Expressive Writing and Wound Healing in Older Adults: A Randomized Controlled Trial

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Objective: To investigate whether expressive writing could speed wound reepithelialization in healthy, older adults. **Methods:** In this randomized controlled trial, 49 healthy older adults aged 64 to 97 years were assigned to write for 20 minutes a day either about upsetting life events (Expressive Writing) or about daily activities (Time Management) for 3 consecutive days. Two weeks postwriting, 4-mm punch biopsy wounds were created on the inner, upper arm. Wounds were photographed routinely for 21 days to monitor wound reepithelialization. Perceived stress, depressive symptoms, health-related behaviors, number of doctor visits, and lipopolysaccharide-stimulated proinflammatory cytokine production were also measured throughout the study. **Results:** Participants in the Expressive Writing group had a greater proportion of fully reepithelialized wounds at Day 11 postbiopsy compared with the Time Management group, with 76.2% versus 42.1% healed, $\chi^2(1, n = 40) = 4.83$, $p = .028$. Ordinal logistic regression showed more sleep in the week before wounding also predicted faster healing wounds. There were no significant group differences in changes to perceived stress, depressive symptoms, health-related behaviors, lipopolysaccharide-induced proinflammatory cytokine production, or number of doctor visits over the study period. **Conclusions:** This study extends previous research by showing that expressive writing can improve wound healing in older adults and women. Future research is needed to better understand the underlying cognitive, psychosocial, and biological mechanisms contributing to improved wound healing from these simple, yet effective, writing exercises. **Trial Registration:** Australian New Zealand Clinical Trials Registry (trial number 343095)
Key words: older adults, wound healing, reepithelialization, expressive writing, randomized controlled trial.

IL-1β = interleukin-1β; **IL-6** = interleukin-6; **LPS** = lipopolysaccharide; **TNF-α** = tumor necrosis factor-α; **EDTA**= ethylenediaminetetraacetic acid.

INTRODUCTION

Stress and depression are related to slower wound healing (1–4), potentially through decreased proinflammatory cytokines in the wound bed, key mediators in infection protection, and wound repair (2,5,6). This decrease may arise from the immunosuppressive effects of glucocorticoids and catecholamines, hormones systemically released during stressful situations (7,8). Interventions designed to reduce psychological stress, including physical exercise and relaxation, improve dermal wound healing (9–12); however, the setting and population groups examined have been limited, and more randomized controlled trials are needed (13). Such interventions may be of particular clinical relevance to older adults because they are at higher risk for slower wound healing due to a natural decline of immune function and age-related changes in collagen deposition, angiogenesis, and reepithelialization (14). Indeed, compared with younger adults, older adults took 1.9 days longer to achieve complete epithelial coverage of 2 × 2-cm^2 superficial split-thickness wounds, a delay worth clinical consideration (15).

At present, only one randomized controlled trial has explored using a stress-reducing intervention (physical exercise) to improve wound healing in older adults (9). Compared with the control group, the exercise group had significantly faster healing punch biopsy wounds. However, exercise interventions often require a considerable time commitment and a certain level of physical ability, which may not be feasible for some older adults. Exercise may also prove difficult for individuals with wounds, highlighting the need to explore alternative interventions.

One feasible alternative is expressive writing, which is brief, easy to administer, and low cost. Expressive writing interventions typically involve three 20-minute writing sessions. Participants write about their most traumatic or upsetting experiences (16). The intervention can be performed at home, making it well suited to populations who may be physically limited or have transportation constraints. The benefits derived from expressive writing interventions are robust, with demonstrated effects on psychological health, physical health, and immune parameters (17). Indeed, compared with writing descriptively on neutral topics, individuals who wrote about upsetting events exhibited greater lymphocyte proliferation after mitogen stimulation (18), higher antibody levels against hepatitis B vaccinations (19), and lower HIV-viral loads and increased CD4$^+$ lymphocyte counts in HIV-infected patients (20), all indicative of improved immune functioning. Recently, expressive writing has been shown to accelerate the healing of punch biopsy wounds in young healthy men (12) However, no research has investigated the effects of expressive writing on wound healing in women or people older than 40 years.

The primary aim of the present study was to evaluate whether expressive writing could improve the speed of wound healing in healthy, older adults. We predicted that, compared with participants who wrote descriptively about daily activities (Time Management), participants who wrote expressively about upsetting life events (Expressive Writing) would have a greater proportion of healed wounds. Secondary aims investigated whether expressive writing could improve immune function, reduce stress and depressive symptoms, and reduce frequency of doctor visits. We predicted that expressive writing participants would have higher

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lipopolysaccharide (LPS)-stimulated proinflammatory cytokine production, would experience greater reductions in perceived stress and depressive symptoms over the study period, and make fewer doctor visits in the 3 months after the intervention.

METHODS

Participants

Participants were volunteers recruited through flyers and/or presentations at retirement villages and apartment complexes in Auckland, New Zealand, and through e-mails at The University of Auckland. Inclusion criteria included being 60 years or older and able to communicate and hand-write (or type) in English. Participants were excluded if they smoked, had a significant skin disease (e.g., eczema, psoriasis, and keloid scarring), were allergic to lignocaine (local anesthetic), or were currently clinically depressed. For individuals recruited from retirement villages, only those who were living independently and could give informed consent were included.

Procedure

Ethics approval was obtained from The University of Auckland Human Participants Ethics Committee. All participants gave written informed consent. This study was registered at the Australian New Zealand Clinical Trials Registry (trial number 343095; http://www.ANZCTR.org.au/Trial/Registration/TrialReview.aspx?id=343095). Data collection commenced in February 2011 and concluded in February 2012.

Recruitment and Screening

Individuals who responded to the advertisement were screened via a brief telephone interview, and those meeting the inclusion criteria were invited to participate. An individual meeting was arranged, and the Baseline Questionnaire (Time 1) was completed.

Randomization and Blinding

Within the following week, participants were randomly assigned following simple randomization procedures (computerized random numbers generated by E.B., not involved in recruitment) to either the Expressive Writing or Time Management group. The randomized group allocation sequence was given to the research assistant (M.D.). From this sequence, the research assistant delivered the appropriate writing instructions to each participant. The writing instructions were delivered orally to minimize the possibility of misunderstanding, similar to previous expressive writing studies with older adults (21,22). A written copy of the instructions was also provided, so the participant could read the instructions before beginning their writing task. The research assistant telephoned each participant the day after they were scheduled to commence the writing intervention, to answer any questions the participant may have had, and to remind the participant to begin the intervention if they had not already started. The research assistant was not involved in any other aspects of the study to ensure that data collection was blinded.

Writing Intervention

Writing instructions were based on those outlined in previous writing studies (22,23). Participants in the Expressive Writing group (intervention group) were asked to write about the most traumatic/upsetting experience in their life, delving into their deepest thoughts, feelings, and emotions about the event, ideally not previously shared with others. Participants in the Time Management group (control group) were asked to write about their daily activities for tomorrow, without mentioning emotions, opinions, or beliefs. For 3 consecutive days, participants were asked to write in a quiet location at home, continuously for 20 minutes a day, without concern for spelling or grammar. After each writing session, participants completed the Post-Writing Questionnaire.

A departure from the usual protocol in writing studies was that participants were left with their essays until the day before the wounding procedure (approximately 2 weeks), which meant that their essays were accessible to them. No instructions were given to read or not read. When the essays were collected, they were sealed in envelopes to emphasize confidentiality, and participants were asked whether they had read their essays to see whether essay reading naturally occurred. Participants also completed the Post-Intervention Questionnaire (Time 2), and were remunerated with NZ$10 in gift vouchers.

Wounding Procedure and Wound Management

Two weeks after the first writing session, each participant received a standard 4-mm skin biopsy approximately 75 mm proximal to the medial epicondyle of the humerus (inner, upper aspect) of their nondominant arm, under local anesthetic from the study doctor (N.K.). The biopsied tissue was collected for immunohistochemistry (immunohistochemistry results will be reported elsewhere). An EOS 1000D Canon camera (Canon Ltd., Tokyo, Japan) with a Canon Ultrasonic EF 100-mm f/2.8 Macro USM lens was used to photograph the wound. Adjacent to the wound, a standard-sized adhesive dot (1/4-in. diameter; Avery Dennison, Brea, CA) was placed for calibration purposes. After photography, the dot was removed, and the wound was sealed with DuoDERM Extra Thin hydrocolloid dressing (ConvaTec, Skillman, NJ) and a water-proof plaster (Cutifilm Plus; Smith&Nephew, London, UK).

The wounds of the first five participants ($n = 3$ for Time Management; $n = 2$ for Expressive Writing) were only covered with a water-proof plaster for the first 7 days, after which the wounds were left uncovered. However, when left uncovered, eschars formed over the wounds, obscuring visualization of reepithelialization. Consequently, these first five participants could not be included in the wound healing analyses but were included in all other analyses.

For the remaining participants, we used hydrocolloid dressings, in addition to the water-proof plasters. Hydrocolloid dressings have previously been used in wound healing studies (1). These dressings provided a moist wound healing environment, which not only encouraged more rapid epithelialization compared with dry (i.e., uncovered) wounds but also prevented eschar formation (24,25), thereby allowing more accurate assessments of wound reepithelialization. Beginning 1 week after biopsy, wounds were photographed every 3 to 5 days (depending on participant availability) until full reepithelialization was achieved. These time points were chosen based on previous wound healing studies (1,9) and provided a balance between obtaining sufficient data to monitor wound healing and being considerate of participant time involvement. Thus, on Days 7, 11 (±1 day), 14, 17 (±1 day), and 21 after the punch biopsy, the wound area was gently cleaned with sterile saline and gauze, photographed, and redressed with DuoDermExtra Thin and a water-proof plaster.

Follow-Up

Eight weeks after the first writing session (Time 3), an End of Study Questionnaire was administered to assess whether any longer-term psychological and health-related behavioral changes occurred after the writing intervention. Participants were also remunerated with NZ$40 in gift vouchers at that time.

Three months after biopsy (Time 4), participants were asked how many times they had visited their doctor within the past 3 months, as previous studies have reported a reduction in physician visits after expressive writing interventions (26,27).

Wound Healing Assessment

The primary outcome for the trial was time to achieve full wound reepithelialization. The digital wound photographs were deidentified (i.e., participant study ID and time-point information removed from the photographs) and ordered in a randomized fashion by a computerized random number generator, to ensure that the dermatologist (P.J.) remained blinded to group allocation and time duration since wounding. The dermatologist rated each wound as "healed" or "not healed," with healed being defined as complete reepithelialization of the wound surface. The complete set of photographs was assessed in a standardized fashion in the same setting twice sequentially, to ensure consistency. A random selection of photographs was then reassessed to determine intrarater reliability. The Cohen k coefficient was 0.97 (28), indicating almost perfect agreement between the two assessments (29).

Ex vivo Stimulation of Whole Blood and Cytokine Detection

Secondary outcomes included LPS-induced proinflammatory cytokine production, to investigate whether expressive writing yielded changes in immune function. Two blood samples were collected: baseline and immediately before the wound

procedure. Whole blood (4 ml) was collected in EDTA–coated tubes (Becton Dickinson). Within 4 hours of collection, 0.5 ml of blood was incubated with 5 μl of 100 μg/ml of *Escherichia coli* LPS (L6529; Sigma-Aldrich) for 24 hours at 37°C under 5% CO_2. After incubation, the blood was centrifuged at 1500 g for 10 minutes at ambient temperature. Plasma was aspirated and stored at −80°C until cytokine measurements. Concentrations of tumor necrosis factor α (TNF-α), interleukin (IL)-1β, and IL-6 were measured using Milliplex MAP Kits (Millipore Corporation, Billerica, MA), as per manufacturer's instructions, using a Luminex 100 instrument (Luminex Corporation, Austin, TX). Plasma samples were assayed undiluted; however, if undiluted concentrations were above detection limits, samples were diluted 1:2 with assay buffer supplied with the kit and reassayed. Each sample was assayed in duplicate. Intra-assay and interassay coefficients of variation were 6.1% and 7.0% for IL-1β, 8.1 and 11.6% for IL-6, and 10.5% and 15.9% for TNF-α.

Measures

The following measures were included in the Baseline Questionnaire (Time 1) only:

- Demographic and Medical History Questionnaire: age, sex, ethnicity, current medical conditions, medications, and the number of times they visited their doctor within the past 3 months
- Perceived Social Support. A 3-item scale, adapted from Zimet and colleagues (30), with scores ranging from 5 to 15; higher scores indicated greater perceived support. The mean interitem correlation was 0.58, suggesting a strong relationship between the items (31).
- Life Orientation Test–Revised (32). A 10-item scale that assessed dispositional optimism, with scores ranging from 0 to 24 (because only 6 of the 10 items were used to derive the score); higher scores indicated greater optimism. The mean interitem correlation was 0.27, falling within the optimal range for internal consistency (31).

The following measures were included in the Baseline Questionnaire (Time 1), the Post-Intervention Questionnaire (Time 2; 2 weeks postwriting), and the End of Study Questionnaire (Time 3; 8 week postwriting):

- Health-Related Behavior Questionnaire. An adapted 5-item scale (33) that assessed alcohol consumption, diet, exercise, and sleep in the previous week. Higher scores indicated greater alcohol and food consumption, greater physical activity, and more nights sleeping at least 7 hours.
- Perceived Stress Scale (34,35). A 10-item scale that assessed perceived stress in the previous week, with scores ranging from 0 to 40; higher scores indicated greater perceived stress. Cronbach α (averaged over the three time points) for this study was .79.
- Geriatric Depression Scale (36,37). A 15-item scale that assessed mood over the previous week, with scores ranging from 0 to 15; higher scores indicated a greater number of depressive symptoms. The Cronbach α (averaged over the three time points) for this study was .76.

The following questionnaire was administered after the completion of each essay:

- Post-Writing Questionnaire (38). A 6-item scale that assessed the effectiveness of the study manipulations (i.e., writing instructions were followed).

For the 3-month follow-up interview conducted over the telephone, the only measure included was a question asking how many times the participant visited their doctor in the past 3 months.

Content Analysis of Writing

Handwritten essays were electronically transcribed to permit text analysis using the Linguistic Inquiry and Word Count (2007), a computer program that automatically categorizes digitized text into multiple psychologically relevant categories (39). Five categories were analyzed because these categories have previously been used to support the validity of experimental manipulation (23,40): negative words (e.g., hurt and ugly), positive words (e.g., love and sweet), cognitive words (e.g., know and ought), insight words (e.g., think and consider), and total pronouns (e.g., I and them).

Analysis

Data were analyzed according to intention-to-treat principles. All variables were examined for normality. Participant demographics, baseline health-related behaviors, psychological factors, and essay rereading characteristics were compared between the two groups using independent *t* tests and Mann-Whitney *U* tests for continuous variables and Pearson χ^2 analyses for categorical variables. Repeated-measures analyses of variance and Friedman analyses of variance were used to evaluate changes in word usage over the 3 writing sessions. To examine the validity of the experimental manipulation, essay ratings and linguistic indicators between the groups were compared using independent *t* tests or Mann-Whitney *U* tests, when appropriate.

To assess the primary outcome, χ^2 tests were performed to compare the association between group allocation and wound healing at each time point (Days 7, 11, 14, 17, and 21). An ordinal logistic regression was also performed to investigate which factors influenced the speed of wound healing. First, a "healing score" was created for each participant. The healing score was a summation of the number of time points (Days 0, 7, 11, 14, 17, and 21) the wound was healed. Scores ranged from 0 (not healed on Day 21) to 5 (healed on Days 7, 11, 14, 17, and 21). For example, a participant with a healed wound on Day 7 received a score of 5, whereas a participant with a healed wound on Day 17 received a score of 2. Higher scores indicated faster healing. (Note: once the wound had healed, it remained healed [i.e., did not reopen]; thus, a wound coded as "healed" retained this coding for each subsequent time point.) Next, relevant predictors of healing, including group allocation, age, sex, sleep, perceived stress, depressive symptoms, optimism, and social support, were included in the model. Predictors that were not significant were removed one by one, leaving the final model with group allocation and sleep. Two interactions (group allocation × depressive symptoms; group allocation × optimism) were also included in the model, separately.

To assess secondary outcomes, analyses of covariance were performed to compare changes between baseline and postwriting LPS-induced proinflammatory cytokine production, psychological factors, health-related behaviors, and doctor visits between the two groups. Corresponding baseline concentrations/scores were entered as covariates (41). Bivariate correlations were carried out to investigate the associations between LPS-induced proinflammatory cytokine production, psychological factors, and health-related behaviors.

For all analyses, a two-tailed α level of <.05 was used. Statistical analyses were performed using PASW Statistics 18, Release 18.0.0 (SPSS, Inc., Chicago, IL; www.spss.com) and SAS 9.3 (SAS Institute Inc., Cary, NC; www.sas.com); figures were produced using Prism 5 for Windows (GraphPad Software, Inc., San Diego, CA; www.graphpad.com).

RESULTS

Participant Attrition and Baseline Characteristics

Of the 73 individuals who responded to the study advertisements, 10 individuals did not meet the inclusion criteria and 10 withdrew from the study before completing the Baseline Questionnaire. Four participants withdrew after baseline measurements, due to illness or caregiving responsibilities, resulting in 49 participants who completed the writing intervention and received the punch biopsy. Of these participants, 33 were from retirement villages, 12 were from the Auckland community, and 4 were from The University of Auckland. The two writing groups did not differ in the number of participants recruited from each source. One retirement village participant withdrew because of illness after achieving full wound reepithelialization, resulting in 48 participants who completed all measures (Fig. 1).

Participant ages ranged between 64 and 97 years (mean [standard deviation] = 78.8 [7.2] years), with the majority being women (57.1%). All participants identified as being of European descent, with one participant also identifying as Cook Island descent. There were 23 participants allocated to the Time Management group and 26 participants in the Expressive Writing

group. Groups did not differ at baseline on any of the demographic and health-related measures, perceived stress, depressive symptoms, perceived social support, or optimism (Tables 1 and 2).

Essay Rereading

There were no group differences in whether the essays were reread or not reread (Essay 1: $\chi^2(1, n = 48) = 1.28, p = .26$; Essay 2: $\chi^2(1, n = 47) = 2.03, p = .15$; Essay 3: $\chi^2(1, n = 47) = 0.01, p = .92$). On average, 61% of Time Management participants and 64% of Expressive Writing participants reread each essay at least once.

Manipulation Checks

Experimental manipulations, as assessed by the Post-Writing Questionnaires and Linguistic Inquiry and Word Count analysis, were successful. Table 3 shows that compared with Time Management, Expressive Writing participants rated their essays as more personal and more emotional. They were more likely to have told others about what they wrote and wanted to share what they wrote with others. Expressive Writing participants also used a greater proportion of negative, positive, cognitive, and insightful words and total pronouns. Results were averaged over the three writing sessions because there were no significant changes in word usage over the course of the three writing sessions in either group ($p > .05$).

Primary Outcome

Wound reepithelialization

There was a significant association between group allocation and wound healing at Day 11 post–punch biopsy ($\chi^2(1, n = 40) = 4.83, p = .028$), with participants in the Expressive Writing group having a greater proportion of fully reepithelialized wounds (76.2% healed) compared with the Time Management group (42.1% healed; Fig. 2). This yielded a medium effect size (Cramer V) of 0.35 and an observed power of approximately 0.6, using a significance level of $\alpha = .05$ and 1 df ($u = 1$) (42). Based on

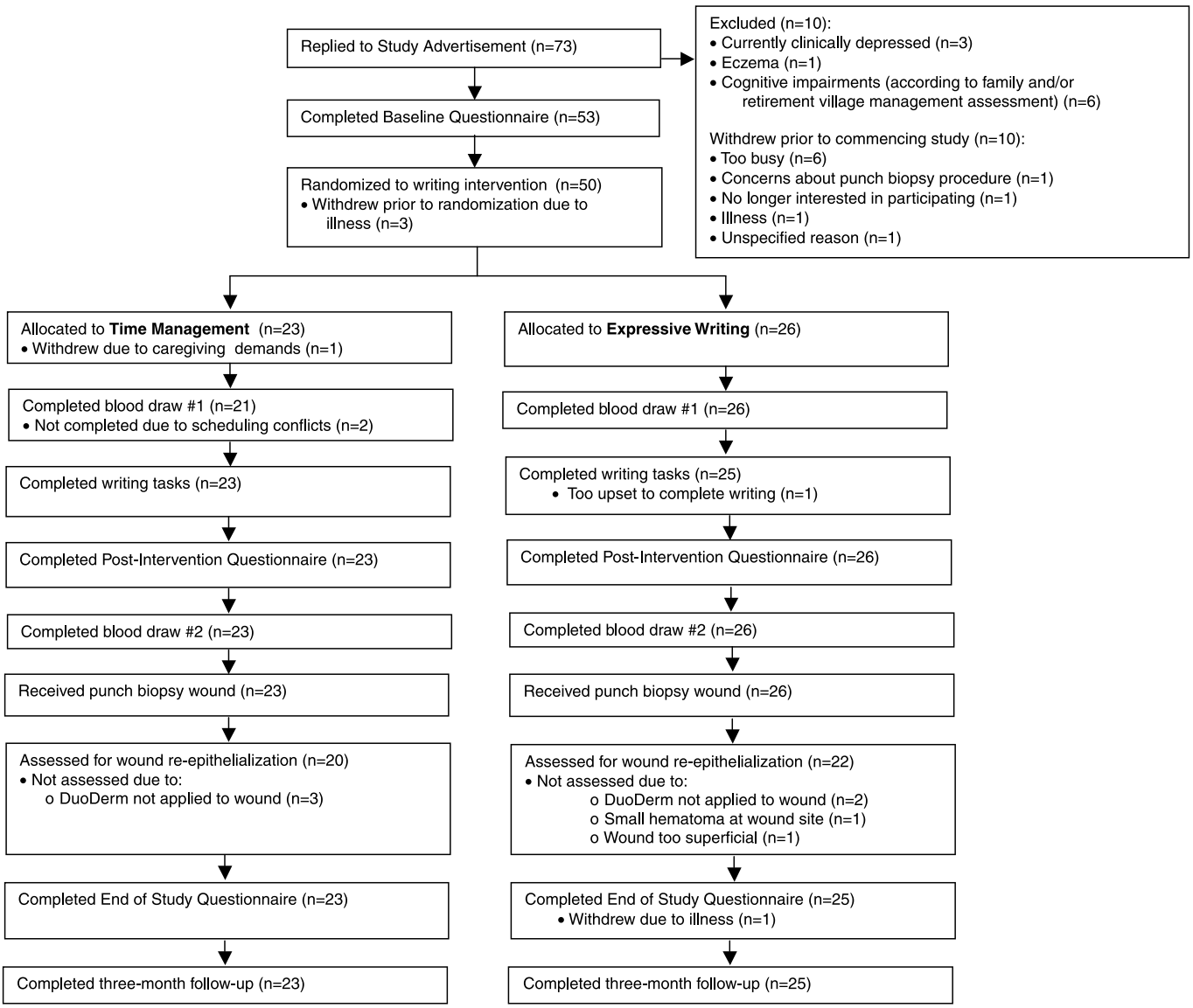

Figure 1. Participant flow diagram.

TABLE 1. Demographics and Baseline Medical Characteristics

	Time Management (n = 23)	Expressive Writing (n = 26)	p Value for t Test/χ^2 Group Difference
Age, M (SD), y	78.7 (7.7)	78.9 (6.8)	.90
Sex			
Women, n (%)	12 (52.2)	16 (61.5)	.51
Men, n (%)	11 (47.8)	10 (38.5)	
Body Mass Index, M (SD), kg/m^2	26.2 (4.8)	26.1 (4.2)	.92
Taking corticosteroids (i.e., prednisone), n (%)	3 (13.0)	3 (11.5)	.63
Taking NSAIDs (i.e., aspirin), n (%)	9 (40.9)	8 (34.8)	.67

M = mean; SD = standard deviation; NSAIDs = nonsteroidal anti-inflammatory drug.

the odds ratio, the odds of a participant with a healed wound on Day 11 were 4.4 times higher if they were in the Expressive Writing group than in the Time Management group. This association was only present at Day 11. There were no group differences in the timing of the Day 11 (±1 day) wound assessments ($\chi^2(2, n = 41) = 2.04$, $p = .36$). On Day 7, 27% of Expressive Writing participants and 10% of Time Management participants had achieved full reepithelialization ($\chi^2(1, n = 42) = 2.03$, $p = .16$). By Day 14, approximately 90% of participants in each group achieved full wound reepithelialization ($\chi^2(1, n = 42) = .01$, $p = .92$). By Day 21, wounds in both groups were fully reepithelialized.

An ordinal logistic regression was performed to determine factors associated with faster healing wounds. As shown in Table 4, two variables were significantly associated with wound reepithelialization: group allocation and sleep (2 weeks postwriting). These predictors indicated that the odds of a participant having a faster healing wound were greater if they were allocated to the Expressive Writing group (odds ratio of 3.66) and slept at least 7 hours on most nights during the week preceding the punch biopsy (odds ratio of 2.15) than the odds if they were allocated to the Time Management group and slept less than 7 hours on most nights. No significant interactions between group allocation × depressive symptoms ($p = .16$) and group allocation × optimism ($p = .89$) were observed.

Secondary Outcomes

Effects of Writing on LPS-Induced Proinflammatory Cytokine Production

After adjusting for baseline cytokine concentrations, there was no main effect of group on changes in LPS-induced proinflammatory cytokine production between baseline and the 2-week postwriting time point (Table 5).

We investigated the association between LPS-induced proinflammatory cytokine production, psychological factors,

TABLE 2. ANCOVAs Investigating Change Scores Between Time Management and Expressive Writing Groups on Psychological Factors and Doctor Visits, After Controlling for Baseline Values

	Time Management (n = 23)	Expressive Writing (n = 26)	F Test for Group × Change Since Baseline			
			F	df	p	η_p^2
Psychological factor						
Perceived stress						
Baseline (T1)	10.4 (5.3)	10.6 (6.8)				
2 wk postwriting (T2)	10.4 (6.4)	10.2 (4.9)				
8 wk postwriting (T3)	8.4 (5.4)	9.9 (3.8)				
Change score (T2-T1), adjusted M (SD)	−0.06 (1.0)	−0.32 (0.9)	−0.04	1,46	.85	0.001
Change score (T3-T1), adjusted M (SD)	−2.1 (0.9)	−0.7 (0.8)	1.37	1,45	.25	0.03
Depressive symptoms[a]						
Baseline (T1)	1 (0–11)	2 (0–7)				
2 wk postwriting (T2)	2 (0–8)	1.5 (0–10)				
8 wk postwriting (T3)	1 (0–6)	1 (0–13)				
Change score (T2-T1), adjusted M (SD)	0.4 (0.3)	−0.05 (0.3)	1.37	1,46	.25	0.03
Change score (T3-T1), adjusted M (SD)	−0.1 (0.4)	−0.02 (0.3)	0.06	1,45	.80	0.001
Doctor visits[a]						
Baseline (T1)	1 (0–3)	1 (0–3)				
3 mo postwriting (T4)	1 (0–7)	1 (0–10)				
Change score (T1-T4), adjusted M (SD)	0.07 (0.3)	0.3 (0.3)	0.53	1,45	.47	0.01

ANCOVAs = analyses of covariance; M = mean; SD = standard deviation.
[a] Nonparametric—results displayed as median (minimum-maximum).

TABLE 3. Essay Ratings and Percentages of Words Used by Time Management and Expressive Writing Groups

Outcome Measure	Time Management	Expressive Writing	*p* Value for *t* Test/Mann-Whitney *U* Test of Group Difference
Essay ratings[a]	*n* = 22	*n* = 25	
How personal was the writing?	4.0 (2.0–5.0)	4.7 (1.7–5.0)	.034
Told others about what was written?	1.2 (1.0–3.3)	2.3 (1.0–4.3)	.012
Revealed emotions in writing?	2.0 (1.0–4.0)	4.0 (1.3–5.0)	<.001
Wanted to tell others about what was written?	1.0 (1.0–3.5)	2.3 (1.0–4.3)	.032
Actively held back from telling others about what was written?	2.2 (1.0–5.0)	3.0 (1.0–5.0)	.19
LIWC category	*n* = 23	*n* = 25	
Negative words[a]	0.39% (0%–1.82%)	2.40% (0.85%–7.01%)	<.001
Positive words	2.08% (1.05%)	2.78% (0.83%)	.014
Cognitive words	13.95% (1.74%)	17.48% (2.79%)	<.001
Insightful words[a]	1.02% (0%–2.25%)	2.63% (0.77%–4.67%)	<.001
Total pronouns	10.91% (3.40%)	15.10% (3.28%)	<.001

LIWC = Linguistic Inquiry and Word Count.
[a] Non-parametric—results displayed as median (minimum-maximum).

and health-related behaviors assessed at 2 weeks postwriting because this time point corresponded to the time immediately before the wounding procedure. Lower LPS-induced IL-6 production was associated with participants who slept less than 7 hours on most nights in the preceding week ($\rho = 0.34$, $p = .023$), experienced higher levels of perceived stress in the preceding week ($\rho = -0.39$, $p = .008$), and reported more depressive symptoms ($\rho = -0.33$, $p = .028$). Lower LPS-induced IL-1β production was associated with more depressive symptoms ($\rho = -0.35$, $p = .015$). LPS-induced TNF-α production was not associated with psychological factors or health-related behaviors. No association between age and body mass index on LPS-induced proinflammatory cytokine production was observed.

Effects of Writing on Psychological Factors

After adjusting for baseline perceived stress and geriatric depression scores, respectively, there were no main effects of group on changes in perceived stress or depressive symptoms between baseline and follow-up time points (2 and 8 weeks postwriting). Throughout the study, both groups reported low levels of perceived stress and depressive symptoms within the "normal" range (scores <5; Table 2).

Effects of Writing on Health-Related Behaviors and Frequency of Doctor Visits

After adjusting for baseline health-related behaviors, there were no main effects of group on changes in sleep, exercise, alcohol intake, or food consumption between baseline and follow-up time points (2 and 8 weeks postwriting; $p > .05$). Similarly, after adjusting for the number of doctor visits in the 3 months preceding the study, there were no main effects of group on the change in doctor visits between the 3 months preceding the study and the 3 months after the writing intervention (Table 2). Participants in both groups visited their doctors once (median) during a 3-month period.

DISCUSSION

This study investigated the effects of an expressive writing intervention on the speed of wound reepithelialization in older adults. Compared with participants who wrote about daily activities, a greater proportion of participants in the Expressive Writing group had fully reepithelialized wounds by Day 11. Faster wound reepithelialization was also associated with sleep in the week preceding the punch biopsy. Sleep, perceived stress, and depressive

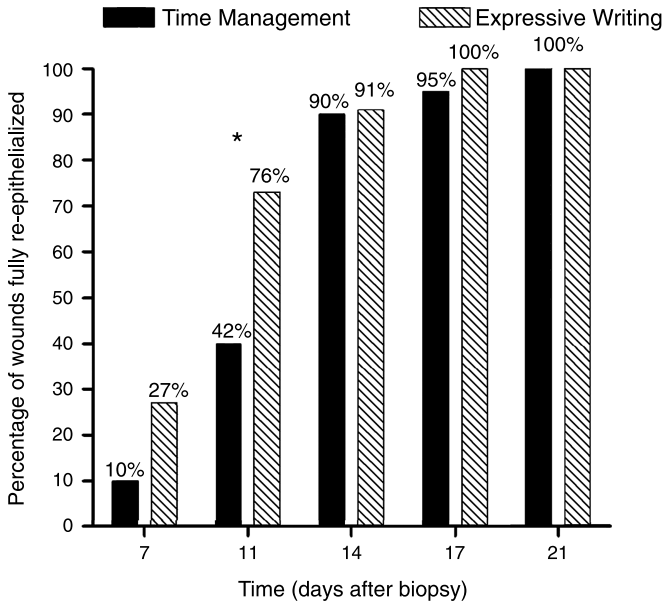

Figure 2. Comparing the percentage (%) of participants with fully reepithelialized wounds in Time Management ($n = 20$) and Expressive writing ($n = 22$) groups at each time point. *$p = .028$.

TABLE 4. Ordinal Logistic Regression Investigating Factors Associated With Faster Wound Reepithelialization

	Estimate	SE	Wald χ^2	*df*	*p*	Odds Ratio (Point Estimate)	95% Wald Confidence Limits	
							Lower	Upper
Group allocation	1.30	0.62	4.43	1	.035	3.66	1.09	12.23
Sleep (2 wk postwriting)	0.76	0.25	9.27	1	.002	2.15	1.31	3.51

SE = standard error.

symptoms were associated with LPS-induced proinflammatory cytokine production. However, changes in LPS-induced proinflammatory cytokine production from baseline to 2 weeks postwriting did not differ between groups. Moreover, groups did not differ with respect to changes in perceived stress, depressive symptoms, health-related behaviors, or the number of doctor visits.

The main result—that expressive writing can accelerate wound healing—extends previous research (12) to older adults and to women. However, the biological and psychological mechanisms behind this effect remain unclear. Consistent with Weinman and colleagues (12), the writing intervention did not lead to any group differences in perceived stress levels, depressive symptoms, or health-related behaviors. It is possible that the self-report measures used were not sufficiently sensitive to detect subtle changes in psychological and health-related factors. More likely, however, is that because participants in both groups were not depressed and reported low levels of perceived stress, there was little room for improvement in these variables.

One theory for the efficacy of expressive writing suggests that it facilitates cognitive processing of traumatic events. By constructing a narrative of the trauma through writing, an individual may gain better insight into the event, derive meaning, and integrate the event more coherently into a self-schema (17), thereby reducing psychological distress. An increase in causal and insightful words over the writing sessions has been associated with improved physical health, presumably because of the effects of such cognitive processing (16,43,44). Although there was no association between the use of cognitive words and wound healing in our study, greater use by expressive writing participants of cognitive processing and insightful words, as well as affective words, suggests that different cognitive and emotional processes were taking place between the groups, which may have affected healing.

Sleep was significantly associated with faster wound healing. Although our study showed no group differences in self-reported sleep because of the intervention, the measure of sleep was not precise. Previous studies have shown that expressive writing improves sleep (45–47), although writing about time management can also improve sleep in older adults (40). Writing may reduce the frequency of intrusive or ruminating thoughts, which may lower anxiety and autonomic arousal (47,48), and therefore reduce the release of stress hormones. Because stress hormones have inhibitory effects on sleep (49), sleep may subsequently

TABLE 5. ANCOVAs Investigating Change Scores Between Time Management and Expressive Writing Groups on LPS-Induced Proinflammatory Cytokine Production, After Controlling for Baseline Cytokine Concentrations

Cytokine Response, pg/ml	Time Management	Expressive Writing	*F* Test for Group × Change Since Baseline			
			F	*df*	*p*	η_p^2
Log IL-1β	*n* = 19	*n* = 26				
Baseline (T1)	3.23 (0.34)	3.13 (0.28)				
2 wk postwriting (T2)	3.21 (0.27)	3.09 (0.44)				
Change score (T2-T1), adjusted M (SD)	−0.003 (0.05)	−0.04 (0.04)	0.27	1,42	.61	0.01
Log IL-6	*n* = 18	*n* = 24				
Baseline (T1)	3.36 (0.46)	3.41 (0.30)				
2 wk postwriting (T2)	3.38 (0.37)	3.31 (0.52)				
Change score (T2-T1), adjusted M (SD)	0.005 (0.09)	−0.08 (0.07)	0.55	1,39	.46	0.01
Log TNF-α	*n* = 21	*n* = 26				
Baseline (T1)	2.38 (0.39)	2.29 (0.35)				
2 wk postwriting (T2)	2.26 (0.29)	2.15 (0.36)				
Change score (T2-T1), adjusted M (SD)	−0.12 (0.04)	−0.15 (0.04)	0.35	1,44	.56	0.01

ANCOVAs = analyses of covariance; LPS = lipopolysaccharide; M = mean; SD = standard deviation; TNF-α = tumor necrosis factor α.

improve. Even modest disturbances in sleep diminish immune function and alter cytokine profiles (50,51). Alterations in circulating cytokine concentrations after sleep deprivation may be an important contributor to slower wound healing (52). Furthermore, deep sleep is critical for proper growth hormone (GH) secretion. GH enhances wound healing, in part, by stimulating macrophage activation and migration (53). Disturbed sleep will not only reduce GH secretions but also elevate cortisol levels (54), compounding delays in wound healing. Therefore, whether expressive writing has effects on wound healing through improved sleep needs to be explored further using more robust measures to assess sleep quality and quantity.

The writing intervention preceded the wounding by 2 weeks. This time interval provided time for the initial increase in distress that often follows expressive writing to subside. Elevated distress could have negatively affected healing. In addition, larger health effect sizes have been observed within the first month of expressive disclosure, compared with later time points, suggesting that the benefits of expressive writing may dissipate over time (17). Previous expressive writing studies have also reported significant physical health improvements in as little as 2 weeks (20,55). Taken together, we presumed that if expressive writing was going to have a beneficial effect on wound healing, the wounding should occur within the first few weeks after the writing intervention. However, future studies may wish to explore alternative time lags between writing and wounding. It may be particularly useful to investigate the effects of writing *after* wounding because this may have clinical applications. Similarly, it may be useful to have an additional blood draw to assess cytokines in the days after wounding.

Although we did not observe group differences in LPS-induced proinflammatory cytokine production, we did observe, at 2 weeks postwriting, lower LPS-induced IL-6 production associated with less sleep and greater perceived stress and lower LPS-induced IL-6 and IL-1β production associated with more depressive symptoms. These findings substantiate previous research in caregivers of spouses with dementia (56,57) and suggest that psychological stress can down-regulate immune function, potentially increasing vulnerability to infectious agents.

Because our participants were healthy, older adults, the frequency of attending doctor appointments was relatively low at baseline, with the majority attending one doctor visit every 3 months for a routine checkup or prescription refill. Had the number of doctor visits reduced from baseline, as found in several other studies (18,27), this effect would have been negative because it would suggest that our participants were no longer attending their routine medical checkups and getting prescription refills.

Limitations and Future Directions

The wound was a small experimental wound, and to further establish the clinical benefits of expressive writing on healing, future research could be performed measuring hydroxyproline deposition as an outcome with patients undergoing surgery, or measuring the surface area of chronic wounds.

The margins of reepithelialization were often difficult to define with sufficient precision to afford reliable estimates of wound area change over time. Therefore, wounds were dichotomized into "healed" and "not healed" categories to allow a simple, rapid, and straight-forward method to assess wound healing. However, this dichotomization may have reduced statistical power to detect relationships between study variables and healing (58).

The extent to which sleep influences the relationship between expressive writing and wound healing requires further investigation. The self-reported sleep data collected in the current study relied on retrospective recall of sleep over the past week; future studies should consider using a wrist activity monitor to objectively assess sleep-wake times and sleep patterns, thereby increasing the accuracy of sleep data.

A larger sample may be necessary to detect differences in LPS-induced proinflammatory cytokine production between the two groups because of the large variance in distributions. Ex vivo LPS stimulation of whole blood may not be the optimal model to investigate the relationship between expressive writing, cytokine concentrations, and wound healing. Future expressive writing studies might consider using the blister wound model, which affords collecting cytokines at the wound site (5).

The current study consisted primarily of participants of European descent, which is consistent with New Zealand demographics, where 92% of individuals 65 years or older identify with European ethnicity (59). In addition, we recruited primarily at retirement villages, which have a high proportion of residents identifying with European ethnicity (60). Although evidence suggests that expressive writing has salutatory physical and psychological effects in other cultural groups (12,61), studies are needed to confirm whether similar wound healing effects can be achieved in more ethnically diverse samples.

Conclusion and Implications

In conclusion, this study replicates an initial study showing that expressive writing can improve wound healing and extends the findings to women and to older adults. Older adults are at greater risk for poor healing, and the findings may have clinical implications for helping older people to heal after injury or surgery, or for those who have chronic wounds. The intervention is suitable for people who have limited mobility and requires few resources. Future research could investigate whether this type of intervention can improve healing in older adults with chronic ulcers or after surgery and also explore the psychological, behavioral, and biological mechanisms underlying the effects.

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