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Association between medication adherence and glycemic control in patients with type 2 diabetes mellitus: A pilot cross-sectional study

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Abstract

Background. In routine outpatient care, glycemic control in patients with type 2 diabetes mellitus (T2DM) is influenced by both clinical and behavioral factors. Medication adherence is considered a potentially modifiable determinant of treatment effectiveness; however, its independent association with glycemic outcomes in real-world settings may be difficult to distinguish from the effects of disease duration and patient characteristics.

Objective. To examine the association between medication adherence, assessed using the Morisky–Green questionnaire, and HbA1c levels in patients with T2DM.

Methods. This analytical cross-sectional pilot study included adult patients with T2DM receiving outpatient care. Medication adherence was assessed using the 8-item Morisky–Green questionnaire and categorized as low, medium, or high. HbA1c levels and clinical variables were obtained from medical records. Differences in HbA1c across adherence categories were evaluated using non-parametric methods. Multivariable linear regression analysis was performed to assess factors associated with HbA1c levels, with additional sensitivity analysis comparing low versus medium/high adherence.

Results. HbA1c levels differed significantly across medication adherence categories (Kruskal–Wallis test, $p = 0.041$). In multivariable analysis, longer diabetes duration was independently associated with higher HbA1c levels ($\beta = 0.24$ per year, $p = 0.008$). Medium/high medication adherence was associated with lower HbA1c values ($\beta = -0.53\%$), although this association did not reach statistical significance after adjustment. Female sex showed a non-significant trend toward lower HbA1c levels.

Conclusions. In patients with T2DM receiving routine outpatient care, diabetes duration represents a key independent determinant of glycemic control. Higher

medication adherence is associated with clinically relevant reductions in HbA1c; however, its independent effect may be attenuated in small real-world samples.

Keywords: type 2 diabetes mellitus, medication adherence, Morisky–Green questionnaire, HbA1c, real-world data.

1. Introduction

Type 2 diabetes mellitus is a persistent disease in which glycemic control typically worsens over time, often requiring long-term pharmacological treatment. HbA1c is routinely applied in clinical practice to summarize long-term glucose exposure and is closely linked to the development of diabetes-related microvascular and macrovascular complications [1–3]. Nevertheless, in routine outpatient practice, achieving recommended HbA1c targets remains uneven, even when patients receive guideline-based pharmacological treatment [3]. In everyday clinical settings, suboptimal glycemic control is rarely explained by drug inefficacy alone. More often, it reflects the combined influence of behavioral and clinical factors that affect how treatment is followed over time, including medication use patterns, self-care behaviors, and patient involvement in disease management [4–6]. Among these factors, medication adherence plays a key role, as incomplete or inconsistent use of prescribed therapy can substantially reduce its effectiveness under real-world conditions.

Numerous studies suggest that inadequate medication adherence in type 2 diabetes is often accompanied by poorer glycemic outcomes, a greater frequency of diabetes-related complications, and higher healthcare use [6,12–16]. However, results obtained in routine clinical settings vary considerably. Separating the effect of adherence from other determinants of glycemic

control, such as disease duration and patient characteristics (e.g., age and sex), remains challenging [8–10]. As the disease advances, progressive β -cell dysfunction and more complex treatment regimens may further obscure the observable relationship between adherence and HbA1c, particularly in small real-world studies [9].

The Morisky–Green questionnaire is commonly used to assess medication adherence in clinical research because it is straightforward and focuses on typical nonadherence behaviors [7]. Its 8-item version has been validated in several populations, including a Kazakh-language version, supporting its feasibility for everyday clinical use [21]. Despite the limitations of self-reported adherence measures, such tools remain useful in real-world studies, especially when objective data on medication use are unavailable.

In this pilot cross-sectional study, we evaluated the association between medication adherence measured by the Morisky–Green questionnaire and glycemic control assessed by HbA1c in patients with T2DM receiving outpatient care. The analysis also accounted for disease duration and selected demographic factors to better interpret the role of adherence in routine diabetes care.

2. Materials and Methods

This analytical cross-sectional observational study included 39 adult patients with type 2 diabetes mellitus receiving outpatient care. Clinical variables assessed included age, sex, duration of diabetes (years), and glycated hemoglobin (HbA1c) levels. Medication adherence was evaluated using the 8-item Morisky–Green questionnaire. According to the total score, patients were categorized as having high (score = 8), medium (scores 6–7), or low adherence (score < 6). For sensitivity analysis, medium- and high-adherence categories were combined and compared with the low-adherence group. Continuous variables were

summarized using medians and interquartile ranges or means and standard deviations, as appropriate based on data distribution. Differences in HbA1c levels across adherence categories were assessed using the Kruskal–Wallis test. Multivariable linear regression analysis was performed with HbA1c as the dependent variable and medication adherence, diabetes duration, sex, and age as independent variables. Statistical significance was defined as $p < 0.05$. All analyses were conducted using R software (version 4.3.2; R Foundation for Statistical Computing, Vienna, Austria).

3. Results

HbA1c levels differed significantly across medication adherence categories (Kruskal–Wallis test, $p = 0.041$; Figure 1). Patients with high adherence

demonstrated the lowest HbA1c values, whereas those with low adherence showed higher and more variable HbA1c levels.

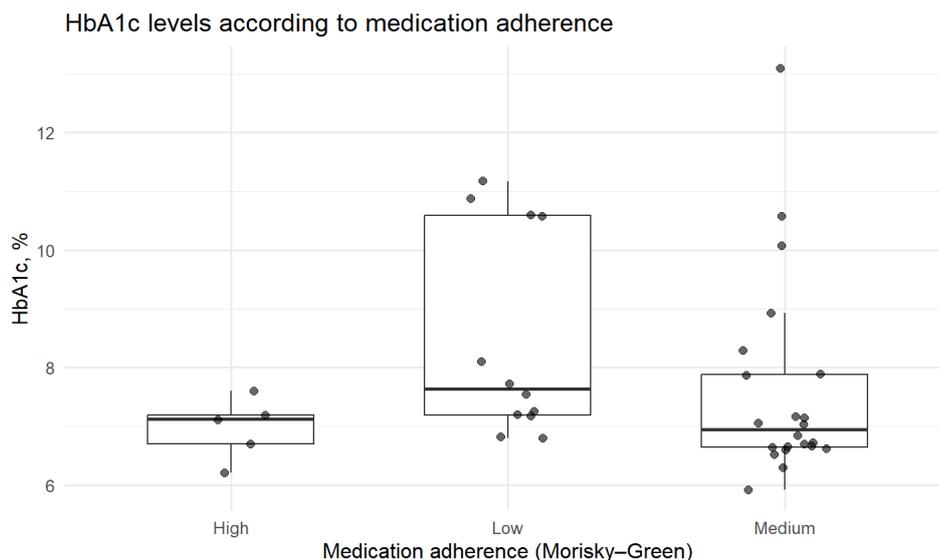


Figure 1 - HbA1c levels according to medication adherence categories
(Boxplot with individual data points; x-axis – adherence category, y-axis – HbA1c, %)

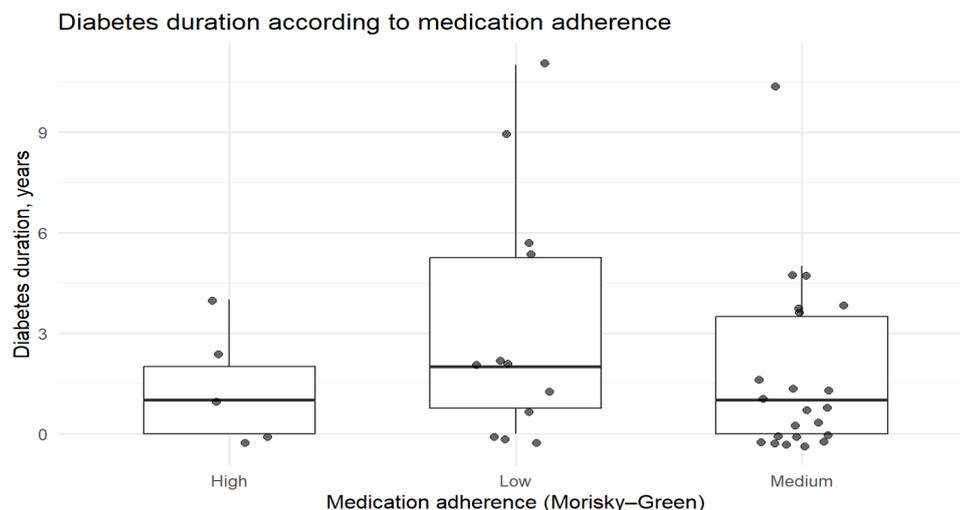


Figure 2 - Diabetes duration according to medication adherence categories
(Boxplot with individual data points; y-axis – diabetes duration, years)

No statistically significant differences in diabetes duration were observed across medication adherence categories (Kruskal–Wallis test, $p = 0.333$; Figure 2). The lack of variation in diabetes duration across adherence levels may reflect the complexity of factors that influence adherence behaviors in real-world clinical settings, including treatment beliefs, regimen complexity, and

patient engagement, rather than simply the chronicity of disease.

Although high adherence was observed only among women, the distribution of adherence categories did not differ significantly between men and women (Fisher’s exact test, $p = 0.17$).

Table 1 - Medication adherence according to the Morisky–Green scale by sex

Sex	High n (%)	Medium n (%)	Low n (%)
Men (n=15)	0 (0.0)	9 (60.0)	6 (40.0)
Women (n=24)	5 (20.8)	13 (54.2)	6 (25.0)

Results of the multivariable linear regression sensitivity analysis are presented in **Table 2**.

Table 2 - Multivariable linear regression analysis of factors associated with HbA1c

Variable	β (95% CI)	p-value
Medium/High adherence vs Low	-0.53 (-1.55 to 0.49)	0.314
Diabetes duration, years	+0.24 (0.06 to 0.42)	0.008
Female sex (vs male)	-0.94 (-1.94 to 0.06)	0.076
Age, years	-0.01 (-0.07 to 0.05)	0.683

In multivariable linear regression analysis (Table 1), diabetes duration remained independently associated with higher HbA1c levels ($\beta = +0.24$ per year; $p = 0.008$). Medium/high adherence was associated with lower

HbA1c levels compared with low adherence; however, this association did not reach statistical significance after adjustment.

4. Discussion

In the present study, diabetes duration showed the strongest independent association with HbA1c levels. This observation aligns with the progressive course of type 2 diabetes mellitus, in which longer disease duration is accompanied by declining β -cell function and increasing difficulty in achieving glycemic targets despite ongoing pharmacotherapy [8,9]. Notably, diabetes duration did not differ across medication adherence categories, indicating that differences in HbA1c cannot be explained by disease chronicity alone. This finding suggests that treatment-related behaviors, including medication adherence, continue to play a role in glycemic control even among patients with long-standing disease.

Lower HbA1c levels were more frequently observed among women, although this association did not remain statistically significant after adjustment. This

pattern may be related to differences in health-related behaviors and diabetes self-management, including medication use, dietary practices, and engagement with healthcare services. While some studies report greater health awareness and adherence to medical recommendations among women, evidence on sex differences in glycemic control remains mixed across real-world and population-based studies, with variation depending on setting and population characteristics [10,11]. Given the limited sample size of this pilot study, the observed sex-related trend should be interpreted cautiously and regarded as hypothesis-generating.

The relationship between medication adherence and glycemic control observed in this study is consistent with findings from real-world research. Lower adherence to glucose-lowering therapy has been associated with

poorer glycemic outcomes, whereas higher adherence is generally linked to lower HbA1c levels. For example, Sendekie et al. reported that patients with high adherence were less likely to have poor glycemic control in routine practice [12]. Similar conclusions have been drawn in systematic reviews and cohort studies using pharmacy refill data, which show better glycemic outcomes among adherent patients [13-20].

Limitations

Although the findings appear clinically relevant, several limitations should be acknowledged. The study design does not allow evaluation of temporal relationships and therefore limits any causal interpretation of the observed associations. The sample size was relatively small, which may have reduced the ability to detect weaker independent relationships between medication adherence and HbA1c. Adherence was assessed using self-reported data; while this

Given the pilot design and small sample size, these results should be considered preliminary. Although they support the clinical relevance of medication adherence in routine diabetes care, larger observational studies are required to more accurately estimate its independent effect on glycemic control and to better characterize the factors influencing adherence in outpatient practice.

approach is feasible in routine outpatient care, it is subject to recall errors and potential response bias. Importantly, this work was conceived as a pilot study, aimed primarily at assessing the feasibility of adherence evaluation and identifying possible patterns linking medication use with glycemic control in real-world clinical practice, rather than formally testing predefined hypotheses.

5. Conclusions

In this outpatient cohort of patients with type 2 diabetes mellitus, glycemic control was most consistently related to disease duration. Patients with higher levels of treatment adherence generally showed lower HbA1c values, indicating a clinically relevant, although not uniformly statistically significant, role of adherence in real-world glycemic outcomes. In small observational cohorts, this relationship may be less apparent due to ongoing disease progression and marked heterogeneity between patients. Overall, these findings imply that improving glycemic control should not rely exclusively on pharmacological intensification, but should also take

into account modifiable behavioral factors, including long-term medication adherence, alongside the natural progression of the disease.

Conflict of Interest. The authors declare no conflict of interest.

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Authors contributions. Conceptualization - S.A.; methodology - K.I.; verification - S.A.; formal analysis - S.A.; writing (original draft preparation) - K.I.; writing (review and editing) - K.I.

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2 типті қант диабетімен ауыратын науқастардағы дәрі-дәрмек қабылдауды сақтау және гликемиялық бақылау арасындағы байланыс: Көлденең пилотты зерттеу

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Түйіндеме

Кіріспе. Күнделікті амбулаториялық тәжірибеде 2-типті қант диабеті (ҚД2) бар науқастардағы гликемиялық бақылау клиникалық және мінез-құлықтық факторлардың ықпалымен қалыптасады. Дәрілік терапияға бейімділік ем тиімділігінің әлеуетті түрде өзгертуге болатын детерминанты ретінде қарастырылады; алайда нақты клиникалық практика жағдайында оның гликемиялық көрсеткіштермен тәуелсіз байланысын ауру ұзақтығы мен пациент сипаттамаларының әсерінен ажырату қиын.

Мақсаты. Мориски–Грин сауалнамасы арқылы бағаланған дәрілік терапияға бейімділік пен HbA1c деңгейі арасындағы байланысты ҚД2 бар науқастарда зерттеу.

Әдістері. ҚД2 диагнозы бар және амбулаториялық бақылауда тұрған ересек пациенттер қатысқан аналитикалық көлденең пилоттық зерттеу жүргізілді. Дәрілік терапияға бейімділік Мориски–Гриннің 8 тармақтан тұратын сауалнамасы арқылы бағаланып, төмен, орташа және жоғары деңгейлерге жіктелді. HbA1c деңгейлері мен клиникалық айнымалылар медициналық құжаттамадан алынды. Бейімділік санаттары бойынша HbA1c деңгейлеріндегі айырмашылықтар параметрлік емес әдістермен бағаланды. HbA1c деңгейімен байланысты факторларды анықтау үшін көп айнымалы сызықтық регрессиялық талдау жүргізілді, сондай-ақ төмен және орташа/жоғары бейімділік топтарын салыстыратын сезімталдық талдауы орындалды.

Нәтижелер. HbA1c деңгейлері дәрілік терапияға бейімділік санаттары арасында статистикалық тұрғыдан мәнді түрде айырмашылық көрсетті (Краскел–Уоллис критерийі, $p = 0,041$). Көп айнымалы талдауда қант диабетінің ұзаққа созылуы HbA1c деңгейінің жоғары болуымен тәуелсіз түрде байланысты болды ($\beta =$ жылына 0,24, $p = 0,008$). Орташа/жоғары бейімділік HbA1c деңгейінің төмендеуімен байланысты болды ($\beta = -0,53\%$), алайда түзетуден кейін бұл байланыс статистикалық мәнділікке жетпеді. Әйел жынысында HbA1c деңгейінің төмен болуына бағытталған, бірақ статистикалық мәнді емес үрдіс байқалды.

Қорытынды. ҚД2 бар және амбулаториялық көмек алатын пациенттерде аурудың ұзақтығы гликемиялық бақылаудың негізгі тәуелсіз детерминанты болып табылады. Дәрілік терапияға жоғары бейімділік HbA1c деңгейінің клиникалық тұрғыдан маңызды төмендеуімен байланысты; алайда шағын нақты клиникалық практика үлгілерінде оның тәуелсіз әсері әлсіреуі мүмкін.

Түйін сөздер: 2 типті қант диабеті, дәрілік терапияға бейімділік, Мориски–Грин сауалнамасы, HbA1c, нақты клиникалық практика деректері.

Взаимосвязь между приверженностью к медикаментозному лечению и гликемическим контролем у пациентов с сахарным диабетом 2 типа: Пилотное поперечное исследование

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Аннотация

Введение. В условиях рутинной амбулаторной практики гликемический контроль у пациентов с сахарным диабетом 2 типа (СД2) определяется как клиническими, так и поведенческими факторами. Приверженность медикаментозной терапии рассматривается как потенциально модифицируемый детерминант эффективности лечения; однако в реальных условиях её независимую связь с показателями гликемического контроля сложно отделить от влияния длительности заболевания и характеристик пациента.

Цель. Изучить связь между приверженностью медикаментозной терапии, оценённой с использованием опросника Мориски–Грина, и уровнем HbA1c у пациентов с СД2.

Методы. Проведено аналитическое поперечное пилотное исследование с участием взрослых пациентов с СД2, получающих амбулаторное лечение. Приверженность терапии оценивалась с помощью 8-пунктового опросника Мориски–Грина и классифицировалась как низкая, средняя или высокая. Данные об уровне HbA1c и клинические характеристики извлекались из медицинской документации. Различия уровней HbA1c между группами приверженности анализировались с использованием непараметрических методов. Для оценки факторов, ассоциированных с уровнем HbA1c, применялся многомерный линейный регрессионный анализ, а также проведён анализ чувствительности с сопоставлением низкой и средней/высокой приверженности.

Результаты. Уровни HbA1c статистически значимо различались между категориями приверженности терапии (критерий Краскела–Уоллиса, $p = 0,041$). В многомерном анализе большая длительность диабета была независимо ассоциирована с более высокими значениями HbA1c ($\beta = 0,24$ на каждый год, $p = 0,008$). Средняя/высокая приверженность терапии была связана с более низкими уровнями HbA1c ($\beta = -0,53\%$), однако после корректировки данная ассоциация не достигла статистической значимости. У женщин отмечалась тенденция к более низким значениям HbA1c, не достигшая статистической значимости.

Заключение. У пациентов с СД2, получающих рутинную амбулаторную помощь, длительность заболевания является ключевым независимым детерминантом гликемического контроля. Более высокая приверженность медикаментозной терапии ассоциирована с клинически значимым снижением HbA1c; однако её независимый эффект может ослабевать в условиях малых выборок реальной клинической практики.

Ключевые слова: сахарный диабет 2 типа, приверженность медикаментозной терапии, опросник Мориски–Грина, HbA1c, данные реальной клинической практики.