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Wearable Health Devices and Health Outcomes: The Moderating Role of User Compliance

Ali Hussain
Department of Forestry, Range and Wildlife Management, Karakoram International University, Gilgit, Pakistan
Email: alihussain221333@gmail.com

Abstract:
The rapid development of wearable health technologies has created new opportunities for continuous health monitoring, preventive care, disease management, and patient engagement. Wearable health devices such as smartwatches, fitness trackers, activity monitors, and biosensor enabled devices can collect real time information regarding physical activity, heart rate, sleep patterns, blood oxygen levels, and other health related indicators. These technologies have the potential to improve health outcomes by providing users and healthcare professionals with timely information that can support healthier behaviors and more informed interventions. However, the availability and technical capability of wearable devices do not necessarily guarantee improved health outcomes. The effectiveness of wearable health technologies may depend substantially on whether users consistently wear the devices, interact with the applications, record or review health information, and follow recommendations generated from collected data. User compliance may therefore represent an important moderating condition affecting the relationship between wearable health device use and health outcomes. This study examines the relationship between wearable health devices and health outcomes and investigates the moderating role of user compliance. The proposed framework is grounded in the Technology Acceptance Model, Self Determination Theory, and Socio Technical Systems Theory. Wearable health devices represent the independent variable, health outcomes represent the dependent variable, and user compliance represents the moderating variable. A quantitative cross sectional research design is proposed, targeting adults who regularly use wearable health technologies for health or wellness purposes. Data may be collected through a structured questionnaire using a five point Likert scale. Partial Least Squares Structural Equation Modeling through SmartPLS can be employed to assess the measurement and structural models and to examine the interaction effect of user compliance. Illustrative results indicate that wearable health devices have a significant positive effect on health outcomes. User compliance also strengthens

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the relationship between wearable health device use and health outcomes. The moderation analysis suggests that the positive effect of wearable health devices is stronger among users with higher levels of compliance. The findings indicate that healthcare organizations and technology developers should focus not only on device functionality but also on sustained user engagement and adherence. User friendly interfaces, personalized feedback, reminders, meaningful health information, privacy protection, and behavioral support may encourage continued device use. The study contributes to digital health literature by demonstrating that technological effectiveness may depend on behavioral compliance and sustained engagement.

Keywords: Wearable Health Devices, Health Outcomes, User Compliance, Digital Health, Wearable Technology, Health Monitoring, Patient Engagement, Health Behavior, SmartPLS, PLS SEM

Introduction

The healthcare sector is experiencing rapid technological transformation as digital devices increasingly become integrated into health monitoring and disease prevention. Wearable health devices have emerged as an important component of this transformation. Smartwatches, fitness trackers, activity monitors, smart rings, and biosensor based devices can continuously collect information about physical activity, heart rate, sleep, exercise, and other physiological or behavioral indicators.

The growing adoption of wearable technology has created opportunities for individuals to become more actively involved in monitoring their own health. Unlike conventional clinical measurements that are typically collected at specific appointments, wearable devices can provide repeated or continuous observations. This potentially enables earlier identification of changes in health behavior and physiological patterns.

Wearable devices may also support healthcare professionals. When appropriately designed and integrated into healthcare systems, wearable generated information can contribute to remote monitoring, preventive interventions, chronic disease management, and personalized health recommendations.

However, technology availability does not automatically produce better health outcomes. A user may purchase a sophisticated wearable device but stop wearing it after a short period. Another user may wear the device regularly but rarely review the information or follow recommended behavioral changes. These circumstances suggest that user compliance is critical to realizing the potential benefits of wearable technology.

User compliance refers to the extent to which users consistently and appropriately engage with wearable devices and follow relevant recommendations. It can include wearing the device regularly, charging it, synchronizing data, reviewing feedback, maintaining engagement with the associated application, and following health related recommendations.

The Technology Acceptance Model provides an important theoretical foundation for

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understanding wearable technology adoption. Perceived usefulness and perceived ease of use can influence individuals' willingness to adopt and continue using technological systems.

Self Determination Theory provides another relevant perspective. Individuals may be more likely to sustain health behaviors when they experience autonomy, competence, and meaningful motivation. Wearable devices can provide feedback that supports self monitoring and potentially strengthens users' sense of control over their health behaviors.

Socio Technical Systems Theory emphasizes the interaction between technology, users, and social or organizational environments. Wearable health outcomes therefore depend on more than technological functionality. They also depend on behavioral patterns, healthcare support, social influences, and the context in which devices are used.

Wearable technology can influence health outcomes through several pathways. Real time monitoring may increase health awareness. Feedback may encourage physical activity. Sleep tracking may promote attention to sleep patterns. Health alerts may encourage users to seek medical attention or modify behaviors.

Nevertheless, these mechanisms require continued user engagement. If users do not wear the device consistently, the amount and quality of available information may decrease. If users ignore recommendations, behavioral changes may not occur.

Privacy concerns can also influence compliance. Users may become reluctant to continue using devices if they are uncertain about how their health information is collected, stored, analyzed, or shared.

Device comfort and usability are additional factors. Bulky devices, limited battery life, complicated applications, inaccurate measurements, and excessive notifications may reduce sustained use.

User compliance may therefore moderate the relationship between wearable health devices and health outcomes. High compliance may strengthen the benefits of wearable technology, while low compliance may weaken them.

Health outcomes in this context can include improvements in physical activity, weight management, sleep quality, physiological indicators, disease management, health awareness, and self reported health status. The appropriate outcome measures should depend on the population and purpose of the study.

The relationship should also be considered carefully because wearable users may differ from nonusers. Individuals who voluntarily adopt health technologies may already be more health conscious or physically active.

This creates potential selection bias in cross sectional studies. Longitudinal or experimental designs can provide stronger evidence concerning causal effects.

The present study examines wearable health devices as the independent variable, health outcomes as the dependent variable, and user compliance as the moderating variable.

The study addresses four major research questions. First, do wearable health devices significantly influence health outcomes? Second, does user compliance influence health outcomes? Third, does user compliance significantly moderate the relationship between wearable health devices and health outcomes? Fourth, does the strength of the technology outcome relationship vary across different levels of compliance?

The study provides theoretical and practical contributions. Theoretically, it emphasizes the

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interaction between technological capability and user behavior. Practically, it suggests that healthcare organizations and developers should design strategies that promote sustained engagement rather than focusing exclusively on device adoption.

Literature Review

Wearable Health Devices

Wearable health devices are electronic technologies designed to be worn on the body and used to monitor health, fitness, behavioral, or physiological information.

Common examples include smartwatches, fitness trackers, smart rings, continuous monitoring sensors, and other wearable biosensors.

Their growing capabilities have expanded their potential applications from general wellness to remote patient monitoring and chronic disease management.

Health Outcomes

Health outcomes represent changes in health status attributable to interventions, behaviors, technologies, or healthcare processes.

Depending on the study population, health outcomes can include physical activity, sleep quality, weight, blood pressure, glucose management, cardiovascular indicators, psychological well being, and overall perceived health.

User Compliance

User compliance refers to the extent to which individuals consistently use a technology according to intended practices.

In wearable health contexts, compliance can include frequency of wearing the device, synchronization, monitoring feedback, application engagement, and adherence to recommendations.

Wearable Health Devices and Health Outcomes

Wearable devices can provide continuous feedback that encourages self monitoring and healthier behavior.

Therefore:

H1: Wearable health devices positively influence health outcomes.

User Compliance and Health Outcomes

Consistent engagement with health technologies may increase opportunities for users to receive information and act upon it.

Therefore:

H2: User compliance positively influences health outcomes.

Moderating Role of User Compliance

The proposed interaction is:

Wearable Health Devices × User Compliance → Health Outcomes

The effectiveness of wearable technology may be stronger when users consistently engage with

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the device and follow health related recommendations.
Therefore:
H3: User compliance positively moderates the relationship between wearable health devices and health outcomes, such that the relationship is stronger when user compliance is high.
Conceptual Model / Theoretical Framework
The study integrates three theoretical perspectives.

Technology Acceptance Model
The Technology Acceptance Model explains how perceived usefulness and ease of use influence technology adoption and usage behavior. Wearable devices that users perceive as useful and convenient may generate stronger engagement.

Self Determination Theory
Self Determination Theory explains how autonomy, competence, and motivation can influence sustained behavioral engagement. Wearable feedback may support users' motivation to pursue health goals.

Socio Technical Systems Theory
This theory emphasizes that technological outcomes emerge through interaction among technology, individuals, organizational processes, and social environments.

Proposed Conceptual Model
Wearable Health Devices → Health Outcomes
with:
User Compliance moderating the relationship.
Graphically:
Wearable Health Devices
↓
Health Outcomes
User Compliance → Moderating Variable
Hypotheses
H1: Wearable health devices positively influence health outcomes.
H2: User compliance positively influences health outcomes.
H3: User compliance positively moderates the relationship between wearable health devices and health outcomes.

Methodology
A quantitative cross sectional research design is proposed to examine the relationship between wearable health devices and health outcomes and the moderating effect of user compliance. The target population should consist of adults who regularly use wearable health technologies for health, fitness, wellness, or monitoring purposes. Respondents should have sufficient experience with their devices to evaluate usage and compliance accurately.
A sample of approximately 300 to 500 respondents may be appropriate for PLS SEM, although

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the final sample size should be determined using statistical power analysis. Purposive sampling can be used to ensure that respondents have actual experience using wearable health devices. Data can be collected through an online or paper based questionnaire using a five point Likert scale ranging from 1 = strongly disagree to 5 = strongly agree.

Wearable health devices can be operationalized through perceived monitoring capability, accuracy, usefulness, accessibility, real time feedback, functionality, and health monitoring support. User compliance can be measured through regular wearing, consistent synchronization, reviewing health information, responding to alerts, maintaining device usage, and following relevant recommendations. Health outcomes can be assessed through perceived improvements in health behavior, physical activity, sleep, health management, and overall health status. Where possible, objective indicators obtained from device records or medical records should supplement self reported measures.

SmartPLS 4 can be employed to estimate the PLS SEM model. The measurement model should be assessed using indicator loadings, Cronbach's alpha, composite reliability, and AVE. Discriminant validity should be examined using HTMT. The structural model should be assessed using path coefficients, t statistics, p values, confidence intervals, R^2, f^2, and predictive relevance. The moderation hypothesis should be tested by creating an interaction term between wearable health device use and user compliance. Bootstrapping with 5,000 resamples can be used to assess statistical significance. Researchers should also mean center or standardize relevant variables when appropriate and visualize significant interactions at low, medium, and high levels of compliance. Ethical procedures should include informed consent, voluntary participation, confidentiality, and secure management of health related information.

Analysis

The following SmartPLS results are **hypothetical and illustrative**, based on an assumed sample of 400 respondents. They must be replaced with actual empirical SmartPLS results before submission.

Table 1. Measurement Model Results

Construct	Loading Range	Cronbach's Alpha	Composite Reliability	AVE
Wearable Health Devices	0.77 to 0.92	0.94	0.95	0.71
User Compliance	0.75 to 0.91	0.92	0.94	0.69
Health Outcomes	0.76 to 0.90	0.93	0.94	0.68

Interpretation of Table 1

The hypothetical measurement model indicates satisfactory reliability and convergent validity for all three constructs.

The factor loadings range from 0.75 to 0.92, suggesting that the indicators adequately represent their respective constructs. Wearable Health Devices demonstrate a Cronbach's alpha of 0.94 and composite reliability of 0.95, indicating strong internal consistency. The AVE value of 0.71

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indicates that the construct explains a substantial proportion of the variance in its indicators.

These results suggest that monitoring capability, perceived accuracy, usefulness, real time feedback, accessibility, and functionality provide consistent representations of wearable health device capability.

User Compliance records a Cronbach's alpha of 0.92 and composite reliability of 0.94. Its AVE of 0.69 indicates satisfactory convergent validity. The indicators related to regular wearing, synchronization, feedback review, response to notifications, continued usage, and adherence to recommendations appear to provide reliable measurement of compliance.

Health Outcomes demonstrate a Cronbach's alpha of 0.93 and composite reliability of 0.94. The AVE of 0.68 indicates satisfactory convergent validity.

The results suggest that all three constructs demonstrate strong measurement quality. Nevertheless, researchers should carefully distinguish between health outcomes that are objectively measured and those that are based on respondents' perceptions.

Self reported improvements in physical activity or health status may be influenced by recall bias and social desirability. Device generated measurements or clinical records can provide stronger evidence where access is ethically and practically possible.

The measurement model should also be tested for discriminant validity before interpreting the structural model. High correlations may occur because users who strongly value wearable technology may also report high compliance and better health outcomes.

Overall, the hypothetical results provide support for proceeding to structural model assessment.

Table 2. Discriminant Validity Using HTMT

Construct Pair	HTMT
Wearable Health Devices ↔ User Compliance	0.79
Wearable Health Devices ↔ Health Outcomes	0.74
User Compliance ↔ Health Outcomes	0.82

Interpretation of Table 2

The hypothetical HTMT results indicate acceptable discriminant validity among the three constructs.

The HTMT value of 0.79 between wearable health devices and user compliance suggests a meaningful association. This is expected because the effectiveness of wearable devices depends partly on users' willingness and ability to engage with them consistently.

However, the constructs remain conceptually different. Wearable health devices concern technological capabilities, whereas user compliance concerns behavioral engagement.

The HTMT value between wearable health devices and health outcomes is 0.74. This indicates that users who perceive greater benefits from wearable technology may also report better health outcomes, but the two constructs remain empirically distinguishable.

The relationship between user compliance and health outcomes produces an HTMT value of 0.82. This relatively strong association supports the theoretical expectation that sustained engagement may contribute to better health related outcomes.

However, the relationship should not be interpreted as proof of causality. Users who are already

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healthier or more motivated may be more likely to comply with wearable technology recommendations.

Therefore, the possibility of reverse causality and self selection should be considered in future research.

For the actual SmartPLS model, bootstrapped HTMT confidence intervals should also be examined.

Overall, the hypothetical results support discriminant validity and provide an appropriate basis for testing the structural relationships and moderation effect.

Table 3. Structural Model Results

Hypothesis	Relationship	β	SE	t value	p value	Decision
H1	Wearable Health Devices → Health Outcomes	0.39	0.06	6.50	<0.001	Supported
H2	User Compliance → Health Outcomes	0.31	0.06	5.17	<0.001	Supported
H3	Wearable Health Devices × User Compliance → Health Outcomes	0.18	0.05	3.60	<0.001	Supported

Illustrative R^2

Endogenous Construct	R^2
Health Outcomes	0.49

Interpretation of Table 3

The hypothetical structural results provide support for all three proposed hypotheses.

H1 predicts that wearable health devices positively influence health outcomes. The coefficient of $\beta = 0.39$, $t = 6.50$, $p < 0.001$ indicates a significant positive relationship.

This suggests that individuals who perceive stronger health monitoring capabilities and usefulness from wearable devices may report better health outcomes. Continuous feedback may increase health awareness and encourage users to modify their behaviors.

H2 predicts that user compliance positively influences health outcomes. The coefficient of $\beta = 0.31$, $t = 5.17$, $p < 0.001$ indicates a significant positive relationship.

This suggests that consistent engagement with wearable technology may provide users with greater opportunities to monitor health information and respond to feedback.

H3 examines the moderation effect. The interaction coefficient is $\beta = 0.18$, $t = 3.60$, $p < 0.001$, indicating a statistically significant positive moderation effect.

This means that the relationship between wearable health devices and health outcomes becomes stronger as user compliance increases.

The finding supports the central argument of the study: technology effectiveness is conditional upon sustained user engagement.

The R^2 value of 0.49 indicates that wearable health device use, user compliance, and their interaction collectively explain approximately 49 percent of the variance in health outcomes.

The results suggest meaningful explanatory power, although a substantial proportion of variation

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remains unexplained.

Other factors such as socioeconomic characteristics, health literacy, motivation, access to healthcare, existing health conditions, lifestyle, environmental conditions, and social support may influence health outcomes.

The moderation finding is particularly important for technology developers. Increasing device functionality alone may not generate substantial health benefits if users fail to maintain regular usage.

Healthcare organizations should therefore combine wearable technology with behavioral support mechanisms.

Table 4. Moderation Analysis at Different Levels of User Compliance

Level of User Compliance	Effect of Wearable Devices on Health Outcomes	Interpretation
Low Compliance	0.21	Weak positive relationship
Medium Compliance	0.39	Moderate positive relationship
High Compliance	0.57	Strong positive relationship

Interpretation of Table 4

The hypothetical simple slope results provide a clearer interpretation of the moderation effect.

At low levels of user compliance, the relationship between wearable health devices and health outcomes is relatively weak, with an illustrative coefficient of 0.21. This indicates that wearable technology may provide limited benefits when users do not consistently wear the device, synchronize information, review feedback, or act on recommendations.

At medium compliance, the relationship increases to 0.39. This suggests that moderate engagement allows users to obtain more consistent information from the technology and potentially respond more effectively to health feedback.

At high compliance, the relationship increases substantially to 0.57. This indicates that wearable technology has its strongest association with health outcomes among users who consistently engage with the technology.

The pattern provides intuitive evidence for the moderation hypothesis. A wearable device cannot continuously monitor health if it is not worn, and information generated by a device may have limited behavioral value if users do not review or act upon it.

High compliance may create a repeated feedback loop. Users receive health information, interpret the feedback, modify behavior, observe subsequent changes, and continue engaging with the device.

This mechanism is consistent with behavioral self monitoring perspectives and Self Determination Theory because feedback may strengthen users' perceived competence and awareness.

The findings also highlight the difference between technological adoption and sustained use. A person may purchase and initially use a wearable device but gradually stop using it. Therefore,

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measuring adoption at a single point in time may overestimate the technology's actual health impact.

Device design may play an important role in maintaining compliance. Comfortable hardware, long battery life, simple interfaces, personalized feedback, meaningful notifications, and accurate measurements can potentially encourage continued engagement.

Privacy and data security are equally important. Concerns regarding personal health information may discourage users from maintaining long term engagement.

The results suggest that healthcare organizations should monitor adherence when implementing wearable based health programs.

Overall, the hypothetical simple slope analysis demonstrates that user compliance is not merely an independent predictor of health outcomes. It changes the strength of the relationship between wearable technology and health outcomes.

Discussion

The proposed findings indicate that wearable health devices have a positive relationship with health outcomes and that user compliance strengthens this relationship.

The direct effect of wearable health devices suggests that digital monitoring technologies may contribute to improved health behaviors and outcomes by increasing access to real time information.

Wearable technology can transform health monitoring from occasional clinical measurement into a more continuous process. Users can observe activity patterns, sleep behavior, heart rate trends, and other indicators.

The positive relationship between user compliance and health outcomes suggests that sustained engagement is important. Simply owning a wearable device is insufficient. Users must interact with the technology consistently to obtain meaningful benefits.

The central contribution of the study is the moderating role of user compliance. The results indicate that the effectiveness of wearable technology depends on how consistently users engage with it.

This finding is important because many digital health interventions experience declining engagement over time. Initial enthusiasm may not translate into sustained behavior.

The moderation finding is consistent with the Technology Acceptance Model because perceived usefulness and ease of use can influence continued engagement.

It is also consistent with Self Determination Theory. Users who perceive wearable feedback as meaningful may develop stronger motivation and competence in managing health behaviors.

The findings can also be interpreted using Socio Technical Systems Theory. Health outcomes result from interaction between technology and human behavior rather than from technological capabilities alone.

For healthcare providers, the findings suggest that wearable technology programs should incorporate compliance monitoring. Patients may require reminders, education, personalized feedback, technical support, and motivational interventions.

For technology developers, the findings emphasize the importance of user experience. Devices should be comfortable, intuitive, reliable, and capable of delivering meaningful rather than excessive information.

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Personalization may also improve compliance. Users may respond more positively when goals and feedback are tailored to their circumstances.

Healthcare organizations should also establish clear privacy policies. Users should understand what information is collected, how it is processed, and who can access it.

An important limitation is that the relationship between wearable technology and health outcomes may be affected by self selection. Individuals who choose wearable devices may already be more health conscious.

Another limitation is reliance on self reported health outcomes. Respondents may overestimate improvements in their health.

Future research should therefore combine survey responses with objective wearable data and clinical outcomes.

Longitudinal studies would also be valuable because sustained compliance is difficult to capture using cross sectional designs.

The study also suggests that future research should examine whether different types of compliance have different effects. Wearing the device, reviewing data, and following recommendations may represent distinct behavioral processes.

Overall, the findings emphasize that successful wearable health interventions require both effective technology and sustained human engagement.

Conclusion

This study examined the relationship between wearable health devices and health outcomes and investigated the moderating role of user compliance.

The proposed theoretical framework draws upon the Technology Acceptance Model, Self Determination Theory, and Socio Technical Systems Theory.

The illustrative SmartPLS findings indicate that wearable health devices have a significant positive relationship with health outcomes. User compliance also demonstrates a positive relationship with health outcomes.

Most importantly, the interaction between wearable health device use and user compliance is statistically significant, indicating that compliance strengthens the relationship between technology and health outcomes.

The moderation analysis suggests that wearable devices have a relatively weak relationship with health outcomes among users with low compliance, while the relationship becomes substantially stronger among highly compliant users.

This finding demonstrates that technological adoption should not be evaluated solely in terms of ownership or initial usage. Sustained engagement is an essential condition for realizing potential health benefits.

Healthcare organizations implementing wearable programs should therefore provide support that encourages long term engagement. Education, reminders, personalized feedback, technical assistance, and regular follow up may improve compliance.

Technology developers should focus on usability, comfort, battery life, accuracy, personalization, and privacy.

The study also emphasizes the importance of distinguishing perceived health improvements from objective clinical outcomes. Future research should combine questionnaire data with device

generated measurements and verified clinical indicators where appropriate.
The study has several limitations. Its proposed cross sectional design restricts causal inference. Self reported data may introduce common method and social desirability biases. Differences in age, health status, technological literacy, and device type may also influence results.
Future research should employ longitudinal and experimental approaches to determine whether wearable technology produces sustained improvements in health.
Researchers should also examine whether user compliance differs according to health condition, age group, device type, or intervention design.
Overall, wearable health devices have considerable potential to support health monitoring and behavioral change, but their effectiveness depends substantially on sustained user engagement. User compliance should therefore be treated as an important behavioral condition rather than a secondary consideration in digital health research and practice.

Future Recommendations

Healthcare organizations should provide structured education on wearable health technologies.
Users should receive personalized feedback to encourage sustained engagement.
Developers should improve device comfort and usability.
Battery life should be optimized to reduce interruptions in monitoring.
Wearable applications should provide meaningful rather than excessive notifications.
Health goals should be personalized according to user needs.
Healthcare providers should monitor long term device engagement.
Reminder systems should be incorporated where appropriate.
Privacy policies should be communicated clearly to users.
Strong cybersecurity measures should protect wearable health information.
Future research should use objective device generated health data.
Clinical outcomes should be incorporated where ethically and practically feasible.
Longitudinal research should examine sustained compliance.
Experimental studies should investigate causal relationships.
Future studies should distinguish between device wearing compliance and recommendation adherence.
Researchers should investigate health literacy as a potential moderator.
Future research should examine motivation as an additional explanatory variable.
Researchers should compare different categories of wearable health devices.
Studies should examine differences between healthy users and patients managing chronic conditions.
Future research should investigate whether personalized digital interventions can increase long term compliance.

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