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Construction of an "Exercise Snacks" Intervention Program Based on Metabolic Phenotype Stratification for Patients with Metabolic Dysfunction-Associated Steatotic Liver Disease

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Abstract

Objective: To construct an "exercise snacks" intervention program based on metabolic phenotype stratification for patients with metabolic dysfunction-associated steatotic liver disease (MASLD), so as to provide a reference for overcoming the bottleneck of poor exercise adherence and implementing precise exercise management in this population. **Methods:** Following a prespecified evidence-synthesis protocol—with reproducible eligibility criteria; systematic searches of PubMed, Web of Science, China National Knowledge Infrastructure (CNKI), and the Wanfang Data Knowledge Service Platform from inception to June 2025; dual independent study selection; and quality appraisal using AGREE II, AMSTAR 2, and the Cochrane RoB 2 tool—evidence on exercise snacks and exercise intervention for MASLD was retrieved and synthesized. Guided by self-efficacy theory and informed by documented barriers to exercise among patients with MASLD, a draft program was developed and then finalized after two rounds of multidisciplinary panel discussion. **Results:** The program consisted of five modules: metabolic phenotype assessment and classification, phenotype-matched exercise snack prescriptions, a standardized movement library, a digital support system, and exercise safety monitoring. Based on bioelectrical impedance analysis and transient elastography, patients were classified through an explicit stepwise algorithm into three mutually exclusive metabolic phenotypes—sarcopenic obesity, central obesity, and mixed—and matched with resistance-dominant, aerobic interval-dominant, or balanced exercise snacks prescriptions, each delivered as an initial dose (weeks 1 - 4) progressing to a target dose, with weekly volumes computed as

bouts/day × min/bout × 7 days. A movement library containing 20 standardized movements across 3 intensity levels was established, together with a "prompt-action-feedback" digital closed-loop support system, explicit intensity control parameters, safety termination criteria, and a home-based escalation pathway for red-flag symptoms. **Conclusion:** Grounded in evidence and behavioral theory, the program combines fragmented exercise with metabolic phenotype stratification and is a theory-informed, potentially feasible tool for precise exercise management. Its clinical effectiveness and implementation fidelity remain to be verified in prospective studies.

Keywords

Metabolic Dysfunction-Associated Steatotic Liver Disease, Exercise Snacks, Metabolic Phenotype, Exercise Prescription, Self-Efficacy, Nursing Care

1. Introduction

Metabolic dysfunction-associated steatotic liver disease (MASLD, formerly known as non-alcoholic fatty liver disease) has become the most prevalent chronic liver disease in China, with an adult prevalence of 29.2% that continues to rise [1] [2]. MASLD can progress to cirrhosis and hepatocellular carcinoma and is closely associated with metabolic disorders such as type 2 diabetes and cardiovascular disease, imposing a substantial health and economic burden on families and society [2] [3]. Authoritative guidelines worldwide consistently recommend regular exercise as a first-line treatment for MASLD [4]-[6], and meta-analyses have confirmed that exercise intervention can reduce liver fat content independently of weight loss [7] [8]. However, traditional continuous exercise regimens (30 - 60 min per session) impose a high time threshold and are difficult to sustain. In real-world practice, adherence to exercise recommendations among patients with MASLD remains low, and the difficulty of translating intention into action—driven largely by low exercise self-efficacy and perceived barriers such as lack of time and physical limitations—has become a major bottleneck in disease management [9].

"Exercise snacks" refer to brief, frequent bouts of exercise lasting 1 - 5 min each, dispersed throughout the day and requiring no specific venue or equipment [10] [11]. Studies have shown that repeated short bouts of exercise can improve metabolism through mechanisms such as repeated activation of the AMPK-PGC-1α signaling pathway, enhanced translocation of glucose transporter 4, and accumulated excess post-exercise oxygen consumption [12]-[14]. A 6-week intervention of stair-climbing exercise snacks (20 s per bout, 3 bouts per day) significantly improved cardiorespiratory fitness [15]. A meta-analysis of 11 randomized controlled trials demonstrated that exercise snacks significantly improved cardiorespiratory fitness and muscular endurance, with an adherence rate as high as 82.8% [16]. Prospective cohort research further found that 3 - 4 short bouts of vigorous intermittent lifestyle physical activity per day were associated with an approximately

40% reduction in all-cause mortality [17]. Nevertheless, existing research on exercise snacks has focused mainly on healthy or diabetic populations, lacking direct evidence on the core pathological indicators of MASLD, and has generally adopted a one-size-fits-all approach that ignores the metabolic phenotype heterogeneity of patients with MASLD [18] [19]: patients with sarcopenic obesity need resistance training to improve muscle mass, whereas those with central obesity require higher-intensity interval exercise to mobilize visceral fat. Against this background, guided by self-efficacy theory and using a structured evidence-synthesis methodology, this study aimed to construct a metabolic phenotype-stratified exercise snacks intervention program for patients with MASLD, thereby providing a scientific and feasible tool for precise exercise management in clinical practice.

2. Methods

2.1. Study Team

The study team consisted of 10 members covering nursing, medicine, rehabilitation, and statistics, including 1 chief nurse (research direction oversight), 2 associate chief nurses (program coordination and quality control), 2 associate chief hepatologists (patient diagnosis and screening, exercise safety assessment, and adverse event management), 1 rehabilitation therapist (exercise prescription design and rehabilitation guidance), 1 statistician (research design and data analysis support), and 3 supervising nurses (literature retrieval, intervention implementation, and data organization). The project leader, a postgraduate nursing student with long-term experience in infectious diseases and chronic liver disease nursing management and experience in leading several chronic disease management projects, was responsible for the overall coordination of program development and manuscript writing.

2.2. Literature Review and Evidence Extraction

A structured evidence-synthesis protocol was prespecified before the search. 1) Eligibility criteria: eligible sources were clinical practice guidelines, expert consensuses, systematic reviews/meta-analyses, randomized controlled trials, and prospective cohort studies addressing exercise or physical activity intervention in MASLD/NAFLD, exercise snacks or vigorous intermittent lifestyle physical activity, phenotype-specific exercise prescription, or digital support for exercise adherence, published in Chinese or English. Animal or in vitro studies, conference abstracts, case reports, non-peer-reviewed materials, and studies of pediatric populations were excluded. 2) Search strategy: PubMed, Web of Science, CNKI, and the Wanfang Data Knowledge Service Platform were systematically searched from inception to June 2025. The PubMed search combined subject headings and free-text terms as follows: ("metabolic dysfunction-associated steatotic liver disease" [Title/Abstract] OR "MASLD" [Title/Abstract] OR "NAFLD" [Title/Abstract] OR "nonalcoholic fatty liver disease" [MeSH Terms]) AND ("exercise snacks" [Title/Abstract] OR "vigorous intermittent lifestyle physical activity" [Title/Abstract]

OR "high-intensity interval training" [Title/Abstract] OR "exercise therapy" [MeSH Terms] OR "exercise prescription" [Title/Abstract]); the Chinese databases were searched with the corresponding Chinese terms "代谢相关脂肪性肝病", "非酒精性脂肪性肝病", "运动零食", "碎片化运动", and "运动处方". 3) Study selection: two team members independently screened titles, abstracts, and full texts; disagreements were resolved through discussion or adjudicated by a third member. 4) Quality appraisal: guidelines and expert consensus were appraised using the AGREE II instrument, systematic reviews/meta-analyses using AMSTAR 2, and randomized controlled trials using the Cochrane RoB 2 tool; only evidence of at least moderate methodological quality informed program development, and the level of each evidence point was graded according to the 2011 Oxford Centre for Evidence-Based Medicine (OCEBM) levels of evidence.

The following evidence points were synthesized: 1) regular exercise is a first-line treatment for MASLD, and its benefits can be achieved independently of weight loss [4]-[8]; 2) exercise snacks can improve cardiorespiratory fitness and muscular endurance, with adherence superior to that of traditional continuous exercise [10] [15]-[17] [20]; 3) patients with MASLD exhibit marked metabolic phenotype heterogeneity, and those with sarcopenic obesity versus central obesity respond differently to exercise modalities, necessitating phenotype-matched exercise prescriptions [18] [19] [21] [22]; and 4) wearable activity trackers and digital feedback systems can improve physical activity participation and the safety of exercise interventions through real-time monitoring and feedback [17] [23].

2.3. Theoretical Framework

Self-efficacy theory was adopted as the theoretical framework for program development. This theory holds that an individual's belief in his or her capability to perform a specific behavior directly influences the initiation and maintenance of that behavior, and that self-efficacy derives from four sources: enactive mastery experience, vicarious experience, verbal persuasion, and physiological and affective states [24]. Evidence indicates that low self-efficacy and large perceived barriers (time and physical limitations) are central obstacles to exercise adherence among patients with MASLD [9]. Accordingly, the program was designed as follows: 1) exercise was decomposed into low-threshold, easily completed short movement "snacks" so that patients could readily accumulate successful experiences (enactive mastery); 2) WeChat group check-ins and peer ranking provided vicarious experience; 3) individualized feedback reports every 2 weeks and encouragement from healthcare professionals provided verbal persuasion; and 4) prescriptions starting at low intensity with progressive increments reduced negative physiological experiences such as fatigue. Together, these strategies enhance exercise self-efficacy through multiple pathways and promote the establishment and maintenance of exercise behavior.

2.4. Drafting of the Intervention Program

Based on evidence extraction and theoretical analysis, combined with clinical prac-

tice experience, the research team held thematic discussions around the intervention pathway of "precise assessment—phenotype-matched prescription—behavioral support—safety monitoring" and drafted the intervention program, which comprised five modules: metabolic phenotype assessment and classification criteria, phenotype-matched exercise snacks prescriptions, a standardized movement library, a digital support system, and exercise safety monitoring.

2.5. Panel Discussion and Revision

Two rounds of panel meetings were held to appraise the draft program. At each meeting, every item was appraised for importance, scientific soundness, and clinical feasibility, and a revision was adopted only after agreement was reached among all members following discussion. The first meeting focused on the clinical operability of the metabolic phenotype classification criteria and the safety of exercise dosage: the diagnostic thresholds for sarcopenic obesity were determined according to the 2019 consensus of the Asian Working Group for Sarcopenia [25], and the initial exercise dosage for the central obesity phenotype was lowered to reduce cardiovascular risk. The second meeting focused on the age-friendliness and home applicability of the movement library: the standard mountain climber was revised to a modified (incline) mountain climber performed with hands on a desk, the wall squat instruction was clarified as "not mandatory to squat to 90 degrees" to protect the knee joints, and exercise termination criteria, a red-flag escalation pathway, and adverse event management procedures were added. The final version of the intervention program was formed after these revisions.

3. Results

3.1. Overall Framework of the Program

The metabolic phenotype-stratified exercise snacks intervention program for patients with MASLD consists of five modules: 1) metabolic phenotype assessment and classification, which categorizes patients into three mutually exclusive metabolic phenotypes through an explicit stepwise algorithm based on objective body composition and liver fat measurements; 2) phenotype-matched exercise snacks prescriptions, which match fragmented exercise of different composition and dosage to each phenotype; 3) a standardized movement library containing 20 movements classified by training goal and graded into 3 intensity levels; 4) a digital support system that achieves closed-loop "prompt-action-feedback" management via smart bands and a WeChat mini-program; and 5) exercise safety monitoring, covering eligibility screening for special populations, pre-exercise assessment, in-process monitoring, termination criteria, a home-based red-flag escalation pathway, and adverse event management. The implementation pathway is as follows: baseline assessment, metabolic phenotype classification, matching of phenotype-specific prescriptions, home-based implementation with digital support, and assessment and dynamic prescription adjustment every 2 weeks.

3.2. Metabolic Phenotype Assessment and Classification Criteria

Skeletal muscle mass index (SMI), body fat percentage (BF%), and visceral fat area (VFA) were measured by bioelectrical impedance analysis, and the controlled attenuation parameter (CAP) and liver stiffness were measured by transient elastography. Three dichotomous indicators were defined: low SMI (<7.0 kg/m^2 in men or <5.7 kg/m^2 in women, according to the 2019 consensus of the Asian Working Group for Sarcopenia [25]), high BF% (>25% in men or >30% in women), and high VFA (≥100 cm^2). Patients were classified into three mutually exclusive metabolic phenotypes using the following fixed-priority algorithm (**Figure 1**): Step 1, patients with low SMI and VFA ≥ 100 cm^2 were classified as the mixed phenotype, regardless of BF%; Step 2, among the remaining patients, those with low SMI and high BF% were classified as sarcopenic obesity; Step 3, among the remaining patients, those with normal SMI and VFA ≥ 100 cm^2 were classified as central obesity; Step 4, patients with normal SMI, VFA < 100 cm^2, but high BF%—whose dominant feature is excess adiposity without visceral accumulation or muscle depletion—were managed using the central obesity prescription starting at the basic intensity level; and patients meeting none of the above criteria received standard guideline-based lifestyle guidance outside the stratified program.

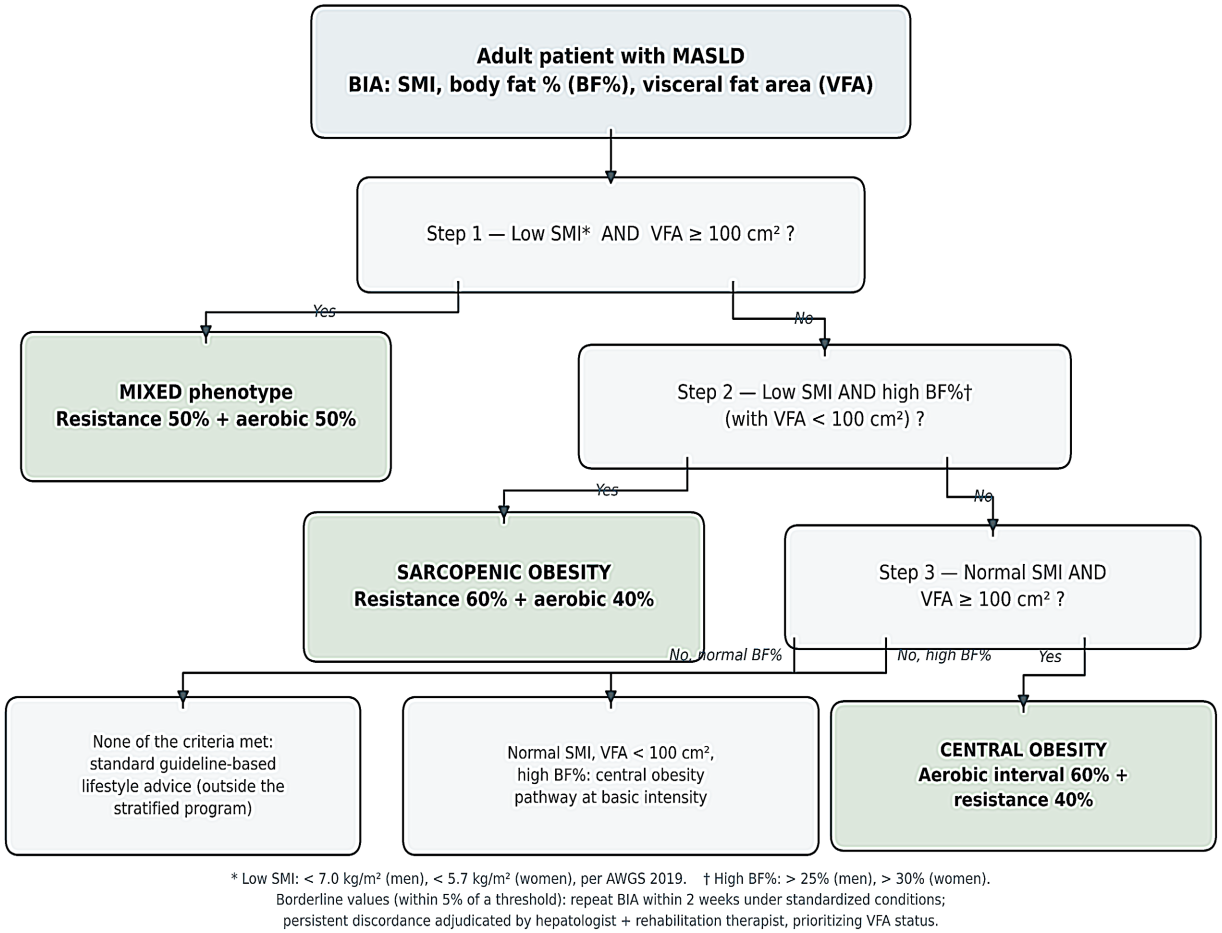

Figure 1. Stepwise algorithm for metabolic phenotype classification.

Because the algorithm is applied in a fixed priority order, each patient is assigned to exactly one category, rendering the three phenotypes mutually exclusive by construction. Borderline cases—defined a priori as any indicator falling within 5% of its threshold—undergo repeat bioelectrical impedance analysis within 2 weeks under standardized conditions (≥8-h fasting, no vigorous exercise within 12 h, and no alcohol within 24 h); if discordance persists, classification is adjudicated jointly by the hepatologist and the rehabilitation therapist, with VFA status prioritized. This rule replaces the ambiguous notion of "atypical features" with a reproducible procedure. The classification criteria are shown in Table 1.

Table 1. Classification criteria for metabolic phenotypes in patients with MASLD.

Metabolic phenotype	Algorithmic criteria (applied in fixed priority order)	Main pathophysiological features
Sarcopenic obesity	Low SMI AND high BF%, with VFA < 100 cm^2 (assigned only if the mixed-phenotype rule below is not met)	Coexistence of reduced skeletal muscle mass and excess adiposity, decreased resting metabolic rate, and reduced myokine secretion
Central obesity	Normal SMI AND VFA ≥ 100 cm^2	Visceral fat accumulation, elevated pro-inflammatory cytokine levels, and marked insulin resistance
Mixed	Low SMI AND VFA ≥ 100 cm^2, regardless of BF% (highest priority)	Combined muscle depletion and visceral fat accumulation

Note. SMI, skeletal muscle mass index; BF%, body fat percentage; VFA, visceral fat area. Low SMI: <7.0 kg/m^2 (men) or <5.7 kg/m^2 (women); high BF%: >25% (men) or >30% (women). Borderline values within 5% of a threshold trigger repeat measurement and adjudication as described in the text.

3.3. Phenotype-Matched Exercise Snacks Prescriptions

Exercise composition and dosage parameters were matched to the pathophysiological characteristics and exercise responsiveness of each metabolic phenotype (Table 2). Because no randomized trial to date has directly compared phenotype-matched exercise snacks prescriptions in patients with MASLD, the composition ratios and dose parameters below are explicitly theory-informed provisional parameters: they are derived from indirect evidence—resistance training reduces liver fat independently of weight loss and is prioritized for patients with sarcopenia [6] [20] [22], whereas low-volume high-intensity interval exercise improves cardiorespiratory fitness and body composition [14] [26]—and are intended to be refined through the planned randomized controlled trial. The general principle of intensity control was to maintain the target heart rate at 55% - 75% of the maximal heart rate (220 minus age), with a rating of perceived exertion (RPE) of 12 - 15 (from "somewhat hard" to "hard"). Each prescription begins with a conservative initial dose during weeks 1 - 4 and progresses to the target dose thereafter; the rehabilitation therapist evaluates exercise load every 2 weeks based on target heart rate attainment, RPE scores, and patient complaints, and adjusts the prescription dynamically, with weekly increases in exercise duration or frequency not exceeding 10%. Notably, the meta-analysis underpinning this program demonstrated cardiorespiratory benefits at weekly volumes as low as approximately 5 - 67.5 min

[16], supporting the conservative initial doses adopted here.

Table 2. Metabolic phenotype-stratified exercise snacks prescriptions.

Metabolic phenotype	Exercise composition	Exercise content	Initial dose (weeks 1 - 4)	Target dose (week 5 onward)
Sarcopenic obesity	60% resistance + 40% aerobic exercise	Wall squats, rapid sit-to-stand, incline push-ups, high-knee marching, etc.	3 bouts/day × 3 min/bout (63 min/week)	4 - 5 bouts/day × 4 - 5 min/bout (112 - 175 min/week)
Central obesity	60% aerobic interval + 40% resistance exercise	Jumping jacks, brisk stair climbing, punch squats, modified mountain climbers, etc.	4 bouts/day × 2 min/bout (56 min/week)	5 - 6 bouts/day × 2 - 3 min/bout (70 - 126 min/week)
Mixed	50% aerobic + 50% resistance exercise	Flexible combination of the above movements	3 bouts/day × 2 min/bout (42 min/week)	4 - 5 bouts/day × 3 - 4 min/bout (84 - 140 min/week)

Note. Weekly volume is computed as bouts/day × min/bout × 7 days and is fully consistent with the stated bout frequency and bout duration. Progression between doses follows the ≤10% increase rule described in the text.

3.4. Standardized Exercise Snacks Movement Library

An exercise snacks movement library containing 20 standardized movements was established, classified into resistance, aerobic interval, and flexibility-coordination categories according to training goals. Movements in each category were graded into 3 intensity levels (basic, intermediate, and advanced) to meet the progressive training needs of patients with different exercise foundations. All movements require no professional equipment and can be completed in office or home settings. The core movements for each phenotype and their key points are shown in Table 3 and Table 4.

Table 3. Core exercise snack movements for the sarcopenic obesity phenotype.

Code	Movement	Key points (1 - 2 min/set)	Training focus
A1	Wall squat	Keep the back flat against the wall and lower the body until the knees are slightly bent (squatting to 90 degrees is not mandatory); hold still with deep breathing	Quadriceps endurance and core capacity; knee-friendly
A2	Rapid sit-to-stand	Using a sturdy chair, stand up quickly and sit down slowly, rising again as soon as the buttocks lightly touch the seat	Lower-limb power and cardiorespiratory capacity
A3	Incline push-up	Place the hands on the edge of a desk or dining table at shoulder width with the body in a straight line; bend the elbows to lower the body until the chest lightly touches the support surface	Upper-body strength and stability; cardiorespiratory and shoulder mobility
A4	High-knee marching	Perform rapid high-knee stepping in place (without jumping), lifting the knees toward hip height with large arm swings	Cardiorespiratory activation and lower-limb coordination

Table 4. Core exercise snacks movements for the central obesity phenotype.

Code	Movement	Key points (1 - 2 min/set)	Training focus
B1	Jumping jacks	Perform standard jumping jacks with the hands raised overhead and the feet jumping apart and together	Whole-body fat burning; rapid heart rate elevation

Continued

B2	Brisk stair climbing	Using office or home stairs, climb 2-3 floors briskly and walk down slowly to recover	High-intensity cardiorespiratory challenge; gluteal and leg strength
B3	Punch squat	Step one leg backward, punch forward 5 times while keeping the body upright, then squat; stand up and repeat	Whole-body coordination; high energy expenditure
B4	Modified mountain climber	Place the hands on the edge of a desk in a push-up position and alternately drive the knees rapidly toward the chest	Abdominal core and cardiorespiratory endurance

3.5. Digital Support System

A closed-loop "prompt-action-feedback" digital support system was built on smart bands and a WeChat mini-program (Table 5), consistent with evidence that wearable activity trackers increase physical activity participation and support safe self-monitoring [23]. Band vibration reminders overcome forgetfulness, and real-time heart rate monitoring safeguards exercise intensity and safety. Combined with peer motivation in WeChat groups and individualized reports pushed every 2 weeks (including exercise adherence rates and CAP trends), the system forms an "online + offline" and "subjective + objective" closed-loop management model that supports the long-term maintenance of exercise behavior.

Table 5. Functional modules of the digital support system.

Functional module	Content
Sedentary reminder	The smart band vibrates automatically when ≥60 min of continuous sitting is detected, prompting the patient to complete one exercise snack
Exercise guidance	The WeChat mini-program pushes phenotype-matched individualized exercise prescriptions and standard movement demonstration videos
Data recording	The band automatically records exercise duration, heart rate, and step count, synchronized in real time to the management platform
Community support	WeChat groups of 15 members with daily check-in rankings are established to foster a peer-motivating atmosphere
Feedback and incentives	Individualized reports are pushed every 2 weeks, covering exercise adherence rates and trends in body composition and CAP

3.6. Exercise Safety Monitoring

1) Eligibility and exercise adaptations for special populations: the program is intended for adults with MASLD in stable condition. Patients with decompensated cirrhosis (Child-Pugh class B or C), unstable cardiovascular disease (unstable angina, myocardial infarction within 3 months, or uncontrolled arrhythmia), resting blood pressure ≥ 180/110 mmHg, proliferative diabetic retinopathy, active diabetic foot ulcer, or mobility limitations that preclude standing exercise are excluded from independent home-based implementation or require physician clearance and individualized prescription. For patients with partial mobility limita-

tions, chair-based substitutes are provided (seated marching, seated punches, and chair-supported partial squats). For patients with cardiovascular comorbidity, the prescription starts at the basic intensity level, the first session is supervised, and breath-holding (Valsalva maneuvers) is explicitly avoided. For patients using insulin or sulfonylureas, exercise during the peak of insulin action is avoided when possible, 15 - 20 g of fast-acting carbohydrate is carried during exercise, and exercise is stopped with self-treatment initiated if hypoglycemia is suspected. For patients taking medications that blunt the heart-rate response (β-blockers, non-dihydropyridine calcium-channel blockers, or ivabradine), intensity is guided by RPE 12 - 15 and the talk test instead of heart-rate targets, and band heart-rate alarms are individually adjusted or disabled. 2) Pre-exercise assessment: comprising medical evaluation (history taking, physical examination, electrocardiography, and exercise risk stratification) and physical fitness assessment (6-min walk test, grip strength, and 30-s sit-to-stand test) to screen for exercise contraindications. 3) In-process monitoring: patients are instructed to pay attention to their own sensations during exercise, and a heart rate alarm is set on the band (upper limit: 90% of maximal heart rate). 4) Termination criteria and home-based escalation pathway: a two-tier pathway distinguishes red-flag symptoms requiring emergency care from non-urgent events managed with the research team (Table 6). Patients and family members are explicitly instructed that, in any red-flag situation, they should call emergency services (120 in China) first rather than contacting the research team, and inform the team only after emergency care has been activated. 5) Adverse event management: an adverse event registry is maintained to record exercise-related injuries and cardiovascular events, with monthly summary analysis and reporting of serious adverse events within 24 h.

Table 6. Home-based termination and escalation pathway for exercise-related symptoms.

Tier	Symptoms or findings	Required action
Red flag (emergency)	Chest pain or pressure lasting >5 min or unrelieved by rest; severe dyspnea; syncope or near-syncope; palpitations accompanied by dizziness; blood pressure >180/110 mmHg with headache or neurological symptoms; suspected hypoglycemia not resolving within 15 min of carbohydrate intake; acute bone, joint, or muscle injury with inability to bear weight	Stop exercise immediately; sit or lie down; call emergency services (120) FIRST rather than the research team; inform the team within 24 h after emergency care; event logged in the adverse event registry and the prescription re-evaluated before resumption
Non-urgent	Transient dizziness resolving within 5 min of rest; muscle soreness persisting >48 h; mild joint discomfort; RPE persistently >15 at the prescribed dose	Stop that exercise session; report via the mini-program or telephone within 24 h; the research team responds within 24 h and adjusts the prescription (reduced intensity, movement substitution, or temporary suspension)

4. Discussion

4.1. Scientific Rigor of the Program

The program is grounded in evidence-based research, framed by behavioral the-

ory, and supported by objective assessment, demonstrating sound scientific rigor. First, its evidence sources were identified through a prespecified, reproducible synthesis protocol with explicit eligibility criteria, dual independent screening, and formal quality appraisal (AGREE II, AMSTAR 2, and RoB 2), covering authoritative domestic and international guidelines [4]-[6], systematic reviews and meta-analyses [7] [8] [16], and high-quality randomized controlled trials and cohort studies [15] [17] [20]; only evidence of at least moderate methodological quality informed program development. The effectiveness of exercise snacks in improving cardiorespiratory fitness and their high adherence characteristics have been confirmed by multiple studies [15]-[17], providing a basis for selecting the core intervention modality. Second, framed by self-efficacy theory, the program translates the four sources of efficacy—enactive mastery experience, vicarious experience, verbal persuasion, and physiological state regulation—into concrete intervention strategies such as low-threshold movement design, group check-ins, individualized feedback, and progressive dosing, rendering the mechanism of behavior change implementable and interpretable. Third, the program uses objective measurements such as bioelectrical impedance analysis and transient elastography for metabolic phenotype classification and outcome evaluation, moving beyond the reliance of previous studies on crude indicators such as body mass index and waist circumference, and the classification is operationalized through an explicit, mutually exclusive stepwise algorithm rather than clinician impression, improving both precision and reproducibility of assignment [18] [22].

4.2. Innovativeness of the Program

1) Innovation in intervention philosophy: targeting the long-neglected metabolic phenotype heterogeneity of patients with MASLD [18] [19], the program is, to our knowledge, among the first to combine exercise snacks with metabolic phenotype stratification—matching resistance-dominant prescriptions for the sarcopenic obesity phenotype to improve muscle mass and aerobic interval-dominant prescriptions for the central obesity phenotype to mobilize visceral fat—representing a shift from a one-size-fits-all approach to phenotype-specific treatment. 2) Innovation in intervention modality: exercise is decomposed into daily "snacks" of 2-5 min each, requiring no specific venue or equipment, which substantially lowers the time and physical thresholds of exercise and directly addresses the core bottleneck of poor exercise adherence in patients with MASLD. 3) Innovation in implementation pathway: the "prompt-action-feedback" digital closed-loop support system materializes behavior-maintenance mechanisms into operable sedentary reminders, community incentives, and individualized feedback, achieving whole-process management from precise assessment to real-time nudging. It should be emphasized that the phenotype-specific modality and dose allocations are provisional parameters informed by indirect evidence and theory; their superiority over non-stratified prescriptions remains a hypothesis to be tested in the planned randomized controlled trial.

4.3. Potential Clinical Applicability and Dissemination Value

The movements in this program are simple and low-cost and can be integrated into patients' daily work and life scenarios, with no special requirements for venues, equipment, or economic conditions, making the program potentially applicable to outpatient, community, and home settings. The program is nurse-led and supported by a multidisciplinary team; metabolic phenotype classification can be completed using testing equipment routinely available in clinical settings, and the exercise prescriptions and movement library are presented in standardized tables and videos, facilitating mastery and implementation by nursing staff in medical institutions at different levels. If its effectiveness and implementation fidelity are confirmed in prospective evaluation, the program could provide a replicable, standardized tool for stratified exercise management of patients with MASLD and help promote the transformation of chronic disease nursing management from experience-based guidance to precise, digitalized management.

4.4. Limitations and Prospects

The program has several limitations: 1) it was developed based on literature evidence and panel discussion, and its clinical effectiveness, as well as differences in responsiveness to exercise snacks among patients with different metabolic phenotypes, remains to be empirically tested; 2) no randomized trial has directly evaluated phenotype-matched exercise snacks prescriptions in MASLD, so the phenotype-specific modality and dose allocations are theory-informed provisional parameters requiring validation; 3) the classification thresholds are mainly based on consensuses related to Asian populations [25], and their applicability to other populations, as well as the reliability and clinical acceptability of the stepwise classification algorithm, requires verification; and 4) the digital support system requires a certain level of smartphone proficiency, and its applicability to older patients needs further observation during implementation. The research team has obtained funding from the Medical Scientific Research Foundation of Guangdong Province and plans to verify the effectiveness and safety of the program through a randomized controlled trial and to further optimize the classification criteria and prescription parameters, so as to provide high-quality evidence-based support for the clinical dissemination of the program.

Declarations

Ethics approval and consent to participate: Not applicable. This methodological study was based on published literature and expert panel discussion and did not involve human participants.

Availability of data and materials: Not applicable. All evidence supporting the program is available in the cited publications.

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Author Contributions

Conceptualization, Juan Wang and Shan Ouyang; methodology, Shan Ouyang and Juan Wang; validation, Juan Wang; investigation, Shan Ouyang; writing—original draft preparation, Shan Ouyang; writing—review and editing, Juan Wang; supervision, Juan Wang; project administration, Juan Wang; funding acquisition, Juan Wang. All authors have read and agreed to the published version of the manuscript.

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Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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