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Research article

An observational study of the impact of professional walking aid prescription on gait parameters for individuals with suspected balance impairments

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ABSTRACT

Background: The primary management strategy for gait impairment is the adoption of a walking aid. However, there are no established criteria upon which to base a decision regarding the need for a walking aid. It appears clinicians prescribe aids based on preference, clinical experience and intuition rather than standardised objective rationale. This may contribute to the inconsistent gait response to walking aids reported in the published literature. Understanding gait changes resulting from gait aid usage may have significant impact on clinical practice by improving confidence of prescribing clinicians and compliance of walking aid usage by patients, maximising the benefits of use, and reducing any risks associated with non-use or inappropriate use, of the walking aid.

Research question: Do professionally prescribed walking aids improve gait parameters?

Methods: This is a secondary data analysis of a cross-sectional study where participants, identified by healthcare staff requiring a mobility assessment due to potential balance impairment of any cause, walked a 20-m straight walking course under three different walking conditions (no aid, walking stick and 4-wheeled walker). Fifty-eight participants were recruited. Commonly reported spatial and temporal gait parameters were assessed using a validated gait analysis device. Changes in gait parameters across the three conditions were compared, noting the individual's professionally prescribed aid and interpreting changes in parameters towards outcomes of the 'no aid required group'.

Results and significance: Gait cycle, cadence, stance, swing and stride length during unaided walking were significantly changed when a walking stick was prescribed ($p < 0.05$). Stance, swing, double support, stride length, speed, max toe clearance and minimum toe clearance were significantly changed when a 4-wheel walker was prescribed ($p < 0.05$). Professional walking aid prescription improves some gait parameters. A greater number and magnitude of gait parameter improvements were seen in people requiring a 4-wheel walker than people requiring a walking stick.

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1. Introduction

Gait impairments may occur for many reasons including acute and chronic diseases, and physiological changes secondary to aging [1]. The main form of management is the adoption of a walking aid such as canes, crutches and walkers [2]. Walking aids are widely used with a higher uptake in the older population, two-thirds of walking aid users being older than 65 years [3]. In the United States, 10 % of adults over 65 years of age use canes and 4.6 % use walkers [3]. In the United Kingdom the frequency of aid use is even higher with 22 % of older people using walking aids indoors and 44 % using walking aids outdoors [4]. It is reported that the rate of falls in community dwelling older people around the world is approximately 30–40 % each year [5]. Fortunately, many falls are preventable [6]. Falls risk may be reduced by the use of mobility aids by those with walking impairments [7].

When walking aids are used, one of the anticipated benefits is improved gait performance. However, this finding is not consistently reported in the literature. Hardi et al. reported increased gait speed and stride length, decreased base of support and double support when assessed using a walking frame and increased stride time and length, decreased cadence and stride length variability when using a cane compared to walking without the aid in experienced users [8]. Mahoney et al. studied 15 elderly patients with mobility problems, reporting that a 3-wheeled walker increased stride length by 3.6 cm, and decreased time on an obstacle course compared to a 2-wheeled walker They reported that participants showed greater reliance on rollator assistive devices for standing balance and demonstrated higher gait speeds during ambulatory assessment [9].

Some negative impacts of walking aids on gait parameters have also been reported. These include decreased speed, cadence, swing time, step and stride length, and increased stance time and double support in people identified as potentially requiring a walker compared to walking without a rolling walker [10]. Individuals with Parkinson's disease showed slower walking speed when using either a cane or a wheeled walker, and shorter stride length when walking with a wheeled walker [11]. Patients identified with neuromuscular disease had decreased walking distance, speed and cadence when observed using a single point cane, bilateral forearm crutch and walker [12].

Mixed impacts of walking aids on gait parameters have also been reported. A wheeled walker increased gait speed with no significant changes to stride time, stride variability, swing time and swing time variability in a sample with high-level gait disorders [13]. No significant change in any measured gait variables was reported in stroke patients when walking with no device or a walking cane [14]. It was found that using a cane produced no significant change in cadence or speed but resulted in a small increase in step length in people with chronic stroke [15].

Much of the research exploring the effect of walking aids on gait parameters has reported effects without considering whether the aid has been prescribed on the basis of clinical assessment and appropriateness. This may contribute to the unreliable effect of walking aids on gait parameters reported in the literature and limited evidence for the benefits of walking aid prescription [16,17]. It is also recommended current guidance needs to be improved to address environmental constraints whilst facilitating stable walking [18]. An understanding of the impact of professionally prescribed walking aids on gait parameters may reduce the variability in the findings and be more informative to clinicians. To date, there is no published literature assessing the effect of professional walking aid prescription on gait parameters. Understanding the gait changes expected based on the prescription of a walking aid may have significant impact on informing clinical decision making which may improve the confidence of prescribing clinicians, the compliance of walking aid usage by patients, and maximising the benefits and reducing the risks associated with non-use of the walking aid.

This study aims to evaluate the impact of walking aid prescription on gait parameters. Specifically, this work seeks to explore the following questions:

1) Do professionally prescribed walking aids improve gait parameters?
2) What gait parameter changes are seen by using the prescribed walking aid?
3) What gait parameter changes are seen between patients requiring different walking aids?

2. Methods

2.1. Study design

This is a secondary data analysis of a cross-sectional study examining tandem stance in balance impaired individuals by Joo et al. [19].

2.1.1. Participants

Participants were sourced from referrals to a Physiotherapy service or those who were identified by health care staff as requiring a mobility assessment with potential balance impairment at a rural hospital from March to December 2019. Eligibility for inclusion was an ability to walk with or without a walking aid and with or without assistance by another person. Patients were excluded if they had: acute severe neurologic conditions, recent orthopaedic surgery or fracture, and cognition impairment determined by a Mini-Mental State Examination (MMSE) score <24 [20]. Ethics approval for this study was granted by the local Human Research Ethics Committee: the approval number: 2018/ETH00233, dated on the 12th of October 2018. All participants provided written informed consent to participate.

2.1.2. Procedure

Participants walked a 20-m straight walking course 3 times, first with no aid, then with a walking stick, and finally with a 4-

wheeled walker. Participants were instructed to walk at their comfortable pace as described by Guralnik et al. [21].

2.1.3. Data sources/measurement

The variables for this study were professional walking aid prescription status: no aid, walking stick or 4-wheeled walker; and gait parameters while walking with no aid, walking stick and 4-wheeled walker: gait cycle, cadence, stance phase, swing phase, double support, stride length, speed, maximum toe clearance and minimum toe clearance. Professional walking aid prescription was determined by a physiotherapist who used their usual clinical approach to determine if a mobility aid was required, and the aid deemed most suitable was prescribed if required. Gait parameters were measured using the PhysiGait Lab gait analysis system (Gaitup SA, Lausanne, Switzerland). Validity of this instrument against an optical motion capture system (Vicon, Oxford Metrics) in young and elderly populations has previously been established [22,23]. Reliability of gait parameters has been demonstrated with intraclass correlation coefficients ranging from 0.91 to 0.96 [22,23].

2.1.4. Statistical methods

Stata BE-Basic Edition 18.0 (StataCorp, Texas, USA) was used for statistical analysis. The significance level (α) was set to 0.05. Characteristics of the sample were reported as median, inter-quartile ranges and percentages. Kruskal-Wallis test and Chi-squared tests were performed to assess differences between walking aid groups. Assessment of individual gait parameter differences using different walking aids within a group was assessed by Wilcoxon signed rank tests. Gait parameter changes were interpreted as positive or negative. To assess this, we used the gait parameters when walking with no aid from the no aid required group as an anchor. Positive was assumed when the gait parameter changes were statistically significant and were towards the anchor. Negative was assumed when the gait parameter changes were statistically significant and were away from the anchor. Assessment of gait parameter changes between groups was performed by Kruskal-Wallis test. If the assessment was found to be statistically significant, post hoc tests were performed with an adjusted p-value.

3. Results

Fifty-eight participants were assessed by a physiotherapist for mobility aid prescription. The study sample had a median age (IQR) of 76.5 (71–83) years (range 40–94), and 35 (60.3 %) were female. From the professional mobility assessment, 36.2 % were assessed as not requiring a walking aid, 22.4 % were prescribed with a walking stick and 41.4 % were prescribed with a 4-wheel walker. There were no statistically significant differences between these three groups with regard to age and gender (Table 1). In the walking stick prescribed group, 38 % were experienced walking stick users. In the 4-wheel walker group, 58 % were experienced 4-wheel walker users.

3.1. Descriptive data

A summary of gait parameters in each of the three groups at baseline when assessed without aids is presented in Table 2. Differences in gait parameters between the groups were statistically significant in five of the nine gait parameters. Post-hoc testing revealed that these differences were between the no aid required group and the walking stick group in the parameters of stride length (1.23m compared to 0.92m, $p = 0.005$) and speed (1.14 m/s compared to 0.82 m/s, $p = 0.004$). Statistically significant differences between the no aid required group and the 4-wheel walker prescribed group in the parameters of double support (23.31 % of the cycle compared to 27.24 %, $p = 0.008$), stride length (1.23m compared to 0.82m, $p < 0.001$) and speed (1.14 m/s compared to 0.69 m/s, $p < 0.001$) were evident. There were no statistically significant differences between the walking stick prescribed group and the 4-wheel walker prescribed group.

Table 3 details the changes in gait parameters that occur in those prescribed a walking stick when walking with that aid and without it. Differences in gait cycle (0.04s), cadence (−3.53 steps/minutes), stance (−0.69 %), swing (0.69 %) and stride length (0.05m) were statistically significant. The direction of changes in stance, swing and stride length were towards (positive) the baseline parameters of the no aid required group. The direction of changes in gait cycle time and cadence were away (negative) from the baseline parameters of the no aid required group.

The changes in gait parameters in the sample who were prescribed to use a 4-wheel walker when walking with a 4-wheel walker and without it are shown in Table 4. Stance (−1.30 %), swing (1.30 %), double support (−2.59 %), stride length (0.13m), speed (0.07 m/s), max toe clearance (0.60 cm) and minimum toe clearance (−0.55 cm) were statistically significant. The direction of changes in stance, swing, double support, stride length, speed and max toe clearance were towards (positive) the baseline parameters of the no aid required group. The direction of changes in minimum toe clearance were away (negative) from the baseline parameters of the no aid required group.

3.2. Gait differences when assessed with no aid and with a walking stick in the no aid required group; the walking stick prescribed group; and the 4-wheel walker prescribed group

Table 5 shows the use of a walking stick statistically significantly increased gait cycle time (0.6 s, 0.04 s and 0.06 s) and decreased cadence (6.24 steps/minute, 3.54 steps/minute and 5.52 steps/minute) respectively in all three groups. It statistically significantly decreased speed (0.07 m/s) and increased minimum toe clearance (0.14 cm) only in the no aid required group. It statistically significantly reduced stance (0.69 %), and increased swing (0.69 %) and stride length (0.05 m) only in the walking stick prescribed

Table 1
Characteristics of the study sample (N = 58).

Age (years)	
Median (IQR)	76.5 (71–83)
Range	40–94
Gender N (%)	
Female	35 (60.3)
Male	23 (39.7)
MSSE score	
Median (IQR)	28 (27–29)
Walking aid prescribed N (%)	
No aid	21 (36.2)
Walking stick	13 (22.4)
4 wheel walker	24 (41.4)
Diagnoses in each group N	
No aid group	
Osteoarthritis	6
Back pain	3
Pneumonia	1
Ventral hernia repair	1
Non-ST-elevation myocardial infarction	1
Acute kidney injury	1
Rheumatoid arthritis	1
Polymyalgia rheumatica	1
Being deconditioned	1
Fracture	1
Hypotension	1
Tendinopathy	1
Syncope	1
Not specified	1
Walking stick group	
Osteoarthritis	2
Balance impairment	2
Fall	2
Cerebral vascular accident	2
Back pain	1
Fracture	1
Coronary bypass	1
Subdural hematoma	1
Chronic obstructive pulmonary disease	1
4 wheel walker group	
Cerebral vascular accident	3
Fall	2
Sepsis	1
Osteoarthritis	1
Gout	1
Pancreatitis	1
Asthma	1
Chronic obstructive pulmonary disease	1
Urinary tract infection	1
Being deconditioned	1
Acute knee pain	1
Heart failure	1
Back pain	1
Ascites	1
Spinal fusion	1
Pneumonia	1
Decreased mobility	1
Non-ST-elevation myocardial infarction	1
Parkinson's disease	1
Coronary bypass	1
Total knee replacement	1

	No aid required group	Walking stick prescribed group	4 wheel walker prescribed group	p-value
Age				0.23£
Median (IQR)	73 (67–81)	77 (72–79)	77.5 (73.5–83)	
Range	40–92	54–92	59–94	
Sex N (%) Female	15 (71.4)	7 (53.9)	13 (54.2)	0.42¥

£: Kruskal-Wallis ¥: Chi-squared test, MMSE = Mini-Mental State Examination.

Table 2
Gait parameter differences between groups when walking with no aids.

	No aid required group gait parameters(n = 21)	Walking stick prescribed group gait parameters(n = 13)	4-wheel walker prescribed group gait parameters(n = 24)	p-Value from Kruskal-Wallis	Post hoc (Adjusted p-value for significance is 0.008)
Gait Parameter	Median(IQR)	Median(IQR)	Median(IQR)		
Gait cycle (seconds)	1.12(1.07–1.15)	1.20(1.10–1.25)	1.21(1.04–1.37)	0.16	
Cadence(steps/ minute)	106.98(104.29–112.57)	100.20(96.19–108.84)	99.68(89.81–115.82)	0.16	
Stance(%)	61.53(60.02–63.53)	64.39(62.04–66.19)	63.59(61.79–69.07)	0.04	Multiple comparison non-significant
Swing(%)	38.47(36.47–39.98)	35.61(33.81–37.96)	36.41(30.93–38.21)	0.04	Multiple comparison non-significant
Double support(%)	23.31(19.89–27.13)	28.74(24.01–32.28)	27.24(23.51–38.16)	0.04	No aid required vs 4-wheel walker prescribed 0.008
Stride length (metres)	1.23(1.11–1.33)	0.92(0.87–1.14)	0.82(0.58–0.94)	<0.01	No aid required vs Walking stick prescribed 0.005 No aid required vs 4-wheel walker prescribed <0.001
Speed(metres/s)	1.14(0.90–1.24)	0.82(0.71–1.01)	0.69(0.50–0.83)	<0.01	No aid required vs Walking stick 0.004 No aid required vs 4-wheel walker <0.001
Max toe clearance (centimetres)	7.88(5.71–9.73)	6.76(5.37–11.07)	6.22(5.64–8.15)	0.63	
Min toe clearance (centimetres)	3.21(2.65–3.78)	2.60(1.69–3.28)	3.26(2.74–3.83)	0.06	

Table 3
Gait parameter differences between walking with a walking stick and walking without an aid (walking stick-no aid) in the walking stick prescribed group.

Gait Parameter	Median(IQR)	p-value	Direction of the statistically significant changes
Gait cycle(seconds)	0.04(0.02–0.08)	<0.01	Negative
Cadence(steps/minute)	−3.53(-6.03–1.10)	<0.01	Negative
Stance(%)	−0.69(-0.99–0.24)	0.05	Positive
Swing(%)	0.69(0.24–0.99)	0.05	Positive
Double support(%)	−1.37(-1.66–0.60)	0.06	
Stride length(metres)	0.05(-0.01–0.07)	0.03	Positive
Speed(metres/s)	−0.01(-0.04–0.06)	0.79	
Max toe clearance (centimetres)	0.42(-0.22–1.21)	0.24	
Min toe clearance(centimetres)	0.03(-0.44–0.29)	1.00	

IQR= Interquartile Range.
Direction of the changes shown only with statistically significant changes: Negative = change further away from no aid required group parameters without aid; Positive = change closer to the no aid required group parameters without aid.

group. When evaluating the changes in all gait parameters across all three groups, it was found that the use of a walking stick decreased speed (by 0.07 m/s) in the no aid required group, while it did not have a significant effect on speed (−0.01 m/s) in the walking stick prescribed group. No other differences were statistically significant.

3.3. Gait differences when assessed with no aid and with a 4-wheel walker in the no aid required group; the walking stick prescribed group; and the 4-wheel walker prescribed group

In the no aid required group, the use of a 4-wheel walker led to significant increases in gait cycle time (by 0.05 s) and reductions in cadence (by 5.36 steps/minute), stride length (by 0.03 m), and speed (by 0.08 m/s), as shown in Table 6. A 4-wheel walker significantly reduced minimum toe clearance (0.30 cm) in the walking stick prescribed group. The changes in gait parameters by the use of a 4-wheel walker in the 4-wheel walker group were statistically significantly different from the no aid required group in stance (−1.30 % vs 0.40 %), swing (1.30 % vs −0.40 %), double support (−2.59 % vs 0.87 %), stride length (0.13 m vs −0.03 m), speed (0.07 m/s vs

Table 4
Gait parameter differences between walking with a 4-wheel walker and walking without an aid (4-wheel walker-no aid) in the 4-wheel walker prescribed group.

Gait Parameter	Median(IQR)	p-value	Direction of the statistically significant changes
Gait cycle(seconds)	0.02(-0.03–0.07)	0.29	
Cadence(steps/minute)	−3.52(-6.50–1.29)	0.14	
Stance(%)	−1.30(-4.38–0.45)	<0.01	Positive
Swing(%)	1.30(0.45–4.38)	<0.01	Positive
Double support(%)	−2.59(-8.64–1.01)	<0.01	Positive
Stride length(metres)	0.13(0.07–0.18)	<0.01	Positive
Speed(metres/s)	0.07(0.01–0.13)	<0.01	Positive
Max toe clearance (centimetres)	0.60(0.16–1.11)	0.02	Positive
Min toe clearance(centimetres)	−0.55(-0.90–0.12)	<0.01	Negative

IQR= Interquartile Range.
Direction of the changes shown only with statistically significant changes: Negative = change further away from no aid required group parameters without aid; Positive = change closer to the no aid required group parameters without aid.

Table 5
Gait parameter differences between walking with a walking stick and walking without aid (walking stick-no aid) in the three groups.

	No aid required group gait parameter changes between no aid and walking stick		Walking stick prescribed group gait parameter changes between no aid and walking stick		4-wheel walker prescribed group gait parameter changes between no aid and walking stick		Kruskal-Wallis test	Post hoc test(Adjusted p-value for significance = 0.008)
Gait Parameter	Median(IQR)	p-value Ш	Median(IQR)	p-value Ш	Median(IQR)	p-value Ш	p-value	
Gait cycle(seconds)	0.06 (0.03–0.12)	<0.01	0.04 (0.02–0.08)	<0.01	0.06 (0.01–0.13)	0.01	0.36	
Cadence(steps/minute)	−6.24 (-9.26–2.56)	<0.01	−3.53 (-6.03–1.10)	<0.01	−5.52 (-9.85–1.96)	<0.01	0.27	
Stance(%)	0.20 (-0.16–0.40)	0.18	−0.69 (-0.99–0.24)	0.05	0.03 (-1.55–0.79)	0.60	0.11	
Swing(%)	−0.20 (-0.40–0.16)	0.18	0.69 (0.24–0.99)	0.05	−0.03 (-0.79–1.55)	0.60	0.11	
Double support(%)	0.48 (-0.24–0.98)	0.14	−1.37 (-1.66–0.60)	0.06	0.16 (-2.99–1.63)	0.60	0.12	
Stride length (metres)	<-0.01(-0.03-0.01)	0.37	0.05 (-0.01–0.07)	0.03	0.02 (-0.04–0.08)	0.22	0.05	Not significant
Speed(metres/s)	−0.07 (-0.14–0.03)	<0.01	−0.01 (-0.04–0.06)	0.79	−0.03 (-0.08–0.03)	0.21	0.02	α (0.003)
Max toe clearance (centimetres)	0.05 (-0.27–0.28)	0.79	0.42 (-0.22–1.21)	0.24	0.17 (-0.13–0.89)	0.17	0.38	
Min toe clearance (centimetres)	0.14 (-0.01–0.32)	0.01	0.03 (-0.44–0.29)	1.00	0.01 (-0.40–0.15)	0.55	0.16	

Ш Wilcoxon signed rank test to assess gait parameter changes before and after walking with the given walking aid within the group.
Post Hoc test: α (Statistical significance between No aid required group and Walking stick prescribed group).
Β (Statistical significance between No aid required group and 4-wheel walker prescribed group).
Γ (Statistical significance between Walking stick prescribed group and 4-wheel walker prescribed group).

−0.08 m/s) and minimum toe clearance (−0.55 cm vs −0.15 cm) respectively. The changes of gait parameters by the use of a 4-wheel walker in the 4-wheel walker group were statistically significantly different from the walking stick prescribed group in stride length (0.13 m vs < 0.01 m) and speed (0.07 m/s vs −0.06) respectively. The changes of stride length and speed were statistically significantly different between the no aid required group and the 4-wheel walker group. The changes occurred in opposite directions, that is stride length (−0.03 m vs 0.13 m) and speed (−0.08 vs 0.07 m/s) respectively. This indicates that the use of 4-wheel walker had an inverse effect in these two groups.

4. Discussion

This study confirms that when people mobilise with walking aids which have been professionally prescribed, there is improvement in some gait parameters. Prescription of walking stick changed gait cycle time, cadence, stance, swing and stride length. Prescription of 4 wheel walker changed stance, swing, double support, stride length, speed, max toe clearance and min toe clearance. It appears that stance, swing and stride length are the parameters most improved with prescribed walking aids. Prescription of a 4-wheel walker had an impact of greater magnitude compared to changes observed with a walking stick. When the changes in the prescribed groups were compared to the other groups, some unique differences were observed.

Table 6
Gait parameter differences between walking with a 4 wheel walker and walking without aid (4 wheel walker-no aid) in the three groups.

	No aid required group gait parameter changes between no aid and 4-wheel walker		Walking stick prescribed group gait parameter changes between no aid and 4-wheel walker		4-wheel walker prescribed group gait parameter changes between no aid and 4-wheel walker		Kruskal-Wallis test	Post hoc test (Adjusted p-value for significance = 0.008)
Gait Parameter	Median(IQR)	p-value Ш	Median(IQR)	p-value Ш	Median(IQR)	p-value Ш	p-value	
Gait cycle(seconds)	0.05 (0.03–0.10)	<0.01	0.04 (0.01–0.05)	0.11	0.02 (-0.03–0.07)	0.29	0.19	
Cadence(steps/minute)	−5.36 (-7.01–2.48)	<0.01	−3.30 (-4.76–0.94)	0.08	−3.52 (-6.50–1.29)	0.14	0.25	
Stance(%)	0.40 (-0.32–0.68)	0.13	−0.25 (-0.94–0.26)	0.17	−1.30 (-4.38–0.45)	<0.01	<0.001	β (<0.001)
Swing(%)	−0.40 (-0.68–0.32)	0.13	0.25 (-0.26–0.94)	0.17	1.30 (0.45–4.38)	<0.01	<0.001	B (<0.001)
Double support(%)	0.87 (-0.66–1.40)	0.09	−0.44 (-1.71–0.28)	0.15	−2.59 (-8.64–1.01)	<0.01	<0.001	B (0.007)
Stride length (metres)	−0.03 (-0.04–0.02)	0.01	<0.01(-0.05-0.04)	0.84	0.13 (0.07–0.18)	<0.01	<0.001	β (<0.001), γ (0.001)
Speed(metres/s)	−0.08 (-0.12–0.06)	<0.01	−0.06 (-0.07–0.01)	0.24	0.07 (0.01–0.13)	<0.01	<0.001	β (<0.001), γ (0.003)
Max toe clearance (centimetres)	0.01(-0.33-<0.29)	0.95	0.27 (-0.01–0.86)	0.27	0.60 (0.16–1.11)	0.02	0.08	
Min toe clearance (centimetres)	−0.15 (-0.42–0.17)	0.19	−0.30 (-0.48–0.09)	0.01	−0.55 (-0.90–0.12)	<0.01	0.03	β (0.004)

Ш Wilcoxon signed rank test to assess gait parameter changes before and after walking with the given walking aid within the group.
Post Hoc test: α (Statistical significance between No aid required group and Walking stick prescribed group).
β (Statistical significance between No aid required group and 4-wheel walker prescribed group).
γ (Statistical significance between Walking stick prescribed group and 4-wheel walker prescribed group).

When comparing between the walking stick prescribed group and the 4 wheel walker prescribed group, the differences of the gait parameters on baseline did not appear to be statistically significant while some statistically significance were observed between the no aid prescribed group and the walking aid prescribed groups. However, there was an indication that the differences between the walking aid prescribed group may be meaningful. For example, the differences of the medians for walking speed of two groups was 0.13 m/s. The magnitude of this difference may be considered clinically meaningful despite the study potentially being under-powered to detect the true group differences. This may also indicate that the three-group comparison may also have been under-powered. For a future study design looking at impact on gait parameters by walking aids, bigger sample size may enable better assessment of the walking aid prescription impact.

Prescription of a walking stick led to significant change in 5 out of 9 gait parameters, and 7 parameters in the 4-wheel walker group. The patterns of gait parameter changes were not unidirectional for all parameters. Two gait parameters for the walking stick prescribed group and one gait parameter for the 4-wheel walker group appeared to change away from the baseline parameters of the no aid required group. However, this needs to be interpreted with caution and may not represent deterioration in the gait performance. In the walking stick prescribed group, gait cycle and cadence changed away from the baseline parameters of the no aid required group. For stride length to increase without increased speed, inevitably gait cycle time increases and cadence decreases, which may be a reflection of the improved stride length without increased gait speed. Within the 4-wheel walker group, minimum toe clearance decreased by a median of −5.49 mm–27.90 mm. This may not represent a clinically meaningful change as previous authors have been unable to determine a minimum toe clearance as a predictor of trips [24]. Furthermore, when the changes of gait parameters with the walking aid in the walking aid prescribed groups are compared to the changes of gait parameters with the same walking aid in the no aid required group, the changes indicate that professionally prescribed walking aids indeed improve gait parameters while the no aid required group deteriorated with walking aids.

The gait changes observed are clinically meaningful. In those prescribed a 4-wheel walker, gait stride length and double support changed by 16 % and 9 % respectively with the use of the aid. Verghese et al. reported increased risk ratios for falls by 1.095 and 1.207 with decreased stride length by 10 % and increased double support by 10 % respectively [25]. Estimates of meaningful change of gait speed have ranged from 0.04 to 0.14 m/s for community-dwelling older adults [26]. The use of the 4-wheel walker group reached a meaningful change of gait speed of 0.7 m/s. However, the walking speed in the walking stick group did not change significantly. This implies that walking stick use may not alter gait velocity to an extent that is clinically meaningful. Alternatively, it may reflect the fact that some participants were not trained in the use of the walking stick, which requires an element of skill, therefore velocity improvements were not immediately apparent but may have become evident following training and practice. It is important to note, that other reported benefits including reduced personal assistance [27], greater functional independence [28], continued community living and involvement in social activities [29,30], slowed decline of function [31], and reduced health care costs [31] may be unrelated to gait parameter changes, and may improve independently as a result of mobilising with a walking stick.

Hardi et al. examined gait speed, cadence, stride time, stride length and double support in community dwelling walking aids users.

The pattern of changes reported by these authors were similar to those seen in our results in the walking stick group [8]. However, the magnitudes of change in the 4-wheel walker group were larger in their sample. This may be the result of their participants being experienced walking aids users whereas our sample included participants who were new to the walking aids used therefore training effects may explain these differences. Additionally, differences may be due to their sample including participants with greater balance impairment resulting in greater scope for improvement. This is evident in a comparison of double support whereby the former study reported a mean of 39.9 % compared to our median value of 27.24 %. This suggests that their sample may have included participants who were more reliant on the 4-wheel walker.

4.1. Limitations

This is a post hoc analysis of data collected for a previous study. Therefore, there are several limitations in the study design. Firstly, the sample includes a combination of experienced and in-experienced walking aid users. As this study does not differentiate between participants based on their walking aid experience, the effect of skill acquisition with practice may mean some participants are more proficient in the use of gait aids than those who are inexperienced, and this would be expected to have an effect on gait parameters. To understand the immediate impact of walking aid prescription, and changes over time with skill acquisition, a study recruiting participants who were prescribed walking aids for the first time with longitudinal assessments would be necessary. Also, we did not compare to normative data, but have used walking with no aid in the no aid required group to assess if the changes are positive or negative in the walking aid prescribed groups. As these participants were sourced from referrals to the Physiotherapy service or were identified by health care staff as requiring a mobility assessment, the validity of this comparison may be questionable. There are also limitations of the walking test. First, straight line walking only was performed. This may not reflect usual function which involves more complex motion and direction changes [9,18,32,33]. Second, although a rest time was given between three different walking conditions, not randomising the order of the three different walking conditions may have elicited some order effects. Furthermore, we selected this sample with heterogenicity in medical conditions, it is highlighted that specific disorders influenced walking conditions and required specific aids and rehabilitation [34]. Therefore, the results need to be interpreted with caution.

4.2. Interpretation

This study endorses the use of gait analysis and the assessment of changes in specific parameters, to guide the prescription of walking aids. The outcome of the study provides confidence to prescribe walking aids to individuals whose gait parameters improve with walking aid use. These findings may give directions for future studies where recruiting a newly prescribed sample and assessing changes of gait parameters would provide more insight. Regardless of the aid prescribed, it appears that stance, swing and stride length are the parameters most useful in detecting changes in gait performance that would indicate the appropriateness of aid prescription. Future studies assessing the utility of using these parameters as a guide for prescription in clinical practice would be worthwhile.

4.2.1. Generalizability

As this study recruited participants in a typical hospital setting, the findings have relevance to routine physiotherapy practice.

5. Conclusion

Professional walking aid prescription improves gait parameters especially with people requiring a 4-wheel walker. The pattern of gait parameter changes by walking aid prescription is positive compared to those assessed as not requiring a walking aid.

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Data availability statement

The data associated with this study has not been deposited into a publicly available repository. However, the data will be made available on request.

CRediT authorship contribution statement

Baeho Joo: Writing – review & editing, Writing – original draft, Software, Resources, Project administration, Methodology, Investigation, Funding acquisition, Formal analysis, Data curation, Conceptualization. **Jodie L. Marquez:** Writing – review & editing, Supervision, Conceptualization. **Peter G. Osmotherly:** Writing – review & editing, Supervision, Conceptualization.

Declaration of competing interest

The authors declare the following financial interests/personal relationships which may be considered as potential competing

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