Development of an Exercise Prescription Framework for Gestational Diabetes Mellitus Patients: A Codebook-Based Systematic Factor Extraction and Structuring Study

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ABSTRACT

INTRODUCTION Gestational diabetes mellitus (GDM) is a glucose metabolism disorder during pregnancy that can cause serious complications without proper management. Appropriate physical activity improves glycemic control, reduces insulin requirements, and positively affects long-term postpartum metabolic health. However, current studies lack systematic exercise prescription frameworks specifically for GDM patients. We aimed to develop a scientifically-based framework by extracting factors from diverse sources and developing a codebook.

METHODS Systematic literature analysis and codebook-based factor extraction methodology were employed. SCI papers, digital healthcare services, educational videos, and professional books were analyzed to identify missing elements in existing guidelines. A structured codebook was developed to classify video content into physician-led and exercise-led interventions. Information from international guidelines (WHO, ACOG, ADA, ACSM) was collected, and exercise components were organized based on measurement units (heart rate, MET, RPE). Technical factors (posture, breathing, safety) were defined with core factors including type, frequency, intensity, and duration. A wearable device data collection system was established, incorporating Talk Test and Borg Scale.

RESULTS Core factors for the framework were systematically extracted and structured. The codebook comprised patient profiles (physical information, gestational week, glucose levels), exercise prescription factors (type, intensity, frequency, duration), monitoring factors (physiological indicators, subjective assessment), and safety factors (contraindications, discontinuation criteria). Video analysis confirmed the need for a hybrid model. International guidelines primarily recommend moderate-intensity exercise (50-70% maximum heart rate or Borg Scale 12-14 points). A standardized measurement system was established for wearable devices, including heart rate, exercise intensity, blood glucose change, and subjective intensity. Talk Test and Borg Scale were integrated for intensity evaluation.

CONCLUSIONS A comprehensive framework was developed through codebook-based systematic factor extraction. Multi-source integration enabled derivation of practical yet scientifically-grounded factors. Standardized systems for wearable device data collection and intensity evaluation were established. The framework provides a standardized approach for safe and effective exercise management of GDM patients and serves as a foundation for digital healthcare platform and digital therapeutics development.

Reference

Davenport, M. H., et al. (2018). Prenatal exercise for the prevention of gestational diabetes mellitus and hypertensive disorders of pregnancy: a systematic review and meta-analysis. British Journal of Sports Medicine, 52(21), 1367-1375.

Jung A. R., et al. (2024). Recent findings on exercise therapy for blood glucose management in patients with gestational diabetes. Journal of Clinical Medicine, 13(17), 5004.

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INTRODUCTION & PURPOSE

- Gestational diabetes mellitus (GDM) is a glucose-metabolism disorder of pregnancy whose complications extend to mother and fetus without structured management.
- Physical activity is a first-line intervention for GDM: it lowers glucose, reduces insulin demand, and shapes favorable postpartum metabolic trajectories.
- Despite this consensus, the literature offers no systematic, GDM-specific exercise prescription framework.
- This study fills that gap by extracting factors across heterogeneous sources and synthesizing them into one operational codebook.

METHODS

- Multi-source + two-layer codebook. Four input streams (SCI papers, digital-health platforms, KCDC / ACOG / YouTube videos, ACSM-aligned textbooks) were independently coded by two annotators as physician-led vs exercise-led; inter-rater agreement verified.
- Standardized intensity units. All prescriptions normalized to %HRmax · MET · RPE / Borg, making WHO, ACOG, ADA, and ACSM recommendations comparable on a single axis.
- FITT + wearable-anchored safety. Core factors (Type, Frequency, Intensity, Time/Duration) layered with posture, breathing, and contraindications; Borg 12–14 + Talk Test feed a continuous HR stream from a wearable device.

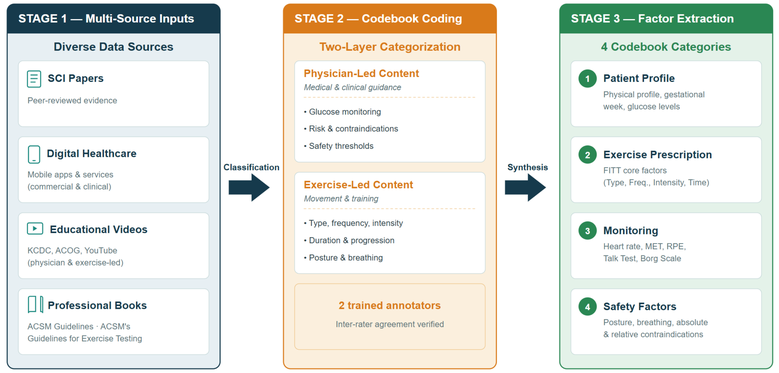


Figure 1. Multi-Source Analysis Pipeline
(From diverse data inputs to a unified GDM exercise prescription framework)

CONCLUSION

- **Multi-Source Integration:** Combined evidence from SCI papers, digital healthcare services, educational videos, and professional books yielded practical yet scientifically grounded factors.
- **Codebook Construction:** A structured codebook successfully classified physician-led and exercise-led interventions, confirming the need for hybrid delivery models.
- **Standardized Measurement Systems:** Established unified systems for wearable device data collection and intensity evaluation (Talk Test + Borg Scale).
- **Framework Comprehensiveness:** The resulting framework addresses all four critical domains: patient characteristics, exercise prescription parameters, monitoring protocols, and safety considerations.

RESULTS

- **Four-category codebook delivered.** (1) Patient Profile · (2) Exercise Prescription · (3) Monitoring · (4) Safety Factors — reusable across digital, video, and clinician-delivered GDM programs; patient profile condensed to **4–6 variables**.
- **Moderate-intensity consensus.** WHO, ACOG, ADA, ACSM converge at **50–70% HRmax (Borg 12–14)**; ACSM's 85% HRmax retained as reference ceiling, not prescription target.
- **Locked FITT load + live monitoring. 3–7 days/week, 30–60 min/session**, with HR, MET, glucose, Talk Test, and Borg streamed into one evaluation layer against explicit stop / discontinuation criteria.

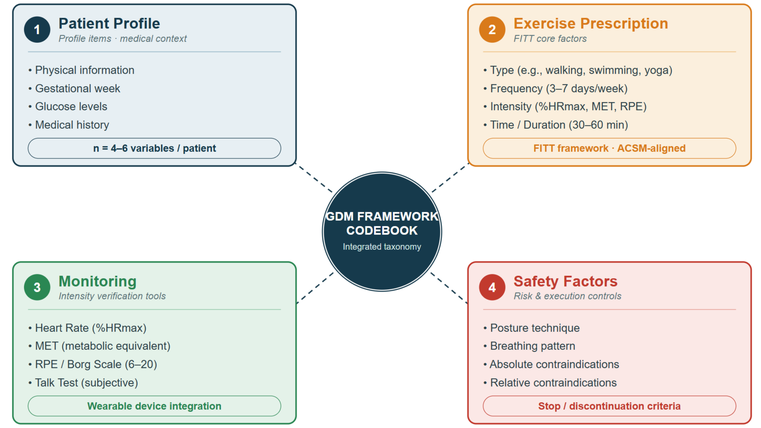


Figure 2. GDM Exercise Prescription Codebook
(Four interconnected categories anchored by the central codebook)

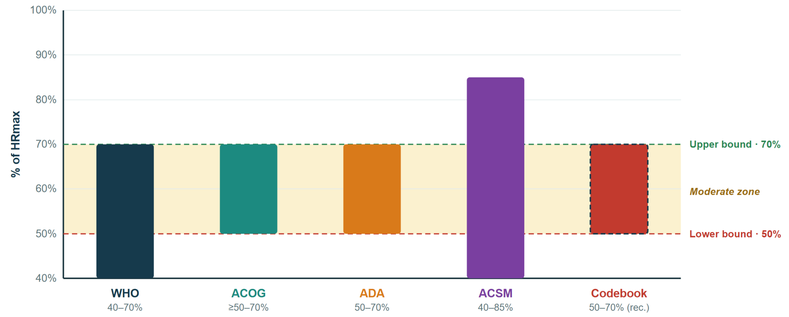


Figure3. Exercise Intensity Targets across Guidelines
(Moderate-intensity zone in %HRmax defined by major GDM exercise guidelines)