu.au.

Contributors: All authors designed the study; or collected, analyzed, or interpreted the data; and drafted or critically revised the article and approved the final draft.

Acknowledgements: The authors thank the physiotherapists and participants involved in this study and Lyndell Keating and the physiotherapists involved in the original Four-Point Pusher Score research. The authors also thank Liz Bainbridge for her contributions.

Physiotherapy Canada 2019; 71(1);34–42; doi:10.3138/ptc.2017-69

This large range in prevalence may be due to the use of different assessments to detect the presence of PB as well as the different characteristics of patients in the studies, such as time post-stroke and severity of motor impairments.¹⁰

PB is associated with worse functional outcomes. Compared with patients who do not demonstrate PB, those who do demonstrate it have longer lengths of stay in hospital,^{4,5,7,11,12} lower balance scores,³ and more severe impairments in their lower extremity when scored using the Fugl-Meyer Assessment,¹⁰ and they require approximately twice as long a rehabilitation time to achieve similar functional outcomes.^{4,5,11}

Two commonly referred-to scales have been validated to evaluate PB: the Burke Lateropulsion Scale (BLS) and the Scale for Contraversive Pushing (SCP).^{2,13–16} However, both scales have their limitations. The BLS takes up to 10 minutes to complete,⁴ which may discourage busy clinicians from its use.¹⁰ The SCP requires less time to administer but may not detect mild PB because it does not explicitly include an assessment during walking.^{10,15,17} Both scales have inconsistencies in the cutoff scores used to define the presence of PB.^{3,4,16}

The Four-Point Pusher Score (4PPS) was devised by five senior neurological physiotherapists whose cumulative work with stroke survivors totals more than 30 years. It was evaluated in 1999 as part of an unpublished Master's of Physiotherapy project (see [Appendix 1](#)), and the preliminary results of its measurement properties were presented at the Australian Physiotherapy Association conference in 1999.²⁰ Since then, it has been used across Australia in several rehabilitation and tertiary hospitals. Its development was based on clinical experience, and the description of pusher syndrome was provided by Davies,¹ Bohannon,¹⁸ and Carr and Shepherd¹⁹ on the assumption that PB is more severe if it is demonstrated in more supported postures.^{1,21} For example, sitting is a more supported posture than standing because less muscle activity is required against gravity. Hence, if PB were demonstrated in sitting, it would be considered more severe than if it were demonstrated only in standing. It is also assumed that if PB were demonstrated in sitting, it would also be demonstrated in standing.^{1,13,21} Thus, one advantage of the 4PPS over other published scales is the reduction in the time taken to identify and grade PB because testing is not required in all positions. Hence, using the 4PPS can be a time-efficient part of the screening assessment among stroke survivors.

The 4PPS takes approximately 2 minutes to administer, is easy to score, and identifies mild and severe presentations of PB.²¹ Nevertheless, published data supporting its reliability and validity are lacking.²⁰ Thus, the main aims of this study were to report the following measurement properties of the 4PPS among stroke survivors in an in-patient rehabilitation setting: (1) intrarater

reliability, (2) interrater reliability, (3) concurrent validity, and (4) convergent construct validity. In addition, we explored the agreement among the 4PPS, BLS, and SCP in identifying the presence of PB and examined scores on the BLS with participants grouped according to the severity of their PB according to the 4PPS.

METHODS

Study design

This was an observational study with repeated measures. We followed the principles of the Declaration of Helsinki.²² Approval was obtained from the relevant human research ethics committees, and we obtained written, informed consent from all participants before undertaking data collection.

Participants

Data collection took place from February 2014 to August 2015 at a stroke rehabilitation unit in a tertiary hospital. Inclusion criteria for the study were as follows: admitted for in-patient rehabilitation, aged 18 years or older, and at least 2 months post-stroke. Exclusion criteria were inability to provide consent (e.g., reduced consciousness, intellectual impairment, severe aphasia), inability to participate in rehabilitation because of medical instability, no motor function impairments from stroke, and severe pre-morbid orthopaedic problems.

Procedure

Data were recorded pertaining to age, date of stroke, sex, hand dominance, side of lesion, location of lesion, presence of visual inattention or homonymous hemianopia, stroke syndrome, and FIM scores. Participation involved one or two visits to the physiotherapy gymnasium on the same day – hence, no change in the participant's status was expected. The scales that measure PB (4PPS, BLS, and SCP) were administered together in a randomized order on the first visit by the treating physiotherapist. The randomization sequence was computer generated and concealed. The 4PPS was administered twice more by the treating physiotherapist and once more by a different physiotherapist over the visits; each administration of the 4PPS was separated by a minimum of 20 minutes.

After each administration, the completed data collection form was placed in an opaque envelope, and the physiotherapists were instructed not to review the results between administrations. Over the visits, the Berg Balance Scale (BBS) and Chedoke-McMaster Stroke Assessment postural control scale (CMPCS) were administered once. All physiotherapists involved in the study were familiar with the 4PPS, BBS, and CMPCS but received 45 minutes of training in the use of the BLS and SCP by one of the senior neurological physiotherapists.

Measurement tools

Four-Point Pusher Score

The 4PPS is an ordinal scale that assesses and hierarchically grades the severity of PB. A modified version of the 4PPS was created to reflect current terminology (see [Appendix 1](#)), and an instruction guide was developed (online Appendix 2). The 4PPS involves concurrent assessment of (1) observation of spontaneous posture, (2) the use of less affected limbs to push toward the more affected side, and (3) resistance to passive correction of posture onto the less affected side in lying, sitting, standing, and walking. A score of zero indicates absence of PB, and a score of 1, 2, or 3 signifies mild, moderate, or severe PB, respectively.

Burke Lateropulsion Scale

The BLS has been reported to be a reliable and valid scale to measure PB among stroke survivors.² The severity of PB is measured by assessing the degree of resistance and the stage at which the resistance begins when attempts are made to bring weight onto the hemiplegic and non-hemiplegic sides.² The BLS consists of five assessment postures or tasks: rolling, sitting, standing, transfers, and walking.² The total maximum score is 17. Although another study used a cutoff score of more than 2⁴ to classify a participant as demonstrating PB, use of this score could miss mild PB in dynamic standing balance and gait;³ thus, we used a cutoff score of 2 or more.³

Scale for Contraversive Pushing

The SCP has been reported to be a reliable and valid scale to measure PB among stroke survivors.^{15,16} It is used to assess three major features of severe PB in both sitting and standing: (1) the symmetry of spontaneous posture, (2) the active use of non-hemiplegic limbs to push, and (3) the resistance to passive correction of tilted posture.^{15,16} Each component has a maximum score of 2. Karnath and colleagues²³ recommended a cutoff score of 1 or more out of 2 for each of the three components to classify the presence of PB. However, more recent articles have reported greater diagnostic accuracy with a cutoff score of > 0 in each of the three components.^{15,16} Hence, in this study, a cutoff score of more than 0 for each component was used to classify the presence of PB.

Berg Balance Scale

The BBS has been reported to be a reliable and valid scale to assess balance and falls risk.^{24–26} It requires a patient to complete 14 static and dynamic balance tasks. Each task is scored on a scale ranging from 0 to 4. The highest total score is 56, with higher scores representing better balance.²⁴

Chedoke-McMaster Stroke Assessment Postural Control Scale

The Chedoke-McMaster Stroke Assessment has been reported to be a reliable and valid set of measures used with stroke survivors.²⁷ The CMPCS is a subscale of the

Chedoke-McMaster Stroke Assessment's Impairment Inventory, which evaluates the severity of physical impairment and disability.²⁷ It categorizes motor recovery into seven stages, with Stage 1 representing the lowest recovery and Stage 7 representing the highest.²⁸

FIM

The FIM has been reported to be a reliable and valid scale in acute care and rehabilitation,^{29–31} and it is used to measure functional disability. The scale consists of 18 tasks: 5 contribute to the FIM Cognitive sub-score, and 13 contribute to the FIM Motor sub-score. Each task is scored on a scale ranging from 1 to 7, with higher scores representing greater independence in completing a task. The maximum Cognitive and Motor sub-scores are 35 and 91, respectively. The highest total score is 126, with higher scores representing greater function and independence.

Data analysis

We performed most data analyses using the IBM SPSS Statistics for Windows, version 23 (IBM Corp., Armonk, NY); for reliability analyses, we used STATA, version 12 (StataCorp LP, College Station, TX). For continuous variables, the distribution of data was visually inspected using frequency histograms. The Shapiro-Wilk test for normality was conducted, normally distributed data were reported as means and SDs, and data that were not normally distributed were reported as median and interquartile range (IQR).

The intrarater reliability of scores on the 4PPS was assessed using data collected over the three administrations of the 4PPS, by the same physiotherapist, using the weighted κ statistic.³² A κ value of more than 0.90 was regarded as excellent agreement; 0.80–0.90, as strong agreement; 0.60–0.79, as moderate agreement; 0.21–0.59, as weak to minimal agreement; and 0.20 or less, as no agreement.³³

The interrater reliability of scores on the 4PPS was assessed using data collected over two administrations of the 4PPS by different physiotherapists, using the weighted κ statistic.^{32,33} Specifically, the score recorded on the 4PPS by the treating physiotherapist in the first administration was compared with the score recorded on the 4PPS by the other physiotherapist on the second administration.

Associations among the scores on the 4PPS, BLS, and SCP (concurrent validity) and associations among the scores on the 4PPS, BBS, CMPCS, and FIM Motor sub-score (convergent construct validity)¹³ were examined using Spearman's correlation coefficients. A coefficient correlation value of 0.80 or more was considered a very strong correlation; 0.60–0.79, a strong correlation; 0.40–0.59, a moderate correlation; and 0.00–0.39, no to weak correlation.³⁴

The number of participants classified as having evidence (or not) of PB using the 4PPS, BLS, and SCP was

Table 1 Characteristics of Participants ($n = 85$)

Characteristic	Median (IQR)*
Age, y	57 (48–63)
Time from stroke to assessment, d	13 (9–21)
Sex, male, no. (%)	55 (64.7)
Hand dominance, right, no. (%)	82 (96.5)
Lesion side, no. (%)	
Right cerebral	36 (42.4)
Left cerebral	26 (30.6)
Unilateral brainstem	12 (14.1)
Bilateral cerebral and/or brainstem	11 (12.9)
Hemianopia or visual inattention, no. (%)	32 (37.6)
Cortical blindness, no. (%)	2 (2.4)
Stroke syndrome, no. (%)†	
TACS	30 (35.3)
PACS	20 (23.5)
LACS	12 (14.1)
POCS	12 (14.1)
BBS score (0–56)	6 (3–40)
Chedoke-McMaster postural control score (1–7)	3 (2–5)
FIM	
Cognitive sub-score (5–35)	25 (21–30)
Motor sub-score (13–91)	36 (23–62)
Total score (18–126)	61 (48–89)

*Unless otherwise indicated.

†Only those with unilateral lesions are represented ($n = 74$); percentages are based on the total number of participants.

TACS = total anterior circulation stroke; PACS = partial anterior circulation stroke; LACS = lacunar stroke; POCS = posterior circulation stroke; BBS = Berg Balance Scale.

calculated. For all analyses, $p < 0.05$ was used to denote statistical significance.

RESULTS

Data collection was undertaken by 10 physiotherapists with a median 13 (IQR 7–15) years of clinical experience, of which 10 (IQR 3–13) years were in neurological physiotherapy. We completed all measures on a single visit.

Participants' characteristics

The characteristics of the 85 participants who completed the study are summarized in Table 1. There were no adverse events during the study.

Intrarater reliability

The weighted κ value among the three administrations of the 4PPS by the same physiotherapist was $\kappa_w = 0.97$ (95% CI: 0.94, 1.00). There were five disagreements: one between a score of 0 and 1, three between a score of 1 and 2, and one between a score of 2 and 3.

Interrater reliability

The weighted κ value between the two administrations of the 4PPS by the two physiotherapists was $\kappa_w = 0.97$ (95%

CI: 0.82, 1.0). There were three disagreements: two between scores of 1 and 2 and one between scores of 2 and 3.

Validity

The Spearman's correlation coefficient for the BLS was $r_s = 0.95$; for the SCP, it was $r_s = 0.86$ (both $ps < 0.001$). The associations between the 4PPS and the three functional scales (BBS, CMPCS, and FIM Motor sub-score) ranged from $r_s = -0.64$ to $r_s = -0.77$ (all $ps < 0.001$), as illustrated in Figure 1.

Prevalence of pusher behaviour

The number of participants who demonstrated PB using the 4PPS, BLS, and SCP was 45 (52.9%), 44 (51.8%), and 36 (42.4%), respectively. The absence or presence of PB in right cerebral, left cerebral, brainstem or cerebellar, and bilateral or mixed lesions is presented in online Appendix 3.

Figure 1 Scatterplots showing the association between scores on the Four Point Pusher Score and scores on the (a) Burke Lateropulsion Scale; (b) Scale for Contraversive Pushing; (c) Berg Balance Scale; (d) Chedoke-McMaster Stroke Assessment postural control scale; and (e) FIM Motor subscore. $p < 0.05$.

Figure 1 Continued

Figure 2 Venn diagram showing the agreement among the three scales that classify participants as demonstrating lateropulsion or pusher behaviour.

4PPS = Four-Point Pusher Score; BLS = Burke Lateropulsion Scale; SCP = Scale for Contraversive Pushing.

Table 2 BLS Scores Using the 4PPS ($n = 85$)

	4PPS			
	0 (Nil)	1 (Mild)	2 (Moderate)	3 (Severe)
BLS median score	0	4	9	15
BLS IQR	0–0	3–5.5	3–11	14–16
BLS, range	0–1	2–11	1–15	8–17
No. of participants	40	9	19	17

BLS = Burke Lateropulsion Scale; 4PPS = Four-Point Pusher Score; IQR = inter-quartile range.

Agreement among scales that measure pusher behaviour

The agreement in classifying someone as demonstrating PB among the 4PPS, BLS, and SCP is illustrated in Figure 2. Of the 85 participants, 46 (54.1%) were classified as demonstrating evidence of PB on at least one of these three scales, and 39 (45.9%) were classified as not demonstrating any evidence of PB on any of the three scales. The 4PPS and BLS agreed in their classification of the presence and absence of PB in 82 (96.5%) participants. The 4PPS and SCP agreed in their classification of the presence or absence of PB in 74 (87.1%) participants. If we had used the same SCP cutoff score as Karnath and colleagues²³ (≥ 1 out of 2 in each of the three components), the 4PPS and SCP would have agreed in their classification of the presence or absence of PB in 67 (78.8%) participants. The BLS scores for participants graded as having mild, moderate, or severe PB according to the 4PPS are presented in Table 2.

DISCUSSION

This is the first study to examine the reliability and validity of the 4PPS in a large sample. The notable findings of this study were as follows:

- scores on the 4PPS demonstrated excellent intrarater and interrater reliability
- scores on the 4PPS demonstrated very strong associations with the BLS and SCP
- scores on the 4PPS showed strong associations with the three functional scales
- there was excellent agreement between the 4PPS and BLS and very good agreement between the 4PPS and SCP in classifying the presence of PB
- there was, on average, consistency in the classification of the severity of PB between the BLS and 4PPS.

Reliability

Our results indicate excellent consistency in scores assigned using the 4PPS between administrations by the same physiotherapist (intrarater reliability) and between administrations by two physiotherapists (interrater reliability).

Of note is the fact that data demonstrating strong to excellent intrarater and interrater reliability are consistent with those previously reported for two other scales used to assess PB: the BLS (interrater reliability: intra-class coefficient [ICC] = 0.93; intrarater reliability: ICC = 0.94; $p < 0.05$)² and SCP (interrater reliability: ICC > 0.93 for all sub-scores and total score; $p < 0.001$).¹⁵ An experienced geriatrician and three physiotherapists were involved in data collection in the study that validated the SCP.¹⁶ In contrast, a strength of our study is that the data used to assess the reliability of the 4PPS were collected by a team of physiotherapists that included junior and senior therapists with varying levels of clinical experience. This suggests that the 4PPS is likely to be reliable in most clinical settings, irrespective of the level of experience of the physiotherapists.

Validity

The concurrent validity of the 4PPS was supported by very strong associations between scores on it and scores on the scales that have been validated to measure PB (BLS and SCP). As expected, the strength of the associations between the 4PPS and the BLS and SCP appeared somewhat stronger than the associations between the 4PPS and scales that measure other aspects of general function, such as the BBS, CMPCS, and FIM. The weakest association seemed to be between the 4PPS and the FIM Motor sub-score. This is consistent with earlier work, which reported associations of moderate strength between both the BLS and the SCP with measures of general function such as the FIM and Barthel Index.^{2,16}

The reason for these somewhat weaker associations relates to the content of these functional scales. That is,

in addition to assessing aspects of balance and postural control, which are known to be impaired in patients with PB,^{7,35} the FIM and Barthel Index assess tasks such as self-care and sphincter control. Therefore, there may have been a weaker correlation between the scales that measure PB and those that measure general function.

Prevalence and agreement in classifying pusher behaviour

In our sample, the prevalence of PB, defined as a 4PPS score of 1 or more, was 52.9%. This prevalence is similar to that reported in a study by Danells and colleagues⁷ (62.9%) in participants who were 1 week post-stroke and in a study by Baccini and colleagues¹⁵ (65.4%) in participants who were a mean of 19 (SD 7.8) days post-stroke.

Agreement about the presence or absence of PB may have been higher between the 4PPS and BLS than between the 4PPS and SCP, as illustrated in Figure 2. Comparing the 4PPS with the BLS, the decision as to whether a participant showed evidence of PB was consistent in 82 of the 85 participants. Broadly speaking, there was also consistency between these two scales in classifying the severity of PB. Some of the differences in classifying the presence or severity of PB between the 4PPS and BLS seen in Table 2 are likely because the 4PPS assesses PB past midline in sitting, and the BLS does not. This difference may explain why some participants who were assigned a score of 2 on the 4PPS were assigned a low (i.e., better) score on the BLS.

Comparing the 4PPS with the SCP, the classification of the presence of PB was consistent in 74 participants, with the 4PPS classifying 10 more participants as having evidence of PB than did the SCP. These data are consistent with earlier work, which reported that the number of people classified as having PB was less when the SCP was used than when the BLS was used.¹⁷

The increased number of people classified as having evidence of PB when using the 4PPS and BLS compared with when using the SCP suggests that the SCP is less likely to identify mild PB. Specifically, mild presentations of PB are more evident in standing or walking,¹⁶ and only the 4PPS and BLS assess for PB in both standing and walking. Our data suggest that by not assessing for PB in walking, clinicians may miss as many as 23.4% of cases with evidence of mild PB; this would delay the implementation of appropriate rehabilitation strategies.

This study had one potential limitation: the excellent intrarater reliability of the 4PPS may have been influenced by the treating physiotherapist remembering scores from previous administrations. This study did not explore the responsiveness of this scale to detect change. However, because the range in possible scores for the 4PPS is limited to 0–3, it is possible that its responsiveness would be compromised. Although our study sample was relatively young, it is unlikely that this influenced our

results because there is limited evidence that age influences the presence of pusher behaviour.¹¹

CONCLUSION

In a busy clinical setting in which time constraints are present, a reliable, valid, and simple-to-administer scale to assess PB is warranted. Our study showed that the 4PPS is a reliable, valid, and therefore time-efficient tool for clinicians. It provides a simple hierarchy of the severity of PB, and its ease of use may make it more likely to be used, both clinically and in research, than the more complex scales available. Using this scale would be an efficient way of detecting PB, and this, in turn, would assist in predicting length of stay in hospital and implementing appropriate rehabilitation strategies to improve functional outcomes.

KEY MESSAGES

What is already known on this topic

Pusher behaviour (PB) has been associated with longer lengths of stay in hospital and longer rehabilitation times to achieve functional outcomes. The current, validated scales that measure PB have their limitations, such as taking up to 10 minutes to administer, having inconsistencies in cutoff scores, and, in some cases, not detecting mild PB.

What this study adds

In a busy clinical setting in which time constraints are present, a reliable, valid, and simple-to-administer scale is ideal. The Four-Point Pusher Score provides a simple hierarchy of the severity of pusher behaviour, is easy to score, and is quick to administer. Using this scale could result in more efficient use of time in a busy clinical setting and could be a method for researchers to screen for pushing behaviour in stroke studies.

REFERENCES

- Davies P. Steps to follow: a guide to the treatment of adult hemiplegia. Berlin: Springer-Verlag; 1985. <https://doi.org/10.1007/978-3-642-96833-4>.
- D'Aquila MA, Smith T, Organ D, et al. Validation of a lateropulsion scale for patients recovering from stroke. *Clin Rehabil*. 2004;18(1):102–9. <https://doi.org/10.1191/0269215504cr7090a>. Medline:14763725
- Babyar SR, White H, Shafi N, et al. Outcomes with stroke and lateropulsion: a case-matched controlled study. *Neurorehabil Neural Repair*. 2008;22(4):415–23. <https://doi.org/10.1177/1545968307313511>. Medline:18334602
- Clark E, Hill KD, Punt TD. Responsiveness of 2 scales to evaluate lateropulsion or pusher syndrome recovery after stroke. *Arch Phys Med Rehabil*. 2012;93(1):149–55. <https://doi.org/10.1016/j.apmr.2011.06.017>. Medline:22200395
- Pedersen PM, Wandel A, Jørgensen HS, et al. Ipsilateral pushing in stroke: incidence, relation to neuropsychological symptoms, and impact on rehabilitation. The Copenhagen Stroke Study. *Arch Phys Med Rehabil*. 1996;77(1):25–8. [https://doi.org/10.1016/S0003-9993\(96\)90215-4](https://doi.org/10.1016/S0003-9993(96)90215-4). Medline:8554469
- Abe H, Kondo T, Oouchida Y, et al. Prevalence and length of recovery of pusher syndrome based on cerebral hemispheric lesion side in patients with acute stroke. *Stroke*. 2012;43(6):1654–6. <https://doi.org/10.1161/STROKEAHA.111.638379>. Medline:22382159
- Danells CJ, Black SE, Gladstone DJ, et al. Poststroke “pushing”: natural history and relationship to motor and functional recovery. *Stroke*. 2004;35(12):2873–8. <https://doi.org/10.1161/01.STR.0000147724.83468.18>. Medline:15528459
- Premoselli S, Cesana L, Cerri C. Pusher syndrome in stroke: clinical, neuropsychological and neurophysiological investigation. *Eura Medicophys*. 2001;37(3):143–51.
- Karnath H-O, Johannsen L, Broetz D, et al. Posterior thalamic hemorrhage induces “pusher syndrome.” *Neurology*. 2005;64(6):1014–9. <https://doi.org/10.1212/01.WNL.0000154527.72841.4A>. Medline:15781819
- Paci M, Baccini M, Rinaldi LA. Pusher behaviour: A critical review of controversial issues. *Disabil Rehabil*. 2009; 31(4):249–58. <https://doi.org/10.1080/09638280801928002>. Medline: 18608360
- Krewer C, Luther M, Müller F, et al. Time course and influence of pusher behavior on outcome in a rehabilitation setting: a prospective cohort study. *Top Stroke Rehabil*. 2013;20(4):331–9. <https://doi.org/10.1310/tsr2004-331>. Medline:23893832
- Babyar SR, Peterson MG, Reding M. Case-control study of impairments associated with recovery from “pusher syndrome” after stroke: logistic regression analyses. *J Stroke Cerebrovasc Dis*. 2017;26(1):25–33. <https://doi.org/10.1016/j.jstrokecerebrovasdis.2016.08.024>. Medline:27614404
- Babyar SR, Peterson MGE, Bohannon R, et al. Clinical examination tools for lateropulsion or pusher syndrome following stroke: a systematic review of the literature. *Clin Rehabil*. 2009;23(7):639–50. <https://doi.org/10.1177/0269215509104172>. Medline:19403555
- Koter R, Regan S, Clark C, et al. Clinical outcome measures for lateropulsion poststroke: an updated systematic review. *J Neurol Phys Ther*. 2017;41(3):145–55. <https://doi.org/10.1097/NPT.0000000000000194>. Medline:28628548
- Baccini M, Paci M, Rinaldi LA. The Scale for Contraversive Pushing: a reliability and validity study. *Neurorehabil Neural Repair*. 2006;20(4):468–72. <https://doi.org/10.1177/1545968306291849>. Medline:17082502
- Baccini M, Paci M, Nannetti L, et al. Scale for Contraversive Pushing: cutoff scores for diagnosing “pusher behavior” and construct validity. *Phys Ther*. 2008;88(8):947–55. <https://doi.org/10.2522/ptj.20070179>. Medline:18617579
- Bergmann J, Krewer C, Rieß K, et al. Inconsistent classification of pusher behaviour in stroke patients: a direct comparison of the Scale for Contraversive Pushing and the Burke Lateropulsion Scale. *Clin Rehabil*. 2014;28(7):696–703. <https://doi.org/10.1177/0269215513517726>. Medline:24459174
- Bohannon RW. Ipsilateral pushing in stroke. *Arch Phys Med Rehabil*. 1996;77(5):524–5. [https://doi.org/10.1016/S0003-9993\(96\)90050-7](https://doi.org/10.1016/S0003-9993(96)90050-7). Medline:8629936
- Carr J, Shepherd R. Neurological rehabilitation: optimizing motor performance. Oxford, UK: Butterworth-Heinemann; 1998.
- King A, Keating L, Story I. Rating the severity of pushing in stroke patients: a reliability study. Presented at: The Australian Physiotherapy Association's 6th International Congress; Canberra; May 1999.
- Walkenhorst H. The Melbourne Pusher Scale: a reliability and validity study [Master's thesis]. Melbourne, Australia: University of Melbourne; 2003.
- World Medical Association. World Medical Association Declaration of Helsinki: ethical principles for medical research involving human subjects. *JAMA*. 2013;310(20):2191–4. <https://doi.org/10.1001/jama.2013.281053>. Medline:24141714
- Karnath H-O, Ferber S, Dichgans J. The origin of contraversive pushing: evidence for a second graviceptive system in humans.

- Neurology. 2000;55(9):1298–304. <https://doi.org/10.1212/WNL.55.9.1298>. Medline:11087771
24. Berg KO, Wood-Dauphinee SL, Williams JI, et al. Measuring balance in the elderly: validation of an instrument. *Can J Public Health*. 1992;83(Suppl 2):S7–11. <https://doi.org/10.2307/41990843>. Medline:1468055
 25. Blum L, Korner-Bitensky N. Usefulness of the Berg Balance Scale in stroke rehabilitation: a systematic review. *Phys Ther*. 2008;88(5):559–66. <https://doi.org/10.2522/ptj.20070205>. Medline:18292215
 26. Berg K, Wood-Dauphin e S, Williams JI. The Balance Scale: reliability assessment with elderly residents and patients with an acute stroke. *Scand J Rehabil Med*. 1995;27(1):27–36. Medline:7792547
 27. Gowland C, Stratford P, Ward M, et al. Measuring physical impairment and disability with the Chedoke-McMaster Stroke Assessment. *Stroke*. 1993;24(1):58–63. <https://doi.org/10.1161/01.STR.24.1.58>. Medline:8418551
 28. Gowland C. Chedoke-McMaster Stroke Assessment: development, validation and administration manual. Hamilton (ON): Chedoke-McMaster Hospitals and McMaster University; 1995.
 29. Hamilton BB, Laughlin JA, Fiedler RC, et al. Interrater reliability of the 7-level Functional Independence Measure (FIM). *Scand J Rehabil Med*. 1994;26(3):115–9. Medline:7801060
 30. Dodds TA, Martin DP, Stolov WC, Deyo RA. A validation of the Functional Independence Measurement and its performance among rehabilitation inpatients. *Arch Phys Med Rehabil*. 1993; 74(5):531–36. [https://doi.org/10.1016/0003-9993\(93\)90119-U](https://doi.org/10.1016/0003-9993(93)90119-U).
 31. Hobart JC, Lamping DL, Freeman JA, et al. Evidence-based measurement: which disability scale for neurologic rehabilitation? *Neurology*. 2001;57(4):639–44. <https://doi.org/10.1212/WNL.57.4.639>. Medline:11524472
 32. Pérez de Vargas Luque A, Abraira Santos V. Generalization of the Kappa coefficient for ordinal categorical data, multiple observers and incomplete designs. *Qüestio, Quad Estad Sist Inform Investig Oper*. 1999;23(3):561–71.
 33. McHugh ML. Interrater reliability: the kappa statistic. *Biochem Med (Zagreb)*. 2012;22(3):276–82. <https://doi.org/10.11613/BM.2012.031>. Medline:23092060
 34. Portney LG, Watkins MP. Foundations of clinical research: applications to practice. 3rd ed. Upper Saddle River, NJ: Pearson Prentice Hall; 2009.
 35. Karnath H-O, Broetz D. Understanding and treating “pusher syndrome.” *Phys Ther*. 2003;83(12):1119–25. <https://doi.org/10.1093/ptj/83.12.1119>. Medline:14640870

APPENDIX 1: FOUR-POINT PUSHER SCORE

As used in this study and with terminology adapted to account for brainstem and cerebellar strokes as well as current clinical practice (with permission from King and colleagues²⁰ and Walkenhorst²¹).

Direction of pushing: **LEFT/RIGHT** (please circle)

Description	Score (please circle)
<i>Score 3: Severe pushing</i>	
In sitting, visible lean or push towards the more affected side and possibly also backwards.	
Accompanied by over-activity in the less affected upper limb, lower limb, and trunk.	
Pushing may be evident in the lying position.	
<i>Score 2: Moderate pushing</i>	
In sitting, no visible lean, but there is resistance to passive weight shift onto the less affected side.	
In standing, visible lean or push towards the more affected side.	
<i>Score 1: Mild pushing</i>	
In sitting, no visible lean and no resistance to passive weight shift onto the less affected side is evident.	
In standing or walking, no visible lean, but there is resistance to passive weight shift onto the less affected side.	
<i>Score 0: No pushing</i>	
During sitting, standing, or walking, no resistance to passive weight shift onto the less affected side is evident.	
No over-activity of the less affected side is evident.	

OVERVIEW OF THE HISTORY AND DEVELOPMENT OF THE FOUR-POINT PUSHER SCORE

In 1999, five senior neurological physiotherapists at the Royal Melbourne Hospital (Parkville, VIC, Australia), led by Lyndell Keating, decided to develop a scale to measure pusher behaviour. After reviewing the literature (e.g., Bohannon,¹⁸ Carr & Shepherd,¹⁹ and Davies¹), they met on several occasions to discuss the key elements of pusher behaviour. After approximately 3 months, consensus was achieved on the criteria to be used to allocate patients scores of 0, 1, 2, and 3, which corresponded to *no pushing*, *mild pushing*, *moderate pushing*, and *severe pushing*, respectively. These criteria incorporated both

testing position (e.g., lying, sitting, and standing) and commonly observed pusher behaviour (e.g., visible lean or push, resistance to passive weight shift). The final scoring system, initially known as the Four-Point Pusher Scale (4PPS) but since changed to the Four-Point Pusher Score (4PPS), is presented next.

The reliability of the scores assigned using the 4PPS was examined as part of a Master's of Physiotherapy qualification from the University of Melbourne. Study results were presented at the Australian Physiotherapy Association Congress in 1999, and the 4PPS was introduced into clinical practice at the Royal Perth Hospital (Perth, WA, Australia) and Royal Perth Rehabilitation Hospitals (Shenton Park, WA, Australia) by the senior stroke physiotherapists. The uptake of the 4PPS has increased since then, and it is now used by the majority of hospitals undertaking stroke rehabilitation in Western Australia.

The original study was not published in a peer-reviewed journal. Therefore, senior neurological physiotherapists from Western Australia initiated a study to report the reliability and validity of 4PPS.

FOUR-POINT PUSHER SCALE (4PPS)

As originally described in King and colleagues.²⁰

Description	Score
<i>Score 3: Severe pushing</i>	
In sitting, visible lean/push towards the hemiplegic side and possibly also backwards.	
Accompanied by increased resistance to passive movement in upper limb, lower limb, and trunk of non-hemiplegic side.	
Pushing may be evident in the lying position.	
<i>Score 2: Moderate pushing</i>	
In sitting, no visible lean, but there is resistance to passive weight shift towards the non-hemiplegic side.	
In standing, there is a visible lean or push towards the hemiplegic side.	
<i>Score 1: Mild pushing</i>	
In sitting, no pushing evident.	
In standing or walking, no visible lean, but there is resistance to passive weight shift towards the non-hemiplegic side.	
<i>Score 0: No pushing</i>	
During sitting, standing, and walking, no resistance to passive weight shift towards the non-hemiplegic side is evident.	
No over-activity of the non-hemiplegic side is evident.	