Effect of Montessori method on the cognitive and behavioral intervention of senile dementia patients: a meta-analysis

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Abstract
Background: To evaluate the effect of Montessori method on cognitive and behavioral function in patients with senile dementia by meta-analysis. Methods: The randomized controlled trials of the effect of Montessori method on cognitive and behavioral functions of Alzheimer’s patients in PubMed, Cochrane Library, Web of Science, Excerpt Medica Database, The Cumulative Index to Nursing & Allied Health Literature, Chinese BioMedical Literature Database, China National Knowledge Infrastructure, Weipu Information Chinese Periodical Service Platform database and Wanfang database were searched by computer, and the references of relevant literatures were traced. Two researchers independently conducted literature screening, data extraction, evaluation and inclusion in the literature, using RevMan 5.4.1 software for meta-analysis. Results: A total of 11 literatures were included and 936 patients were enrolled. Meta analysis shows that compared with routine nursing, Montessori method is helpful to improve the overall cognitive function (standardized mean difference = 1.53, 95% confidence interval (1.32, 1.73), P < 0.01), activities of daily living and reduce the incidence of adverse events (relative risk = 0.37, 95% confidence interval (0.21, 0.63), P < 0.01) in patients with Alzheimer’s disease. Conclusion: Montessori method is helpful to improve the overall cognitive function, activities of daily living and reduce the incidence of adverse events in patients with senile dementia. Affected by the included study, it still needs to be confirmed by multi center and large sample randomized controlled study.

Keywords: Montessori method; cognitive function; behavioral intervention; senile dementia; nursing
Highlights
This meta-analysis systematically evaluates the cognitive and behavioral effect of Montessori education in patients with Alzheimer's disease. The results show that Montessori education is helpful to improve the overall cognitive function, activities of daily living and reduce the incidence of adverse events.

Background
Statistics show that the prevalence of Alzheimer's disease is increasing year by year. It is estimated that by 2050, the number of people with dementia in the world will reach 152 million [1]. The most common typical symptoms of Alzheimer's disease patients are cognitive impairment. Patients have obvious symptoms such as memory loss, cognitive impairment, aphasia, apraxia and agnosia, reduced quality of life and increased the burden of family and society [2]. At present, there is no effective drug treatment for dementia. Most drugs can only temporarily alleviate symptoms, and there will be some adverse reactions after long-term use [3]. Studies have shown that non drug treatment is more conducive to reducing the frequency of dementia symptoms than drug treatment [4]. The study pointed out that Montessori method can be applied to patients with dementia and effectively improve their cognitive ability and bad behavior. At present, several studies have been conducted in China and abroad to investigate the effectiveness of Montessori method in patients with dementia. However, there is still a lack of meta-analysis of the intervention effect of Montessori on dementia patients at home and abroad. Therefore, the research on the impact of Montessori on the outcome of dementia patients is still worthy of in-depth discussion. This study evaluated the effect of Montessori method on cognition and behavior of dementia patients through meta-analysis, so as to provide reference for the implementation of Montessori education method for dementia patients in China in the future.

Methods
Inclusion and exclusion criteria
Inclusion criteria (1) Study design: All the included studies are Randomized Controlled Trial (RCT) of the effect of Montessori on cognitive and behavioral function in patients with Alzheimer's disease, and the language is limited to Chinese or English. (2) Participants: Patients is diagnosed with Alzheimer's disease according to the diagnostic criteria of the international classification of diseases of the World Health Organization. (3) Intervention measures: The control group adopted routine nursing measures (such as diet nursing, rehabilitation training, etc.); The experimental group was treated with Montessori method on the basis of the control group. The Montessori method adopted by the experimental group includes sensory education, life education, language education, mathematics education and science and culture education. (4) Outcome measures: The primary outcome measure was the Mini mental state examination scale, and the secondary outcome measures were the Activity of daily living score (ADL) scale and the Incidence of adverse events, etc.
Exclusion criteria (1) Patients with other serious mental diseases and severe diseases; (2) Republished literature; (3) There was no literature related to outcome indicators; (4) Incomplete original data or data cannot be extracted; (5) Unable to get full text.

Retrieval strategy
PubMed, Cochrane Library, Web of Science, Excerpt Medica Database, The Cumulative Index to Nursing & Allied Health Literature, Chinese Biomedical Literature Database, China National Knowledge Infrastructure, Weipu Information Chinese Periodical Service Platform database and Wanfang database were searched by computer to find the RCT on the effects of Montessori method on cognitive and behavioral functions of patients with Alzheimer's disease. The retrieval time was from the establishment of the database to March 2022. In addition, the references included in relevant literatures were traced, The English search words are (“Montessori”) and “Alzheimer disease” or “Alzheimer dementia” or “dementia” or “sentile dementia”).

Literature screening and data extraction
Two researchers extracted data according to the developed data extraction table. The extraction content: the basic information included in the study, including the first author and publication time; The basic information of patients in the experimental group and the control group, including the number of cases, age, treatment time limit, outcome indicators.

Literature quality evaluation
The evaluation of literature quality was carried out by two researchers according to the evaluation criteria formulated by Cochrane Collaboration Network for RCT. The evaluators need to make judgments on low risk of bias, high risk of bias and unclear in each aspect. If the study fully meets these criteria, the possibility of bias is small; if the study part meets this criterion, the possibility of bias is medium; if the above criteria are not met at all, the possibility of bias is high. In case of disagreement, a third party needed to decide whether to include the study.

Data analysis method
Revman 5.4.1 provided by Cochrane Collaboration Network is adopted. The software performs meta-analysis on the data. Binary variable was analyzed by relative risk. For continuous data, if the same measurement tool is used in the literature, the weighted mean difference is used for analysis; if different measurement tools are used, the standardized mean difference (SMD) is used for analysis. 95% confidence interval (95% CI) was calculated for all analyses. When $P > 0.1$ and $I^2 < 50\%$, it is considered that there is homogeneity among the studies, and the fixed effect model is selected for meta-analysis; if $P < 0.1$ and $I^2 \geq 50\%$, it is judged that there is heterogeneity, and the random effect model is used for meta-analysis. If appropriate, subgroup analysis is made according to the source of heterogeneity. If necessary, sensitivity analysis shall be used to test the stability of the results. If the source of heterogeneity cannot be judged, meta-analysis will be abandoned and descriptive research will be used.

Results
General information included in the study
In the initial examination, 416 documents were obtained, including 332 in English and 84 in Chinese. Finally, 11 documents were obtained. The document screening process and results are shown in Figure 1.

Basic characteristics and methodological quality of the included research
A total of 11 literatures and 936 patients were included in this study. The basic characteristics of the included literature are shown in Table 1. According to the quality evaluation method of Cochrane Handbook, the quality of literature is evaluated and graded. The overall qualities were all B grade, as shown in Figure 2.

Meta analysis results
Effect of Montessori method on cognition of patients with senile dementia A total of 9 literatures reported the cognition of dementia patients [5–8, 11–15]. There was heterogeneity among the studies ($I^2 = 94\%$, $P < 0.01$). Sensitivity analysis of the included studies found that the heterogeneity comes from the studies of Chen WW, Hu HJ, Xiao YQ [11–13]. After exclusion, there was no heterogeneity among the studies ($I^2 = 0\%$, $P = 0.62$), so fixed effect model was used for meta-analysis. The results showed that the effect of Montessori
Figure 1 Flow chart and results of literature screening. EMBASE, Excerpt Medica Database; CINAHL, The Cumulative Index to Nursing & Allied Health Literature; CBM, Chinese BioMedical Literature Database; CNKI, China National Knowledge Infrastructure; VIP, Weipu Information Chinese Periodical Service Platform.

Table 1 Basic characteristics of the included studies

| Study, Year | Number (T/C) | Age (T/C) | Time (month) | Outcome indicator |
|-------------|--------------|-----------|--------------|-------------------|
| Tao ZP [5]; 2018 | 40/40 | 71.2 ± 5.3/71.5 ± 5.1 | - | ①③ |
| Wang H [6]; 2018 | 40/40 | 70.24 ± 1.34 | 6 | ①② |
| Cai QY [7]; 2018 | 25/25 | 68.94 ± 2.73/66.76 ± 2.71 | 6 | ①② |
| Xing YP [8]; 2019 | 45/45 | 72.21 ± 4.43/73.30 ± 4.23 | 3 | ①③ |
| Zhang YM [9]; 2019 | 56/57 | 69.2 ± 1.3/70.3 ± 1.2 | 2 | ②③④ |
| Zhang HR [10]; 2020 | 58/58 | 79.26 ± 6.15/79.31 ± 6.11 | 6 | ②③④ |
| Xiao YQ [11]; 2020 | 45/45 | 82.13 ± 7.28/82.37 ± 7.26 | 10 | ①② |
| Hu HJ [12]; 2020 | 30/30 | 68.60 ± 1.50/68.10 ± 1.40 | 3 | ①② |
| Chen WW [13]; 2020 | 45/45 | 71.8 ± 4.6/72.6 ± 4.8 | - | ①③ |
| Zhao LR [14]; 2020 | 60/60 | 70.9 ± 19.8/69.8 ± 20.9 | 6 | ②③ |
| Guo Z. [15]; 2018 | 23/24 | 77.70 ± 4.8/76.21 ± 4.62 | 3 | ①② |

T, Test group; C, Control group; ① Mini mental state examination scale; ② ADL; ③ Incidence of adverse events; ④ Senile dementia quality of life scale; ⑤ Montreal Cognitive Assessment; ⑥ Nurses’ Observation Scale for Inpatient Evaluation.

Figure 2 Quality evaluation of included literature
method in improving the cognition of patients with Alzheimer’s disease in the observation group was better than that in the control group ($SMD = 1.53$, 95% CI (1.32, 1.73), $P < 0.01$). The difference was statistically significant, as shown in Figure 3. In order to explore the effect of Montessori on Alzheimer’s patients, subgroup analysis was used in this study. Zhang HR and Zhang YM used Montreal Cognitive Assessment to measure the cognitive function of patients [9, 10]. The results also showed that Montessori method can improve the cognitive level of patients ($SMD = 0.50$, 95% CI (0.37, 0.64), $P < 0.01$), see Figure 4.

**Effect of Montessori on activities of daily living in patients with senile dementia** Since the six included studies used different ADL scales, this study conducted subgroup analysis according to the evaluation scale, as shown in Table 2 [6, 7, 9–12]. The results showed that compared with the control group, the effect of Montessori method in improving the ability of daily living of Alzheimer’s patients in the observation group was better than that in the control group ($P < 0.01; P = 0.25$).

**Effect of Montessori on adverse events in patients with Alzheimer’s disease** Three literatures were included to record the occurrence of adverse events in patients with dementia [5, 8, 13]. The results showed that the effect of Montessori method in the observation group on improving the cognition of patients with Alzheimer’s disease was better than that in the control group (relative risk = 0.37, 95% CI (0.21, 0.63), $P < 0.01$). The difference was statistically significant, as shown in Figure 5.

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**Table 2** Subgroup analysis of Montessori method on activities of daily living in patients with senile dementia

| Project                | Group              | Number of studies | Effect quantity | Effect model | Heterogeneity |
|------------------------|--------------------|-------------------|-----------------|--------------|---------------|
| Ability of daily living| ADL scale          | 3                 | 0.97 (0.69, 1.26) | $< 0.01$ | FE | 88 | 16.4 | $< 0.01$ |
|                        | ADL scale (Barthel Index) | 3 | $-1.26$ ($-1.52$, $-1.00$) | 0.52 | FE | 0 | 1.3 | $< 0.01$ |

ADL, Activity of daily living; SMD, standardized mean difference; CI, confidence interval; FE, fixed effect.

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Sensitivity analysis
The stability of meta-analysis results was evaluated by sensitivity analysis. The main outcome indicators of cognitive and activities of daily living of patients with Alzheimer’s disease were excluded one by one. The results showed that the combined effect of the included study had not changed, indicating that the meta-analysis results of this study were stable and effective.

Discussion
Montessori method can improve the cognitive level of patients
The results of this study showed that the cognitive level of patients in the observation group was significantly different from that in the control group. This is consistent with the research of Du HD [16].
Dementia takes cognitive impairment as the core. Patients have typical symptoms such as memory impairment, aphasia and loss of use, which not only seriously affect the quality of life of patients, but also bring a heavy burden to caregivers. The intervention method based on Montessori education theory emphasizes the coordinated development of many aspects, which can improve the cognitive ability of Alzheimer’s patients more effectively than single training. At present, Montessori method has been carried out more abroad and applied in China in recent years, but the specific process of nursing staff in the implementation of Montessori method needs to be further standardized.

Effect of Montessori on activities of daily living in patients with Alzheimer’s disease
The results of this study show that Montessori method can improve the ability of daily living of patients. Research pointed out that ADL requires complex cognitive processes, and the improvement of cognitive function contributes to the improvement of ADL [17]. Montessori method takes teaching aids that can stimulate patients’ senses as the medium, and improves the comprehensive ability of educational objects through orderly and targeted training, so as to improve the quality of life of patients with Alzheimer’s disease and delay the disease process [18]. Sensory education activities are in the form of collective or competition entertainment, while giving individual guidance, continuous material encouragement, creating a harmonious atmosphere, enhancing the communication relationship between doctors and patients, and mobilizing the enthusiasm of patients to participate in activities, which is conducive to promoting patients’ emotional expression, enhancing self-confidence, willing to cooperate with their families and try to complete their daily activities in daily life, which indirectly promotes the improvement of ADL ability.

Effect of Montessori on adverse events in patients with Alzheimer’s disease
The results of this study show that Montessori can reduce the incidence of adverse events, which is consistent with the study of Thierry [19]. With the change of time and place, the memory ability of patients with Alzheimer’s disease decreases, poor or even completely lost. In addition, the flexibility of patients’ response to external things decreases. Simple clinical nursing work is passive and inefficient, and it is easy to have adverse events that harm patients in nursing [20]. Montessori education can exercise patients’ motor function, thinking ability and other related factors, enhance patients’ self-management ability, and then improve safety.

Limitations of this study
All the studies included in this study are Chinese literature, which may have some deviation. Foreign studies tend to adopt time series design for the same group of people and it’s not a RCT, so they are not included in this study. Most patients with Alzheimer’s disease included in the study are light and medium-sized, and there is a vacancy in the intervention research of patients with severe Alzheimer’s disease. In addition, it is found that this study only searched Chinese and English literature, and other languages may be omitted. Although meta-analysis involves cognitive function, ADL and the incidence of adverse events, but the included studies were all Chinese literature, which may have a certain offset. Therefore, more large sample studies are needed to verify the results.

Summary
This meta-analysis shows that Montessori method is helpful to improve the cognitive function and ADL of patients with Alzheimer’s disease, and provides a potentially effective intervention strategy for improving the cognitive function and ADL of patients. The current research in mainland China is mainly focused on cognitive function, while Taiwan, China mainly focuses on diet behaviors and mental health of dementia patients. However, the nursing of dementia patients in China is mainly family nursing, and there is a lack of nursing model based on Montessori principle suitable for China’s national conditions. It needs to be further discussed and studied to localize Montessori intervention.

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