

Psychological effects of recumbent isometric yoga and their associations with fatigue and functional recovery in myalgic encephalomyelitis and chronic fatigue syndrome

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Research Article

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Abstract

Background

Myalgic encephalomyelitis/chronic fatigue syndrome (ME/CFS) is a disabling illness with no established treatment. Our previous randomized controlled trial demonstrated that recumbent isometric yoga practiced for 12 weeks, in addition to usual care, significantly improved fatigue severity and functional status compared with usual care alone. However, the effects of recumbent isometric yoga on psychological measures remain unclear. Therefore, the present analysis examined (1) whether recumbent isometric yoga influences psychological measures (depression, anxiety, alexisomia, and alexithymia), and (2) whether changes in these measures are associated with improvements in fatigue and functional status.

Methods

Patients with ME/CFS ($n = 16$) completed a 12-week recumbent isometric yoga program. Fatigue (Chalder Fatigue Scale [FS]), functional status (Performance Status scale [PS]), depression (Hospital Anxiety and Depression Scale depression subscale [HADS-D]), anxiety (HADS anxiety subscale [HADS-A]), alexisomia (Shitsu-Taikan-Sho Scale [STSS]), and alexithymia (20-item Toronto Alexithymia Scale [TAS-20]) were assessed before and after the intervention. Pre- to postinterventional changes were analyzed using paired t tests or Wilcoxon signed-rank tests. Factors associated with fatigue reduction (Δ FS) were examined using multiple linear regression, and factors associated with postintervention PS were examined using ordinal logistic regression.

Results

FS and PS scores improved significantly postintervention. HADS-D and HADS-A scores decreased significantly, as did the STSS total score and the difficulty identifying bodily feelings (DIB) and overadaptation (OA) subscale scores. The reduction in TAS-20 score was not significant. Improvement in depressive symptoms (Δ HADS-D) [$\beta = 0.926$, $p = 0.020$] was the only factor independently associated with fatigue reduction. Postintervention functional status was associated with baseline PS [OR = 9.70, 95% CI = 2.14–44.00, $p = 0.03$] and improvement in difficulty identifying bodily feelings (Δ STSS-DIB) [OR = 0.74, 95% CI = 0.56–0.98, $p = 0.038$].

Conclusions

Fatigue, functional status, and psychological measures improved after yoga in patients with ME/CFS. Improvements in depressive symptoms were associated with reduced fatigue, whereas baseline

functional status and improvements in DIB were associated with postintervention functional status. These preliminary findings warrant confirmation in larger controlled studies.

Introduction

Myalgic encephalomyelitis/chronic fatigue syndrome (ME/CFS) is a debilitating condition characterized by persistent fatigue, postexertional malaise (PEM), sleep disturbance, autonomic dysfunction, pain, neurocognitive impairment, and substantial functional limitations [1–3]. Despite extensive clinical and research efforts, no curative or definitively effective treatment has been established, and many patients remain symptomatic for years.

We previously developed isometric yoga as an adjunctive intervention tailored to the limitations of patients with ME/CFS, including severe fatigue, PEM, pain, and orthostatic intolerance [4]. The program incorporates several poses involving sustained muscle engagement followed by postisometric relaxation, as well as controlled breathing and interoceptive attention. In an initial randomized controlled trial, 8 weeks of seated isometric yoga, in addition to usual care, significantly improved fatigue severity in patients with moderate ME/CFS who were able to remain seated for more than 30 min [5]. Because patients with more severe disease could not participate in seated practice, we subsequently developed a recumbent isometric yoga program [1, 6].

After the feasibility of this program was demonstrated [6], another randomized controlled trial involving patients with severe ME/CFS, including those who were nearly bed-bound, showed that recumbent isometric yoga for 12 weeks significantly improved fatigue and functional status compared with usual care alone [1]. Beyond these clinical effects, accumulating evidence suggests that isometric yoga may also have psychological effects. For example, seated isometric yoga has been shown to reduce depressive symptoms [5]. Regular yoga practice has been associated with improvements in alexisomia in both patients with chronic diseases and healthy individuals [7]. These findings suggest that yoga may enhance awareness of bodily sensations. Therefore, we investigated whether regular practice of recumbent isometric yoga produces similar effects in patients with ME/CFS.

Accordingly, the present study aimed to determine: (1) whether recumbent isometric yoga influences psychological measures, such as depression and alexisomia, in addition to physical outcomes; and (2) whether changes in these psychological measures predict improvements in fatigue and functional status in patients with ME/CFS.

Methods

Study design and participants

This prospective, single-arm, 12-week pilot study examined the effects of recumbent isometric yoga on patients with ME/CFS. Participants were outpatients with ME/CFS who attended the Department of Psychosomatic Internal Medicine at the International University of Health and Welfare Hospital. Eligible

participants were adults who continued to experience difficulties in daily life and sought additional treatment options despite receiving at least 3 months of conventional treatment at the hospital. Click or tap here to enter text.. Conventional treatment included self-management support, guidance on activity adjustment and pacing, regulation of sleep-wake rhythms and daily routines, psychological support for distress-related symptoms, environmental modifications at home, work, or school, and pharmacological treatment when clinically indicated [1, 8, 9]. Patients with prior yoga experience were excluded to minimize potential bias related to familiarity with the practice. The present study was approved by the Ethics Committee of the International University of Health and Welfare Hospital (approval No. 13-B-249). Written informed consent was obtained from all participants before enrollment. The study was conducted in accordance with the principles of the Declaration of Helsinki.

Diagnosis of ME/CFS

Patients were diagnosed with ME/CFS if they met all the following sets of diagnostic criteria: the 1994 Fukuda case definition for chronic fatigue syndrome [3]; the 2003 Canadian clinical case definition for ME/CFS [2]; the 2011 International Consensus Criteria for ME [10]; the 2015 diagnostic criteria for systemic exertion intolerance disease (SEID) [11]; and the 2017 Japanese clinical case definition for ME/CFS [12].

Yoga intervention

The intervention consisted of a standardized 25-minute recumbent isometric yoga program developed for patients with ME/CFS who experience severe fatigue, orthostatic intolerance, and reduced exercise tolerance [1]. The program was originally developed by Oka and colleagues and has been shown to be safe, feasible, and beneficial for patients with ME/CFS unresponsive to conventional treatment [1, 6]. Participants attended supervised yoga sessions during routine outpatient visits and were instructed to practice the same program daily at home. The program consisted of four components: (1) adjustment of external and internal conditions, including posture, breathing, and attentional focus; (2) performance of gentle isometric yoga postures in the recumbent position; (3) deep relaxation followed by gradual reactivation; and (4) application of the bodily awareness cultivated during yoga practice to daily activities and symptom management. The yoga protocol was designed to minimize excessive physical exertion while promoting awareness of bodily sensations and self-regulation of physical and psychological states. Participants continued conventional treatment while practicing recumbent isometric yoga for approximately 12 weeks. During the intervention period, medications and their dosages were unchanged.

Outcome measures

Assessments were conducted at baseline and after the 12-week intervention.

Fatigue Severity

Fatigue severity was evaluated using the Japanese version of the Chalder Fatigue Scale (FS) [13, 14]. This 11-item instrument assesses physical and mental fatigue, with higher scores indicating greater fatigue severity. Total scores range from 0 to 33.

Functional Status

Functional status was assessed using the Performance Status (PS) scale included in the Japanese clinical diagnostic criteria for ME/CFS. The attending physician rated disease severity and activity limitations on an ordinal scale ranging from 0 (no functional impairment) to 9 (severe impairment with complete restriction of daily activities) [12, 15, 16].

Anxiety and Depression: Psychological distress was measured using the Japanese version of the Hospital Anxiety and Depression Scale (HADS) [17, 18]. The HADS consists of two 7-item subscales assessing anxiety (HADS-A) and depression (HADS-D), with higher scores indicating greater psychological distress. HADS scores are typically classified into three categories: 0–7, normal; 8–10, borderline abnormal; and 11 or higher, indicative of clinically meaningful anxiety or depressive symptoms.

Alexisomia: Alexisomia was measured using the Shitsu-Taikan-Sho Scale (STSS), a validated self-report measure assessing difficulties in perceiving, interpreting, and appropriately responding to bodily sensations [7, 19]. The STSS comprises three subscales: 1) Difficulty in identifying bodily feelings (DIB): difficulty recognizing internal bodily states and physical signals; 2) Overadaptation (OA): tendency to prioritize external demands over bodily needs; 3) Lack of health management based on bodily feelings (LHM): difficulty using bodily sensations in everyday health management. Higher scores indicate greater alexisomic traits.

Alexithymia: Alexithymia was evaluated using the Japanese version of the 20-item Toronto Alexithymia Scale (TAS-20) [20, 21]. The TAS-20 includes three subscales: Difficulty Identifying Feelings (DIF), Difficulty Describing Feelings (DDF), and Externally Oriented Thinking (EOT). Higher scores indicate greater alexithymic traits.

Study outcomes

We assessed changes in fatigue severity (Chalder FS score), functional status (PS score), depression (HADS-D), anxiety (HADS-A), alexisomia (STSS) and alexithymia (TAS-20) after the intervention. Exploratory analyses examined whether changes in depression, anxiety, alexisomia, and alexithymia were associated with improvements in fatigue and functional status. The STSS-DIB, STSS-OA, and TAS-DIF subscales were selected as candidate predictors in regression analyses because they showed significant changes after the isometric yoga intervention.

Statistical analysis

Continuous variables are presented as means $\pm$ standard deviations (SD), and categorical variables as frequencies. Pre- and postintervention scores on the Chalder FS, HADS, STSS, and TAS-20 were compared using paired t tests. Effect sizes were calculated using Cohen's d . Because PS scores were ordinal and non-normally distributed, they were analyzed using a Wilcoxon signed-rank test. To identify factors associated with fatigue reduction, multiple linear regression (MLR) analysis was performed with the change in Chalder FS score (Δ FS) as the dependent variable. Predictor variables included changes in depression (Δ HADS-D), anxiety (Δ HADS-A), difficulty in identifying bodily feelings (Δ STSS-DIB), overadaptation (Δ STSS-OA), and difficulty identifying feelings (Δ TAS-DIF). To identify factors associated with functional outcome, ordinal logistic regression (OLR) analysis was conducted using postintervention PS as the dependent variable. Baseline PS was included as a covariate along with Δ HADS-D, Δ HADS-A, Δ STSS-DIB, Δ STSS-OA, and Δ TAS-DIF. Regression assumptions were evaluated before analysis. For the MLR model, normality of residuals, homoscedasticity, and multicollinearity were assessed. Multicollinearity was examined using variance inflation factors, with values > 5 indicating potential multicollinearity. For the OLR model, the proportional odds assumption was tested using the Brant test. Because no participants reported post-intervention PS scores in the lowest theoretical categories (0 or 1), the outcome variable was modeled as an ordered factor with unused levels dropped, confirming that the proportional odds assumption was fully satisfied via Brant's test ($\chi^2 = 2.35 \times 10^{-7}$, $df = 30$, $p = 1.000$). All statistical tests were two-tailed, and $p < 0.05$ was considered significant. Analyses were performed using R version 4.5.3 (R Foundation for Statistical Computing).

Results

Participants

All 16 enrolled patients with ME/CFS completed the 12-week intervention without serious adverse events. The mean age was 38.6 ± 9.2 years, and 14 patients (87.5%) were female.

Changes in fatigue, functional status, depression, and anxiety

After the intervention, functional status and fatigue severity both improved significantly (Table 1). The Chalder FS score decreased significantly from 23.75 ± 5.78 to 19.12 ± 6.04 ($p < 0.001$). The median PS score decreased significantly from 7.0 [5.0–8.0] to 5.0 [4.0–7.25] ($p = 0.010$). Depressive and anxiety symptoms decreased significantly. The mean HADS-D score decreased from 10.94 ± 4.02 to 7.81 ± 4.17 ($p = 0.002$), and the mean HADS-A score decreased from 7.62 ± 2.80 to 5.31 ± 3.00 ($p = 0.018$).

Table 1

Changes in fatigue, functional status, and psychological measures following recumbent isometric yoga

Scale		Preintervention	Postintervention	<i>p</i>	Effect Size (<i>d</i> or <i>r</i>)
Chalder FS		23.75 ± 5.78	19.12 ± 6.04	< 0.001*	-0.78
PS†		7.0 [5.0–8.0]	5.0 [4.0–7.25]	0.010*	-0.64
HADS–D		10.94 ± 4.02	7.81 ± 4.17	0.002*	-0.76
HADS–A		7.62 ± 2.80	5.31 ± 3.00	0.018*	-0.80
STSS	Total	65.50 ± 12.27	57.94 ± 10.88	0.008*	-0.65
	DIB	25.56 ± 7.02	22.06 ± 5.84	0.031*	-0.54
	OA	18.12 ± 5.99	13.75 ± 5.01	0.001*	-0.77
	LHM	22.44 ± 5.43	22.12 ± 4.73	0.861	-0.06
TAS-20	Total	53.25 ± 10.69	50.19 ± 11.33	0.088	-0.28
	DIF	19.56 ± 6.41	17.00 ± 6.23	0.019*	-0.41
	DDF	15.56 ± 5.15	14.69 ± 4.67	0.199	-0.18
	EOT	18.12 ± 2.58	18.50 ± 4.94	0.709	0.08

Note: Data are presented as mean ± SD, except for PS, which is reported as median [IQR]. Cohen's *d* is reported for paired *t* tests, and *r* is reported for Wilcoxon signed-rank tests. **p* < 0.05

Abbreviations: DDF, Difficulty in describing feelings; DIB, Difficulty in identifying bodily feelings; DIF, Difficulty in identifying feelings; EOT, Externally-oriented thinking; FS, Fatigue Scale; HADS, Hospital Anxiety and Depression Scale; HADS–A, Hospital Anxiety and Depression Scale–Anxiety; HADS–D, Hospital Anxiety and Depression Scale–Depression; LHM, Lack of health management based on bodily feelings; OA, Over-adaptation; PS, Performance Status; SD, Standard Deviation; STSS, Shitsu-Taikan-Sho Scale; TAS-20, 20-item Toronto Alexithymia Scale.

Changes in alexisomia and alexithymia

Before the intervention, participants exhibited marked alexisomic traits, whereas alexithymic traits were not pronounced. For comparison, the mean STSS and TAS-20 scores among Japanese adults are 56.3 ± 10.2 [22] and 50.5 ± 9.5 [21], respectively.

Total STSS score significantly improved after the intervention (*p* = 0.008). Among the STSS subscales, the DIB (*p* = 0.031) and OA scores decreased significantly (*p* = 0.001). The TAS-20 total score decreased, although the change was not significant (*p* = 0.088). However, the DIF subscale score decreased significantly from 19.56 ± 6.41 to 17.00 ± 6.23 (*p* = 0.019).

Factors associated with fatigue reduction

Multiple linear regression analysis was conducted to identify factors associated with fatigue reduction (Δ FS; Table 2). Improvement in depressive symptoms (Δ HADS-D) was the only factor significantly associated with reduced fatigue ($p = 0.020$). Changes in anxiety (Δ HADS-A), alexisomia (Δ STSS-DIB and Δ STSS-OA), and alexithymia (Δ TAS-DIF) were not significantly associated with changes in fatigue. The model explained 53.2% of the variance in fatigue reduction ($R^2 = 0.532$).

Table 2
Factors associated with fatigue reduction: multiple linear regression analysis (Δ FS)

Variable		Estimate (β)	Standard error	<i>t</i>	<i>p</i>
(Intercept)		-3.102	1.667	-1.861	0.092
Δ HADS-D		0.926	0.336	2.754	0.020*
Δ HADS-A		-0.251	0.303	-0.827	0.428
Δ STSS	Δ DIB	-0.199	0.174	-1.143	0.280
	Δ OA	-0.068	0.237	-0.286	0.781
Δ TAS-20	Δ DIF	0.078	0.250	0.312	0.761

Note: $R^2 = 0.532$; adjusted $R^2 = 0.299$. * $p < 0.05$.

Abbreviations: DIB, Difficulty in identifying bodily feelings; DIF, Difficulty in identifying feelings; FS, Fatigue Scale; HADS, Hospital Anxiety and Depression Scale; HADS-A, Hospital Anxiety and Depression Scale-Anxiety; HADS-D, Hospital Anxiety and Depression Scale-Depression; OA, Over-adaptation; STSS, Shitsu-Taikan-Sho Scale; TAS-20, 20-item Toronto Alexithymia Scale.

Factors associated with functional status

Ordinal logistic regression analysis was performed to identify factors associated with postintervention PS (Table 3). Baseline PS was the factor most strongly associated with postintervention functional status (OR = 9.70, $p = 0.003$). Improvement in difficulty identifying bodily feelings (Δ STSS-DIB) was independently associated with better functional status (OR = 0.74, $p = 0.038$). Improvement in depressive symptoms (Δ HADS-D) was not significantly associated with functional status OR = 1.93, $p = 0.068$). Changes in anxiety (Δ HADS-A), overadaptation (Δ STSS-OA), and difficulty identifying feelings (Δ TAS-DIF) were not significantly associated with functional outcome.

Table 3

Factors associated with functional status: ordinal logistic regression analysis (postintervention PS)

Variable		Estimate (β)	Standard error	Odds ratio	95% CI	<i>p</i>
Baseline PS		2.272	0.772	9.70	2.14–44.00	0.003**
Δ HADS–D		0.659	0.361	1.93	0.95–3.92	0.068
Δ HADS–A		-0.373	0.244	0.69	0.43–1.11	0.126
Δ STSS	Δ DIB	-0.300	0.144	0.74	0.56–0.98	0.038*
	Δ OA	0.060	0.160	1.06	0.78–1.45	0.708
Δ TAS-20	Δ DIF	-0.031	0.163	0.97	0.70–1.33	0.847
* $p < 0.05$, ** $p < 0.01$.						

Abbreviations: DIB, Difficulty in identifying bodily feelings; DIF, Difficulty in identifying feelings; HADS, Hospital Anxiety and Depression Scale; HADS–A, Hospital Anxiety and Depression Scale–Anxiety; HADS–D, Hospital Anxiety and Depression Scale–Depression; OA, Over-adaptation; PS, Performance Status; STSS, Shitsu-Taikan-Sho Scale; TAS-20, 20-item Toronto Alexithymia Scale.

Discussion

The present study showed that fatigue, functional status, and psychological outcomes, including depression, anxiety, and alexisomia, improved after recumbent isometric yoga in patients with ME/CFS. The psychological changes were differentially associated with clinical outcomes: reductions in depressive symptoms were associated with reduced fatigue, whereas post interventional functional status was associated with baseline disability and improvements in alexisomia, particularly DIB. These results support the potential of recumbent, interoception-focused yoga as a feasible therapeutic approach to ME/CFS, a condition with limited evidence-based treatment options.

Recumbent isometric yoga improves fatigue [1, 6, 23] and functional status [1] in patients with ME/CFS. The present study extends these findings by identifying psychological factors differentially associated with improvements in fatigue and functional status, thereby providing insight into potential mechanisms of therapeutic benefit. Reductions in depressive symptoms were associated with reduced fatigue, consistent with previous research demonstrating strong bidirectional associations between depression and fatigue in ME/CFS [24]. Depression may amplify fatigue through cognitive-emotional mechanisms such as negative appraisal, reduced motivation, and heightened interoceptive threat perception, mechanisms widely observed in chronic illnesses and likely relevant to ME/CFS [25–27]. Emerging psychoneuroimmunological and interoceptive models provide a framework for understanding why improvements in depressive symptoms may be associated with reduced fatigue. Depression and fatigue share biological substrates, including chronic low-grade inflammation, hypothalamic–pituitary–adrenal (HPA) axis dysregulation, and altered interoceptive processing [23, 28, 29]. Mind–body interventions

such as yoga have been shown to downregulate proinflammatory cytokines including Interleukin-6 (IL-6), normalize stress–response systems, and modulate insular cortex activity, which may reduce both mood disturbance and perceived exhaustion [30–32]. These mechanisms are consistent with the cytokine-mediated “sickness behavior” model, in which inflammatory signaling drives both depressive symptoms and profound psychomotor slowing [33, 34]. Recumbent isometric yoga incorporates slow breathing, attentional regulation, and gentle isometric engagement, components that may enhance parasympathetic activity, reduce cognitive rumination, and recalibrate interoceptive processing [35]. Although these mechanisms were not examined in the present study, attenuating neuroimmune activity and interoceptive threat perception may provide biologically plausible links between recumbent isometric yoga, depressive symptoms, and fatigue.

Postinterventional functional status was associated with baseline disability and reductions in alexisomia, particularly DIB. The present findings suggest that improved awareness of bodily sensations may facilitate functional gains by enabling patients to recognize their physical limits more accurately, regulate exertion, and engage in daily activities with greater self-efficacy. This interpretation aligns with contemporary interoception research, which emphasizes the role of accurate bodily signal processing in adaptive behavior, emotional regulation, and symptom management [36]. The reduction in alexisomic traits observed in this study may reflect the interoceptive nature of recumbent isometric yoga. The intervention emphasizes sustained isometric engagement, slow breathing, and mindful attention to subtle bodily sensations, all of which may enhance interoceptive awareness. Yoga can modulate insular cortex activity, improve autonomic regulation, and increase interoceptive accuracy [37, 38]. Although interoception was not directly measured in this study, the pattern of results suggests that recumbent isometric yoga may influence interoceptive processes relevant to ME/CFS symptoms. Future studies incorporating objective interoceptive measures would help clarify this mechanism.

This study has several limitations. The sample size was small, limiting statistical power and the stability of the multivariable analyses. Fatigue and psychological outcomes were assessed using self-report measures, which may be susceptible to reporting bias. The observed associations with alexisomia were identified primarily at the subscale level and should therefore be considered exploratory. Moreover, the identified factors were associated with improvements specifically within the context of recumbent isometric yoga. It remains unclear whether other treatments would show similar patterns of associations between depressive symptoms and fatigue or between alexisomia and functional status. Finally, although our findings suggest that recumbent isometric yoga may enhance interoceptive awareness, this mechanism was not directly assessed and requires further investigation using objective measures and larger controlled studies.

Despite these limitations, the present study provides insights into the psychological effects of recumbent isometric yoga in patients with ME/CFS. In addition to showing improvements in fatigue and functional status, the findings showed that changes in depressive symptoms and alexisomia were differentially associated with fatigue reduction and postintervention functional status, respectively. These findings suggest that psychological factors may be differentially associated with the clinical

effects of recumbent isometric yoga and highlight the potential clinical value of addressing bodily awareness and emotional well-being in the management of ME/CFS.

Conclusion

The present study showed that fatigue, functional status, depression, anxiety, and alexisomia improved after recumbent isometric yoga in patients with ME/CFS. Improvements in depressive symptoms were associated with reductions in fatigue, whereas postinterventional functional status was associated with baseline functional status and reduced DIB.

Abbreviations

DDF

difficulty describing feelings

DIB

difficulty identifying bodily feelings

DIF

difficulty identifying feelings

EOT

externally oriented thinking

FS

fatigue scale

HADS

Hospital Anxiety and Depression Scale

HADS–A

Hospital Anxiety and Depression Scale–Anxiety

HADS–D

Hospital Anxiety and Depression Scale–Depression

HPA

hypothalamic–pituitary–adrenal

IL-6

Interleukin-6

LHM

lack of health management based on bodily feelings

ME

Myalgic encephalomyelitis

ME/CFS

Myalgic encephalomyelitis/chronic fatigue syndrome

MLR

multiple logistic regression

OA

overadaptation
OLR
ordinal logistic regression
PEM
post-exertional malaise
PS
performance status
SD
standard deviation
SEID
systemic exertion intolerance disease
STSS
Shitsu-Taikan-Sho Scale
TAS-20
20-item Toronto Alexithymia Scale
VIF
variance inflation factor.

Declarations

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Ethical approval

This study was approved by the ethics committee of International University of Health and Welfare Hospital (approval No. 13-B-249). Written informed consent was obtained from all study participants.

Consent for publication

Not Applicable.

Data availability statement

Data sharing is not applicable.

Competing interests

TO is a field editor for *BioPsychoSocial Medicine*.

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None.

Authors' contributions

TO designed the study, collected the data, and supervised the project. AD performed the data analysis and drafted the initial manuscript. SA and TO assisted with data analysis and the interpretation of results. SA and TO helped in revising the manuscript. All authors read and approved the final manuscript.

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