

**Table 1.** Overview of the search term used in PubMed

Assistive mobility device	Robotic functionality	Gait/mobility support	Evaluation measure
#1 'robotics'[Mesh]	#14 'electric power supplies'[Mesh]	#23 'gait'[Mesh]	#32 'evaluation studies as topic'[Mesh]
#2 'walkers'[Mesh]	#15 robot*[tiab]	#24 'Walking'[Mesh]	#33 'Technology Assessment, Biomedical'[Mesh]
#3 'self-help devices'[Mesh]	#16 smart[tiab]	#25 'Dependent Ambulation'[Mesh]	#34 evaluat*[tiab]
#4 'biomedical technology'[Mesh]	#17 intelligent[tiab]	#26 gait[tiab]	#35 assess*[tiab]
#5 robot*[tiab]	#18 power*[tiab]	#27 walk*[tiab]	#36 measur*[tiab]
#6 rollator*[tiab]	#19 electric[tiab]	#28 ambulant*[tiab]	#37 trial*[tiab]
#7 mobile platform*[tiab]	#20 motorized[tiab]	#29 mobility[tiab]	#38 experiment*[tiab]
#8 mobility aid*[tiab]	#21 motorised[tiab]	#30 OR (#23-#29)	#39 test*[tiab]
#9 mobility device*[tiab]	#22 OR (#14-#22)	#31 (#13 AND #22 AND #30)	#40 clinical[tiab]
#10 assistive device*[tiab]	#23 (#13 AND #22)		#41 OR (#32-#40)
#11 assistive system*[tiab]			#42 (#13 AND #22 AND #30 AND 41)
#12 walking aid*[tiab]			
#13 OR (#1-#12)			

**Table 2.** Study characteristics and assessment methods of the 28 studies included in this systematic review

Name of device Authors [Ref. No.]	User group definition	Study sample	Study object	Study design	Assessment methods Type: outcome measurement: outcome variable
<b>Context-aware Assisted Interactive Robotic Walker (CAIROW)</b> Mou et al. 2012 [16 <sup>1,2</sup> ]	PD patients	<u>Study 1</u> n = 6 (F = n/a) Age: n/a PD patients of senior care unit; mHY, stage range 1.5-3	UP	IV: repeated assessment on six consecutive days	TAM: gait analysis on straight walking path <sup>b</sup> ; CAIROW gait analysis system (based on LRF) <sup>b</sup> ; SD of gait speed/step length; expert rating of gait <sup>d</sup> : number of abnormal gait patterns (festinating gait, freezing of gait)
		<u>Study 2</u> n = 7 (F = n/a) Mean age: 86 yrs PD patients of senior care unit; mHY, stage range 1-3	UE	OB	SEM: user comments <sup>c</sup> after gait analysis
			UP	Inter-DC: walking with CAIROW vs. normal walking (with own/ without assistive device)	TAM: gait analysis on walking path with obstacles, people randomly passing by, up- and down-going slopes, short section for backward walking <sup>d</sup> ; CAIROW gait analysis system <sup>b</sup> or LRF <sup>c</sup> placed in test environment when normal walking: SD of gait speed/step length; expert rating of gait <sup>d</sup> : number of abnormal gait patterns
TC (gait analysis system)	EC: gait analysis system vs. expert rating	TEM (see original article for details)			
<b>Care-O-bot II</b> Graf 2009 [26]	Elderly people in home environment	n = 6 (F = 5) Age range: 86-92 yrs Inhabitants of an old people's residence using mobility aids in daily life	UP, PD	Inter-/intra-DC: target mode (robot-determined motion control) vs. direct control mode (user-determined motion control) vs. conventional walker	TAM: navigation trail in old people's residence with a ramp, tables, and people randomly passing by <sup>d</sup> ; robot's guidance system <sup>c</sup> , bicycle speedometer <sup>c</sup> mounted on conventional walker: walking time, number of collisions, maximum speed, walking distance, distance to obstacle PHY: force/torque sensors <sup>c</sup> in robot's handles, force measurement when using conventional walker not reported <sup>d</sup> : pushing force
			UP	OB	TAM: navigation trail in old people's residence with transition between ground floor and 1 <sup>st</sup> floor, a ramp, tables, people randomly passing by <sup>d</sup> : achievement of target
			UE	OB	SEM: questionnaire <sup>b</sup> after navigation trail: n/a
<b>Chugo group walker</b> Chugo et al. 2009 [30]	Elderly people in need for nursing in daily routine	n = 7 (F = n/a) Age: ≥ 67 yrs People in need of long-term care at level I or II in Japanese Long-term Insurance System	UE	Inter-/intra-DC: STS transfer without assistance vs. with previous/novel STS assistance system	SEM: questionnaire <sup>b</sup> after STS transfer: ease of standing up, fear of falling (1= inferior, 3 = same, 5 = better feeling compared to STS transfer without assistance)
<b>CO-Operative Locomotion Aide (COOL-Aide)</b> Wasson et al. 2008 [22]	Elderly people	n = 12 (F = 2) Mean age (SD): 36.8 (18.1) yrs Healthy subjects (n = 8), subjects with disorders affecting mobility (cerebral palsy, familial torsion dystonia) (n = 8) note: (1) total sample, (2) - (5) subsample: only healthy subjects	TC (guidance, user intent detection and obstacle avoidance system)	OB	TEM (see original article for details)
			TC (obstacle avoidance system with vs. without stability preservation)	Intra-DC: standard vs. stability-preserved obstacle avoidance	TEM (see original article for details)
			UE	OB	SEM: user comments <sup>d</sup> after performing a set of short obstacle courses
<b>Gait Rehabilitation Service Robot (GRSR)</b> Jang et al. 2008 [33]	Disabled or elderly with mobility problems or paralysis; weighing up to 75 kg	n = 2 (F = 0) Mean age (SD): 28.5 (2.1) yrs Ordinary adult males	TC (guidance system)	OB	TEM (see original article for details)
			PD	Intra-DC: 40/20 % body weight support vs. full body weight	PHY: EMG <sup>a</sup> during straight walking with standardized gait speed of 0.2 m/s: muscle activity of lower extremities (EMG signal) (quadriceps, hamstrings, gastrocnemius, tibialis anterior)

**Table 2.** (continued)

Name of device Authors [Ref. No.]	User group definition	Study sample	Study object	Study design	Assessment methods Type: outcome measurement: outcome variable
<b>Guido</b> Rentschler et al. 2008 [34]	Frail elderly people with visual impairment	n = 17 (F = n/a) Mean age (SD): 85.3 (7.0) yrs Residents of a supportive living facility/nursing home with visual impairment due to macular degeneration, cataract, glaucoma or other reasons; mean time (SD) since onset of visual impairment: 20.4 (13.0) yrs; ambulatory ( $\geq$ 20 min within 90 min period) with limited assistance	UP	Inter-/intra-DC: Guido vs. conventional assistive mobility device or normal walking (with own/ no assistive device); automatic (user- determined motion control) vs. manual mode (shared user-robot motion control)	TAM: obstacle course with randomly placed obstacles before each trial <sup>d</sup> : walking time, number of obstacle/wall collisions, number of reorientations
			UE	PPC: before and after 3 trials	SEM: Subjective Mobility Questionnaire <sup>b</sup> after obstacle course: appearance, ease of use, usefulness in living environment, embarrassment (1 = best score; 5 = worst score)
<b>Hitachi walker</b> Tamura et al. 2001 [32]	Elderly people who have difficulty walking	n = 6 (F = n/a) Mean age (SD): 82 (7.9) yrs Subjects ambulatory with supervision (n = 4), subjects in need for walking assistance (n = 2)	UP PD	Inter-DC: Hitachi vs. caster vs. conventional walker; robot vs. parallel bars	CPM:10MWT <sup>a</sup> : gait speed PHY: EMG <sup>c</sup> , tri-axial accelerometer <sup>c</sup> during non-standardized gait speed (10MWT): muscle activity (EMG signal), trunk acceleration
<b>HUST walking-aid robot</b> Xu et al. 2013 [23]	Elderly or disabled people	n = 3 (F = n/a) Age: n/a Volunteering subjects with/ without experience using robot; one subject with restricted knee joint to imitate lower limb disorders	TC (motion control system)	PPC: autonomous learning process of HUST in motion behavior over a series of trials	TEM (see original article for details)
			UE	OB	SEM: subjective evaluation after completing a series of obstacle courses, assessment measure not reported <sup>d</sup> : flexibility, comfort, maneuverability, obstacle avoidance
<b>i-Go</b> Ko et al. 2014 [24]	Elderly people	n = 3 (F = n/a) Age: "in their twenties"	TC (guidance system) UE	OB	TEM (see original article for details) SEM: user comments <sup>d</sup> after completing an S-shaped walking path
<b>Intelligent Mobility Platform (IMP)</b> Glover 2003 [29]	Older adults (primarily without major visual or cognitive impairment)	n = 6 (F = n/a) Age: n/a Residents of a care facility with/ without need for walker	UE	OB	SEM: user comments <sup>d</sup> after presentation and informal testing of the robot
<b>iWalker</b> Kulyukin et al. 2008 [27]	Persons with stroke, early- to mid-stage AD, traumatic brain injury, macular degeneration, cataracts, visual impairment; primarily in nursing and assisted living homes	n = 4 (F = n/a) age: n/a Clients of in-home supportive service currently using cane, walker or bot, with history of way finding problems; MMSE, mean score (SD): 26 (3.6)	UP	Inter-DC: iWalker vs. conventional device (cane/walker) accompanied by researcher	TAM: several navigation trails <sup>b</sup> : walking time, number of navigational mistakes
			UE	Intra-DC: map-based (+ auditory cues) vs. text-and- arrow-based (+ auditory cues) user interface design	SEM: dichotomous question <sup>b</sup> : choice of user interface; user comments <sup>d</sup>

**Table 2.** (continued)

Name of device Authors [Ref. No.]	User group definition	Study sample	Study object	Study design	Assessment methods Type: outcome measurement: outcome variable
<b>i-Walker</b> (EU) Annicchiarico 2012 [36]	Post-stroke patients with hemiparesis	n = 20 (F = 11) Mean age: 59.9 yrs Acute hemiparetic stroke patients (event < 1 yrs) receiving rehabilitation treatment; MMSE score $\geq$ 20; CNS upper & lower limb > 0	UP	IV (RCT): robot-assisted ambulatory training (EG) vs. in parallel bars (CG) (4 weeks, 5x a week)	CPM: POMA <sup>a</sup> : total score; 6mWT <sup>a</sup> : walking distance; 10MWT <sup>a</sup> : gait speed ADL screening: Barthel ADL Index <sup>a</sup> : score
<b>i-Walker</b> (Japan) Kikuchi et al. 2010 [31]	Patients with imbalanced motor/sensory functions (e.g. hemiplegic patients), difficulties in smooth walking	n = 6 (F = 2) Mean age (SD): 88.7 (6.1) yrs Residents of elder care facility with wheelchair due to loss of vision/muscle strength which occasionally train walking with forearm caster walker; chronic disease: stroke, dementia, muscle atrophy, high blood pressure, heart failure, AD, cataract, PD	UP	Intra-DC: passive vs. active robot motion control system	TAM: walking path with obstacles <sup>b</sup> , robot-integrated web camera <sup>c</sup> : deviations from a path marked on the floor, number of collisions
<b>JAIST Active Robotic Walker (JARoW)</b> Lee et al. 2014 [38]	Elderly people with certain level of ambulatory capability (FAC score 4-5)	n = 5 (F = 4) Age range: 75-84 yrs Subjects using traditional walkers in daily routine	UE	Inter-DC: JARoW vs. conventional walker	SEM: questionnaire <sup>b</sup> after walking around for 10 min: ease of walking, safety, maneuverability, suggestions for improvements
<b>MOBIL walking &amp; lifting aid</b> Bühler et al. 2001 [18 <sup>1</sup> ]	Frail, elderly and walking disabled people	<u>Study 1</u> n $\geq$ 2 (F = n/a) Age: n/a Selected users, technical and rehabilitation experts	TC (overall system functionality) UE	OB	TEM (see original article for details) SEM: user/expert ratings, comments and interviews <sup>d</sup>
<b>MOBIL test bed</b> [18 <sup>2</sup> ]	Frail, elderly and walking disabled people	<u>Study 2</u> n $\geq$ 2 (F = n/a) Age: n/a Rehabilitation engineers, walking impaired persons	TC (overall system functionality)	OB	TEM (see original article for details)
<b>MOBIL walking &amp; lifting aid, MOBIL test bed</b> [18 <sup>3</sup> ]	Frail, elderly and walking disabled people	<u>Study 3</u> n $\geq$ 2 (F = n/a) Age: n/a Community-dwelling people, institutionalized elderly disabled people, care staff	UE	OB	SEM: questionnaire <sup>b</sup> after demonstration, video presentations, practical trials: n/a

**Table 2.** (continued)

Name of device Authors [Ref. No.]	User group definition	Study sample	Study object	Study design	Assessment methods Type: outcome measurement: outcome variable
<b>Nomad XR 4000</b> Morris et al. 2003 [28]	Frail older people with cognitive impairment	n = 4 (F = n/a) Age: n/a Residents of a retirement facility	UP	Intra-DC: passive (no navigational assistance) vs. active (with navigational assistance) vs. forced mode (full robot motion control)	TAM: navigational trail <sup>d</sup> ; robot's navigation system (based on LRF, 'Monte Carlo localization') <sup>d</sup> : deviation from optimal path
			UE	OB	SEM: user comments after navigational trails <sup>d</sup>
<b>Personal Aid for Mobility and Monitoring (PAMM SmartWalker)</b> Yu et al. 2003 [17 <sup>1,2</sup> ]	Independently living or institutionalized elderly people with mobility difficulties due to physical frailty and/or disorientation due to age and sickness	<u>Study 1</u> n = 8 (F = n/a) Age: n/a Elderly residents of assisted living facility with mobility aid	UE	OB	SEM: questionnaire <sup>b</sup> after free driving at facility: ease of control, going straight, turning, heaviness, support, satisfaction (1 = worst score, 5 = best score)
			UP	Intra-DC: full robot motion control vs. adaptive shared user-robot motion control vs. without any motion control	TAM: wall-limited walking path through assisted living facility <sup>d</sup> ; robot's vision-based localization system (based on charged-coupled device camera) <sup>b</sup> : deviations from robot-generated, pre-planned path, distance to wall
		<u>Study 2</u> n = 8 (F = 5) Age range: 84-95 yrs Elderly residents of assisted living facility with need for walkers	UE	OB	SEM: user comments <sup>d</sup>
<b>Robotic Mobility Platform (RMP)</b> Grondin & Qinggou 2013 [19]	n/a	n = 10 (F = 5) Mean age (SD): 24.6 (3.0) Subjects without previous/current gait-related injuries and without experience in using rollators or robotic walkers	UP, PD	Intra-DC: novel vs. previous motion control system	TAM: walking with targeted velocity of 1 m/s through a circular path in low-traffic hallways <sup>b</sup> ; technical outcome measurement not reported <sup>d</sup> : mean and SD of robot velocity; PHY: force/torque sensor <sup>d</sup> under robot's left handle: pushing force
			PD	Inter-/intra-DC: novel vs. previous motion control system vs. conventional rollator vs. no assistive device	PHY: walking with targeted velocity of 1 m/s through the circular path <sup>c</sup> (use of a Hall effect sensor mounted on the conventional rollator to display target velocity); respirometry <sup>a</sup> : metabolic cost of transport, oxygen consumption
			UE	Intra-DC: novel vs. previous motion control system	SEM: questionnaire <sup>b</sup> : comfort, intuition, speed control, exertion, overall experience (0 = worst score, 5 = best score)
<b>robuWALKER</b> Rumeau et al. 2012 [21]	elderly people	n = 8 (F = 5) Mean age (SD): 82.6 (8.7) yrs Healthy elderly (n = 4): 4MWT < 4s, TUG < 13s, MMSE score ≥ 26; elderly patients with motor & cognitive impairment (n = 4): 4MWT > 4s, TUG > 13s, MMSE mean score (SD): 20 (3.5); all subjects without experience in using walking frames	UP	Inter-DC: robuWalker vs. conventional walker	CPM: 4MWT <sup>a</sup> : gait speed, modified TUG <sup>a</sup> : completion time; gait analysis by video recordings <sup>c</sup> during 4MWT and TUG: step time, double support time

**Table 2.** (continued)

Name of device Authors [Ref. No.]	User group definition	Study sample	Study object	Study design	Assessment methods Type: outcome measurement: outcome variable
<b>Robotic Travel Aid (RoTA)</b> Mori et al. [35]	visually impaired community-dwelling people, hospital patients, or residents of senior homes loss of ability to walk with mobility aids for the blinds	n > 60 (F = n/a) Age: n/a Blind and weak-sighted elderly people	UE	OB	SEM: user comments <sup>d</sup> after walking course
<b>RT Walker</b> Taghvaei et al. 2010 [20]	n/a	n = 2 (F = n/a) Age: n/a	TC ( motion control system)	OB	TEM (see original article for details)
<b>SIMBIOSIS Walker</b> Frizera-Neto et al. 2011 [12]	SCI patients mainly using wheelchair, but usually able to walk for short periods of time with assistance of device, WISCI II = 16	n = 8 (F = n/a) Age: n/a Subjects with preserved cognitive functions; ability to (1) maintain standing position, (2) walk 10 m without assistance of another person and with or without support of a mobility aid, and (3) to grasp; WISCI II, mean score (SD): 15.9 (2.9)	TC (user intent detection system) UE	OB OB	TEM (see original article for details) SEM: questionnaire <sup>b</sup> after completing U-shaped walking path: maneuverability, safety, posture & comfort (0 = worst score, 100 = best score)
<b>Smart Mobile Walker (SMW)</b> Lee et al. 2012 [37]	elderly people, people with hemiplegia, people with incomplete SCI	n ≥ 2 (F = n/a) Age: n/a Stroke patients, SCI patients, clinical experts	UE	OB	SEM: user comments/interviews <sup>d</sup> after demonstrations
<b>Walking Helper</b> Hirata et al. 2005 [25]	elderly people, disabled people	n = 8 (F = n/a) Age: n/a	UP	Intra-DC: novel vs. traditional motion control system	TAM: following S-shaped walking path <sup>b</sup> (marked on the floor); technical outcome measurement not reported <sup>d</sup> : deviation from path marked on the floor

*Abbreviations:* PD = Parkinson's disease; F = females; n/a = not available; mHY = modified Hoehn and Yahr Scale; UP = User performance; UE = User experience; IV = interventional; OB = observational; TAM = tailored assessment measure; LRF = laser rangefinder; SD = standard deviation; SEM = subjective evaluation measure; TC = technical capability; inter-DC = inter-device comparative; EC = comparison with external criterion measure; TEM = technical evaluation measure; PD = physical/physiological demands; intra-DC = intra-device comparative; PHY = evaluation of physical or physiological demands; STS = sit-to-stand; EMG = electromyography; PPC = pretest-posttest comparative; CPM = clinical performance-based measure; 10MWT = 10-meter walk test; MMSE = Mini-Mental State Examination; CNS = Canadian Neurological Scale; RCT = randomized controlled intervention trial; EG = experimental group; CG = control group; POMA = Performance Oriented Mobility Assessment; 6mWT = 6-minute walk test; ADL = activities of daily living; AD = Alzheimer's disease; FAC = Functional Ambulation Classification; TUG = Timed Up and Go; 4MWT = 4-meter walk test; WISCI = Walking Index for Spinal Cord Injury; SCI = Spinal Cord Injury.

<sup>a</sup> established, standardized and validated assessment test or outcome measurement.

<sup>b</sup> standardized, but not validated test procedure or outcome measurement.

<sup>c</sup> potentially an established outcome measurement, but no reference given.

<sup>d</sup> non-standardized or unclear test procedure or outcome measurement.