Archives of Rehabilitation Research and Clinical Translation (2023) 5, 100263

ACRM
AMERICAN CONGRESS OF REHABILITATION MEDICINE

Archives of Rehabilitation Research and Clinical Translation

Archives of Rehabilitation Research and Clinical Translation 2023;5:100263

Available online at www.sciencedirect.com

ORIGINAL RESEARCH

Prism Adaptation Treatment for Right-Sided and Left-Sided Spatial Neglect: A Retrospective Case-Matched Study

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KEYWORDS
Occupational therapy;
Perceptual disorders;
Rehabilitation;
Stroke;
Therapeutics

Abstract *Objective:* To compare the effectiveness of prism adaptation treatment (PAT) between patients with right- and left-sided spatial neglect (SN).
Design: Retrospective case-matched design.
Setting: Inpatient rehabilitation hospitals and facilities.
Participants: A total of 118 participants were selected from a clinical dataset of 4256 patients from multiple facilities across the United States. Patients with right-sided SN (median age: 71.0 [63.5-78.5] years; 47.5% female; 84.8% stroke, 10.1% traumatic/nontraumatic brain injury) were matched 1:1 with patients with left-sided SN (median age: 70.0 [63.0-78.0] years; 49.2% female; 86.4% stroke, 11.8% traumatic/nontraumatic brain injury) based on age, neglect severity, overall functional ability at admission, and number of PAT sessions completed during their hospital stay.
Intervention: Prism adaptation treatment.
Main Outcome Measures: Primary outcomes were pre—post change on the Kessler Foundation Neglect Assessment Process (KF-NAP) and the Functional Independence Measure (FIM). Secondary outcomes were whether the minimal clinically important difference was achieved for pre—post change on the FIM.

List of abbreviations: ADL, activities of daily living; FIM, Functional Independence Measure; KF-NAP, Kessler Foundation Neglect Assessment Process, KF-PAT, Kessler Foundation Prism Adaptation Treatment; LBD, left brain damage; MCID, minimal clinically important difference; OR, odds ratio; PAT, prism adaptation treatment; RBD, right brain damage; SN, spatial neglect.

Supported by the Wallerstein Foundation for Geriatric Improvement (no grant number), the Charles and Ann Serraino Foundation (no grant number), and Kessler Foundation. Funding sources had no role in study design; in the collection, analysis, or interpretation of data; in the writing of the report; or in the decision to submit this article for publication. The KF-NAP and KF-PAT are registered trademarks of Kessler Foundation in the United States.
Disclosures: T.J.R. and P.C. are employees of Kessler Foundation but receive no personal financial compensation for the use or purchase of the KF-NAP or KF-PAT. The other authors have nothing to disclose.
Cite this article as: Arch Rehabil Res Clin Transl. 2023;5:100263

https://doi.org/10.1016/j.arrct.2023.100263

Results: We found greater KF-NAP gain for patients with right-sided SN than those with left-sided SN (Z = 2.38, P=.018). We found no differences between patients with right-sided and left-sided SN for Total FIM gain (Z=−0.204, P=.838), Motor FIM gain (Z=−0.331, P=.741), or Cognitive FIM gain (Z=−0.191, P=.849).
Conclusions: Our findings suggest PAT is a viable treatment for patients with right-sided SN just as it is for patients with left-sided SN. Therefore, we suggest prioritizing PAT within the inpatient rehabilitation setting as a treatment to improve SN symptoms regardless of brain lesion side.

Spatial neglect (SN) is a disorder of spatial cognition commonly experienced by survivors of acquired or traumatic brain injury.[1,2] Those with SN demonstrate deficient spatial attention toward the contralesional side of space and/or objects. A recent review indicates an incidence of SN after right brain damage (RBD) as approximately double the incidence of SN after left brain damage (LBD).[3]

However, the occurrence of right-sided SN after LBD is likely underestimated for several reasons. First, some authors have suggested an underestimate of right-sided SN because patients with LBD are often excluded in SN research to limit the potential confounding of aphasia.[4-6] Although it is true that those with LBD are often excluded, several studies that included patients with aphasia found the greater incidence of SN after RBD persists.[1,7-9]

Second, a variety of assessments have been used in previous studies to measure SN.[4,5,10,11] With disparate demands, each assessment detects different aspects of the heterogenous disorder. For example, most tests of SN rely on marking, writing, or drawing with a pen or pencil. For those with LBD, right hemiparesis is common, causing potential interference for the approximate 90% of patients who are right-handed.[12] Furthermore, it has generally been supposed that injury to homologous structures and mechanisms in the left and right hemispheres induce SN. However, a recent lesion analysis showed that left and right hemisphere lesions that induce SN are anatomically nonhomologous,[13] suggesting that spatial cognition might rely on distinct and co-dependent brain networks in each hemisphere. Thus, the selection of assessments may have different sensitivities to SN in those with RBD and those with LBD.[14]

Finally, the underestimate of SN after LBD likely reinforces itself in a cyclical fashion. Researchers and clinicians, especially those with less experience, have resultant misperceptions about SN - that it is solely a consequence of RBD, or that right-sided SN improves more quickly than left-sided SN. In turn, researchers tend to exclude those with right-sided SN and clinicians tend to allocate to it fewer rehabilitative resources, leaving affected individuals underdetected and undertreated.

As a case in point, although prism adaptation treatment (PAT) is one of the most empirically supported interventions for left-sided SN,[15,16] little is known about its effects for right-sided SN. PAT consists of a series of brief sessions in which participants wear goggles fitted with binocular unidirectional prisms. The goggles cause an ipsilesional optical deviation, which results in an ipsilesional motor error during reaching or pointing. With visual feedback and repetition, the motor system adapts to the optical deviation to correct the ipsilesional motor error. Finally, with removal of the goggles, a contralesional motor error is induced. It is this so-called aftereffect of PAT over repeated sessions that benefits patients with SN.[17-20] The few studies that have explored the effectiveness of leftward PAT for patients with right-sided SN have shown mixed results.[21-23] However, the samples from those studies were small and did not involve a direct comparison with rightward PAT. Thus, it remains unknown whether patients with right-sided SN completing leftward PAT experience effects comparable to those with left-sided SN completing rightward PAT.

The purpose of this study was to compare the effects of PAT on those with right-sided SN with those with left-sided SN based on a clinical dataset collected from an implementation project.[24] Using a retrospective case-matched method, we compared the effect of PAT on symptoms of SN via the Kessler Foundation Neglect Assessment Process (KF-NAP)[25,26] as well as general functional performance via the Functional Independence Measure (FIM).[27]

Methods

Participants

This study, performed at Kessler Foundation, Center for Stroke Rehabilitation Research, West Orange, New Jersey, retrospectively analyzed clinical data of 4256 patients collected between April 2016 and December 2020 from 16 inpatient rehabilitation facilities across the United States, which were identified through clinician collaborators' professional conferences as part of a knowledge dissemination and translation initiative. Details of the process of KF-NAP and Kessler Foundation Prism Adaptation Treatment (KF-PAT) implementation are reported in Hreha et al.[24] The same dataset used in this study was used in previous analyses with published results.[28,29] We restricted our analyses to patients who (1) had evidence of SN documented by a score >0 on the KF-NAP; (2) completed at least 3 PAT sessions; and (3) had documented scores at admission and discharge for FIM and/or KF-NAP. Patients with right-sided SN were matched 1:1 with patients with left-sided SN based on their initial KF-NAP score (±2 points), the number of PAT sessions they completed (±1), their Total FIM score at admission (±2 points), and age (±5 years). Before data collection, the study was approved by the institutional review boards of participating facilities. The requirement for informed consent was waived as this was a retrospective analysis of an anonymized clinical dataset.

The reason for selecting patients who completed at least 3 PAT sessions was based on the preliminary analysis of a multiple regression model on Total FIM at discharge. The model considered the number of sessions (1-14) as a categorical variable with the reference being 0 sessions (ie, no PAT). After controlling for age, sex, time post-brain injury at admission, FIM at admission, initial KF-NAP score, neglected side, and the length of stay, the number of PAT sessions that showed greater effect (alpha = 0.05) than no PAT were numbers greater than or equal to 3.

Prism Adaptation Treatment

Patients completed PAT following the protocol of KF-PAT.[a,30] Patients wore goggles with binocular, unidirectional 20-diopter prism lenses that shift the visual fields 11.4° to the ipsilesional side. Patients marked with a pen the midpoint of a series of 24 cm lines or 1-cm diameter circles positioned 32 cm to their left, 32 cm to their right, and at their body midline. Patients also wore an occlusion shelf that blocked view of their trunk, arm, and proximal hand while reaching for the stimuli. Patients completed up to 30 lines and 30 circles within a 20-minute time limit in each session. In the context of the implementation project, patients received PAT as part of their inpatient occupational therapy.[24]

Outcome Measures

The KF-NAP, a method for administering the Catherine Bergego Scale,[31] assesses the effect of SN across 10 items sampled in the context of activities of daily living (ADL). It is intended to be completed within a typical 45-minute occupational therapy session. The KF-NAP, as far as we know, is the most sensitive measure of SN available.[25] For each of 10 items, the patient receives a score of 0-3, with 0 indicating no neglect and 3 indicating severe neglect. The final score is a sum of all 10 categories, or, in the case of missed items, an average of the items scored. The measure has been shown to have adequate reliability with at least 7 items scored.[28]

The FIM assesses function across ADL, mobility, and cognition. It was widely used in postacute rehabilitation facilities across the United States at the time of data collection as a Medicare requirement but has since been phased out in favor of a different measure. In contrast to the KF-NAP, it does not assess for SN severity but, rather, the patient's overall functional independence.[25] It is conventionally divided into 2 subtests: Motor FIM and Cognitive FIM. The Motor FIM includes 13 items across ADL (eg, grooming, bathing), bowel and bladder management, and functional mobility (eg, toilet transfers, stairs). The Cognitive FIM subtest includes 5 items evaluating communication (eg, comprehension, expression), social interaction, and mentation (eg, problem solving, memory). Each item of the FIM is scored on a 1-7 scale representing overall level of task dependence, with greater scores indicating greater functional independence. A score of 0 is assigned if an item was not performed and is only acceptable at admission (ie, at discharge, a score of 1-7 must be assigned).

Primary outcome measures included KF-NAP gain, Total FIM gain, Motor FIM gain, and Cognitive FIM gain. These were score changes between the time of admission and the time

Table 1 Demographics

	All	Left-Sided SN	Right-Sided SN	*P* Value
N	118	59	59	
Age	70	70	71	.583*
Median [IQR]	[63.0-78.0]	[63.0-78.0]	[63.5-78.5]	
% Female	48.30%	49.20%	47.50%	.854†
Race				.290†
White	67.00%	69.50%	64.40%	
Black	18.60%	13.60%	23.70%	
Asian	0.90%	0%	1.70%	
Unknown	13.60%	17.00%	10.20%	
Ethnicity				.008†
Hispanic	8.50%	15.30%	1.70%	
Non-Hispanic	91.50%	84.80%	98.30%	
Length of stay	21	21	19	.214*
Median [IQR]	[16.0-24.0]	[17.0-25.0]	[16.0-23.0]	
Diagnosis				.548†
Stroke	85.60%	86.40%	84.80%	
Traumatic brain injury	3.40%	5.10%	1.70%	
Nontraumatic brain injury	7.60%	6.70%	8.40%	
Other	3.40%	1.70%	5.10%	
Spatial neglect severity at admission				>.999†
Mild (KF-NAP 1-10)	52.50%	54.20%	50.90%	
Moderate (KF-NAP 11-20)	33.90%	32.20%	35.60%	
Severe (KF-NAP 21-30)	13.60%	13.60%	13.60%	

Abbreviations: KF-NAP, Kessler Foundation Neglect Assessment Process; SN, spatial neglect.
* Wilcoxon signed ranks test.
† χ^2 test.

Table 2 FIM Gain, FIM MCID, and home discharge

	All	Left-Sided SN	Right-Sided SN	*P* Value
Number of PAT sessions	6.0 [4.0-10.0]	6.0 [4.0-10.0]	6.0 [4.0-10.0]	.841*
Total FIM gain	25.7 (12.8)	26.0 (11.7)	25.3 (13.9)	.838*
Total FIM MCID	58.50%	59.30%	57.60%	.857†
Motor FIM gain	20.0 (10.9)	20.4 (10.7)	19.6 (11.1)	.741*
Motor FIM MCID	55.90%	55.90%	55.90%	>.999†
Cognitive FIM gain	.6 (4.4)	5.5 (4.1)	5.7 (4.7)	.849*
Cognitive FIM MCID	78.00%	79.70%	76.30%	.683†
Home discharge	55.90%	52.50%	59.30%	.435†

NOTE. Number of PAT sessions presented as Median [IQR], FIM gain presented as mean ± SD.
Abbreviations: IQR, interquartile range; MCID, minimum clinically important difference; PAT, prism adaptation treatment; SN, spatial neglect.
* Wilcoxon signed ranks test.
† Conditional logistic regression.

of discharge. A secondary outcome was whether patients achieved the minimal clinically important difference (MCID) for Total FIM, Motor FIM, and Cognitive FIM (established at 22, 17, and 3 points of gain, respectively).[32]

Analysis

SPSS v26[b] was used for statistical analyses. The case-matched design used here allows each pair of participants to be directly compared because they were matched on factors with the potential for confounding (in this case, age, SN severity and functional independence at baseline, and PAT dosage). Because we determined the data were not normally distributed, we used Wilcoxon signed-ranks test to compare the differences of the paired means for KF-NAP and FIM gains. We set our alpha at 0.05. To determine whether there was a difference in reaching MCID between matched pairs, odds ratios (ORs) were calculated using conditional logistic regression. Matched pairs with missing data for either or both participants were removed from analysis for the applicable outcome measure.

Results

Of 4256 records in the database, we matched 118 patients to 59 pairs based on our criteria. Patient characteristics are detailed in table 1. As expected, because of the matching procedure, there was no difference between the 2 groups in age (*P*=.583), sex (*P*=.854), race (*P*=.290), in-hospital length of stay (*P*=.214), diagnosis (*P*=.548), or SN severity at admission (*P*=1.0). There was a difference found for ethnicity, with 15.3% and 1.7% of the left-sided and right-sided SN groups, respectively, reporting Hispanic ethnicity (χ^2=6.99, *P*=.008).

Results for FIM gain, FIM MCID, and home discharge are detailed in table 2. The median number of completed sessions was 6 (interquartile range, 4-10), with 3-5 sessions completed by 54 patients (45.8%), 6-8 sessions completed by 22 patients (18.6%), and 9-11 sessions completed by 42 patients (35.6%). A series of Wilcoxon signed ranks tests showed no differences between groups for Total FIM gain (*Z*=−0.204, *P*=.838), Motor FIM gain (*Z*=−0.331, *P*=.741), or Cognitive FIM gain (*Z*=−0.191, *P*=.849). Conditional logistic regression analyses showed no effect of group for discharging home (OR, 0.733, *P*=.435) or for achieving MCID for Total FIM (OR, 1.07, *P*=.857), Motor FIM (OR, *1.0*, *P*=1.0), or Cognitive FIM (OR, 1.18, *P*=.683).

Results for KF-NAP gain are detailed in table 3. Post-PAT KF-NAP scores were missing for 18 patients with left-sided SN and 10 patients with right-sided SN. Therefore, only the 36 matched pairs with complete data were included in this analysis. We found greater KF-NAP gain for patients with right-sided SN (on average 7.6-point gain) than those with left-sided SN (6.0-point gain) (*Z*=2.38, *P*=.018), with a moderate effect size ($r_{equivalent}$ = 0.397).

Discussion

The purpose of this study was to explore whether differences exist in the clinical effectiveness of PAT between those with left-sided and right-sided SN. To answer this question, we retrospectively examined clinical data to match patients

Table 3 KF-NAP gain

	All	Left-Sided SN	Right-Sided SN	*P* Value
N	72	36	36	
Number of PAT sessions	9.0 [5.0-10.0]	9.0 [4.75-10.0]	8.5 [5.0-10.0]	.782*
KF-NAP gain	6.8 (5.2)	6.0 (5.4)	7.6 (4.9)	.018*

NOTE. Number of PAT sessions presented as median [IQR], KF-NAP gain presented as mean ± SD.
Abbreviations: KF-NAP, Kessler Foundation Neglect Assessment Process; PAT, prism adaptation treatment; SN, spatial neglect.
* Wilcoxon signed-rank test.

with right-sided SN 1:1 with patients with left-sided SN based on neglect severity, number of PAT sessions, overall function at admission, and age. We found no significant differences in FIM gain between matched pairs, suggesting that patients with right-sided SN experience improvements similar to those with left-sided SN in general functional independence after 3 or more sessions of PAT. Furthermore, we found a difference in KF-NAP gain between matched pairs, with patients with right-sided SN achieving greater KF-NAP gain, indicating that they might derive even greater benefit from PAT than those with left-sided SN. Finally, we found those with left-sided SN to be no more likely to achieve MCID for Total FIM, Motor FIM, or Cognitive FIM than those with right-sided SN.

To our knowledge, only 2 previous case studies have investigated the effects of leftward PAT on right-sided SN. Although we emphasized functional outcome measures (KF-NAP and FIM), these previous studies only used conventional paper-and-pencil assessments of SN. Thus, our ability to contextualize our findings within the extant literature is limited. That being said, our findings are generally aligned with one study that examined the effects of leftward PAT on 1 patient with mild right-sided SN after a hemorrhagic stroke to left frontoparietal areas,[21] and another study with 1 patient with right-sided SN and homonymous hemianopia after an ischemic stroke to left temporoparietal areas.[22] Both reported improvement of SN symptoms immediately after leftward PAT. However, after 1-2 weeks, their SN symptoms returned to approximately their pre-PAT state. In the present study, no information was available after patients' discharge from the rehabilitation hospital, and, thus, we are unable to comment on long-term outcomes.

Study Limitations

This study has several limitations that must be addressed. First, although the use of clinical data allows us to explore the ecologic implications of interventions, it inherently lacks controlled conditions to minimize confounding. Thus, the fidelity with how PAT was conducted is unknown and could have potentially varied between individual clinicians. Other interventions that patients received for SN or for other stroke-related deficits are unknown and could have influenced outcomes (also see discussions in Chen et al, 2022).[33] Furthermore, as handedness was not collected as a variable, there may have been differences between the groups in terms of hemispheric dominance (however, see Ringman et al., 2004 and Tatuene et al., 2016).[34,35] Given that both groups had equivalent likelihood of right hemisphere dominance, however, this was unlikely to appreciably affect the findings.

Second, the outcome measures that we used are relatively broad measures of function. Because the dataset lacked scores for other standardized tests for SN, we were not able to determine the specific SN deficits that were addressed by PAT. It is possible that improved FIM scores, and, to a lesser extent, KF-NAP scores, were due to gains in disparate skill areas. For example, Cognitive FIM gains for those with right-sided SN could have been similar to those with left-sided SN because of improved communication rather than spatial attention.

Third, the clinical dataset did not contain neuroimaging or detailed lesion data, so we could not determine whether lesion location played a role in PAT effectiveness. Nonetheless, given the current knowledge on SN, it is plausible that patients with left-sided SN had injuries to their right cerebral hemisphere primarily, and vice versa for patients with right-sided SN. Thus, the present findings can inform future studies that prospectively investigate PAT effects on patients with LBD vs RBD. Finally, we suspect that the significant difference we found between groups with regard to ethnicity is due to chance, given the relatively small sample size. However, it is not out of the realm of possibility that biases exist in assessment and/or intervention decisions made by therapists based on ethnicity, especially when considering the frequency of communication deficits after LBD. Further research is warranted to explore the effect of PAT on the symptoms of right-sided SN using a prospective, randomized controlled design.

Conclusions

Right-sided SN is common and contributes to poor functional outcomes. Although PAT is a promising treatment with empirical support for patients with left-sided SN, few studies have explored its utility in treating right-sided SN. In this study, we compared the functional outcomes of patients with right-sided SN matched 1:1 with patients with left-sided SN. Our results suggest patients with left- and right-sided SN experience similar beneficial effects of PAT on general functional independence and spatial attention. Clinicians should, therefore, consider PAT as an intervention for patients with right-sided SN.

Suppliers

a. Stoelting Co.
b. IBM Corp.

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