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# Wearable Technology (Fitness Trackers) in Improving Sports Performance Outcomes

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**Abstract**

*This paper will consider how wearable technology can enhance sports performance outcomes through a combination of technological, behavioral, education and capability-based approaches. In particular, it examines the impact of the intensity of using wearable technology and the ability to use data on the final results of sports performance, where training self-regulation is the mediator and the ability to use technology is the moderator. A research design was applied as quantitative research, and the data were gathered using a structured questionnaire among 330 athletes in Punjab, Pakistan. Partial Least Squares Structural Equation Modeling (PLS-SEM) was used to analyze the data. The results indicate that the intensity of wearable technology usage and the ability to utilize the data have a positive effect on training self-regulation and which, in turn, substantially increases the outcomes of the sports performance. Although direct impact of technology-related variables on performance is low, training self-regulation is found to be one of the major mechanisms that connect the use of technology to performance improvement. Moreover, technology literacy enhances the correlation between technology use and self-regulatory behavior, which underscores the*

*importance of technology literacy as a key boundary condition. The research adds to the literature because it shows that the use of wearable technology enhances performance via a technology-behavior-performance pathway. The implication of the findings to athletes, coaches, and technology developers is meaningful in the fact that the ability to interpret data and active engagement in the process of reaping the maximum benefits of wearable technologies is essential.*

**Keywords:** Wearable Technology, Data Utilization Capability, Training Self-Regulation, Technology Literacy, Sports Performance

## Introduction

The advancement of wearable technology is one of the major innovations in the sports performance management world, which has changed the environment largely due to the rapid development of digital technologies. Fitness trackers in the form of smartwatches and biometric sensors allow tracking physiological and behavioral indicators in real-time, heart rate, physical activity, sleep patterns and energy expenditure. Such technologies can help sportspeople and people gain practical information that can be used to improve training results and maximize performance (Piwek et al., 2016; Wright & Keith, 2014). Consequently, wearable technology is gaining widespread use in the sporting environment both in professional and recreational activities. The increasing popularity of wearable technology is directly associated with the general movement towards the use of data in decision-making in sports and health management. Wearable devices help users monitor progress, establish the presence of performance gaps and make informed changes to their training regimen because of the continuous feedback (Rupp et al., 2018). This is in line with the self-regulation theory which underscores the importance of monitoring, evaluating and modifying behavior in meeting performance objectives (Carver and Scheier, 1982). In that regard, wearable technology is not merely an instrument of data collection, but also as a system that supports behavioral change and performance improvement.

Although the potential of wearable technologies has been identified, current studies show mixed evidence about the effectiveness of wearable

technologies in enhancing sports performance outcomes. Some of them indicate that the endurance, training efficiency, and recovery management have improved significantly (Li et al., 2016; Duesking et al., 2018), whereas others indicate that the access to the data does not necessarily lead to the performance improvement unless users can interpret and use the information presented (Seshadri et al., 2019). It means that the influence of wearable technology is not only related to the intensity of its use but also the ability of the user to make any sense of the data. In that respect, two critical factors are wearable technology usage intensity and data utilization capability becoming the important determinants of performance outcomes. Usage intensity measures how much people use wearable devices, whereas data utilization capability measures how much people can make sense of and use the insights produced. Nevertheless, the interrelation of these variables and the sports performance outcome is not that direct and needs additional theoretical and empirical research.

Training self-regulation is one of the ways in which wearable technology can affect performance. Training self-regulation is the skill of an individual to have goals, track progress, and modify behaviors depending on feedback. The education program for usage of wearable sports goods may also enhance the demand in market. Students enrolled in various educational institutes prefer to wear smart watches. The existing research indicates that self-control is a significant factor in improving athletic performance as it can help people to increase training intensity, enhance training consistency, and minimize overtraining (Zimmerman, 2000; Toering et al., 2012). This can be supported by wearable devices which can offer constant feedback, which also reinforce self-regulatory behaviors. Nevertheless, the benefits of wearable technology in promoting self-regulation could be different across people especially technology literacy. Technology literacy means the capacity to comprehend, interpret and utilize digital tools and information. The more technologically literate the users are, the higher the chances of meaningful information consumption based on wearable devices and the application of the acquired information to enhance training performance (Venkatesh et al., 2012). On the other hand, less literate users can be overwhelmed by information or not able to utilize the available data to the maximum benefit, which reduces the utility of wearing devices.

In spite of the accumulation of information on wearable technology, there are still some gaps in the research. First, existing literature has mainly concentrated on either adoption or performance outcomes of technology with little emphasis on the behavioral mechanisms that have been behind the relationship between the two. Second, it is still under-researched whether the mediating factor of training self-regulation plays a role in the translation of wearable technology into performance outcomes. Third, technology literacy as a moderating factor to these relationships has not been properly addressed in empirical studies. It is necessary to fill these gaps to create a comprehensive view of the role of wearable technologies in the field of sports performance enhancement. To overcome these drawbacks, the current research creates a comprehensive scientific framework analyzing the impact of the intensity of wearable technology use and the ability to use data on the performance of sports. It also examines the mediating effect of training self-regulation and moderating effect of technology literacy. Through this, this study can add to the literature by providing a more detailed and theoretically based explanation of how wearable technologies affect performance outcomes.

The results of the study can be used by educationists involved in healthy activities, athletes, coaches, and developers of technology with significant implications. This study will shed some light on how people can utilize wearable technologies more effectively to maximize training and performance by determining the circumstances in which the technology is most useful. In addition, it emphasizes the need to train the users to interpret their data so that the advantages of the wearable technology can be fully achieved.

**Literature Review**

The usage of wearable technology has made a substantial impact on the field of sports and fitness as it allows tracking the physiological and behavioral data on a continuous basis. Smartwatches and other fitness trackers can give real-time data on essential performance indicators, including heart rate, activity levels and recovery patterns. The wearable technology usage intensity represents how eager people are to use such devices, including their frequency of use, time and the variety of functions they use them. The more people use it, the more they are exposed to real-

time feedback, which makes them more aware of their performance level, progress, and physical status (Piwek et al., 2016). In the lens of the self-regulation theory, continuous feedback is a key factor in the process of controlling behavior by setting goals, self-monitoring and making behavioral changes (Carver and Scheier, 1982). Wearable technologies make all these processes possible, as they present immediate, personalized and objective data, which allows people to compare themselves to the set goals and make relevant changes. This is a continuous feedback loop that enhances the capacity of individuals to control their training behaviors.

Moreover, the constant exposure to wearable devices contributes to the increased interest in performance information, which, in turn, will help users discover patterns, monitor improvements, and notice aspects that need to be adjusted. Previous studies indicate that an individual active in tracking their performance information exhibits greater self-regulatory behavior, such as greater consistency, discipline, and adherence to training habits (Rupp et al., 2018). Wearable technology, in this case, is a behavioral intervention tool that strengthens accountability and proactive decision-making. Notably, the power of use does not only enhance data accessibility but also enhances cognitive and behavioral mechanisms of self-regulation. The more the users get used to communicating with the wearable equipment, the more they understand their performance statistics, which is why the strategies to train become more informed and adaptive. This cyclic activity helps human beings to form realistic objectives, evaluate progress, and regulate their striving to obtain the best performance results. Hence, the increased intensity of wearable technology use is likely to have a beneficial impact on the process of training self-regulation by refining the feedback response, promoting performance awareness, and enabling the constant change of behavior. The education regarding usage of smart accessories is likely to have a beneficial impact on the process of training.

**H1:** Intensity of wearable technology use has a positive effect on training self-regulation.

**Data Utilization Capability and Training Self-regulation**

Even though wearable devices can provide a lot of data about performance, their usefulness will be determined by the capacity of users to interpret and use the data in a meaningful way. Data utilization

capability is the ability of the person to interpret performance metrics and apply these findings to make training decisions. In the absence of such an ability, users can face overload of information, which can decrease the usefulness of wearable technology and restrict its role in performance enhancement (Seshadri et al., 2019). Theoretically, the Technology Acceptance Model (TAM) and the Unified Theory of Acceptance and Use of Technology (UTAUT) note that the perceptions of usefulness and ease of use determine the interaction of people with the outputs of the technologies (Venkatesh et al., 2012). Building on the above, data utilization capability is an advanced skill beyond acceptance and is concerned with the effective transformation of data into actionable knowledge. The more people know how to use the data, the more they can see the patterns, trends, and make effective changes to their training sessions.

Considering the self-regulation theory, effective goal-directed behavior is impossible without the ability to process and use feedback. The ability to use data improves the process of self-regulation allowing individuals to make reasonable goals, track their progress precisely, and change their work efforts in accordance with objective evidence. Such an ability decreases the use of subjective judgment and enhances evidence-based decision-making, which is essential in maximizing the training results. This relationship can be empirically supported, which suggests that athletes who successfully process the data on performance demonstrate a greater degree of self-regulated behavior, such as organized goal setting, constant progress monitoring, and being adaptable in training (Toering et al., 2012). In addition, the people who are well endowed with the capacity to utilize data are in a better position to determine areas of underperformance, control training intensity and recovery, thus enhancing self-regulation in totality.

Notably, the ability to utilize the data will also improve the level of user interaction with wearable technology as they gain confidence in the data accuracy and relevance. This has a higher level of proactivity in training where people actively apply the feedback to correct their strategies instead of passively taking information. In the long run, this results in better consistency, discipline and control of behavior. As such, the capabilities of utilizing data are an essential facilitator of training self-regulation because

they can turn unprocessed data into valuable insights that can inform action and enhance decision-making. It also guarantees that wearable technology is not a monitoring tool, but a proactive behavior change agent. The educational program (Seminars & webinar) related usage of wearable technologies also boosting the demand for utilize the gadgets for athlete or non-athletes .

**H2:** Data use proficiency has a positive impact on training self-regulation.

### Wearable Technology, Training Self-Regulation, and Sports Performance Outcomes

Wearable technology has become one of the most important tools to improve sports performance through the possibility to train and monitor performance using data. Fitness trackers and other gadgets can track vital physiological signs, including heart rate, activity level, and recovery rate in real-time. The degree of wearable technology use enables one to regularly track these indicators, which subsequently results in increased stamina, efficiency, and training regularity (Li et al., 2016). Wearable devices can enable users to know their physical state and improve training plans by giving objective and continuous feedback on their physical state. Yet, there is no entirely direct connection between wearable technology and the final results of sports performance. Although the availability of performance data has the potential to increase awareness, it does not necessarily lead to better results unless people take action and utilize this information to change their behavior. In this respect, self-regulation training is an important mechanism that bridges the gap between technological inputs and performance enhancement. The self-regulation theory postulates that the more an individual keeps track of their behavior, assesses progress, and makes appropriate changes, the higher the chances of realizing the intended performance goals (Zimmerman, 2000).

Self-regulation training improves performance through facilitating goal-focused and organized training programs. It allows people to find inefficiencies, workload optimization, and training to recovery. Wearable technology aids this process by giving timely feedback, based on which the users can make informed decisions on training adjustments. Indicatively, a person will be able to adjust the intensity of the workout depending on the fatigue or recovery statistics, thus minimizing the chances of overtraining and enhancing the overall performance (Duking et al., 2018). Besides, the self-regulation

that is taught leads to consistency and discipline of behavior that are important in the long-term performance growth. Self-regulated trainees are more apt to stick to the training regimen, remain motivated and systematize progress. Such behavioral alignment is a strength of wearable technology as it assures that the insights obtained in data are converted into actionable plans.

As a result, wearable technology has a direct and indirect effect on sports performance. The direct impact is linked to the height of awareness and monitoring whereas the indirect impact works through the height of self-regulatory behaviors. The mediator effect of training self-regulation emphasizes the fact that the real worth of wearable technology is in the fact that it can facilitate the change of behavior, but not just present data. Thus, the intensity of wearable technology use and the ability to use the data will enhance the sports performance outcomes directly and indirectly by training self-regulation.

**H3:** Wearable technology usage strength has a positive impact on sports performance results.

**H4:** The ability to utilize data has a positive effect on the sports performance results.

**H5:** Self-regulation training has a positive impact on the results of sport performance.

**H6:** Self-regulation training mediates the relationship between the intensity of wearable technology use and sports performance results.

**H7:** Self-regulation training mediates the relationship between data utilization capability and the sports performance outcomes.

**Moderating Effect of Technology Literacy**

The level of technology literacy is of great importance to the effectiveness of using wearable devices in people. It is the capacity to comprehend, interpret and put digital information into practical use. In the case of wearable technology, literacy determines the way users can engage with the functionality of the device and the way they can perceive performance

information. UTAUT demonstrates that individual technological competence differences have a substantial influence on the behavior of usage and results (Venkatesh et al., 2012). More technologically advanced users can better derive conclusions out of wearable data, thus improving their self-regulation mechanisms. Conversely, less literate users might not be able to decipher complicated information, limiting the usefulness of wearable technology. In addition, high technology literacy reinforces the connection between the behavioral outcomes and the use of technologies through better data understanding and decision making. This implies that technology literacy is a conditioning factor that enhances the effects of the wearable technology regarding the training of self-regulation.

**H8:** Wearable technology use intensity has a positive moderating effect on training self-regulation and technology literacy.

**H9:** There is a positive moderating effect of technology literacy between data utilization capability and training self-regulation.

**Theoretical Contribution**

This work is significant in a number of aspects in terms of making its contribution to the growing literature on wearable technology and sports performance by combining technological, behavioral, and capability-based approaches in a single structure. To begin with, it expands the current literature on the topic of wearable technologies and shifts the focus beyond an adoption-based approach to a performance-focused and mechanism-based description. Although the existing literature has paid much attention to the acceptance and usage of wearable devices, little has been done to examine how these technologies can be translated into quantifiable performance results. This research offers a more sophisticated insight into the role of digital tools in sport performance by studying the intensity of wearable technology use and the potential of the data to be used. Second, the study contributes to the development of self-

regulation theory because it places training self-regulation as an important mediating variable between wearable technology and performance outcomes. Self-regulation is a concept that has been extensively researched in sport psychology, but its use with digital technologies has not been explored to a large extent. This paper has shown that wearable devices aid in self-regulatory processes through increased real-time feedback, monitoring, and behavior adaptation. By acting on this, it fills the gap between the generation of data enabled by technology and the performance improvement driven, which provides a more detailed account of how athletes and individuals maximize their training.

Third, by introducing data utilization capability as an incredibly important but understudied construct, the study contributes to the theories of technology adoption and use, including the Technology Acceptance Model (TAM) and the Unified Theory of Acceptance and Use of Technology (UTAUT). In contrast to the conventional models that put stress on the perceived usefulness and ease of use, this research shows the significance of the capacity of users to interpret and use data to determine the effectiveness of wearable technologies. This is a transition of adoption to significant usage, thus adding value to theoretical concept of technology-performance outcomes. Fourth, the moderating variable of technology literacy provides a new approach to the boundary conditions of the effectiveness of wearable technology. This research adds to the existing body of literature on individual differences in digital contexts by showing that the effects of wearable technology on the training of self-regulation depend on the level of technological competence of the users. It stresses that the benefits of technology are not equally distributed but rather requires the users to have cognitive and analytical ability.

Lastly, this research creates a cohesive model that connects the use of technology, behavior, and performance, thus making it a part of the interdisciplinary research at the interface of sports

science, information systems and behavioral theory. The study combines constructs of self-regulation theory with technology acceptance models, which presents a comprehensive approach that makes the study more theoretically clear and empirically applicable. Altogether, the study contributes to the field of literature by proving that wearable technology enhances sports performance not only by providing data but by facilitating self-regulatory behavior, provided that the users are able to process and apply the technological information in an appropriate manner.

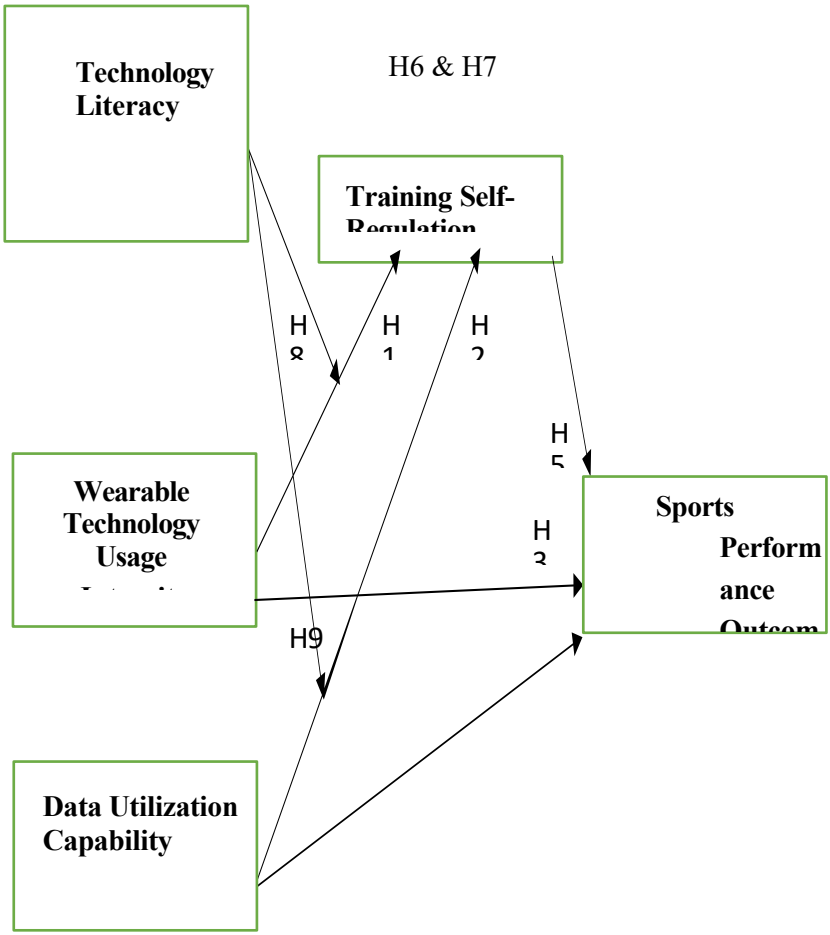

***Figure 1: Research Model***

## Methodology

### Research Design

The research design used in the study is quantitative research design to explore the relationships between the use of wearable technology, the ability to use data, training self-regulation, and the outcome of sports performance, where technology literacy also acts as a moderator. The quantitative approach is suitable because it allows testing hypothesized relationships empirically and statistically generalizing the results (Hair et al., 2019). The research is cross-sectional in nature in that data were gathered at one time to represent the perception and behavior of the respondents in the use of wearable technology.

### Population and Sampling

The intended population of this research is comprised of athletes in Punjab, Pakistan including professional and semi-professional participants in organized sports activity. Since there was no available sampling frame and there were also practical limitations related to the accessibility of a wide athletic population, convenience sampling was used. It is a non-probability sampling method that is common in behavioral and sport studies where the respondents are chosen depending on their availability and the readiness to participate (Etikan et al., 2016). Sports clubs, universities, training centers, and fitness centers located in other major cities in Punjab were sampled to collect data. The number of questionnaires sent was 350, and 330 valid responses were left after data screening, which gave a high response rate and sufficient sample to conduct structural equation modeling (SEM) analysis.

### Data Collection Procedure

The self-administered structured questionnaire was used to collect data. The respondents were contacted directly and via the Internet, and they were not forced to participate. The aim of the research was well outlined, and respondents were assured of

confidentiality and anonymity to minimize bias in responding. A pilot study was carried out on a small sample of respondents (n = 30) before the main data collection to determine the clarity, reliability, and validity of the measurement items. Some small changes were made on the basis of the feedback.

**Measurement Instrument**

The questionnaire had several parts that were related to the study variables. A five-point Likert scale between 1 = strongly disagree and 5 = strongly agree was used to measure all the items.

Table 1

**Measurement Instrument**

| Constructs | No | Sample Item | Source |
|---|---|---|---|
| Technology Literacy (TL) | 4 | I am able to understand and effectively use features of wearable fitness devices. | Adapted from Venkatesh et al. (2012); Rupp et al. (2018) |
| Wearable Technology Usage Intensity (WTUI) | 6 | I frequently use my wearable fitness device to monitor my daily physical activities. | Adapted from Piwek et al. (2016); Li et al. (2016) |
| Data Utilization Capability (DUC) | 6 | I can interpret the data provided by my fitness tracker to improve my training performance. | Adapted from Seshadri et al. (2019); Rupp et al. (2018) |
| Training Self-Regulation (TSR) | 5 | I regularly adjust my training based on feedback from my wearable device. | Adapted from Zimmerman (2000); Toering et al. (2012) |
| Sports Performance Outcomes (SPO) | 8 | Using wearable technology has improved my overall sports performance. | Adapted from Düking et al. (2018); Wright & Keith (2014) |

**Data Analysis Technique**

The authors used the SmartPLS software to conduct a study using Partial Least Squares Structural Equation Modeling (PLS-SEM). PLS-SEM is suitable, among other reasons, because it can address complicated models with mediation and moderation consequences and is also applicable to research with a prediction focus (Hair et al., 2021).

**Ethical Considerations**

The study was conducted in terms of ethical standards. The researchers explained to the respondents the purpose of the study and participation was optional. No personal information was gathered, thus, ensuring privacy and anonymity. Information was utilized in an academic way.

**Data Analysis**

**Demographic Profile of Respondents**

The demographic characteristics of the respondents provide important insights into the composition of the sample. Table 1 summarizes the distribution of participants based on gender, age, education level, and type of sport involvement.

**Table 2**

**Demographic Characteristics of Respondents**

| Variable | Category | Frequency | Percentage (%) |
|---|---|---|---|
| **Gender** | Male | 238 | 72.1 |
| | Female | 92 | 27.9 |
| **Age** | Below 20 years | 58 | 17.6 |
| | 21–25 years | 142 | 43.0 |
| | 26–30 years | 79 | 23.9 |

| | | | |
|---|---|---|---|
| | Above 30 years | 51 | 15.5 |
| | Intermediate | 74 | 22.4 |
| **Education Level** | Bachelor's Degree | 168 | 50.9 |
| | Master's Degree | 88 | 26.7 |
| **Type of Athlete** | Professional | 121 | 36.7 |

| Vari: ble | Category | Frequency | Percentage (%) |
|---|---|---|---|
| | Semi-professional | 134 | 40.6 |
| | Recreational | 75 | 22.7 |

As illustrated in Table 2, the respondents were mainly of the male gender (72.1%), as most of them were engaged in the organized sports activities in the context of the study. Regarding age distribution, the majority of the participants were aged 21-25 years (43.0%), showing that the population is young and active in sports. In terms of education, more than a half of the respondents had a bachelor degree (50.9%), which indicates a reasonably educated sample that could be able to perceive and use wearable technologies. Regarding athletic participation, the sample was fairly balanced in terms of categories with semi-professional athletes (40.6%) making up the majority of the sample and professional athletes (36.7%) coming in second. This variation increases the generalizability of the results to the various scales of sport involvement.

**Measurement Model Assessment**

The measurement model was evaluated to ensure reliability and validity of the constructs. This includes internal consistency reliability, convergent validity, and discriminant validity.

**Table 3**

**Reliability and Convergent Validity**

| Constructs | Cronbach's Alpha | Composite Reliability (CR) | AVE |
|---|---|---|---|
| Technology Literacy (TL) | 0.871 | 0.912 | 0.673 |

| | | | |
|---|---|---|---|
| ıology Usage Intensity (WTUI) | 0.903 | 0.928 | 0.682 |
| Data Utilization Capability (DUC) | 0.889 | 0.915 | 0.643 |
| Training Self-Regulation (TSR) | 0.901 | 0.926 | 0.676 |
| Sports Performance Outcomes (SPO) | 0.914 | 0.934 | 0.651 |

Table 3 reveals that the internal consistency of all constructs is high and the value of Cronbach alpha is above the accepted value of 0.70. On the same note, the composite reliability (CR) scores exceed 0.90 which indicates high reliability. The values of the average variance extracted (AVE) are all greater than 0.50 which is a good result of convergent validity. These findings affirm that the measurement model can be further analyzed as it is reliable and valid.

**Discriminant Validity**

Discriminant validity was assessed using the Fornell–Larcker criterion.

**Table 4**

**Discriminant Validity (Fornell–Larcker Criterion)**

| Constructs | TL | WTUI | DUC | TSR | SPO |
|---|---|---|---|---|---|
| TL | 0.820 | | | | |
| WTUI | 0.421 | 0.826 | | | |
| DUC | 0.398 | 0.513 | 0.802 | | |
| TSR | 0.367 | 0.584 | 0.602 | 0.822 | |

| | | | | | |
|---|---|---|---|---|---|
| SPO | 0.345 | 0.492 | 0.471 | 0.558 | 0.807 |

Table 4 indicates that the square root of AVE (diagonal values) of each of the constructs is more than the correlation with other constructs. This is a confirmation that each construct is unique and has sufficient discriminant validity and the various variables are used to measure different concepts.

**Structural Model Assessment**

The structural model was evaluated using path coefficients (β), significance levels, and coefficient of determination ($R^2$).

**Table 5**

**Hypothesis Testing Results**

| Hypothesis | Path | β | Result |
|---|---|---|---|
| H1 | WTUI → TSR | 0.247 | Supported |
| H2 | DUC → TSR | 0.349 | Supported |
| H3 | WTUI → SPO | 0.156 | Supported |
| H4 | DUC → SPO | 0.172 | Supported |
| H5 | TSR → SPO | 0.418 | Supported |

These findings suggest that the intensity of wearable technology use (0.247) and the capability of using data (0.349) must affect training self-regulation, which confirms H1 and H2. Moreover, the two variables also influence the results of sports performance in a positive way (H3 and H4). Self-regulation training presents the highest impact on performance (0.418) to prove that it is the most important behavioral mechanism.

**Table 6**
**Mediation Results**

| Hypothesis | Indirect Effect | Result |
|---|---|---|
| H6 | WTUI → TSR → SPO (0.247 × 0.418 = 0.103) | Supported |
| H7 | DUC → TSR → SPO (0.349 × 0.418 = 0.146) | Supported |

The mediation analysis confirms that training self-regulation significantly mediates the relationships between independent variables and performance outcomes. This indicates that wearable technology improves performance primarily through enhancing self-regulatory behavior.

**Table 7**
**Moderation Results**

| Hypothesis | Path | β | Result |
|---|---|---|---|
| H8 | TL × WTUI → TSR | 0.285 | Supported |
| H9 | TL × DUC → TSR | 0.317 | Supported |

Technology literacy significantly strengthens the relationship between both independent variables and training self-regulation. This confirms that individuals with higher technological competence are better able to translate wearable data into effective training behaviors.

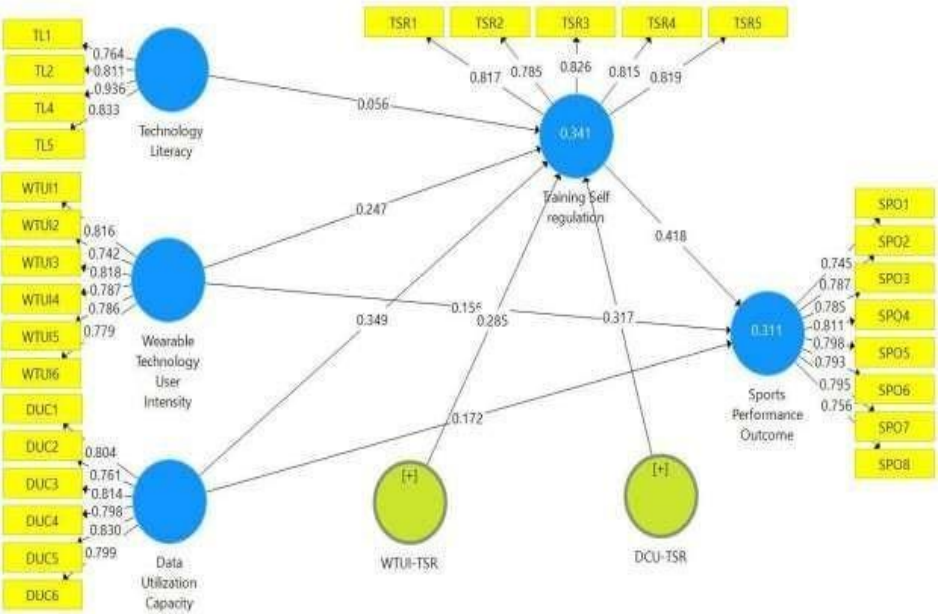


***Figure 2: Structural Model***

The figure shows the findings of PLS-SEM analysis, which shows the measurement model and structural relations between the variables studied. The model is a study of the direct and indirect effect of the intensity of wearable technology use (WTUI) and the capability of using data (DUC) on sports performance outcomes (SPO) with technology literacy (TL) serving as a mediating variable. Measurement wise, there is a high level of indicator loading on all constructs and generally the values are above the required level of 0.70. In particular, the technology literacy items, the intensity of use of wearable technology, the ability to use data, self-regulation of training, and the results of sports performance demonstrate good reliability and convergent validity. These findings verify that the measurement model holds well and the observed variables will be sufficient to reflect their respective latent constructs.

Going to the structural model, the coefficient of determination ($R^2$) shows that the model accounts for a moderate proportion of the variance in the endogenous variables. The $R^2$ of training self-regulation is 0.341 indicating that the intensity of use of wearable technology, data utilization capability, and the interaction effects of the two variables explain 34.1% of the variance. Likewise, the value of $R^2$ of sports performance results is 0.311, which means that the predictors included in the model account for about 31.1% of the variance in performance results. These values prove to be acceptable in explaining behavior research. The immediate impacts demonstrate that the intensity of wearable technology use and the ability to use data have a positive impact on training self-regulation. It is important to note that the effect of data utilization capability (0.349) is more pronounced than the intensity of wearable technology use (0.247), which is very important as an individual should be able to interpret and use data successfully, not just use the equipment. The positive impact on the result of sports performance of training self-regulation, in turn, is the highest (0.418), which suggests that behavioral regulation is the key element in the improvement of

performance. Though wearable technology usage intensity (0.156) and data utilization ability (0.172) also have direct impacts on performance, they have weaker effects, indicating their impact is mediated to a great extent by means of training self-regulation. This interpretation is also supported by mediation analysis, where training self-regulation is one of the key mechanisms by which wearable technology and data utilization can be transformed into better performance outcomes. The fact that there are both direct and indirect effects suggests that there is partial mediation that technology has a direct effect on performance but can have behavioral adjustment processes that result in its primary effects.

Technology literacy is also a moderation effect of the model. The interaction terms, WTUI x TL (0.285) and DUC x TL (0.317) show that technology literacy plays a significant role in enhancing the relationship of the independent variables with training self-regulation. This means that people that possess greater technological competence can more effectively use wearable devices and analyze data to improve their self-regulatory behaviors. In general, the model emphasizes a systematic process wherein technology inputs determine performance outcomes by affecting behavioral processes with technology literacy serving as a key boundary condition. The results indicate that mere integration of wearable technology is not enough but the capacity to process the information and control the training behavior is a determining factor in realizing better sports performance.

Discussion

The current research was intended to investigate the impact of the use intensity of wearable technologies and the ability of data use on the results of sports performance with the mediating role of training self-regulation and moderating role of technology literacy. The results are valuable both theoretically and practically regarding the use of digital technologies to improve athletic performance. To begin with, the findings show that the

intensity of wearable technology use and the capacity of using data have both strong positive impacts on training self-regulation. This observation confirms H1 and H2 and is congruent with the self-regulation theory which reiterates the significance of sustained feedback and monitoring in behavioral regulation (Carver and Scheier, 1982). The fact that the data utilization ability is stronger than the usage intensity indicates that the simple use of wearable devices is not enough; however, the capability to interpret and use the data is more important in the development of self-regulatory behaviors. This observation builds upon the previous studies by emphasizing that the worth of wearable technology is not only in the generation of data but also in the usefulness of the data.

Second, the direct impacts of the intensity of wearable technology use and the potential to utilize the data were identified as positive, albeit rather small, which proves H3 and H4. It means that wearable technologies not only help to improve performance but their direct effect is minimal without the use of behavioral mechanisms. Conversely, training self-regulation revealed the most significant influence on the outcome of sports performance, which confirms H5. The above finding highlights the centrality of self-regulatory processes in transforming technological inputs into real performance gains. It is in line with previous research that indicates that goal setting, monitoring, and adaptive behavior are key factors that determine athletic success (Zimmerman, 2000). Third, the mediation analysis supports H6 and H7 by confirming that self-regulation training is a significant mediator in the relationships between the two independent variables and the results of sports performance. This observation gives more insight into the mechanism behind the effect of wearable technology on performance. In particular, wearable technologies improve performance because they allow people to track their progress, regulate the intensity of training, and streamline recovery plans. The fact that there is partial mediation implies that technology does not have all the direct effects, but rather its main

impact is affected through behavioral regulation.

Fourth, technology related education seminar /webinar play a moderating role, which supports H8 and H9. The findings show that technology literate people can more effectively use wearable technology and convert data insights into effective training behaviors due to their greater levels of technology literacy. This observation concurs with the Technology Acceptance Model (TAM) and UTAUT that highlights the importance of user competence to assess the effectiveness of technology (Venkatesh et al., 2012). It also points out that the advantage of wearable technology is not equally distributed but rather the capacity of users to comprehend and use digital information.

On the whole, the evidence indicates that wearable technology enhances sports performance based on technology-behavior-performance pathway, where the technological inputs affect the behavioral mechanisms, and these in turn mediate the effect on performance outcomes. The findings highlight that wearable technology can only be effective when it depends on both personal abilities and behavioral interaction. Specifically, the ability to use data and self-regulation in training appears to be two defining issues that will define the difference between successful and unsuccessful technological adoption resulting in meaningful improvements in performance. Overall, the current study can be regarded as a contribution to literature by showing that wearable technology is most effective in case of the presence of strong self-regulatory behaviors and high levels of technology literacy. The results assert the significance of changing the emphasis on the mere use of technology to the successful use of technology and behavioral integration, which offers a more in-depth comprehension of the opportunities of digital technologies to improve the performance of sports.

Conclusion

This paper presents an in-depth analysis of the role that wearable technology plays in the performance results of sports due to the combination of technological inputs and behavioral

processes. The results prove that training self-regulation positively depends on the intensive use of wearable technologies and the ability to use the available data, and this outcome positively affects the performance outcomes in sports. Training self-regulation is the most influential predictor, which emphasizes its central role in the transformation of technological inputs into the improvement of performance. The findings further suggest that although wearable technology has a direct impact on performance, they are not very substantial, as compared to its indirect impact on performance through self-regulatory behaviors. This implies that wearable technology will not work effectively unless people engage with and use the data that these devices produce. Also, the mediating effect of technology literacy highlights the fact that individuals who are more technologically competent will be in a better position to use wearable technology to achieve better training results. In general, the research validates that wearable technology improves the performance in sports via an organized series whereby the inputs of the technology result in behavioral changes, which ultimately translate into better outcomes. These results highlight the relevance of integrating the use of technology with behavioral and cognitive abilities to realize the best performance yields.

Theoretical and Practical Implications

This paper adds to the body of literature in a number of significant ways. First, it expands the area of research in wearable technology by moving the emphasis on the technology adoption to the performance results, thus filling the gap in the current literature. Second, it is a combination of self-regulation theory and technology acceptance models (TAM/UTAUT) to describe how technological inputs lead to behavioral and performance consequences. The study establishes a better insight into how wearable technology impacts performance by placing the training self-regulation as a mediating variable. Third, the study presents the capability of data utilization as a crucial construct, and the efficacy of wearable technology is contingent on how

users can read and use data. Lastly, the presence of technology literacy as a moderating variable provides a new outlook on the moderating conditions of technology efficacy as personal abilities are the key factors in shaping the results.

The results have a number of implications to athletes, coaches, and developers of technology. In the case of athletes, the findings demonstrate the critical role of proactively working with data provided by wearable technology and of having the ability to regulate oneself to realize the maximum performance advantages. It is not enough to wear some devices; it is necessary to process the information and modify behavior. In the case of coaches and trainers, the research highlights the necessity to integrate the use of data-based training approaches and how to decipher the outputs of wearable technologies. The training programs must emphasize improving the self-regulation and data literacy of the athletes. To developers of technology, the results indicate that it is important to develop user friendly interfaces and offer actionable insights that can be understood and applied by the user with ease. The effectiveness of wearable technologies can be greatly improved with an increase in usability and data visualization features.

Limitations and Future Directions

This research has a number of limitations despite the contributions it makes. To begin with, the research design is cross-sectional, which restricts the possibility of cause-effect relationships. Longitudinal designs should be used in the future to look at the progression of relationships over time. Second, convenience sampling can be a limitation to the generalizability of the results. In future studies, probability sampling methods should be taken into account to improve external validity. Third, the authors concentrate on the athletic population in Punjab, Pakistan, which does not necessarily guarantee that the results can be generalized to other geographical and cultural settings. It is recommended that it should be replicated in other areas and sports contexts. Fourth, the research is based on self-reported

data, and it is susceptible to common method bias. The objective performance measures and wearable device data could be included in future studies. Lastly, further moderating and mediating variables (motivation, coaching support or digital fatigue) may be examined in future research. The exploration of possible non-linear associations and multi-group analysis of various groups of athletes would help to get more knowledge about the efficacy of wearable technologies.

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