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Mobile Health Applications and Physical Activity Adherence among Urban Pakistani Adults: A Multi-City Descriptive Study

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Abstract: *Background: Physical inactivity is a major public health challenge in Pakistan, where fewer than 15% of adults meet WHO recommendations for weekly physical activity. Mobile health (mHealth) applications have emerged as scalable, low-cost tools for health promotion; however, their effectiveness within Pakistan's distinct sociocultural and infrastructural context remains largely unexplored.*

Objective: To characterize the prevalence and patterns of mHealth physical activity (PA) application use, evaluate user experience and application quality, assess adherence trajectories, and identify barriers and determinants of adherence among Pakistani adults.

Methods: A descriptive cross-sectional design with an embedded qualitative component was employed. A purposively stratified sample of 384 adults (mean age: 31.7 years; 50% female) was recruited across Lahore, Karachi, and Islamabad. Instruments included the International Physical Activity Questionnaire–Short Form (IPAQ-SF), Mobile Application Rating Scale (MARS), Technology Acceptance Model constructs, and a validated barrier checklist. Descriptive statistics and binary logistic regression were performed using SPSS v25.0; qualitative data from 30 semi-structured interviews were analyzed thematically.

Results: Sixty-two percent of participants (61.7%; 95% CI: 56.7–66.5%) reported current or past use of PA applications. App users demonstrated significantly higher mean physical activity (2,214 vs. 1,287 MET-min/week; $p<0.001$). Applications received moderate quality ratings (MARS total: 3.42/5.0), with Functionality scoring highest (3.71) and Engagement lowest (3.18). High adherence (≥4 days/week) was maintained by 48.5% of users. Significant predictors of adherence included perceived usefulness (aOR=2.31), app personalization (aOR=2.14), social features (aOR=1.98), and exercise self-efficacy (aOR=1.87), while female gender was a negative predictor (aOR=0.54; $p=0.001$). Primary barriers included inconsistent internet connectivity (67.4%), English-language interfaces (54.2%), affordability concerns (42.1%), and cultural incongruence (38.7%).

Keywords: Health applications; physical activity adherence; Pakistan; digital health; Technology Acceptance Model; exercise behavior; low-and-middle-income countries

Introduction

Physical inactivity has reached epidemic proportions globally and stands as the fourth leading risk factor for mortality worldwide, responsible for approximately 3.2 million deaths annually (WHO, 2020; Guthold et al., 2018). In 2022, around 27.5% of adults globally failed to achieve minimum recommended activity levels, with the burden disproportionately concentrated in low-and-middle-income countries (LMICs) undergoing rapid urbanization and occupational transition (Guthold et al., 2018; Pratt et al., 2019).

Pakistan exemplifies the dual burden facing many LMICs. The Pakistan National Health Survey (2019) found that only 14.7% of adults met WHO-recommended physical activity guidelines of 150 minutes of moderate-intensity aerobic activity per week. This pervasive inactivity is a primary driver of rising non-communicable disease (NCD) rates: cardiovascular disease accounts for 25% of all deaths, adult type 2 diabetes prevalence stands at 26.3% (among the highest globally), and hypertension affects approximately 44% of adults (Shafique et al., 2019; IDF, 2021). The associated economic burden from inactivity-attributable diseases is estimated at USD 1.7 billion annually in direct healthcare costs alone (Ding et al., 2016).

The rapid proliferation of mobile technology in Pakistan presents a compelling opportunity to address this public health crisis at scale. By 2024, the Pakistan Telecommunication Authority reported over 197 million mobile subscribers, with smartphone penetration nearing 47% of the population. Mobile connectivity has outpaced expansion of traditional healthcare infrastructure in many areas, positioning mHealth interventions as a viable bridge for preventive health services. The global mHealth market reached USD 45.7 billion in 2023, with physical activity and fitness applications constituting the largest application category (IQVIA Institute, 2023).

Evidence from high-income countries indicates that mHealth PA interventions can achieve modest but meaningful short-term increases in physical activity, particularly through goal-setting, self-monitoring, and social accountability features (Stephenson et al., 2017; Schoeppe et al., 2016; Direito et al., 2017). However, this evidence base derives almost entirely from Western populations, and the applicability of these findings to LMIC settings such as Pakistan remains uncertain. Pakistan presents a unique constellation of contextual factors variable digital literacy, predominantly English-language application interfaces, unreliable internet connectivity, gender-based mobility constraints, and sociocultural norms around exercise that may substantially modify the effectiveness and adoption patterns of PA applications.

Despite the salience of this question, the published literature on mHealth PA applications within Pakistan is sparse and methodologically limited. No prior study has conducted a comprehensive, multi-city examination of mHealth PA application use patterns, application quality, adherence trajectories, and barriers across a socio demographically diverse Pakistani adult sample. The present study addresses this gap, providing an empirical foundation for evidence-based mHealth PA policy and application development in Pakistan.

2. Methods

2.1 Design and Setting

This study employed a descriptive cross-sectional design with an embedded qualitative component using individual semi-structured interviews, following a sequential explanatory mixed-methods framework (Creswell & Plano Clark, 2018). Data collection was conducted across three major urban centers Lahore (Punjab), Karachi (Sindh), and Islamabad/Rawalpindi (Federal Capital Territory) selected to represent Pakistan's dominant urban typologies in terms of demographic composition, socioeconomic profile, and smartphone penetration. Within each city, participants were recruited from public parks, university campuses, primary healthcare centers, and residential neighborhoods spanning high, middle, and lower-middle socioeconomic zones.

2.2 Participants

The target population comprised Pakistani adults aged 18–60 years who were smartphone owners residing in the three study cities for a minimum of 12 months. Individuals were excluded if they had medical conditions contraindicating physical activity, were pregnant, or were employed in the health or technology sectors to minimize expert-user bias. Sample size was calculated using the Cochran (1977) formula for estimating a

population proportion (p=0.50; d=0.05; 95% CI), yielding a minimum of 384 participants. Purposive stratified sampling ensured representation across city, gender, age group, and socioeconomic stratum. Of 412 individuals approached, 384 provided complete data (response rate: 93.2%). City stratification was proportional: Lahore (n=154; 40.1%), Karachi (n=154; 40.1%), and Islamabad/Rawalpindi (n=76; 19.8%). For the qualitative component, a maximum variation purposive sample of 30 participants was selected, representing diversity in gender, age, socioeconomic status, and application adherence level.

2.3 Instruments

Physical activity levels were assessed using the International Physical Activity Questionnaire–Short Form (IPAQ-SF), classifying participants as Insufficiently Active (<600 MET-min/week), Moderately Active (600–3,000 MET-min/week), or Highly Active (>3,000 MET-min/week). Application quality was evaluated by users with reference to their most frequently used PA app using the Mobile Application Rating Scale (MARS; Stoyanov et al., 2015), adapted for self-administration using the protocol of Terhorst et al. (2020). The MARS yields subscale scores (Engagement, Functionality, Aesthetics, Information Quality, Subjective Quality) and a total score on a 1–5 scale. Technology acceptance was assessed using validated constructs of Perceived Usefulness (PU) and Perceived Ease of Use (PEOU) from the Technology Acceptance Model (Davis, 1989; α=0.87–0.89). Exercise self-efficacy (McAuley, 1993), social support for exercise (Sallis et al., 1987), and digital health literacy (eHEALS; Norman & Skinner, 2006) were also measured using validated scales. Adherence barriers were assessed through a custom 21-item checklist. The composite questionnaire was available in both Urdu and English and underwent rigorous forward-backward translation and pilot testing (n=30).

Validity and reliability were rigorously established. Content validity was confirmed through expert panel review (overall Scale-CVI=0.87). Internal consistency of all multi-item scales exceeded Cronbach's α=0.78. Test-retest reliability over two weeks yielded ICC values of 0.82–0.91. Confirmatory factor analysis demonstrated acceptable construct validity (χ^2/df=2.14; CFI=0.94; RMSEA=0.055).

2.4 Statistical Analysis

Quantitative data were analyzed using IBM SPSS v25.0. Descriptive statistics, chi-square tests, and independent samples t-tests or Mann-Whitney U tests were used as appropriate. Binary logistic regression identified independent predictors of high physical activity adherence (≥4 days/week application use), with variable selection guided by univariate analyses (p<0.20 threshold) and theoretical considerations. Results are reported as adjusted odds ratios (aOR) with 95% confidence intervals; statistical significance was set at α=0.05. Qualitative data were analyzed using reflexive thematic analysis (Braun & Clarke, 2006) in NVivo 12.0, with analytical rigor enhanced through member checking, peer debriefing, and reflexive journaling. Ethical approval was obtained from the Institutional Review Board of the University of Health Sciences, Lahore. All participants provided written informed consent.

3. Results

3.1 Socio demographic Profile

The final sample comprised 384 participants (192 male, 192 female; mean age: 31.7 years, SD=9.8). Nearly half were aged 18–30 years (47.4%). Most held bachelor's or postgraduate degrees (66.4%), and the largest occupational group was students (33.9%). Forty-four percent of households fell in the middle-income bracket (PKR 40,000–100,000/month). Android devices were predominant (71.4%), and internet connectivity was largely mobile-data-dependent (68.2%), with consistent daily access reported by 71.9% of participants. Detailed socio demographic characteristics are presented in Table 1.

Table 1. Socio demographic Characteristics of Study Participants (N=384)

Variable	Category	n	%
Gender	Male	192	50.0
	Female	192	50.0
Age Group	18–30 years	182	47.4
	31–45 years	141	36.7
	46–60 years	61	15.9
Educational Level	Primary/None	12	3.1
	Matriculation	36	9.4
	Intermediate	81	21.1
	Bachelor's Degree	161	41.9
	Postgraduate	94	24.5
City of Recruitment	Lahore	154	40.1
	Karachi	154	40.1
	Islamabad/Rawalpindi	76	19.8
Monthly HH Income	<PKR 40,000	120	31.3
	PKR 40,000–100,000	169	44.0
	PKR 100,001–200,000	71	18.5
	>PKR 200,000	24	6.2
Occupation	Student	130	33.9
	Private Sector	110	28.6
	Government	67	17.4
	Self-Employed	43	11.2
	Homemaker	34	8.9

3.2 Application Use Prevalence and Physical Activity Levels

Overall, 61.7% of participants (n=237; 95% CI: 56.7–66.5%) reported current or past use of at least one PA-related mHealth application. Prevalence varied significantly by gender (male: 69.3%; female: 54.2%; χ^2=8.73; p=0.003), age group (18–30 years: 71.4%; 46–60 years: 41.0%; p<0.001), and income level (upper-middle/high: 78.9%; lower-middle: 49.2%; p<0.001). The most commonly used applications were Google Fit (38.4% of users), Samsung Health (29.1%), Strava (24.1%), Nike Training Club (22.4%), and My Fitness Pal (19.4%). Locally developed Urdu-language applications accounted for fewer than 15% of total app use.

Physical activity levels were significantly higher among application users than non-users (mean 2,214 vs. 1,287 MET-min/week; p<0.001). Whereas 52.4% of non-users were classified as Insufficiently Active, only 29.5% of app users fell in this category. These comparisons are summarized in Table 2, though the cross-sectional design precludes causal interpretation.

Table 2. Physical Activity Levels by mHealth Application Use Status

PA Category	Total (N=384)	App Users (n=237)	Non-Users (n=147)	p
Insufficiently Active	38.3% (n=147)	29.5% (n=70)	52.4% (n=77)	<0.001
Moderately Active	38.5% (n=148)	43.5% (n=103)	30.6% (n=45)	0.012
Highly Active	23.2% (n=89)	27.0% (n=64)	17.0% (n=25)	0.032
Mean MET-min/week (SD)	1,847 (1,623)	2,214 (1,712)	1,287 (1,298)	<0.001

Equivalent of Task; SD = Standard Deviation. Between-group comparisons by chi-square (categorical) and Mann-Whitney U (continuous).

3.3 Application Quality (MARS)

Applications received a mean total MARS score of 3.42 (SD=0.68) from the 237 users, indicating moderate overall quality. Functionality achieved the highest subscale rating (M=3.71, SD=0.63), reflecting generally reliable technical performance. Engagement scored lowest (M=3.18, SD=0.82) the quality dimension most directly related to sustained use. Qualitative interviews illuminated this finding: participants attributed low engagement ratings to the absence of Urdu-language content, culturally incongruent exercise demonstrations, generic coaching messages, and lack of locally relevant activity options. MARS subscale results are presented in Table 3.

Table 3. Mobile Application Rating Scale (MARS) Subscale Scores (n=237)

MARS Subscale	Mean	SD	Min	Max
Engagement	3.18	0.82	1.4	5.0
Functionality	3.71	0.63	2.0	5.0
Aesthetics	3.48	0.74	1.6	5.0
Information Quality	3.54	0.71	1.8	5.0
Subjective Quality	3.21	0.79	1.2	5.0
Total MARS Score	3.42	0.68	1.8	5.0

All items rated on a 1 (Inadequate) to 5 (Excellent) Likert scale. SD = Standard Deviation.

3.4 Adherence Patterns and Predictors

Among the 237 app users, 48.5% (n=115) demonstrated high adherence (≥4 days/week), 18.6% (n=44) exhibited low adherence (1–3 days/week), and 32.9% (n=78) had discontinued use. Among those who discontinued, the median time to abandonment was 2.8 months (IQR: 1.4–5.6), consistent with global mHealth attrition literature.

Binary logistic regression identified nine significant independent predictors of high adherence (Table 4). Perceived usefulness was the strongest positive predictor (aOR=2.31; p<0.001), followed by app personalization features (aOR=2.14; p<0.001), social/community features (aOR=1.98; p=0.001), and exercise self-efficacy (aOR=1.87; p<0.001). Higher MARS total score, digital health literacy, and household income also predicted higher adherence. Female gender was a significant negative predictor (aOR=0.54; 95% CI: 0.38–0.77; p=0.001), indicating substantially lower odds of sustained adherence among women after controlling for other variables.

Table 4. Binary Logistic Regression: Independent Predictors of High Physical Activity Adherence

Predictor Variable	aOR	95% CI	p-value
Perceived Usefulness (per 1-unit increase)	2.31	1.74–3.07	<0.001
Application Personalization Features	2.14	1.56–2.94	<0.001
Social/Community Features Present	1.98	1.32–2.97	0.001
Exercise Self-Efficacy Score	1.87	1.38–2.53	<0.001
MARS Total Score (per 1-unit increase)	1.63	1.21–2.19	0.001
Digital Health Literacy Score	1.44	1.11–1.87	0.007
Monthly HH Income (per PKR 10,000)	1.08	1.02–1.14	0.008
Age (per 1-year increase)	0.97	0.94–1.00	0.048
Female Gender (ref: Male)	0.54	0.38–0.77	0.001

aOR = Adjusted Odds Ratio; CI = Confidence Interval. Dependent variable: High adherence (≥4 days/week) vs. low/non-adherence. Model fit: Hosmer-Lemeshow χ^2 (df=8) = 9.32; p=0.316; Nagelkerke R^2=0.41.

3.5 Barriers to Application Use and Adherence

Six primary barrier categories emerged from the quantitative analysis (Table 5). Inconsistent internet connectivity was the most prevalent barrier, affecting 67.4% of participants, with

disproportionate impact on lower-SES individuals (82.3%). Language barriers predominantly English-only interfaces were reported by 54.2%, with significantly higher rates among women (66.1% vs. 42.2%; p<0.001). Cultural incongruence of fitness content was identified by 38.8% overall, with marked gender disparity (female: 54.7%; male: 22.9%; p<0.001). Affordability of premium features was a concern for 42.2% of participants.

Table 5. Prevalence of Barriers to mHealth Application Use by Gender

Barrier	Overall	Male	Female	p-value
Inconsistent Internet Connectivity	67.4%	63.0%	71.9%	0.042
Language Barriers (English Interface)	54.2%	42.2%	66.1%	<0.001
Affordability of Premium Features	42.2%	38.5%	45.8%	0.124
Cultural Incongruence of Content	38.8%	22.9%	54.7%	<0.001
Technical Issues (crashes/battery)	35.4%	35.4%	35.4%	1.000
Lack of Social Support Features	29.7%	28.1%	31.3%	0.465
Absence of Urdu-Language Content	25.5%	17.7%	33.3%	<0.001
Privacy/Data Security Concerns	18.8%	19.8%	17.7%	0.590

Between-group comparisons by chi-square test. Statistically significant differences (p<0.05) in bold.

3.6 Qualitative Findings

Thematic analysis of the 30 qualitative interviews yielded four overarching themes that contextualize and enrich the quantitative findings.

Theme 1: "The App as a Starting Point, Not a Journey Partner "Participants across demographic groups described initial enthusiasm followed by progressive disengagement as novelty waned. They expressed a desire for applications capable of responding to real-life context family illness, Ramadan scheduling, seasonal heat rather than issuing context-blind reminders. This theme underscores the quantitative finding that perceived usefulness and personalization are the strongest adherence predictors.

Theme 2: "Lost in Translation "Beyond literal language barriers, participants experienced deeper cultural disconnects. Exercise videos featuring Western gym settings and attire felt irrelevant to female users observing Islamic modesty norms. Dietary advice was misaligned with Pakistani food culture. Social comparison features displaying Western marathon runners were demotivating rather than inspiring. One participant summarized this as the app seeming to "think I live in New York."

Theme 3: "The Wi-Fi Problem Is the Real Problem "Infrastructure constraints interrupted tracking from data plan exhaustion, GPS inaccuracy in dense urban environments, device overheating in summer, and electricity load-shedding fundamentally limited application utility. Participants had developed workarounds such as downloading content over Wi-Fi for offline use, but these adaptations compromised the contextual flexibility that is a defining feature of mobile-based health promotion.

Theme 4: "When My Family Exercises, I Exercise" Social embedded ness of PA behavior was a powerful theme, particularly for women. Exercise required not merely individual motivation but social permission structures within households and communities. Participants who sustained PA engagement consistently described shared app use with family members, workplace peer challenges, or community walking groups organized around shared applications. This qualitative dimension deepens the quantitative finding that social features are significant adherence predictors, illuminating the specifically communal and familiarly embedded character of social support in the Pakistani context.

4. Discussion

This study provides the first multi-city, socio demo graphically stratified characterization of mHealth PA application use, quality, adherence, and barriers among urban Pakistani adults. The 61.7% prevalence of PA application use is notably higher than comparable reports from Bangladesh (41.8%; Islam et al., 2021) and similar to urban India (54.3%; Nair et al., 2020), suggesting that urban Pakistani adults have embraced mHealth technology at a pace consistent with regional peers. However, significant demographic gradients by gender, age, and socioeconomic status signal that aggregated adoption rates mask important equity disparities.

The association between application use and higher physical activity levels (mean difference: 927 MET-min/week; p<0.001) is directionally consistent with meta-analytic evidence from high-income countries (Stephenson et al., 2017; Direito et al., 2017). The cross-sectional design does not allow causal inference: self-selection of more motivated individuals into app use likely contributes to this difference alongside any genuine behavioral effect. Nevertheless, the association is of sufficient magnitude to support continued investment in mHealth PA promotion as a plausible population health strategy.

The MARS total score of 3.42 is broadly

comparable to the mean of 3.28 reported across international mHealth applications in a large-scale validation study (Terhorst et al., 2020). Importantly, the Engagement subscale received the lowest rating (3.18) a consistent pattern across international MARS evaluations and a critical concern because engagement is the quality dimension most directly linked to sustained use. The qualitative data reveal that this engagement deficit is partly rooted in cultural mismatch: applications designed for Western user contexts engage Pakistani users less effectively because they fail to reflect familiar environments, culturally appropriate content, or locally relevant activity modalities.

The finding that perceived usefulness (aOR=2.31), personalization (aOR=2.14), and social/community features (aOR=1.98) are the strongest predictors of adherence aligns with the Technology Acceptance Model's prediction that PU is the primary driver of sustained technology use (Davis, 1989; Kruse et al., 2019), and with evidence that personalized applications achieve substantially higher adherence than generic alternatives (Armanasco et al., 2017). Exercise self-efficacy (aOR=1.87) as a significant predictor is consistent with Social Cognitive Theory (Bandura, 1986) and supports designing applications with graduated challenge structures, mastery-based goal setting, and vicarious reinforcement features to build users' confidence in their exercise capacity.

The gender adherence gap is among this study's most important findings. Female participants had 46% lower odds of high adherence after controlling for other variables (aOR=0.54; p=0.001), a disparity amplified by significantly higher rates of language barriers, cultural incongruence, and lower application prevalence. This pattern extends documented gender disparities in PA participation (Saqib et al., 2017) into the mHealth domain and suggests that universal mHealth PA strategies will insufficiently address women's needs without deliberate gender-responsive design and implementation. The qualitative theme of social permission structures women describing exercise as contingent on family approval and participation points to the culturally specific mechanisms through which gender norms mediate PA behavior in Pakistan.

The barrier profile identifies structural challenges that application design alone cannot resolve. Internet connectivity a prerequisite for GPS tracking, real-time coaching, and social features was disrupted for two-thirds of participants. This finding underscores that digital health equity depends not only on application quality but on the underlying telecommunications infrastructure that enables or constrains application use. Similarly, the English-language dominance of available applications creates an inverse access pattern, where higher-risk, lower-educated populations are least able to engage with currently available tools.

5. Conclusion

Mobile health applications have achieved meaningful penetration among urban Pakistani adults and are associated with higher physical activity levels, establishing them as a legitimate component of Pakistan's PA promotion ecosystem. However, one-third of app adopters discontinue use within approximately three months, and engagement quality the dimension most critical for sustained behavior change is rated lowest by Pakistani users. Gender, digital literacy, internet access, and sociocultural factors are critical moderators that collectively constrain the real-world effectiveness of currently available applications. Realizing the potential of mHealth PA promotion in Pakistan requires a convergent strategy: culturally adapted, Urdu-language, offline-capable application design, alongside structural investments in digital equity and evidence-based policy frameworks.

6. Practical Implications and Recommendations

For application developers, priority actions include: (1) developing Urdu-language primary interfaces with optional English toggle; (2) implementing full offline functionality for core tracking and exercise guidance; (3) integrating culturally congruent exercise demonstrations featuring Pakistani environments and attire appropriate to Islamic modesty norms; (4) designing family- and community-based goal-sharing and social accountability features; and (5) adopting premium models that place engagement-enhancing features (personalized coaching, progress analytics, social challenges) in free tiers rather than behind pay walls.

For clinicians and public health practitioners, PA counseling should systematically assess patients' app use and digital literacy, guide patients toward higher-quality applications using MARS criteria, and provide gender-sensitive digital health literacy support. mHealth PA guidance should be integrated into clinical exercise prescriptions for patients with cardiovascular risk factors, diabetes, and

obesity.

At the policy level, the National Health Authority should develop a mHealth application quality framework with minimum standards for cultural appropriateness and linguistic accessibility. Integration of mHealth PA promotion into existing community health worker programs specifically the Lady Health Worker network could leverage established community trust to extend digital health reach to lower-SES and rural populations. Advocacy for data affordability subsidies within the Universal Service Fund mandate would reduce a foundational structural barrier to equitable mHealth access.

Future research should prioritize a randomized controlled trial comparing culturally adapted Urdu-language PA applications against standard applications, using objective accelerometer over 12 months as the primary outcome. Longitudinal cohort studies tracking adherence trajectories over 24–36 months, co-design research with Pakistani women, and health economic analyses estimating cost-effectiveness relative to standard care are equally pressing research priorities.

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