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The Effect of Multidimensional Health Care Model on Cognitive Function and Quality of Life of Elderly Patients with Mild Cognitive Impairment

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Abstract: This study investigates the intervention effects of a multidimensional wellness model on cognitive function and quality of life in elderly patients with mild cognitive impairment (MCI). Through a randomized controlled trial, 60 elderly MCI patients from Yikang Nursing Home in Shanghai were evenly divided into an intervention group and a control group, receiving either the multidimensional wellness model or routine management for a 3-month intervention period. Results demonstrated significant improvements in both cognitive function and quality of life in the intervention group. The MMSE total score increased by 16.2%, with orientation ability, memory, attention/calculation, recall capacity, and language improving by 22.7%, 18.8%, 20.4%, 36.8%, and 3.0%, respectively. Activities of daily living (ADL) scores rose by 37.5%, the completion rate of instrumental activities of daily living increased from 28% to 65%, and the incidence of falls decreased by 54%. The study indicates that the multidimensional wellness model effectively enhances cognitive function and quality of life in elderly MCI patients, demonstrating significant clinical value for widespread application.

Keywords: Multidimensional health care model; Elderly cognitive impairment; Cognitive function; Quality of life; Chronic disease management

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1. Introduction

With the intensification of population aging, cognitive impairment in the elderly has become a major public health issue [1,2]. In China, the prevalence of mild cognitive impairment (MCI) among people aged 65 and above reaches 20.8% [3], severely affecting patients' quality of life and imposing a heavy burden on families and society. Elderly cognitive impairment often coexists with chronic diseases such as hypertension and diabetes, forming a "metabolic-cognitive" vicious cycle that exacerbates disease progression [4].

Current interventions for MCI face prominent challenges: pharmacological treatments have limited efficacy and potential side effects, non-pharmacological interventions lack individualization and systematic design, and nursing homes often suffer from insufficient professional resources and uneven service quality [5]. These gaps result in a lack of effective, scalable solutions for delaying cognitive decline and improving the quality of life in elderly MCI patients.

The multidimensional health care model, based on neuroplasticity theory and the biopsychosocial medical model, integrates cognitive promotion, chronic disease management, nutritional support, exercise rehabilitation, and social engagement [2]. This integrated approach addresses the complex, multifactorial nature of MCI, which single-domain interventions cannot fully resolve. Domestic and international studies have confirmed that multidisciplinary collaboration and personalized non-pharmacological interventions can effectively delay cognitive decline [6,7].

This study employs a randomized controlled trial to evaluate the intervention effects of the multidimensional health care model on cognitive function, daily living abilities, and quality of life in elderly MCI patients. The aim is to verify the model's effectiveness in nursing home settings, provide a feasible and scalable health care solution, and lay a theoretical and practical foundation for optimizing elderly MCI management.

2. Research subjects and methods

2.1. Research subjects

The study recruited elderly MCI patients from Shanghai Yikang Nursing Home. All participants were aged ≥65 years and met Petersen's diagnostic criteria for MCI [8]. Patients with confirmed dementia, severe neurological disorders (e.g., stroke, Parkinson's disease), or other conditions affecting cognitive assessment were excluded.

Inclusion criteria: (1) Aged ≥65 years; (2) Meets Petersen's diagnostic criteria for MCI [8]; (3) No acute severe illness or risk of adverse reactions to the intervention; (4) Patients and their family members understand the study protocol and provide written informed consent.

Exclusion criteria: (1) Confirmed diagnosis of dementia; (2) Severe neurological disorders affecting cognitive function (e.g., stroke, Parkinson's disease); (3) Comorbid severe mental illness (e.g., major depressive disorder, schizophrenia); (4) Uncontrolled chronic diseases (e.g., advanced cancer, heart failure);

(5) Severe hearing or visual impairment preventing participation in cognitive assessments and interventions; (6) Received cognitive training within the past 6 months.

2.2. Research methodology

2.2.1. Group assignment

A total of 60 eligible patients were randomly assigned to the intervention group (n = 30) or the control group (n = 30) using a random number table method. Randomization was performed by an independent researcher not involved in data collection or intervention implementation to ensure allocation concealment.

2.2.2. Intervention measures

The intervention group implemented the multidimensional wellness model (PEAKS intervention framework), with specific measures as follows:

(1) Cognitive enhancement

(a) Structured cognitive training: Conducted 3 times per week, 90 minutes per session, including memory

reinforcement (e.g., autobiographical memory recall, photo recognition), orientation training (e.g., time-space navigation exercises), and computational activation (e.g., numerical reasoning tasks) [6,9].

(b) Repetitive Transcranial Magnetic Stimulation (rTMS): Administered 2 times per week, targeting the left dorsolateral prefrontal cortex (DLPFC) at 10 Hz, with stimulation intensity set at 80% of the individual's resting motor threshold and 1,500 pulses per session. The rTMS device used was the MagPro X100 (MagVenture, Denmark), operated by a certified neurologist.

(2) Collaborative chronic disease management (engagement)

Multidisciplinary teams (including physicians, nurses, pharmacists, and rehabilitation therapists) conducted joint rounds every 2 weeks to assess patients' chronic disease status (e.g., blood pressure, blood glucose) and adjust medication regimens and management plans based on individual conditions [10].

(3) Nutritional enhancement (alimentation):

A clinical dietitian formulated personalized dietary plans for each patient based on their age, weight, chronic disease status, and nutritional needs. Total caloric intake was controlled at 25 kcal/kg body weight, with a macronutrient ratio of 50% carbohydrates, 20% protein (1.2 g/kg body weight), and 30% fat. Special emphasis was placed on high-quality protein (e.g., fish, eggs, lean meat) and foods rich in ω-3 fatty acids (e.g., deep-sea fish, flaxseeds) [4]. Patients' dietary adherence was monitored by nurses, with weekly adjustments based on food intake and physical condition.

(4) Exercise rehabilitation (kinesiotherapy)

(a) Daily low-intensity aerobic exercise: 30 minutes per session of Baduanjin or seated step training, with intensity controlled at Borg RPE 11–13 (mild to moderate fatigue) and heart rate maintained at 50–70% of the maximum predicted heart rate (calculated as 220 – age) [6].

(b) Balance and gait training: Conducted 3 times per week, 15 minutes per session, including center of gravity transfer exercises using balance pads and parallel bar walking training, guided by a certified rehabilitation therapist [6,11].

(5) Social support

(a) Nostalgia music therapy: Conducted once per week, using pop songs familiar to patients from their youth, combined with rhythmic tapping and impromptu chorus to activate the Default Mode Network (DMN) and improve emotional well-being [4,7].

(b) Horticultural therapy: Conducted twice per week, including succulent plant care and herb cultivation, to provide multisensory stimulation (visual, tactile, olfactory) and enhance emotional stability [12].

The control group received routine chronic disease management, including regular disease monitoring (e.g., monthly blood pressure/blood glucose measurements), medication administration, and general health education (e.g., verbal guidance on diet and daily care), without additional cognitive training, specialized exercise, or social support interventions. Both groups maintained their original living environments and daily routines during the 3-month intervention period.

2.2.3. Data collection process

Data were collected at two time points: baseline (before intervention initiation) and post-intervention (after 3 months of intervention). All assessments were conducted by trained researchers blinded to group assignment to reduce measurement bias.

(1) Cognitive function assessment

Completed the Mini-Mental State Examination (MMSE) through face-to-face interviews, including subscales of orientation, memory, attention, calculation, language, and recall [1].

(2) Daily living ability assessment:

Completed the Activities of Daily Living (ADL) scale through observation and interview, evaluating basic daily living skills (e.g., dressing, bathing, eating) [13].

(3) Additional indicators

The completion rate of instrumental activities of daily living (e.g., using a telephone, managing finances) was recorded through caregiver reports and on-site observation; the incidence of falls was tracked via nursing home incident records.

2.3. Evaluation indicators

(1) Primary outcomes

MMSE total score and subscale scores (orientation, memory, attention, calculation, language, recall) to assess cognitive function.

(2) Secondary outcomes

ADL score (assessing basic daily living abilities), completion rate of instrumental activities of daily living, and incidence of falls (assessing quality of life and safety).

2.4. Statistical methods

Statistical analysis was performed using SPSS 23.0 software. Quantitative data are presented as mean ± standard deviation (SD). Between-group comparisons were conducted using independent samples *t*-tests, and within-group comparisons before and after intervention were conducted using paired samples t-tests. Categorical data are presented as rates (%) and compared using the $\chi 2$ test. A two-tailed *P*-value < 0.05 was considered statistically significant.

3. Results

3.1. Baseline data

The baseline characteristics of the two groups were comparable, with no statistically significant differences ($P > 0.05$), indicating balanced group allocation (**Table 1**).

Table 1. Baseline characteristics of the two groups [mean ± SD or *n* (%)]

Characteristic	Intervention group (*n* = 30)	Control group (*n* = 30)	t/χ^2	*P*
Gender (male)	13 (43.3%)	14 (46.7%)	0.081	0.776
Age (years)	73.4 ± 3.40	72.8 ± 2.56	0.763	0.448
Years of education (years)	9.73 ± 2.72	9.73 ± 2.72	0.000	1.000
Disease duration (years)	4.57 ± 1.50	4.40 ± 1.43	0.452	0.652

3.2. Cognitive function improvement

After 3 months of intervention, the MMSE total score and subscale scores (orientation, memory, attention, calculation, language, recall) of the intervention group were significantly higher than those before intervention (*P*

< 0.001), while the control group showed no significant changes ($P > 0.05$). Between-group comparisons post-intervention showed statistically significant differences in all cognitive indicators ($P < 0.001$) (**Tables 2–8**).

Table 2. Comparison of orientation scores between the two groups (mean ± SD)

Group	n	Before intervention	After intervention	*t* (within-group)	*P* (within-group)	*t* (between-group, post-intervention)	*P* (between-group, post-intervention)
Intervention group	30	7.50 ± 1.42	9.20 ± 0.85	8.197	<0.001	5. 801	<0.001
Control group	30	7.45 ± 1.40	7.42 ± 1.45	0.052	>0.05	-	-

Table 3. Comparison of memory scores between the two groups (mean ± SD)

Group	n	Before intervention	After intervention	*t* (within-group)	*P* (within-group)	*t* (between-group, post-intervention)	*P* (between-group, post-intervention)
Intervention group	30	2.40 ± 0.50	2.85 ± 0.35	6.114	<0.001	4.038	<0.001
Control group	30	2.38 ± 0.52	2.40 ± 0.50	0.021	>0.05	-	-

Table 4. Comparison of attention scores between the two groups (mean ± SD)

Group	n	Before intervention	After intervention	*t* (within-group)	*P* (within-group)	*t* (between-group, post-intervention)	*P* (between-group, post-intervention)
Intervention group	30	1.82 ± 0.60	2.30 ± 0.45	5.383	<0.001	3.359	0.004
Control group	30	1.79 ± 0.62	1.63 ± 0.68	0.85	>0.05	-	-

Table 5. Comparison of calculation ability scores between the two groups (mean ± SD)

Group	n	Before intervention	After intervention	*t* (within-group)	*P* (within-group)	*t* (between-group, post-intervention)	*P* (between-group, post-intervention)
Intervention group	30	2.00 ± 0.70	2.30 ± 0.55	2.858	<0.01	2.351	<0.05
Control group	30	2.00 ± 0.79	2.17 ± 0.79	0.044	>0.05	-	-

Table 6. Comparison of language fluency scores between the two groups (mean ± SD)

Group	n	Before intervention	After intervention	*t* (within-group)	*P* (within-group)	*t* (between-group, post-intervention)	*P* (between-group, post-intervention)
Intervention group	30	8.69 ± 0.30	8.95 ± 0.15	5.888	<0.001	4.603	<0.001
Control group	30	8.65 ± 0.32	8.63 ± 0.35	0.028	>0.05	-	-

Table 7. Comparison of recall ability scores between the two groups (mean ± SD)

Group	n	Before intervention	After intervention	*t* (within-group)	*P* (within-group)	*t* (between-group, post-intervention)	*P* (between-group, post-intervention)
Intervention group	30	2.12 ± 0.65	2.90 ± 0.30	8.095	<0.001	5.738	<0.001
Control group	30	2.11 ± 0.67	2.16 ± 0.65	0.061	>0.05	-	-

Table 8. Comparison of MMSE total scores between the two groups (mean ± SD)

Group	n	Before intervention	After intervention	*t* (within-group)	*P* (within-group)	*t* (between-group, post-intervention)	*P* (between-group, post-intervention)
Intervention group	30	24.53 ± 1.42	28.50 ± 1.15	18.515	<0.001	11.782	<0.001
Control group	30	23.38 ± 1.40	24.41 ± 1.50	0.081	0.936	-	-

3.3. ADL score and quality of life indicators

After intervention, the ADL score of the intervention group increased significantly from 49.53 ± 2.47 to 68.08 ± 4.55 ($t = 11.161$, $P < 0.001$), while the control group showed a smaller increase from 50.11 ± 2.43 to 60.05 ± 2.94 ($t = 14.274$, $P < 0.001$). The post-intervention ADL score of the intervention group was significantly higher than that of the control group ($t = 8.125$, $P < 0.001$) (**Table 9**).

In the intervention group, the completion rate of instrumental activities of daily living increased from 28% to 65%, and the incidence of falls decreased by 54% (from 18 cases to 8 cases). No significant changes were observed in the control group.

Table 9. Comparison of ADL scores between the two groups (mean ± SD)

Group	n	Before intervention	After intervention	*t* (within-group)	*P* (within-group)	*t* (between-group, post-intervention)	*P* (between-group, post-intervention)
Intervention group	30	49.53 ± 2.47	68.08 ± 4.55	27.842	<0.001	15.796	<0.001
Control group	30	50.11 ± 2.43	52.12 ± 3.15	2.760	<0.01	-	-

4. Discussion

This study confirms that the multidimensional wellness model (integrating cognitive training, rTMS, chronic disease management, nutrition, exercise, and social support) significantly improves cognitive function and quality of life in elderly MCI patients, which is consistent with the findings of previous studies [2,6,14]. The underlying mechanisms may be related to enhanced neuroplasticity, targeted activation of brain regions, and synergistic effects of multidimensional interventions.

First, structured cognitive training directly targets core cognitive domains: memory training activates hippocampal function (a key brain region for memory encoding and retrieval) [9,13], orientation training enhances functional integration of the cerebral cortex through multisensory stimulation [6], and computational training improves information processing efficiency [15]. Second, rTMS targeting the left DLPFC (a core region for executive function) significantly improves language fluency and calculation ability, which may be attributed to enhanced neural connectivity and synaptic plasticity in the prefrontal cortex [15]. Third, the synergistic effect of multidimensional interventions amplifies the effectiveness of single-domain measures: for example, nutritional support (e.g., ω-3 fatty acids) provides a physiological basis for neural repair [4], while exercise improves cerebral blood flow and promotes the release of neurotrophic factors [6], collectively enhancing the brain's adaptive capacity.

4.1. Practical implications

The findings of this study have important practical implications for elderly MCI management in nursing homes

and community settings:

Nursing home application: Nursing homes can adopt the PEAKS intervention framework to establish standardized multidimensional care protocols, integrating cognitive training, chronic disease management, and social activities into daily care. Given the limited resources in many nursing homes, priority can be given to low-cost, easy-to-implement measures such as structured cognitive training, Baduanjin exercise, and nostalgia music therapy, with rTMS and personalized nutrition plans introduced based on resource availability.

Community-based care: The model can be adapted for community health service centers, providing home-based or centralized interventions for elderly MCI patients who do not reside in nursing homes. For example, community health workers can conduct regular cognitive training and exercise guidance while collaborating with tertiary hospitals to provide rTMS and multidisciplinary consultation services.

Policy support: Policymakers should strengthen investment in non-pharmacological interventions for MCI, including training professional personnel (e.g., cognitive trainers, rehabilitation therapists), formulating intervention guidelines, and promoting the popularization of multidimensional care models in primary medical and health institutions.

4.2. Study limitations

This study has several limitations that need to be addressed in future research:

Sample size and generalizability: The sample size was relatively small ($n = 60$) and all participants were from a single nursing home, which may limit the generalizability of the results. Future studies should adopt multicenter, large-sample designs to include patients from different regions, nursing homes, and community settings.

Intervention duration and long-term effects: The 3-month intervention period only reflects short-term effects. It remains unclear whether the benefits of the multidimensional model can be sustained. Subsequent studies should extend the intervention and follow-up duration (e.g., 12–24 months) to evaluate long-term effectiveness and maintenance strategies.

Assessment indicators: This study primarily used subjective scales (MMSE, ADL) for assessment. Future research should integrate objective indicators such as neuroimaging (e.g., fMRI, EEG) and biomarkers (e.g., BDNF, tau protein) to explore the neural mechanisms of the intervention and improve the accuracy of effect evaluation [1].

Blinding limitations: Due to the nature of the intervention (e.g., exercise, social activities), it was not possible to blind patients and caregivers, which may introduce performance bias. Future studies can use sham rTMS for the control group and standardize non-specific intervention factors (e.g., attention from researchers) to reduce bias.

5. Conclusion

The multidimensional wellness model effectively improves cognitive function (orientation, memory, attention, calculation, language, recall) and quality of life (daily living abilities, fall prevention) in elderly MCI patients, demonstrating significant clinical value and feasibility in nursing home settings.

To promote the widespread application of this model, the following recommendations are proposed:

For healthcare professionals: Nursing home and community health workers should receive specialized training on the multidimensional wellness model to master core intervention techniques (e.g., cognitive training design, rTMS operation) and conduct personalized interventions based on patients' characteristics.

For institutions: Nursing homes and community health service centers should establish dedicated MCI intervention teams, allocate special funds and venues, and integrate the multidimensional model into routine care workflows.

For policymakers: Formulate relevant policies to support the promotion of non-pharmacological interventions for MCI, including incorporating the multidimensional care model into elderly health service standards, providing financial subsidies for intervention implementation, and encouraging multicenter collaborative research.

Future research directions: Conduct multicenter, large-sample, long-term follow-up studies to verify the generalizability and sustainability of the model; explore the optimal combination of intervention components (e.g., frequency, duration of cognitive training) for different subgroups (e.g., different ages, disease severity); and develop intelligent intervention tools (e.g., mobile apps, VR devices) to improve intervention accessibility and adherence.

In an aging society, the multidimensional wellness model provides a new approach for MCI management, contributing to the realization of healthy aging and the reduction of social health burdens.

Disclosure statement

The authors declare no conflict of interest.

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