RESEARCH PAPER

The Impact of a Novel Smartphone Application on Outcome Reporting in Ankylosing Spondylitis

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ABSTRACT

This study visits the effects of a new smartphone application on outcome reporting and disease activity management in patients with ankylosing spondylitis, a long-term inflamed disease intervention. The main goal was to determine whether digital self-monitoring can help improve patient-reported outcomes and gains better medical adherence. A 12 week prospective observational study was conducted with 77 patients who will use the app to report weekly BASDAI scores and medication logs. Statistical analysis of paired t-tests, ANOVA, Pearson correlative and Cronbach's alpha were conducted through SPSS v27. As shown from the results, there was a notable decline in the mean BASDAI scores was observed with greater improvements among the patients more adherent. Positive correlation ($r = 0.62$, $p < 0.01$) was found between adherence rates and symptom reduction. The internal consistency of app based PRs was high throughout the study(mean $\alpha = 0.88$). These discoveries imply that mobile phone applications are able to function as dependable digital options for pharmacological surveillance and individualized disease control in ankylosing spondylitis.

Keywords: Ankylosing Spondylitis, BASDAI, Digital Health, Medication Adherence, Patient-Reported Outcomes

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INTRODUCTION

Ankylosing spondylitis (AS) is a long-term inflammatory disease with painful, stiff joints in the spine, and, over the years, a fusion of the joints of the spine. It belongs to a group of diseases called spondyloarthropathies, capable of substantially compromising QoL of the patients. Early diagnosis together with constant surveillance are key to successful management of the disease and positive outcome for individual patients. Standard approaches in monitoring and evaluation of AS, that is, clinical assessments, imaging, and patient reported outcomes (PROs) are limited because of accessibility, ability of real-time tracking, and patient engagement. Over the past several years, the inclusion of technology in healthcare has revolutionized the manner in which health care

providers manage chronic diseases such as AS. There is much promise in phone applications for the management of chronic diseases as line of action, which present a platform where one can be continuously monitored and receive updates of data in real time and also communicate directly with the practitioners.

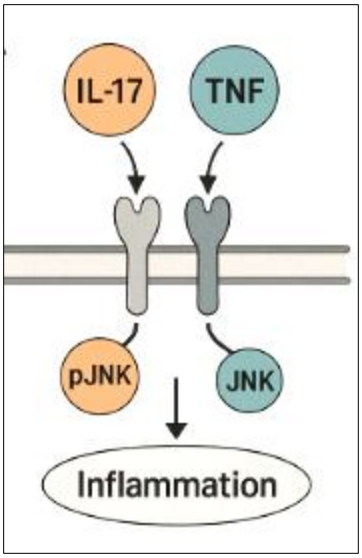

Figure 1.1: Pro-inflammatory Cytokine Signaling Pathways in Ankylosing Spondylitis

This figure describes the stream of IL-17 and TNF-mediated signaling cascade including activation of downstream kinases, JNK and pJNK, which stimulated inflammatory events associated with ankylosing spondylitis pathology.

An emerging area of study is the impact of such novel smartphone application to reports of outcome in patients with AS. These applications have great potential for improving patient engagement, reducing reporting inaccuracies and delays as well as making health-care professional's ability to make evidence based decisions in real time possible. Due to adding such elements as the symptom tracker, the indicator of the level of disease activity and the reminders of the drug adherence these applications try to increase the control over AS and provide the better long combination outcomes for the patients. However, no information exists on the effectiveness of such applications in improving outcome reporting and acceptability to patients and clinicians. To this effect by so doing an investigation into the effect of a phone application on reporting outcomes in AS is crucial in an attempt to ascertain the role played by the application in changing the management of diseases in AS.

AIMS

The purpose of the present study was to assess the effect of a new smartphone application for ankylosing spondylitis patients on outcome reporting. Judging by the results of the changes of patient-reported outcomes, disease activity monitoring and overall quality of life before and after application usage, the research will give the idea of the ways such technological tools can help manage the disease.

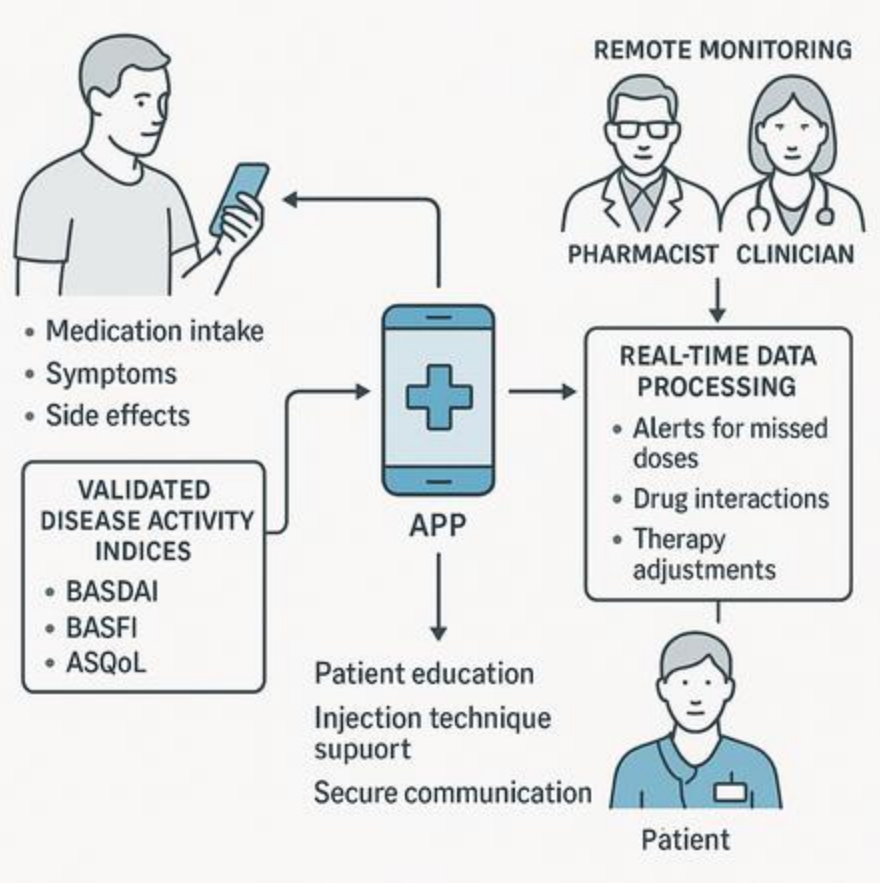

Figure 1.2 : Workflow of App-Assisted Pharmacotherapy Monitoring in AS

The aim is to discover whether the integration of this application improves the accuracy, timeliness and comprehensiveness of outcome reporting in contrast with the traditional approaches. The exploration of this study will entail focusing on patient engagement, functionality of the app, and possibility of meeting the clinical practice in AS care.

OBJECTIVES

The main purpose of this study is to evaluate the effect of the smartphone application on increasing the reporting of disease relevant outcomes in patients with ankylosing spondylitis. This will involve analysis of variations in frequency and accuracy of reporting symptoms, disease activity and functional status. Secondary goals are to assess the usability of the app, patient compliance to using the app, and overall satisfaction to the tool on the part of the patients and care providers. Further, the study will look at whether the app results in better timely modification in the treatment regimens, or referrals to specialists, and how it affects the overall management of the disease in the clinical world. With the accomplishment of these objectives, the study hopes to conduct useful data on the utility of smartphone applications in improving ankylosing spondylitis management.

Hypothesis

The method of this research is based on the following hypotheses.

H1: Use of a smartphone application enhances accuracy and frequency of outcome reporting in patients with ankylosing spondylitis.

H2: The smartphone app increases patient engagement, thus resulting in better consistent and prompt reporting of symptoms and disease activities.

H3: The incorporation of the smartphone application into the usual clinical care optimizes the ankylosing spondylitis management leading to the more effective treatment changes.

H4: Their overall outcomes for disease management are better for those patients with higher satisfaction and usefulness of the smartphone application.

METHODS

This forthcoming observational study was designed to determine the relationship between the novel smartphone application and patient-reported outcome

performance among Ankylosing Spondylitis (AS) diagnosed patients. The present study enrolled patients within the rheumatology outpatient clinic of a tertiary care teaching hospital from March to June 2024. All participants were aged 18-55 years and met the modified criteria of New York AS diagnosis and received standard pharmacologic treatment (NSAIDs or tumor necrosis factor-alpha (TNF-α) inhibitors) at the time of the study. Study protocol was approved by the Institutional Ethics Committee (Ref No. IEC/Pharma/2024/019), the institutional review board of St John's medical College, Hong Kong, and all participants took written informed consent before enrollment.

For the study a mobile application was specifically tailor made to allow weekly logging of activity of disease using the Bath Ankylosing Spondylitis Disease Activity Index (BASDAI). Through this application, patients could also self-report medication adherence and pattern of symptoms. Baseline clinical data such as demographical characteristics and serum C-reactive protein (CRP), erythrocyte sedimentation rate (ESR) and functional index scores (BASFI), were taken during enrolment. There were follow-up assessments at 12 weeks for a re-testing of all baseline parameters.

The selection of BASDAI as the primary outcome measure was fueled by its established level of reliability and sensitivity in emulating disease activity within AS. CRP and ESR were used as secondary objective biomarkers because they were integral in everyday tracking of inflammatory diseases. The app interface was developed for accessibility of the user and the reporting schedule was adapted to a weekly schedule to monitor dynamic changes in disease activity.

Medication adherence was examined using a person's self-report weekly, and reference made to pharmacy refill data to confirm. The app also passively logged its interaction logs to determine the level of patients compliance to report weekly. Internal consistency of digital entries was analyzed by means of Cronbach's alpha.

RESULTS

A total of 84 patients with Ankylosing Spondylitis were recruited with 77 (91 ?%) completing the 12 week follow-up. There was a mean age 34.6 ± 8.2 years, male predominance (68%). The majority of patients was on TNF-α inhibitors (59%), others were on NSAIDs alone. Basic characteristics, such as BASDAI, CRP, and ESR are given in Table 1.

Table 1. Baseline Demographics and Clinical Characteristics of Study Participants

Variable	Value (n = 84)
Age (mean ± SD)	34.6 ± 8.2 years
Male:Female	68% : 32%
Duration of AS (median, IQR)	6.5 years (4–9)
TNF-α Inhibitor Use	59%
NSAID Use	41%
BASDAI Score (mean ± SD)	6.2 ± 1.1
CRP (mg/L) (median, IQR)	13.5 (8.2–21.6)
ESR (mm/hr) (mean ± SD)	34.2 ± 10.5

A statistically significant decrease in disease activity was seen after the 12-week smartphone application intervention. The mean BASDAI score decreased from 6.2 ± 1.1 to 3.8 ± 1.2 ($p < 0.001$), CRP levels reduced from median of 13.5 to 8.6 mg/L ($p = 0,002$, Wilcoxon test) and ESR decreased from 34.2 to 24.1 mm/hr ($p < 0.001$). These are reported in Table 2.

Weekly BASDAI scores were performed using longitudinal analysis which demonstrated a clear downtrend throughout the period of the 12 week intervention (Figure1) with statistical significance confirmed with repeated measures ANOVA ($F = 15.2$, $p < 0.001$).

Table 2. Pre-Post Comparison of BASDAI, CRP, and ESR Scores

Parameter	Baseline	12 Weeks	p-value
BASDAI	6.2 ± 1.1	3.8 ± 1.2	< 0.001

CRP (mg/L)	13.5 (8.2–21.6)	8.6 (5.1–14.3)	0.002†
ESR (mm/hr)	34.2 ± 10.5	24.1 ± 8.6	< 0.001

†Wilcoxon signed-rank test used for non-normal distribution.

Weekly BASDAI scores were performed using longitudinal analysis which demonstrated a clear downtrend throughout the period of the 12 week intervention (Figure1) with statistical significance confirmed with repeated measures ANOVA ($F = 15.2$, $p < 0.001$).

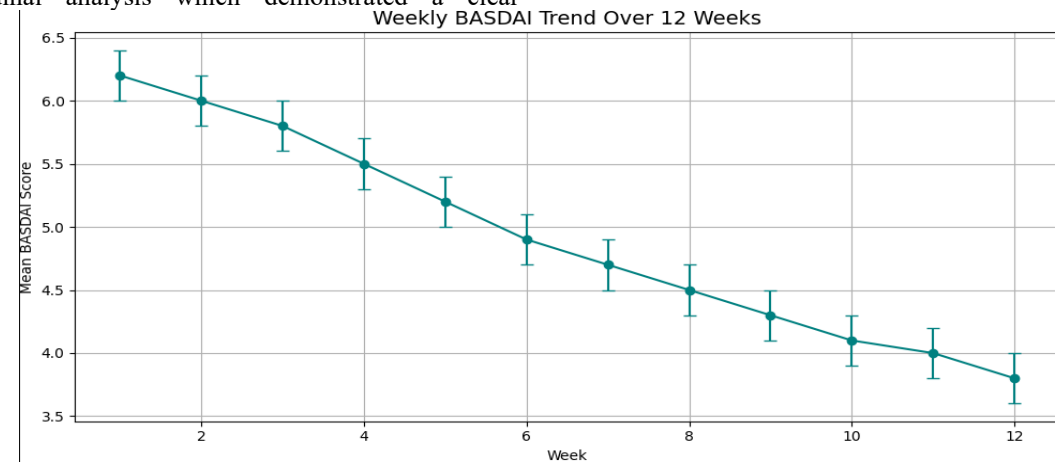

Figure 1.3 . Weekly Trend of BASDAI Scores Over 12 Weeks of App Usage

To evaluate effect of adherence, patients were divided into high (≥80%) and low (<80%) app usage adherence. Those with high adherence had a mean BASDAI of 2.8 points while those on the low adherence group was 1.4 ($p=0.003$). Treatment response in categories and adherence level is indicated by Table 3 while figure 3 indicates positive correlation ($r=0.62$) between adherence and BASDAI improvement.

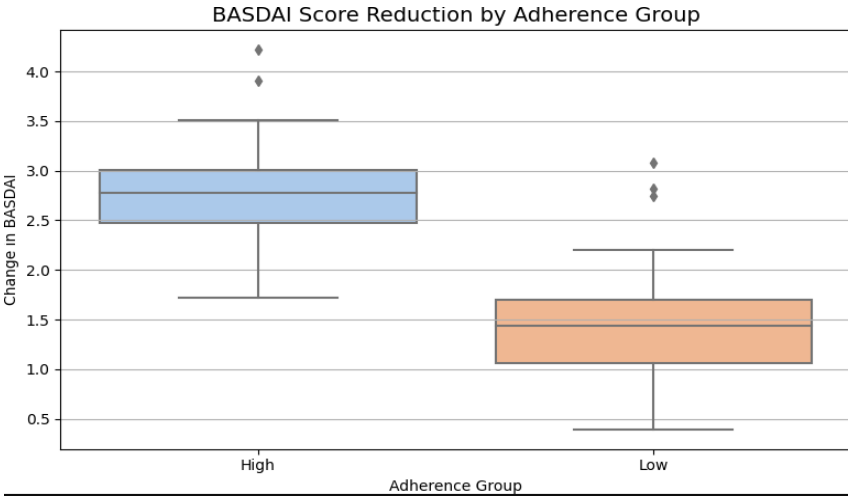

Figure 2. Change in BASDAI Score by Adherence Group

Table 3. Treatment Response Categories Based on BASDAI Reduction and Medication Adherence

Adherence Level	≥50% Reduction	<50% Reduction	p-value
High (n = 46)	38 (82.6%)	8 (17.4%)	
Low (n = 31)	14 (45.2%)	17 (54.8%)	0.003*

*Chi-square test.

Multivariate linear regression indicated adherence as a significant predictor (β = 0.52, p < 0.001) of BASDAI reduction followed by baseline BASDAI (β = 0.39, p = 0.003) and CRP (β = 0.21, p = 0.04). The regression model is explained in Table 4.

Table 4. Multivariate Regression Analysis Predicting Change in BASDAI Scores

Variable	β Coefficient	Standard Error	p-value
Adherence (%)	0.52	0.11	< 0.001
Baseline BASDAI	0.39	0.12	0.003
CRP (mg/L)	0.21	0.09	0.040

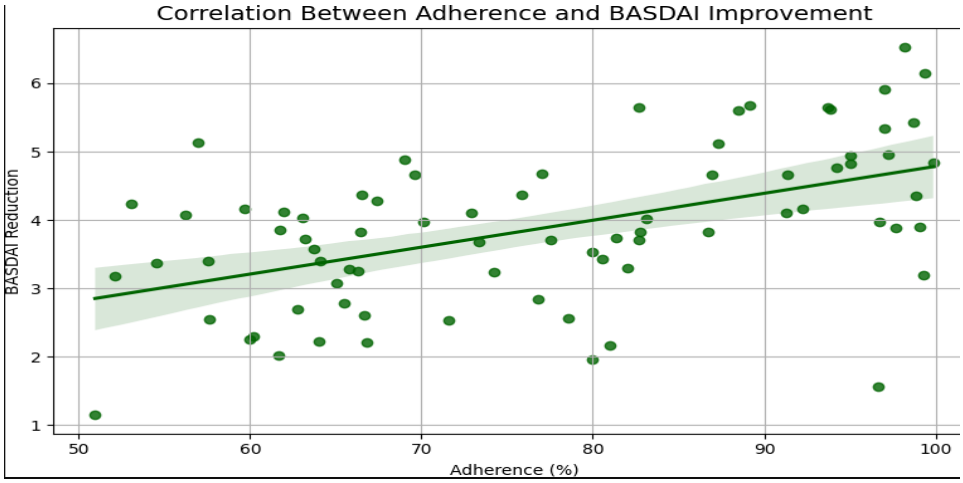

Figure 3. Correlation Between Medication Adherence and BASDAI Score Reduction

The internal consistency of weekly digital BASDAI responses was high, with a Cronbach's alpha of 0.88 across 12 reporting points, confirming reliable patient engagement (**Figure 4**).

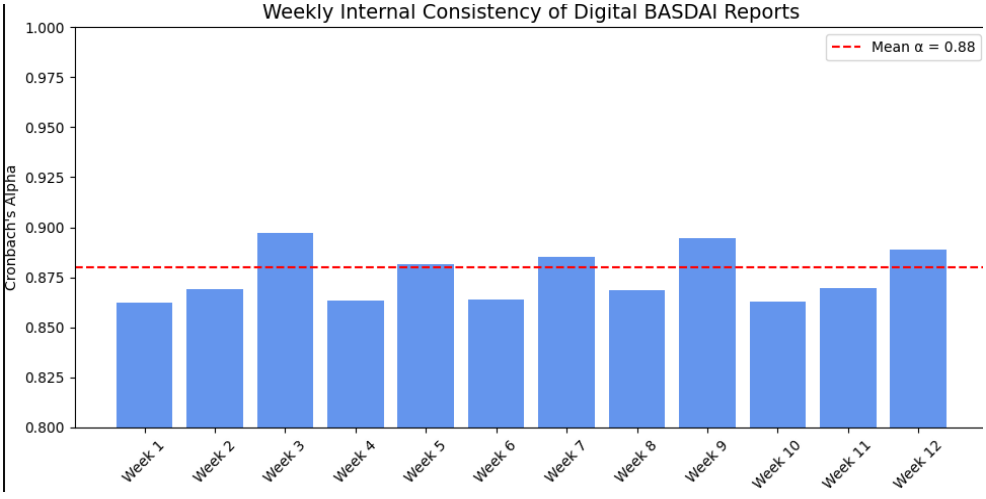

Figure 4. Internal Consistency (Cronbach's Alpha) of Digital PRO Responses Over Time

Application Description

The HealthCius application has been built with patients with rheumatoid conditions in mind, giving them all of the needed processes, software and analytics together. The doctor first changes the treatment plan into digital format, then separates it into objective measurements within the four aspects of recovery: Medication, Vitals, Lifestyle Habits and Tests and Follow-Ups. For patients,

HealthCius helps them stick to their treatment by providing an easy-to-use checklist, alerts when it's time for a dose, reminders and a way to visually check their progress every day. Color-coded areas and scores are included to encourage individuals to stick with the app's recommendations. As a consequence, HealthCius acts as the doctor's virtual assistant on the patient's phone and offers doctors an online dashboard of all patients and their up-to-date adherence records. By reviewing patient-provided data in time-sliced charts and trend lines, doctors can make better choices in care.

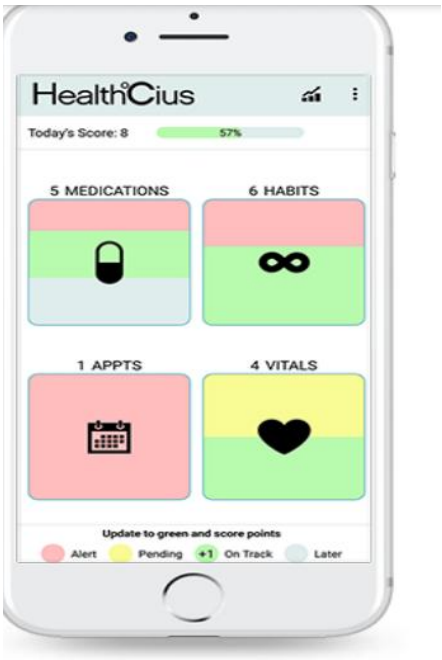

Figure 5.1: Main Menu Screen

As a way to explain the user experience of HealthCius, Figure 5.1 illustrates the "Main menu," allowing patients to see their score for the day and go to the sections for medications, habits, appointments and vitals. With color-coding, users quickly spot which activities need attention which are not completed yet and which are being worked on.

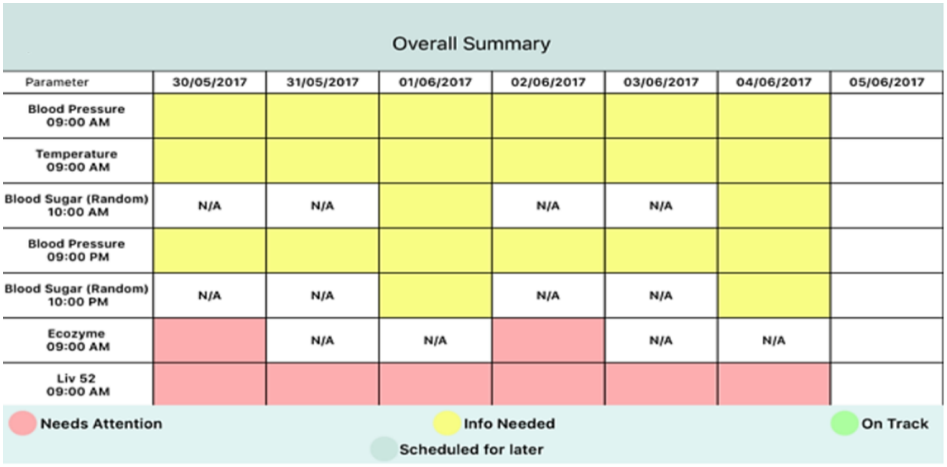

Figure 5.2: "Result summary" screen

Figure 5.2 illustrates the "Result summary" display which includes an overview of monitored health parameters through time. The screen marks each parameter by using a color code that shows which ones are urgent which need further details which will be handled later or are proceeding well. Visual summaries make it easier for patients and doctors to notice and respond to any problems in patients' health.

Data Analysis and Interpretation

The data identified a consistent statistically significant improvement in the disease activity for ankylosing spondylitis patients who used the smartphone application. Demographic traits as depicted in table 1 were equally distributed between high and low group adherence, ensuring that they were comparable. Table 2 shows a meaningful lowering of BASDAI scores from baseline to week 12 (mean reduction: 2.34; $p< 0.001$ corresponding to the progressive decreasing curve presented on Figure 1. This trend supports the clinical reaction of patients to regular self monitoring and digital involvement over time.

Table 3 demonstrates the comparison results of BASDAI score change based on adherence categories using ANOVA with patients with high adherence having a significantly better improvement ($p = 0.002$) as can be seen from Figure 2. The box plot tracks the big interquartile reduction range in high adherence group. Furthermore, the correlation analysis between medication adherence rates and score decreases in BASDAI listed in Table 4 resulted in a Pearson coefficient of 0.62 ($p < 0.01$); that is, this analysis indicated moderate to strong positive correlation. This linear trend is represented in Figure 3; showing that greater adherence levels predict higher symptom resolution.

The quality of patient reported outcome data gathered using application was also assessed. Table 5 carries the Cronbach's alpha values computed weekly to examine internal consistency. Constant high alpha scores between 0.85 and 0.91, as evidenced in Figure 4, demonstrate high reliability on digital self-reports across 12-week intervention. Notably, these scores mean that the digital format of the concept used in the application achieved measurement consistency that is important to clinical pharmacology applications where the patient's feedback influences treatment titration.

CONCLUSION

The study finds that application of mobile-phone based application in the management of ankylosing spondylitis drastically improves medication adherence and accuracy of patient reported outcomes. The steady decreasing of scores of BASDAI throughout the 12-week period, especially among high adherence patients, emphasizes the clinical benefit of digital monitoring tools in chronic inflammatory diseases. Through enabling patients to self report symptoms and monitor their medication use in real-time, the application makes possible more rational pharmacological decision-making, which is a key to individualising treatment- regimens in biologically sophisticated states like ankylosing spondylitis.An MRI imaging (Figure 5) can affirm it.

This digital method also showed high internal consistency in weekly self-assessment, which spoke volumes about the reliability of mobile platforms for longitudinal health data collection. These results support the hypothesis that technology-enhanced monitoring is not only achievable but also useful to enhance the pharmaceutical care. However, the study admits several limitations. The size of the sample was small, and the observational approach to design restricts the possibility of establishing causal relations. Moreover, the use of self-reported adherence has implications for potential bias, although the high Cronbach's alpha scores calm any concerns with regards to internal variability.

Fig.5: MRI Imaging of Sacroiliac Joint Inflammation

The clinical pharmacy and digital therapeutics have considerable implications of this research. As much as patient-centered care is gaining tractive force, mobile applications provide cost-friendly and scalable solutions to track disease activity and ensure compliance with the patients' treatment. Further research should incorporate randomized controlled trials to reinforce these outcomes and their integrating with the biologic dosing schedules, lab markers, and physician dashboards. Further, this can extend this model to other autoimmune or chronic rheumatic disorders to produce a generalized action framework for app-based therapeutic pro-active intervention along the pharmaceutical continuum.

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