OXFORD
UNIVERSITY PRESS

Archives of Clinical Neuropsychology 00 (2023) 1–16

Archives of CLINICAL NEUROPSYCHOLOGY

The Association of Personal Neglect with Motor, Activities of Daily Living, and Participation Outcomes after Stroke: A Systematic Review

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Accepted 8 July 2023

Abstract

Despite its potential clinical impact, the association of personal neglect (PN) with motor, activities of daily living (ADL), and participation outcomes after stroke is not well-understood. This first-ever systematic review on the topic therefore evaluates this association, taking into account suggested subtypes of PN, including body representation neglect, somatosensory neglect, motor neglect, and premotor neglect. A systematic literature search was conducted on February 17, 2023 in PubMed, Web of Science, Scopus, PubPsych, and PsycArticles databases. The study adheres to the guidelines of Preferred Reporting Items for Systematic Reviews and Meta-Analyses, and its protocol was registered on PROSPERO (CRD42020187460). Eleven observational studies were included, gathering 1,400 individuals after stroke (429 showed PN). Results show that individuals with body representation neglect after stroke have significantly decreased movement control and motor strength, lower functional mobility, and ADL independency compared with those without body representation neglect after stroke. Individuals with motor neglect after stroke showed worse motor function and spasticity than to those without motor neglect after stroke. Nonspecified PN (i.e., PN evaluated with an outcome measure that does not allow subcategorization) was related to worse lateropulsion with pushing, longer length of stay and greater odds of being discharged to somewhere other than home. No study evaluated somatosensory and premotor neglect. This review highlights the limited research in this area and emphasizes the need for a more comprehensive PN assessment. However, currently available assessment tools show limited ability to accurately diagnose PN subtypes and future research should prioritize the development of comprehensive diagnostic test batteries.

Keywords: Stroke; Personal neglect; Spatial neglect; Motor; ADL; Participation

Introduction

Spatial neglect is a common disorder after stroke that involves a lateralized spatial cognition, awareness, and attention deficit with an impaired ability to report toward stimuli primarily within the contralesional hemispace, which cannot be attributed to sensorimotor, perceptual, or memory impairments (Heilman et al., 2000; Vallar & Calzolari, 2018). The clinical manifestation of the disorder is highly heterogeneous, such that neglect symptoms may manifest within three physical spaces: the self-body space (personal neglect [PN]), within-reach (peri-PN), and beyond-reach area (extra-PN).

The association of peri-PN and extra-PN subtypes (e.g., visuospatial neglect [VSN]) with motor, activities of daily living (ADL), and participation-related outcomes after stroke is well-documented (Bosma et al., 2020; Doron & Rand, 2019; Embrechts et al., 2021). VSN concerns neglect for visual stimuli (Rode et al., 2017), and is the most frequently present and investigated type

https://doi.org/10.1093/arclin/acad063

of spatial neglect, with prevalence ranging from 23% to 48% in the acute phase poststroke (Demeyere & Gillebert, 2019; Esposito et al., 2021). It is typically assessed using traditional paper-and-pencil tests, such as cancelation tests, line bisection tests, and representational drawing tests, or test batteries, such as the Behavioural Inattention Test (Cassidy et al., 1998; Jehkonen et al., 2000, 2007; Levine et al., 1986; Nijboer et al., 2013; Samuelsson et al., 1997; Stone et al., 1992). Prior studies have demonstrated that more severe VSN is associated with worse motor function, balance, walking, ADL independency, and participation outcomes (Bosma et al., 2020; Doron & Rand, 2019; Embrechts et al., 2021). In contrast to VSN, the association of PN with such outcomes is not well-understood. Despite the potential impact on daily life through the presentation of specific clinical observations, such as individuals only shaving the non-neglected facial side, forgetting to dress the neglected body side, or disregarding the neglected arm (Caggiano & Jehkonen, 2018; Rode et al., 2017), PN remains a highly understudied disorder, and its systematic consideration in scientific and clinical studies is limited (Caggiano & Jehkonen, 2018). Consequently, the association of PN with motor, ADL, and participation-related outcomes is unknown. The lack of a uniform definition of PN may contribute to this, although recent studies suggest that multiple subtypes exist under this term (Williams et al., 2021), including body representation neglect (i.e., reduced body exploration related to a disorder in the representation of one's own body; Caggiano & Jehkonen, 2018; Cocchini et al., 2001; Rode et al., 2017; Williams et al., 2021), somatosensory neglect (i.e., errors tactile or proprioceptive stimuli perception applied on the neglected body side, without primary somatosensory deficits; Caggiano & Jehkonen, 2018; Rode et al., 2017; Williams et al., 2021), motor neglect (i.e., reduced spontaneous use of the contralesional body side; Caggiano & Jehkonen, 2018; Punt & Riddoch, 2006; Rode et al., 2017; Williams et al., 2021), and premotor neglect (i.e., reduced tendency to move the non-neglected limbs toward the neglected body side; Rode et al., 2017).

Given the limited understanding of PN and its association with motor, ADL, and participation outcomes after stroke, a systematic review of the existing literature is warranted. This first-ever review will therefore evaluate the association between PN (and its subtypes) with motor, ADL, and participation outcomes after stroke.

Materials and Methods

Protocol and Registration

This review adheres to the guidelines of Preferred Reporting Items for Systematic Reviews and Meta-Analyses (Moher et al., 2009), and its protocol has been registered on PROSPERO (CRD42020187460).

Search Strategy and Study Selection

A systematic literature search was conducted on February 17, 2023 in PubMed, Web of Science, Scopus, PubPsych, and PsycArticles databases. Search queries were built by using the following free-text terms and medical subject headings: "PN," "stroke," "upper limb," "lower limb," "activities of daily living," "participation," and their synonyms (Supplementary files). We included studies that (i) investigated adult individuals after stroke with PN adhering to the definitions (see Introduction), (ii) evaluated the association between PN and motor, ADL, or participation outcomes, and (iii) were written in English, Portuguese, Spanish, German, or Dutch. No restrictions or filters were added. We excluded studies that (i) did not perform sub-analysis for PN when multiple types of neglect were present as this prohibits the ability to evaluate the single contribution of PN to the outcome, (ii) were letters to the editors, meta-analyses, reviews, or abstracts, and (iii) were unavailable in full-text. After removing duplicates, the first author (EE) performed screening on title and abstract. In case of uncertainty, a consensus meeting with the second author (RL-C) was held. Afterwards, screening on full-text was independently performed by both reviewers (EE and RL-C) and disagreements were resolved by discussion.

Risk of Bias

Risk of bias of the included studies was independently assessed by two independent reviewers (EE and RL-C) using the Newcastle–Ottawa Scale (NOS). It assesses risk of bias using a star rating system, judging three categories: selection, comparability, and outcome. A star was given if a criterion was met, suggesting low risk of bias for that criterion. Items were adapted to fit the research questions. Nine stars can be obtained for longitudinal and 10 for cross-sectional studies. No cutoff values are known for the NOS and different study designs, therefore the cutoff values as described by McPheeters et al. (2012) were used. A score of ≥ 7 was considered good, of 5 or 6 moderate, and of <5 poor. Disagreements were resolved by discussion. Depending on study design, the checklists for cohort or cross-sectional studies were used (Supplementary files).

Table 1. Terms and definitions

Term	Definition
Motor outcomes	Clinical or instrumented assessment methods that evaluate motor function of the trunk and the upper and lower limbs (i.e., paresis, reaching, grasping, balance, lateropulsion [with/without pushing], body alignment, gait, etc.). In case of motor neglect, in which the definition implies the absence of spontaneous movements, measures of such spontaneous movements were not regarded as "motor outcome," but as a measure of motor neglect. These spontaneous movements refer to the spontaneous use of the limbs, for example, during talking or other activities. Movements carried out upon verbal prompts or involuntary movement (such as spasticity) are not considered spontaneous movements.
Lateropulsion with pushing (LwP)	Disorder of postural control, characterized by a typical lateropulsion to the paretic side which is accompanied by pushing with the non-paretic limbs and a tilted pelvis toward the paretic side (Pérennou et al., 2008).
Activities of daily living	The execution of tasks or actions of daily living. This includes routine activities people perform every day related to (mainly) self-care, such as eating, bathing, dressing. This could be evaluated using observational scales (such as the Barthel Index) or questionnaires completed by the patient/caregivers (International Classification of Functioning, Disability, and Health: ICF, 2001).
Participation	These outcomes encompass active involvement in a variety of contexts, such as domestic, community, social, educational, recreational, economic, cultural, and civil life. This includes, for example, attending social events, engaging in hobbies or leisure activities, and participating in community activities (e.g., grocery shopping, attending medical appointments). Within this review, even discharge destination and length of stay are considered participation outcomes. These are not typically considered as direct outcomes of participation, but rather indirect as they are influenced by the extent of participation abilities of the individual (International Classification of Functioning, Disability, and Health: ICF, 2001).

Data Extraction and Definitions

Two reviewers (EE and RL-C) independently extracted authors, year, study design, number individuals, lesion information, age, sex, different participant groups, PN assessment tools, PN subtype evaluated, other spatial neglect assessment tools (when applicable), other cognitive functions assessed, time poststroke of assessments from the studies. Also the evaluated outcomes (motor, ADL, and participation outcomes) and study results were collected (Tables 4–7).

To define PN, we refer to the definitions stated within the introduction. When PN assessment tools used by the studies prohibited the differentiation of a specific PN subtype (e.g., in the case of the Semistructured Functional Evaluation Scale; Caggiano & Jehkonen, 2018), we used the term nonspecified PN. Definitions on outcome variables of interest can be found in Table 1.

Results

Study Selection

A total of 2,778 unique articles were retrieved. Considering screening on Title and Abstract, EE had to consult RL-C for three studies (i.e., in .10% of cases), after which consensus was reached to evaluate these studies further during the full-text screening phase. Regarding screening on full-text, there was 84.6% agreement between reviewers. All ambiguities concerned PN definition and were successfully resolved. Ultimately 11 articles were included. The selection process is visualized in the flowchart (Fig. 1).

Risk of Bias

Agreement between reviewers concerning risk of bias was 72.6%, and disagreements were successfully resolved. Scores ranged from 4 to 8 out of 9. Four studies had good methodological quality (Iosa et al., 2016; Lafosse et al., 2005; Siekierka-Kleiser et al., 2006; Spaccavento et al., 2017), six moderate (Appelros et al., 2004; Chen-Sea, 2000, 2001; Jamal et al., 2018; Rousseaux et al., 2013; Wee & Hopman, 2008), and one poor (Wee & Hopman, 2005). All seven longitudinal cohort studies received a star on the item assessing the selection of a cohort of individuals without PN from the same source as those with PN after stroke. Additionally, they received a star on the item of ascertainment of exposure, representing that standardized PN assessment tools were employed for PN diagnosis. However, only two studies earned a star on the item regarding the demonstration of the outcome of interest at the beginning of the study, which required the diagnosis of PN before identifying outcome on any other measure, such as ADL (Appelros et al., 2004; Iosa et al., 2016). Similarly, also all four cross-sectional studies received one star on the item assessing the selection of a cohort of individuals without PN from the same source as those

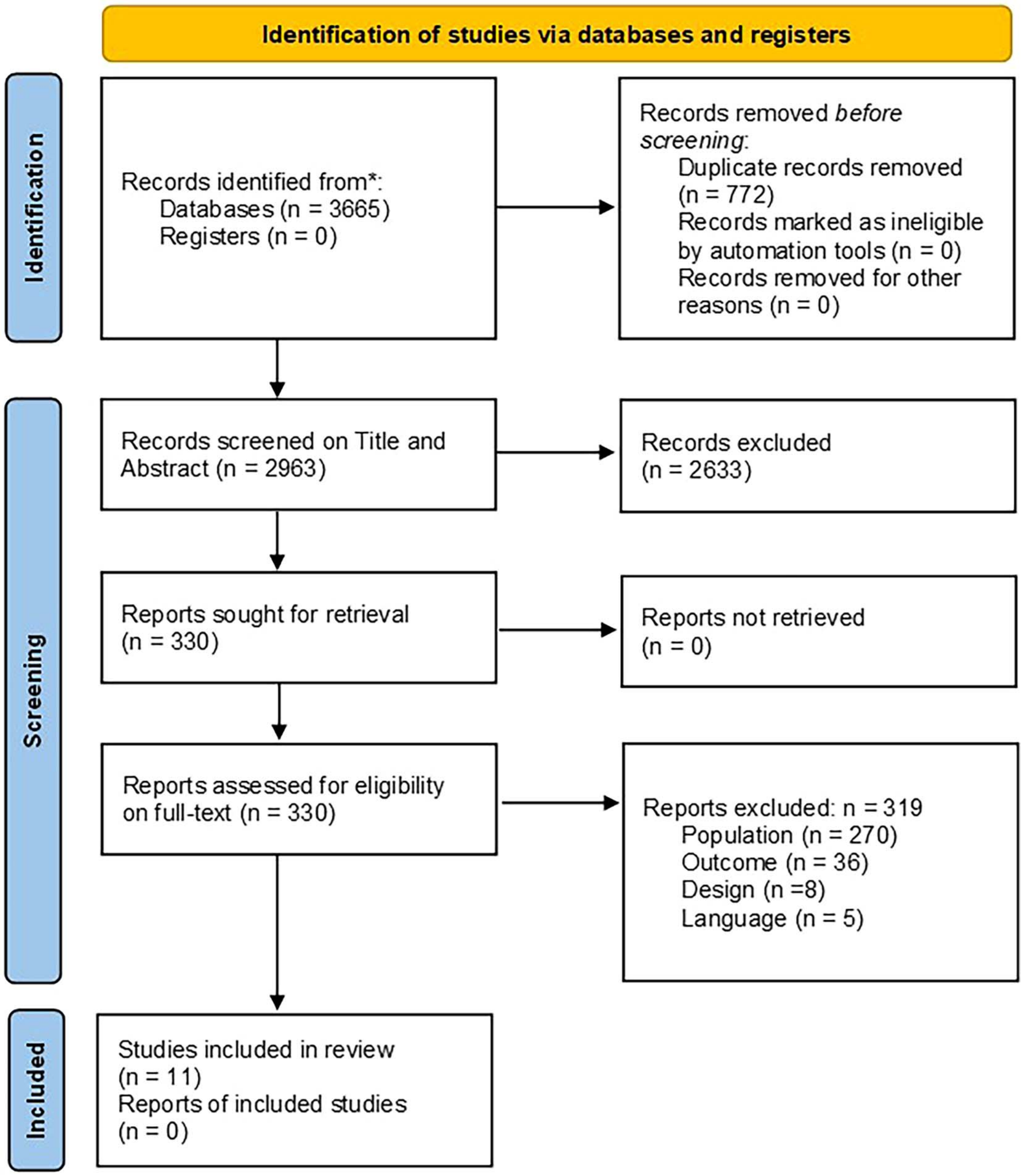

Fig. 1. Flowchart showing the selection process of eligible studies (Moher et al., 2009).

with PN after stroke, and on the item of ascertainment of exposure. However, none of the studies received a star on outcome assessment that implicates independent blind assessment of the outcome of interest (Tables 2 and 3).

Descriptive Data

All studies were observational with four cross-sectional (Chen-Sea, 2000, 2001;Jamal et al., 2018 ; Rousseaux et al., 2013) and seven longitudinal (Appelros et al., 2004; Iosa et al., 2016; Lafosse et al., 2005; Siekierka-Kleiser et al., 2006; Spaccavento et al., 2017; Wee & Hopman, 2005, 2008) studies. In total, 1,400 individuals with stroke were analyzed, at least 950 had a right-sided stroke and 406 a left-sided stroke. The lesion-side of the remaining 44 individuals was not specified. However, two studies did provide more detailed information about stroke location, demonstrating that only medial cerebral artery territory strokes were included in their analysis (Lafosse et al., 2005; Siekierka-Kleiser et al., 2006). Stroke severity was evaluated in only three studies, by using the National Institute of Health Stroke Scale (Appelros et al., 2004), Canadian Neurological Scale (Iosa et al., 2016), or lesion volume metrics (Rousseaux et al., 2013). These studies evaluated whether

Table 2. NOS risk of bias assessment: longitudinal cohort studies

Longitudinal cohort studies										
Author	Selection				Comparability	Outcome			Total	MQ
	1	2	3	4	1	1	2	3		
Appelros et al. (2004)		*	*	*	**		*		6	Mod
Iosa et al. (2016)		*	*	*	**	*	*	*	8	Good
Lafosse et al. (2005)	*	*	*		**	*	*		7	Good
Siekierka-Kleiser et al. (2006)	*	*	*		**	*		*	7	Good
Spaccavento et al. (2017)		*	*		**	*	*	*	7	Good
Wee and Hopman (2005)	*	*	*				*		4	Poor
Wee and Hopman (2008)	*	*	*				*	*	5	Mod

Mod = moderate, MQ = methodological quality category, *(*) indicates that one or more stars were given to that particular item (see Attachment for items).

Table 3. NOS risk of bias assessment: cross-sectional studies

Cross-sectional studies									
	Selection				Comparability	Outcome		Total	MQ
	1	2	3	4	1	1	2		
Chen-Sea (2000)			*	**	**		*	6	Mod
Chen-Sea (2001)			*	**	**		*	6	Mod
Jamal et al. (2018)	*	*	*	**				5	Mod
Rousseaux et al. (2013)			*	**		*	*	5	Mod

Mod = moderate, MQ = methodological quality category, *(*) indicates that one or more stars were given to that particular item (see Attachment for items).

stroke severity was associated with the (severity of) PN, of which only one found a significant association at 1 year poststroke (Appelros et al., 2004).

The Draw-A-Man test (Chen-Sea, 2000, 2001) and the Subjective Straight Ahead test (Jamal et al., 2018; Rousseaux et al., 2013) were indicated as measures for body representation neglect. Activity trackers were used to determine spontaneous movement activity as a measure for motor neglect (Siekierka-Kleiser et al., 2006). The Semistructured Functional Evaluation Scale of Zoccolotti (Appelros et al., 2004; Iosa et al., 2016; Lafosse et al., 2005; Spaccavento et al., 2017) as well as observation (Wee & Hopman, 2005, 2008) were used to evaluate nonspecified PN. Of the 1,400 individuals, at least 429 individuals had confirmed symptoms of PN: 48 individuals had body representation neglect (Chen-Sea, 2000, 2001; Jamal et al., 2018; Rousseaux et al., 2013), 19 had motor neglect (Siekierka-Kleiser et al., 2006), and 368 individuals had nonspecified PN (Appelros et al., 2004; Iosa et al., 2016; Lafosse et al., 2005; Spaccavento et al., 2017; Wee & Hopman, 2005, 2008). Considering the evaluated rehabilitation outcomes, motor function was assessed by seven studies (Chen-Sea, 2000, 2001; Iosa et al., 2016; Jamal et al., 2018; Lafosse et al., 2005; Rousseaux et al., 2013), ADL by seven studies (Appelros et al., 2004; Chen-Sea, 2000, 2001; Iosa et al., 2016; Spaccavento et al., 2017; Wee & Hopman, 2005, 2008), and participation outcomes by two studies (Wee & Hopman, 2005, 2008). Motor outcomes were divided into six subcategories: voluntary movement control of the contralesional limbs (Chen-Sea, 2000, 2001), motor strength on the ipsilesional limbs (Chen-Sea, 2000, 2001), functional mobility (Iosa et al., 2016), standing balance (Jamal et al., 2018), combined balance (sitting, standing, and mobility; Rousseaux et al., 2013), and lateropulsion with pushing (Lafosse et al., 2005; Table 4).

Body Representation Neglect

Motor outcomes. As shown by four moderate methodological quality studies (Chen-Sea, 2000, 2001; Jamal et al., 2018; Rousseaux et al., 2013), individuals with body representation neglect after stroke had significantly lower voluntary movement control of the contralesional limbs and motor strength of the ipsilesional limbs compared with individuals without body representation neglect after stroke ($p < .004$ and $p < .001$, respectively; Chen-Sea, 2000). Chen-Sea (2001) evaluated coexisting VSN. Individuals with both body representation neglect and VSN after stroke had significantly lower voluntary movement control of the contralesional limbs and motor strength of the ipsilesional limbs, compared with individuals without coexisting body representation neglect and VSN after stroke ($p < .05$), but not compared with those with only VSN after stroke (Chen-Sea, 2001). Additionally, body representation neglect after stroke was significantly associated with lower scores on the Postural Assessment Scale for Stroke, which evaluates balance and mobility ($r = -.34$, $p = .027$; Rousseaux et al., 2013), whereas it was not significantly associated with weight-bearing asymmetry during quiet standing ($p > .05$; Jamal et al., 2018; Table 5).

Table 4. Descriptive data: study design, assessment tools, and individuals

Author	Design	PN assessment tools *(PN type)*	Other spatial neglect assessment tools**	Other cognitive functions evaluated
Appelros et al. (2004)	OBS: long (pr)	Semistructured Functional Evaluation Scale *(nonspecified PN)*	Behavioral Inattention test	Cognitive impairment (MMSE), aphasia. MMSE was not significantly associated with PN at 2–4 weeks, 6 months, and 1 year poststroke ($p > .05$).
Chen-Sea (2000)	OBS: CS	Draw-A-Man test *(body representation neglect)*	NA	NA
Chen-Sea (2001)	OBS: CS	Draw-A-Man test *(body representation neglect)*	Random Chinese Word Cancelation	NA
Iosa et al. (2016)	OBS: long (re)	Semistructured Functional Evaluation Scale *(nonspecified PN)*	Barrage test, letter cancelation test, sentence reading test, Wundt-Jastrow area illusion test	NA
Jamal et al. (2018)	OBS: CS	Subjective Straight Ahead *(body representation)*	Bell's Cancelation Test, 20 cm Line Bisection Test, Fluff test[1], OTA test[2]	NA
Lafosse et al. (2005)	OBS: long (pr)	Semistructured Functional Evaluation Scale *(nonspecified PN)*	Albert's test, observation (searching for a comb, eating from a plate, remove blocks from a board, draw a daisy, match, and sort figures)	NA
Rousseaux et al. (2013)	OBS: CS (re)	Subjective Straight Ahead *(body representation)*	Line Bisection Test, Scene Copy Test, Bell's Cancelation Test	NA
Siekierka-Kleiser et al. (2006)	OBS: long (pr)	Activity trackers to evaluate spontaneous motor behavior of the upper limbs (*Motor neglect)*	NA	NA
Spaccavento et al. (2017)	OBS: long (re)	Semistructured Functional Evaluation Scale *(nonspecified PN)*	Barrage test, Letter Cancelation Test, sentence reading test, Wundt-Jastrow area illusion test	NA
Wee and Hopman (2005)	OBS: long (pr)	Sensory testing: one side of body ignored + Observation: lack of awareness of one body side (*nonspecified PN)*	Describing of a complex picture (observation)	Cognitive impairment (MMSE), aphasia, apraxia (taken into account in further analyses)
Wee and Hopman (2008)	OBS: long (pr)	Sensory testing: one side of body ignored; Observation: lack of awareness of one side of the subject's own body *(nonspecified PN)*	Line Bisection Test, Rivermead perceptual assessment battery testing, reading of sentences, reading of a menu, cancelation tests, light board examination, clock drawing	Aphasia (not taken into account in further analyses)

CS = cross-sectional; long = longitudinal; MMSE = Mini-Mental State Examination; NA = not applicable; OBS = observational; PN = personal neglect; pr = prospective; re = retrospective. Italic text indicates subtype of PN being evaluated.

(*Continued*)

Table 4. Continued

Author	Different groups	Mean age (SD/range) in years	Biological sex (M/F)	TPS of (initial) assessment (mean and SD/range)	TPS of follow-up	Stroke severity and lesion location
Appelros et al. (2004)	Total: n=37 PN+: n=23 PN-: n=14	74 (33-90)	15/22	2-4 w	6 m, 1 y	Severity: National Institute of Health Stroke Scale (NIHSS): significantly correlated with PN at 1 year (r=0.42, $p<.05$), but not at 2-4 weeks and 6 months post-stroke ($p>.05$). Location: R, no further information provided
Chen-Sea (2000)	Total: n=51 PN+: n=13 PN-: n=38	PN+: 59.46 (7.59) (42-70) PN-: 59.39 (9.09) (37-75)	PN+: 8/5 PN-: 30/38	PN+: 106.85 (49.71)(60-2234) d PN-: 110.16 (66.50)(56-4400) d	NA	Severity: NM Location: R, no further information provided
Chen-Sea (2001)	Total: n=44 PN-, VSN-: n=26 PN-, VSN+: n=7 PN+, VSN+: n=11	PN-, VSN-: 57.65 (0.96) PN-, VSN+: 65.57 (7.76) PN+, VSN+: 58.81 (8.08)	34/12	PN-, VSN-: 102.62 (37.46)(56-185) d PN-, VSN+: 99.43 (51.71)(67-213) d PN+, VSN+: 104.82 (47.81)(60-234) d	NA	Severity: NM Location: NM
Iosa et al. (2016)	Total: n=49 Mod PN+: n=17 Sev PN+: n=18 PN-: n:14	PN-: 68.79 (14.45) Mod PN+: 63.59 (16.25) Sev PN+: 68.56 (13.44)	NM	PN-: 14.93 (7.36) d Mod PN+: 15.29 (8.19) d Sev PN+: 17.06 (6.62) d	Discharge	Severity: Canadian Neurological Scale score: no difference between PN-, Mod PN+ and Sev PN+ groups at admission (P=.900) and discharge (P=.611). Location: NM
Jamal et al. (2018)	Total: n=30 Groups: NM	60.3 (10)	24/06	4.78 (3) y	NA	Severity: NM Location: 15R, 15L, no further information provided
Lafosse et al. (2005)	Total: n=114 Groups: NM	67.7 (7.06)	57/57	52.29 (34.64) d	12 w post-admission	Severity: NM Location: 56R, 58L (all ACM territory)
Rousseaux et al. (2013)	Total: n=42 VSN+ group: n=21 VSN- group: n=21 *(no PN groups, only VSN groups)*	VSN+: 61.0 (14.4) VSN-: 55.5 (11.1)	VSN+: 8/13 VSN-: 10/11	VSN+: 59.6 (33.7) d VSN-: 64.7 (37.3) d	NA	Severity: Lesion volume: did not significantly correlate with balance (PASS, r=-0.233, $p>.05$), and PN (SSA, r=0.256, $p>.05$) Location: R
Siekierka-Kleiser et al. (2006)	Total: n=52 PN+: n=19 PN-: n=33	PN+: 65 (15) PN-: 60 (14)	PN+: 11/8 PN-: 24/9	Day 1 post-stroke	Day 7 post-stroke	Severity: NM Location: 30R, 22L (all ACM territory)
Spaccavento et al. (2017)	Total: n=359 PN+: n =60 PN-: n=299	71.92 (11.46)	199/160	32.38 (33.20) d	Discharge	Severity: NM Location: R, no further information provided
Wee and Hopman (2005)	Total: n=313 PN+: n=134 PN-: n=179	76 (8)	162/151	37 (22) d	Discharge	Severity: NM Location: "R/L equally divided" , no further information provided
Wee and Hopman (2008)	Total: n=309 PN+: n=134 PN-: n=179	75.5 (8.1)	161/148	37 (22) d	Discharge	Severity: NM Location: "R/L equally divided", no further information provided

D: days, L: left, mod: moderate, n: number, NM: not mentioned, PN: personal neglect, PN+/-: individuals with/without personal neglect, R: right, SD: standard deviation, sev: severe, VSN: visuo-spatial neglect, VSN+/-: individuals with/without visuo-spatial neglect, w: weeks.

Table 5. Association of body representation neglect with outcomes

Author	Assessment tool and/or category	Score type	Results	PN related to outcome?	MQ
Motor outcomes					
Chen-Sea (2000)	Brunnstrom's assessment: voluntary movement control of UL/LL (CL)	Total (1–6)	Sig. difference between PN+ (8.00 ± 3.00) and PN− group (12.08 ± 4.52; $t = 3.03$, $p < .0039$*)	Yes	Mod
Chen-Sea (2001)	Brunnstrom's assessment: voluntary movement control of UL/LL (CL)	Total (1–6)	Sig. difference between "PN−, VSN− group" (12.73 ± 4.49), "PN−, VSN+ group" (11.57 ± 5.47), and "PN+, VSN+ group" (8.09 ± 2.59); ($F = 4.56$, $p = .016$*). Post hoc: sig. Difference between the "PN−, VSN− group" and the "PN+, VSN+ groups" only ($p < .05$*)	Yes*	Mod
Chen-Sea (2000)	Muscle strength using MRC: UL/LL, dynamometer; grip (CL)	Total (0–5), *N*	Sig. difference between PN+ (47.75 ± 12.43) and PN− group (64.67 ± 22.68; $t = 3.17$, $p < .0001$*)	Yes	Mod
Chen-Sea (2001)	Muscle strength using MRC: UL/LL, dynamometer; grip (CL)	Total (0–5), *N*	Sig. difference between "PN−, VSN− group" (68.04 ± 23.51), "PN−, VSN+ group" (52.14 ± 14.46), and "PN+, VSN+ group" (47.36 ± 12.96; $F = 4.73$, $p < .016$*). Post hoc: sig. Difference between the "PN−, VSN− group" and the "PN+, VSN+ groups" only ($p < .05$*)	Yes*	Mod
Jamal et al. (2018)	WBA quiet stance: standing balance	% toward most-affected leg (mean of four trials, two eyes open, two eyes closed)	No sig. Correlation between WBA and SSA (*r* unknown, $p = .580$)	No	Mod
Rousseaux et al. (2013)	PASS: sitting, standing balance, mobility	Total (0–36)	The SSA correlated sig. With the PASS ($r = -.34$, $p = .027$*)	Yes	Mod
ADL outcomes					
Chen-Sea (2000)	Klein-Bell ADL scale	Total (0–313)	Sig. difference between PN+ (178.46 ± 59.95) and PN− group (271.21 ± 44.45; $t = 5.93$; $p < .0001$*).	Yes	Mod
Chen-Sea (2001)	Klein-Bell ADL scale	Total (0–313)	Sig. difference between "PN−, VSN− group" (276.77 ± 43.01), "PN−, VSN+ group" (260.14 ± 55.73), and "PN+, VSN+ group" (166.73 ± 52.18; $F = 21.17$, $p \leq .0001$*). Post hoc: sig. Lower scores for the "PN+, VSN+ group" compared with the "PN−, VSN− group" ($p \leq .0001$*) and "PN−, VSN+ group" ($p \leq .006$*).	Yes	Mod
Chen-Sea (2000)	Klein-Bell ADL scale	Dressing (0–103)	Sig. difference between PN+ (58.15 ± 23.12) and PN− group (93.21 ± 12.45; $t = 5.21$, $p \leq .0001$*).	Yes	Mod
Chen-Sea (2001)	Klein-Bell ADL scale	Dressing (0–103)	Sig. difference between "PN−, VSN− group" (95.19 ± 10.92), "PN−, VSN+ group" (88.86 ± 17.24), and "PN+, VSN+ group" (53.36 ± 20.22; $F = 31.82$, $p \leq .001$*). Post hoc: sig. Lower scores for the "PN+, VSN+ group" compared with the "PN−, VSN− group" ($p \leq .0001$*), and "PN−, VSN+ group" ($p \leq .006$*).	Yes	Mod
Chen-Sea (2000)	Klein-Bell ADL scale	Elimination/ toilet (0–46)	Sig. difference between PN+ (25.38 ± 13.13) and PN− group (40.03 ± 9.45; $t = 4.35$, $p \leq .0001$*).	Yes	Mod
Chen-Sea (2001)	Klein-Bell ADL scale	Elimination/toilet (0–46)	Sig. difference between "PN−, VSN− group" (41.73 ± 7.35), "PN−, VSN+ group" (36.86 ± 11.99), and "PN+, VSN+ group" (23.45 ± 12.66; $F = 13.88$, $p \leq .0001$*). Post hoc: sig. Lower scores for the "PN+, VSN+ group" compared with the "PN−, VSN− group" ($p \leq .006$*) and "PN−, VSN+ group" ($p \leq .05$*).	Yes	Mod
Chen-Sea (2000)	Klein-Bell ADL scale	Mobility (0–68)	Sig. difference between PN+ group (19.54 ± 18.47) and PN− group (52.32 ± 18.68); ($t = 5.48$, $p \leq .0001$*).	Yes	Mod
Chen-Sea (2001)	Klein-Bell ADL scale	Mobility (0–68)	Sig. difference between "PN−, VSN− group" (54.38 ± 19.10), "PN−, VSN+ group" (47.71 ± 22.95), and "PN+, VSN+ group" (16.45 ± 16.94; $F = 15.22$, $p \leq .0001$*). Post hoc: sig. Lower scores for the "PN+, VSN+ group" compared with the "PN−, VSN− group" ($p \leq .0001$*) and "PN−, VSN+ group" ($p \leq .006$*).	Yes	Mod

(*Continued*)

Table 5. Continued

Author	Assessment tool and/or category	Score type	Results	PN related to outcome?	MQ
Chen-Sea (2000)	Klein-Bell ADL scale	Bathing (0–56)	Sig. difference between PN+ (37.62 ± 8.88) and PN− group (49.00 ± 5.90; $t = 5.25$, $p \leq .0001$*).	Yes	Mod
Chen-Sea (2001)	Klein-Bell ADL scale	Bathing (0–56)	Sig. difference between "PN−, VSN− group" (50.23 ± 5.95), "PN−, VSN+ group" (46.71 ± 5.59), and "PN+, VSN− group" (36.09 ± 7.62; $F = 19.20$, $p \leq .0001$*). Post hoc: sig. Lower scores for the "PN+, VSN+ group" compared with the "PN−, VSN− group" ($p \leq .001$*) and "PN−, VSN+ group" ($p \leq .006$*).	Yes	Mod
Chen-Sea (2000)	Klein-Bell ADL scale	Eating (0–30)	No sig. Difference between PN+ (28.77 ± 2.52) and PN− group (29.34 ± 2.31; $t = .75$, $p > .05$)	No	Mod
Chen-Sea (2001)	Klein-Bell ADL scale	Eating (0–30)	No sig. Difference between "PN−, VSN− group" (29.15 ± 2.74), "PN−, VSN+ group" ($30.00 \pm .00$), and "PN+, VSN+ group" (28.55 ± 2.70; $F = .71$, $p > .05$).	No	Mod
Chen-Sea (2000)	Klein-Bell ADL scale	Communication (0–10)	Sig. difference between PN+ (9.00 ± 1.41) and PN− group ($9.95 \pm .32$; $t = 2.39$, $p < .05$*).	Yes	Mod
Chen-Sea (2001)	Klein-Bell ADL scale	Communication (0–10)	Sig. difference between "PN−, VSN− group" ($9.92 \pm .39$), "PN−, VSN+ group" ($10.00 \pm .00$), and "PN+, VSN+ group" (8.82 ± 1.47; F = 8.37, $p \leq .0009$*). Post hoc: sig. Lower scores for the "PN+, VSN+ group" compared with the "PN−, VSN− group" ($p \leq .05$*) and "PN−, VSN+ group" ($p \leq .05$*).	Yes	Mod

ADL = activities of daily living; CL = contralesional; LL = lower limb; Mod = moderate; MQ = methodological quality; MRC = Medical Research Council scale; n = number; NM = not mentioned; PASS = Postural Assessment Scale for Stroke; PN = personal neglect; PN+/− = individuals with/without personal neglect; R = right; r = correlation coefficient; RMI = Rivermead Mobility Index; sig. = significant(ly); SSA = Subjective Straight Ahead test; UL = upper limb; VSN = peri- or extra-personal visuo-spatial neglect; VSN+/− = individuals with/without peri -or extra-personal visuo-spatial neglect; WBA = weight-bearing asymmetry; Yes* = in some cases; ± = SD. *Indicates a statistically significant result.

Activities of daily living. As shown by two moderate methodological quality studies (Chen-Sea, 2000, 2001), individuals with body representation neglect after stroke showed significantly lower Klein Bell ADL scores ($p < .001$), as well as lower dressing ($p < .001$), elimination ($p < .001$), mobility ($p < .0001$), bathing ($p < .001$), and communication ($p < .001$) sub-scores on the Klein-Bell ADL compared with individuals without body representation neglect after stroke. Eating scores ($p > .05$) were similar between these groups (Chen-Sea, 2000).

Chen-Sea (2001) measured body representation neglect and VSN, and showed that individuals with both types after stroke showed significantly lower scores compared with individuals with only VSN or without neglect after stroke, within the following categories: total Klein Bell ADL ($p < .001$ and $p \leq .006$, respectively), dressing ($p < .001$ and $p \leq .006$, respectively), elimination ($p \leq .006$ and $p < .05$, respectively), mobility ($p < .001$ and $p \leq .006$, respectively), bathing ($p < .001$ and $p \leq .006$, respectively), and communication scores ($p < .05$ and $p < .05$, respectively). On eating scores, individuals with both body representation neglect and VSN after stroke did not significantly differ from individuals without neglect or with only VSN after stroke ($p > .05$; Chen-Sea, 2001; Table 5).

Motor Neglect

Motor outcomes. One good methodological quality study demonstrated that at Day 1 poststroke, individuals with motor neglect showed worse motor scores, subjective self-assessment scores for motor function, and spasticity scores compared with individuals without motor neglect after stroke ($p < .01$), with similar scores for grip strength reduction, apraxia, limb coordination, and dexterity (Siekierka-Kleiser et al., 2006). Within the motor neglect group, there were two distinct recovery groups with one group experiencing almost full recovery at Day 7 poststroke ($p < .05$) and the other showing only very limited recovery throughout the first 7 days after stroke. In those with a good recovery profile, bilateral spontaneous movement activity of the hands was inversely correlated to motor score recovery ($r = -.75$, p not given; Siekierka-Kleiser et al., 2006; Table 6).

Nonspecified PN

Motor outcomes. One good methodological quality study demonstrated that individuals with moderate or severe PN after stroke had similar functional mobility as individuals without PN after stroke, both at admission and discharge (Iosa et al., 2016).

Table 6. Association of motor neglect with outcomes

Author	Assessment tool and category	Score type	Results	PN related to outcome?	MQ
Siekierka-Kleiser et al. (2006)	Motor score: maximal grip force reduction, subjective self-assessment, spasticity, apraxia, limb coordination, dexterity (at Day 1 and evolution [Days 1–7])	Sub-scores, total scores (0 = normal; 32 = complete loss)	Day 1 poststroke: no sig. Difference between PN+ and PN− for grip force reduction, apraxia, limb coordination and dexterity (p not given); sig. Difference ($p < .01^*$) for total motor score (PN+: 21 ± 5; PN−: 13 ± 5), subjective self-assessment (PN+: $3.7 \pm .8$; PN−: 2.7 ± 1.3), and spasticity (PN+: $3.5 \pm .9$, PN−: 1.4 ± 1.4) scores. Two distinct recovery profiles in the PN+ group: group who improved limitedly ($n = 13$, change score of ± 3) and group with almost complete recovery ($n = 5$, change score of ± 15) from Days 1–7 ($p < .05^*$)	Yes	Good
Siekierka-Kleiser et al. (2006)	Motor score: maximal grip force reduction, subjective self-assessment, spasticity, apraxia, limb coordination, dexterity in different recovery groups	Sub-scores, total scores (0 = normal; 32 = complete loss)	In individuals with PN and a good recovery profile, recovery of the motor score was inversely correlated with the spontaneous movement activity of both hands ($r = -.75$, p not given)	Yes	Good

MQ = methodological quality; PN = personal neglect; PN+/− = individuals with/without personal neglect; r = correlation coefficient; sig. = significant(ly); Yes* = in some cases; ± = SD. *Indicates a statistically significant result.

Moreover, PN did not significantly correlate with functional mobility scores at admission and discharge ($p = .757$ and $p = .646$, respectively), neither with improvement of functional mobility ($p = .960$; Iosa et al., 2016; Table 7).

Another good methodological quality study (Lafosse et al., 2005) evaluated lateropulsion with pushing after stroke (defined according to Davies 1985). In individuals with a right-sided stroke, left PN was significantly associated with lateropulsion with pushing on admission ($r = .19$, $p < .037$) and at 12 weeks post-admission ($r = .47$, $p < .001$). When sex was considered in the analysis within right-sided strokes, lateropulsion with pushing was only significantly associated with left PN in females, both on admission ($r = .47$, $p < .001$) and 12 weeks post-admission ($r = .71$, $p < .001$). In left-sided strokes, right PN was significantly associated with lateropulsion with pushing on admission ($r = .40$, $p < .001$), but not at 12 weeks post-admission ($r = .08$, $p = .502$). In left-sided strokes, right PN was associated with lateropulsion with pushing in males ($r = .38$, $p = .008$) and females ($r = .45$, $p < .001$) at admission. The correlation increased at 12 weeks post-admission for females ($r = .71$, $p < .001$), but disappeared in males ($r = .18$, $p = .237$; Table 7; Lafosse et al., 2005).

Activities of daily living. One good methodological quality study measured ADL independency using the Barthel Index (for instrument details, see Quinn et al. 2011), and showed that individuals with moderate or severe PN after stroke had similar scores as those without PN after stroke at admission ($p = .654$) and discharge ($p = .896$; Iosa et al., 2016). Also the percentage of improvement from admission to discharge was similar in these groups ($p = .574$; Iosa et al., 2016). PN did not significantly correlate with scores at admission ($p = .984$), scores at discharge ($p = .880$), and effectiveness ($p = .986$; Iosa et al., 2016). This effectiveness score reflects the proportion of functional improvement achieved with respect to the maximum achievable improvement (Table 7).

ADL was also evaluated using the Functional Independence Measures (FIM; for instrument details, see Linacre et al. 1994). As shown by two studies, PN correlated significantly with lower FIM scores (r not given, $p < .001$; Wee & Hopman, 2005; poor methodological quality study), both at 2–4 weeks poststroke ($r = .42$, $p < .01$), 6 months poststroke ($r = .41$, $p < .05$), and 1 year poststroke ($r = .45$, $p < .05$; Appelros et al., 2004; moderate methodological quality study). However, it was not a significant independent predictor for motor (Spaccavento et al., 2017), cognitive (Spaccavento et al., 2017), and total (Spaccavento et al., 2017; Wee & Hopman, 2005) FIM scores ($p > .05$) on admission, based on one poor (Wee & Hopman, 2005) and one good methodological quality study (Spaccavento et al., 2017). Additionally, one good methodological quality study showed that PN was not significantly associated with FIM effectiveness ($p > .05$; Spaccavento et al., 2017; Table 7).

Regarding coexisting VSN, one moderate methodological quality study showed that individuals with both PN and VSN after stroke had significantly lower total FIM scores on admission and discharge than individuals with only VSN after stroke (p-values not given). Individuals with right PN after stroke had significantly lower FIM scores at admission, but not at discharge, compared

Table 7. Association of nonspecified neglect with outcomes

Author	Assessment tool and category	Score type	Results	PN related to outcome?	MQ
Motor outcomes					
Iosa et al. (2016)	RMI: functional mobility at adm	Total (0–15)	No sig. Difference between PN− group (1 ± 2), Mod PN+ group (0 ± 1) and Sev PN+ group (0 ± 2; $p = .889$). No sig. Correlation between PN score and RMI-score: $r = -.045$ ($p = .757$).	No	Good
Iosa et al. (2016)	RMI: functional mobility at disch	Total (0–15)	No sig. Difference between PN− group (3 ± 4), Mod PN+ group (5 ± 4), and Sev PN+ group (3 ± 4; $p = .960$). No sig. Correlation between PN score and RMI-score ($r = .067$, $p = .646$).	No	Good
Iosa et al. (2016)	RMI: effectiveness	Improvement (0–15)	No sig. Correlation between PN score and effectiveness (improvement): $r = -.102$, $p = .539$	No	Good
Lafosse et al. (2005)	Davies' LwP criteria: severity of LwP at adm (L-sided stroke)	Total 0 (no LwP)-3 (LwP while standing, sitting, and lying)	R PN was sig. Correlated with LwP ($r = .40$, $p < .001$*), whereas L PN was not ($r = .16$, $p = .099$).	Yes*	Good
Lafosse et al. (2005)	Davies' LwP criteria: severity of LwP at adm (L-sided stroke): sex-related differences	Total 0 (no LwP)-3 (LwP while standing, sitting, and lying)	Male: R PN was sig. Correlated with LwP ($r = .38$, $p = .008$*), L PN was not ($r = .15$, $p = .122$); Female: R PN was sig. Correlated with LwP ($r = .45$, $p < .001$*), no info on L PN.	Yes*	Good
Lafosse et al. (2005)	Davies' LwP criteria: severity of LwP at adm (R-sided stroke)	Total 0 (no LwP)-3 (LwP while standing, sitting, and lying)	L PN was sig. Correlated with LwP ($r = .19$, $p < .037$*), R PN was not ($r = -.04$, $p = .704$).	Yes*	Good
Lafosse et al. (2005)	Davies' LwP criteria: severity of LwP at adm (R-sided stroke): sex-related differences	Total 0 (no LwP)-3 (LwP while standing, sitting, and lying)	Male: L PN ($r = -.08$, $p = .562$) and R PN ($r = .14$, $p = .584$) were not sig. Correlated with LwP; Female: L PN was sig. Correlated with LwP ($r = .47$, $p < .001$*), R PN was not ($r = -.15$, $p = .257$).	Yes*	Good
Lafosse et al. (2005)	Davies' LwP criteria: severity of LwP at 12 weeks post-admission	Total 0 (no LwP)-3 (LwP while standing, sitting, and lying)	In participants with LBD: R PN was not sig. Correlated with LwP ($r = .21$, $p = .071$); no info on L PN. In participants with RBD: L PN was sig. Correlated with LwP ($r = .47$, $p < .001$*), R PN was not ($r = .08$, $p = .502$)	Yes*	Good
Lafosse et al. (2005)	Davies' LwP criteria: severity of LwP at 12 weeks post-admission: sex-related differences	Total 0 (no LwP)-3 (LwP while standing, sitting, and lying)	In participants with LBD: Male: R PN was not sig. Correlated with LwP ($r = -.08$, $p = .652$), no info on L PN; Female: R PN was sig. Correlated with LwP ($r = .48$, $p = .004$*), no info on L PN. In participants with RBD: Male: L PN ($r = .18$, $p = .237$) and R PN ($r = .18$, $p = .236$) were not sig. Correlated with LwP; Female: L PN was sig. Correlated with LwP ($r = .71$, $p < .001$*), no information on R PN available.	Yes*	Good
ADL outcomes					
Appelros et al. (2004)	Functional Independence Measures	Total (1–7)	**2–4 weeks:** sig. Correlation between BIT-subtest scores for PN (higher = less PN) and FIM scores ($r = .42$, $p < .01$*); **6 months:** sig. Correlation between PN+ and FIM score ($r = .41$, $p < .05$*); **1 years:** sig. Correlation between PN+ and FIM score ($r = .45$, $p < .05$*; although evaluated, the analyses were not corrected for MMSE scores).	Yes	Mod
Wee and Hopman (2005)	Functional Independence Measures	Total (1–7)	Correlation analysis: PN was sig. Correlated to lower FIM scores (r not given, $p < .001$*). Regression model adjusted for balance (BBS), number of impairments and cognitive impairment (MMSE): PN was not sig. Associated with lower FIM scores (no values given).	No	Poor
Wee and Hopman (2008)	Functional Independence Measures	Total (adm; 1–7)	Sig. difference between "R PN+, R VSN+ group" (81.1 ± 17.0) and "L VSN+ only group" (97.2 ± 16.0). Sig. difference between "L PN+, L VSN+ group" (81.8 ± 15.2) and "L VSN+ only group" (97.2 ± 16.0). Sig. difference between "R PN+ only group" (77.7 ± 14.9) and "R VSN+ only group" (88.6 ± 20.8). Sig. difference between "VSN+, PN+ group" (81.5 ± 15.9) and "VSN+ only group" (93.7 ± 18.5).	Yes*	Mod

(*Continued*)

Table 7. Continued

Author	Assessment tool and category	Score type	Results	PN related to outcome?	MQ
Spaccavento et al. (2017)	Functional Independence Measures	Adm: total, motor, cognitive (1–7)	PN was not a sig. Predictor in the model for the prediction of the total, motor, or cognitive FIM (β not given, $p > .05$).	No	Good
Wee and Hopman (2008)	Functional Independence Measures	Total (disch; 1–7)	Sig. difference between “R PN+, R VSN+ group” (100.2 ± 17.1) and “L VSN+ only group” (110.8 ± 12.5); sig. Difference between “L PN+, L VSN+ group” (96.4 ± 18.1) and “L VSN only group” (110.8 ± 12.5); sig. Difference between “VSN+, PN+ group” (97.9 ± 17.7) and “VSN+ only group” (107.3 ± 16.0).	Yes*	Mod
Spaccavento et al. (2017)	Functional Independence Measures	Effectiveness (NM)	PN was not a sig. Predictor in the model for the prediction of the effectiveness for total, motor, or cognitive FIM scores (β not given, $p > .05$).	No	Good
Spaccavento et al. (2017)	Functional Independence Measures	Effectiveness (NM)	PN was not sig. Correlated with effectiveness for total ($r = -.09$), motor ($r = -.11$) or cognitive ($r = -.15$) FIM scores ($p > .05$).	No	Good
Wee and Hopman (2008)	Functional Independence Measures	Gains (improvement from adm-disch)	FIM scores improved sig. For “R PN+, R VSN+ group,” “L PN+, L VSN+ group,” and “R PN+ only group” ($p < .001$*), but not for the “L PN+ only group” ($p = .005$). Those with PN+ only showed larger gain than those with VSN+ only (no values given).	Yes	Mod
Iosa et al. (2016)	Barthel Index	Total (0–20)	Adm: No sig. Difference between PN− group (15 ± 17); Mod PN+ group (16 ± 16) and Sev PN+ group (12 ± 14; $p = .654$). Disch: No sig. Difference between PN− group (52 ± 20), Mod PN+ group (57 ± 23), and Sev PN+ group (53 ± 40; $p = .896$).	No	Good
Iosa et al. (2016)	Barthel Index	% of improvement (adm-disch)	No significant difference between PN− group (41.46 ± 18.24), Mod PN+ group (47.43 ± 21.44), and Sev PN+ group (51.76 ± 28.44; $p = .574$).	No	Good
Iosa et al. (2016)	Barthel Index	Total and improvement (adm-disch; 0–20)	No sig. Correlation between PN and BI at admission ($r = -.003$, $p = .984$) and discharge ($r = .022$, $p = .880$). No sig. Correlation between PN score and improvement ($r = .003$, $p = .986$).	No	Good
Participation					
Wee and Hopman (2005)	Length of stay	Total days	PN was sig. Related to longer length of stay (r not given, $p = .001$). Regression model adjusted for balance (BBS), number of impairment, support at home and aphasia: PN was no longer sig. Associated with longer LOS.	No	Poor
Wee and Hopman (2008)	Length of stay	Total days	Sig. differences between “R PN+, R VSN+ group” (64.0 ± 25.3) and “L VSN+ only group” (43.5 ± 19.0); Sig. difference between “R PN+ only group” (67.1 ± 17.1) and “L VSN+ only group” (43.5 ± 19.0); Sig. difference between “PN and VSN group” (59.7 ± 24.0) and “no PN and/or VSN group” (51.7 ± 21.8; $p = .044$).	Yes	Mod
Wee and Hopman (2005)	Discharge destination	Destination (home/other than home)	PN was sig. Correlated to a discharge destination “other than home” (r not given, $p = .001$). Regression model adjusted for balance (BBS), cognitive impairment (MMSE), and support at home: PN remained a sig. Predictor for “other than home” discharge destination (OR = 2.20, $p = .045$, 95%CI [1.00; 4.84]).	Yes	Poor
Wee and Hopman (2008)	Discharge destination	Destination (home/other than home)	Sig. difference between number of individuals with PN+ (31.1%) and without PN (13.0%) that are discharged to a destination other than home ($p < .001$).	Yes	Mod

Adm = admission; BBS = Berg Balance Scale; CI = confidence interval; DD = discharge destination; disch = discharge; PN = personal neglect; PN+/− = individuals with/without personal neglect; CI = confidence interval; d = day(s); L = left; LOS = length of stay; LwP = lateropulsion with pushing; MMSE = Mini-Mental State Examination; MQ = methodological quality; NM = not mentioned; OR = odd’s ratio; R = right; r = correlation coefficient; sig. = significant(ly); vs = versus; VSN+/− = individuals with/without visuo-spatial neglect; ± = SD. *Indicates a statistically significant result.

with individuals with right VSN after stroke (*p*-values not given; Wee & Hopman, 2008). Individuals with right PN after stroke and individuals with both (left or right) PN and VSN after stroke had similar improvements on the FIM from admission to discharge (*p*-values not given). Individuals with only PN after stroke showed greater FIM gains (improvements from admission to discharge) compared with individuals with only VSN after stroke (Wee & Hopman, 2008; Table 7).

Participation. A poor methodological study showed that PN was a predictor of a longer length of stay ($p < .05$); however, the significance disappeared when corrected for balance (Wee & Hopman, 2005). With regards to PN side, those with right PN (either with or without coexisting VSN) after stroke had a significantly longer length of stay compared with those with left VSN after stroke ($p = .044$), even when the regression model was adjusted for balance, number of impairments, support at home, and aphasia, as shown by a moderate methodological quality study (Wee & Hopman, 2008).

The same studies show that individuals with PN after stroke were 2.2 times more likely to be discharged to a destination other than home ($p = .045$), even when the regression model was adjusted for balance, cognitive impairment, and support at home (Wee & Hopman, 2005) and the amount of individuals discharged to a destination other than home was significantly higher in individuals with PN after stroke (31.1%) compared with those without PN after stroke (13%; $p < .001$; Wee & Hopman, 2008; Table 7).

Discussion

This first-ever systematic review on the association between PN subtypes and motor, ADL, and participation outcomes poststroke highlights the limited research in this area and warrants the need for further research. Despite the limited literature on the topic, we were able to provide a first indication of an association between PN subtypes and poststroke outcomes. Specifically, studies showed that individuals with body representation neglect experience significantly lower voluntary movement control and motor strength, as well as lower scores on the Postural Assessment Scale for Stroke and multiple ADL domains as compared with individuals without body representation neglect after stroke. Similarly, motor neglect was associated with worse total motor scores, subjective self-assessment scores for motor function, and spasticity scores. Nonspecified PN was linked to lower total FIM scores and lateropulsion with pushing compared with individuals without PN after stroke, but did not correlate with functional mobility scores or the Barthel Index.

The results of the present systematic review show a marked level of heterogeneity in results, which may have been influenced by the assessment tools used to evaluate PN. Specifically, most studies relied on a limited number of tests, typically only one or two, to detect PN, with a primary focus on nonspecified PN. Additionally, certain types of PN, such as somatosensory and premotor neglect, are yet to be addressed.

The difficulty of conducting a thorough and efficient assessment of PN and its subtypes may have contributed to the heterogeneity in study results. Currently available tests provide only a general indication of the disorder rather than a definitive diagnosis (Caggiano & Jehkonen, 2018; Rode et al., 2017), highlighting the pressing need for more comprehensive and standardized assessment tools to advance research on PN. Studies that have utilized assessment tools capable of detecting specific PN subtypes (e.g., motor neglect or body representation neglect) exhibited greater consistency in their results, particularly when assessing certain outcomes such as ADL independence (Chen-Sea, 2000, 2001). In addition, Chen-Sea (2001) demonstrated that mainly the combined presence of PN and VSN was negatively associated with motor outcomes and ADL independence. However, it is worth noting that Chen-Sea (2001) employed the Draw-A-Man test, a representational drawing test, to assess PN. This test evaluates both body representation as well as visual representation. This is significant because representational drawing tests are also included in commonly used VSN test batteries, such as the Behavioral Inattention Test. Nonetheless, despite its overlap with VSN assessment, the Draw-A-Man test has also been demonstrated a reliable and valid instrument for assessing PN (Chen-Sea, 2000). Therefore, a thorough assessment on various spatial neglect characteristics seems necessary to gain better understanding of potential associations. It is possible that PN becomes a significant factor to consider only when it is present in combination with other types of neglect. However, it is unclear whether the larger negative outcomes observed in individuals with both PN and VSN reflect the true impact of this coexistence or rather the presence of different lesion characteristics, such as a larger lesion volume, considering this was generally not taken into account by the studies during analyses.

Apart from neglect assessment tools, also the outcome measures employed by the studies were diverse, with limited attention given to motor and participation outcomes. Outcomes should be more thoroughly evaluated, preferably repeatedly over time, given the potential for divergent recovery patterns between individuals. For example, some individuals with PN (here, motor neglect) may experience rapid and complete motor recovery, whereas others may exhibit only limited recovery over time (Siekierka-Kleiser et al., 2006). The distinction between these two recovery groups may already be found in the acute poststroke phase. This underscores the importance of early evaluation of PN, particularly because the majority of behavioral recovery occurs in the first few weeks poststroke onset (Siekierka-Kleiser et al., 2006). Additionally, the relationship between the subtypes of PN and an individual's participation in life situations, their independence, and their need for caregiver assistance remains unclear because of the limited assessment of participation outcomes. This is a crucial area that needs to be addressed to assist individuals in their transition back to society, particularly because individuals with PN were found to have longer stays in care facilities and are frequently discharged to locations other than their homes (Wee & Hopman, 2005, 2008).

Another important aspect to consider when evaluating the association of PN with the investigated outcomes after stroke is the potential mediating role of other cognitive impairments. This is especially relevant considering that the prevalence of cognitive impairments has been reported to be higher in individuals with neglect compared with those without neglect after stroke (Lee et al., 2008; Linden et al., 2005). However, the mediating role of these cognitive impairments could not be thoroughly evaluated within the present systematic review as only three studies documented the presence of such impairments (Appelros et al., 2004; Wee & Hopman, 2005, 2008), with only one study specifically examining their mediating role (Wee & Hopman, 2005). Wee and Hopman (2005) show a significant correlation between the presence of PN and reduced independence in ADL, longer hospital stays, and higher odds of being discharged to a destination other than home (Wee & Hopman, 2005). However, when the presence of other cognitive impairments was considered within the analysis, the significant contribution of PN to ADL independence and length of stay disappeared, whereas it remained significant for discharge destination. These findings highlight the complex interplay between PN, cognitive impairments, and poststroke outcomes, and emphasize the need for comprehensive assessments that consider multiple cognitive domains.

Suggestions for Further Research and Clinical Implications

This study highlights the lack of research on the association between PN and rehabilitation outcomes, underlining the need for more comprehensive and longitudinal assessments of PN, including its various subtypes. However, the assessment tools available only provide a general indication of the disorder rather than a definitive diagnosis, which makes it challenging to accurately identify specific PN subtypes. Therefore, future research should prioritize the development of comprehensive diagnostic test batteries that can efficiently and accurately identify subtypes. Coexistence of other types of spatial neglect, such as VSN, may be important to consider when evaluating rehabilitation outcomes. This calls for investigating the relationship between PN and other spatial neglect types further. Moreover, the current studies do not adequately evaluate the potential impact of lesion location, stroke severity, and other cognitive impairments on the relationship between PN and rehabilitation outcomes. Therefore, future studies should more thoroughly investigate the influence of these factors on the association between PN and rehabilitation outcomes after stroke.

Strengths and Limitations

A strength of this study is the subcategorization of PN into different subtypes, providing insight into the importance of doing so in clinical practice and future research. Another strength is the focus of outcomes on different levels of the International Classification of Functioning, Disability, and Health (International Classification of Functioning, Disability, and Health: ICF, 2001; Organization, 2017), which demonstrates a comprehensive approach. However, the limitations of the included studies, such as heterogeneity and limited sample sizes, may reduce the generalizability of the results and the ability to draw definitive conclusions regarding the association of PN with rehabilitation outcomes, which could also be considered a limitation of this review.

Conclusion

Although the association between PN and rehabilitation outcomes is largely understudied, this systematic review provides an initial indication of the association between PN subtypes and motor, ADL, and participation outcomes poststroke. Given that the majority of studies have focused on nonspecified PN, future research should focus on the assessment of these subtypes, and should aim to develop a comprehensive test battery for PN that allows to evaluate them in a time-efficient way. The limited focus on motor and participation outcomes of the studies included in this review calls for further research in these areas.

Supplementary material

Supplementary material is available at *Archives of Clinical Neuropsychology* online.

Funding

The BOF University Research Fund under a STIMPRO Grant (39800); DOCPRO Grant (40180).

Conflict of interest

None declared.

Author contributions

Elissa Embrechts (Conceptualization, Data curation, Formal analysis, Funding acquisition, Methodology, Visualization, Writing—original draft, Writing—review & editing), Renata Loureiro-Chaves (Data curation, Formal analysis, Methodology, Writing—review & editing), Tanja Nijboer (Conceptualization, Formal analysis, Methodology, Supervision, Writing—original draft), Christophe Lafosse (Conceptualization), Steven Truijen (Supervision), and Wim Saeys (Supervision)

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