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Original Article

Relationship Between Digital Health App Engagement and Physical Activity Adherence in Adults With Type 2 Diabetes: A Correlational Study

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ABSTRACT

Background: Type 2 diabetes mellitus requires sustained self-management, and digital health applications are increasingly used to support behavioral monitoring, education, and lifestyle modification. However, evidence remains limited regarding the relationship between app usability and physical activity adherence in adults with established type 2 diabetes, particularly in clinical populations from lower-resource settings. Objective: To determine the relationship between digital health app usability and physical activity adherence in adults with type 2 diabetes mellitus. Methods: This descriptive correlational study included 42 adults with type 2 diabetes recruited through non-probability convenience sampling from diabetes and endocrinology clinics in Lahore, Pakistan. App usability was assessed using the mHealth App Usability Questionnaire, while physical activity adherence was measured using the International Physical Activity Questionnaire and expressed as total MET-minutes per week. Data were analyzed in SPSS version 27.0 using descriptive statistics, the Shapiro-Wilk test for normality, and Pearson correlation. Results: The mean age of participants was 54.38 ± 6.39 years, and 69.0% were female. Most participants had used digital health applications for 3-6 months (45.2%), and 78.6% were classified as moderately active. A statistically significant moderate positive correlation was observed between app usability and physical activity adherence ($r = 0.564$, $p < 0.001$), indicating that better perceived usability was associated with higher physical activity levels. Conclusion: Better usability of digital health applications was associated with greater physical activity adherence among adults with type 2 diabetes. These findings support the potential role of user-centered mobile health tools in diabetes self-management, although larger longitudinal studies using objective outcome measures are needed.
Keywords: Adult; Diabetes Mellitus; Diabetes Mellitus, Type 2; Mobile Applications; Physical Activity; Telemedicine.

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INTRODUCTION

Type 2 diabetes mellitus is a chronic metabolic disorder characterized by persistent hyperglycemia resulting from insulin resistance and relative insulin deficiency, and it remains one of the leading contributors to global morbidity, disability, and healthcare expenditure (1,2). The disease is associated with a wide spectrum of microvascular and macrovascular complications, including neuropathy, nephropathy, retinopathy, and cardiovascular disease, all of which substantially impair functional independence and quality of life (3-5). In addition to these biomedical consequences, adults with type 2 diabetes frequently experience reduced participation in regular physical activity because of fatigue, pain, fear of complications, limited exercise tolerance, psychological distress, and coexisting obesity or musculoskeletal limitations (6). Since physical activity is a core component of diabetes self-management and is strongly linked to glycemic regulation, weight control, cardiovascular risk reduction, and overall well-being, identifying practical strategies that support long-term adherence remains a priority in contemporary diabetes care (7).

Digital health interventions, particularly mobile health applications, have emerged as accessible tools for supporting self-management in chronic diseases by enabling glucose monitoring, medication reminders, behavioral prompts, educational reinforcement, dietary tracking, and personalized feedback (8,9). Recent evidence suggests that digital health technologies may improve self-care behaviors, treatment engagement, and selected clinical outcomes in individuals with type 2 diabetes; however, the extent of benefit appears to depend on sustained engagement, perceived usability, digital literacy, and contextual relevance of the intervention (10). While a growing body of research has examined the effectiveness, reach, and feasibility of digital interventions for diabetes management, much of the available literature has focused on glycemic outcomes, app adoption, or general self-care behaviors rather than the specific relationship between app engagement characteristics and physical activity adherence (10,11). This distinction is important because individuals may download or use an application without achieving meaningful behavioral change, and the usability of the application may influence whether patients translate digital interaction into sustained real-world activity.

Survey-based and population-level studies have shown that people with and without type 2 diabetes commonly use health applications for diet, exercise, and self-monitoring, yet the behavioral mechanisms linking app use to actual activity patterns remain insufficiently defined, especially in middle-aged and older adults receiving routine care in lower-resource clinical settings (11,12). Similarly, systematic reviews have reported promising but heterogeneous effects of digital interventions, with variation attributable to intervention design, adherence, patient motivation, and the practical usability of the platform itself (8,10). Digital health literacy has also been recognized as an important determinant of health technology uptake and effectiveness, indicating that the quality of patient interaction with an application may be as important as mere access to it (9). Despite this, relatively limited evidence has quantified the relationship between perceived app usability and physical activity adherence among adults with established type 2 diabetes in Pakistan, where the burden of disease is high and scalable self-management strategies are urgently needed (2).

Given this gap, examining whether higher engagement with and usability of digital health applications is associated with better physical activity participation may provide clinically useful evidence for designing more effective, patient-centered diabetes interventions. Understanding this relationship may also help clinicians identify whether digital platforms are functioning simply as informational tools or as meaningful behavioral supports within long-term chronic disease management. Therefore, this study aimed to determine the relationship between digital health app engagement, assessed through app usability, and physical activity adherence in adults with type 2 diabetes. It was hypothesized that better digital health app usability would be positively associated with higher levels of physical activity (1-12).

MATERIALS AND METHODS

This descriptive correlational study was conducted at diabetes and endocrinology outpatient settings in Lahore, Pakistan, over a four-month period following approval of the research synopsis. The study was designed to examine the relationship between digital health app usability and physical activity adherence among adults with established type 2 diabetes mellitus. A correlational approach was selected because the objective was to quantify the direction and strength of association between two measured variables in a real-world clinical population rather than to test the effect of an intervention. Eligible participants were men and women aged 45 to 65 years with a confirmed diagnosis of type 2 diabetes mellitus for at least one year and current use of a digital health application for a minimum of the preceding three months (11,12). Participants were also required to be able to understand the study questions and provide informed consent. Individuals with severe comorbid conditions likely to independently limit physical activity or interfere with self-management participation, including advanced renal disease, active malignancy, significant intellectual disability, major psychiatric illness, pregnancy, bedridden status, or a history of lower-extremity trauma or musculoskeletal injury affecting mobility or balance, were excluded from participation (13).

Participants were recruited through non-probability convenience sampling from patients attending the selected clinical sites during the study period. Potentially eligible individuals were approached in person, informed about the purpose and procedures of the study, and enrolled after written informed consent had been obtained. The target sample size was 42 participants, determined using G*Power on the basis of correlation analysis for detecting a statistically meaningful association at the predefined significance threshold. Recruitment continued until the required sample size was achieved. To reduce selection ambiguity, eligibility was assessed prior to questionnaire administration using a structured screening approach based on age, confirmed diagnosis duration, app usage history, and exclusion criteria.

Data were collected using a structured demographic form and two standardized instruments. Demographic and clinical variables included age, sex, height, weight, body mass index, and duration of app use. Digital health app engagement was operationalized through perceived usability and measured using the mHealth App Usability Questionnaire (MAUQ), an 18-item instrument designed to assess mobile health application usability across usefulness, ease of use, and interface and satisfaction domains. Each item is scored on a 7-point Likert scale, with higher scores indicating better perceived usability. The questionnaire has demonstrated good psychometric properties, including strong internal consistency and acceptable construct validity in prior validation studies, making it suitable for evaluating users' interaction quality with mobile health platforms (14). Physical activity adherence was measured using the International Physical Activity Questionnaire (IPAQ), which captures self-reported walking, moderate-intensity activity, and vigorous-intensity activity performed over the preceding week. Total physical activity was expressed in MET-minutes per week by multiplying reported minutes in each activity domain by the corresponding metabolic equivalent value and summing the products to derive the total activity score (14). For analytic interpretation, participants were categorized according to standard IPAQ activity levels on the basis of total MET-minutes per week.

All data were collected in a standardized manner by administering the questionnaires directly after participant enrollment. Responses were reviewed at the time of collection to minimize item omission and improve completeness. To reduce information bias, the same data collection procedure and instrument sequence were used for all participants. Standardized questionnaire wording was maintained throughout, and demographic variables were recorded using uniform definitions. App usage was defined as ongoing use of a digital health application for self-management purposes during the preceding three months, while physical activity adherence was defined by the total IPAQ-derived activity level expressed in MET-minutes per week. The primary study variable was the total MAUQ score, and the primary outcome variable was the total IPAQ MET-minutes per week score.

Data were entered and analyzed using SPSS version 27.0. Quantitative variables were summarized using mean, standard deviation, and range, whereas categorical variables were presented as frequencies and percentages. Prior to inferential testing, the distribution of continuous variables was assessed using the Shapiro-Wilk test. Because the data met the assumption of approximate normality, parametric analysis was used. Pearson's correlation coefficient was applied to assess the relationship between the continuous MAUQ total score and continuous IPAQ total MET-minutes per week score. Correlation strength was interpreted according to conventional thresholds, and statistical significance was determined at a p-value of less than 0.05. To improve interpretability, the analysis plan was structured to present descriptive characteristics first, followed by the correlation estimate and significance value for the association of interest. Data were analyzed on a complete-case basis after on-site review of questionnaire completeness, and no imputation procedure was applied. Variables known to influence physical activity, such as age, sex, and body mass index, were documented to support clinical interpretation of the findings and to reduce unexplained variability in the sample, although the primary analysis remained bivariate because of the study's exploratory correlational design.

Ethical conduct was maintained throughout the study. Participation was voluntary, confidentiality of participant information was preserved, and collected data were used exclusively for research purposes.

Written informed consent was obtained from all participants before enrollment, and the study was carried out after institutional ethical approval. To support data integrity and reproducibility, all participants were assessed using the same eligibility framework, the same validated outcome measures, and the same statistical workflow from data entry through final analysis (11-14).

RESULTS

A total of 42 adults with type 2 diabetes mellitus were included in the analysis. The participants had a mean age of 54.38 ± 6.39 years, with an observed age range of 45 to 65 years. The mean height was 5.42 ± 0.33 feet, ranging from 4.92 to 5.91 feet, while the reported mean weight was 80.63 ± 9.59 kg. The sample was predominantly female, with 29 women (69.0%) and 13 men (31.0%). Based on body mass index classification, 5 participants (11.9%) had normal weight, 9 (21.4%) were overweight, 14 (33.3%) were classified as underweight, and 14 (33.3%) were obese. In relation to digital health app exposure, 19 participants (45.2%) reported using the application for 3–6 months, 8 (19.0%) for 7–12 months, 7 (16.7%) for 20–23 months, and 8 (19.0%) for more than 24 months. Regarding physical activity adherence measured through the International Physical Activity Questionnaire, 9 participants (21.4%) were categorized as having low physical activity, defined as total activity below 600 MET-minutes per week, whereas 33 participants (78.6%) demonstrated moderate physical activity levels between 600 and 1500 MET-minutes per week.

Table 1. Demographic and Clinical Characteristics of the Participants (n = 42)

Variable	Category / Summary	n (%) / Mean ± SD	Range
Age (years)	Continuous	54.38 ± 6.39	45–65
Height (feet)	Continuous	5.42 ± 0.33	4.92–5.91
Weight (kg)	Continuous	80.63 ± 9.59	Reported range inconsistent in source text
Sex	Male	13 (31.0)	—
	Female	29 (69.0)	—
BMI category	Normal weight	5 (11.9)	—
	Overweight	9 (21.4)	—
	Underweight	14 (33.3)	—
	Obese	14 (33.3)	—
App usage duration	3–6 months	19 (45.2)	—
	7–12 months	8 (19.0)	—
	20–23 months	7 (16.7)	—
	>24 months	8 (19.0)	—
IPAQ activity level	Low activity (<600 MET-min/week)	9 (21.4)	—
	Moderate activity (600–1500 MET-min/week)	33 (78.6)	—

Table 2. Correlation Between Digital Health App Usability and Physical Activity Adherence

Variable Pair	Statistical Test	n	Correlation Coefficient (r)	Coefficient of Determination (r^2)	p-value	Strength of Association	Direction
MAUQ total score vs IPAQ total MET-min/week	Pearson correlation	42	0.564	0.318	<0.001	Moderate	Positive

Pearson correlation analysis demonstrated a statistically significant positive association between digital health app usability and physical activity adherence. The total mHealth App Usability Questionnaire score showed a moderate positive correlation with total IPAQ MET-minutes per week ($r = 0.564$, $p < 0.001$, $n = 42$), indicating that participants with better perceived app usability tended to report higher levels of physical activity. The coefficient of determination derived from this correlation ($r^2 = 0.318$) suggests that approximately 31.8% of the variability in physical activity adherence was shared with app usability at the bivariate level. This pattern supports the study hypothesis that better digital engagement, operationalized through usability, is associated with greater adherence to physical activity in adults with type 2 diabetes.

The study population was mainly female and middle-aged, with the largest proportion reporting 3–6 months of app use and most participants classified in the moderate physical activity category. The

reported weight range in the source text was internally inconsistent with the mean and standard deviation and should be verified before final submission.

Better perceived usability of digital health applications was moderately associated with higher physical activity adherence. The magnitude of association indicates a clinically relevant bivariate relationship, although causal inference is not possible because of the correlational design.

Table 3. Distribution of Behavioral Engagement Indicators in the Study Sample

Indicator	Category	n	%
Duration of digital health app use	3–6 months	19	45.2
	7–12 months	8	19.0
	20–23 months	7	16.7
	>24 months	8	19.0
Physical activity adherence	Low activity	9	21.4
	Moderate activity	33	78.6

Nearly half of the participants had relatively recent but sustained app exposure of 3–6 months, while more than three-quarters achieved moderate physical activity levels, suggesting a generally engaged self-management profile within the sampled population.

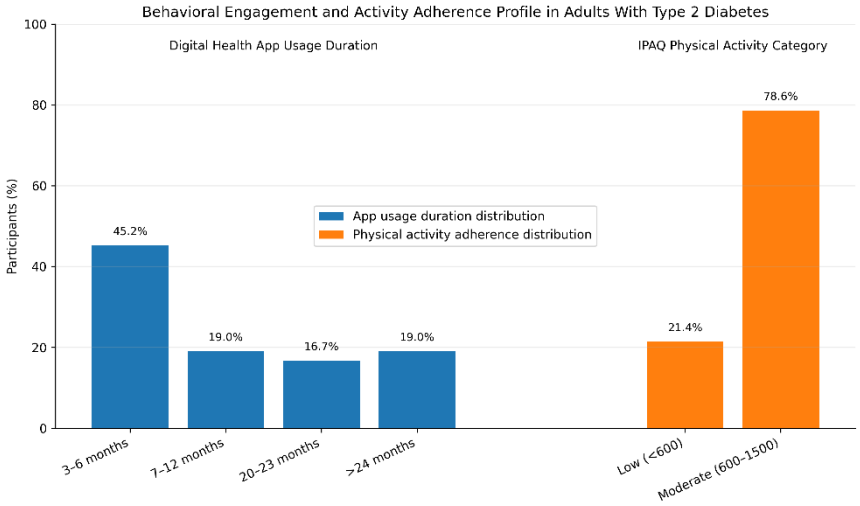

Figure 1 Behavioural profile of the cohort was dominated by intermediate-duration digital engagement and moderate physical activity adherence

Table 1 shows that the sample consisted of 42 adults with type 2 diabetes, with a mean age of 54.38 years and a standard deviation of 6.39 years, indicating a predominantly middle-aged cohort. Female participants constituted more than two-thirds of the sample at 69.0%, compared with 31.0% males. Body mass index categories were unevenly distributed, with obesity and underweight each representing 33.3% of the cohort, while only 11.9% had normal weight and 21.4% were overweight. With respect to app exposure, the largest subgroup, comprising 45.2%, had been using a digital health application for 3–6 months, whereas each of the longer-term use groups represented approximately one-fifth or less of the sample. Physical activity classification revealed that 78.6% of participants were moderately active and 21.4% had low activity levels.

Table 2 demonstrates the principal inferential finding of the study. The correlation between total MAUQ score and total IPAQ MET-minutes per week was positive and moderate in magnitude ($r = 0.564$), with a highly statistically significant p-value of less than 0.001. The derived r^2 value of 0.318 indicates that approximately 31.8% of the variation in physical activity adherence was shared with app usability in the bivariate model. This is a meaningful association in behavioral health research, suggesting that perceived ease of use, usefulness, and satisfaction with the application may be linked to more favorable physical activity adherence patterns among adults with type 2 diabetes.

Table 3 complements the main correlation result by showing the behavioral distribution of the cohort. Almost half of the participants were concentrated in the 3–6 month app-use category, while the remaining duration categories were relatively evenly dispersed between 16.7% and 19.0%. In parallel, the physical activity profile was skewed toward the moderate category, which included nearly four out of every five participants. Taken together, these distributions suggest that the sample was characterized by a predominance of ongoing app engagement and moderate physical activity adherence, which is consistent with the positive direction of the observed correlation.

The figure 1 shows that the behavioral profile of the cohort was dominated by intermediate-duration digital engagement and moderate physical activity adherence. The largest app-use subgroup was 3–6 months, accounting for 45.2% of participants, whereas the longer-duration categories of 7–12 months, 20–23 months, and more than 24 months were comparatively similar at 19.0%, 16.7%, and 19.0%, respectively. In contrast, physical activity adherence was strongly concentrated in the moderate category, which included 78.6% of the sample, while only 21.4% had low activity levels. This asymmetric distribution suggests that although app engagement duration was dispersed across several exposure intervals, the activity profile was markedly weighted toward moderate adherence, supporting the overall pattern of a positive association between digital health app usability and physical activity participation in adults with type 2 diabetes.

DISCUSSION

The present study examined the relationship between digital health app usability and physical activity adherence in adults with type 2 diabetes mellitus and found a statistically significant moderate positive association between the two variables. Participants with better perceived usability of digital health applications, as measured by the mHealth App Usability Questionnaire, tended to report higher physical activity levels on the International Physical Activity Questionnaire. This finding suggests that when patients perceive mobile health applications as useful, easy to navigate, and satisfactory to use, they may be more likely to engage in recommended self-management behaviors such as regular physical activity. Although the correlational design does not permit causal inference, the observed association is clinically meaningful because physical activity remains a cornerstone of type 2 diabetes management and is often difficult to sustain in routine practice.

These findings are consistent with previous literature suggesting that mobile health technologies can support self-care and behavior change in people living with diabetes. Stone et al. reported that mobile health applications may promote sustained self-care behaviors in adults with type 2 diabetes, especially when patients remain actively engaged with the platform over time (15). The present study extends that perspective by showing that perceived usability itself may be an important behavioral correlate, indicating that not only app availability but also the quality of user interaction may influence patient adherence to health-promoting activities. This interpretation is also in line with the broader systematic evidence demonstrating that digital interventions can improve diabetes-related self-management when they are acceptable, accessible, and practically usable in everyday settings (16).

The results also correspond with the population-based observations of Stühmann et al., who found that health applications are commonly used for diet and physical activity management among individuals with and without type 2 diabetes (17). However, whereas prior studies often focused on adoption patterns or general use behaviors, the present analysis specifically linked app usability with physical activity adherence, thereby contributing more directly to the understanding of how digital engagement may relate to an actionable lifestyle outcome. In this sense, the current findings support the view that usability is not merely a technical feature of an application but a potentially relevant determinant of whether patients can integrate digital support into everyday disease management routines.

At the same time, the present findings should be interpreted in light of studies that have emphasized barriers to the sustained adoption of mobile health applications. Andersen et al. highlighted that

technological literacy, privacy concerns, and usability obstacles may reduce long-term acceptance of diabetes-related applications (18). The positive association observed in the current study does not contradict those barriers but instead reinforces their importance; if usability is positively related to physical activity adherence, then poor usability may reasonably impede engagement and limit behavioral benefit. This underscores the need for patient-centered digital design, particularly for middle-aged and older adults who may face greater challenges in navigating health technologies. Applications that are complex, poorly structured, or insufficiently tailored may fail to generate sustained lifestyle improvements even if they are technically available.

The current findings are also compatible with the work of Fields et al., who described smartphone applications as promising tools for diabetes self-management but emphasized that continued benefit depends on sustained use and practical relevance to the patient's daily life (19). In the present study, most participants were classified in the moderate physical activity category, and nearly half reported app use of 3–6 months, suggesting that a meaningful proportion of the sample had ongoing exposure to digital self-management support. The moderate strength of correlation observed here indicates that app usability may explain part, but not all, of the variation in physical activity behavior. This is expected because adherence to physical activity in diabetes is multifactorial and may also be influenced by age, comorbidity burden, motivation, family support, body composition, pain, education, and broader environmental or socioeconomic constraints.

Several methodological considerations should be acknowledged when interpreting these findings. First, the cross-sectional correlational design precludes any conclusion about directionality or causation; it cannot be determined whether better app usability promotes physical activity, whether more active individuals engage more favorably with digital tools, or whether both are influenced by a third factor. Second, the sample size was modest and derived through non-probability convenience sampling from a limited clinical setting, which restricts external validity and generalizability. Third, physical activity was measured through self-report using the IPAQ rather than through objective activity monitoring, introducing the possibility of recall bias and social desirability bias. Fourth, although validated instruments were used, the study relied on perceived usability rather than directly observed app interaction metrics. Finally, the source dataset contained at least one internal inconsistency in the descriptive reporting of anthropometric values, indicating that the final manuscript should undergo careful verification of numeric accuracy before submission.

Despite these limitations, the study has practical implications for digital diabetes care. It highlights that usability should be considered a clinically relevant dimension when selecting, recommending, or designing mobile health tools for adults with type 2 diabetes. Applications that are easy to use and perceived as beneficial may better support patient participation in physical activity, which in turn may strengthen broader self-management efforts. Future research should use larger and more diverse samples, incorporate multivariable modeling to adjust for potential confounders, and employ objective indicators such as wearable activity tracking and real-time app usage analytics. Longitudinal and interventional designs would also be valuable in determining whether improved app usability can directly enhance physical activity adherence and other diabetes-related outcomes in routine clinical care (15-19).

CONCLUSION

In adults with type 2 diabetes mellitus, better perceived usability of digital health applications was significantly associated with higher physical activity adherence, with a moderate positive correlation observed between MAUQ scores and IPAQ total MET-minutes per week. These findings support the potential relevance of user-centered mobile health tools in diabetes self-management, particularly for promoting physically active behavior. However, because the study was cross-sectional, based on a small convenience sample, and relied on self-reported activity measures, the findings should be interpreted as

associative rather than causal. Larger prospective studies using objective digital and behavioral metrics are warranted to clarify the role of app usability in improving long-term diabetes-related outcomes.

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