E-ISSN:2618-5911
Turkish Journal of Sports Science
https://dergipark.org.tr/en/pub/tusbid

Research Article │ **DOI: 10.32706/tusbid.1864121**

Received: 15.01.2026 Accepted: 26.03.2026 Online Published: 30. 03.2026

Validity and Reliability Study of The Sports Technology Adaptation Scale

Muhammet Kusan[1] **Fatih Samet Atasoy**[2] **Neşe Mumcu**[3]
Osman Kusan[4] **Hasan Erdem Mumcu**[3] **Soner Çankaya**[1]

[1]Ondokuz Mayıs University, Faculty of Sports Sciences, Samsun-Turkiye. [2]Samsun Provincial Police Department, Samsun-Türkiye. [3]Tokat Gaziosmanpaşa University, Faculty of Sports Sciences, Tokat-Türkiye. [4] Gümüşhane University, Faculty of Sports Sciences, Gümüşhane-Türkiye.

Abstract

The aim of this study is to develop a valid and reliable measurement tool to assess athletes' perceptions of sport technologies and their level of digital adaptation. The research was designed as a methodological, cross-sectional scale development study based on the Technology Acceptance Model. The sample consisted of 730 athletes aged between 18 and 25 who actively participated in organized sports activities. Of the participants, 47.3% were female and 52.7% were male. Participants were recruited from university sport environments and local training settings where sport technologies such as wearable monitoring devices, training applications, and digital performance tracking systems are regularly used. To examine construct validity, the dataset was divided into two independent subsamples. Data from 300 athletes were used for Exploratory Factor Analysis, and data from 430 athletes were used for Confirmatory Factor Analysis. The analyses revealed a two-factor structure: Perceived Technological Support and Digital Adaptation. The model demonstrated satisfactory validity and reliability. The findings indicate that the scale can be used to evaluate athletes' performance-related perceptions of sport technologies and their ability to adapt to digital systems in training environments. The scale may provide a practical assessment tool for researchers, coaches, and sport organizations in the integration of technology into sport practice.

***Keywords**:* Digital adaptation, reliability, sports technology, technology acceptance model, validity

Introduction

One of the most influential theoretical approaches for explaining individuals' adoption of information and communication technologies is the Technology Acceptance Model (TAM), developed by Davis (1989). TAM posits that individuals' attitudes toward using a technology and their behavioral intentions are primarily shaped by two core cognitive evaluations: perceived usefulness and perceived ease of use. Perceived usefulness refers to the individual's belief that using a particular technology will enhance their performance, whereas perceived ease of use reflects the degree to which the technology is perceived as requiring minimal mental and physical effort (Davis, 1989; Davis, Bagozzi, & Warshaw, 1989).

The theoretical foundation of TAM is grounded in the Theory of Reasoned Action and the Theory of Planned Behavior, which assume that attitudes toward a behavior constitute one of the strongest predictors of behavioral intention (Ajzen, 1991). Since its initial introduction, TAM has gained widespread acceptance in the management information systems literature and has served as the basis for numerous empirical studies across different sectors, user groups, and technological contexts (Venkatesh

---

Corresponding Author: Muhammet Kusan, muhammetkusan0055@gmail.com

Citation: Kusan, M., Atasoy, F.S., Mumcu, N., Kusan, O., Mumcu, H.E., Çankaya, S. (2026). Validity and reliability study of the sports technology adaptation scale. *Turkish Journal of Sports Science, 10*(1):48-60. DOI: 10.32706/tusbid.1864121

& Davis, 2000; Venkatesh & Bala, 2008). Bibliometric analyses further indicate that the use of TAM and its extensions has increased substantially over the past decade and that the model continues to demonstrate strong explanatory power across diverse fields (Eriş & Kocabıyık, 2023).

Despite its robust explanatory framework, TAM has also been subject to criticism regarding certain limitations, leading to the development of several extended models. In this context, TAM2 incorporated social and contextual variables—such as subjective norm, image, voluntariness, and experience—into the model to provide a more detailed explanation of the formation of perceived usefulness (Venkatesh & Davis, 2000). Subsequently, TAM3 integrated cognitive and affective determinants of perceived ease of use, including computer self-efficacy, computer anxiety, and perceived enjoyment, thereby offering a more comprehensive account of the role of individual differences in technology acceptance (Venkatesh & Bala, 2008). Parallel to these theoretical developments, the Technology Readiness (TR) approach has gained prominence in the literature as a framework for explaining individuals' general predispositions and mental preparedness toward new technologies. Developed by Parasuraman (2000), the TR model conceptualizes technology readiness through four dimensions: optimism, innovativeness, discomfort, and insecurity. The integration of TAM and TR into the Technology Readiness and Acceptance Model (TRAM) emphasizes the need to jointly consider individuals' general technology-related tendencies and system-specific perceptions when explaining technology adoption behaviors (Lin et al., 2007). Collectively, these theoretical advancements demonstrate that technology acceptance is a multidimensional process shaped not only by technical characteristics but also by individuals' psychological perceptions, experiences, and contextual conditions. Empirical evidence from various sectors consistently confirms the pivotal role of perceived usefulness and perceived ease of use in predicting technology usage intentions (Turan, 2008; Toraman & Yüksel, 2022). Studies conducted within the Turkish context likewise reveal that TAM-based variables serve as strong predictors of user behavior (Turan, 2008; Toraman & Yüksel, 2022).

The sports domain presents a unique and complex context for testing technology acceptance models. Wearable technologies, performance monitoring systems, video analysis software, and artificial intelligence–based applications directly influence athletes' training, feedback, and decision-making processes. From the athlete's perspective, however, technology use extends beyond a voluntary choice and represents an adaptation process intertwined with performance expectations, coach directives, and competitive pressure. Despite this complexity, most Technology Acceptance Model (TAM)-based measurement instruments have been developed for general user populations or organizational contexts, limiting their ability to capture domain-specific experiences such as those encountered in sport environments. Widely used scales based on TAM, including those developed by Fred Davis (1989) and extended models such as TAM2 and TAM3 (Venkatesh & Davis, 2000; Venkatesh & Bala, 2008), primarily focus on perceived usefulness and ease of use in general technology adoption contexts. Similarly, instruments used in digital technology, e-learning, and information systems research tend to assess user acceptance without considering the unique cognitive, physical, and performance-related demands of athletes. In this study, "adaptation" refers to athletes' ability to integrate sports technologies into their training and performance routines in a practical and effortless manner. Importantly, adaptation is not used to denote broad digital literacy or general technological competence; rather, it is operationalized as (i) adapting quickly to new sport-related applications, (ii) becoming accustomed to the technologies used within the team/training environment, and (iii) perceiving sport-related digital systems as easy to learn and use. Thus, digital adaptation represents athletes' sport-specific adjustment and ease-of-use experiences when interacting with sports technologies. Accordingly, the construct operationalizes perceived ease of use within a sport-specific behavioral context rather than general technology competence.

Accordingly, the present scale aims to adapt TAM's core constructs—perceived usefulness and perceived ease of use—to the sports context in order to assess how athletes perceive sports technologies both as performance-enhancing tools and as digital systems requiring adaptation. In this respect, the study addresses a critical need in the sports technology literature by providing a theoretically grounded, athlete-centered, and psychometrically sound measurement instrument. In sport environments, technology use frequently requires rapid adjustment to structured routines (training plans, coach directives, and performance monitoring practices). For this reason, the present study treats digital adaptation as a sport-specific operationalization of TAM’s perceived ease of use (PEOU). In other words, while TAM explains acceptance through perceived usefulness and perceived ease of use, the “adaptation” wording in this study emphasizes the athlete’s practical adjustment and comfort in using sport technologies during real training and performance contexts.

The aim of the present study is to develop a Sports Technology Adaptation Scale that can measure athletes' perceptions and adaptation levels to sports technologies, based on Davis' (1989) Technology Acceptance Model. Within this framework, adaptation is measured through athletes’ perceived ease and speed of adjusting to sport-related digital applications and systems, and their comfort in using technologies integrated into their training environment.

Methods

Ethical Approval

Ethical approval was obtained from the Ondokuz Mayıs University Social and Human Sciences Ethics Committee (Decision No: 2025-1197; Date: 31 October 2025).

Research Design

This research is a methodological (scale development) and cross-sectional study conducted within the framework of a quantitative research approach aiming to develop a measurement tool to assess athletes' adaptation levels to sports technologies. The research focuses on examining the psychometric properties of the scale developed in accordance with the existing theoretical framework. In this context, the item writing, construct validity, and reliability analysis stages of the scale development process were followed.

Theoretical Foundation of the Item Development Process (TAM)

In this study, the scale items were developed based on the Technology Acceptance Model (TAM) proposed by Davis (1989). TAM posits that individuals’ adoption and use of a technology are shaped by two fundamental cognitive constructs: perceived usefulness and perceived ease of use. Accordingly, during the item development process, statements reflecting athletes’ perceptions of sports technologies as performance-supportive tools were designed to represent the perceived usefulness dimension, whereas statements related to learning, using, and adapting to digital systems were structured to represent the perceived ease of use dimension. In this way, the scale items were operationalized in direct alignment with the theoretical components of TAM. In this respect, the perceived ease of use component was expressed using sport-contextualized adaptation statements (e.g., quickly adapting to new applications, getting used to team-used technologies, and perceiving digital systems as easy to use), ensuring conceptual consistency between the “adaptation” wording and TAM’s theoretical structure.

Research Sample

The study sample consisted of athletes actively participating in different sports disciplines. The participants were between the ages of 18 and 25 and included both male and female athletes. All participants were actively involved in organized sports activities during the data collection period. The athletes were recruited from university sports environments and local training settings where sports technologies (e.g., wearable tracking devices, digital performance monitoring systems, and training applications) are regularly used. Data were collected voluntarily during the competitive season. The participants completed the questionnaires in supervised group settings either before or after training sessions. Participation was anonymous, and no personally identifiable information was recorded. To examine the construct validity of the Sports Technology Adaptation Scale more rigorously, the dataset was divided into two independent subsamples. Accordingly, data obtained from 300 participants were used for Exploratory Factor Analysis (EFA), while data from 430 participants were used for Confirmatory Factor Analysis (CFA). The adequacy of the sample size was evaluated based on the commonly recommended criterion in scale development studies, which suggests that the sample size should be at least 5–10 times the number of items (Gül ve Sözbilir, 2015: Tavşancıl, 2010). In the present study, the total sample size (n = 730) exceeded ten times the number of scale items, indicating a sufficient sample size. Furthermore, each subsample used for EFA and CFA separately met this criterion. This methodological approach ensured that both exploratory and confirmatory analyses of the Sports Technology Adaptation Scale were conducted within a robust and rigorous framework, thereby enhancing the validity and generalizability of the findings.

Item Pool Development and Expert Review Process

The item generation process for the Sports Technology Adaptation Scale (STAS) was carried out using a multi-stage approach. In the first stage, the literature on sports technologies, digital adaptation, perceived ease of use, technology acceptance, and digitalization in sports performance was comprehensively reviewed (Davis, 1989; Venkatesh & Davis, 2000). In addition, the item structures of well-established and widely used measurement models were examined, particularly those based on the Technology Acceptance Model (TAM) (Davis, 1989), TAM2 (Venkatesh & Davis, 2000), TAM3 (Venkatesh & Bala, 2008), and the Unified Theory of Acceptance and Use of Technology (UTAUT). In parallel, studies examining technology use in wearable devices and digital sport/health applications were also reviewed (Kim & Shin, 2015; Pérez-Romero., 2022). The items were designed to encompass athletes' perceptions of technology, their levels of adaptation to digital tools, expectations regarding performance support, and motivation to use technology. All items were formatted using a five-point Likert scale (1 = Strongly Disagree, 5 = Strongly Agree).

Expert Review and Content Validity

To assess the content validity of the initial item pool, a panel of four experts was consulted. The expert panel consisted of academicians with expertise in sports sciences, sports technologies, measurement and evaluation, and psychometrics. The experts were asked to evaluate each item in terms of the following criteria:

(a) alignment with the construct being measured,

(b) clarity and linguistic appropriateness,

(c) conceptual consistency, and

(d) the presence of unnecessary, repetitive, or ambiguous expressions.

Expert evaluations were analyzed using Lawshe's Content Validity Ratio (CVR) method. Each item was rated as "Essential" or "Not Essential," and CVR values were calculated accordingly. For a panel of four experts, the minimum acceptable CVR value was set at $\geq .75$. As a result of this evaluation process, 15 items were removed from the item pool due to low CVR values, conceptual ambiguity, insufficient relevance to the construct, or redundancy. The remaining 15 items were deemed appropriate by the experts, with several items revised linguistically in line with expert suggestions. At the end of this stage, the scale was reduced from 30 to 15 items and prepared for pilot testing.

Pilot Study

Following expert evaluation, the 15-item preliminary form with established content validity was finalized for pilot testing. The pilot study was conducted to preliminarily assess item clarity, item functionality, and internal consistency. In this context, the scale was administered to a sample of 50 participants representing the target population (Şeker & Gençdoğan, 2006). Based on the collected data, item analyses and reliability analyses were performed to statistically evaluate the contribution of each item to the scale (Özdamar, 2016). After the pilot application, item–total correlations and Cronbach's alpha reliability coefficient were calculated to assess internal consistency and item-level functionality. Analyses conducted using SPSS indicated that all items demonstrated significant and adequate item–total correlations, and no items with low internal consistency were identified. The results showed that all 15 items made a strong contribution to the scale (Büyüköztürk, 2018). Although no items were removed at the pilot stage, five items were excluded during the EFA process based on factor loadings, cross-loading issues, and theoretical alignment criteria. Overall, these findings indicate that the developed scale demonstrated satisfactory reliability at the preliminary application stage.

Table 1. Item discrimination analysis results

Item	t	p	Low.	Upper.
1	-12.074	< .001	2.94	4.23
2	-13.669	< .001	2.95	4.32
3	-11.137	< .001	2.89	4.24
4	-13.962	< .001	2.79	4.27
5	-14.669	< .001	2.90	4.38
6	-13.512	< .001	2.88	4.26
7	-14.193	< .001	2.91	4.32
8	-15.669	< .001	2.85	4.43
9	-11.894	< .001	2.99	4.26
10	-13.403	< .001	2.72	4.15
11	-14.490	< .001	3.02	4.38
12	-13.199	< .001	2.94	4.35
13	-13.751	< .001	3.05	4.40
14	-11.548	< .001	3.00	4.26
15	-12.222	< .001	3.06	4.28

Lower and upper groups were formed by ranking participants according to the total scale scores and selecting the lowest 27% and highest 27% of the sample. Independent samples t-tests were then conducted to examine item discrimination. The comparison of total item scores between the lower and upper 27% groups revealed that all items of the STAS were statistically significant discriminators. According to the independent samples t-test results, t values ranged from 11.13 to 15.66, and all items yielded p values below .001. These findings indicate that the scale items effectively differentiate between individuals with low and high levels of the measured construct. Accordingly, none of the items were removed based on item discrimination criteria, and the scale demonstrated strong discriminatory power at the item level.

In addition, corrected item–total correlation coefficients ranged between .577 and .744. These values indicate that all items consistently represent the overall scale score. According to the measurement and evaluation literature, item–total correlation coefficients of .30 or higher indicate that an item has adequate discriminatory power and contributes meaningfully to the scale (Tavşancıl, 2010; Büyüköztürk, 2018). In this respect, all items were found to exhibit acceptable levels of item discrimination.

Evaluation of Pilot Study Results in Terms of Transition to EFA

Since item–total correlations obtained in the pilot study were within acceptable ranges, no items were removed at the pilot stage. However, the primary purpose of pilot testing is to evaluate item clarity, comprehensibility, and functional performance during administration, whereas the determination of the factor structure can only be achieved through Exploratory Factor Analysis (EFA). Therefore, during the EFA stage, items were re-evaluated not only based on correlation values but also in terms of factor loadings, cross-loading patterns, theoretical relevance, and contribution to factor integrity. Based on these criteria, five items that weakly represented the target constructs or loaded significantly on more than one factor were excluded from further analyses. Consequently, the scale—reduced to 15 items after expert review—was finalized as a 10-item, two-factor structure following the completion of the EFA process. This procedure is consistent with standard practices recommended in the scale development literature (DeVellis & Thorpe, 2021; Worthington & Whittaker, 2006).

Psychometric Properties of the Scale

The psychometric evaluation aimed to determine whether the developed items accurately measured the intended constructs and whether the scale demonstrated adequate reliability. This evaluation consisted of several stages. First, Exploratory Factor Analysis (EFA) was conducted to examine the underlying factor structure. Second, Confirmatory Factor Analysis (CFA) was performed to assess the fit and robustness of the two-factor model. Third, reliability was evaluated by examining Cronbach's alpha coefficients.

Exploratory Factor Analysis

Exploratory and confirmatory factor analyses were conducted on two independent subsamples. To identify the underlying factor structure of the scale, Exploratory Factor Analysis (EFA) was applied using the Principal Axis Factoring (PAF) extraction method. Furthermore, the correlation between the two factors was high (r = .72), indicating that although conceptually distinct, the constructs are substantially related. Oblique rotation allows factors to correlate and provides a more realistic representation of psychological constructs in social science measurement models. The number of factors was determined based on eigenvalues greater than 1, inspection of the scree plot, and theoretical considerations. Items with factor loadings of ≥ .40 were retained. In cases of cross-loadings, a minimum difference of ≥ .20 between the primary and secondary loadings was required. Corrected item–total correlation values of ≥ .30 were considered acceptable. When statistical criteria conflicted, theoretical relevance and conceptual clarity were taken into consideration.

The analysis was conducted using data obtained from 300 participants with diverse demographic characteristics. The sample size met recommended minimum criteria for factor analysis (e.g., at least 5–10 participants per item) and was deemed sufficient relative to the number of items (Tabachnick & Fidell, 2013; Worthington & Whittaker, 2006). This adequacy enhanced the reliability and generalizability of the resulting factor structure. To assess the suitability of the data for factor analysis, the Kaiser–Meyer–Olkin (KMO) measure and Bartlett's Test of Sphericity were performed. The KMO value of .918 indicated excellent sampling adequacy and sufficient shared variance among variables (Kaiser, 1974; Hair et al., 2019). Bartlett's Test of Sphericity was statistically significant ($\chi^2 = 1366.666$, df = 45, $p < .001$), confirming that correlations among items were adequate for factor analysis. Together, these results strongly supported the appropriateness of the dataset for factor analysis.

Initially, the scale was examined using 15 items. However, during the analysis process, five items were removed due to low factor loadings, significant cross-loadings, inadequate item–total correlations, or weak theoretical alignment. Subsequent analyses conducted with the remaining items revealed a final two-factor structure consisting of 10 items. This two-factor model demonstrated strong psychometric properties, with high factor loadings, meaningful inter-item relationships, and a total explained variance of 53.785%. The reported total explained variance is based on the Extraction Sums of Squared Loadings prior to rotation. The clear clustering of items under their respective factors supports both the structural validity and theoretical coherence of the scale. Overall, these findings indicate that the scale reliably and validly represents the intended constructs. Inter-factor correlations obtained from the Promax rotation are presented in Table 2.

Table 2. Factor correlation matrix (promax rotation)

Factor	1	2
1	1.00	.72
2	.72	1.00

Note. Values represent correlations between latent factors obtained from Promax rotation.

Table 3. Pattern matrix of the sports technology adaptation scale (promax rotation)

		Items	λ	TVE %
F1	I3	Digital applications enable me to identify my shortcomings.	0.846	53.785
	I4	Sports technologies save time during the training process.	0.740	
	I6	Technology-generated data provide me with objective feedback.	0.740	
	I5	Sports technologies make it easier for me to follow scientific and technical developments in sports.	0.704	
	I2	The use of sports technology supports performance improvement.	0.700	
F2	I14	I find it useful to use different technological devices (e.g.. smartwatches. sensors).	0.764	
	I11	I adapt quickly to new applications.	0.747	
	I13	I get used to the technologies used by my team quickly.	0.720	
	I9	Using digital systems is easy for me.	0.696	
	I15	I make an effort to keep up with technological innovations.	0.666	

λ: Factor Loading; TVE: Total Explained Variance; F1=Perceived Technological Support, F2=Digital Adaptation,

Extraction method: Principal Axis Factoring; Rotation method: Promax with Kaiser normalization. Only loadings ≥ .40 are displayed.

Because the factors showed a high correlation (r = .72), an oblique rotation method (Promax) was preferred. The EFA solution was rotated using an oblique technique to avoid forcing factor independence and to obtain a conceptually and statistically coherent loading pattern. The rotated factor solution revealed that the items loaded onto two theoretically anticipated subdimensions: Perceived Technological Support (F1) and Digital Adaptation (F2). This finding confirms the conceptual coherence of the scale and demonstrates that the items adequately represent their respective dimensions. The reported total explained variance is based on the Extraction Sums of Squared Loadings calculated prior to rotation.

Factor Descriptions

Factor 1 (F1): Perceived Technological Support

This dimension reflects the functional benefits athletes experience when using technology, including perceived performance enhancement, time efficiency, progress monitoring, objective feedback, and overall efficiency. Perceived Technological Support is conceptually aligned with the construct of perceived usefulness proposed within Davis's (1989) Technology Acceptance Model (TAM). According to Davis, perceived usefulness refers to an individual's belief that using a particular technology will improve performance. In the sports context, technological tools—such as digital performance analysis applications, sensor-based monitoring systems, and video feedback technologies—enable athletes to evaluate their performance more accurately, identify shortcomings, monitor development processes, and enhance training efficiency (Carling et al., 2008; Liebermann et al., 2002). Consequently, technology is perceived as a supportive instrument that facilitates athletes' decision-making processes, enhances predictive capacity, and contributes to performance development. Items loading on this factor reflect athletes' awareness of the functional contributions of technology to performance and the internalization of technology as a supportive component in sports. Therefore, Perceived Technological Support represents a theoretical construct capturing the empowering, facilitating, and performance-enhancing role of technology in the athletic context.

Factor 2 (F2): Digital Adaptation

This dimension encompasses athletes' openness to using new digital tools, their ability to rapidly adapt to applications, willingness to integrate technological systems, and confidence in using technology. This construct is closely related to information systems acceptance models, such as TAM and TAM2, which explain technology adoption behaviors. In particular, perceived ease of use, as defined by Davis (1989), refers to the belief that a technology can be used with minimal effort and constitutes a fundamental determinant of the adaptation process. Furthermore, the TAM2 model proposed by Venkatesh and Davis (2000) highlights that individuals' attitudes toward technology, behavioral intentions, and adaptation behaviors are shaped by social influence, facilitating conditions, and individual expectations. In the sports domain, the rapid diffusion of technological innovations necessitates athletes' swift adaptation to digital tools and integration into technology-driven performance processes. Accordingly, technological adaptation in athletes involves not only technical competence but also psychosocial elements such as digital literacy, openness to innovation, and adjustment to an evolving training ecosystem. The items associated with this factor represent characteristics such as agility in digital environments, adaptability, technological self-confidence, and the tendency to adopt innovations. Thus, the Digital Adaptation dimension constitutes a theoretical structure that explains athletes' active participation in the digitalized sports environment and their level of internalization of technology.

Confirmatory Factor Analysis

Confirmatory Factor Analysis (CFA) was conducted to validate the two-factor structure obtained from the Exploratory Factor Analysis. CFA was performed using the AMOS 24 software package, and model parameters were estimated using the Maximum Likelihood (ML) estimation method. Model fit was evaluated based on multiple goodness-of-fit indices, including the chi-square to degrees of freedom ratio (χ^2/df), RMSEA, CFI, TLI (NNFI), GFI, and AGFI. These confirmatory analyses were carried out to verify the final 10-item, two-factor structure identified through the EFA process.

Table 4. Results of confirmatory factor analysis for the sports technology adaptation scale

Factors	Standardized Factor Loadings	t	CR	AVE	R^2
	Factor1				
Digital applications help me identify my	.797				.636
Sports technologies save time during the	.739	16.112			.547
Technology-generated data provide me with	.775	17.085	0.887	0.611	.600
Sports technologies make it easier for me to	.812	18.076			.659
The use of sports technology supports	.784	16.716			.614
	Factor2				
I find it useful to use different technological	.776				.602
I adapt quickly to new applications.	.751	16.660	0.882	0.601	.564
I get used to the technologies used by my team	.720	15.131			.518
Using digital systems is easy for me.	.869	18.753			.755
I make an effort to keep up with technological	.754	14.829			.566

Confirmatory Factor Analysis Results and Construct Reliability

As shown in Table 4, the standardized factor loadings for Factor 1 range between 0.739 and 0.812. The composite reliability coefficient of this factor (CR = 0.887) indicates a high level of internal consistency. The average variance extracted (AVE = 0.611) exceeds the commonly accepted minimum threshold of 0.50, providing strong support for construct validity. In addition, the R^2 values ranging from 0.547 to 0.659 indicate that Factor 1 explains a substantial proportion of variance in its observed items.

For Factor 2, standardized factor loadings range from 0.720 to 0.869. The composite reliability of this factor is also high (CR = 0.882), and the AVE value (0.601) exceeds the recommended threshold, indicating that the factor is both reliable and well represented by its items. Furthermore, R^2 values ranging between 0.518 and 0.755 demonstrate that the items are adequately explained by the underlying factor. Across both factors, all *t*-values were statistically significant (CR > 1.96), confirming that the items exhibit strong and meaningful relationships with their respective latent constructs. Moreover, all standardized factor loadings exceeded 0.50, indicating that the items adequately represent their factors and that construct validity is achieved. Overall, the fact that CR values for both Factor 1 and Factor 2 exceed 0.80, while AVE values are approximately 0.60, demonstrates that the scale exhibits high reliability, sufficient explained variance, and strong construct validity.

Convergent Validity

For both factors, composite reliability (CR) values exceeded 0.70 (F1 = 0.887; F2 = 0.882), and average variance extracted (AVE) values were above 0.50 (F1 = 0.601; F2 = 0.611), indicating that convergent validity was established (Fornell & Larcker, 1981; Hair et al., 2019). These findings confirm that the items adequately represent their respective factors and further support the strong construct validity of the model.

Table 5. Discriminant validity (fornell–larcker criterion)

Constructs	Square Root of AVE	Perceived Technological Support	Digital Adaptation
Perceived Technological Support	0.781	1	0.72
Digital Adaptation	0.775	0.72	1

Discriminant Validity Analysis

The square roots of AVE values exceeded inter-factor correlations, indicating adequate discriminant validity. According to the Fornell–Larcker criterion, the square root of the average variance extracted (AVE) for each construct is expected to be greater than the correlations between that construct and the other constructs in the model. The findings indicate that the square root of AVE for the Perceived Technological Support factor (0.781) and the square root of AVE for the Digital Adaptation factor (0.775) are both higher than the correlation between the two factors (0.72). Although the correlation between factors was relatively high, the square roots of AVE exceeded inter-factor correlations, supporting discriminant validity (Fornell & Larcker, 1981).

Table 6. Internal consistency coefficients of participants' responses to scale items.

Sub-Dimensions	Internal Consistency Coefficient	Evaluation
Perceived Technological Support	0.882	Highly Reliable
Digital Adaptation	0.840	Highly Reliable
Scale Total	0.908	Highly Reliable

Internal Consistency Reliability

The internal consistency coefficients (Cronbach’s alpha) of the Sports Technology Adaptation Scale provide important evidence regarding the reliability of the instrument. The overall reliability of the scale was calculated as $\alpha = 0.908$, indicating a high level of internal consistency. According to the classifications proposed by DeVellis & Thorpe (2021) and Taber (2018), Cronbach’s alpha values of 0.80 and above are considered to reflect high reliability. In this context, the overall structure of the scale can be regarded as consistent and reliable. At the subscale level, the internal consistency coefficient was found to be $\alpha = 0.882$ for *Perceived Technological Support* and $\alpha = 0.840$ for *Digital Adaptation*, both of which indicate high reliability. DeVellis & Thorpe (2021) notes that although values between 0.60 and 0.70 are considered acceptable, such levels may be tolerated particularly during the scale development phase, as they still represent an adequate degree of reliability. Similarly, Taber (2018) emphasizes that in newly developed multidimensional scales within the social sciences, alpha values around the 0.60 range for certain subdimensions may be expected due to the structural complexity of the measurement model. When evaluated together with the scale’s factor structure and content validity, these findings indicate that the instrument possesses sufficient statistical reliability and can be considered an appropriate and reliable tool for its intended measurement purposes.

Table 7. Confirmatory Factor Analysis Fit Indices for The Sports Technology Adaptation Scale.

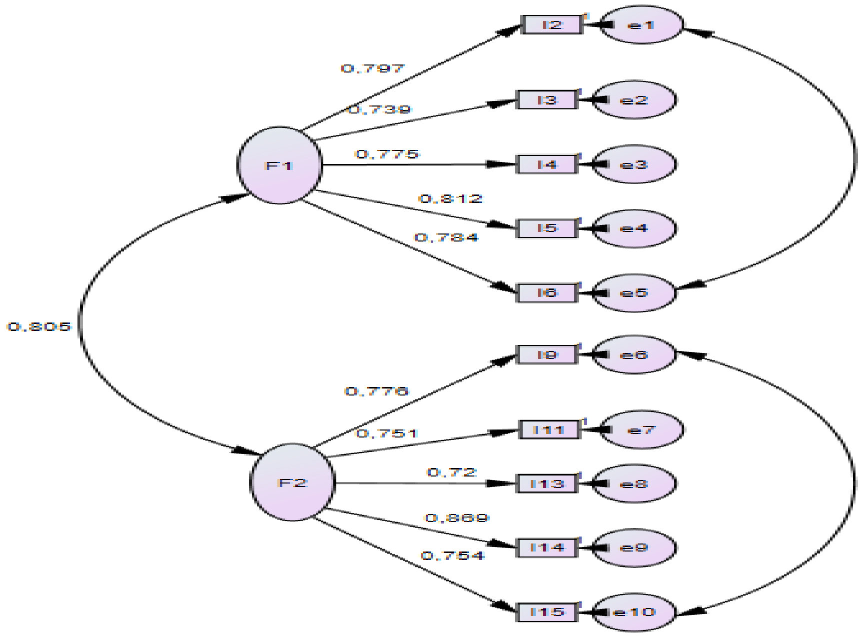
Adaptation Metric	Score	Adjustment
χ^2=55.421, /df = 32	1.73	Excellent Fit
RMSEA	0.041	Excellent Fit
RMR	0.018	Excellent Fit
NFI	0.975	Excellent Fit
NNFI	0.985	Excellent Fit
CFI	0.989	Excellent Fit
GFI	0.975	Excellent Fit
AGFI	0.958	Excellent Fit
PCLOSE	0.771	Excellent Fit

χ^2/df = Chi-square goodness-of-fit ratio; RMSEA = Root Mean Square Error of Approximation; NFI = Normed Fit Index; NNFI = Non-Normed Fit Index; CFI = Comparative Fit Index; GFI = Goodness-of-Fit Index; AGFI = Adjusted Goodness-of-Fit Index.

The fit indices obtained from the Confirmatory Factor Analysis (CFA) indicate that the two-factor model of the scale demonstrates a very good fit to the data. First, the ratio of chi-square to degrees of freedom (χ^2/df = 1.73) is below the threshold commonly accepted as indicative of good model fit (≤ 2), suggesting a strong overall model fit (Schermelleh-Engel, Moosbrugger, & Müller, 2003; Kline, 2023). The RMSEA value of 0.041, which reflects the approximate amount of error in the model, indicates an excellent level of fit in accordance with the < 0.05 criterion proposed by Hu and Bentler (1999). In addition, the narrow 90% confidence interval for RMSEA (.022–.059) and a PCLOSE value of .771 further support the close-fit hypothesis of the model.

The absolute fit indices GFI (0.975) and AGFI (0.958) both exceed the recommended threshold of 0.90, indicating that the model fits the data well and demonstrates stable fit characteristics (Hooper et al., 2008). Examination of the comparative fit indices shows that NFI (0.975), NNFI/TLI (0.985), and CFI (0.989) not only exceed the acceptable cutoff value of 0.90 but also surpass the more stringent criterion of 0.95, which is commonly interpreted in the literature as reflecting an excellent level of fit (Hu & Bentler, 1999; Hair et al., 2019). These results suggest that the proposed model exhibits a substantially stronger fit compared to alternative models.

Schermelleh-Engel et al. (2003) indicate that models with χ^2/df < 3 and RMSEA < .08 can generally be considered to have acceptable fit; the fact that the present model demonstrates considerably better values further strengthens the evidence for model adequacy. Moreover, Hu and Bentler (1999) emphasize that reliance on a single fit index may be misleading and that model fit should be evaluated holistically by considering sample size, model complexity, and data characteristics. Overall, the collective evaluation of all fit indices indicates that the model demonstrates strong overall fit, excellent comparative fit, and a low level of error. Error covariances were allowed only between items belonging to the same factor and sharing similar wording (e.g., items reflecting rapid adjustment and ease of use). These modifications were theoretically justified and introduced cautiously to improve model fit without altering the conceptual structure of the model. In addition, the significance and strength of the factor loadings further support the conceptual coherence of the two-factor structure and provide clear evidence for the scale’s confirmatory construct validity. In addition, modification indices were examined to improve model fit. Limited covariances between error terms were allowed only for item pairs loading on the same latent factor and sharing similar wording and contextual meaning. These modifications were applied cautiously and were theoretically justified, as they reflect shared measurement variance rather than changes in the conceptual structure of the scale. No cross-factor error correlations were permitted, and the underlying two-factor theoretical model was preserved



Chi- Square = 55,421, df = 32, P-value = <0,001, RMSEA = 0,041

Figure 1. Standardized Solution Values of the Confirmatory Factor Analysis

In Figure 1, the scale factors are labeled as F1 = Perceived Technological Support and F2 = Digital Adaptation.

Discussion

The aim of this study is to develop a measurement tool that evaluates athletes’ adaptation to sports technologies within real training environments. The findings indicate that athletes’ interaction with sports technologies is not limited to the level of acceptance but also involves an adaptation process embedded within structured performance systems.

The two-factor structure reveals that athletes distinguish between evaluating the contribution of technology to performance and adapting to its practical use. The relatively high correlation between the factors suggests that these dimensions may represent related components of a broader sports technology adaptation construct. Therefore, future studies may test second-order confirmatory factor analysis models to examine the hierarchical structure of the scale.

In competitive sports environments, technologies are typically integrated into training processes through coach expectations and performance monitoring systems. In this context, athletes may acknowledge the usefulness of a technology while simultaneously experiencing difficulty in using it comfortably. Conversely, some athletes may easily adapt to technological tools but may not strongly perceive their contribution to performance. This distinction indicates that the athlete–technology interaction is not only a cognitive process but also a behavioral one. Adaptation requires learning how to use applications, becoming accustomed to monitoring systems, and integrating feedback into training behaviors. Therefore, digital adaptation in sports reflects a behavioral adaptation process rather than a voluntary acceptance of technology.

Within the framework of the Technology Acceptance Model, the Perceived Technological Support dimension corresponds to perceived usefulness, while the Digital Adaptation dimension reflects a sport-specific interpretation of perceived ease of use. However, unlike traditional information systems contexts, athletes do not always have full autonomy in choosing whether to use technology. Technology use is often embedded within structured training processes guided by coaches. Thus, adaptation becomes not merely a matter of user preference but a requirement for performance.

From a practical perspective, the findings indicate that simply providing athletes with technological devices is insufficient for effective technology integration. Coaches and sports organizations need to support the adaptation process through guided training, practical demonstrations, and gradual integration into training routines. Educational programs for athletes may enhance the effective use of technology and reduce resistance to digital monitoring systems. Additionally, designers of sports technologies should prioritize usability and ease of learning. Technologies perceived as difficult to use may not be effectively adopted, even if their performance benefits are recognized. Therefore, incorporating user feedback and user-centered design approaches into technology development processes is essential.

From a theoretical perspective, the Perceived Technological Support dimension aligns with the concept of perceived usefulness defined in the Technology Acceptance Model. Athletes' perception of technology as a tool that enhances performance, provides feedback, supports time management, and facilitates monitoring of development processes indicates that technology has evolved from being a supportive element to becoming an integral component of performance systems. The Digital Adaptation dimension reflects athletes' perceptions of ease of use, their ability to adapt to new systems, and their openness to digital innovations. This structure corresponds to perceived ease of use and demonstrates conceptual consistency with TAM-based interpretations in the sports context.

Conclusion

In conclusion, the Sports Technology Adaptation Scale enables the understanding of athletes' interaction with technology not only in terms of acceptance but also through adaptation processes. The findings demonstrate that athletes evaluate technology not only based on its contribution to performance but also on the extent to which it can be integrated into training processes. This indicates that the effective use of technology in sports depends on both perceived performance value and ease of use.

The scale provides a functional tool for coaches, sports organizations, and researchers to identify challenges in the adaptation process and to support athletes accordingly. It is emphasized that access to technological tools alone is not sufficient; guided use, training, and usability-focused design are critical factors.

Future studies are recommended to test the scale across different levels of sports performance and cultural contexts. Additionally, longitudinal research designs may provide a clearer understanding of how adaptation to sports technologies evolves over time.

Acknowledgements

This study was not derived from any thesis and has not been presented at any scientific conference.

Author Contributions

Conceptualization: MK. Methodology: MK, FSA. Investigation: MK, FSA, OK, NM, HEM, SÇ. Data Curation: MK, FSA, OK, NM, HEM, SÇ. Formal Analysis: MK, SÇ. Writing – Original Draft:MK, SÇ, HEM. Writing – Review & Editing: SÇ, HEM.

Funding

This study received no specific financial support from any public, commercial, or non-profit funding agencies.

Conflict of Interest

The authors declare that they have no conflicts of interest.

Ethics Statement

Ethical approval was obtained from the Ondokuz Mayıs University Social and Human Sciences Ethics Committee (Decision No: 2025-1197; Date: 31 October 2025).

References

Ajzen, I. (1991). The theory of planned behavior. *Organizational Behavior and Human Decision Processes, 50*(2), 179–211.

Büyüköztürk, Ş. (2018). *Sosyal bilimler için veri analizi el kitabı*. Pegem Atıf İndeksi.

Carling, C., Reilly, T., & Williams, A. M. (2008). *Performance assessment for field sports*. Routledge.

Davis, F. D. (1989). Perceived usefulness, perceived ease of use, and user acceptance of information technology. *MIS Quarterly*, *13*(3), 319–340.

Davis, F. D., Bagozzi, R. P., & Warshaw, P. R. (1989). User acceptance of computer technology: A comparison of two theoretical models. *Management Science, 35*(8), 982–1003.

DeVellis, R. F., & Thorpe, C. T. (2021). Scale development: Theory and applications. *Sage Publications.*

Eriş, E. D., & Kocabıyık, M. S. (2023). Teknoloji kabul modelleri ve teknoloji hazırlık odaklı çalışmalara yönelik bibliyometrik bir analiz. *Paradigma: İktisadi ve İdari Araştırmalar Dergisi, 12*(Özel Sayı), 42–56.

Fornell, C., & Larcker, D. F. (1981). Evaluating structural equation models with unobservable variables and measurement error. *Journal of Marketing Research*, *18*(1), 39-50.

Gül Ş. ve Sözbilir, M. (2015). Fen ve matematik eğitimi alanında gerçekleştirilen ölçek geliştirme araştırmalarına yönelik tematik içerik analizi. *Eğitim ve Bilim*, 40(178), 85-102. doi: 10.15390/EB.2015.4070

Hair, J. F., Black, W. C., Babin, B. J., & Anderson, R. E. (2019). Multivariate Data Analysis (8th ed.). Cengage.

Hooper, D., Coughlan, J., & Mullen, M. R. (2008). Structural equation modeling: Guidelines for determining model fit structural equation modeling. *Dublin Institute of Technology ARROW@ DIT, 6*(1), 53–60. https://doi.org/10.21427/D7CF7R

Hu, L. T., & Bentler, P. M. (1999). Cutoff criteria for fit indexes in covariance structure analysis: Conventional criteria versus new alternatives. *Structural Equation Modeling: a Multidisciplinary Journal*, *6*(1), 1-55.

Kim, K. J., & Shin, D. H. (2015). An acceptance model for smart watches: Implications for the adoption of future wearable technology. Internet Research, *25*(4), 527-541.

Kline, R. B. (2023). *Principles and practice of structural equation modeling*. Guilford publications.

Liebermann, D. G., Katz, L., Hughes, M. D., Bartlett, R. M., McClements, J., & Franks, I. M. (2002). Advances in the application of information technology to sport performance. *Journal of Sports Sciences, 20*(10), 755-769.

Lin, C. H., Shih, H. Y., & Sher, P. J. (2007). Integrating technology readiness into technology acceptance: The TRAM model. *Psychology & Marketing, 24*(7), 641-657.

Özdamar, K. (2016). *Eğitim, sağlık ve davranış bilimlerinde ölçek ve test geliştirme yapısal eşitlik modellemesi*. Eskişehir: Nisan Kitabevi.

Parasuraman, A. (2000). Technology readiness index (TRI): A multiple-item scale to measure readiness to embrace new technologies. *Journal of Service Research, 2*(4), 307–320.

Pérez-Romero, N., Reigal, R. E., Franquelo, M. A., Monteiro, D., Castillo, I., Hernández-Mendo, A., & Morales-Sánchez, V. (2022). Testing Psychometric Properties and Measurement Invariance of Basic Psychological Needs in the Digital Version of the Sport Scale. *Sustainability*, *14*(19), 12126.

Schermelleh-Engel, K., Moosbrugger, H., & Müller, H. (2003). Evaluating the fit of structural equation models: Tests of significance and descriptive goodness-of-fit measures. *Methods of Psychological Research Online*, *8*(2), 23-74.

Şeker, H., & Gençdoğan, B. (2006). *Psikolojide ve eğitimde ölçme aracı geliştirme*. Nobel Akademik Yayıncılık.

Taber, K. S. (2018). The use of Cronbach's alpha when developing and reporting research instruments. *Research in Science Education*, *48*, 1273–1296.

Tavşancıl, E. (2010). *Tutumların ölçülmesi ve SPSS ile veri analizi*. Nobel Akademik Yayıncılık.

Toraman, Y., & Yüksel, C. A. (2022). COVID-19 sürecinde tüketicilerin yeni teknolojileri benimsemelerinin teknoloji kabul modeli çerçevesinde incelenmesi. *Doğuş Üniversitesi Dergisi, 23*(Özel Sayı), 17–34.

Turan, A. H. (2008). İnternet alışverişi tüketici davranışını belirleyen etmenler: Geliştirilmiş teknoloji kabul modeli (E-TAM). *Akademik Bilişim*, 723–730.

Venkatesh, V., & Bala, H. (2008). Technology acceptance model 3 and a research agenda on interventions. *Decision Sciences, 39*(2), 273–315.

Venkatesh, V., & Davis, F. D. (2000). A theoretical extension of the technology acceptance model: Four longitudinal field studies. *Management Science, 46*(2), 186–204.

Worthington, R. L., & Whittaker, T. A. (2006). Scale development research: A content analysis and recommendations for best practices. *The Counseling Psychologist,* 34(6), 806-838.