Review Article

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Effects of auditory or visual stimuli on gait in Parkinsonic patients: a systematic review

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Abstract
Background: External stimuli can improve gait performance in Parkinsons Disease (PD): auditory stimuli can increase velocity and visual stimuli may act at step length.

Objective: To systematize the scientific evidence about the effects of auditory or visual stimuli on gait in patients with PD.

Methods: From January 2016 to December 2018, a systematic literature research was conducted in the PubMed/Medline and Web of Science databases. Study designs considered were randomized controlled trials (RCTs) and observational studies, which evaluated the effects of auditory or visual stimuli on gait in PD. The methodological quality was assessed by the Critical Appraisal Skills Program.

Results: Five articles were included with 232 participants and a methodological rank of mean of 10.3 on the cohort studies (n = 3), 8 on the case control studies (n = 1), and 6 on the RCTs (n = 1). Although 3 evaluated the effects of auditory stimuli on gait in PD, 2 analyzed those of visual stimuli. Based on these, it was verified a significant improvement of diverse gait parameters.

Conclusion: The application of auditory or visual stimuli have beneficial effects on gait parameters. Further investigation is required.

Keywords: auditory perception, exercise, gait, Parkinson disease, physical therapy modalities, visual perception

Introduction

Parkinson disease (PD) is a chronic and progressive neurodegenerative condition that affects approximately 10 million individuals worldwide.[1] The pathophysiology results from the degeneration of dopamine-producing cells, mainly affecting the basal ganglia and the substantia nigra of the striated body area of the cerebral hemispheres.[2] The prevalence of the disease ranges from 41 people per 100,000 in the fourth decade of life to more than 1900 people per 100,000 among those who are 80 and older. The incidence generally increases with age, although it can stabilize in people who are older than 80 years. Meantime, it is estimated that 4% of people with PD are diagnosed before the age of 50 years. In addition, men are 1.5 times more likely to have the disease than women.[1,4,5]

The degeneration of PD leads to motor and nonmotor complications. First, the nonmotor include autonomic dysfunction, fatigue, apathy, sensory complaints, sleep disturbance, depression, cognitive dysfunction, and consequent decreased quality of life, whereas the motor complications consist of tremor, stiffness, bradykinesia, decreased lung capacity, deterioration of muscle strength, balance, and gait performance.[3,6,7]

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Individuals with PD commonly have gait disturbances, characterized by decreased step length and gait speed and, consequently, increased cadence. Freezing of Gait (FoG) often occurs during the onset or deviation, being the main risk factor for falls. Gait disorders are considered the most disabling motor symptoms of PD, leading to a substantial decline in mobility and independence, a high fall rate and a reduction in quality of life.[8,9]

Gait is one of the main areas of intervention in physiotherapy. Physiotherapy allows maximizing and/or preserving the patients functional capacities, avoiding or reducing the appearance of secondary complications and allowing the deceleration of the disease progression rate.[10,11] Physiotherapy should include motor exercises, balance training, high-intensity exercises, breathing exercises, practice of daily life activities, and gait training (with and without external stimuli).[12–14]

It was observed that external stimuli can improve gait performance in patients with PD.[9,15,29] These favor movement, including the start and progression of walking, increase of step size, and reduce the frequency and intensity of freezing. Different types of stimuli have been proposed, and their specific action on gait parameters is related to the stimulated sensory system. From the clinical practice experience, it seems that use auditory stimuli can improve velocity, whereas visuals are able to influence mainly on the step length, corroborating previous studies.[17,18]

Over the years, some reviews have emerged about the important role of external stimuli in patients with PD, but it is rare to show whether interventions are supervised by physiotherapists, key elements in patient rehabilitation.[19–21] The aim of this study is to systematize the scientific evidence regarding the effects of auditory or visual stimuli on gait in patients with PD, with the supervision of physiotherapists.

Methods

Search strategy

A systematic review of the literature was conducted to identify experimental studies, including randomized controlled trials

(RCTs), and observational studies, with case-control and cohort designs that evaluated the effects of auditory or visual stimuli on gait in patients with PD, with the supervision of physiotherapists.

A search was made using PubMed/Medline and Web of Science Core Collection databases and was carried out between January 2016 and December 2018. The keywords were combined, and the search strategy was *Parkinson disease AND physical therapy OR physiotherapy AND physical exercise OR training AND auditory stimuli OR visual stimuli AND gait*.

Databases search, as well as title and abstract screening were conducted by 2 independent investigators (M.F.D.T., R.A.V.), which confronted both results to check for overlapping. Any disagreements were discussed by until consensus was reached.

Inclusion and exclusion criteria

From the screening of all titles and abstracts, the articles were read assessing the eligibility according to the following inclusion criteria: experimental studies including RCTs; observational studies, including case-control and cohort designs; articles in Portuguese and / or English; articles that include a physical exercise program and guided by a physiotherapist; individuals with a clinical diagnosis of PD according to the Unified Parkinsons Disease Rating Scale (UPDRS); no cognitive impairment by performing the Mini-Mental State Examination (>24 points); with an average age older than 40 years; with diseases stage 1 to 4 in 5, according to Hoehn and Yahr Scale (H&Y); with a good understanding and communication; no severe auditory and visual deficits; medically stable, including antiparkinsonian medication and without significant fatigue or subjective fatigue, by Parkinsons Disease Fatigue Scale-16.

Data collection and extraction

Two independent investigators (M.F.D.T., R.A.V.) retrieved all the information and matched for consensus. From the selected studies, information of the study participants characteristics (Table 1), the intervention group (IG) and the control group (CG) (Table 2), the results of the RCTs (Table 3), case-control studies (Table 4), and cohort studies (Table 5) was collected. The variables studied on RCTs were walking speed (a), stride length (b), cadence (c), Timed Up and Go Test (d), UPDRS – Part III (e) and FoG Questionnaire (FoG-Q) (f). Already on case-control studies, it was studied the age (a), UPDRS – Part III (b), Montreal Cognitive Assessment (c), Geriatric Depression Scale (d), fluctuation of attention (e), judgment of line orientation (f), Executive Clock Drawing Test (g), digit span (h), visual acuity (i), and contrast sensitivity (j). Finally, on the cohort studies, the variables studied were support phase (a), balance phase (b), double support phase (c), stride time (d), cadence (e), step length (f), speed (g), stride length (h), stride width (i), H&Y mode ON (j), UPDRS—Part III mode ON (k), FoG-Q (l), UPDRS—Part II (FoG-Q) mode ON (m), Parkinsons Disease Questionnaire (n), Berg Balance Scale (o), walking test at a distance of 10 m at comfortable speed (p), and walking test at a distance of 10 m at maximum speed (q).

Methodological quality assessment

The quality of the scientific evidence of the studies was rated according to the Critical Appraisal Skills Program (CASP).[22] It includes 8 critical assessment tools for different study designs such as systematic reviews, RCTs, cohort studies, case-control studies, cross-sectional studies, among others. It is noteworthy that it is designed for research reading from a wide range of fields. In addition, this scale assesses the objective of the study, adequacy of the methodological design to the objective of the investigation, presentation of methodological procedures, sample selection criteria, details of the data collection, relationship between the researcher and the participants, considerations on ethical aspects, rigor in data analysis, ownership in the presentation and discussion of results, and the value of the research, including the contributions, limitations, and needs of new research. Articles with a higher score have a better methodological quality, with the maximum score in RCTs being 10, and continuously, in case-control and cohort designs its 12 and 14, respectively.[23]

Results

Eight hundred eighty-two articles were found in the databases and were shortened to 876 after removal of duplicates. Then, only 8 articles were selected after reading the title and the

Table 1

Characteristics of study participants

Participants							
References	**Study design/ CASP score**	**Sample size**	**Age (mean ± standard deviation)**	**Sex (M/W)**	**Disease duration (mean ± Standard deviation)**	**Dropouts (timeframe)**	**Stage of PD***
Agosta et al, 2017 [25]	Cohort study (10/14)	IG1 = 12 IG2 = 13 CG = 19	(64.0 ± 7.0) (69.0 ± 8.0) (66.0 ± 8.0)	10/2 8/5 9/10	–	–	II–III
Bukowska et al, 2015[26]	Cohort study (9/14)	IG = 30 CG = 25	(63.4 ± 10.6) (63.4 ± 9.7)	15/15 15/10	(5.5 ± 3.9) (6.8 ± 4.3)	–	II–III
Pau et al, 2016[27]	Cohort study (12/14)	IG = 26 CG = -	(70.4 ± 9.0) –	20/6 –	(7.5 ± 5.4) -	5 (–) -	I–III
Schlick et al, 2016[28]	Randomized controlled trial (6/10)	IG = 10 CG = 10	(71.2 ± 10.9) (68.9 ± 6.8)	2/8 4/6	(10.4 ± 5.2) (9.1 ± 3.1)	2 (6 wk after study start) 4 (2 mo follow-up) 1 (6 wk after study start) 3 (2 mo follow-up)	II–IV
Stuart et al, 2018[16]	Case control study (8/12)	IG = 55 CG = 32	(67.9 ± 7.9) (67.0 ± 10.8)	36/19 15/17	60.0 (-) –	–	I–III

- = unspecified information; CG = control group; IG = intervention group; M = man; PD = Parkinsons disease; RCT = randomized controlled trial; W = woman.

* Parkinson disease stage according to Hoehn and Yahr Scale.

Table 2

Characteristics of intervention group and control group

References	External sensory stimuli (yes/no)	IG protocol (duration, frequency)	CG protocol
Agosta et al, 2017[25]	Auditory: yes Visual: no	8 wk; 3 times per week 60 min of training (24 min of observation and 36 min of precision imitation to the rhythm of the auditory stimuli), during ON time, under the supervision of a physiotherapist. IG_1 = Observation and subsequent practice of actions at the rate of auditory stimuli. IG_2 = Same exercise training through physiotherapists instructions, only combined with the observation of landscape videos.	At baseline, the healthy controls performed neuropsychological and magnetic resonance imaging assessments.
Bukowska et al, 2015[26]	Auditory: yes Visual: no	4 wk; 4 times per week. 45 min per session of neurological music therapy, with warm-up exercises, daily life activities, pregait, and with gait pattern stimulation through rhythmic auditory stimulation, and in the end, the breathing exercises.	Maintenance of daily life activities.
Pau et al, 2016[27]	Auditory: yes Visual: no	5 wk, 2 times per week. 45 min of exercises to improve mobility, balance, posture, and gait. Twenty minutes of each session consisted of a paced gait with soundtracks through a portable MP3 player and headphones. In addition, the training was performed at home, including 30 min of walking with rhythmic auditory clues.	-
Schlick et al, 2016[28]	Auditory: no Visual: yes	5 wk, 2 to 3 times per week. Treadmill training combined with visual stimuli.	Unique treadmill training.
Stuart et al, 2018[16]	Auditory: no Visual: yes	- 7 m in self-selected pace and different walking conditions, with 3 attempts in each condition. 1) Single task (straight walking); 2) Single task with visual stimuli (tape with black lines, placed 50 cm apart and transverse to the starting point); 3) Double task (maximum forward digit range and gait); 4) Double task with visual stimuli.	Same protocol as the IG.

- = unspecified information; CG = control group; IG = intervention group; MP3 = moving picture experts group layer.

abstract. After full text reading, 5 studies that met the inclusion criteria were identified and included in this review, of which 3 were cohort studies, 1 case-control study, and 1 RCT. All reporting of the systematic review was according to PRISMA (Preferred Reporting Items For Systematic Reviews) (Fig. 1).[24]

The following flowchart demonstrates the selection of the articles (Fig. 1).[24]

Two hundred thirty-two individuals participated in the included studies (minimum sample of 20 and maximum of 87), with a mean number of participants per study of 46.4 and a standard deviation of 23.8 in this sample, with ages between 28 and 88 years (Table 1). Regarding methodological quality, the case-control studies, specifically, the study by Stuart et al,[16] showed a methodological quality of 8 out of 12 on the CASP scale, where the methodological quality of arithmetic mean was 8. The data from the cohort studies showed, by the study by Agosta et al,[25] a methodological quality of 10 out of 14. By Bukowska et al,[26] had 9 out of 14 and finally, by Pau et al,[27] 12 out of 14. This sums up a methodological quality of arithmetic mean of 10.3 out of 14. To finish, RCTs, namely Schlick et al[28]

Table 3

Results of randomized controlled trials

		IG				CG			
References	Variable	Baseline	End of treatment	Follow-up	*P*	Baseline	End of treatment	Follow-up	*P*
Schlick et al, 2016[28]	a	1.7±0.8	2.6±0.7	2.6±0.5	.000	2.4±0.7	3.5±0.9	2.5±1.1	.001
	b	61.1±29.6	90.4±21.7	78.4±23.4	.001	75.1±18.2	104.5±21.7	82.2±25.2	.002
	c	9.9±28.1	95.4±10.9	95.6±8.4	.665	107.4±21.8	110.0±13.2	99.7±23.1	.650
	d	14.4±6.8	11.8±5.5	10.9±4.4	.006	10.9±4.7	10.8±4.0	10.4±5.0	.237*
	e	28.9±13.8	23.8±13.5	21.8±13.4	.019	25.3±15.1	23.4±10.1	28.2±13.7	–
	f	9.6±5.7	10.0±6.9	3.2±4.1	.001*	10.5±6.2	9.8±6.5	4.2±4.5	.521*

* The *P* values are relative to the results obtained after the 2-month follow-up.

- = unspecified information; CG = Control group; IG = Intervention group; *P* = significance level; a = walking speed; b = stride length; c = cadence; d = Time Up and Go Test; e = Unified Parkinsons Disease Rating Scale—Part III; f = Freezing of Gait Questionnaire.

Table 4

Results of case-control studies

References	Task	Variable	IG β	IG P	CG β	CG P
Stuart et al, 2018[16]	Δ CUE	a	−0.281	.097	0.232	.410
		b	−0.294	.101	–	–
		c	−0.346	.057	−0.055	.813
		d	0.154	.326	−0.139	.500
		e	−0.348	.035	0.050	.859
		f	0.209	.189	0.061	.814
		g	−0.129	.411	−0.067	.812
		h	0.190	.167	0.125	.621
		i	−0.008	.961	0.026	.917
	Δ CUE - DUAL	j	−0.451	.033	0.199	.407
		a	0.121	.513	0.300	.270
		b	−0.290	.143	–	–
		c	−0.010	.960	−0.136	.544
		d	0.080	.644	0.183	.358
		e	−0.077	.666	−0.472	.090
		f	0.116	.509	0.455	.078
		g	−0.043	.804	−0.241	.380
		h	−0.133	.379	−0.104	.667
		i	0.120	.531	−0.221	.359
		j	0.066	.772	0.051	.822

- = unspecified information; β = regression coefficient; CG = control group; IG = intervention group; *P* = significance level; a = age; b = Unified Parkinsons Disease Rating Scale—part III; c = Montreal Cognitive Assessment; d, = Geriatric Depression Scale; e = fluctuation of attention; f = judgment of line orientation; g = Executive Clock Drawing Test; h = digit span; i = visual acuity; j = contrast sensitivity.

Table 5

Results of cohort studies

References	Variable	IG Baseline	IG End of treatment	IG Follow-up	IG P	CG Baseline	CG End of treatment	CG Follow-up	CG P
Bukowska et al, 2015[26]	a	–	62.2 ± 1.5	–	<.001	–	63.2 ± 2.0	–	.131
	b	–	37.8 ± 1.5	–	<.001	–	36.9 ± 2.0	–	.056
	c	–	12.3 ± 1.5	–	<.001	–	13.2 ± 2.1	–	.065
	d	–	1.0 ± 0.1	–	<.001	–	1.1 ± 0.1	–	.438
	e	–	116.6 ± 9.1	–	.001	–	113.1 ± 12.8	–	.545
	f	–	0.5 ± 0.1	–	<.001	–	0.5 ± 0.1	–	.035
	g	–	1.2 ± 0.2	–	<.001	–	1.1 ± 0.2	–	.03
	h	–	1.2 ± 0.2	–	<.001	–	1.1 ± 0.2	–	.038
	i	–	0.2 ± 0.0	–	.172	–	0.2 ± 0.0	–	.107
Pau et al, 2016[27]	f	0.5 ± 0.1	0.6 ± 0.1	0.6 ± 0.1	<.001	–	–	–	–
	g	1.1 ± 0.3	1.2 ± 0.3	1.2 ± 0.3	<.001	–	–	–	–
	e	114.6 ± 13.4	120.8 ± 9.4	120.6 ± 12.3	.024	–	–	–	–
	i	0.2 ± 0.0	0.2 ± 0.0	0.2 ± 0.1	<.001	–	–	–	–
	a	61.1 ± 2.8	59.4 ± 3.1	60.1 ± 2.0	.002	–	–	–	–
	b	38.7 ± 2.6	40.3 ± 2.5	39.9 ± 2.0	.004	–	–	–	–
	c	11.6 ± 2.6	10.2 ± 2.1	10.2 ± 2.0	.002	–	–	–	–

References	Variable	IG_1 Baseline	IG_1 End of treatment	IG_1 Follow-up	IG_1 P	IG_2 Baseline	IG_2 End of treatment	IG_2 Follow-up	IG_2 P	CG Baseline	CG End of treatment	CG Follow-up	CG P
Agosta et al, 2017*[25]	j	2.3 ± 0.4	2.4 ± 0.4	2.2 ± 0.4	.9	2.2 ± 0.3	2.2 ± 0.3	2.2 ± 0.4	1	-	-	-	-
	k	27.6 ± 9.7	23.3 ± 7.8	23.3 ± 10.1	.05	23.5 ± 7.9	24.2 ± 8.3	22.1 ± 8.4	.59	-	-	-	-
	l	11.7 ± 2.9	9.7 ± 3.4	10.2 ± 2.4	.02	12.6 ± 3.8	10.9 ± 3.0	11.3 ± 3.0	.05	-	-	-	-
	m	1.3 ± 1.0	1.2 ± 0.9	0.9 ± 0.9	.36	1.0 ± 0.9	1.3 ± 0.8	0.9 ± 1.0	.35	-	-	-	-
	n	24.7 ± 11.1	19.0 ± 9.2	17.0 ± 7.0	.02	20.2 ± 11.6	14.0 ± 8.9	16.7 ± 10.5	.02	-	-	-	-
	o	50.9 ± 3.8	53.6 ± 2.6	53.4 ± 2.7	.002	52.2 ± 4.3	54.4 ± 2.4	54.4 ± 2.2	.06	-	-	-	-
	p	9.0 ± 1.7	8.2 ± 1.1	8.2 ± 1.4	.03	8.0 ± 1.8	7.2 ± 1.2	7.7 ± 1.7	.03	-	-	-	-
	q	6.6 ± 1.8	6.0 ± 1.4	6.1 ± 2.0	.01	6.3 ± 1.4	5.6 ± 1.0	6.0 ± 1.6	.01	-	-	-	-

- = unspecified information; CG = control group; IG = intervention group; *P* = significance level; a = support phase; b = balance phase, c = double support phase, d = stride time; e = cadence; f = step length, g = speed; h = stride length; i = stride width; j = Hoehn e Yahr Scale mode ON; k = Unified Parkinsons Disease Rating Scale—Part III mode ON; l = Freezing of Gait Questionnaire; m = Unified Parkinsons Disease Rating Scale—Part II (Freezing of Gait Questionnaire) mode ON; n, Parkinsons Disease Questionnaire; o = Berg Balance Scale; p = walking test at a distance of 10 m at comfortable speed; q = walking test at a distance of 10 m at maximum speed.

*The article of Agosta et al (2017) presents 2 IGs, requiring a different table from the other cohort studies.

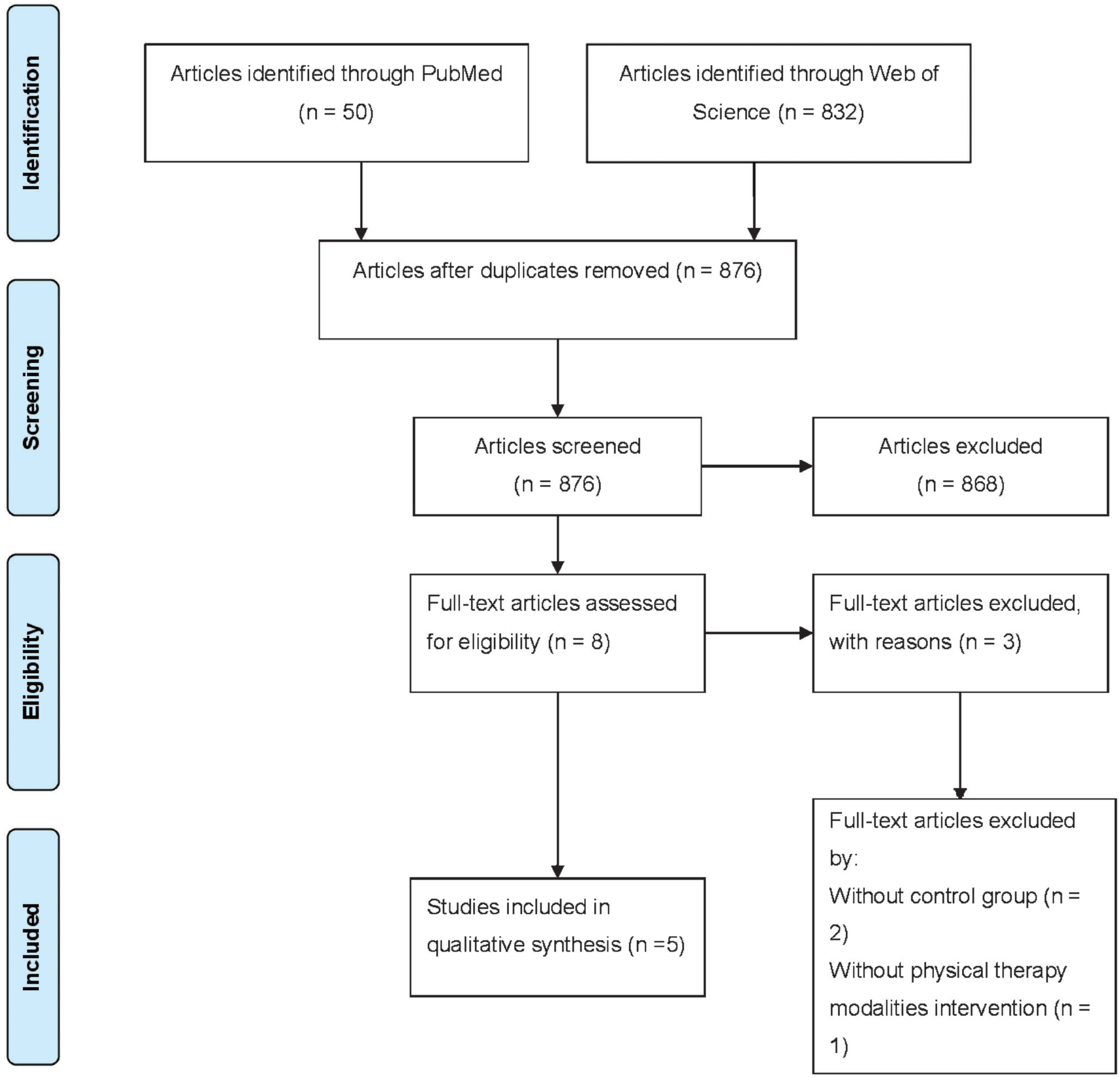

Figure 1. Flowchart of article selection according to items for systematic reviews and meta-analyses (PRISMA) (Moher, Liberati, Tetzlaff e Altman, 2009).

had 6 out of 10, and the same methodological quality of arithmetic mean (Table 1).

Of the 5 studies mentioned, 3 assess the effects of auditory stimuli on gait in patients with PD, whereas 2 analyze the effects of visual stimuli on the same parameter (Table 2). In the same table, the interventions for each article are also reported. Thus, in Agosta et al,[25] the intervention consisted of 8 weeks, with a frequency of 3 times per week, 60 minutes per training (24 minutes of observation and 36 minutes of precision imitation to the rhythm of the auditory stimuli), during ON time, under the supervision of a physiotherapist. Although the IG_1 did the observation and subsequent practice of actions at the rate of auditory stimuli, the IG_2 did the same exercise training through physiotherapists instructions, only combined with the observation of landscape videos. Finally, the CG at baseline, performed neuropsychological and magnetic resonance imaging assessments. Already in Bukowska et al,[26] it was based on 4 weeks, with a frequency of 4 times per week. The IG performed 45 minutes per session of neurological music therapy, with warm-up exercises, daily life activities, pregait, and with gait pattern stimulation through rhythmic auditory stimulation, and in the end, the breathing exercises, whereas the CG only maintained their daily life activities. Yet, Pau et al[27] submitted the participants to 5 weeks, with a frequency of 2 times per week. The IG accomplished 45 minutes of exercises to improve mobility, balance, posture, and gait (20 minutes of each session consisted of a paced gait with soundtracks through a portable MP3 player and headphones). In addition, the training was performed at home, including 30 minutes of walking with rhythmic auditory clues. It were unknown the details of CG performance. In Schlick et al,[28] the intervention consisted of 5 weeks, with a frequency of 2 to 3 times per week. The IG performed the treadmill training combined with visual stimuli, whereas the CG was submitted to the unique treadmill training. Lastly, in Stuart et al,[16] the IG and CG performed the same protocol, which was walking 7 m in self-selected pace and different walking conditions, with 3 attempts in each condition: single task (straight walking), single task with visual stimuli (tape with black lines, placed 50 cm apart and transverse to the starting point), double task (maximum forward digit range and gait), and double task with visual stimuli.

In ceaselessly, the results of each study are presented in Tables 3–5, thus highlighting the most relevant ones. Thus, in Schlick et al,[28] both groups improved gait speed and stride length after the training period (IG with P = .000 and P=.001, respectively, and CG with P=.001 and P=.002, respectively), and cadence remained at 2 groups (P=.665 and P=.650, respectively), indicating that increased gait speed was achieved by improving stride length rather than cadence. In addition, the FoG-Q score improved more in IG (P=.001), than in CG (P=.521). After the 2-month follow-up, both groups showed reduced gait speed (P=.046 and P=.018, respectively) and stride length (P=.028 and P=.008, respectively), but the decrease was bigger in CG. Already, Stuart et al[16] found that individuals with PD submitted to physical exercise, including single and double tasks, combined with visual stimuli, obtained significant effects. Both attention ($\beta = -0.35$, P=.035) and visual function ($\beta = -0.45$, P=.033) were associated with change in saccade frequency with a visual cue (ΔCUE) in PD. Results indicated better attention and contrast sensitivity related to increased saccade frequency with a visual cue (Table 4). In addition, attention was central to direct and indirect relationships between visual function, saccade frequency response, and cued gait in PD. Better attention was directly related with greater increase in saccade frequency (ΔCUE; $\beta = -0.27$, P=.037) and faster gait ($\beta = -0.37$, P=.036) with a cue. Yet, in Bukowska et al,[26] significant effects were found on IG, mainly on the step length, stride length, and velocity (P<.001), whereas in the CG, only the step width was higher (P=.107) (Table 5). In comparison, Pau et al[27] obtained significant values in IG, namely in step length, speed, and step width (P < .001). Thus, it cannot be compared to CG, because there is no detailed information on the values about this throughout the study (Table 5). Finally, in the investigation of Agosta et al,[25] in both groups there were equal but significant results, specifically on Parkinsons Disease Questionnaire (P =.02), walking test at a distance of 10 m at comfortable and maximum speeds (P=.03 and P=.01, respectively). Thus, IG_1 obtained more evidence gains compared to IG_2, namely on FoG-Q (P=.002 and P=.05, respectively) and Berg Balance Scale (P=.002 and P=.06, respectively) (Table 5).

Discussion

The findings of our review support the hypothesis that the application of auditory or visual stimuli have positive effects on gait parameters in patients with PD, with the supervision of physiotherapists.

For example, Schlick et al[28] showed significant improvement on gait speed, stride length, and FoG-Q score after the combination of visual stimuli and treadmill training, conforming the study performed by Schlick et al,[30] who hypothesized that individuals with PD are able to achieve a normal gait pattern, but have difficulty activating the locomotor control system. Visual stimuli may contribute to the appropriate stride length and thus compensate for deficiency in the motor set. Furthermore, after the follow-up period, the IG showed better results than CG; thus, the increase in stride length was correlated with the FoG-Q score, suggesting that patients with a higher FoG-Q score had a greater benefit with treadmill training combined with visual stimuli than unique treadmill training. This relates with the study by Ginis et al,[31] where patients with PD and FoG exhibit inadequate inhibition control, specifically under conditions that require rapid response selection, thus interfering with motor production. Through a well-designed and properly executed training, it is seen a more obvious improvement on these patients. Already, Stuart et al,[16] revealed that attention was directly related with saccade frequency and gait, when walking under single task with visual cues, being highlighted that those were underpinned by attention rather than visual functions in PD. When attention was, however, restricted under dual task, there were no relationships between saccade frequency and attention or contrast sensitivity, which supported our assertion. These findings corroborate with the investigation of Stuart et al,[33] which highlight the important effects of attention on saccade frequency and gait in patients with PD. Continuously, Bukowska et al[26] and Pau et al,[27] demonstrated greater improvement in step length, stride length, velocity, and step width, through the application of auditory stimuli on gait in patients with PD. In both studies, significant results were found with similar time periods, although Bukowska et al[26] presented more evident results and higher frequency, hypothesizing that the greater the training frequency, the faster the results will be obtained. These findings are related to those of the study by Lirani-Silva et al,[32] who presented a distinct type of intervention, but both authors hypothesized that auditory stimuli provide an effective strategy for compensation of the loss of dopamine production in the basal ganglia, even in early stages. In comparison, Agosta et al[25] verified that both groups enhanced equal but significant results, yet IG_1 obtained more evidence gains compared to IG_2, namely on FoG-Q and Berg Balance Scale. Stands out an analysis of the treatment versus interaction time with a significant effect on the UPDRS III ON score in IG_1 versus IG_2 at 4 weeks (P=.03), and a significant improvement trend at 8 weeks (P=.07). It is possible to relate these values to the improvement of the scores of Parkinsons Disease Questionnaire, the Berg Balance Scale, and the walking test of 10 m at maximum and comfortable speeds. Matched to the discussed investigations, although presenting some different evaluation parameters, there are considered results with lower significance considered. Thus, the hypothesis that the greater the ease of training and with shorter time periods, the more effective and faster the results will be considered, as observed in the study by Lirani-Silva et al.[32]

It should be noted that the results are not considered definitive, since the articles present a high methodological heterogeneity. First, the sample of each article differs in terms of size, sex, and level of pathology, according to the H&Y scale. In addition, there is a lack of information regarding some parameters in the articles. Agosta et al[25] and Stuart et al[16] did not mention the duration of the participants illness, whereas Pau et al[27] did not present detailed information about the CG, making it impossible to compare the results with the IG. In addition to these factors, the remaining parameters are similar.

Continuously, the type of intervention varied according to the article. Agosta et al,[25] Bukowska et al,[26] and Pau et al[27] applied auditory stimuli in patients with PD and controls, being the last 2 with the most similar interventions, differing in the time and frequency of the experiment. Agosta et al[25] were the most distinguished in methodological terms, since they had 2 IG, a longer time in the intervention protocol, as well as IG_1 and IG_2

were submitted to a divergent experiment (observation and consequent execution of actions at the pace of auditory stimuli). In the same context, Schlick et al[28] and Stuart et al[16] used visual stimuli, although in different protocols. Schlick et al[28] just performed the combination of a simple task with and without visual cues, whereas Stuart et al[16] submitted the participants to simple and double tasks with and without visual cues. In addition, it should be noted that the latter did not mention the time and frequency of the intervention, and equivalent to Pau et al,[27] did not mention the protocol of the CG.

Regarding outcome measures, Schlick et al[28] and Stuart et al[16] presented a great divergence, except in UPDRS—Part III. Already, Bukowska et al[26] and Pau et al[27] decreed practically the same outcome measures, except the addition of time and stride length by the first authors. It should be noted that there were similarities between Schlick et al,[28] Bukowska et al,[26] and Pau et al,[27] namely in the qualification of stride length, gait speed, and cadence in their search. Finally, Agosta et al[25] presented diverse outcome measures from the other studies, except for FoG-Q, which was similar in the investigation by Schlick et al.[28]

Finally, in relation to the effects of the intervention of each article, it was possible to verify greater efficiency in the investigations by Bukowska et al[26] and Pau et al,[27] who showed significance in practically all outcome measures, although the former exhibited greater evidence compared to the latter. But it is noteworthy that Schlick et al[28] revealed a more expressive effect on terms of gait speed, regarding the articles mentioned above. Accordingly, this demonstrated more evident results regarding the FoG-Q, compared to the study by Agosta et al.[25]

In the present systematic review, it was possible to verify that the application of the auditory stimuli was more effective on the gait parameters in patients with PD, compared to the visual stimuli. This finding was corroborated with the systematic reviews by Spaulding et al[20] and Ghai et al,[21] in which the advances obtained in the early incorporation of rhythmic auditory cues to improve gait performance in PD. The first study intended to compare the relative effectiveness of visual and auditory cues on gait among individuals with PD, whereas the second aimed to analyze the effects of different auditory feedbacks (concerning the effects of presence/absence of medications, tempo variations, dual-task settings, and training dosage) on gait and postural performance in the same pathology. In contrast, these reviews have flaws, making the current review complementary to the scientific evidence. First, Spaulding et al[20] did not apply a methodological quality assessment scale, and continuously, the PRISMA guidelines, 2 focal points of a systematic review and possible bias in this study. Already in Ghai et al,[21] these points were present, but in comparison with the present review, they only addressed the auditory stimuli, and consecutively, their selection criteria were very general, leading to the inclusion of interventions supervised by other professionals. Thus, our review becomes complementary, because it only addressed the interventions performed by the physiotherapist, a relevant health professional in the rehabilitation of patients with PD. It is also worth highlighting the review by Rocha et al,[19] whose objective was to assess the benefits of external cues on the gait of patients with PD and their impact on quality of life, freezing, and psychomotor performance. On the contrary, they addressed several types of stimuli (visual, auditory, somatosensory, and/or cognitive), and in addition, included quasi-RCTs, which immediately leads to less reliability of the study results, because there is no randomization of the participants. Equivalent to Spaulding et al,[20] they did not present PRISMA, an essential tool for reporting the eligibility criteria and the selection of studies.

Overall, the current review would suggest that auditory cues provide a more consistent and positive change on the kinematic gait characteristics, leading to important implications for rehabilitation in patients with PD. They are, however, not considered definitive results, because of the following limitations: small number of studies on the proposed theme, namely RCTs and follow-up periods, selection of a short period (2016–2018), use of only 2 databases, varied investigation methods and the CG performs a type of intervention, questioning the effectiveness of the evaluation instruments in the respective parameters. Finally, it is noteworthy that the methodological quality of the articles applied in the review, using the CASP scale, is reasonable, specifically, the RCTs obtained the lowest rating. Future studies are essential, creating hypothesis with reliable results, to improve the methodological quality of the articles.

Conclusions

In conclusion, the application of auditory or visual stimuli seem to have beneficial effects on gait parameters in patients with PD, and among the supervision of physiotherapists. Thus, auditory stimuli appears to be the best method to use in the future.

Future studies should, however, be developed to demonstrate the effectiveness of external stimuli on gait pattern in patients with PD. Further investigations are recommended, including RCTs and a follow-up period, a greater homogeneity of investigation methods, where the CG does not perform any intervention and the test of the combination of both stimuli.

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