

Laboratory-Based Documentation Of Patient Response To Exercise Therapy In Diabetes

Faten Ali Alblawi¹, Reem Houmud Albalawi², Mohammad Ahmad Alajaji³, Karmah Ibrahim Alenzi⁴, Hesham Ali Alsheekh⁵, Dhafer Abdullah Alshehri⁶, Khaled Muqeem Alatawi⁷, Nada Rashid Albalawi⁸, Fatima Ibrahim Alanzi⁹, Samar Rasheed Albalawi¹⁰

1. Laboratory Technician, Maternity and Children's Hospital, Tabuk, Saudi Arabia
2. Laboratory Technician, Maternity and Children's Hospital, Tabuk, Saudi Arabia
3. Laboratory Specialist, Buraydah Central Hospital, Buraydah, Saudi Arabia
4. Laboratory Technician, Maternity and Children's Hospital, Tabuk, Saudi Arabia
5. Laboratory Technician, Maternity and Children's Hospital, Tabuk, Saudi Arabia
6. Laboratory Specialist, Maternity and Children's Hospital, Tabuk, Saudi Arabia
7. Nursing Technician, General Medical Authority, Tabuk, Saudi Arabia
8. Health Informatics Technician, King Fahd Specialist Hospital, Tabuk, Saudi Arabia
9. Physiotherapy Technician, King Khalid Hospital, Tabuk, Saudi Arabia
10. Laboratory Technician, Maternity and Children's Hospital, Tabuk, Saudi Arabia

Abstract

Background: Exercise therapy is a cornerstone of diabetes management, yet patient response is often evaluated using subjective or functional measures alone. Laboratory-based documentation provides objective evidence of metabolic and physiological adaptation to exercise interventions.

Objective: This review aims to examine the role of laboratory investigations in documenting patient response to exercise therapy in diabetes, emphasizing their clinical value in monitoring effectiveness, safety, and individualized care.

Methods: A narrative review of international guidelines and peer-reviewed literature was conducted, focusing on laboratory markers commonly used to assess glycemic control, lipid metabolism, insulin sensitivity, and inflammatory status in patients undergoing exercise therapy.

Results: Evidence consistently demonstrates that structured exercise programs lead to significant improvements in laboratory markers such as HbA1c, fasting plasma glucose, lipid profiles, and inflammatory indicators. Laboratory-based monitoring enables early identification of responders and non-responders, supports treatment personalization, and enhances interdisciplinary collaboration among physiotherapists, laboratory professionals, nurses, and physicians.

Conclusion: Integrating laboratory documentation into exercise therapy programs strengthens evidence-based diabetes care by providing objective outcome measures, improving patient safety, and supporting personalized treatment strategies. Future models should combine laboratory data with digital health tools to optimize long-term diabetes management.

Keywords

Diabetes Mellitus; Exercise Therapy; Laboratory Diagnostics; Glycemic Control; Physiotherapy; Interdisciplinary Care

INTRODUCTION

Diabetes mellitus represents one of the most significant global public health challenges, characterized by chronic hyperglycemia resulting from defects in insulin secretion, insulin action, or both. The global prevalence of diabetes has increased markedly over recent decades, driven by sedentary lifestyles, population aging, and rising obesity rates. According to the **World Health Organization**, diabetes affects hundreds of millions of individuals worldwide and is a leading cause of cardiovascular disease, renal failure, blindness, and lower-limb amputations (WHO, 2023).

Exercise therapy is widely recognized as a cornerstone of diabetes management, alongside pharmacological treatment and nutritional interventions. Regular physical activity improves glycemic control by enhancing insulin sensitivity, increasing glucose uptake by skeletal muscle, and reducing insulin resistance. Clinical guidelines issued by the **American Diabetes Association** emphasize that structured aerobic and resistance exercise programs significantly reduce glycated hemoglobin (HbA1c) levels and improve overall metabolic health in individuals with type 2 diabetes (American Diabetes Association [ADA], 2024).

Despite strong evidence supporting exercise therapy, the evaluation of patient response to physical activity interventions often relies heavily on subjective measures such as self-reported adherence, perceived exertion, or functional improvement. While these indicators are valuable, they may not fully capture the physiological and metabolic adaptations induced by exercise. In contrast, laboratory-based investigations provide objective and quantifiable markers that reflect underlying metabolic control and systemic responses to therapeutic exercise. Key laboratory parameters, including fasting plasma glucose, HbA1c, lipid profile, and inflammatory markers, offer critical insights into both short-term and long-term responses to exercise therapy (Colberg et al., 2016).

Laboratory documentation plays a vital role in diabetes care by enabling clinicians to monitor disease progression, assess treatment effectiveness, and adjust management plans accordingly. The **International Diabetes Federation** highlights that integrating laboratory biomarkers into routine diabetes monitoring enhances clinical decision-making and supports personalized treatment strategies (IDF, 2023). When applied to exercise therapy, laboratory data can help identify responders and non-responders, detect early metabolic improvements, and ensure patient safety during physical rehabilitation programs.

From an interdisciplinary perspective, laboratory-based documentation strengthens collaboration between physiotherapists, laboratory professionals, nurses, and physicians. Physiotherapists rely on laboratory indicators to tailor exercise intensity and progression, while laboratory specialists ensure accuracy and reliability of biomarker measurements. Nursing professionals contribute by coordinating follow-up testing, educating patients, and reinforcing adherence to exercise and monitoring protocols. Such integrated care models align with international recommendations for patient-centered and evidence-based diabetes management (WHO, 2019).

Given the increasing emphasis on outcome-driven healthcare and precision medicine, there is a growing need to systematically document patient responses to exercise therapy using laboratory evidence. This approach not only enhances the scientific evaluation of exercise interventions but also supports safer, more effective, and individualized diabetes care. Therefore, this article aims to explore the role of laboratory-based documentation in assessing patient response to exercise

therapy in diabetes, highlighting its clinical relevance, interdisciplinary implications, and potential for improving long-term outcomes

2. Diabetes Mellitus and Exercise Therapy

Diabetes mellitus is a chronic metabolic disorder characterized by impaired glucose regulation and associated with long-term microvascular and macrovascular complications. Type 2 diabetes mellitus (T2DM), which accounts for the majority of cases globally, is strongly linked to physical inactivity and insulin resistance. Exercise therapy is therefore considered a foundational component of diabetes management, complementing pharmacological and nutritional interventions (American Diabetes Association [ADA], 2024).

Regular physical activity enhances glucose uptake by skeletal muscle through insulin-dependent and insulin-independent pathways. During exercise, glucose transporter type 4 (GLUT4) translocation to the muscle cell membrane is increased, leading to improved glycemic control even in the presence of insulin resistance. Both aerobic and resistance training have been shown to reduce fasting plasma glucose levels and glycated hemoglobin (HbA1c), with combined exercise modalities demonstrating superior metabolic benefits (Colberg et al., 2016).

Clinical guidelines recommend that adults with diabetes engage in at least 150 minutes of moderate-intensity aerobic exercise per week, in addition to resistance training on two or more days per week. These recommendations are supported by robust evidence indicating improvements in cardiovascular fitness, lipid profiles, body composition, and insulin sensitivity (Umpierre et al., 2011). However, individual responses to exercise therapy vary considerably, influenced by factors such as baseline metabolic status, adherence, comorbidities, and exercise intensity. Despite its proven benefits, exercise therapy is not without potential risks in diabetic populations, including hypoglycemia, musculoskeletal injuries, and cardiovascular events in high-risk individuals. This highlights the importance of systematic monitoring and objective evaluation to ensure both effectiveness and safety. Laboratory-based assessments provide an essential mechanism for identifying physiological responses and potential adverse effects associated with exercise interventions in patients with diabetes (ADA, 2024).

3. Role of Laboratory Diagnostics in Diabetes Care

Laboratory diagnostics are central to the diagnosis, monitoring, and long-term management of diabetes mellitus. Objective laboratory measurements allow clinicians to assess glycemic control, evaluate metabolic risk, and guide therapeutic decision-making. According to the **World Health Organization**, standardized laboratory testing is essential for effective diabetes surveillance and quality care delivery (WHO, 2022).

Key laboratory markers used in diabetes management include fasting plasma glucose (FPG), postprandial glucose, and glycated hemoglobin (HbA1c). HbA1c remains the gold standard for assessing long-term glycemic control, reflecting average blood glucose levels over a period of approximately three months. Reductions in HbA1c are strongly associated with decreased risk of diabetes-related complications, making it a critical outcome measure when evaluating therapeutic interventions such as exercise therapy (ADA, 2024).

In addition to glycemic markers, lipid profile parameters—including total cholesterol, low-density lipoprotein (LDL), high-density lipoprotein (HDL), and triglycerides—are routinely monitored due to the elevated cardiovascular risk in

diabetic patients. Exercise therapy has been shown to favorably modify lipid profiles, particularly by reducing triglyceride levels and increasing HDL cholesterol, which can be objectively documented through laboratory testing (Umpierre et al., 2011).

Emerging evidence also supports the role of inflammatory and metabolic biomarkers, such as C-reactive protein (CRP), insulin levels, and measures of insulin resistance, in evaluating patient response to exercise therapy. These markers provide deeper insight into the systemic effects of physical activity beyond glucose control alone and may help identify early metabolic improvements before clinical changes become apparent (Colberg et al., 2016).

Laboratory professionals play a critical role in ensuring the accuracy, reliability, and standardization of these measurements. Proper sample collection, analytical precision, and result interpretation are essential for meaningful documentation of patient response to exercise therapy. In this context, laboratory-based documentation serves not only as a monitoring tool but also as a foundation for interdisciplinary collaboration and evidence-based diabetes care.

4. Laboratory-Based Documentation of Exercise Therapy Outcomes

Objective laboratory documentation provides a robust framework for evaluating patient response to exercise therapy in diabetes. Unlike subjective clinical observations, laboratory markers offer quantifiable evidence of metabolic adaptation, treatment effectiveness, and patient safety. Baseline laboratory assessment prior to initiating exercise therapy establishes a reference point against which subsequent changes can be objectively measured (American Diabetes Association [ADA], 2024).

Routine laboratory monitoring during exercise-based interventions enables clinicians to track short-term metabolic responses, such as reductions in fasting plasma glucose, as well as long-term improvements reflected in HbA1c levels. Evidence indicates that sustained exercise programs are associated with clinically meaningful reductions in HbA1c, often comparable to the effects of adding a second-line glucose-lowering medication (Umpierre et al., 2011). These changes are best captured through standardized laboratory documentation at predefined intervals.

Beyond glycemic indices, exercise therapy influences lipid metabolism, inflammatory status, and insulin sensitivity. Laboratory markers such as triglycerides, HDL cholesterol, C-reactive protein (CRP), and fasting insulin levels provide complementary information on cardiometabolic risk reduction and systemic health improvements. Documenting these parameters allows healthcare teams to evaluate holistic patient outcomes rather than isolated glucose control (Colberg et al., 2016).

Systematic laboratory documentation also supports early identification of non-responders or patients experiencing adverse metabolic responses, enabling timely modification of exercise intensity, frequency, or modality. From a safety perspective, laboratory trends can signal hypoglycemia risk, overtraining, or inadequate metabolic adaptation, reinforcing the importance of laboratory data in exercise-based diabetes management.

Table 1. Baseline and Follow-Up Laboratory Markers for Documenting Response to Exercise Therapy in Diabetes

Laboratory Parameter	Clinical Significance	Baseline Assessment	Short-Term Follow-Up (4–8 weeks)	Long-Term Follow-Up (12–24 weeks)	Expected Response to Exercise Therapy	Clinical Interpretation
Fasting Plasma Glucose (mg/dL)	Immediate glycemic control	Required	Recommended	Required	Gradual reduction	Improved insulin sensitivity
HbA1c (%)	Long-term glycemic control	Required	Optional	Required	≥ 0.5 – 1.0% reduction	Reduced complication risk
Postprandial Glucose (mg/dL)	Meal-related glucose response	Optional	Recommended	Recommended	Decreased excursions	Improved glucose handling
Total Cholesterol (mg/dL)	Cardiovascular risk	Required	Optional	Required	Mild reduction	Cardiovascular benefit
LDL Cholesterol (mg/dL)	Atherogenic risk	Required	Optional	Required	Reduction	Lower ASCVD risk
HDL Cholesterol (mg/dL)	Protective lipid marker	Required	Optional	Required	Increase	Improved lipid profile
Triglycerides (mg/dL)	Metabolic syndrome marker	Required	Recommended	Required	Reduction	Improved metabolic health
Fasting Insulin (μ U/mL)	Insulin resistance indicator	Optional	Recommended	Recommended	Decrease	Improved insulin sensitivity
HOMA-IR	Insulin resistance index	Optional	Optional	Recommended	Reduction	Enhanced metabolic response
C-reactive Protein (mg/L)	Inflammatory marker	Optional	Optional	Recommended	Reduction	Reduced systemic

Laboratory Parameter	Clinical Significance	Baseline Assessment	Short-Term Follow-Up (4–8 weeks)	Long-Term Follow-Up (12–24 weeks)	Expected Response to Exercise Therapy	Clinical Interpretation
						inflammation
Creatine Kinase (U/L)	Muscle stress indicator	Optional	Recommended (if symptomatic)	Optional	Transient increase	Exercise adaptation vs injury
Serum Lactate	Exercise tolerance marker	Optional	Optional	Optional	Improved clearance	Enhanced aerobic capacity

Table reference: Adapted from ADA (2024), Colberg et al. (2016), and WHO laboratory monitoring principles.

5. Multidisciplinary Perspective in Laboratory-Based Exercise Monitoring

Effective documentation of patient response to exercise therapy in diabetes requires close collaboration among multiple healthcare disciplines. Physiotherapists play a central role in designing individualized exercise programs, adjusting intensity based on laboratory feedback, and ensuring safe progression of physical activity. Laboratory results inform decisions regarding exercise prescription, particularly in patients with poor glycemic control or multiple comorbidities.

Laboratory professionals are responsible for ensuring analytical accuracy, standardized testing protocols, and reliable longitudinal comparisons. Consistency in sample timing, analytical methods, and result reporting is critical for valid interpretation of exercise-induced metabolic changes. Inaccurate or inconsistent laboratory data may lead to inappropriate clinical decisions and undermine the evaluation of therapeutic outcomes (WHO, 2022).

Nursing professionals contribute by coordinating laboratory testing schedules, educating patients on preparation for blood sampling, and reinforcing adherence to exercise and monitoring plans. Health informatics specialists further enhance this process by integrating laboratory data into electronic health records, enabling trend analysis, automated alerts, and data-driven clinical decision support. Such interdisciplinary integration aligns with international recommendations for patient-centered and outcomes-focused diabetes care (WHO, 2019).

Table 2. Roles of Healthcare Professionals in Laboratory-Based Documentation of Exercise Therapy in Diabetes

Discipline	Primary Responsibilities	Contribution to Laboratory Documentation	Impact on Patient Outcomes
Physiotherapy	Exercise prescription, supervision	Adjust program based on lab trends	Optimized glycemic and functional outcomes
Laboratory Sciences	Sample analysis, quality control	Ensure accuracy and standardization	Reliable outcome measurement
Nursing	Patient education, coordination	Facilitate testing adherence	Improved safety and continuity
Health Informatics	Data integration, analytics	Longitudinal tracking and alerts	Enhanced clinical decision-making
Physicians	Clinical oversight	Interpret lab trends	Individualized treatment adjustment

6. Clinical Implications and Practice Integration

Integrating laboratory-based documentation into exercise therapy programs for patients with diabetes has significant clinical implications. Objective laboratory trends enable clinicians to personalize exercise prescriptions, optimize safety, and enhance therapeutic effectiveness. By correlating laboratory markers with exercise intensity and progression, healthcare teams can tailor interventions to individual metabolic responses rather than relying on uniform protocols (American Diabetes Association [ADA], 2024).

Laboratory data support early identification of patients who exhibit suboptimal responses to exercise therapy. In such cases, clinicians may adjust exercise modality, frequency, or duration, or consider additional lifestyle or pharmacological interventions. Conversely, favorable laboratory trends reinforce adherence and provide measurable evidence of benefit, which can improve patient motivation and engagement (Colberg et al., 2016).

From a systems perspective, integrating laboratory documentation into routine practice promotes continuity of care across outpatient clinics, rehabilitation units, and primary care settings. Health informatics solutions further enhance this integration by enabling automated trend analysis, alerts for abnormal results, and standardized reporting across disciplines. These practices align with international recommendations for evidence-based, patient-centered diabetes care (World Health Organization [WHO], 2019).

Table 3. Clinical Use of Laboratory Markers to Guide Exercise Therapy Decisions in Diabetes

Laboratory Marker	Observed Trend	Clinical Interpretation	Recommended Exercise Adjustment	Safety Considerations
HbA1c	Decreasing	Effective metabolic response	Maintain or gradually increase intensity	Continue routine monitoring

Laboratory Marker	Observed Trend	Clinical Interpretation	Recommended Exercise Adjustment	Safety Considerations
HbA1c	No change	Limited response	Modify exercise type or duration	Assess adherence
Fasting Glucose	Persistent elevation	Inadequate glycemic control	Increase frequency of aerobic activity	Monitor hypoglycemia risk
Triglycerides	Decreasing	Improved lipid metabolism	Continue combined training	Cardiovascular benefit
CRP	Decreasing	Reduced inflammation	Maintain program	Positive systemic response
Creatine Kinase	Elevated	Muscle stress or injury	Reduce intensity temporarily	Prevent overtraining

7. Challenges and Limitations

Despite its advantages, laboratory-based documentation of exercise therapy outcomes faces several challenges. Variability in laboratory testing intervals, differences in analytical methods, and patient adherence to follow-up testing can limit the consistency and interpretability of results. In resource-limited settings, access to comprehensive laboratory panels may be constrained, potentially reducing the feasibility of extensive monitoring (WHO, 2022).

Patient-related factors, including inconsistent exercise adherence, dietary variations, and comorbid conditions, may confound laboratory outcomes. Additionally, some laboratory markers respond slowly to exercise interventions, requiring long-term follow-up to detect meaningful changes. These limitations underscore the need for standardized protocols and clear documentation frameworks to ensure reliable interpretation of laboratory data in exercise-based diabetes management.

8. Future Directions

Advances in digital health and laboratory informatics offer new opportunities to enhance laboratory-based documentation of exercise therapy outcomes. Integration of electronic health records with laboratory information systems allows real-time monitoring of metabolic trends and supports data-driven clinical decision-making. Emerging research also highlights the potential role of novel biomarkers, such as adipokines and metabolomic profiles, in capturing early responses to exercise therapy (Colberg et al., 2016).

Future studies should focus on developing standardized documentation models that combine laboratory data with wearable device metrics and patient-reported outcomes. Longitudinal research designs are needed to clarify the optimal frequency of laboratory monitoring and to establish evidence-based thresholds for clinically meaningful changes in response to exercise therapy.

Table 4. Future Innovations in Laboratory-Based Monitoring of Exercise Therapy in Diabetes

Innovation Area	Description	Potential Benefit	Implementation Considerations
Digital Health Integration	Linking lab data to EHR systems	Continuous trend analysis	Data privacy and interoperability
Wearable–Lab Synergy	Combining glucose sensors with lab results	Enhanced monitoring accuracy	Cost and patient training
Advanced Biomarkers	Inflammatory and metabolic profiling	Early response detection	Standardization required
Automated Alerts	Threshold-based notifications	Improved patient safety	Clinical validation

The innovations outlined in Table 4 highlight a paradigm shift toward data-driven and technology-enabled monitoring of exercise therapy outcomes in diabetes. Integrating laboratory diagnostics with digital health solutions allows for continuous, longitudinal assessment of metabolic responses, moving beyond episodic evaluation toward proactive clinical management. These innovations align with international recommendations emphasizing precision medicine, interoperability, and patient-centered care, particularly in chronic disease management such as diabetes (World Health Organization [WHO], 2019). By leveraging laboratory data alongside emerging technologies, healthcare systems can enhance early detection of suboptimal responses, improve patient safety, and optimize long-term outcomes.

To operationalize laboratory-based documentation in routine clinical practice, a structured and comprehensive monitoring framework is required. Such a framework should clearly define the laboratory markers to be assessed, the recommended frequency of testing, and the clinical purpose of each parameter. Establishing standardized laboratory monitoring protocols supports consistency across healthcare settings and facilitates interdisciplinary collaboration. This structured approach aligns with international recommendations emphasizing objective outcome measurement and evidence-based decision-making in diabetes management (American Diabetes Association [ADA], 2024). Table 5 presents an integrated laboratory framework designed to guide clinicians in systematically documenting patient response to exercise therapy in diabetes and translating laboratory findings into actionable clinical decisions.

Table 5. Comprehensive Laboratory Framework for Monitoring Exercise Therapy Outcomes in Diabetes

Category	Laboratory Marker	Recommended Monitoring Frequency	Clinical Purpose	Expected Exercise-Induced Change	Decision-Making Value
Glycemic Control	Fasting Plasma Glucose	Baseline; every 4–8 weeks	Immediate glucose regulation	Gradual reduction	Adjust exercise intensity and frequency
Glycemic Control	HbA1c	Baseline; every 3–6 months	Long-term glycemic control	≥ 0.5 – 1.0% decrease	Evaluate intervention effectiveness
Glycemic Control	Postprandial Glucose	Baseline; follow-up as needed	Meal-related glucose response	Reduced excursions	Optimize exercise timing
Lipid Metabolism	LDL Cholesterol	Baseline; every 3–6 months	Cardiovascular risk assessment	Reduction	Lower atherosclerotic risk
Lipid Metabolism	HDL Cholesterol	Baseline; every 3–6 months	Protective lipid marker	Increase	Improved cardiometabolic profile
Lipid Metabolism	Triglycerides	Baseline; every 3–6 months	Metabolic risk indicator	Reduction	Enhanced metabolic control
Insulin Sensitivity	Fasting Insulin	Optional; follow-up if available	Insulin resistance assessment	Decrease	Personalize exercise prescription
Insulin Sensitivity	HOMA-IR	Optional; follow-up	Quantify insulin resistance	Reduction	Monitor metabolic adaptation
Inflammation	C-reactive Protein (CRP)	Optional; long-term follow-up	Systemic inflammation	Reduction	Assess cardiometabolic improvement
Muscle Response	Creatine Kinase (CK)	As clinically indicated	Muscle stress and adaptation	Transient increase	Prevent overtraining and injury
Safety Monitoring	Serum Electrolytes	High-risk patients	Exercise-related safety	Stability	Prevent metabolic complications

The comprehensive framework presented in Table 5 underscores the central role of laboratory diagnostics in guiding exercise therapy and evaluating its effectiveness in diabetes care. By systematically categorizing laboratory markers according to clinical purpose, monitoring frequency, and decision-making value, this framework

facilitates individualized exercise prescription and enhances patient safety. The integration of glycemic, lipid, inflammatory, and muscle-related parameters reflects a holistic approach to outcome assessment, consistent with evidence-based recommendations from international diabetes organizations (American Diabetes Association [ADA], 2024; Colberg et al., 2016). Adoption of such structured laboratory frameworks can strengthen clinical documentation, support interdisciplinary collaboration, and promote personalized, outcome-oriented diabetes management.

9. CONCLUSION

Laboratory-based documentation provides a comprehensive and objective framework for evaluating patient response to exercise therapy in diabetes. By integrating laboratory markers into exercise monitoring, healthcare teams can enhance personalization, safety, and effectiveness of interventions. This approach supports interdisciplinary collaboration and aligns with contemporary models of patient-centered, evidence-based diabetes care. As healthcare systems increasingly emphasize outcome-driven practice, laboratory-informed exercise therapy represents a critical component of modern diabetes management.

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