Postprint of a Meta-Analysis of the Effects of Exercise Interventions Under Community Health Worker Management on Type 2 Diabetes Mellitus

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Abstract

Background Patients with type 2 diabetes mellitus (T2DM) typically lack sufficient awareness of safe exercise practices and exhibit low exercise adherence, necessitating professional exercise intervention management to better improve their condition. A noteworthy strategy involves utilizing community health workers to provide exercise intervention management for patients. Currently, research on exercise intervention management is scarce, and studies on health management for T2DM patients typically mention exercise without specifying concrete exercise management protocols, leaving a gap in relevant quantitative systematic evaluations. Objective To systematically evaluate the health impacts of exercise interventions managed by community health workers on patients with type 2 diabetes mellitus and to delineate specific exercise intervention protocols. Methods A computerized search of eight Chinese and English databases, including PubMed, Cochrane Library, Web of Science, Embase, CNKI, Wanfang Data Knowledge Service Platform, VIP, and the Chinese Biomedical Literature Database (CBM), was conducted to screen randomized controlled trials examining the effects of exercise interventions managed by community health workers on T2DM patients. The intervention group received exercise intervention protocols managed by community health workers, while the control group received routine care. The search timeframe spanned from database inception to October 17, 2022. Literature screening, quality assessment, and data extraction were performed independently by two researchers. Meta-analysis was conducted using RevMan 5.4 and Stata 15.1 software. Heterogeneity sources were identified through subgroup analysis and sensitivity analysis. Predetermined subgroups included intervention duration (3 months, 6 months, >6 months), exercise frequency (3 times/week, >3 times/week), and single-session

exercise duration ($ $30 min/session, >30 min/session). Results This study ultimately included 11 articles, comprising a total of 1,079 participants, with 550 in the intervention group and 529 in the control group. Meta-analysis results demonstrated that exercise interventions under the community health worker management model were more effective than the control group in reducing glycated hemoglobin (MD=-1.07, 95%CI=-1.31~-0.83, P<0.00001), fasting blood glucose (MD=-1.26, 95%CI=-1.57~-0.96, P<0.00001), 2-hour postprandial blood glucose (MD=-1.47, 95%CI=-1.90~-1.04, P<0.00001), total cholesterol (MD=-1.02, 95%CI=-1.52~-0.51, P<0.0001), low-density lipoprotein (MD=-0.62, 95%CI=-0.87~-0.37, P<0.00001), and triglyceride levels (MD=-0.71, 95%CI=-1.13~-0.28, P=0.001) in T2DM patients, while showing no significant difference in high-density lipoprotein improvement (MD=0.09, 95%CI=-0.02~0.21, P=0.11). Subgroup analysis revealed that, compared with an exercise frequency of 3 times/week, a frequency of >3 times/week yielded more significant improvements in total cholesterol (P=0.02); compared with a single-session duration of $ $30 min/session, a duration of >30 min/session produced more significant improvements in 2-hour postprandial blood glucose (P=0.001); and compared with intervention durations of 6 months or longer, a 3-month exercise intervention demonstrated more significant improvements in glycated hemoglobin (P<0.00001) and triglycerides (P=0.008). Egger' s test indicated no significant publication bias for glycated hemoglobin (P=0.34) or fasting blood glucose (P=0.281). Evidence quality assessment results showed that glycated hemoglobin and fasting blood glucose were of low certainty, while 2-hour postprandial blood glucose and lipid-related outcome measures were of very low certainty. Conclusion Exercise interventions managed by community health workers can significantly improve glycemic and lipid profiles in patients with type 2 diabetes mellitus. Community health workers should design exercise protocols for future T2DM exercise intervention management following the recommendations of >30 min/session, >3 times/week, and lasting $ $3 months for aerobic exercise interventions. For T2DM patients with concurrent dyslipidemia, it is recommended that the exercise intervention duration be sustained for 6 months or longer.

Full Text

Effect of Exercise Interventions Based on Community Health Workers' Management on Type 2 Diabetes Mellitus: A Meta-analysis

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Abstract

Background: Patients with type 2 diabetes typically lack sufficient awareness of safe exercise practices and demonstrate poor exercise compliance, necessitating professional management of exercise interventions to improve their health outcomes. A promising strategy involves utilizing community health workers to provide exercise intervention management. However, research on exercise intervention management remains limited, and studies on health management for type 2 diabetes often mention exercise only in general terms without specifying concrete management protocols. Moreover, quantitative systematic reviews on this topic are lacking.

Objective: To systematically evaluate the health effects of exercise interventions managed by community health workers on patients with type 2 diabetes and to identify specific exercise intervention protocols.

Methods: Eight Chinese and English databases (PubMed, Cochrane Library, Web of Science, Embase, CNKI, Wanfang Data, VIP, and CBM) were searched from inception to October 17, 2022, for randomized controlled trials examining exercise interventions under community health worker management for type 2 diabetes. The intervention groups received exercise interventions managed by community health workers, while control groups received usual care. Literature screening, quality assessment, and data extraction were performed independently by two researchers. Meta-analysis was conducted using RevMan 5.4 and Stata 15.1 software. Heterogeneity sources were explored through subgroup and sensitivity analyses. Pre-specified subgroups included intervention duration (3 months, 6 months, >6 months), exercise frequency (3 times/week, >3 times/week), and single session duration ($ $30 min/session, >30 min/session).

Results: Eleven studies with 1,079 participants were included (550 in intervention groups, 529 in control groups). Meta-analysis showed that community health worker-managed exercise interventions were more effective than control groups in reducing glycated hemoglobin (MD=-1.07, 95%CI=-1.31~-0.83, P<0.00001), fasting blood glucose (MD=-1.26, 95%CI=-1.57~-0.96, P<0.00001), 2-hour postprandial glucose (MD=-1.47, 95%CI=-1.90~-1.04, P<0.00001), total cholesterol (MD=-1.02, 95%CI=-1.52~-0.51, P<0.0001), low-density lipoprotein (MD=-0.62, 95%CI=-0.87~-0.37, P<0.00001), and triglyceride levels (MD=-0.71, 95%CI=-1.13~-0.28, P=0.001). No significant difference was observed in high-density lipoprotein improvement (MD=0.09, 95%CI=-0.02~0.21, P=0.11). Subgroup analyses revealed that exercise frequency >3 times/week produced greater improvements in total cholesterol compared to 3 times/week (P=0.02), and single sessions >30 min showed greater improvements in 2-hour postprandial glucose compared to $ $30 min (P=0.001). Compared to interventions lasting 6 months or longer, 3-month interventions showed more significant improvements in glycated hemoglobin (P<0.00001) and triglycerides (P=0.008). Egger' s test indicated no significant publication bias for glycated hemoglobin (P=0.34) or fasting blood glucose

(P=0.281). GRADE evidence quality assessment showed low-quality evidence for glycated hemoglobin and fasting blood glucose, and very low-quality evidence for 2-hour postprandial glucose and lipid-related outcomes.

Conclusion: Community health worker-managed exercise interventions can significantly improve glycemic and lipid levels in patients with type 2 diabetes. For future exercise intervention management, community health workers should develop aerobic exercise protocols of >30 min/session, >3 times/week, for $ $3 months. For patients with concurrent dyslipidemia, intervention duration should ideally exceed 6 months.

Keywords: Diabetes mellitus, type 2; Exercise interventions; Community health workers; Management; Meta-analysis

1. Introduction

Type 2 diabetes is a metabolic disorder characterized by chronically elevated blood glucose levels due to insufficient insulin secretion from pancreatic β-cells [1]. Recent epidemiological data indicate that the number of diabetes patients in China will exceed 140 million in 2021, with the International Diabetes Federation (IDF) projecting this will surpass 174 million by 2045, the vast majority being type 2 diabetes cases [2]. Without appropriate treatment and management, the epidemic of diabetes and its complications will place enormous pressure on China' s healthcare system [3].

Numerous studies have confirmed that exercise provides substantial benefits for glycemic and lipid metabolism, inflammatory factors, and vascular function maintenance in type 2 diabetes patients [4-8]. However, current research shows these patients often lack adequate awareness of safe exercise practices and demonstrate poor exercise compliance, requiring professional management of exercise interventions to improve their condition [9-11]. With a large diabetic population and severe shortages of specialists in tertiary hospitals, coupled with heavy workloads among frontline medical staff, comprehensive exercise guidance is often unfeasible [12]. Consequently, community health workers at community health service centers play an irreplaceable role in exercise intervention management for type 2 diabetes [13].

Current research on exercise interventions for type 2 diabetes primarily focuses on exercise types [7,14-15], with limited attention to management models [16]. Although studies have demonstrated the important role of community health workers in comprehensive diabetes management [17-18], many management studies only mention exercise recommendations without specifying concrete exercise intervention protocols [17,19-20], resulting in a lack of research evidence on exercise intervention management. Furthermore, quantitative systematic reviews are currently unavailable. Therefore, this study conducted a meta-analysis of relevant literature to explore the effects of community health

worker-managed exercise interventions on type 2 diabetes patients, providing theoretical and evidence-based support for exercise intervention management models.

2. Methods

This study followed the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) checklist [21] and is registered with PROSPERO (CRD42023434588).

2.1 Search Strategy

Eight Chinese and English databases were searched from inception to October 17, 2022: PubMed, Cochrane Library, Web of Science, Embase, CNKI, Wanfang Data, VIP, and CBM. A combination of MeSH terms and free-text terms was used with database-specific search strategies. Chinese search terms included "2 型糖尿病" (type 2 diabetes), "运动" (exercise), and "社区" (community). English search terms included "Diabetes Mellitus, Type 2," "Exercise," and "community." The specific PubMed search strategy is shown in Table 1 .

2.2 Inclusion and Exclusion Criteria

Inclusion criteria: (1) Participants: diagnosed type 2 diabetes patients (age $ $18 years); (2) Interventions: >50% of interventions were exercise-based with specific protocols, conducted in community settings; (3) Control groups: no exercise intervention or exercise management, or usual care; (4) Management model: exercise interventions managed by community health workers (community doctors, nurses, volunteers, or researchers) providing continuous management and follow-up according to specialist prescriptions, developing individualized exercise plans, and offering guidance/supervision during exercise; (5) Study design: randomized controlled trials (RCTs); (6) Outcomes: primary outcomes included glycated hemoglobin, fasting blood glucose, and 2-hour postprandial glucose; secondary outcomes included total cholesterol, high-density lipoprotein, low-density lipoprotein, and triglycerides; (7) Language: Chinese or English.

Exclusion criteria: (1) Patients unsuitable for exercise due to acute/chronic diseases, severe complications, or other serious conditions; (2) Interventions mentioning exercise without specific protocols; (3) Duplicate publications (most complete dataset included); (4) Conference abstracts without full text; (5) Unavailable full text or incomplete data.

2.3 Literature Screening and Data Extraction

Two researchers independently conducted literature screening and data extraction using standardized forms. Extracted data included study characteristics, baseline information, intervention details (exercise type, duration, frequency), management approaches, outcome indicators (glycemic and lipid parameters),

adverse events, and descriptive statistics (means and standard deviations). Discrepancies were resolved through discussion or consultation with a third researcher.

2.4 Quality Assessment

Two researchers independently assessed risk of bias using the Cochrane tool [22], evaluating: selection bias (randomization and allocation concealment), performance bias (blinding of participants and personnel), detection bias (outcome assessment), attrition bias (incomplete outcome data), reporting bias (selective reporting), and other biases. Each domain was rated as low, high, or unclear risk. Disagreements were resolved through discussion or by a third assessor.

2.5 Evidence Quality Evaluation

Two researchers independently used the GRADE system to assess overall evidence quality, with results presented in summary tables generated by GRADEpro GDT. Discrepancies were resolved through discussion or consultation with a third researcher.

2.6 Statistical Analysis

Meta-analysis was performed using RevMan 5.4 and Stata 15.1. Mean difference (MD) was used for continuous outcomes with 95% confidence intervals (CI). Statistical significance was set at P<0.05. Heterogeneity was assessed using I^2 and Q tests. Random-effects models were used for substantial heterogeneity (I^2\$ 50 0.10), $otherwise fixed - effects models were applied (I\hat{}\{2\}<$ 50 \$30 min/session, >30 min/session). Sensitivity analysis was conducted by sequentially excluding studies to assess result robustness. Publication bias was evaluated using funnel plots and Egger' s test.

3. Results

3.1 Literature Search Results

The database search yielded 12,693 records: PubMed (n=1,174), Embase (n=2,689), Web of Science (n=3,784), Cochrane Library (n=1,243), CNKI (n=915), VIP (n=93), Wanfang (n=1,756), and CBM (n=1,039). An additional 22 records were identified through other sources. After removing duplicates (n=4,264) and applying inclusion/exclusion criteria, 11 studies [24-34] with 1,079 participants (550 intervention, 529 control) were included. The screening process is illustrated in Figure 1 [Figure 1: see original paper].

3.2 Characteristics of Included Studies

The 11 included studies comprised 1,079 participants. Detailed characteristics are presented in Table 2 . Exercise interventions primarily included walking,

yoga, tai chi, and aerobic training, with frequencies ranging from 3 to $ $5 times/week and durations from 12 weeks to 12 months. Community health workers included community doctors, nurses, volunteers, and research teams who provided supervision, developed individualized plans, and conducted follow-up.

3.3 Quality Assessment

Of the 11 studies, 10 reported randomization methods [24,26-34], while one did not specify the method [25] (rated as unclear risk). Only one study [25] described allocation concealment; the remainder did not, resulting in unclear risk ratings. Regarding blinding, only one study [25] implemented blinding, while another [24] was rated high risk for lack of blinding; others did not mention blinding. Seven studies [24-28,31,33] used objective measurement instruments (low risk for detection bias), while others had subjective components (unclear risk). All studies reported attrition rates without attrition bias. No selective outcome reporting was detected (low risk). Other biases were rated low risk across all studies. The risk of bias assessment is shown in Figure 2 [Figure 2: see original paper].

3.4 Meta-Analysis Results

3.4.1 Glycated Hemoglobin Nine studies [24,26,28-34] with 965 participants reported glycated hemoglobin. High heterogeneity was observed (I^2=91%), requiring a random-effects model. The intervention group showed significantly greater improvement than controls (MD=-1.07, 95%CI=-1.31~-0.83, P<0.00001). Sensitivity analysis identified two studies [30-31] contributing to heterogeneity; their removal reduced I^2 to 16% with minimal effect size change (MD=-1.03, 95%CI=-1.16~-0.91, P<0.00001) (Figure 3 [Figure 3: see original paper]).

3.4.2 Fasting Blood Glucose Eleven studies [24-34] with 1,079 participants reported fasting blood glucose. High heterogeneity was observed (I^2=77%), requiring a random-effects model. The intervention group showed significantly greater improvement (MD=-1.26, 95%CI=-1.57~-0.96, P<0.00001). Sensitivity analysis identified two studies [26,31] contributing to heterogeneity; their removal reduced I^2 to 57% with minimal effect size change (MD=-1.27, 95%CI=-1.65~-0.90, P<0.00001) (Figure 4 [Figure 4: see original paper]).

3.4.3 2-Hour Postprandial Glucose Eight studies [26,28-34] with 904 participants reported 2-hour postprandial glucose. High heterogeneity was observed (I^2=70%), requiring a random-effects model. The intervention group showed significantly greater improvement (MD=-1.47, 95%CI=-1.90~-1.04, P<0.00001). Sensitivity analysis identified two studies [26,32] contributing to heterogeneity; their removal reduced I^2 to 6% but decreased effect size (MD=-1.34, 95%CI=-1.66~-1.02, P<0.00001) (Figure 5 [Figure 5: see original paper]).

3.4.4 Total Cholesterol Five studies [24,26,29,32-33] with 541 participants reported total cholesterol. High heterogeneity was observed (I^2=96%), requiring a random-effects model. The intervention group showed significantly greater improvement (MD=-1.02, 95%CI=-1.52~-0.51, P<0.0001). Sensitivity analysis identified two studies [26,32] contributing to heterogeneity; their removal reduced I^2 to 56% but decreased effect size (MD=-0.62, 95%CI=-0.92~-0.32, P<0.0001) (Figure 6 [Figure 6: see original paper]).

3.4.5 High-Density Lipoprotein Four studies [24,26,29,33] with 461 participants reported high-density lipoprotein. High heterogeneity was observed (I^2=92%), requiring a random-effects model. No significant difference was found between groups (MD=0.09, 95%CI=-0.02~0.21, P=0.11). Sensitivity analysis identified two studies [29,33] contributing to heterogeneity; their removal reduced I^2 to 40% but maintained non-significant differences (MD=-0.01, 95%CI=-0.05~0.03, P=0.59) (Figure 7 [Figure 7: see original paper]).

3.4.6 Low-Density Lipoprotein Five studies [24,26,29,32-33] with 533 participants reported low-density lipoprotein. High heterogeneity was observed (I^2=92%), requiring a random-effects model. The intervention group showed significantly greater improvement (MD=-0.62, 95%CI=-0.87~-0.37, P<0.00001). Sensitivity analysis identified one study [33] contributing to heterogeneity; its removal maintained high heterogeneity (I^2=89%) but increased effect size significance (MD=-0.76, 95%CI=-0.98~-0.53, P<0.00001) (Figure 8 [Figure 8: see original paper]).

3.4.7 Triglycerides Five studies [24,26,29,32-33] with 541 participants reported triglycerides. High heterogeneity was observed (I^2=94%), requiring a random-effects model. The intervention group showed significantly greater improvement (MD=-0.71, 95%CI=-1.13~-0.28, P=0.001). Sensitivity analysis identified one study [32] contributing to heterogeneity; its removal reduced I^2 to 74% but decreased effect size (MD=-0.44, 95%CI=-0.69~-0.19, P=0.0005) (Figure 9 [Figure 9: see original paper]).

3.5 Subgroup Analyses

3.5.1 Exercise Frequency Subgroup analysis by exercise frequency showed that glycated hemoglobin (P=0.45), fasting blood glucose (P=0.12), and 2-hour postprandial glucose (P=0.69) were not differentially affected by frequency. However, frequency >3 times/week produced significantly greater improvements in total cholesterol compared to 3 times/week (P=0.02). Effects on low-density lipoprotein (P=0.27) and triglycerides (P=0.15) were not significantly different between frequencies (Table 3).

3.5.2 Single Session Duration Subgroup analysis by session duration revealed that >30 min sessions produced significantly greater improvements in 2-

hour postprandial glucose compared to $ $30 min (P=0.001). Sessions $ $30 min did not significantly affect total cholesterol (P=0.19) or low-density lipoprotein (P=0.42). Other glycemic and lipid markers were not significantly influenced by session duration (Table 4).

3.5.3 Intervention Duration Subgroup analysis by intervention duration showed that 3-month interventions produced significantly greater improvements in glycated hemoglobin (P<0.00001) and triglycerides (P=0.008) compared to 6-month or longer interventions. Three-month interventions did not significantly improve total cholesterol (P=0.19) or low-density lipoprotein (P=0.42). Other markers were not significantly affected by intervention duration (Table 5).

3.6 Adverse Events

None of the 11 included studies reported adverse events.

3.7 Publication Bias

Only glycated hemoglobin and fasting blood glucose had $ $10 studies available for publication bias assessment [23]. Funnel plots and Egger' s test showed no significant publication bias for glycated hemoglobin (P=0.34) or fasting blood glucose (P=0.281).

3.8 Evidence Quality Assessment

GRADE assessment indicated low-quality evidence for glycated hemoglobin and fasting blood glucose, and very low-quality evidence for 2-hour postprandial glucose and lipid-related outcomes (Table 6).

4. Discussion

While type 2 diabetes is influenced by genetic factors, it is more strongly associated with sedentary lifestyles and improper diet [35]. Scientific exercise is known to play a positive role in diabetes treatment [5-6,14] and constitutes an important component of diabetes management [36]. Integrating regular exercise into patients' lives can effectively improve their condition. Research indicates that professional supervision during community-based exercise interventions benefits glycemic control and disease management [37]. As communities are where patients live long-term, community health worker-managed exercise interventions represent a highly recommended health management strategy.

Community health workers are dedicated personnel with close understanding of their served communities, promoting health through education, assistance, advocacy, social support, informal counseling, and community resource linkage [38]. Current community-based exercise interventions are primarily implemented by community doctors, nurses, volunteers [25,34], or research teams [26,30] who

recruit participants. This meta-analysis of 11 RCTs including 1,079 type 2 diabetes patients demonstrates that community health worker-managed exercise interventions significantly improve glycated hemoglobin, fasting glucose, 2-hour postprandial glucose, total cholesterol, low-density lipoprotein, and triglyceride levels. These findings align with previous systematic reviews on exercise training effects [5-6,8] and community-based comprehensive interventions [37,39], confirming that community health worker-managed exercise is effective for improving glycemic control and delaying disease progression.

Regarding lipid outcomes, unlike previous meta-analyses showing significant improvements across all lipid parameters [8,40], this study found no significant high-density lipoprotein improvement, possibly because participants' baseline high-density lipoprotein levels were predominantly within normal ranges.

Heterogeneity was substantial across outcomes. Sensitivity analysis identified variations in exercise type, frequency, session duration, intervention length, and baseline values as potential sources. One large-sample study [30] may have contributed to heterogeneity due to quality control challenges. Despite heterogeneity, results remained consistent after excluding outlier studies, indicating robust findings.

This study is the first meta-analysis systematically evaluating community health worker-managed exercise interventions for type 2 diabetes and examining exercise dosage parameters. Limitations include: (1) inclusion of only Chinese and English literature with Chinese predominance, potentially reflecting regional management differences; (2) moderate methodological quality with unclear allocation concealment and blinding procedures that may introduce selection bias; (3) limited analysis of exercise types, as only one study combined aerobic and resistance training while others used aerobic exercise alone.

Subgroup analyses revealed that exercise frequency $ $3 times/week improved glycemic control and total cholesterol, with >3 times/week showing superior total cholesterol reduction. Both $ $30 min and >30 min sessions improved glycemic and triglyceride levels, but >30 min sessions produced greater 2-hour postprandial glucose and triglyceride improvements, demonstrating that accumulated exercise time under community health worker management yields better outcomes. Notably, 3 times/week did not significantly improve low-density lipoprotein or triglycerides, and >30 min sessions did not significantly improve total cholesterol or low-density lipoprotein, possibly due to small subgroup sample sizes requiring future high-quality studies.

Three-month interventions improved glycated hemoglobin and triglycerides, but not total cholesterol or low-density lipoprotein, suggesting longer management may be needed for clinical lipid reductions. While exercise metabolic benefits are significant, they are transient, diminishing within 48-96 hours [41], necessitating sustained long-term management to establish permanent lifestyle changes and maintain metabolic improvements like enhanced insulin sensitivity and glucose uptake [42].

In conclusion, community health worker-managed exercise interventions significantly improve glycemic and lipid levels in type 2 diabetes, effectively delaying disease progression and reducing complication risks. Community health workers should implement continuous management and follow-up according to specialist prescriptions, develop individualized exercise plans based on patient conditions, and supervise interventions through combined online and offline approaches. Recommended protocols include aerobic exercise >30 min/session, >3 times/week, for $ $3 months. For patients with dyslipidemia, intervention duration should ideally exceed 6 months.

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