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ORIGINAL RESEARCH

Managing Post-Stroke Fatigue Using a Mobile Health Called iHealth After Intracerebral Hemorrhage

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Background: Post-stroke Fatigue (PSF) after Intracerebral Hemorrhage (ICH) is a long-term symptom in stroke survivors. However, the pathogenesis of PSF remains inadequately understood and sufficient evidence-based treatments are lacking. Mobile health (mHealth) technology offers a promising approach to expanding access to high-quality and culturally tailored evidence-based mental care.

Aim: This study examined the role of mHealth called iHealth in the management of PSF after ICH.

Methods: A total of 225 patients diagnosed with intracerebral hemorrhage (ICH) were included in the study and randomly assigned to either the Mobile Health Intervention Group (mHI Group) or the non-Mobile Health Intervention Group (non-mHI). The management involved the utilization of a digital healthcare application named iHealth, which incorporated digital questionnaires, fatigue scale tests, and online videos for the purpose of administering the Patient Fatigue Reporting Measurement Information System (PFRMIS) short form as part of the initial patient assessment following ICH. The study was conducted remotely via video conferencing over a 12-week period in mHI Group, with fatigue assessments being conducted 3 months post-ICH onset in two groups.

Results: Following the administration of PSF by iHealth, Univariate Logistic analyses indicated a significant association between fatigue and the type of activity, with patients who were sedentary or did nothing experiencing higher levels of fatigue (β=2.332, p<0.001; β=2.517, p<0.001). Multivariate Logistic analyses demonstrated a positive association between the intensity of physical activity and decreased emotional well-being and family support, as well as increased fatigue. (p=0.001, p=0.002, p=0.001). The FSS results demonstrated a significantly reduced incidence of PSF in the MHI group in comparison to non-mHI group following the conclusion of the programme. (13.1% vs 40%, p<0.001).

Conclusion: This study explored the effectiveness of the iHealth app for PSF following ICH, indicating that iHealth is a clinically valuable tool that warrants further dissemination.

Keywords: post-stroke fatigue, mobile health intervention, fatigue severity scale, intracerebral hemorrhage, iHealth

Introduction

In terms of illness, disability and early death, stroke is the second leading cause of death worldwide.[1] The prevalence of stroke is estimated to range from 25% to 85%, and Fatigue is a prevalent and enduring outcome of stroke.[2] Post-stroke fatigue (PSF) has a negative impact on daily functioning and social participation. Prior research on PSF has primarily concentrated on individuals with ischaemic stroke. Nonetheless, there is a scarcity of studies examining fatigue following ICH. It may also hinder rehabilitation progress and is linked to worse neurological recovery and increased morbidity and mortality.[3,4]

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Moreover, the cause of PSF is not well understood and evidence-based treatments are limited. Individual differences in PSF cannot be solely attributed to stroke-related characteristics, such as stroke type, location, or neurological deficits.[5] For example, the medical literature has documented that acute spontaneous lobar hemorrhage is characterized by a unique clinical profile and a more severe early prognosis when compared to subcortical deep intracerebral hemorrhage.[6] PSF is a complex phenomenon influenced by neurobiological, psychological, and social factors. Although the neurobiological mechanisms of PSF remain obscure,[7] several neurobiological mechanisms have been proposed to underline fatigue symptoms in neurological and other conditions.[8]

Many healthcare systems are focused on acute care, centred around specialists, located in urban areas, and fragmented.[9] As a result, they are often not equipped to handle chronic conditions. In poorly resourced regions, patients receive suboptimal care that falls short of evidence-based standards. Relying solely on the limited number of overwhelmed specialists to provide such services is unrealistic and unsustainable.[10] Therefore, an innovative strategy is required to overcome the health system's limitations in stroke and mental health care. The term mhealth refers to services provided using technology, including mobile phones, the Internet, computer programs, and interactive videos. A range of services are available via mhealth, including assessment, monitoring, prevention, intervention, supervision, education, consultation, and counseling.[11]

The management of individuals who have suffered a stroke has become a key area of focus, as it represents the only way to secure the benefits of acute treatment in the long term. Due to the differing approaches and sectors involved, post-stroke management appears challenging and is hindered by existing barriers between treatment sectors. In recent years, it has been demonstrated that digital interventions can also be an effective tool in the management of post-stroke patients.[12]

PSF has been found to predict great dependence in activities of daily living in previous prospective studies. An experimental 12-week program called Cognitive and Graded Activity Training was developed to treat PSF. The program consists of cognitive–behavioral therapy, education, urance, strengthening, and graded flexibility activity provided by physiotherapist and neuropsychologists[13.] Furthermore, research has shown that both clients with PSF and their caregivers can benefit from psychoeducation on stroke-related information and interventions, particularly in coping with stress and developing problem-solving skills.

Interventions available for PSF are minimal. Against this background, the PSF-Manager, called iHealth, was designed based on mHealth technology as a novel concept combining multiple digital and assistive-based innovations. The PostStroke-Manager combines digital with assessment, monitoring, prevention, intervention, supervision, education, consultation, counseling and personal assistance to enable intersectoral cooperation, the best possible reduction of stroke-related disability, optimal secondary prevention, and the idenitfication of physical and psychological comorbidities. The development phase of this software has now been completed, and the tool has been verified to function in a reliable manner.

The objective of this study was to examine the relationship between daily activities and PSF after ICH through iHealth and to propose a novel intervention for PSF through teleconference, a form of telehealth delivery, within the iHealth intervention function.

Materials and Methods

Ethics Approval and Informed Consent

A pilot study was conducted using a case-control research design to examine the effectiveness of a teleconference-based fatigue management course for patients with PSF. Ethics Committee at First Affiliated Hospital of Anhui University of Science and Technology approved the study procedures, according to the Declaration of Helsinki. (Approval No. 2019B20, 2019-1-1). Informed consent was obtained from the participants prior to their participation in the study.

Study Design

This is a single-centre observational study in which patients recovering from intracerebral haemorrhage and capable of using mobile digital technology will be equipped with a mobile phone with the iHealth app installed. Following a training phase under inpatient conditions and subsequent discharge from the hospital, patients will utilise the iHealth app for a three-month follow-up period. During this period, all participants were required to complete the questionnaire via the iHealth APP. However, only the patients in mHI Group received follow-up intervention treatment from specialists via video teleconferencing of iHealth (Figure 1).

Participants

We recruited participants from consecutively admitted patients with sICH to the First Affiliated Hospital of Anhui University of Science and Technology from November 2021 to June 2023.

Inclusion criteria included: (1) The diagnosis of ICH must be made within 24 hours of symptom onset. (2) The patient should be over 18 years of age.(3) Permission to consent in writing.

Exclusion criteria included: (1) secondary bleeding due to vascular anomalies, intracranial aneurysms, tumors, or hemorrhage transformation and abnormal coagulation; (2) organic mental illness; (3) Patients with anxiety or depression; (4) dementia; (5) severe dysarthria or aphasia; (6) seriously critically ill patients who die during the 3-month follow-up period; (7) no smartphone; (8) dividual reported a diagnosis of chronic fatigue syndrome. In total, 225 patients with ICH were enrolled in this study. (Figure 2).

Sample Size Calculation and Randomisation

The sample size was calculated a priori using G*Power 3.1.9.6 software[14] ($\alpha = 0.05$, $1\text{-}\beta = 0.95$, $f = 0.05$), with the minimum sample size determined to be 45 per group. To account for potential sample loss during follow-up, the minimum sample size was adjusted by 10% to 50 per group. This is a randomised study evaluating the intervention in iHealth APP in patients with PSF following ICH. Patients will be randomised into two groups (MHI group vs non-MHI group). The recruitment process employed convenience sampling and simple random allocation. The randomisation and group allocation of participants was conducted by a researcher who was not involved in the assessment or intervention procedures (BS). Randomisation was based on a single sequence of random allocation using a table of random numbers (https://www.randomizer.org/)[15.]

Measurements

A smartphone-based mHealth application called iHealth was developed by First Affiliated Hospital of Anhui University of Science and Technology for timed assessment of daily life. The application was designed to randomly prompt

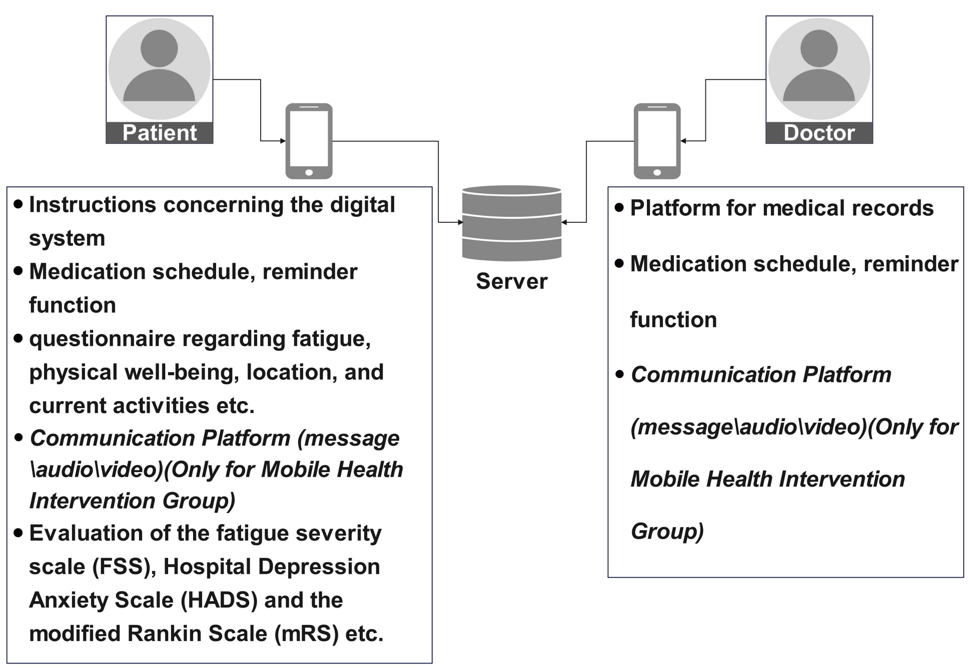

Figure 1 A flowchart of study process.

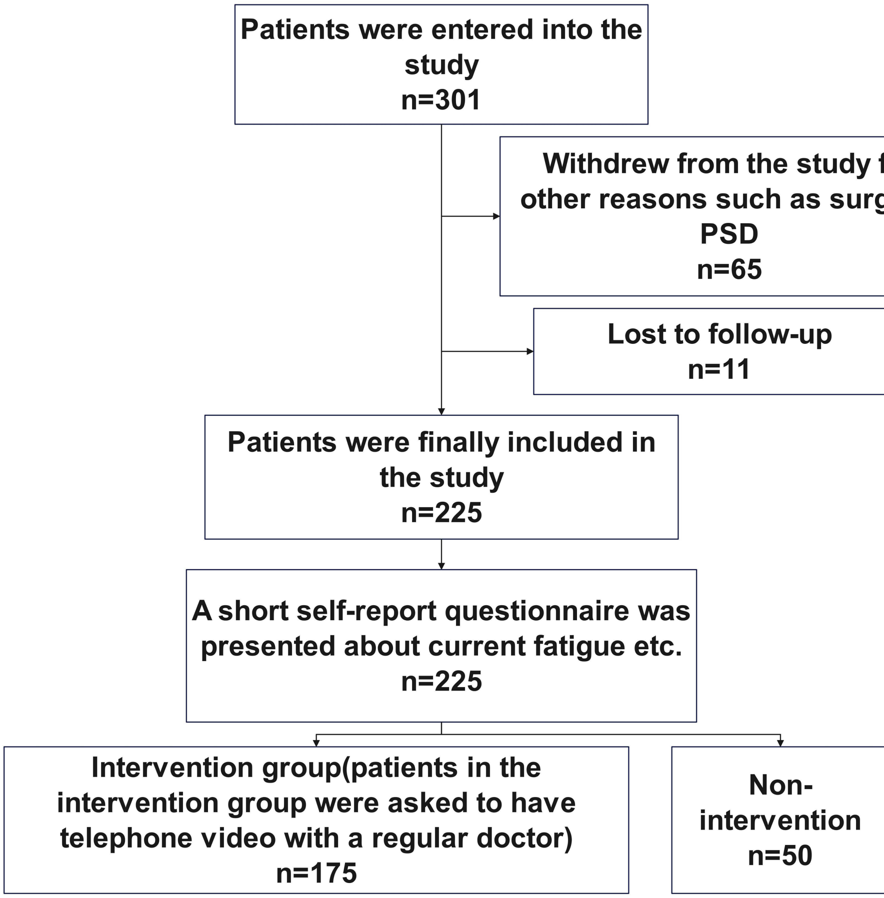

Figure 2 Study recruitment profile.

participants with 10 beeps each day between 8:00 and 22:00 on Monday, Wednesday and Saturday. A 90-minute interval was averaged between the beeps, with a minimum of 20 minutes and a maximum of 240 minutes between beeps. Every beep signal was followed by a self-report questionnaire (approximately 3 minutes) regarding fatigue, mood, physical well-being, location, and current activities. After each beep, participants had 30 minutes to complete the questionnaire before it was skipped.

The fatigue severity scale (FSS),[16] Hospital Depression Anxiety Scale (HADS),[17,18] and the modified Rankin Scale (mRS) score[19] were administered to describe general fatigue and depressive, anxiety symptoms and functional outcome, respectively, at 3 months after the stroke through telephone interview. A validated version of the HADS has been used to assess anxiety and depression symptoms in stroke patients A score of 8 or higher indicates clinical depression or anxiety, depending on the subscale. The depression and anxiety subscales range between 0–21.[17,18] Poor outcome was mRS >2, and good outcome was mRS≤2.

Assessment of PSF

The fatigue severity scale (FSS) consists of nine items rated on a seven-point scale. A higher score indicates greater fatigue. The responses were averaged to calculate overall fatigue scores. Having post-stroke fatigue (PSF) was defined as having an FSS score of 4 or higher.[16]

Intervention

Through the app, physicians distribute information to eligible patients in the intervention group for a 45-minute telephone video session. During this session, participants were instructed to use the app and practice the questionnaire. And, patients in the intervention group were asked to have telephone video sessions with a regular doctor three times per week, for 12 consecutive weeks to receive guidance on lifestyle, exercise, and emotional regulation.

Statistical Analysis

The Student's *t*-test was used to compare normally distributed continuous variables with Mann–Whitney *U*-tests for non-normally distributed variables. The chi-square test was used to compare categorical variables. Multiple Logistic analyses were used to examine the correlation of post-stroke fatigue with type of activity, perceived effort and pleasure, and level of physical activity. Comparing the incidence and severity of post-stroke fatigue between MHI Group and non- MHI Group. We used SPSS version 22.0 software to conduct statistical analyses. A p value of less than 0.05 was regarded as statistically significant.

Result

The study enrolled a total of 301 patients. Followed for 3 months, 65 withdrew from the study for other reasons such as surgery and PSD, and 11 patients were lost to follow-up. Patients included in the final analysis did not differ from those excluded in terms of baseline characteristics. In total, 225 patients were included in the study, 175 in the intervention group and 50 in the non-intervention group.

See details in Figure 2.

In terms of types of activities, the respondents most often indicated relaxation (24.6%) or doing nothing (12.8%), followed by "housework" (12.2%), resting (11.9%), work (6.2%), self-care (5.7%) or using transportation (3.7%). Approximately 22.5% of participants reported doing something else while completing the questionnaire. A moderate strenuous activity scored (3.01 ± 1.32) on a scale of 1 to 7, while a pleasant activity (5.03 ± 1.13; Range, 1 to 7). The mean score for self-rated physical activity (since the last tweet) was 2.91 ± 1.81 (Range, 1 to 7).

Table 1 displays the results of four regression models that examined the association between activity predictors and fatigue using data collected from the iHealth APP questionnaire. Activity type was found to be a significant predictor of fatigue when participants did nothing, followed by sedentary activity. (β=2.517, p<0.001; β= 2.332, p<0.001); A significant reduction in fatigue was observed in all other daily activities. In addition, family support, emotional well-being and physical activity all significantly reduced the degree of fatigue, with statistical significance.

Table 2 demonstrates that, after administering the iHealth APP questionnaire and adjusting for variables such as gender, age, education, and site of hemorrhage, the multiple regression model analysis revealed a significant and consistent association between enjoyable activities, family support, emotional well-being, physical activity (p=0.001, p=0.001, p=0.002, p=0.001), and the onset of PSF after ICH.

Table 3 illustrates the efficacy of the iHealth application in the management of PSF after ICH. After a three-month follow-up period, there were 23 (13.1%) and 20 (40%) instances of PSF in the iHealth app management intervention

Table 1 Fixed Parameter Overview of the 4 Final Models with Each Activity Feature as the Fatigue Predictor

Model	Predictor	SCC (ß)	SE	95% CI	P value
Type of activity	Doing nothing	2.517	0.299	2.114–3.315	<0.001
	Sedentary	2.332	0.257	1.986–3.243	<0.001
	Daily work	−0.436	0.153	−0.779–−0.143	0.004
	Domestic work	−0.336	0.121	−0.514–−0.074	0.007
	Relaxin	−0.405	0.113	−0.621–−0.172	<0.001
	Daily traffic	−0.380	0.134	−0.613–−0.101	0.014
	Enjoyable activities	−0.274	0.051	−0.323–−0.154	<0.001
	Other activities	−0.313	0.112	−0.595–−0.132	0.001
Family support	Intercept	3.882	0.318	3.122–4.271	<0.001
	Support	−0.261	0.064	−0.371–0.162	<0.001
Emotional Well-being	Intercept	2.872	0.291	1.987–3.282	<0.001
	Well-being	−0.278	0.037	0.091–0.243	<0.001
Physical activity	Intercept	2.631	0.213	2.112–3.213	<0.001
	Activity	0.078	0.027	0.022–0.142	0.013

Table 2 Multivariate Analysis of Various Models for PSF Following ICH

Model	OR	95% CI	P value
Enjoyable activities	0.029	0.009–0.063	<0.001
Family support	0.032	0.008–0.051	0.001
Emotional Well-being	0.031	0.011–0.079	0.002
Physical activity	1.702	1.067–3.132	0.001

Abbreviation: CI, confidence interval.

Table 3 Clinical and Demographic Characteristics of the Participants Between Non-mHI and mHI Groups

Variables	Non-mHI Group (n=50)	mHI Group (n=175)	*P*-value
Demographic characteristics			
Age (IQR)	57(52,73)	60(51,72.5)	0.663
Sex, male (%)	35 (70)	123 (70.3)	0.969
Education, median (IQR)	4(3, 5)	4(3, 5)	0.895
Married, n (%)	47(94)	159(90.9)	0.578
Vascular risk factors			
Smoking, n (%)	17(34.1)	57(32.6)	0.850
Drinking, n (%)	17(34)	62(35.4)	0.852
Hypertension, n (%)	32(64)	126(72)	0.275
Diabetes, n (%)	8(16)	24(13.7)	0.683
Atrial fibrillation, n (%)	2(4)	4(2.3)	0.617
Coronary heart disease, n (%)	5(10)	19(10.9)	0.863
Previous stroke, n (%)	16(32)	65(37.1)	0.504
Hematoma location, n (%)			
Frontal lobe, n (%)	2(4)	4(2.3)	0.617
Parietal lobe, n (%)	1(2)	9(5.1)	0.465
Temporal lobe, n (%)	2(4)	3(1.7)	0.308
Occipital lobe, n (%)	2(4)	11(6.29)	0.738
Basal ganglia, n (%)	26(52)	82(46.9)	0.521
Brainstem, n (%)	1(2)	8(4.6)	0.688
Cerebellum, n (%)	4(8)	19(10.86)	0.556
Concurrent ventricular hemorrhage, n (%)	8(16)	39(22.3)	0.335
Hematoma volume, mL, median (IQR)	12(10, 17)	13(10, 17)	0.407
Neuropsychological function at time of discharge, median (IQR)			
NIHSS score	11(7, 14)	11(8, 13)	0.932
mRS score	2(2, 4)	2(1, 4)	0.897
HAMA score	13(9.5, 19)	12(9,15)	0.093
HAMD score	5(3, 6)	5(3, 6)	0.924
Neuropsychological function at 3 month			
NIHSS score, median (IQR)	10(6, 15)	8(5.5, 12)	<0.001
FSS ≥4, n(%)	20 (40)	23 (13.1)	<0.001
mRS score	2(1, 4)	1(1, 2)	<0.001
HAMA score	12(10, 15)	6(5, 8)	<0.001
HAMD score	6(5, 8)	4(2, 6)	<0.001

Abbreviations: IQR, interquartile range; mHI, mobile Health Intervention; GCS, Glasgow Coma Scale; NIHSS, National Institute of Health Stroke Scale; HAMD, Hamilton Depression Scale; HAMA, Hamilton Anxiety Scale; mRS, modified Rankin Scale.

group and control group, respectively. Importantly, the iHealth app management intervention exhibited a notable decrease in the prevalence of PSF.

Discussion

Studies on the incidence of PSF following ICH have mostly focused on psychological factors, depression, and cognitive abilities, and fewer on indicators such as activities of daily living. Also, there is still a lack of clarity regarding the most effective management strategies.[20] We examined the relationship between daily activities and PSF in intracerebral hemorrhage (ICH) patients, as well as assessed and assisted PSF management using iHealth. This study represents a novel approach in the field as it is the first prospective investigation to employ an mHealth application in examining the correlation between daily activities and PSF after ICH, while also evaluating the app's potential as an intervention for PSF. Our study found when participants reported doing nothing, fatigue levels were highest, with PSF differing significantly between types of activity. It has been reported that excessive rest behavior may lead to long-term chronic fatigue and physical discomfort.[21] We might also understand our results based on the conclusion above.

Moreover, the research findings indicated that participants experienced increased levels of fatigue after ICH during activities that were both physically demanding and less enjoyable, as indicated by data collected through the iHealth administration questionnaire. Therefore, the recommendation is to minimize laborious and unpleasant activities in the administration of care to patients after ICH. The finding in this study supports the theoretical explanation of fatigue symptoms, which are a result of high perceived effort levels[22]. In addition, PSF increased significantly with physical activity, according to the results. This may indicate that inappropriate physical activity after ICH promotes the occurrence of PSF, which is detrimental to rehabilitation.

Furthermore, a significant discovery of this research indicates that individuals lacking familial support and exhibiting lower levels of emotional well-being are at an increased risk of experiencing PSF subsequent to ICH. It is suggested in this study that improving family care and support for survivors of ICH will reduce the incidence of PSF.

Finally, following the iHealth app management course intervention, a notable reduction in the prevalence of PSF was observed in the MHI group as compared to the non-intervention group. A recent cross-sectional survey was conducted among occupational and physiotherapists who provide care for stroke survivors across the continuum of care.[23] The findings of this survey indicate that a majority of clinicians frequently encounter post-stroke fatigue, which manifests with diverse symptoms. However, there is a lack of consensus among these clinicians regarding the optimal management strategies for this condition.[23] Our study findings suggest that the implementation of online intervention guidance through the iHealth app can effectively reduce the occurrence of PSF in patients with cerebral hemorrhage following discharge. This approach offers a practical and accessible method for managing post-stroke fatigue, potentially leading to cost savings and improved accessibility.

This study is subject to several limitations. Firstly, the sample size was relatively small. Secondly, the evaluation of PSF was conducted using various scales, resulting in differing emphases. Specifically, the FSS scale was chosen, primarily reflecting physical fatigue, while cognitive and emotional factors contributing to psychological fatigue in patients with fatigue were less assessed. In our future research, the study will increase the sample size and utilize an online questionnaire through the APP to investigate the correlation between various age groups, bleeding sites, bleeding volume, and PSF. Additionally, the follow-up and management intervention time will be prolonged via the APP to enhance the scale's comprehensiveness. This approach will facilitate more precise prediction of the diverse risk factors for PSF following ICH, as well as the risk factors for various complications and mortality post-cerebral hemorrhage. Moreover, the capabilities of the application will be improved to support individualized management and decrease the occurrence of disability and mortality linked to cerebral hemorrhage. This stratification could aid in determining which patients are most likely to benefit from a combination of digital and personalized assistance.

Conclusion

This study identified a significant association between strenuous physical activity, unpleasant activities, lack of family support, and unhealthy emotions with the occurrence of PSF following ICH, as determined through the utilization of an online questionnaire administered via the iHealth app. Furthermore, the implementation of the iHealth app online management intervention was found to significantly decrease the prevalence of PSF.

Informed Consent Statement

A written informed consent was obtained from all participants.

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Disclosure

The authors report no conflicts of interest in this work.

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