Postprint: Therapeutic Efficacy of Wuti Pingheng Cao Exercise Based on a Hospital-Gymnasium-Community Rehabilitation Model for Obesity-Related Hypertension

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Abstract

Background: Obesity-related hypertension (ORH), as a chronic and persistent disease, has shown an increasing incidence in China. Exercise is an important intervention for prevention and treatment of ORH; however, due to limitations in venue, distance, and cost in exercise rehabilitation, exercise completion and adherence are often difficult to maintain, which substantially reduces the health benefits brought by exercise. Therefore, exploring suitable exercise prescriptions and management models is essential.

Objective: To evaluate the clinical efficacy and safety of Wuti Balance Exercise based on the "hospital-gym-community" model in patients with ORH.

Methods: This study was a prospective randomized controlled trial. A total of 84 ORH patients recruited from Guang'anmen Hospital, China Academy of Chinese Medical Sciences between June 2022 and December 2023 were enrolled and randomly assigned to either an experimental group (n=42) or a control group (n=42) using the SPSS 26.0 online random number generator. Both groups received the same lifestyle intervention; the control group underwent moderate-intensity aerobic exercise, while the experimental group underwent Wuti Balance Exercise training based on the "hospital-gym-community" rehabilitation model. The intervention period was 6 months. The systolic blood pressure (SBP), diastolic blood pressure (DBP), mean arterial pressure (MAP), waist circumference (WC), body weight (BW), body mass index (BMI), hip circumference (HC), waist-to-hip ratio (WHR), waist-to-height ratio (WHtR), fasting blood glucose (GLU), total cholesterol (TC), low-density lipoprotein cholesterol (LDL-C), very low-density lipoprotein cholesterol (VLDL-C), triglyceride (TG), serum ceramide (Cer), as well as scores of the Self-Rating Anxiety Scale (SAS),

Self-Rating Depression Scale (SDS), 36-Item Short Form Health Survey (SF-36), and Pittsburgh Sleep Quality Index (PSQI) were measured before and after the intervention in both groups, and the occurrence of major adverse cardiovascular events (MACE) and exercise-related injuries was recorded.

Results: Finally, 37 subjects in the experimental group and 36 subjects in the control group completed the trial. After 6 months of rehabilitation exercise, the experimental group had significantly lower SBP, DBP, MAP, WC, BW, BMI, HC, WHR, WHtR, LDL-C, Cer, and scores of SAS, SDS, and PSQI compared with the control group ($P<0.05$), and significantly higher SF-36 scores ($P<0.05$); there were no statistically significant differences between the two groups in GLU, TC, VLDL-C, and TG ($P>0.05$). In the experimental group, post-intervention levels of SBP, DBP, MAP, WC, BW, BMI, HC, WHR, WHtR, GLU, LDL-C, VLDL-C, TG, Cer, and scores of SAS, SDS, and PSQI were significantly lower than baseline ($P<0.05$), while SF-36 scores were significantly higher than baseline ($P<0.05$); there was no statistically significant difference in TC compared with pre-intervention values ($P>0.05$). No MACE or exercise-related injuries occurred in either group.

Conclusion: Wuti Balance Exercise based on the "hospital-gym-community" rehabilitation model effectively improves blood pressure and anthropometric parameters, enhances quality of life in ORH patients, demonstrating superior efficacy to conventional aerobic exercise with a favorable safety profile. Additionally, it can reduce serum Cer levels, suggesting potential beneficial effects of this exercise program on cardiovascular risk reduction.

Full Text

Efficacy of Five-Body Balance Exercise on Obesity-Associated Hypertension Based on the "Hospital-Gym-Community" Rehabilitation Model

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Abstract

Background

Obesity-related hypertension (ORH), a chronic disease requiring long-term management, is becoming increasingly prevalent in China. Exercise represents a crucial preventive and therapeutic intervention for ORH, yet limitations related to venue accessibility, travel distance, and cost often compromise exercise completion rates and patient compliance, substantially diminishing the health benefits. Therefore, identifying optimal exercise prescriptions and management models is essential.

Objective

To evaluate the clinical efficacy and safety of five-body balance exercise based on the "hospital-gym-community" rehabilitation model for patients with ORH.

Methods

This prospective randomized controlled trial enrolled 84 ORH patients recruited from Guang' anmen Hospital of the China Academy of Traditional Chinese Medicine between June 2022 and December 2023. Participants were randomly assigned to either the experimental group (n=42) or control group (n=42) using SPSS 26.0 online random number generator. Both groups received identical lifestyle interventions; the control group performed moderate-intensity aerobic exercise, while the experimental group underwent five-body balance exercise training based on the "hospital-gym-community" rehabilitation model for six months. Outcome measures included systolic blood pressure (SBP), diastolic blood pressure (DBP), mean arterial pressure (MAP), waist circumference (WC), body weight (BW), body mass index (BMI), hip circumference (HC), waist-to-hip ratio (WHR), waist-to-height ratio (WHtR), fasting glucose (GLU), total cholesterol (TC), low-density lipoprotein cholesterol (LDL-C), very low-density lipoprotein cholesterol (VLDL-C), triglycerides (TG), serum ceramides (Cer), Self-Rating Anxiety Scale (SAS), Self-Rating Depression Scale (SDS), 36-Item Short-Form Health Survey (SF-36), and Pittsburgh Sleep Quality Index (PSQI). Major adverse cardiovascular events (MACE) and exercise-related injuries were recorded throughout the intervention.

Results

Ultimately, 37 participants in the experimental group and 36 in the control group completed the trial. After six months, the experimental group showed significantly lower SBP, DBP, MAP, WC, BW, BMI, HC, WHR, WHtR, LDL-C, Cer, SAS, SDS, and PSQI scores compared with the control group ($P<0.05$), while SF-36 scores were significantly higher ($P<0.05$). No significant differences were observed in GLU, TC, VLDL-C, or TG between groups ($P>0.05$). Within-group comparisons revealed that the experimental group demonstrated significant improvements across all parameters except TC ($P>0.05$). No MACE or exercise injuries occurred in either group.

Conclusion

The five-body balance exercise based on the "hospital-gym-community" reha-

bilitation model effectively improves blood pressure control, anthropometric measures, and quality of life in ORH patients, demonstrating superior efficacy to conventional aerobic exercise with favorable safety profiles. The reduction in serum ceramide levels suggests potential cardiovascular risk reduction benefits.

Keywords: obesity-related hypertension; five-body balance exercise; traditional Chinese medicine exercise; rehabilitation model; efficacy study

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Introduction

Obesity represents a major driver of the rapid increase in hypertension prevalence, with the two conditions exhibiting strong comorbidity. Hypertension associated with obesity, excluding secondary causes, is termed obesity-related hypertension (ORH). Both global obesity and hypertension incidence have risen annually in recent years, with hypertension being the most common and significant complication among obesity-related comorbidities. Data from the China Health and Retirement Longitudinal Study monitoring 10,108 participants across 28 provinces revealed that among Chinese adults aged $ $45 years, the prevalence of hypertension and ORH reached 39.1% and 22.7%, respectively, with nearly three-fifths of hypertensive patients concurrently having ORH.

ORH management requires simultaneous blood pressure reduction and obesity control, as antihypertensive efficacy correlates with weight loss magnitude. Beyond medical nutrition therapy and pharmacological treatment, exercise constitutes a critical preventive and therapeutic intervention. The *Suwen* classic states that "the sedentary should be mobilized," highlighting how early mobilization promotes qi and blood circulation and aids digestion, as noted in *Shanghan Zhige*. Current guidelines recommend aerobic exercise as the conventional modality; however, this population' s characteristics—higher body weight and poor exercise tolerance—combined with venue limitations often compromise exercise completion and adherence, substantially reducing health benefits. As a chronic disease requiring relatively long-term treatment, ORH outcomes are also influenced by patients' subjective motivation. Therefore, regular exercise supervision, appropriate exercise prescriptions, and efficient rehabilitation models are crucial for maximizing intervention effectiveness.

Professor Wang Shihan from Guang' anmen Hospital of the China Academy of Traditional Chinese Medicine, collaborating with experts in traditional Chinese medicine, sports medicine, and rehabilitation, developed the five-body balance exercise—a traditional Chinese medicine-based intervention integrating principles from tai chi and baduanjin with modern sports training. This exercise trains the five body constituents (tendons, vessels, muscles, skin, and bones) externally while cultivating essence, qi, and spirit internally to harmonize five-organ function and balance yin-yang. It has been widely applied in chronic disease rehabilitation in our research group' s previous work. The "hospital-gym-community" rehabilitation model represents a three-tier management sys-

tem for cardiovascular chronic diseases constructed by our team. Building upon conventional hospital-based rehabilitation, this model enhances exercise standardization, intensity, and frequency while breaking medical venue constraints by extending rehabilitation settings to gyms and communities. Research demonstrates that transitioning from hospital to community and even home-based management models offers clear advantages in certain disease rehabilitations. This randomized controlled trial combines exercise prescription with delivery model to investigate the effects of five-body balance exercise under the "hospital-gym-community" model on blood pressure, anthropometric measures, cardiovascular risk factors, and quality of life in ORH patients, exploring a safe, effective, and clinically transmissible rehabilitation technique.

Methods

Study Design This prospective randomized controlled trial employed parallel-group comparison with both within-group and between-group analyses.

Sample Size Calculation Sample size was estimated using the formula for comparing two means in a completely randomized design from the third edition of *Medical Statistics*. With α=0.05 (two-sided), power=0.9, $\mu\alpha$=1.96, and $\mu\beta$=1.28, and using SBP as the primary outcome (δ=10 mmHg, σ=12.5 mmHg based on prior literature), the calculation indicated 42 participants per group were needed, totaling 84 cases after accounting for 20% attrition.

Randomization and Allocation Concealment Randomization was performed by a researcher not involved in participant recruitment. Eighty-four eligible patients were sequentially coded according to enrollment time. SPSS 26.0 generated 84 unique random integers (range 1-84); the first 42 numbers were assigned to the experimental group and the remaining 42 to the control group. The random sequence was sealed in opaque envelopes unknown to other researchers until participant enrollment, when envelopes were opened sequentially to determine group allocation.

Blinding Due to the nature of exercise interventions, this open-label study could not implement participant or therapist blinding. To minimize bias, statisticians and data analysts remained blinded to group allocation, and communication between participants from different groups was prevented.

Ethics The study was registered with the Chinese Clinical Trial Registry (ChiCTR2200060360) and approved by the Guang' anmen Hospital Ethics Committee (Approval No. 2022-030-KY). All participants provided informed consent.

Intervention Protocols

Both groups received identical lifestyle interventions based on the *Chinese Expert Consensus on Obesity-Related Hypertension Management* and the *Chinese Hypertension Prevention and Treatment Guidelines (2018 Revision)*, including low-sodium/high-potassium diet (<2,000 mg sodium, >3.5 g potassium daily), calorie-controlled diet (1,500-1,800 kcal/day for men, 1,200-1,500 kcal/day for women), smoking cessation, limited alcohol intake ($ $25 g/day for men, $ $15 g/day for women), and stress reduction.

Five-Body Balance Exercise Based on the "Hospital-Gym-Community" Model Exercise Prescription: The five-body balance exercise comprises three phases: 10-minute warm-up (alternating knee lifts, side kicks, waist rotations), 40-minute main exercise (lung-benefiting, spleen-strengthening, heart-nourishing, kidney-tonifying, and liver-regulating movements combined with integrated five-body balance routines incorporating mindfulness, breathing, and physical training; Borg Scale 11-15 recommended), and 10-minute cool-down (stretching and standing meditation). Target heart rate for moderate intensity was calculated as (maximum heart rate - resting heart rate) × (50%-80%) + resting heart rate, with maximum heart rate = 220 - age.

Three-Tier Management Model: 1. **Hospital Phase (Month 1):** Hospital-based intervention by a rehabilitation team comprising physicians and exercise specialists providing twice-weekly sessions. This initial phase covered diagnosis, assessment, and rehabilitation, establishing the foundation for the model. 2. **Gym Phase (Months 2-3):** Participants transitioned to partnered fitness facilities for thrice-weekly supervised intensive training under professional guidance. Research coordinators monthly evaluated monitoring data to adjust training intensity and ensure safety while maximizing training quality. 3. **Community Phase (Months 4-6):** Community-based physicians supervised four-times-weekly sessions within 15-minute walking distance, promoting peer interaction and mutual support to enhance adherence and consolidate rehabilitation effects.

Quality Control: Certified rehabilitation physicians supervised all training. Exercise videos were provided for home practice. Hospital phase concluded with competency assessment before progression. Participants signed in for group sessions; home trainers submitted video recordings. Both groups used wrist-worn pulse oximeters (Model MD300W628) for heart rate and oxygen saturation monitoring.

Conventional Aerobic Exercise The control group performed supervised conventional aerobic exercise (60 minutes/session: 10-minute warm-up, 40-minute aerobic activity [brisk walking, jogging, cycling], 10-minute stretching). Frequency progressed from $ $2 sessions/week in month 1 to $ $3 sessions/week in months 2-3 and $ $4 sessions/week in months 4-6.

Outcome Measures

Blood Pressure: Measured in hospital clinics between 8:00-9:00 AM after $ $5 minutes rest using an upper-arm electronic sphygmomanometer (Omron HBP-1300). Two measurements were taken 2 minutes apart and averaged. MAP was calculated at baseline, 1 month (hospital phase completion), 3 months (gym phase completion), and 6 months (community phase completion).

Anthropometric Measures: Height and weight were measured at baseline and 6 months using a stadiometer (SUHONG RGZ-200) with participants fasting, bladder-empty, wearing minimal clothing. BMI was calculated as weight/height^2. WC was measured at the midpoint between the lower rib margin and iliac crest; HC at the most prominent gluteal point. WHR and WHtR were calculated to 0.1 precision.

Cardiovascular Risk Factors: Fasting venous blood (8:00-9:00 AM) was collected at baseline and 6 months. GLU, TC, TG, LDL-C, and VLDL-C were measured using a Roche Cobas 8000 c701 analyzer. Serum ceramide levels were determined by ELISA.

Quality of Life: Anxiety and depression were assessed using SAS and SDS (20 items each, 4-point scale; standard score = raw score $\times$ 1.25). Health-related quality of life was evaluated with SF-36 (8 domains; higher scores indicate better health). Sleep quality was measured using PSQI (7 components, 0-3 points each, total 0-21; higher scores indicate worse sleep).

Safety: MACE (cardiac death, non-fatal stroke, non-fatal myocardial infarction) and musculoskeletal injuries were recorded.

Statistical Analysis

SPSS 26.0 was used for all analyses. Normally distributed continuous data were expressed as mean $\pm$ standard deviation and compared between groups using independent samples t-tests and within groups using paired t-tests. Non-normally distributed data were presented as median (P25, P75) and analyzed using Mann-Whitney U tests (between-group) and Wilcoxon signed-rank tests (within-group). Categorical data were compared using Pearson ^{2} tests. Repeated measures ANOVA compared blood pressure across four time points. Safety data were analyzed descriptively. Statistical significance was set at $P<0.05$.

Results

Participant Flow and Baseline Characteristics Of 84 enrolled participants, 11 withdrew (5 experimental, 6 control), yielding 73 completers (37 experimental, 36 control; 13% attrition). Baseline demographic and clinical characteristics were comparable between groups (P>0.05) .

Blood Pressure Outcomes Repeated measures ANOVA revealed significant group × time interactions for SBP, DBP, and MAP (P-interaction<0.05). Group effects were significant for SBP and MAP (P-group<0.05) but not DBP (P-group>0.05). Time effects were significant for all three parameters (P-time<0.05). At baseline, no differences existed between groups in SBP, DBP, or MAP (all P>0.05). After 1 month, blood pressure remained similar between groups (P>0.05). However, at 3 and 6 months, the experimental group demonstrated significantly lower SBP, DBP, and MAP compared with controls (P<0.05) .

Anthropometric Changes Baseline anthropometric measures were comparable between groups (P>0.05). After 6 months, the experimental group showed significantly greater reductions in BW, BMI, HC, WHR, and WHtR compared with controls (P<0.05). Both groups achieved significant within-group improvements in all anthropometric parameters (P<0.05) .

Cardiovascular Risk Factors Baseline metabolic parameters did not differ between groups (P>0.05). Following intervention, the experimental group exhibited significantly lower LDL-C and Cer levels versus controls (P<0.05), while GLU, TC, TG, and VLDL-C showed no between-group differences (P>0.05). Within-group analyses revealed significant improvements in GLU, TG, LDL-C, VLDL-C, and Cer in both groups (P<0.05), with no significant TC changes .

Quality of Life Baseline quality-of-life scores were similar between groups (P>0.05). After 6 months, the experimental group demonstrated significantly higher SF-36 scores and lower SAS, SDS, and PSQI scores compared with controls (P<0.05). Within-group comparisons showed the experimental group achieved significant improvements across all quality-of-life measures (P<0.05), while controls only improved in SF-36 scores (P<0.05) .

Safety No MACE or exercise-related injuries occurred in either group.

Discussion

ORH is a chronic disease with increasing prevalence in China that severely impacts quality of life and imposes substantial economic burden. Even among

metabolically healthy individuals, obesity phenotype significantly increases hypertension risk, while elevated BMI exacerbates target organ damage including cardiac remodeling, arterial stiffness, and renal impairment. Increased WC also correlates with higher mortality risk. ORH management requires concurrent blood pressure control and weight reduction, considering both short-term efficacy and long-term benefits. While pharmacotherapy has limitations including side effects, cost burden, and frequent follow-up requirements, exercise therapy offers non-pharmacological potential for weight reduction, blood pressure lowering, and complication prevention.

Both five-body balance exercise and conventional aerobic exercise reduced blood pressure progressively over time, with the experimental group achieving greater and faster reductions, particularly evident at 3 and 6 months ($P<0.05$). Similar findings were reported in a study of baduanjin exercise in 104 obese hypertensive patients, where 12 months of practice significantly improved SBP, DBP, BW, and WC. Traditional exercises may improve blood pressure by reducing serum angiotensin II and endothelin-1 while increasing nitric oxide levels. This study incorporated MAP as an outcome measure, which represents mean peripheral vascular pressure throughout the cardiac cycle and provides more stable, comprehensive assessment of blood pressure control and vascular function than SBP or DBP alone. MAP influences arterial stiffness progression and independently predicts all-cause mortality. The experimental group' s significantly lower MAP at 3 and 6 months demonstrates five-body balance exercise as an effective tool for hypertension management and atherosclerosis prevention.

Regarding anthropometric outcomes, the experimental group achieved significantly greater reductions in BMI, WC, BW, WHR, and WHtR compared with controls ($P<0.05$), indicating that regular, integrated five-body balance exercise is more effective than conventional aerobic exercise for weight loss and body composition improvement.

ORH patients frequently develop dyslipidemia and metabolic syndrome due to insulin resistance and disrupted lipid homeostasis, substantially increasing cardiovascular risk. Both groups showed significant improvements in GLU, TG, LDL-C, and VLDL-C ($P<0.05$), confirming exercise as an effective metabolic intervention. However, between-group differences in GLU, TC, TG, and VLDL-C were not significant, consistent with previous research showing that longer follow-up may be needed to detect differential effects, particularly for glucose control.

Ceramides, bioactive sphingolipids involved in apoptosis, inflammation, and stress responses, correlate with atherosclerosis progression and predict cardiovascular mortality, with prognostic value exceeding that of LDL-C. The experimental group' s significantly lower post-intervention LDL-C and Cer levels ($P<0.05$) suggest the "hospital-gym-community" five-body balance exercise model may reduce MACE risk.

The *China Cardiovascular Health and Disease Report 2022* highlights that while

cardiovascular disease incidence is declining in developed countries like the United States, China' s burden continues rising, partly due to poor patient engagement and adherence in prevention and rehabilitation programs. Current cardiac rehabilitation services are concentrated in tertiary hospitals of developed regions, limited by small capacity, travel time, and cost, yielding suboptimal clinical outcomes. Exploring extra-hospital rehabilitation models can alleviate resource constraints and reduce venue, distance, and financial barriers.

This study innovatively integrated gyms and communities into a three-tier "hospital-gym-community" rehabilitation model. Building upon hospital-based safety assurance, the model enhanced exercise standardization, frequency, and intensity while breaking medical venue limitations through multi-disciplinary collaboration. Blood pressure differences between groups emerged only after the gym and community phases, not during hospital phase. Furthermore, the experimental group demonstrated significant improvements in anxiety, depression, and sleep quality ($P<0.05$) versus controls, with both groups improving in SF-36 scores but experimental group showing greater enhancement ($P<0.05$). This transition from hospital to community-based group intervention fosters supportive supervision mechanisms, enhances self-management awareness, improves compliance, and solidifies rehabilitation habits for sustained antihypertensive effects. The group support, peer encouragement, and companionship effects improve social function, satisfaction, confidence, and reduce loneliness, yielding substantial psychosocial and physical benefits that complement the mind-body regulation principles of five-body balance exercise.

Limitations This single-center study enrolled 84 patients, which may be insufficiently powered. Future multi-center, large-sample randomized controlled trials are warranted. Additionally, while clinical efficacy and safety were demonstrated, the underlying biological mechanisms—whether related to endothelial function improvement, inflammation reduction, neuroendocrine modulation, or autophagy regulation—require further basic research investigation.

References

[1] LIU M B, WANG Z W, FAN J, et al. Interpretation of key points in the "China Cardiovascular Health and Disease Report 2023" [J]. Chinese Journal of Cardiovascular Research, 2024, 22(7): 577-593. DOI: 10.3969/j.issn.1672-5301.2024.07.001.

[2] SERAVALLE G, GRASSI G. Obesity and hypertension [J]. Pharmacol Res, 2017, 122: 1-7. DOI: 10.1016/j.phrs.2017.05.013.

[3] ZHANG Y, ZHANG W Q, TANG W W, et al. The prevalence of obesity-related hypertension among middle-aged and older adults in China [J]. Front Public Health, 2022, 10: 865870. DOI: 10.3389/fpubh.2022.865870.

[4] Hypertension Group, Chinese Society of Cardiology, Chinese Medical Association. Chinese expert consensus on the management of obesity-related hypertension [J]. Chinese Journal of Cardiology, 2016, 44(3): 212-219. DOI: 10.3760/cma.j.issn.0253-3758.2016.03.006.

[5] YANG S, LIU F R. Study on weight management effects in patients with abdominal obesity and hypertension [J]. Preventive Medicine Tribune, 2020, 26(1): 9-11. DOI: 10.16406/j.pmt.issn.1672-9153.2020.01.004.

[6] HALL M E, COHEN J B, ARD J D, et al. Weight-loss strategies for prevention and treatment of hypertension: a scientific statement from the American heart association [J]. Hypertension, 2021, 78(5): e38-e50. DOI: 10.1161/HYP.0000000000000202.

[7] GAO Y. Study on syndrome distribution of metabolic syndrome in elderly and intervention of five-body balance exercise on cardiopulmonary function [D]. Beijing: China Academy of Traditional Chinese Medicine, 2022.

[8] XIAO K J, CAI C Q, JIANG K, et al. Application effect of "hospital-community-family" integrated chronic disease management model in Parkinson's disease patients [J]. Clinical Medical Research and Practice, 2023, 8(35): 141-144. DOI: 10.19347/j.cnki.2096-1413.202335035.

[9] YANG S, ZHAO H X, GE X H, et al. Effect of hospital-community-patient integrated chronic disease management pathway on postoperative colorectal cancer patients [J]. Chinese General Practice, 2024, 27(22): 2724-2730. DOI: 10.12114/j.issn.1007-9572.2023.0661.

[10] YAN H. Medical Statistics [M]. 2nd ed. Beijing: People's Medical Publishing House, 2010: 541-542.

[11] WANG Z W, CHEN Z, ZHANG L F, et al. Status of hypertension in China: results from the China hypertension survey, 2012-2015 [J]. Circulation, 2018, 137(22): 2344-2356. DOI: 10.1161/CIRCULATIONAHA.117.032380.

[12] CHENG Y F, PENG H Y, WANG W, et al. Investigation of baseline characteristics, risk stratification, and blood pressure control rate of 25,336 outpatients with hypertension in some urban hospitals in China [J]. Journal of Clinical Cardiology, 2008, 24(8): 603-605. DOI: 10.3969/j.issn.1001-1439.2008.08.017.

[13] Chinese Hypertension Prevention and Treatment Guidelines Writing Group. Chinese hypertension prevention and treatment guidelines (2018 revision) [J]. Chinese Journal of Cardiovascular Medicine, 2019, 24(1): 24-56.

[14] WANG Z Y, CHI Y F. Self-Rating Anxiety Scale (SAS) [J]. Shanghai Archives of Psychiatry, 1984(2): 73-74.

[15] WANG Z Y, CHI Y F. Self-Rating Depression Scale (SDS) [J]. Shanghai Archives of Psychiatry, 1984(2): 71-72.

[16] UNALAN D, SOYUER F, OZTURK A. Comparison of SF-36 and WHOQOL-100 life quality scales in early period tuberculosis subjects [J]. J

Pak Med Assoc, 2012, 62(11): 1161-1167.

[17] LU T Y, LI Y, XIA P, et al. Analysis of reliability and validity of Pittsburgh Sleep Quality Index [J]. Chongqing Medicine, 2014, 43(3): 260-263. DOI: 10.3969/j.issn.1671-8348.2014.03.002.

[18] LI X, NIU H Q, BAI X G, et al. Association of obesity and hypertension: a cohort study in China [J]. Int J Hypertens, 2021, 2021: 1607475. DOI: 10.1155/2021/1607475.

[19] ATHANASAKIS K, BALA C, KOKKINOS A, et al. The economic burden of obesity in 4 south-eastern European countries associated with obesity-related co-morbidities [J]. BMC Health Serv Res, 2024, 24(1): 354. DOI: 10.1186/s12913-024-10840-4.

[20] ZHAO Y, QIN P, SUN H H, et al. Metabolically healthy general and abdominal obesity are associated with increased risk of hypertension [J]. Br J Nutr, 2020, 123(5): 583-591. DOI: 10.1017/S0007114519003143.

[21] XU J C, GONG H B, LI C M, et al. Correlation analysis between central arterial pressure and target organ damage in patients with obesity-related hypertension [J]. Chinese Journal of Cardiovascular Research, 2020, 18(5): 401-406. DOI: 10.3969/j.issn.1672-5301.2020.05.004.

[22] SHI X Y, CHAI L R, ZHANG D F, et al. Association between complementary anthropometric measures and all-cause mortality risk in adults: NHANES 2011-2016 [J]. Eur J Clin Nutr, 2025, 79(1): 71-78. DOI: 10.1038/s41430-024-01496-8.

[23] EON K S, CHUL C Y, YOUNG L J. Hypertension is more affected by fitness and waist circumference than exercise frequency and bmi in middle age [J]. J MENS HEALTH, 2019, 15(4): e58-66.

[24] BAYKAL SAHIN H, SAHIN M. Effects of cardiac rehabilitation on obese hypertensive patients: a controlled trial [J]. Hipertens Riesgo Vasc, 2023, 40(4): 197-204. DOI: 10.1016/j.hipert.2023.05.007.

[25] DENG S K, YUAN P, ZHOU Q Y, et al. Effects of precise aerobic exercise prescription based on cardiopulmonary exercise testing on body composition and metabolic indicators in patients with central obesity [J]. Chinese Journal of Rehabilitation Medicine, 2023, 38(2): 199-206. DOI: 10.3969/j.issn.1001-1242.2023.02.010.

[26] YU H L. Clinical observation of baduanjin exercise therapy in 104 obese hypertensive patients [J]. Chinese Journal of Clinical Physicians, 2013, 41(8): 47-48. DOI: 10.3969/j.issn.1008-1089.2013.08.025.

[27] LIU D C, YI L, SHENG M X, et al. The efficacy of Tai Chi and Qigong exercises on blood pressure and blood levels of nitric oxide and endothelin-1 in patients with essential hypertension: a systematic review and meta-analysis of

randomized controlled trials [J]. Evid Based Complement Alternat Med, 2020, 2020: 3267971. DOI: 10.1155/2020/3267971.

[28] LIN B, JIN Q, LIU C H, et al. Effect and mechanism of Tai Chi on blood pressure of patients with essential hypertension: a randomized controlled study [J]. J Sports Med Phys Fitness, 2022, 62(9): 1272-1277. DOI: 10.23736/S0022-4707.21.13394-8.

[29] LIU Q, HAN X, MA Y H, et al. Effect of mean arterial pressure on arterial stiffness progression in non-hypertensive population [J]. Chinese Journal of Hypertension, 2021, 29(8): 733-739. DOI: 10.16439/j.issn.1673-7245.2021.08.008.

[30] Protogerou A D, Vlachopoulos C, Thomas F, et al. Longitudinal changes in mean arterial pressure, pulse pressure and all-cause mortality: data from 71,629 untreated normotensive and high-normal participants [J]. Chinese Journal of Hypertension, 2018, 26(8): 798. DOI: 10.16439/j.issn.1673-7245.2018.08.030.

[31] TIAN X, CHEN S H, WANG P L, et al. Insulin resistance mediates obesity-related risk of cardiovascular disease: a prospective cohort study [J]. Cardiovasc Diabetol, 2022, 21(1): 289. DOI: 10.1186/s12933-022-01729-9.

[32] LU S C, AKANJI A O. Leptin, obesity, and hypertension: a review of pathogenetic mechanisms [J]. Metab Syndr Relat Disord, 2020, 18(9): 399-405. DOI: 10.1089/met.2020.0065.

[33] CHAN A W K, CHAIR S Y, LEE D T F, et al. Tai Chi exercise is more effective than brisk walking in reducing cardiovascular disease risk factors among adults with hypertension: a randomised controlled trial [J]. Int J Nurs Stud, 2018, 88: 44-52. DOI: 10.1016/j.ijnurstu.2018.08.009.

[34] TU C C, XIE L, WANG Z J, et al. Association between ceramides and coronary artery stenosis in patients with coronary artery disease [J]. Lipids Health Dis, 2020, 19(1): 151. DOI: 10.1186/s12944-020-01329-0.

[35] LEIHERER A, MÜNDLEIN A, LAAKSONEN R, et al. Comparison of recent ceramide-based coronary risk prediction scores in cardiovascular disease patients [J]. Eur J Prev Cardiol, 2022, 29(6): 947-956. DOI: 10.1093/eurjpc/zwab112.

[36] YIN W, LI F, TAN X, et al. Plasma ceramide levels and cardiovascular events in hypertensive patients at high cardiovascular risk [J]. Chinese Journal of Hypertension, 2022, 30(6): 600.

[37] LAAKSONEN R, EKROOS K, SYSI-AHO M, et al. Plasma ceramides predict cardiovascular death in patients with stable coronary artery disease and acute coronary syndromes beyond LDL-cholesterol [J]. Eur Heart J, 2016, 37(25): 1967-1976. DOI: 10.1093/eurheartj/ehw148.

[38] MA L Y, WANG Z W, FAN J, et al. Interpretation of key points in the "China Cardiovascular Health and Disease Report 2022" [J]. Chinese General Practice, 2023, 26(32): 3975-3994. DOI: 10.12114/j.issn.1007-9572.2023.0408.

[39] PAN F. China' s chronic disease management system still needs strengthening and improvement under new circumstances: interview with Professor Huo Yong, member of the National Committee of the Chinese People' s Political Consultative Conference and Peking University First Hospital [J]. China Medical Herald, 2021, 18(9): 1-3.

[40] HE Q L. Effect of hospital-community-family follow-up integrated health management model on cardiac rehabilitation in coronary heart disease patients [J]. Gansu Medical Journal, 2024, 43(3): 257-260.

[41] LIU W Q, WANG C M, ZENG H S, et al. Association between obesity and insomnia in adult population [J]. Preventive Medicine, 2022, 34(4): 366-370. DOI: 10.19485/j.cnki.issn2096-5087.2022.04.009.

[42] LIU Y Y, JU Y, CUI L L, et al. Association between dietary fiber intake and incidence of depression and anxiety in patients with essential hypertension [J]. Nutrients, 2021, 13(11): 4159. DOI: 10.3390/nu13114159.

[43] MA C H, ZHOU W, TANG Q B, et al. The impact of group-based Tai Chi on health-status outcomes among community-dwelling older adults with hypertension [J]. Heart Lung, 2018, 47(4): 337-344. DOI: 10.1016/j.hrtlng.2018.04.007.

[44] PAPATHANASIOU J V, PETROV I, TOKMAKOVA M P, et al. Group-based cardiac rehabilitation interventions. A challenge for physical and rehabilitation medicine physicians: a randomized controlled trial [J]. Eur J Phys Rehabil Med, 2020, 56(4): 479-488. DOI: 10.23736/S1973-9087.20.06013-X.

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Note: Figure translations are in progress. See original paper for figures.